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*Via US Priority Mail*

Public Comments Processing
Attn: Docket No. FWS-R6-ES-2016-0042
U. S. Fish & Wildlife Service, MS:BPHC
U. S. Department of the Interior
5275 Leesburg Pike
Falls Church, VA 22041-3803

***Re:*** ***Grizzly Bears – Comments in Opposition to Removal of Endangered Species Act Protection for Greater Yellowstone Population of Grizzly Bears as Published in the Federal Register on March 11, 2016 (81 Fed. Reg. 13174)***

Dear Ms. or Mr.:

I oppose removal of protection of the Greater Yellowstone Ecosystem ("GYE") population of grizzly bears under the Endangered Species Act ("ESA"), as amended, 16 U.S.C. §§ 1531-1544, as proposed by the U. S. Fish & Wildlife Service ("FWS"), in the Federal Register on March 11, 2016, 81 Fed. Reg. 13174 et seq. ("2016 PDR"), for the reasons set forth below.

## I. Disregard of the Rule of Law

The Rule of Law in the United States means that it and its citizens submit to a set of laws to govern behavior and to an independent judiciary to administer and enforce those laws.. As Theodore Roosevelt said in 1903, "Ours is a government of liberty by, through and under law. No man is above it, and no man is below it." The Rule of Law protects the public from government abuse of power.

U. S. Supreme Court Justice Felix Frankfurter wrote in a concurring opinion in *United States v. United Mine Workers*, 330 U.S. 258, 307-09, 312 (1947:

> The historic phrase 'a government of laws and not of men' epitomized the distinguishing character of our political society. When John Adams put that phrase into the Massachusetts Declaration of Rights, pt. 1, art. 30, he was not indulging in a rhetorical flourish. He was expressing the aim of those who, with

him, framed the Declaration of Independence and founded the Republic. 'A government of laws and not of men' was the rejection in positive terms of rule by fiat, whether by the fiat of governmental or private power. Every act of government may be challenged by an appeal to law, . . . .
. . . .

In our country law is not a body of technicalities in the keeping of specialists or in the service of any special interest. There can be no free society without law administered through an independent judiciary. If one man can be allowed to determine for himself what is law, every man can. That means first chaos, then tyranny. ***Legal process is an essential part of the democratic process.*** For legal process is subject to democratic control by defined, orderly ways which themselves are part of law. In a democracy, power implies responsibility. . . . (Emphasis Added.)

In 2005 the FWS issued a proposed rule to remove ESA protection for the GYE population of grizzly bears ("2005 PDR"); and in 2007 the FWS issued the final delisting rule ("2007 FDR"). The 2007 FDR was challenged in three lawsuits, including a lawsuit filed by the undersigned.[1]

In 2009 the Federal District Court for the District of Montana invalidated the 2007 FDR; and the U. S. Court of Appeals for the Ninth Circuit unanimously affirmed the District Court's decision. *Greater Yellowstone Coalition v. Salazar*, 672 F. Supp.2d 1105 (D. Mont. 2009), aff'd, 665 F.3d 1015 (9th Cir. 2011).

The *Greater Yellowstone* case was thoroughly and competently litigated by the FWS and other federal defendants and the States of Montana and Wyoming, which intervened as defendants on behalf of the FWS, and by multiple hunting organizations as intervenors-defendants. The evidence was set forth in the Administrative Record ("2007 AR"),[2] which was compiled by the FWS and contained over 50,000 pages and was filed with the Montana District Court (and with the Idaho District Court in the other two cases; see Aland Case, Doc. 16 (Feb. 11, 2008)) with a Declaration executed by the FWS's Grizzly Bear Recovery Coordinator was "full and complete" and "true and complete" under penalty of perjury.

The FWS, having reviewed the record from the Montana District Court and Ninth Circuit Court of Appeals, ***affirmatively decided not to seek a rehearing en banc or reconsideration of the Ninth Circuit's decision or appeal the Ninth Circuit's decision to the U. S. Supreme Court.*** Thus, at this point in time the Rule of Law was intact. However, that status did not last long.

Instead of following the Rule of Law and accepting the essential "legal process" that Justice Frankfurter described that resulted in the decisions of the Montana District Court and the Ninth Circuit Court of Appeals in *Greater Yellowstone*, the federal government, through the FWS,

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[1] *Aland v. Kempthorne*, Idaho Federal District Court, Case No. 1:08-cv-00024-EJL ("Aland Case").

[2] The 2007 AR contained substantial evidence that continues to be highly relevant with regard to the 2016 PDR and, therefore, will be cited throughout these comments.

rejected those decisions and issued the 2016 PDR. In other words, the federal government, which should be at the forefront of adherence to and respect for the Rule of Law, has shown ***utter disrespect*** for the Rule of Law by issuing the 2016 PDR.

The reasons why the FWS acted in this manner are discussed below and certainly included improper political influence to which it readily succumbed. The FWS's conduct is the very type of conduct that the Rule of Law is intended to prevent.

Fortunately there are specific case law rules that can be applied by the courts to correct the FWS's abuse of the Rule of Law in the litigation that almost certainly will follow the issuance, presumably before the end of 2016, of the final rule removing ESA protection for GYE grizzly bears ("2016 FDR"). The courts are likely to invalidate the 2016 FDR based upon (a) the *Greater Yellowstone* precedents and/or (b) the doctrine of collateral estoppel announced by the U. S. Supreme Court in *Commissioner v. Sunnen*, 333 U.S. 591 (1948) ("[The collateral estoppel] principle is designed to prevent repetitious lawsuits over matters which have once been decided and which have remained substantially static, factually and legally.").

There have been no significant legal changes in the FWS's favor since the *Greater Yellowstone* decisions; and the factual changes, many significant, all support retention of ESA protection for the GYE grizzly bears because those changes indicate that the bears' chances of survival have deteriorated since 2007. The 2016 PDR and the 2016 FDR are and will be nothing more than the 2005 PDR and 2007 FDR, respectively, in disguise.

It is irresponsible for the federal government, through the FWS, to re-litigate the issues that were decided in *Greater Yellowstone*, at great expense to taxpayers from the standpoint of both human and financial resources, and, even more important, from the standpoint of the fundamental principle of the Rule of Law upon which this country was founded and depends to support its democratic principles.

## II. Violation of FWS Mission and Objectives

The mission of the FWS is stated on its website as follows: "***Work with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people.***" **http://www.fws.gov/help/about_us.html**

This mission is enhanced by the following "objectives" stated on the website: (1) "Assist in the development and application of an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility"; and (2) "Guide the conservation, development, and management of the Nation's fish and wildlife resources.

The 2016 PDR fails to achieve the FWS's mission and objectives in the most fundamental manner. ***It is a morbid, cynical document; its focus throughout is on death and destruction of***

***grizzly bears, icons of American history.***[3] The 2016 PDR is dominated by discussions of which, and how many, bears will live and which, and how many, will die. It is a roadmap for renewed slaughter for the great bears. It is a paean to local ranchers, hunters, outfitters, resource exploiters and states-righters.

The 2016 PDR is completely disconnected from the FWS's mission to provide "an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility"; it is devoid of "ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility."

The U. S. Supreme Court stated in *Tennessee Valley Authority v. Hill*, 437 U.S. 153 (1978), relying on the legislative history, that the ESA "as it was finally passed, . . . represented the most comprehensive legislation for the preservation of endangered species ever enacted by any nation." *Id.* at 180. The Court stated that "one would be hard pressed to find a statutory provision whose terms were any plainer than those in [16 U.S.C. § 1536]. Its very words affirmatively command all federal agencies 'to *insure* that actions *authorized, funded, or carried out* by them do not *jeopardize* the continued existence' of an endangered species or '*result* in the destruction or modification of habitat of such species . . . ." *Id.* at 173 (citation omitted; emphasis in original). As a result, the Court stated, "examination of the language, history, and structure of the [ESA] indicates beyond doubt that Congress intended endangered species to be afforded the ***highest of priorities***."[4] *Id.* at 174 (emphasis added).

The 2016 PDR has no scientific or moral integrity. It does not afford GYE grizzly bears the "highest of priorities"; it gives them the ***lowest*** of priorities by elevating the priorities of all special interests above them. The 2016 PDR must be withdrawn in its entirety.

The relatively few remaining GYE grizzly bears, consistent with the purpose of the ESA, as eloquently stated by the Supreme Court in *Tennessee Valley Authority,* must be protected indefinitely under the ESA, which was enacted to protect and preserve a species of this type.

### III. Violation of Public Comments Requirement of Administrative Procedure Act

The Administrative Procedure Act ("APA"), 5 U. S. C. § 553, requires federal agencies, including the FWS, to (a) give general notice of proposed rule making in the Federal Register

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[3] See *Mayo v. Jarvis*, 2016 WL 1254213 (D. D. C. March 29, 2016) ("The American West is rich with wildlife of considerable ecological value. These related cases involve two iconic species – the elk and the grizzly bear . . . .").

[4] The Supreme Court in *Tennessee Valley Authority* focused squarely on grizzly bears, quoting the following comments by the House manager: "Another example . . . [has] to do with the continental population of grizzly bears which may or may not be endangered, but which is surely threatened. . . . Once this bill is enacted, the Secretary, whether of Interior, Agriculture or whatever, *will have to take action* to see that this situation is not permitted to worsen, and that these bears are not driven to extinction." 437 U.S. at 183-84 (emphasis in original). The FWS has ignored this mandate in the 2016 PDR.

and thereafter (b) give interested persons the opportunity to participate in rule making by submitting written data, views and arguments. 5 U.S.C. § 553(c). The House and Senate reports with regard to this provision state that "the agency must analyze and consider all relevant matter presented." S. Rep. No. 752, 79th Cong., 1st Sess. 15 (Nov. 19, 1945); H. Rep. No. 1980, 79th Cong., 1st Sess. 25 (May 3, 1946). "[Public] participation . . . in the rule-making process is essential in order to permit administrative agencies to inform themselves and to afford safeguards to private interests. . . ." Report submitted by Pat McCarran, Chairman, U. S. Senate Committee on the Judiciary, *Administrative Procedure Act, Legislative History 1944-46*, 79th Cong. (July 26, 1946).

Courts have recognized the importance of the public comment process. See *Ober v. U. S. Environmental Protection Agency*, 84 F.3d 304, 312-15 (9th Cir. 1996); *Idaho Farm Bureau Federation v. Babbitt*, 58 F.3d 1392, 1401-06 (9th Cir. 1995); *Wilderness Society v. Rey*, 180 F.Supp.2d 1141, 1143 (D. Mont. 2002) ("It is presumptuous to believe that the agency's final decision has a perfection about it that would not be illuminated by interested comment, questioning, or requests for justification of propositions asserted in it.").

Immediately after removal of ESA protection, the GYE population of grizzly bears will be managed by the States of Idaho, Montana and Wyoming. However, on March 11, 2016, the date the 2016 PDR was published in the Federal Register, these three states had ***not*** issued ***final*** post-delisting management plans. Montana and Wyoming have issued 2016 ***draft*** management plans; Idaho has not issued a 2016 draft management plan.

The Idaho, Montana and Wyoming management plans are, and will be, critical parts of the 2016 PDR and 2016 FDR, respectively. Therefore, complete comments under the APA with regard to the 2016 PDR can only be made after the ***final*** plans are available.

Despite the absence of final management plans, the FWS in the 2016 PDR established ***May 10, 2016***, as the deadline for comments on the the 2016 PDR. That deadline violates the APA, since, without those final plans, interested persons are precluded from submitting complete comments to be considered by the FWS.

Violation of the public comments requirement of the APA is not a new phenomenon for the FWS; it has violated the APA's public comment requirement before and no doubt, based on the record, would not hesitate to do so again. Approximately 194,000 comments were filed by the public pursuant to the APA in response to the FWS's 2005 proposed delisting rule[5]; 99.3%,

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[5] The FWS's long-time Grizzly Bear Recovery Coordinator, Dr. Chris Servheen, stated in an internal e-mail (AR 05331) that 215,000 comments were received from the public with regard to the 2005 PDR; but the "official" tally in the AR says that 193,578 comments were received. (AR 11288) The FWS attempted to explain the large (21,422) discrepancy on the ground that at the time the Coordinator stated the former number (May 30, 2006, 2 months after the comment period was closed on March 20, 2006; AR 11287) he "did not know" the actual number. That is a surprising statement, since on October 17, 2006, 4 months later, then-FWS Director H. Dale Hall stated in a memorandum to then-Secretary of the Interior Dirk Kempthorne that "we received approximately 215,000 comments." (AR 05188)

including about 90% from Idaho, Montana and Wyoming, opposed de-listing.[6] FWS disregarded that overwhelming sentiment and issued the 2007 FDR, which was invalidated in litigation as described above.[7]

The FWS justified its disregard on the ground that the public comments were not a "vote count" (AR 46683) or a "binding referendum" (Aland Case, Defendants' Response in Opposition to Plaintiff's Motion for Summary Judgment, Doc. 87, p. 18), even though the APA explicitly requires the FWS to consider "written data, views, or arguments" submitted by the public. The FWS's Grizzly Bear Recovery Coordinator, Dr. Servheen, who was primarily responsible for preparing the 2005 PDR, 2007 FDR and 2016 PDR, stated, arrogantly and dismissively, in an internal e-mail on May 30, 2006 (AR 05332) :

> If this all seems like a lot of comments and issues on our draft rule, keep in mind there is an entire NGO 'industry' devoted to grizzly bears and many of the technical comments were generated by people who were paid to comment and spend a lot of time digging up issues for the comments.

The cynicism in that statement and disrespect for the APA comment process are palpable.

The FWS's disregard of the public comments contravened the purpose of the APA; constituted extraordinary arrogance by federal officials representing the American public; and showed that the FWS will not be deterred by the requirements of the APA.

It can reasonably be expected, based on this history, that a very large number of public comments will be filed with regard to the 2016 PDR; that those comments again will overwhelmingly oppose delisting the GYE grizzly bears; and that the FWS will ignore those comments and proceed in due course (probably by the end of 2016) to issue another final rule removing the GYE grizzly bears' ESA protection.

## IV. <u>Improper Political Influence and Conflict of Interest</u>

### A. <u>Political Influence</u>

The FWS is required by the ESA to make a delisting decision solely on the basis of the best available scientific and commercial data. 16 U.S.C. § 1533(b)(1)(A); 50 C.F.R. § 424.11(b). The FWS cannot rely upon "possible economic or other impacts" in making a delisting decision. 50 C.F.R. § 424.11(b).

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[6] The enormity of the public's participation in the 2005 - 2007 grizzly bear delisting process by submitting comments can be placed in perspective by considering the following statement by the court in *Wilderness Society v. Rey*, 180 F. Supp. 2d at 1143: "The number of comments in the administrative process, over 4,000, show the case is unusual in both public interest and public participation."

[7] See *Spirit of the Sage Council v. Norton*, 294 F.Supp.2d 67, 77-78 (D. D.C. 2003) (94% opposition; rule invalidated).

The courts have held that political interference can contaminate an agency rule such. *Earth Island Institute v. Hogarth*, 484 F.3d 1123, 1134-35 (9th Cir. 2007) (political interference); *Portland Audobon Society v. Oregon Lands Coalition*, 984 F.2d 1534, 1543-48 (presidential interference). See *Latecoere Int'l, Inc. v. U. S. Dept. of the Navy*, 19 F.3d 1342 (11th Cir. 1994); *Koniag, Inc. v. Andrus*, 580 F.2d 601, 610 (D.C. Cir. 1978), cert denied, 439 U.S. 1052 (1978) (congressional interference); *Pillsbury Co. v. Federal Trade Comm'n*, 354 F.2d 952 (5th Cir. 1966) (congressional interference); *Sokaogon Chippewa Community v. Babbitt*, 961 F. Supp. 1276 (W. D. Wis. 1997).

From the FWS's point of view the delisting process no doubt began with the issuance of the 2005 PDR and has continued uninterrupted, with the loss in litigation in *Greater Yellowstone* constituting only a ***temporary setbac***k (see above discussion), to the present date. The issuance of the 2016 PDR, in the FWS's view, is nothing more than a continuation of the previously invalidated effort. Thus, it is important that members of Congress and state governors improperly interfered in the 2005 - 2007 delisting process by exerting strong pressure for delisting (even threatening to amend the ESA by legislation), especially in the months before the 2005 PDR was issued, as summarized in **Exhibit A**; and the FWS no doubt has felt continuing pressure to issue the 2016 PDR. It is important that Dr. Servheen, the FWS's Grizzly Bear Recovery Coordinator, was directly involved in the communications summarized in **Exhibit A.**

In May 2012 Wyoming Governor Matthew Mead, refusing to accept the result of the *Greater Yellowstone Coalition* litigation, requested then-Secretary of the Interior Ken Salazar to issue a new delisting rule (**Exhibit B**).[8] In July 2012 Secretary Salazar responded affirmatively (**Exhibit C**).

That exchange of letters reconfirmed the transformation of the delisting process, begun years earlier (see **Exhibit A**), in violation of the ESA, into a political exercise. The FWS, the Idaho, Montana and Wyoming wildlife agencies and the inter-agency grizzly bear committees have spent enormous amounts of time and resources preparing the 2016 PDR; their focus has been on ***overcoming litigation deficiencies***,[9] not applying the best available science, to achieve the desired political result. For example, the FWS has tried to bolster its legal position by issuing a new and abstract formula for counting the GYE grizzly bears, which produces a larger number

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[8] By letter dated December 18, 2012, to Secretary Salazar, with copies to Governor Mead and Dr. Servheen, the undersigned provided evidence obtained from the Wyoming Game & Fish Department under the Wyoming Public Records Act that the "average annual cost to Wyoming for grizzly bear management" was $1,248,413 rather than $2,000,000 as stated in Governor Mead's May 2012 letter – a 60% overstatement. Later the undersigned provided this evidence to other senior officials of the Department of the Interior and the DOI. However, the undersigned has not received responses from the Secretary's office, Governor Mead, Dr. Servheen or the other officials.

[9] **Exhibit D at pp. 21-22** (Davis March 9, 2012, email to Servheen focusing on "hopes of legal success" and "legal complications" due to "the 9th circuit decision on [whitebark pine]." See 2016 PDR at 1393.

than before (see 2016 PDR at 13186-88), [10] and a new and controversial definition of a critical ESA term, "significant portion of its range" (see 2016 PDR at 13193, 13221-23).[11]

More recently, the Commissioners of Park County, Wyoming, which comprises a substantial portion of the GYE, sent a letter dated October 26, 2015, and a copy of Resolution 2015-052 adopted by the Commissioners at their October 20, 2015, meeting (together **Exhibit E**) to the FWS Director, Dan Ashe, "encouraging the USFWS to move forward with all due haste in proposing a rule to delist the grizzly bear in the [GYE]." Copies of the the letter and Resolution were sent to the President of the United States, Secretary of the Interior Sally Jewell, Wyoming Governor Mead and his Policy Advisor, the Director of the Wyoming Game & Fish Department and the Executive Director of the Wyoming County Commissioners Association.

The minutes of the October 20, 2015, meeting at which Resolution 2015-052 was adopted contained the following discussion:

> Chairman Tilden charged James Davis, Deputy County Attorney, with the task of preparing a resolution for the Board to encourage delisting of the Grizzly Bear from the US Fish and Wildlife's Endangered Species list. The Board has been actively waiting for the delisting for seven years. The Grizzly population has tremendously increased, and an increase in the number of bear and human encounters has occurred. ***The Board's concern lies in the potential for harm the Grizzly bears' growing presence brings to the County as a whole.*** . . . Commissioner Livingston move to adopt RESOLUTON NO. 2015-052 for the delisting of Grizzly Bears, seconded by Commissioner Grosskopf and unanimously carried. (Emphasis added.)

The Commissioners' letter stated that "it is essentially unanimous among ***wildlife managers*** that the grizzly bear is recovered." (Emphasis added.) The Commissioners' reference to wildlife "managers," which described employees of federal and state wildlife agencies who favor delisting for hunting and other non-scientific reasons (such as the Wyoming Game & Fish Department, which received a copy of the letter) but are not able to assess recovery from the

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[10] A critical element of grizzly bear recovery is the size of the population in the area involved. Since an actual count of the number of bears is impractical, if not impossible, the FWS relies upon abstract formulas to estimate the number of bears. In 2013 FWS adopted a new formula for counting grizzly bears in the Greater Yellowstone Ecosystem to replace, and no doubt produce a higher number than, the prior formula. *Grizzly Bear Recovery Plan, Draft Revised Supplement: Revised Demographic Recovery Criteria for the Yellowstone Ecosystem* (Feb. 19, 2013; see 78 Fed. Reg. 17708 (March 22, 2013)).

[11] The phrase "significant portion of its range" in 16 U.S.C. §§ 1532(6) and (20) is important with regard to the protection of endangered or threatened species under the ESA, since the phrase, depending on its interpretation, either restricts or expands the geographic area in which the species will be protected and, in turn, restricts or expands the size of the protected population. FWS and NMFS recently issued a highly restrictive policy interpretation, contrary to the opinions of most ESA experts and federal court decisions, that does not take into account the species' historic distribution and instead defines the phrase in terms of where the species is found now. 79 Fed. Reg. 37578 (July 1, 2014).

scientific standpoint as required by the ESA, is especially noteworthy. The letter did not refer to wildlife "biologists" or "scientists," who have expertise relating to GYE grizzly bears and, under the ESA are the only persons who are legally able to assess whether or not the GYE bears have recovered within the meaning of the ESA.

The discussions in the Commissioners' (a) minutes of "the potential for harm [that] the Grizzly bears' growing presence brings to the County as a whole" and (b) letter to the "significant waning of tolerance" for grizzly bears by Park County residents constituted ***not-so-subtle threats*** to the President of the United States, the Secretary of the Interior and the FWS Director of ***dire consequences*** that might follow if the bears are not delisted.[12]

The undersigned has not been able to find any document in the public record in which the Interior Secretary or the FWS Director rejected this threat. To the contrary, the FWS proceeded less than 5 months later to issue the 2016 PDR as demanded by the Park County Commissioners.

Thereafter the FWS, primarily acting through its Director Ashe, who in an internal email in early 2015 inappropriately (for the occupant of the Director's position) described grizzly bears as "troublesome," continued to succumb to the pressure exerted by the 3 states' governors and wildlife agencies and others. Director Ashe sent a letter to the three wildlife agencies on September 25, 2015 (**Exhibit F**), in which he completely defaulted in his official duty to protect and preserve GYE grizzly bears by allocating GYE grizzly bear licenses to kill among the 3 states. In January 2016, when the 2016 PDR supposedly was in the progress of preparation, Director Ashe inappropriately joined with Governor Mead in the publication of an op-ed article (**Exhibit G**) in the *Jackson Hole (WY) News & Guide* that is nothing more than bald propaganda in support of delisting (". . . . Yellowstone grizzly bears . . . are recovered."); and thereafter he personally met with some or all of these officials for the purpose of continuing the already contaminated delisting process.

The broad-based political contamination of the FWS's decision-making process as an institutional matter was confirmed by a recent report, *"Progress and Problems: Government Scientists Report on Scientific Integrity at Four Agencies (2015),"* issued by the Union of Concerned Scientists, which surveyed 981 FWS scientists and received 382 written responses. The report is damning. It establishes that FWS, at the national and regional levels, is plagued by

[12] Four Wyoming four counties having most of the grizzly bears in Wyoming and in the GYE – Fremont, Lincoln, Park and Sublette – enacted laws that allow grizzly bears within their borders to be eradicated as threats to public health, safety and livelihoods. (AR 55676-77) To the undersigned's knowledge, those laws have not been repealed and continue in effect today. In June 2003 Fremont County, relying on its earlier resolution characterizing grizzly bears as threats to public health, safety and livelihoods, defiantly (and presumably illegally) prohibited the U. S. Forest Service from implementing a back country food storage plan designed to keep food brought into the forest by humans away from bears; and in December 2004 the county "[prohibited] the inclusion of any part of Fremont County to comprise, in whole or in part, any area for the occupation, or proposed occupation, by Grizzly bears." (AR 55490-91, 55676-77)

lack of scientific integrity due to the heavy influence of politics; under-funding by Congress; leadership that lacks scientific knowledge, bows to political pressure and is concerned with protecting their jobs; under-staffing; and declining morale. A sample comment: "The political machine in the FWS seems to be growing, and it's beating us down more every day." Another: "I am currently being asked to manage habitat against my scientific opinion to appease a state agency."

In summary, the 2016 PDR is contaminated beyond repair by improper political influence and must be withdrawn in favor of continued ESA protection for the GYE grizzly bears.

## B. Conflict of Interest

The possibility exists that a serious conflict of interest involving Dr. Servheen, the FWS's Grizzly Bear Recovery Coordinator and the author of the 2005 PDR, 2007 FDR and 2016 PDR, also might have irreparably contaminated the 2016 PDR. Attached **(Exhibit H)** is a page from the website of Bear Trust International, a nonprofit organization that supports hunting and the removal of ESA protection for grizzly bears. The attached page states that Dr. Servheen, while serving as Coordinator, was "instrumental in creating the organization and helping design [its] program structure" and was (and perhaps still is) a member of the organization's Advisory Council. If that statement is correct, Dr. Servheen's involvement with the organization created a serious conflict of interest, since, as discussed in **Exhibit I (pp. 47-69),** Dr. Servheen's position as Coordinator required him to act in a fiduciary capacity for the bears or at the very least in a completely independent manner.

By email dated April 29, 2016, the undersigned transmitted **Exhibit H** to Michael Thabault, Assistant Regional Director, Ecological Services, Mountain Prairie Region, Lakewood, Colorado, who is Dr. Servheen's direct supervisor, and requested a response with regard to whether the information set forth in **Exhibit H** was (and is) correct. The undersigned has not received a response from Mr. Thabault despite sending follow-up email requests on May 2 and 5, 2016, stating that the response might be relevant to the comments herein.

The FWS must investigate Dr. Servheen's involvement, if any, with Bear Trust International. If the information in **Exhibit H** is correct, Dr. Servheen's involvement, indicative of unacceptable bias, further contaminated the 2016 PDR, which must be withdrawn.

## V. Peer Review Misinformation in 2016 PDR

The FWS, recognizing that delisting and other decisions under the ESA must be based upon the "best scientific and commercial data available," adopted a policy, together with the National Oceanic and Atmospheric Administration, in 1994 that requires the FWS to incorporate independent peer review in ESA listing and recovery activities during the public comment period ("1994 FWS Peer Review Policy"). 59 Fed. Reg. 34270 (July 1, 1994). The 1994 FWS Peer Review Policy states that "independent peer reviewers should be selected from the academic and scientific community, . . . Federal and State agencies, and the private sector; those selected [should] have demonstrated expertise and specialized knowledge related to the scientific area under consideration."

On December 15, 2004, the Federal Office of Management and Budget ("OMB") issued a "Final Information Quality Bulletin for Peer Review" establishing that "important scientific information shall be peer reviewed by qualified specialists before it is disseminated by the federal government" ("2004 OMB Peer Review Policy"). The purpose of the 2004 OMB Peer Review Policy is to "enhance the quality and credibility of the government's scientific information." The 2004 OMB Peer Review Policy states that "the most important factor in selecting reviewers is expertise: ensuring that the selected reviewer has the knowledge, experience, and skills necessary to perform the review." Thus, the peer reviewers, according to the 2004 OMB Peer Review Policy, "shall be selected based on expertise, experience and skills . . . . The group of reviewers shall be sufficiently broad and diverse to fairly represent the relevant scientific and technical perspectives and fields of knowledge. Agencies shall consider requesting that the public, including scientific and professional societies, nominate potential reviewers."

Proper peer review can be important to assure scientific integrity of actions by federal agencies such as the FWS's issuance of the 2016 PDR. However, great care must be taken to assure that the peer review process accomplishes its purpose and is not abused as discussed in **Exhibit I.**

The 2016 PDR states (81 Fed. Reg. at 13176):

> In accordance with our [1994 FWS Peer Review Policy], we will seek the expert opinion of at least three appropriate specialists who are independent of the [FWS], the States, and the Interagency Grizzly Bear Study Team (IGBST) regarding scientific data and interpretations contained in the [2016 PDR]. Those experts will each submit separate opinions for the [FWS] to consider. We will send copies of this [2016 PDR], the draft 2016 Conservation Strategy, and the draft Grizzly Bear Recovery Plan Supplement: Revised Demographic Criteria to the peer reviewers ***immediately following publication of the [2016 PDR] in the Federal Register***. The purpose of such review is to ensure that our decisions are based on scientifically sound date, assumptions, and analysis. Accordingly, the final rule and decision may differ from this [2016 PDR]. (Emphasis added.)

In order to determine whether the FWS complied with the 1994 FWS Peer Review Policy and the 2004 OMB Peer Review Policy, on ***March 21, 2016, which was 10 days after the 2016 PDR was published in the Federal Register***, the undersigned filed a request under the federal Freedom of Information Act ("FOIA"), 5 U.S.C. § 552, for all documents relating to peer review of the 2016 PDR. In response, the undersigned has received 3 emails from the FWS's FOIA official responsible for the request as follows:

| Email Date | Email Response |
|---|---|
| March 24, 2016<br>(13 days after publication) | "I wanted you to be aware that the field staff have notified me that the peer review will be due the same time the comment period ends. At this time, we do not have the peer reviews." |
| March 29, 2016<br>(18 days after publication) | "[T]he peer reviewers have not been selected yet. They are doing a contract for the peer reviews so it could be 2-3 weeks to know names, if names are provided to them." |

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|---|---|
| April 18, 2016 (38 days after publication) | "[T]he contracting process [did not start] immediately after publication in the Federal Register. They opted to do peer reviews through contracting to ensure unbiased review of the science behind the proposed delisting." |

As of the date of this comment letter (59 days after publication), the undersigned has not received any documents responsive to his March 11, 2016, FOIA request.

In light of the unequivocal statement in the 2016 PDR that the 2016 PDR and related documents would be sent to the peer reviewers "immediately after" publication in the Federal Register, it is obvious that either (a) erroneous information was included in the 2016 PDR with regard to peer review or (b) the FOIA official, possibly acting on erroneous information provided by the FWS's "field staff," is providing erroneous information to the undersigned with regard to the availability of documents responsive to his March 21 FOIA request.

The 2016 PDR has been irreparably contaminated by (a) in the preceding paragraph and possibly also by (b).

## VI. GYE Grizzly Bears Not Recovered

A decision to delist a species must be supported by the "best scientific and commercial data available to [FWS] after conducting a review of the status of the species." 50 C.F.R. § 424.11(d). The factors considered in de-listing are the same 5 factors considered for listing purposes. 50 C.F.R. § 424.11(d).

The "principal goal" for de-listing is "recovery," which is defined as the "point at which protection under the Act is no longer required"; a species can be de-listed based upon recovery "only if the best scientific and commercial data available indicate that it is no longer endangered or threatened." 50 C.F.R. § 424.11(d)(2).

It is not sufficient that the population is "merely [able] to survive"; it must have recovered from its endangered or threatened status. *Sierra Club v. U. S. Fish & Wildlife Service*, 245 F.3d 434, 438 (5th Cir. 2001). ***A minimum numerical threshold for the population, determined by the best available science, must be crossed before there can be a recovery.***

Since an actual count of the number of bears is impossible, the FWS relies upon abstract formulas to estimate the number of bears. As discussed above, in 2013 FWS adopted a new formula for counting the GYE grizzly bear population to replace, and no doubt produce a higher number than, the prior abstract formula.[13]

The GYE grizzly bear population, in 4 decades of ESA protection under the FWS's stewardship, has not even come close to crossing the requisite numerical threshold as indicated by the following table (which uses numbers that are available from various sources, including the FWS, but cannot be verified by actual counts or the FWS's abstract, self-serving formulas):

[13] See footnote 10 and accompanying text.

| Date | Total # | GYE # |
|---|---|---|
| 1975 | 800-1,000 | 136-312 |
| 1982 | 800-1,000 | 236 |
| 1984-2006 | | 400+ |
| 2007 | 1,000+ | 500+ |
| 2016 | 1,500+ | 700+ |

The miniscule increase of grizzly bears clearly establishes that the bears have ***not*** recovered in the GYE, a vast, mountainous and relatively unpopulated area that could support a far greater number of grizzly bears (see Section VII below), and that the bears will be harmed by delisting that will subject them to unacceptable levels of mortality as a result of trophy hunting and other human causes without enforceable limitations.[14]

Numerous scientists and bear specialists submitted written comments with regard to the 2005 PDR, and a number of those persons set forth minimum numerical thresholds to be achieved before the GYE grizzly bears could be determined to be "recovered" from the scientific standpoint within the meaning of the ESA. Those thresholds are equally relevant with regard to the 2016 PDR and are summarized in the following table:

| Scientist/Specialist | Date | Threshold Number | Source |
|---|---|---|---|
| Brian Peck for the Great Bear Foundation | 3/18/06 | 2,000 – 5,000 | AR55291-92 |
| Craig M. Pease, Prof. of Science & Law, Vermont Law School | 2/18/06 | 1,850 – 18,500 | AR55354 |
| Louisa Willcox for the Natural Resources Defense Council | 3/20/06 | 3,000+ | AR55478 |
| Lance Craighead for the Craighead Environmental Research Institute & 268 other listed scientists attached as **Exhibit J** | 3/20/06 | 2,000 – 3,000 | AR55755 |

In addition, the renowned wildlife biologist, Jane Goodall, and 65 other experts, by letter dated May 5, 2016 (**Exhibit K**), submitted comments with regard to the 2016 PDR in which they

[14] The miniscule increase in the number of GYE grizzly bears starkly contrasts with the far greater increase for bald eagles during their period of ESA protection. On June 28, 2007, the Secretary of the Interior announced the delisting of bald eagles, stating, in a Press Release, that there were "barely 400 nesting pairs of bald eagles" in the coterminus 48 states when they were listed in 1963 and that "after decades of conservation effort, [the coterminus 48 states] are home to some 10,000 nesting pairs, a 25-fold [2,500%] increase in the last 40 years." Moreover, the Secretary emphasized that "bald eagles will continue to be protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Both federal laws prohibit 'taking' – killing, selling or otherwise harming eagles, their nests or eggs." No continuing federal statutory protection exists for grizzly bears after delisting.

stated that 700 (a contested figure) grizzly bears in the GYE does not constitute a recovery. The obvious implication is that many more grizzly bears are needed before recovery is achieved.

In a recent case the Montana District Court held that the FWS erred by not properly considering the small population size and lack of genetic diversity as a threat to wolverines. *Defenders of Wildlife v. Jewell*, ___ F.Supp.3d ___, 2016 WL 1363865 (D. Mont. April 4, 2016).

Absent recovery, the GYE grizzly bears cannot be delisted; the issues and factors delisting factors discussed below become moot.

## VII. GYE Carrying Capacity Not Reached

The FWS attributes slow growth of the GYE grizzly bear population to the fact tjhat the bears have reached the GYE's carrying capacity. 2016 PDR at 13179-81. This is erroneous. The GYE bears have not reached carrying capacity as clearly explained by Dr. David Mattson, a renowned grizzly bear biologist and former member of the IGBST.[15] **Exhibit L** at pp. 1-4, 15, 19-20, 28-35.

## VIII. GYE Grizzly Bears Not a Distinct Population Segment

The ESA defines "species" to include "any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532(16).

The ESA does not contain a definition of "distinct population segment" or "DPS." However, in 1996 the FWS and the National National Marine Fisheries Service ("NMFS") adopted a policy ("1996 DPS Policy") to clarify their interpretation of the term DPS for the purpose of listing, delisting and reclassifying species under the ESA. 67 Fed. Reg. 4722 (Feb. 7, 1996). They stated in the 1996 DPS Policy that the term DPS must be interpreted in a "clear and consistent fashion"; that, in accordance with congressional intent, their DPS authority must be exercised "sparingly and only when the biological evidence indicates that such action is warranted"; and that the DPS policy must be "aimed at carrying out the purposes of the [ESA]." "The DPS Policy is designed to draw a line around a population whose conservation status differs from other populations within that species." *Defenders of Wildlife v. U.S. Department of the Interior*, 354 F.Supp.2d 1156, 1170 (D. Ore. 2005).

The FWS begins its DPS analysis by drawing the population line in an artificial manner based on manmade landmarks. 2016 PDR at 13191. This non-scientific, non-biological line, in turn, sets up the FWS to apply the 1996 DPS Policy in an arbitrary and capricious manner by isolating the GYE population and other populations, including the Northern Continental Divide Ecosystem ("NCDE") population, which has the largest population of grizzly bears.

The 1996 DPS Policy requires the FWS to consider two scientific or biological factors in making any decision with regard to DPS status under the ESA. The two factors are applied in the 2016 PDR as follows:

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[15] The FWS has relied heavily upon Dr. Mattson's work for purposes of the 2005 PDR, 2007 FDR and 2016 PDR.



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| Factor | FWS Conclusion in 2016 PDR |
| --- | --- |
| (1) Discreteness of population segment in relation to remainder of species to which it belongs as a consequence of<br>(A) physical, physiological, ecological or behavioral factors **or**<br>(B) international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status or regulatory mechanisms exist that are significant, | **(A) Satisfied.** "Based on the best available scientific data about grizzly bear locations and movements," GYE grizzly bear population "markedly, physically separated from" other grizzly bear populations, including the NCDE population; complete separation is not required despite the fact that "over the last few decades, the NCDE grizzly bear population has been slowly expanding to the south, and there have been several confirmed grizzly bears within [20-50 miles] of the GYE grizzly bear DPS boundaries . . . ." 2016 PDR at 13191.<br><br>**(B) not analyzed.** |
| (2) Significance of population segment to species to which it belongs based on consideration of (A) persistence of the discrete population segment in an ecological setting unusual or unique for the species; (B) evidence that loss of the discrete population segment would result in a significant gap in the range of the species; (C) evidence that the discrete population segment represents the only surviving natural occurrence of a species that might be more abundant elsewhere as an introduced populations outside its historic range; **or** (D) evidence that the discrete population segment differs markedly from the other populations of the species in its genetic characteristics. | **(A) Not satisfied.** GYE grizzly bears do not consume more meat than other populations; and their use of whitebark pine as a major food source has waned. 2016 PDR at 13192.<br><br>**(B) Satisfied.** The loss of the GYE population would significantly impact representation of the species because it would further curtail the range of the grizzly bear in North America, which has already been substantially curtailed from the species' historic range, by moving the range approximately 200 miles to the north. 2016 PDR at 13192-93.<br><br>**(C) Not applicable.** There are several other extant grizzly bear populations in North America. 2016 PDR at 13192.<br><br>**(D) Not satisfied.** Do not know biological significance, if any, of observed genetic differences between GYE grizzly bears and other North American populations. 2016 PDR at 13193. |

The FWS erroneously applied the DPS procedure for a number of important reasons. *First*, by delisting piecemeal only a part of grizzly bears' range, the FWS has unlawfully circumvented the requirement that the species must be protected so long as it remains endangered "throughout . . . a significant portion of its range" within the meaning of 16 U.S.C. § 1532(6).[16] The FWS's application of the discreteness factor in the 1996 DPS Policy to "artificial or manmade" boundaries – several highways in the GYA – as "easily identifiable boundaries" to demarcate the DPS falls far short of the bears' historic, or even current, range.

*Second*, the ESA and the 1996 DPS Policy preclude the FWS from using a DPS as a ***delisting*** tool; and this is especially true when the original 1975 listing did not designate the GYE as a DPS and the threats to the bears have increased in the intervening 41 years.

*Third*, the FWS ignored the need for natural connectivity to post-delisting conservation of GYE grizzly bears.

*Fourth*, even if the FWS can lawfully create a new DPS for delisting purposes, (a) the GYE boundaries selected by the FWS contravene the ESA mandate that the species must be given the

[16] See footnote 11.

highest of priorities and (b) the reasons given by the FWS in the 2016 PDR why the two factors were satisfied are argumentative and not scientific or biological.

*Fifth*, the GYE grizzly bear population does not differ from the NCDE grizzly bears population within the meaning of the *Defenders of Wildlife* case.

The FWS has used the DPS procedure as a tactic to "divide and conquer." It has divided the species into arbitrary segments in order to manipulate and distort the delisting process contrary to congressional intent and the 1996 DPS Policy. It has converted its DPS authority from a shield to protect the bears, to be used only "sparingly," as intended by Congress and the 1996 DPS Policy, into a sword to withdraw needed ESA protection for the bears.

The FWS's identical divide and conquer tactic has been rejected by all 4 district courts that have considered the issue. See *Humane Society of the United States*, 76 F.Supp.3d 69 (D. D. C. 2011); *Humane Society of the United States v. Kempthorne*, 579 F.Supp.2d 7 , 2008 U.S. Dist LEXIS 74495 (D.D.C. Sept. 29, 2008) (delisting); *National Wildlife Federation v. Norton*, 386 F.Supp.2d 553, 562-65 (D. Vermont 2005) (downlisting); *Defenders of Wildlife v. U.S. Department of the Interior*, 354 F.Supp.2d at 1169-73 (downlisting). See also *Friends of Wild Swan v. U.S. Fish & Wildlife Service,* 12 F.Supp.2d 1121 (D. Ore. 1997).

## IX. <u>Failure To Satisfy Statutory Delisting Factors</u>

### A. Factor #1 – Present or Threatened Destruction, <u>Modification or Curtailment of Habitat or Range</u>

The ESA requires the FWS for delisting purposes to consider the present or threatened destruction, modification or curtailment of the species' habitat or range. 16 U.S.C. § 1533(a)(1)(A); 50 C.F.R. § 424.11(c)(1), (d).

The FWS identifies 9 "considerations" in the 2016 PDR that "warrant discussion" for purposes of Factor 1 (2016 PDR at 13194) and initially discusses these 9 "considerations" ***inside*** the Primary Conservation Area ("PCA"), which it describes as follows:

> [A] core secure area for grizzly bears where human impacts on habitat conditions will be maintained at or below levels that ***existed in 1998*** . . . . Specifically, the amount of secure habitat will not decrease below 1998 levels while the number of developed sites and livestock allotments will not increase above 1998 levels. The 1998 baseline for habitat standards was chosen because the levels of secure habitat and developed sites on public lands remained relatively constant in the 10 years preceding 1998 . . . , and the selection of 1998 assured that habitat conditions existing at a time when the population was increasing at a rate of 4 to 7 percent per year would be maintained. (Citations omitted; emphasis added.)

The selection of the 1998 baseline for the habitat or range level – covering a 98% smaller area than the bears' historic, or even 1975, habitat or range – undermines the FWS's entire discussion of Factor 1, because the selection was completely arbitrary and obviously was designed[17] to support the FWS's delisting decision. This arbitrary disregard of the bears' historic range is contrary to law. See *Defenders of Wildlife v. Norton*, 258 F.3d 1136, 1145 (9th Cir. 2001) (historic range must be taken into account).

The discussion of the 9 "considerations" that follows – with the arbitrary 1998 baseline as the foundation – contains many words without (a) any meaningful evidence to support the conclusions and (b) any confirmation of whether and how any stated actions will be funded and enforced; apparently the FWS, without evidence, opted to extend the discussion to give the impression that it was analytical. The discussion piles unsupported (and unfunded, unenforceable) conclusions upon unsupported (and unfunded, unenforceable) conclusions as indicated by the following table:

| Consideration | Conclusion |
|---|---|
| (1) Motorized access that can cause mortalities and temporary or permanent habitat loss | "Because of the positive effect that secure habitat has on grizzly bear survival and reproduction, one of the draft 2016 Conservation Strategy objectives is no netdecrease in these levels of secure habitat inside the PCA so that the PCA can continue to function as a course area for grizzly bears in the GYE. Therefore, ***we do not foresee*** that decreases in secure habitat inside the PCA will pose a threat to the grizzly bear DPS now, or in the future." 2016 PDR at 13195 (emphasis added). |
| (2) Developed sites (i.e., sites on public lands for government administration, public use and recreation) that can cause mortalities resulting from bear-human encounters and unsecured attractants | "[B]ecause the National Parks and National Forests within the PCA will continue to manage developed sites at 1998 levels within each bear management subunit and because food storage rules will be enforced on these public lands, ***we do not foresee*** that the existing number of, nor an increase in the number of, developed sites inside the PCA will pose a threat to the GYE grizzly bear DPS now, or in the future." ." 2016 PDR at 13195 (emphasis added). |
| (3) Livestock allotments that can cause mortalities resulting from (i) "control actions" (i.e., killing of bears by federal or state wildlife officials) after livestock depredations and conflicts and habituation and (ii) displacement due to livestock "or related management activity" | "Because there will be no net increase in cattle or sheep allotments allowed on public lands inside the PCA, ***we do not expect*** that livestock allotments inside the PCA will constitute a threat to the GYE grizzly bear DPS now, or in the future." 2016 PDR at 13195-96 (emphasis added). |
| (4) Mineral and energy development (i.e., oil and gas drilling, mining) | Despite the possibility that 94 square miles of surface occupancy will be approved for oil and gas drilling (approximately 4% of the PCA) and the existence of 1,354 pre-1998 mining claims (28 with operating plans included in the 1998 baseline), "because any new mineral or energy development will continue to be approved only if it conforms to the secure habitat and developed site standards set forth in the draft 2016 Conservation Strategy, we do not expect that such development inside the PCA will constitute a threat to the GYE grizzly bear DPS now, or in the future." 2016 PDR at 13196 (emphasis added). |
| (5) Tourism and recreation by at least 3.0 million persons | ""[B]ecause the few motorized access routes inside the PCA will not increase, and because the National Parks and National Forests within the PCA |

[17] The 1998 baseline initially was used by the FWS as a "divide and conquer" tactic in the 2005 PDR and 2007 FDR and has been carried over to the 2016 PDR.

| | |
|---|---|
| annually (plus expected increases) that increase the probability of bear-human encounters resulting in bear mortalities | will continue to educate visitors on its lands about how to recreate safely in bear country and avoid grizzly bear-human conflicts, ***we do not expect*** that the current level of recreation, nor increases in recreation, will constitute a threat to the GYE grizzly bear DPS now, or in the future. 2016 PDR at 13196 (emphasis added). |
| (6) Snowmobiling that can disturb bears (a) while in their dens and result in increased activity and heart rate, den abandonment and possible decline in physical condition and cub mortality and (b) after emergence from their dens in the spring | "Because there are no data or information suggesting snowmobile use in the GYE is negatively affecting grizzly bear population, or even individual bears, we ***determine*** that snowmobiling does not constitute a threat to the GYE grizzly bear DPS now, or in the future. Yet, because the potential for disturbance and impacts to reproductive success exists, ***monitoring will continue*** to support ***adaptive*** management decisions about snowmobile use in areas where disturbance is documented or likely to occur." 2016 PDR at 13196-97 (emphasis added). |
| (7) Vegetation projects, including timber harvests, thinning, prescribed fires and salvage of burned, diseased or insect-infested stands that can cause loss of bears' hiding cover, disturbance or displacement of bears, increased bear-human encounters resulting in bear mortalities and construction of new roads and/or increased use of existing roads resulting in bear mortalities | "[V]egetation management ***may result in positive effects*** on grizzly bear habitat once the project is complete, provided key habitats such as riparian areas and known food production areas are maintained or enhanced. . . . Changes in the distribution, quantity and quality of cover are ***not necessarily detrimental*** to grizzly bears as long as they are coordinated on a BMU or subunit scale to ensure that grizzly bear needs are addressed throughout the various projects occurring on multiple jurisdictions at any given time. Although there are known, usually temporary, impacts to individual bears from timber management activities, these impacts have been adequately mitigated . . . . Therefore, ***we do not expect*** that vegetation management inside the PCA will constitute a threat to the GYE grizzly bear DPS now, or in the future." 2016 PDR at 13197 (emphasis added). |
| (8) Climate change that can result in a reduction of snowpack levels, shifts in denning times, shifts in the abundance and distribution of some natural and food sources and changes in fire regimes | "Most grizzly bear biologists in the United States and Canada do not expect habitat changes predicted under climate changes scenarios to directly threaten grizzly bears (*Servheen* and Cross 2010, p. 4). ***These effects may even make habitat more suitable and food sources more abundant.*** However, these ecological changes may also affect the timing and frequency of grizzly bear-human interactions (*Servheen* and Cross 2010, p. 4). 2016 PDR at 13197 (emphasis added). |
| (9) Fragmentation of the GYE grizzly bears' current contiguous habitat that can cause loss of connectivity and increase human-caused bear mortalities | "[T]he evaluation of all road construction projects in ***suitable*** habitat on Federal lands throughout the GYE DMA will continue to include impacts of the project on grizzly bear connectivity. . . . By identifying areas used by grizzly bears, officials can mitigate potential impacts from road construction both during and after a project. Federal agencies will continue to identify important crossing areas . . . . Potential ***advantages*** of this data collection requirement include reduction of grizzly bear mortality due to vehicle collisions, access to seasonal habitats, maintenance of traditional dispersal routes, and decreased risk of fragmentation of individual home ranges. . . . [B]ecause these activities that combat habitat fragmentation will continue to occur under the draft 2016 Conservation Strategy, ***we do not expect*** that fragmentation within the GYE grizzly bear boundaries will constitute a threat to the GYE grizzly bear DPS now, or in the future. 2016 PDR at 13197-98 (emphasis added). |

In addition to the fundamental defects described above – absence of supporting scientific evidence, defective 1998 baseline and absence of committed, funded and enforceable actions to avoid or remediate bear harmful situations – it is readily apparent that the FWS has had to resort to pure speculation and argument to reach its conclusions. For example, applying an old, but usually unsuccessful, debate trick, the FWS even goes so far as to argue that – see (7), (8) and (9) above – that activities that clearly are harmful to GYE bears would provide ***benefits*** to the bears!

Three points in the above table confirm the FWS's level of analytical desperation. *First*, the FWS introduces a new and unjustified (under the ESA) concept – "suitable" habitat – see (9) above – to further restrict the already restricted 1998 baseline for habitat fragmentation.

*Second*, the FWS's reliance on "adaptive" management – see (6) above – to reduce the impact of snowmobiling, a winter activity that obviously can be harmful to denning grizzly bears. The term "adaptive" is meaningless; it says nothing about the proper management of GYE grizzly bears; it only says that "we are concerned about the harmful effects of snowmobiling but have no clue what to do about it."

*Third*, the FWS, having no other support, has had to resort to reliance on Dr. Servheen, its own Grizzly Bear Recovery Coordinator, to support its conclusions with regard to the over-arching problems presented by climate change [see (8) above].

The FWS's discussion of the above "considerations" for lands ***outside*** the PCA, including wilderness and other lands managed under forest plans issued by the U. S. Forest Service ("USFS") [18] and private lands, suffers from the same absence of supporting evidence, speculation and other defects described above. 2016 PDR at 13198-13200. *First*, the FWS again relies throughout the discussion on the new and unjustified (under the ESA) concept – "suitable" habitat – to restrict the geographic areas of concern.

*Second*, the FWS relies upon the USFS's designation of grizzly bears as a "sensitive species" or "species of conservation concern" that will "ensure" protection on USFS lands, but that reliance is not justified because the designation is nothing more than wishful thinking by the USFS due to the absence of both an enforceable obligation and funding to transform the designation into a real protective mechanism.

*Third*, the FWS relies on Idaho, Montana and Wyoming management plans, which have not been issued in current final form (or even in draft form by Idaho), to "recognize the importance" of managing lands to provide security for grizzly bears in "suitable" habitat outside the PCA, but that reliance certainly is not justified by any concrete actions by the states in the form of enforceable commitments, funding or otherwise.

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[18] A forest plan serves as a statement of policy and information to guide future management decisions in a forest and designates which areas within a forest are suitable for timber harvesting and a myriad of other uses. 16 U.S.C. §§ 1601(e)(1), (k). See *Citizens for Better Forestry v. U. S. Department of Agriculture*, 481 F. Supp. 2d 1059, 1064 (N. D. Cal. 2007).

The 2005 USFS regulations were enjoined on a national basis in the *Citizens for Better Forestry* case. Defendants proposed new regulations in 2007 in essentially the same form as the 2005 regulations and adopted final regulations in 2008. 73 Fed. Reg. 23 (April 21, 2008).

*Fourth*, in another exercise of wishful thinking, without support of any type, the FWS "[does] not expect livestock allotments or developed sites in suitable habitat outside of the PCA to reach densities that are likely to be a threat to the GYE grizzly bear DPS in the future."

*Fifth*, despite its recognition that a disproportionate number of grizzly bear deaths occur on private lands, which account for a significant portion (9%) of "suitable" habitat outside the PCA, and that development on private lands will increase in the future, the FWS is able by some stretch of the imagination to conclude that "due to the large areas of widely distributed suitable habitat on public lands that are protected by Federal legislation and managed by agencies committed to the maintenance of a recovered grizzly bear population, we do not consider human population growth on private lands to constitute a threat to he GYE bear DPS now, or in the future."

In summary, the FWS's analysis of delisting Factor #1 is based on speculation throughout rather than scientific evidence and cannot withstand scrutiny by a court in litigation.

**B. Factor #2 – Overutilization for Commercial, <u>Recreational, Scientific or Educational Purposes</u>**

The FWS is required to take into account the "overutilization for commercial, sporting, scientific or educational purposes" in delisting a species. 16 U.S.C. § 1533(a)(1)(B); 50 C.F.R. § 424.11(c)(2), (d).

In the 2016 PDR the FWS has limited its consideration of this factor to an "[evaluation of] legal grizzly bear hunting for commercial and recreation purposes in the GYE if this population were no longer protected from this type of take by the [ESA]." 2016 PDR at 13200.

The FWS again begins by manipulating the geographic area within which hunting is evaluated. This time, however, rather than restrict the area as in its Factor #1 analysis, the FWS ***expands*** the geographic area to ***minimize*** the impact of hunting. Thus, the FWS adopts another new concept unknown to the ESA, "demographic monitoring area" or "DMA," as the "suitable habitat boundary . . . (17,774 sq mi) [because it] is sufficiently large to support a viable population in the long term, so that mortalities outside of it and inside the DPS could be excluded from consideration." 2016 PDR at 13201.

Next the FWS establishes the size of the DMA population size – 674 bears based solely on the abstract formula described above[19] – that will be "managed around," which allows, again by abstract formula, "the total mortality limits for independent females [to be] set at 7.6 percent when the population is at 674, less than 7.6% when the population is lower, and more than 7.6% when the population is higher." According to the FWS, "a total mortality limit of 7.6% for independent females is the mortality level that the best available science shows results in population stability." 2016 PDR at 13201.

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[19] See footnote 10 and accompanying text.

Finally, based on the above, the FWS arbitrarily establishes allowable GYE grizzly bear mortalities as set forth in the following table (2016 PDR at 13201):

| # of DMA Bears | Allowable Hunting Mortalities |
|---|---|
| Below 600 | None except for human safety |
| 600 - 673 | Less than 7.6% for independent females; 15% for independent males; less than 7.6% for dependent young |
| At 674 | 7.6% for independent females; 15% for independent males; 7.6% for dependent young |
| 675 - 747 | Not exceed 9% for independent females; 20% for independent males; 9% for dependent young |
| More than 747 | Not exceed 10% for independent females; 20% for independent males; 10% for dependent young |

The arbitrariness of this quantification and allocation of GYE grizzly bear deaths is completely devoid of scientific justification. The process begins, as discussed above, with spatial trickery to expand the geographic area to the so-called DMA; continues with mathematical trickery to establish the base number of GYE grizzly bears in the DMA; and ends with scientific trickery to determine how many of those bears shall live and how many shall die due to "discretionary" actions.

The level of cynicism involved in the quantification and allocation of GYE grizzly bear deaths in this manner is incomprehensible. The FWS, the mission of which is to "work with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people," obviously has completely lost sight of that mission and instead, presumably due to improper political influence and other non-scientific and inappropriate considerations, has entered into a mephistophelian bargain with the States of Idaho, Montana and Wyoming as set forth is a September 25, 2015, letter from the FWS Director Dan Ashe to the wildlife agencies for the 3 states (**Exhibit F**).

There is no doubt that GYE grizzly bears will be hunted as trophies in Idaho, Wyoming and Montana under state laws and regulations that place substantial discretion in wildlife officials without legally enforceable limitations. The FWS attempts to alleviate this problem by (a) prescribing inadequate and unenforceable conditions that it expects the 3 states formally to adopt prior to the issuance of a final delisting rule to implement mortality management and (b) stating that it will review the GYE grizzly bear population every 5 – 10 years and "make appropriate adjustments" in mortality management if needed.

Montana and Wyoming have issued draft management plans and Wyoming has received public comments; Idaho has not issued a draft management plan. It is not known when the final Montana and Wyoming plans and the draft Idaho plan will be issued. Based on prior experience,[20] it is not likely that these states will accept the FWS's conditions, even though they

[20] For example, Montana law allows, without limits, a person to kill a grizzly bear in the act of attacking or killing livestock. Wyoming has taken no steps to prevent four counties containing most grizzly bear habitat in that state from eradicating the bears within their borders. See footnote 9. Wyoming's post-delisting attitude with regard to grizzly bears can be readily discerned from its attitudes with regard to another predator, wolves, which led to rejection by a district court of Defendants' delisting of northern

are inadequate to accomplish the objective of limiting discretionary mortalities. Nevertheless, the FWS is likely to issue the 2016 FDR without adequate conditions.

The FWS relies upon voluntary relisting of the bears under the ESA as the ultimate solution if bear mortalities exceed the prescribed limits. 2016 PDR at 13204. However, relisting is not a solution. The relisting process typically takes many years and results only from lawsuits filed by citizen plaintiffs.[21] Defendants have failed to list species facing substantial harm[22] and have been found derelict in their ESA duty to protect grizzly bears.[23] The FWS has determined that grizzly bear populations in the North Cascades, Cabinet-Yaak and Selkirk Ecosystems should be uplisted from threatened to endangered but have declined to take that action. Relisting of GYE grizzly bears also might be precluded by "higher priority actions," even if warranted under the ESA, and improper political influence.

The FWS's "analysis" of Factor #2 sadly shows that, due to political pressure and possibly other improper pressures, it has completely abandoned science, which is the foundation upon which the ESA is built, and ignored the slaughter of grizzly bears in the name of "hunting" that necessitated ESA protection in 1975, and, contrary to overwhelming public sentiment, has approved the renewed slaughter in the name of "hunting" for reasons so flimsy that they would be laughable if the consequences were not so deadly serious.[24]

### C. <u>Factor #3 – Disease or Predation</u>

The FWS is required to take into account "disease or predation" delisting a species. 16 U.S.C. § 1533(a)(1)(C); 50 C.F.R. § 424.11(c)(3), (d).

Focusing initially on disease and acknowledging that grizzly bears "***have been documented*** with a variety of bacteria, pathogens, parasites and diseases, including brucellosis, clostridium, toxoplasmosis, canine hepatitis and rabies, the FWS concludes that fatalities from these diseases are "uncommon and do not appear to have ***population-level*** impacts on grizzly bears." 2016 PDR at 13205 (citations omitted; emphasis added). However, directly contradicting itself, the FWS states that "based on nearly 40 years of research, natural mortalities in the wild due to disease ***have never been documented***." Id. Based on this flimsy scientific support, and despite the factual contradiction, the FWS is able to conclude that "mortalities due to bacteria,

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Rocky Mountain wolves based upon the inadequacy of Wyoming's wolf plan and depredation control law. *Defenders of Wildlife v. Hall*, 565 F. Supp. 2d 1160 (D. Mont. 2008).]

[21]See *Friends of the Wild Swan v. U. S. Fish & Wildlife Service*, 12 F. Supp.2d 1121 (D. Ore. 1997); *Friends of the Wild Swan v. U. S. Fish & Wildlife Service*, 945 F. Supp. 1388 (D. Ore. 1996).

[22]See *Center for Biological Diversity v. Kempthorne*, 466 F.3d 1098, 1100-01 (9th Cir. 2006).

[23]See *Rock Creek Alliance v. U. S. Fish & Wildlife Service*, 390 F. Supp. 993 (D. Mont. 2005).

[24] It has been argued by some pro-delisting advocates that hunting will provide a benefit to grizzly bears because they will learn to fear human beings. This absurd argument has been dispelled by Dr. David Mattson in **Exhibit M**.

pathogens, or disease are negligible components of total mortality in the GYE and are likely to remain an insignificant factor in the future" and, therefore, "this source of mortality does not constitute a threat to the GYE grizzly bear DPS now, or in the future." Id.

This conclusion, lacking scientific support, is (a) pure speculation and (b) completely disregards the possibility that an outbreak of disease could decimate or completely eliminate the relatively small and isolated GYE grizzly bear DPS.

The FWS next turns in the 2016 PDR to natural predation involving the killing of grizzly bears by other wildlife (e.g., other grizzly bears, wolves). However, after stating that these occurrences are "rare," the FWS concludes that natural predation is "likely to remain an insignificant factor in population dynamics in the future." 2016 PDR at 13205.

Finally, the FWS turns in its Factor #3 analysis to human predation, including illegal poaching, killing in defense of life and property, accidental killing and killing as a management tool. 2016 PDR at 13205-08. The FWS's analyses can be summarized as follows:

| Factor | FWS Analysis | Response |
|---|---|---|
| Illegal poaching | Poaching cannot be stopped but can be limited by: | |
| | (1) Delisting followed by regulated hunting; | (1) The FWS attributes poaching to "a general perception that grizzly bears in the area may be dangerous, frusteration over depredation of livestock, or to protest land-use restrictions associated with grizzly bear habitat management." 2016 PDR at 13205. It is absurd to assert that law-breaking individuals willing to kill protected grizzly bears will become law-abiding when it becomes legal to kill the bears; other unprotected species (e.g., moose, bison) are regularly poached. |
| | (2) State and federal law enforcement; and | (2) Despite the FWS's self-serving assertion that "illegal grizzly bear mortalities are often prosecuted under State statutes" and "a long record of this enforcement approach being effective," in actual fact prosecutions are few, sentences/fines are light and enforcement has not been an effective poaching deterrent. Enforcement could become a deterrent with adequate resources and, most important, a change of attitude by enforcement officials. |
| | (3) Public information and education programs.<br><br>**Conclusion:** Not significant enough to hinder population stability. | (3) Although an informed and educated public is good for grizzly bears and wildlife generally, poachers who knowingly kill protected grizzly bears will not be deterred to any extent by public information and education programs. |
| Self-defense killings | These killings, which increased in the 2012-2014 period to 31% of grizzly | The FWS accepts the reality that these killings cannot be prevented. However, it fails to point |

| | | |
|---|---|---|
| | mortalities, "will always be a reality when conserving a species that is capable of killing humans," can be reduced by "promoting the use of bear spray and continuing information and education programs pertaining to food and carcass storage and retrieval." 2016 PDR at 13206. | out the well-known fact that a significant number of alleged self-defense killings in reality were not in self-defense at all and that self-defense was asserted after-the-fact to avoid the consequences that might follow for the killers for killing protected grizzlies. |
| Accidental killings | These killings, consisting primarily of vehicle collisions, electrocution, failed research trappings and mistaken identification of grizzly bears by black bear hunters, can be reduced by removing roadkill carcasses that attract grizzly bears, installing wildlife-safe crossing on roads, informing and educating hunters to emphasize patience, awareness and correct identification of targets and proactive management.<br><br>**Conclusion:** "[T]his source of mortality does not constitute a threat to the GYE grizzly bear DPS now, or in the future." | The FWS accepts the reality that these killings cannot be prevented. |
| Agency management killings | Killing "nuisance" grizzly bears, constituting 43% of human-caused mortalities in the 2002-2014 period, is a "necessary component of grizzly bear conservation," because it minimizes illegal bear killings, provides opportunities to educate the public about how to avoid conflicts and "promotes tolerance of grizzly bears by responding promptly and effectively when bears pose a threat to public safety."<br><br>**Conclusion:** "[W]e do not consider management removals a threat to the GYE grizzly bear population now, or in the future." | The FWS in a self-serving manner acknowledges that agency killings of GYE grizzly bears will continue after delisting. However, the FWS fails to recognize that killings have happened unnecessarily on too many occasions by agency officials who view killing as the first option; that record numbers of GYE grizzly bears have been killed in 2014 - 2016 and, therefore, that agency wildlife officials, even more than the public, must be educated (or, more likely, instructed) with regard to resolving "problem" bears by non-lethal methods such as effective relocation.<br><br>In addition, the FWS and the Idaho, Montana and Wyoming wildlife agencies must implement effective procedures for investigating all agency killings and punishing (and possibly prosecuting) agency officials who killed, or authorized or supervised, unnecessary killings. |

In applying Factor #3 the FWS again has adopted a "divide and conquer" tactic by considering each component separately from the other components and concluding that the isolated component does not constitute a threat to the GYE grizzly bear DPS. The reason why the FWS applied Factor #3 in this manner is obvious. The FWS could not deny the fact that mortalities from each component necessarily will continue indefinitely, and, therefore, it had to force its analysis into separate slots to achieve its ultimate delisting goal.

Factor #3 can only be applied in a scientifically correct manner by considering the ***totality*** of the mortalities of GYE grizzly bears from ***all*** of the components. In totality the mortalities clearly constitute a threat to the GYE grizzly population today and in the future.

**D. <u>Factor #4 – Inadequacy of Existing Regulatory Mechanisms</u>**

Defendants are required to take into account the "inadequacy of existing regulatory mechanisms" delisting a species. 16 U.S.C. § 1533(a)(1)(D); 50 C.F.R. § 424.11(c)(4), (d).

The lack of adequate regulatory mechanisms was a significant contributing factor to grizzly bear population declines that led to the listing of grizzly bears in 1975 (2016 PDR at 13208); and there was no significant improvement in that situation when the 2005 PDR and 2007 FDR were issued as held by the Montana Federal District Court in the *Greater Yellowstone* case; and that situation has not improved as of today.

The Ninth Circuit Court of Appeals reversed the Montana District Court's decision with regard to the inadequacy of regulatory mechanisms, but that reversal was based on holdings of only two members of the 3-judge panel; the 3rd judge wrote a separate opinion in which he disagreed only with the majority's decision with regard to regulatory mechanisms. Since the 3rd judge agreed with the 2-judge majority with regard to the other delisting factor involved in the appeal (i.e., the whitebark pine issue), the Ninth Circuit's affirmance was 3-0; and the 2-1 vote with regard to regulatory mechanisms certainly was not a strong victory for the FWS with regard to that issue and cannot be viewed by the FWS as strong precedent in subsequent litigation, especially if that litigation takes place outside the Ninth Circuit.

The FWS's "analysis" of Factor #4 (2016 PDR at 13208-11) is not an analysis at all; it is nothing more than speculation and unsupported conclusions.

***It (a) begins with the standard trick of narrowing the geographic areas at issue to "suitable habitat," a concept not found in the ESA; (b) relies throughout on such speculative terms as "will," "would," "if" and "anticipated"; (c) does not contain a detailed list of the specific protective mechanisms upon which it relies; and (d) does not contain any meaningful analyses of those mechanisms that it does mention and why they would be legally enforceable.***

Why would the FWS treat such an important factor so inadequately in the 2016 PDR? The answer must be (a) the FWS does not have confidence in the various specific mechanisms as protections for the GYE grizzly bears, including, in particular, the management plans of Idaho, Montana and Wyoming, states that have demonstrated in many ways over many years hostility to grizzly bears and other predators and almost certainly after delisting will allow the GYE grizzly bear population to be reduced substantially from its current non-recovered level; (b) has not adequately analyzed the specific mechanisms and cannot provide meaningful analyses; or (c) a combination of (a) and (b). It this situation the FWS obviously decided to apply an age-old truism – "the less said, the better" – which also explains why the FWS did not seek *en banc* review or reconsideration of, or appeal, the Ninth Circuit's decision in *Greater Yellowstone*. The FWS feared that *en banc* review, reconsideration or appeal would result in reinstatement of the



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Montana District Court's decision that the regulatory mechanisms were not adequate to protect the bears in the future.

Focusing specifically on the Idaho, Montana and Wyoming management plans, it is of critical importance that not even one of these states had finalized its plan as of the date the 2016 PDR was issued and has not finalized its plan as of today. Thus, the FWS does not know what the 3 states' plans will provide with regard to hunting or otherwise and can only look to the management plans that existed when the 2005 PDR and 2007 FDR were issued. Those plans did not require adherence to mortality limits; gave broad discretion to the state wildlife agencies with regard to bear mortality; and (c) did not provide legal frameworks to prevent excessive bear mortalities. Moreover, the 3 states made it clear at that time that they could make changes in their management plans at any time in their sole discretion,

Wyoming's 2016 Draft Management Plan explicitly states that the plan can be changed at any time in Wyoming's sole discretion (pp. v-vi):

> The most current science and technical information pertaining to grizzly bear recovery and management are incorporated into this plan. The management plan is adaptive in nature and additional knowledge on GYA DPS grizzly bears gained through research, management experience, and/or public input (e.g., improved population estimation methodologies and conflict management techniques) mauy warrant future updates.[25]

A similar provision allowing changes was contained in the Idaho's 2002 management plan as follows:

> Future management must be adaptive and responsive over time. As new data and knowledge of various biological and sociological factors are attained, management programs and frameworks will be adjusted and monitored as to their effect. . . .

Moreover, the 2002 Idaho plan contains the following disclaimer at the beginning:

> **This plan was modified by the 56th Idaho Legislature, Second Regular Session. As a result of these amendments, certain members of the [Idaho Yellowstone Grizzly Bear Delisting Advisory Team, which prepared the Plan] may no longer support the management direction in this plan.** (Boldface type in original)

Montana's 2002 management plan contained similar language with regard to future changes as follows:

> The programs recommended in this document should not result in any irreversible/irretrievable commitment of resources with few exceptions. If

[25] Wyoming 2002 management plan contained a comparable provision and was amended in 2005.

> expansion of bears proves untenable in some areas, [Montana Fish, Wildlife & Parks] has demonstrated the ability to remove bears. Likewise, habitat programs, access management, and so on can all be reversed or revised if needed. . . .

The Acting Director of Wyoming's Game and Fish Department ("WGFD") confirmed in a January 10, 2003, letter to the FWS's Grizzly Bear Recovery Coordinator that the states could change their management plans at any time:

> [A]ccording to working group discussions during the recent [FCS] development process, any time demographic information that provides a new perspective on how [the GYA grizzly bear] population should be managed becomes available, the agencies that are members of the Yellowstone Grizzly Coordinating Committee . . . should revise management guidance in the [FCS] to reflect that new information. . . . The [FCS] is supposed to be an adaptive document . . . .

The 3 states' message is clear and unequivocal; the states are not bound by legally enforceable agreements and can change their commitments, to the bears' detriment, at any time in their sole discretion. The absence of legally binding commitments, coupled with laws in the 3 states that allow excessive human-caused mortalities, clearly shows that the bears are in jeopardy after delisting.

As if there were not already enough evidence of the unwillingness of Wyoming to be bound in the future by commitments with regard to grizzly bears, additional evidence is provided by HB0018 **(Exhibit N)**, recently introduced in the Wyoming legislature by the "Select Federal Natural Resource Management Committee," a committee presumably established to throw down the gauntlet at the feet of the FWS with regard to delisting grizzly bears and wolves and probably also at some point with regard to "management" of public lands in Wyoming.

The reference in Section (a) of HB0018 to "any official, agent or employee of the United States government" undoubtedly was primarily to the FWS and presumably was intended to intimidate the FWS, a pliant partner of the state wildlife agencies for delisting grizzlies.

The reference in Section (b)(iv) of HB0018 to "any official, agent or employee of the United States government" presumably is to the USDA's notorious Wildlife Services, since Wyoming no doubt is well aware of the special capability and willingness of Wildlife Services to "reduce the number of gray wolves or grizzly bears" by lethal means. This bill is an open invitation to Wildlife Services to kill wolves and grizzlies even though they are ESA-protected.

HB0018, even though it was not enacted, completely destroyed the FWS's argument for ESA delisting purposes that grizzlies will be protected by adequate regulatory mechanisms after de-listing. The bill establishes that Wyoming will not protect grizzlies with adequate regulatory mechanisms after delisting as a matter of official management policy.

Even if the mechanisms relied upon by the FWS were adequate and enforceable, there are no assurances that funding would be available at the federal or state levels.

**E. Factor #5 – Other Natural or Manmade Factors Affecting Continued Existence**

Defendants are required to take "other natural or manmade factors affecting [a species'] continued existence" into account in delisting a species. 16 U.S.C. § 1533(a)(1)(E); 50 C.F.R. § 424.11(c)(5), (d).

In the 2016 PDR the FWS considers 4 elements of Factor #5 as follows:

| Element | FWS Conclusion |
|---|---|
| Genetic diversity of isolated GYE grizzly bear population 2016 PDR at 13211 | "Indicators of fitness in the GYE grizzly bear population demonstrate that the current levels of genetic diversity are captable of supporting healthy reproductive and survival rates, as evidenced by normal litter size, no evidence of disease, high survivorship, an equal se ratio, normal body size and physical characteristics, and a stable to increasing population." (Citations omitted.) Grizzlies from the NCDE population can be translocated to the GYE if needed to enhance the level of genetic diversity and assure long-term genetic health. |
| Changes in GYE grizzly bears' 4 main food sources: Whitebark pine seeds (most important for mortality risk and reproduction), army cutworm moths, winter-killed ungulates, spawning cutthroat trout 2016 PDR at 13212-16 | Winter-killed ungulates will not decline; decrease in cutthroat trout is not significant because only a small portion of the GYE grizzly bear population uses the trout; availability of cutworm moths will not decrease due to back country visitors and climate change because the moths "display foraging plasticity" that will "allow for distributional changes"; loss of whitebark pine seeds, the GYE bears' most important food source, will not adversely affect the bears because, based on a self-serving IGBST study (noticeably after the Ninth Circuit's decision in *Greater Yellowstone*) and despite a contrary pre-*Greater Yellowstone* study by two highly-respected biologists, they are "resourceful"[26] and will find alternative food sources. |
| Climate change 2016 PDR at 13216-17 | Despite recognition that "unprecedented" changes in climate, particularly warming, have occurred and will continue, which causes reduction in snowpack levels, shifts in denning times, shifts in the abundance and distribution of some natural food sources, changes in fire regimes and increased bear-human conflicts, the bears are "resilient"[27] and will not be directly threatened. |
| Public support and human attitudes 2016 PDR at 13217-19 | Despite recognition that human attitudes – perceived threats to human life and economic livelihoods – were the primary reason grizzly bears were almost completely extirpated, those attitudes have changed and can be further ameliorated by information and education programs, "flexibility" with regard to depredating bears and compensating ranchers for losses caused by grizzly bears. |

The analysis is flawed for many reasons. *First*, the FWS has again adopted by "divide and conquer" approach by assessing each element separately rather than assessing the totality of all

[26] "Resourceful" and "resilient," along with "adaptive," appear to be the FWS's favorite words to characterize the GYE grizzly bears' desire to overcome their drastic loss of critical food sources. See **Exhibit D** at pp. 41.

[27] See footnote 26.

elements. There is no doubt that the ***totality*** of all elements presents a serious threat to the survivability of the GYE bears.

*Second*, the "analysis" not an analysis at all. In its entirety it is nothing more than a series of conclusions based on unsupported assertions.

*Third*, the supporting citations that are provided are almost all self-serving. The most egregious example is the frequent reliance on studies performed by the FWS's own Grizzly Bear Recovery Coordinator.

*Fourth*, the analysis of food sources, particularly whitebark pine, is contradicted by the best available science. **Exhibit D** at pp. 1-20; **Exhibit L** at pp. 5-14, 20; **Exhibit O**.

*Fifth*, the FWS's underpinning for its conclusions almost always is future monitoring with the implication that appropriate actions to protect and preserve the bears will be taken in the future if needed. However, nothing is said about funding for the monitoring, which certainly is not assured, or about what actions will be taken, which almost certainly cannot be legally enforced.

In *Defenders of Wildlife v. Jewell*, *supra*, the Montana District Court held that the FWS erred in failing to consider the effects of climate change on wolverine denning.

## X. Conclusion

Removal of ESA protection for GYE grizzly bears is (a) legally invalid due to the complete absence of scientific justification, as discussed above, and (b) morally reprehensible because the great bears, almost completely extirpated in the past, cannot again be subjected to slaughter for fun and profit. Instead the great bears must be preserved and protected indefinitely.

The FWS cannot fulfill its mission to protect and preserve the GYE grizzly bears solely by retaining the bears' ESA status; the FWS also must fundamentally change its attitude, as reflected in the 2016 PDR, with regard to the bears from assessing mortality to promoting vitality. It must monitor the bears to assure that they are not slaughtered by the FWS's own employees, the employees of other federal agencies such as the Department of Agriculture's notorious "Wildlife Services," and the officials of the Idaho, Montana and Wyoming wildlife agencies. It must throw off the yoke of improper political interference so that it can fulfill its mission based on science.

Sincerely,

Robert Aland

Robert H. Aland

Exhibits attached:

A – Political interference

B – Mead letter
C – Salazar letter
D – Experts
E – Park County
F – Ashe letter
G – Ashe/Mead article
H – Bear Trust International
I – Experts
J – Craighead et al. letter
K – Goodall et al. letter
L – Experts
M - Expert
N – HB0018
O - Expert

**EXHIBIT A**

**Improper Political Interference**

**Communications Involving Members of Congress and Others with Regard to Delisting GYE Grizzly Bears**

| Date/From/To | Excerpt |
|---|---|
| September 29, 1997 Bray (FWS) to Kemper & ***Servheen*** (FWS) (AR 00124-26) | "[Director Clark] was meeting w/Senator Thomas, WY, about him ***possibly putting a rider on the ESA reauthorization to delist the Yellowstone grizzly*** . . . ." (Emphasis added.) |
| January 21, 1998 Sen. Thomas (WY) to FWS Director Clark (AR 04461) | "Further delay in delisting of the grizzly only serves to strengthen the fears of folks who believe the FWS never intended to remove these animals from the endangered list . . . . I hope the agency is serious about moving forward with this effort and will act in an expeditious manner." |
| May 3, 2000 Sen. Thomas (WY) to FWS Director Clark (AR 03637) | "Given our ***many conversations*** regarding the delisting of the grizzly in Yellowstone, . . . [Y]ou predicted a December 1999 ribbon cutting ceremony for the delisting of the grizzly bear. Now, May 2000, no such joyous occasion appears imminent . . . . I find this news discouraging. . . ." (Emphasis added.) |
| June 8, 2000 FWS Director Clark to Sen. Thomas (WY) (AR 03633-36) | "Since my letter of February 9, 2000, to you regarding the steps necessary prior to delisting of the grizzly . . ., we have released the draft 'Conservation Strategy . . . As an example of how we have worked with the State of Wyoming to meet their needs, the section on nuisance bear management in the draft Conservation Strategy was written by the [Wyoming Game & Fish] Department and inserted verbatim into the document. . . . We will continue to work closely with the Department to finalize the Conservation Strategy and pursue other efforts necessary to achieve recovery and delisting of the Yellowstone grizzly population." |
| July 6, 2000 FWS Director Clark to Sen. Thomas (WY) (AR 04629-30) | "Thank your for your May 3, 2000, letter concerning management and delisting of the grizzly bear population in the Yellowstone Ecosystem . . . . [FWS] realizes we have not met our original deadline . . . . [FWS] has gone to great lengths to involve the States of Wyoming, Montana, and Idaho in all facets of this process." |
| May 27, 2005 Willey (FWS) to Lyke et al. (FWS) (AR 04800-01) | "Subject: Yellowstone grizz timing & ***political fallout***" . . . . "***Chris [Servheen]*** has indicated that if the Grizzly Bear rule does not publish in June the ***Governor of WY will declare the process a failure***. . . . Wondering what steps we might take to give then an early heads up and smooth the waters . . . ." (Emphasis added.) |
| May 27, 2005 ***Servheen*** (FWS) to | "Subject: Yellowstone grizz timing & ***political fallout***" . . . . "I am working with Wyoming on this issue. I do need to have some response |

| | |
|---|---|
| Willey (FWS)<br>(AR 04800) | from DC that: . . . . 2. There is knowledge and interest . . . in the ***political levels in the Department [of the Interior]*** of the rule draft review process in DC . . . ." (Emphasis added.) |
| May 31, 2005<br>Kelly (FWS) to<br>Morgan (FWS)<br>(AR 04799) | "Subject: Yellowstone grizz timing & ***political fallout***' . . . . Some insight from WY and a former species coordinator (wolf). . . . ***If you think wolf in WY is an issue – fasten your seatbelt. If we don't do this until late summer . . . I suspect that the term 'nuclear option' will take on a whole new meaning in the [Washington Office] – or should I say in the three affected states! We need to think twice about what our priorities are...especially as congress debates the ESA. . . .*** [I]n these times hitting our timeline on this highly visible species seems like the preferred alternative. ***Chris [Servheen]*** knows how bad my office is right now from a staffing and funding perspective, . . . ." (Emphasis added.) |
| October 11, 2005<br>Sen. Enzi (WY) to<br>DOI Sec. Norton<br>(AR -----) | "I have been told many times that we will move forward with grizzly bear delisting, and I am disappointed that this effort has not moved forward. Today, ***I seek written assurance*** from you that the process will move forward this fall and that a final decision to delist the grizzly bear will occur in early 2006. . . ." (Emphasis added.) |
| November 15, 2005<br>Sen. Enzi (WY) Press Release: "Delegation: Grizzly Delisting Overdue."<br>(Judicial notice) | The Wyoming Congressional Delegation announced today that after 30 years of being 'endangered or threatened,' the Yellowstone grizzly bear population will take its next lumbering step toward being removed from the Endangered Species List. . . . Senators Craig Thomas and Mike Enzi, along with Congresswoman Barbara Cubin, all R-WY, continue to fight to reform the ESA." |
| November 21, 2005<br>Defendant Hall (FWS) to Sen. Enzi (WY)<br>(AR -----) | "As you are aware, the Service announced a proposed rule to delist Yellowstone grizzly bears on November 15, 2005. . . . We expect to make a final decision on delisting . . . in 2006." |
| January 24, 2006<br>Willey (FWS) to Sens. Thomas (WY), Burns (MT), Craig (ID)<br>(AR 00499) | Points re delisting GYA grizzly bears for meeting with the three Senators. |
| May 4, 2006<br>55 members of Congress to DOI Sec. Scarlett<br>(AR -----) | "Three decades of experience have demonstrated that we need to ***refine the [ESA]*** so that it does a better job of recovering species while minimizing a high degree of conflict, high costs, and unintended consequences. . . ." (Emphasis added.) |
| March 22, 2007<br>Sen. Thomas (WY) Press Release: "Thomas Lauds Grizzly Delisting, Slams Slowness."<br>(Judicial notice) | "While it's certainly a laudable milestone for the grizzly, taking the bear off the list took far too long – 15 years too long in fact, Thomas said. I continue to advocate for changes to the [ESA] that would call for species to be automatically delisted upon reaching recovery goals. With a set trigger for delisting, we could avoid this bureaucratic and legal jumble that ties the hands of land and wildlife managers for |

| | |
|---|---|
| | decades. It's quite simply a waste of time, money, and resources not to have a more efficient process. . . . |
| March 22, 2007<br>Sen. Enzi (WY) Press Release: "Enzi pleased Interior 'waking up' to grizzly delisting."<br>(Judicial notice) | "Decades passed. The bears increased in number. The federal government stood immobile. Today that is finally changing. . . . Just as the bears are coming out of hibernation we see the federal government is finally waking up to the realization that it's long past time to delist the grizzlies in Yellowstone, Enzi said." |
| March 22, 2007<br>Rep. Cubin (WY) Press Release<br>(Judicial notice) | "The State of Wyoming has been ready to manage grizzlies for a long time but this process just kept dragging on. Unfortunately, that is the rule, not the exception, under our current [ESA] system. . . ." |
| March 22, 2007<br>Gov. Freudenthal (WY) Press Release<br>(Judicial notice) | "Today's announcement represents a huge step forward in not only the management of grizzly bears, but also in the administration of the [ESA], Freudenthal said. I hope that the decision to return management for the bears back to the states is a harbinger of good things to come for [other species]." |

**EXHIBIT B**

MATTHEW H. MEAD
GOVERNOR

THE STATE OF WYOMING

STATE CAPITOL
CHEYENNE, WY 82002

# Office of the Governor

May 24, 2012

The Honorable Ken Salazar
Secretary of the Interior
United States Department of the Interior
1849 C Street, NW
Washington, D.C. 20240

Dear Secretary Salazar:

Thank you again for your work on the wolf and sage-grouse. These are issues important to both the U.S. Fish and Wildlife Service and to Wyoming. We have continuing opportunities to work together and to illustrate the success of cooperative coordination on many important topics.

Grizzly bears present a unique slate of circumstances and considerations. The gravity of this topic cannot be overemphasized. The situation is severe and costly. There were four human deaths over the past two years in the Greater Yellowstone Area. Damage to private and public property was disturbing and costly. Wyoming's investment in recovery over the past 28 years exceeds $35 million. The average annual cost to Wyoming for grizzly management approaches $2 million. This is paid by Wyoming hunting license revenue, not United States Fish and Wildlife Service (USFWS) grants and Wyoming does not have jurisdiction for the bears—the USFWS does.

Many knowledgeable people, including grizzly bear scientists within the Department of Interior. believe the species is unquestionably recovered within the Yellowstone Ecosystem. The court ordered relisting of grizzly bears is a public safety concern and a source of frustration. The Interagency Grizzly Bear Committee directed a team to evaluate existing data and to address concerns of the 9th Circuit on white bark pine as it relates to grizzly bear populations. This evaluation could take two years. Two years is too long and the cost is too great.

The continued listing of a recovered population of grizzly bears is a threat to people especially recreationalists, hunters, and property owners and it is costly to manage. I would like to work with you to expedite the analysis of this situation. I look forward to hearing from you and working again with you and your Department toward a productive resolution of this important matter.

Sincerely,

Matthew H. Mead
Governor

MHM:mdm

PHONE (307) 777-7434

FAX (307) 632 3909

**EXHIBIT C**

THE SECRETARY OF THE INTERIOR
WASHINGTON

JUL 1 9 2012

16367

04-024-00
SE-GOV-KG
SO-file

The Honorable Matthew Mead
Governor of Wyoming
Cheyenne, Wyoming 82002

Dear Governor Mead:

Thank you for your letter dated May 24, 2012, concerning the delisting of the Yellowstone grizzly bear population. Though the population was delisted in 2007, it was returned to listed status after a United States District Court ruling in 2009 overturning the delisting.

The U.S. Fish and Wildlife Service (Service) appealed this ruling to the U.S. Court of Appeals for the Ninth Circuit, and in the fall of 2011 the Ninth Circuit reversed part of the District Court ruling but sustained another part. The Service was challenged in four areas: (1) Whether our evaluation of "significant portion of its range" was appropriate and in accordance with law; (2) whether our evaluation of the genetics of the grizzly bear population was correct; (3) whether we evaluated the conservation strategy appropriately and in accordance with law; and (4) whether we appropriately evaluated the implication of whitebark pine on the status of the grizzly bear.

The Service prevailed on issues 1 and 2 at the District court level. The Service subsequently prevailed on issue 3 on appeal. I want to emphasize the importance of prevailing on these first three issues, particularly issue number 3. The Service is in a far better position now to ultimately defend a future delisting of the Yellowstone grizzly bear population. However, the issue that the Ninth Circuit sustained and remanded was the ruling that the Service had failed to establish that the decline in whitebark pine in the Yellowstone ecosystem was not a continuing threat to the grizzly bear.

The Service concurs with your desire to bring resolution to the grizzly bear issue quickly. Immediately upon the appellate ruling, the Service convened all the agency partners in the Interagency Grizzly Bear Study Team in the Yellowstone ecosystem, including members of the Wyoming Game and Fish Department, for group discussions how to best proceed. We also brought in numerous outside experts in bear biology and statistics to give careful consideration to reexamination of whether the declines in whitebark pine poses a threat to grizzly bears sufficite to remain on the lists of endangered or threatened species. All participants agreed that the Yellowstone grizzly population was recovered and that declines in whitebark pine do not threaten the future of this grizzly population.

The Service and our State and Federal partners were disappointed at the ruling and discussed the best way to improve the probability of success if a new decision was again challenged in court. After several meetings and input from all partner agencies, we developed the best approach

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This approach will build a strong scientific synthesis of all the information we have on the relationship between whitebark pine and grizzly bears in the Yellowstone ecosystem and to use this synthesis as a foundation for a new proposed decision. A timeline has been established to complete this synthesis within 18 months and then to develop and publish a new proposed rule by early 2014. The synthesis involves a significant amount of re-analysis of the existing data on the relationship between white bark pine changes and grizzly bear vital rates, as well as adding the data sets from the 2002-2013 time periods to the data to better evaluate these factors. This re-analysis will strengthen the scientific approach we will use to again propose delisting. All agencies are now working cooperatively on this synthesis document, which is being lead by U.S. Geological Survey.

In summary, we agree that the Yellowstone grizzly bear population is recovered and believe our earlier decision was based on the best available science. However, the court decisions require that we revisit the implication of white bark pine to the grizzly bear. We are working with our agency partners through a carefully designed scientific process to do that.

We recognize that the State of Wyoming is a key partner in the recovery and management of the Yellowstone grizzly population. We also recognize that the State of Wyoming has invested significant amounts of expertise and funds in this recovery effort. We deeply appreciate the contributions of Wyoming to the recovery of the Yellowstone grizzly population and the State's commitment to their future welfare. We look forward to a scientifically sound decision which will validate our State/Federal partnership and as one of the greatest success stories under the Endangered Species Act.

Sincerely,

Ken Salazar

Ken Salazar

**EXHIBIT D**

# Grizzly Times

## Partisan Scientists in Public Service II: The Strange Case of the Interagency Grizzly Bear Study Team

**March 31, 2016**

**David Mattson**

Researchers radio-collar an immobilized grizzly bear in this undated IGBST photo.

The Interagency Grizzly Bear Study Team, hereafter the IGBST, was established in 1973 to provide managers and other stakeholders with reliable scientific information relevant to managing Yellowstone's grizzly bears. The impetus for constituting this research group grew from a period of stormy and often strident controversy arising from a decision by the National Park Service to cut bears off from access to human garbage. The famous grizzly bear researchers, Frank and John Craighead, were on one side, advocating a titrated closure of garbage dumps whereas Park Service managers, led by Glen Cole, were on the other, staunchly supporting a cold turkey approach (follow this link for more on this history).

Without going into excruciating details of this controversy, suffice it to say, blood was probably not literally shed only because of our laws against murderous mayhem. The involved guys hated each other. Or more directly to the point of what follows, all sorts of less than objective emotions and motivations seethed under the covering rubric of objective science, which was freely invoked by all involved.

### Grizzly bear science in litigation

Fast forward to around 2005. After more than a decade of political and scientific maneuvering that began in the early 1990s, the US Fish & Wildlife Service's (USFWS) Grizzly Bear Recovery Coordinator, Chris Servheen, oversaw a bid to remove Endangered Species Act (ESA) protections for Yellowstone's grizzly bears. The population had been listed under the ESA in 1975 because of grave concerns about population viability on the heels of a slaughter resulting from closure of Yellowstone's garbage dumps. The USFWS released the official Rule to delist Yellowstone's grizzlies in 2007 only to see the Rule overturned in 2009 by Judge Malloy of Montana's federal District Court, upheld in 2011 by the federal 9th Circuit Court of Appeals.

Why? Because in a virtually unprecedented move, the Courts serially ruled that the USFWS had disregarded or misrepresented a large body of relevant science. The Courts rarely rule on the substance of the science in matters such as this one; they almost always defer to the expertise of the involved federal agencies, which made these rulings truly remarkable.

More specifically, the District and Appeals Courts both concluded that the USFWS, or more specifically, Chris Servheen, had flubbed or otherwise spun the science regarding the effects of a critically important grizzly bear food: whitebark pine seeds. A number of more-or-less definitive scientific studies linked birth and death rates of Yellowstone's grizzlies to the amount of fat-rich pine seeds they had eaten, which mattered all the more because, during the process of judicial review, whitebark pine was being close to functionally extirpated by an unprecedented outbreak of lethal bark beetles driven, in turn, by a warming climate (see this article by Macfarlane et al 2013). The USFWS denied not only the importance of this tree species to grizzlies, but also the magnitude of the tree's losses.

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Interestingly enough, Chris Servheen has a doctorate in wildlife ecology. Moreover, the IGBST scientists at the time, led by Dr. Charles Schwartz, were deeply involved with and fully complicit in, not only putting together the 2007 delisting Rule, but also in crafting court briefs. In other words, ignorance or lack of education can't be plausibly invoked as an explanation for why the government scientists involved in authoring the 2007 Rule so egregiously misrepresented the relevant science.

**Grizzly bear science as politics**

So, what followed the Courts' rulings? Something equally amazing. The USFWS's Grizzly Bear Recovery Coordinator, Dr. Servheen, publicly castigated the federal judges, including reference to them in agency meetings and in media interviews as "activist judges with an agenda." Chris Servheen made additional public statements around this time (and since) to the effect that Yellowstone's grizzly bears needed to be delisted as part of a strategy to thwart those in Congress who wanted to gut or otherwise dramatically change the ESA (see this blog for some context). In other words, a low-level federal bureaucrat in an administrative agency charged with implementing policy was baldly confessing to playing electoral and legislative politics—paradoxically enough, an "activist bureaucrat."

This alone should alarm anyone who cares about the integrity of our government. But, of more relevance to my thesis here, Dr. Servheen also publicly stated that his response to the Courts' rulings would be to simply go back and, in essence, fix the scientific record so as to demonstrate that whitebark pine didn't matter to Yellowstone's grizzly bears—as opposed to another alternative he considered, which was to simply damn the Courts and reissue the exact same Rule (for example, see this email and this draft of a USFWS letter to Wyoming's governor Matt Meade). In other words, he had already decided what any follow-on science would show. This by someone who works for an agency—the USFWS—singled out in virtually every study that's

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looked at scientific integrity as being the most prone to subvert science in service of political ends (for example, see this UCS report).

All of this matters to my story because guess who paid for most of the follow-on science? Yep, the USFWS, at the behest of Chris Servheen. And, getting back to where I started, guess who executed all of the paid-for science? Yep, the IGBST, the same guys who helped create the overturned 2007 Rule. And guess who was deeply involved in crafting research questions and reviewing pre-published research results? Yep, Dr. Servheen again (for example, see this IGBST study plan that Dr. Servheen annotated). And guess what all of the resulting science was interpreted to show? Yep, that whitebark pine didn't matter to Yellowstone's grizzlies (for example, see this recent paper Van Manen et al 2016). And, finally, guess who produced in unprecedented fashion a white paper summarizing the unpublished new science, timed to serve the purposes of rushing ahead with a new delisting rule? Yep, the IGBST, hand-in-glove with Dr. Servheen (see this more-or-less ecstatic press release by the IGBC).

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In fact, the group charged with overseeing management of Yellowstone's grizzly bears—the Interagency Grizzly Bear Committee—voted almost immediately upon receiving the IGBST's white paper to support a new delisting Rule, which was released by the USFWS in due course during March 2016.

Which is to say, this brief history is one that I would argue provides clear evidence of science corrupted to serve political ends, which can happen even when the involved people have the best of intentions (more on this next week). And the political ends are not hard to divine.

**The political imperative**

Both the USFWS and politicians and wildlife managers from the states of Wyoming, Montana, and Idaho have made clear that they are committed to stripping ESA protections from Yellowstone's grizzly bears and transferring management authority to the states—no matter what (see this relevant blog). In the process, the USFWS, which has authority over the delisting process, has assiduously ignored any and all who have expressed concerns, including 40 plus Tribes who have demanded that they be consulted. The USFWS seems to be slaved to a narrative wherein they perversely "save" the ESA by removing protections for currently listed species, including Yellowstone's grizzlies. In contrast, the states seem to be obsessively driven by a largely ideological need to control all wildlife management, coupled with a visceral hostility to any semblance of federal authority.

These diverse motives have produced some pretty strange outcomes, including a pro-delisting op-ed in a regional newspaper co-authored by Dan Ashe, the USFWS Director charged with implementing the ESA, and Matt Mead, Wyoming's Governor and vitriolic critic of the ESA (see a comment here). As with Ashe's minion Chris Servheen, this coupling of a federal bureaucrat with an elected official to advance a political agenda should be alarming to anyone who cares about the integrity of our public servants. But my main point is the extent to which the USFWS and the involved states are joined at the hip when it comes to delisting Yellowstone's grizzlies.

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# An innovative aerial assessment of Greater Yellowstone Ecosystem mountain pine beetle-caused whitebark pine mortality

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*Abstract*. An innovative aerial survey method called the Landscape Assessment System (LAS) was used to assess mountain pine beetle (MPB; *Dendroctonus ponderosae*)-caused mortality of whitebark pine (*Pinus albicaulis*) across the species distribution in the Greater Yellowstone Ecosystem (GYE; 894 774 ha). This large-scale implementation of the LAS method consisted of 8673 km of flight lines, along which 4653 geo-tagged, oblique aerial photos were captured at the catchment level (a subset of 12-digit USGS hydrologic units) and geographic information system (GIS) processed. The Mountain Pine Beetle-caused Mortality Rating System, a landscape-scale classification system designed specifically to measure the cumulative effects of recent and older MPB attacks on whitebark pine, was used to classify mortality with a rating from 0 to 6 based on the amount of red (recent attack) and gray (old attack) trees visible. The approach achieved a photo inventory of 79% of the GYE whitebark pine distribution. For the remaining 21%, mortality levels were estimated based on an interpolated surface. Results that combine the photo-inventoried and interpolated mortality indicate that nearly half (46%) of the GYE whitebark pine distribution showed severe mortality (3–4 or 5.3–5.4 rating), 36% showed moderate mortality (2–2.9 rating), 13% showed low mortality (1–1.9 rating), and 5% showed trace levels of mortality (0–0.9). These results reveal that the proliferation of MPB in the subalpine zone of the GYE due to climate warming has led to whitebark pine mortality that is more severe and widespread than indicated from either previous modeling research or USDA Forest Service Aerial Detection surveys. Sixteen of the 22 major mountain ranges of the GYE have experienced widespread moderate-to-severe mortality. The majority of catchments in the other six mountain ranges show low-to-moderate mortality. Refugia from MPB outbreaks, at least for now, also exist and correspond to locations that have colder microclimates. The spatially explicit mortality information produced by this project has helped forest managers develop and implement conservation strategies that include both preservation and restoration efforts. Future research aimed at documenting and quantifying the ecological impacts of widespread decline and collapse of this foundation and keystone species is warranted.

*Key words: aerial survey method; climate change impacts;* Cronartium ribicola; Dendroctonus ponderosae; *geographic information system, GIS; Greater Yellowstone Ecosystem; Mountain pine beetle; pest monitoring;* Pinus albicaulis; *rapid assessment system; whitebark pine; white pine bluster rust.*

## Introduction

The Greater Yellowstone Ecosystem (GYE) is an ecological reserve of regional, national, and international significance (Fig. 1). This collection of national parks, national forests, wildlife refuges, and tribal lands is generally recognized as one of the last remaining large, nearly intact ecosystems in the earth's northern temperate region (Keiter and Boyce 1991). Throughout the GYE, at elevations greater than ~2000 m, coniferous forests are the dominant land cover (Marston and Anderson 1991). Approximately 80% of Yellowstone National Park (YNP), which lies in the center of the GYE and encompasses ~9000 km$^2$ of predominantly high-elevation (2100–2700 m) volcanic plateau with relatively mild topography, is covered by forests of lodgepole pine *Pinus contorta latifolia* (Romme et al. 2011). Outside the Yellowstone Plateau, the GYE's topography is much more rugged and consists of 22 major mountain ranges with semiarid river valleys in between. Douglas-fir (*Pseudotsuga menziesiia glauca*) and lodgepole pine are the most common species in the GYE montane zone, between 2000 m and 2500 m (Marston and Anderson 1991), while whitebark pine (*Pinus albicaulis*), the focal species of this study, dominates drier and more exposed slopes of the subalpine zone (above ~2500 m). On wetter, less exposed sites, whitebark is a major species, but is successionally replaced by shade-tolerant subalpine fir (*Abies lasiocarpa*) or Engelmann spruce (*Picea engel-*

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[5] Retired.



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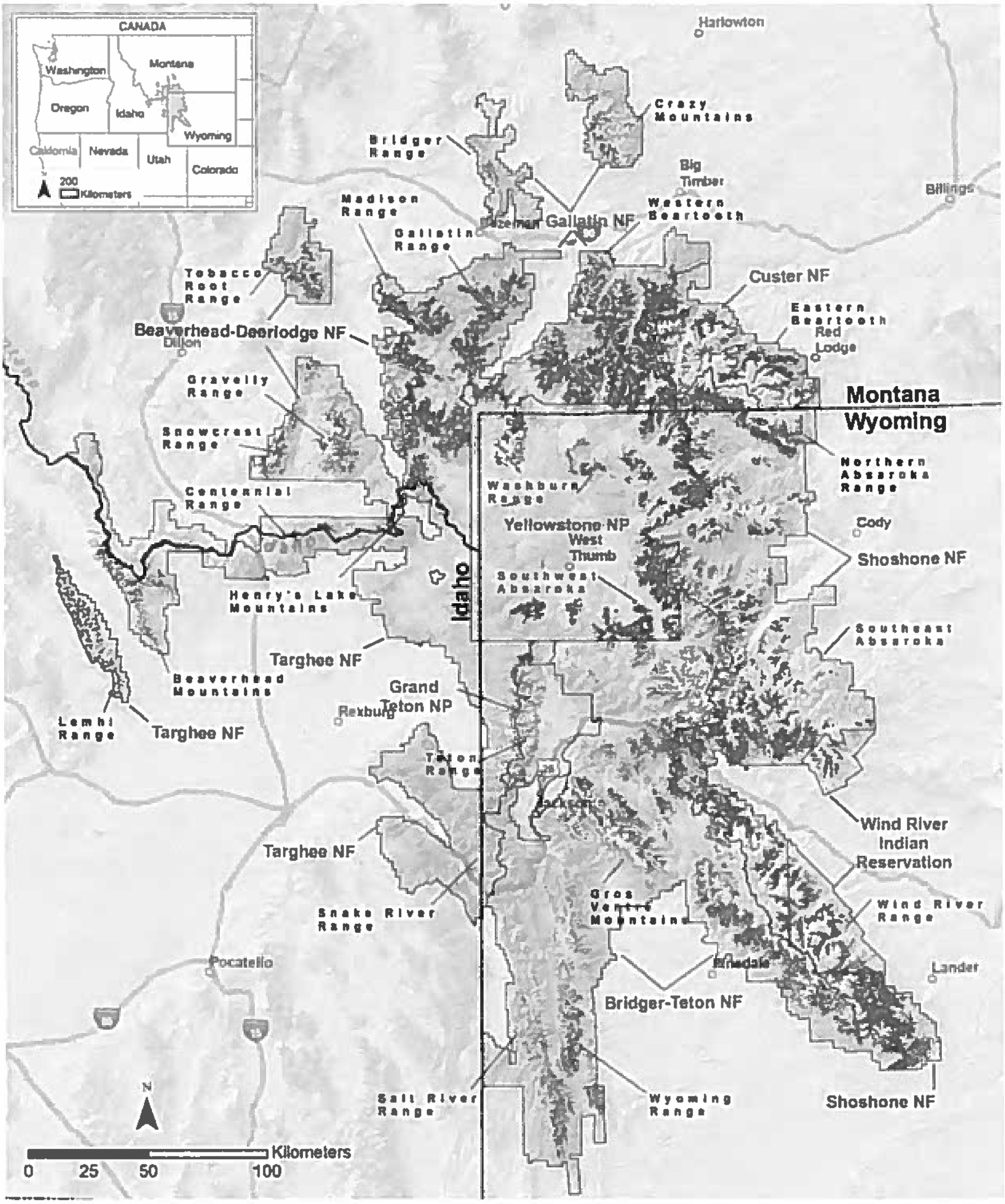


FIG. 1. The Greater Yellowstone Ecosystem (GYE), located in south-central Montana, northwest Wyoming, and southeast Idaho, USA, covering ~59 000 $km^2$ of mountainous terrain. Displayed are the administrative areas of the GYE, including two national parks (NP) and six national forests (NF). The GYE's 22 major mountain ranges are identified, and the whitebark pine (*Pinus albicaulis*) distribution is shown in dark gray (894 774 ha).

*mannii*). At the upper end of the subalpine zone, whitebark pine is dominant (Despain 1990), and extensive contiguous climax forests are found on each of the 22 major mountain ranges of the GYE (Fig. 1). According to the 2010 Whitebark Pine Distribution Map (2011) compiled by the Greater Yellowstone Coordinating Committee (GYCC) Whitebark Pine Subcommittee, there are an estimated 1 023 175 ha of

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whitebark pine within the GYE, representing roughly 18% of the land cover (*available online*).[6]

Whitebark pine functions as both a foundation and a keystone species in the high elevations of the GYE (Tomback et al. 2001, Ellison et al. 2005, Resler and Tomback 2008). It forms the foundation of the subalpine zone by colonizing sites with difficult growing conditions. Once established, whitebark pine enhances soil formation and improves site conditions, enabling other conifer species to establish (Callaway 1998). At the landscape scale, healthy whitebark pine forests help regulate snow capture and retention, thus increasing the quantity and duration of summer runoff (Farnes 1989). Whitebark pine's large, highly nutritious seeds are critically important for a wide array of wildlife, including Clark's Nutcrackers (*Nucifraga columbiana*; Tomback 1978), red squirrels (*Tamiasciurus hudsonicus*; Podruzny et al. 1999), as well as black bears (*Ursus americanus*) and the iconic Yellowstone grizzly bears (*Ursus arctos horribilis*; Kendall 1983, Kendall and Arno 1990, Mattson and Reinhart 1994, Lorenz et al. 2008, Tomback et al. 2001). A review of the unique role whitebark pine plays in the GYE can be found in Logan and Macfarlane (2010).

Historically, the range of the mountain pine beetle (MBP; *Dendroctonus ponderosae*) was limited primarily to lower elevation forests because of the unfavorable climatic conditions found at higher elevations (Amman 1973). For this reason, whitebark pine forests have largely avoided past MPB outbreaks. Although widespread tree mortality did occasionally occur during periods of unusually warm weather (e.g., the 1930s), these past outbreaks were short lived and limited in scale (Ciesla and Furniss 1975, Perkins and Swetnam 1996) compared to the current outbreak in the GYE.

Since 1999, a warming climate in the Northern Rockies (Mote et al. 2005, Westerling et al. 2006) has coincided with MPB eruptions that have exceeded the frequencies, impacts, and ranges documented during the previous 125 years (Raffa et al. 2008). In particular, warming temperatures have allowed MPB to thrive in previously inhospitable whitebark pine forests. Several studies have shown that whitebark pine is highly susceptible to infestation by the MPB (Logan and Powell 2004, Six and Adams 2007, Bockino and Tinker 2012). In 1999, the annual USDA Forest Service's Aerial Detection Survey (ADS) of the GYE recorded only 217 ha of MPB-infested whitebark pine, but by 2007 the infestation levels had increased 320-fold to 69 433 ha (Gibson et al. 2008, Logan et al. 2009).

However, for a number of reasons related to the ADS mission, ADS may not be an adequate measure of GYE-wide whitebark pine mortality: (1) Priorities for areas to be flown are set at the national forest level and often reflect values (e.g., timber) other than the ecological services provided by whitebark pine, and as a result, appropriate funds are often not available for surveying whitebark pine habitat; (2) ADS is a "red top" survey, i.e., mortality estimates are limited to current red trees that result from successful beetle attack just the previous summer, and as a result, an individual year's survey does not represent a cumulative mortality estimate; (3) not every area is flown every year; (4) perhaps most importantly for the GYE, national parks and designated wilderness areas are not regularly flown. Approximately 62% of the whitebark pine distribution in the GYE is contained in either national parks or designated wilderness (Appendix A).

In 2008, motivated by a desire to more adequately document the mortality trend in GYE whitebark pine, a pilot study was initiated that combined a newly designed rapid assessment aerial survey system (Landscape Assessment System; LAS) and a prototype Mountain Pine Beetle Mortality Rating System (MPBM Rating System; *available online*).[7] In contrast to ADS, the MPBM rating system was designed to specifically measure the cumulative effects of current, recent, and older MPB attacks on whitebark pine rather than single-year mortality for all forest insects and pathogens. Recent mortality is evident by the large numbers of trees with red needles (symptomatic of trees killed the previous summer); older mortality is evident by red trees turning to gray as they lose their needles, leaving the residual ghost forest (Fig. 2; see Plate 1).

The pilot project demonstrated that LAS was a reliable monitoring technique capable of rapid assessment of both recent and older MPB impacts on whitebark pine in large, remote landscapes (Logan et al. 2009). The ability of the LAS method to quickly and affordably assess forest mortality attracted the attention of the GYCC Whitebark Pine Subcommittee and the USDA Forest Service's Forest Health Protection program, and in 2009, with the help from the Natural Resources Defense Council (NRDC), a LAS survey for the entire GYE was funded. The main objective of the project was to provide resource managers, for the first time, with a complete assessment of GYE-wide, MPB-caused whitebark pine mortality. The spatially explicit mortality information produced by this project was intended to help forest managers develop and implement conservation strategies that included both preservation and restoration efforts.

## Methods

### *The Landscape Assessment System (LAS)*

LAS is an innovative rapid aerial survey assessment method that combines low-cost geo-tagged aerial photos and straightforward geographic information system (GIS)-based post-processing to photographically docu-

[6] http://fedgycc.org/documents/WBPStrategyFINAL5.31.11.pdf

[7] http://www.fsl.orst.edu/wfiwc/awards/speeches/logan-address.pdf

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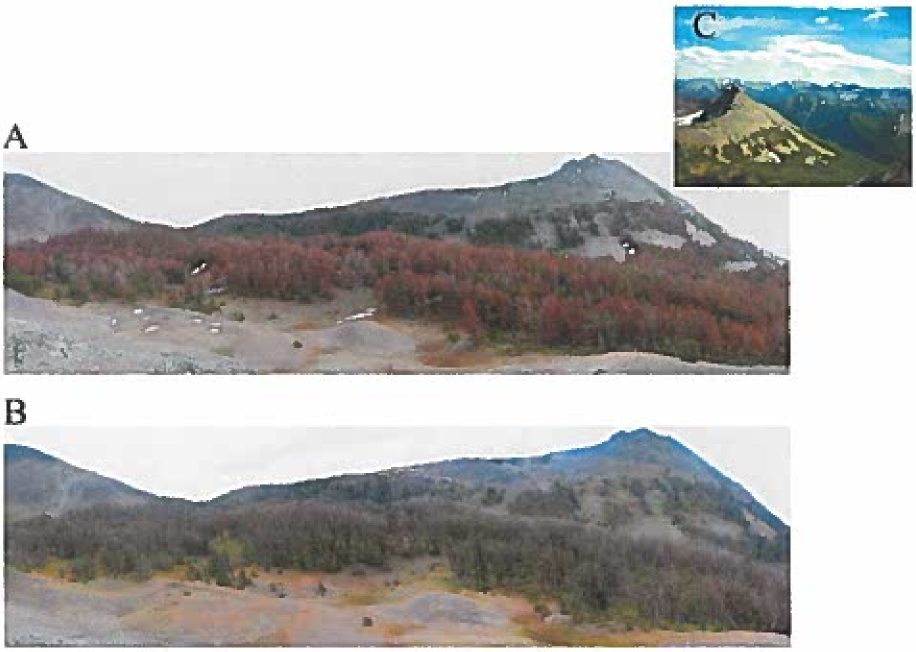


FIG. 2. Repeat photos of the Avalanche Peak area looking toward Hoyt Peak near the East Entrance of Yellowstone National Park. (A) The upper photo was taken in 2005 and shows active widespread mountain pine beetle (MPB; *Dendroctonus ponderosae*)-caused whitebark pine mortality. (B) The lower photo was captured in 2011 and shows a residual forest post-outbreak. (C) The photo insert is a tourist photo downloaded from the internet, taken in 1995; back when, in the words of Thomas Turiano, the trail to Avalanche Peak led through "a beautiful forest of whitebark pine . . ." (Turiano 2003:240–241). Photo credits: (A) J. A. Hicke; (B) W. W. Macfarlane; (C) David Hodge.

ment and then map landscape-level conditions. The geo-tagged photos had precise geographic coordinates that permitted them to be easily and precisely positioned on a map. In this application, ecological condition was assessed using the MPBM Rating System by which researchers manually assigned a numeric (0–5.4) mortality rating based on the proportion of dead trees visible in each aerial photo (Appendix D).

Results from our pilot study (Logan et al. 2009) indicated the LAS aerial survey-based approach was an effective means to assess and document MPB-caused whitebark pine mortality in the GYE for the following reasons: (1) Reliable GYE-wide whitebark pine distribution layers are available and can be used to help identify whitebark pine forests from the air (Landenburger et al. 2008). (2) GYE whitebark pine follows a predictable elevational distribution: In the northern portion of the GYE, it generally occurs above ~2500 m, and in the southern portion it occurs above ~2800 m; therefore, onboard GPS data could be used to help delineate whitebark pine forests from the air. (3) Whitebark pines have distinctive rounded and irregularly spreading crowns that are easily recognized and distinguished from other conifers, even from the air (Fig. 3). (4) MPB-caused mortality has an obvious signature because the needles on dead trees turn bright red during the summer following successful beetle attack. Red canopies are clearly visible from aircraft and easily captured with photography (Fig. 3). Older mortality, likewise, is clearly distinguishable by its gray canopy (no needles). (5) In the aftermath of an outbreak, beetle-killed trees can be distinguished from high-intensity fire-killed trees (including more than one-quarter of Yellowstone National Park's whitebark pine zone that burned during the 1988 fires; Renkin and Despain 1992) because the fine material, other than needles, remains on the beetle-killed tree, giving it a distinctive appearance (Fig. 3). However, in areas of low-to-moderate intensity fire (i.e., heat killed), fine materials remain and look similar to the beetle-killed tree. Therefore, in these cases, wildfire perimeter maps (Landscape Fire and Resource Management Planning Tools Project [LANDFIRE] Rapid Refresh products) were used to exclude MPB as the mortality agent (LANDFIRE 2007; map *available online*).[8]

### *Oblique aerial photography*

Photos captured at an oblique angle were collected for this project and used for analysis in conjunction with existing vertical imagery of the study area. We chose to collect oblique photographs for the following reasons: (1) Given a constant altitude, oblique aerial photos can cover a much larger area than vertical aerial photos; and (2) an oblique view of a forest in conjunction with a vertical view, obtained in this case from base imagery in Google Earth, provided the interpreter with comple-

[8] www.landfire.gov/updatedproducts_fireperimeter.php

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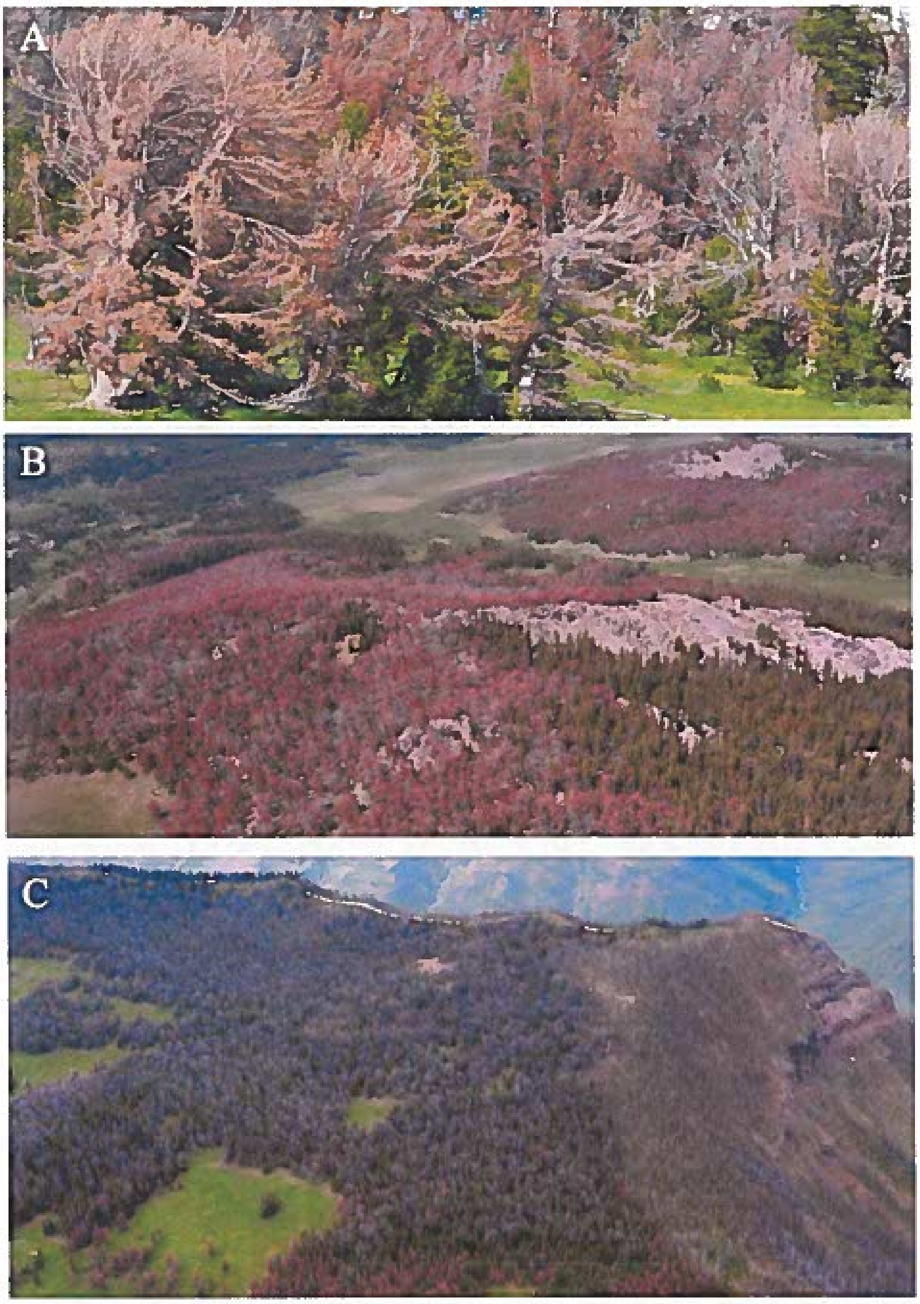


FIG. 3. (A) The rounded and irregularly spreading crowns are common characteristics of whitebark pine (Union Pass, Gros Ventre Range). (B) Recent mortality is evident by large numbers of trees with red needles, which is symptomatic of trees killed the pervious summer (Union Pass, Gros Ventre Range). (C) The left side of the photo shows whitebark pine killed by MPB, with fine material remaining on the tree, and the right side shows trees killed by high intensity fire, with fine material burned off the tree (Yellowstone National Park). Photo credits: W. W. Macfarlane.

mentary views of forest structure, height, and understory and thus allowed for effective visualization of tree mortality. However, because oblique aerial photos distort perspective, specific measures were taken before the photos were used for GIS mapping purposes. This issue was resolved by capturing photos with Global Positioning System (GPS)-enabled cameras that embed (geo-tag) location information to each photo, and then each photo point was "spatially joined" to a corresponding catchment polygon (see *Overflights and oblique aerial photo capture* below).

### *LAS spatial scale*

We determined that the catchment would serve as the project's minimum mapping unit (i.e., the smallest area unit to be mapped as a discrete entity; Lillesand and

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Kiefer 1994) because this proved to be an effective management unit size for implementing conservation strategies. The catchment units are a subset of the subwatershed unit (12-digit U.S. Geological Survey [USGS] hydrologic units) and were delineated in ESRI ArcGIS 9.3 (ESRI 2009) based on a 30-m digital elevation model (DEM). Catchment size is directly related to topographic relief and complexity: The greater the relief and complexity, the smaller the catchment size. Over 70% of the GYE whitebark pine distribution is located in complex mountainous topography, and therefore the catchments in these landscapes are relatively small, ranging from 100 ha to 400 ha. The remainder of the GYE whitebark pine is distributed on high plateaus where the topography is less complex, and therefore the catchments are larger, ranging from 401 ha to 3000 ha.

### *LAS data collection and processing*

The LAS data collection and processing workflow consisted of five steps: (1) flight line development, (2) overflights and oblique aerial photo capture, (3) image processing, (4) mortality assessment and mapping, and (5) ground verification.

*Flight line development.*—Flight lines were developed within Google Earth 5 Pro (2010 Google; *available online*)[9] by first identifying whitebark pine habitat using both the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee (2011; see footnote 6) and the USGS (Landenburger et al. 2008) whitebark pine distribution maps, along with a 2500-m contour as background layers to ensure complete spatial coverage of all potential whitebark pine habitat. A system of parallel flight lines was developed for this habitat map, using a fixed parallel line interval of 8 km (Appendix B). This interval was used because our 2008 pilot study indicated an optimal 4–5 km width for this type of oblique photography. Therefore, with an observer on each side of the plane, an 8-km interval translated into each observer capturing a 4-km swath of forest on his/her respective side of the plane.

Flight lines were also delineated to run parallel to mountain ridges instead of over ridge crests, allowing for lower flight heights. This approach resulted in higher quality imagery, a better perspective to visualize and capture the catchments from the aerial perceptive, and a better perspective for post-processing three-dimensional viewing and analysis in Google Earth. Flight line data were transferred to both an onboard GPS used by the pilot for navigation, and to a handheld GPS unit used by the observers to record flight path information.

*Overflights and oblique aerial photo capture.*—Low-flying airplane overflights (300–1000 m above ground level) were conducted by EcoFlight, a nongovernmental organization (NGO) that facilitates conservation efforts by providing aerial support using a Cessna 210 Centurion airplane (more information *available online*).[10] A flight speed of ~44–46 m/s (85–90 knots) was used throughout the flights. Flight lines consisted of a total of 8673 km in length. The aerial survey required 55 hours of flying that were divided into 11 flight days. Each flight started and ended at the airport in Jackson, Wyoming, USA.

Nikon D5000 GPS-enabled digital single-lens reflex (SLR) cameras (Nikon, Tokyo, Japan) were used to capture the desired 12.5-megapixel, geo-tagged, oblique aerial photographs. A two-observer technique was used, with an observer seated on each side of the aircraft, each responsible for photo-documenting the whitebark pine visible from his/her position at the catchment spatial scale (Appendix C). Each photo captured had an associated GPS coordinate for the location and time at which the photo was taken, and this information was written in the exchangeable image file format (EXIF). Each geo-tagged photo was recorded as point data and later used to assign mortality ratings to polygon (catchment-level) data.

*Image processing.*—After each flight, the photos captured on that flight were transferred from the camera to a hard drive in both high-quality Jpeg and Raw format. An image viewing and editing program Picasa 3 (2010 Google; *available online*)[11] was used to examine each photo for image quality. Some images were visually improved using standard image enhancement techniques under the "Basic Fixes" tab (e.g., contrast, fill light, and brightness).

Then, RoboGEO version 5.6 (2003–2010 Pretek, *available online*)[12] was used to transfer the flightpath and tagged photos to keyhole markup language (KML) format for use in Google Earth. This processing step generated a point ($x$, $y$, and $z$ coordinate) that identified the location of each photo along the flight line. We called these identifiers "photo points." In the small number of instances where photos were missing coordinates because the camera's GPS unit temporarily lost satellite reception, the handheld GPS unit's data was used to geo-tag photos. In Google Earth, the flight lines, photo points, and linked images were examined for spatial accuracy and spatial coverage on a three-dimensional globe. All photo point location errors were identified and fixed.

After the photo points were fine-tuned by the observer within Google Earth, a "snap shot" view was established. Generating the snap shot view was a manual process that required zooming to the precise location of each photo and framing the photo with the correct rotational angles provided by the Google Earth interface. The snap shot view, therefore, represented and saved the view that the camera "saw" when the oblique

[9] www.earth.google.com

[10] http://www.ecoflight.info/

[11] www.picasa.google.com

[12] www.robogeo.com

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PLATE 1. Close-up photograph of upper-elevation whitebark pine forest shown in Fig. 2. All mature, cone-bearing whitebark pine have been killed by mountain pine beetle. The future of this forest resides in understory seedlings and saplings that were too small for mountain pine beetle invasion during the current outbreak episode. This future, however, is uncertain with continued climate warming. Will these residual trees reach cone-bearing size, only to fall victim to future generations of mountain pine beetle? Photo credit: J. A. Logan.

photo was taken. Each photo's snap shot view provided the user with a three-dimensional visualization of the forest condition. This process also generated coordinates of the ground location for the center of each photo. These locations were called "look-at points."

*Mortality assessment and mapping.*—Mortality ratings were manually assigned by a team of four observers that used ongoing field-, laboratory-, and plane-based discussions to calibrate their mortality assessments at the catchment level. Mortality ratings were assigned during post-processing using workstations with dual high-definition flat-panel monitors. On one monitor, Google Earth was used to display the appropriate look-at point and associated pop-up low-resolution aerial photo. On the other monitor, Picasa 3 displayed the respective aerial high-resolution photo centered at the appropriate look-at point. Mortality levels were assigned at the catchment level by zooming in on the high-resolution photo, visually examining the photo for evidence of whitebark pine mortality, and then applying a single numeric (0–5.4) rating to both the photo and the associated look-at point based on the MPBM Rating System (Appendix D). In most cases, the same observer that took the photo made the mortality classification.

This MPBM Rating System ranks whitebark pine mortality based on the proportion of dead canopy visible in each aerial photo. In forests with active outbreaks, the amount of red (recent attack) and gray (older attack) whitebark pine was visually assessed and rated. The active outbreak ratings ranged from 0 to 4, with fraction categories (in steps of 0.25) to describe variation within major categories. Areas where the outbreak cycle had ended (no remaining red trees) were classified as residual forests, with ratings from 5 through 5.4, depending upon the amount of remaining green whitebark pine visible in the photo (Table 1).

Both point and polygon whitebark pine mortality maps were generated in ArcGIS 9.3 (ESRI 2009). Point map generation consisted of plotting look-at points and associated mortality values onto a project area map. Polygon map generation involved a GIS process that consisted of spatially joining the look-at points and the catchment boundaries, then "clipping" the catchment extents by the whitebark pine distribution to form the catchment-level mortality map. For catchments not directly sampled by look-at points (21%), a "kriged" mortality surface was interpolated. In an effort to avoid overestimating mortality intensity across the interpolated mortality surface, the post-outbreak ratings (5.3, 5.325, 5.35, 5.375, and 5.4) that reflect both mortality intensity and outbreak timing were reclassified to their corresponding intensity values (3, 3.25, 3.5, 3.75, and 4, respectively). These reclassified values were added to the look-at point GIS layer and were used as the input

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TABLE 1. Numeric ratings and mortality levels associated with the Mountain Pine Beetle (*Dendroctonus ponderosae*) Mortality (MPBM) Rating System for whitebark pine (*Pinus albicaulis*).

| Numeric rating | Mortality level | Description |
|---|---|---|
| 0–0.75 | trace | Green forest with trace levels of mortality. "Trace mortality" refers to a catchment that contains an occasional red tree but there is no evidence of mortality expanding to neighboring trees. |
| 1–1.75 | low | Green forest with occasional spots of red trees across the catchment. The increasing frequency of current-year red spots is assessed with a 1.25, 1.5, and 1.75 rating. Spots do not show evidence of multiyear mountain pine beetle-caused mortality. |
| 2–2.75 | moderate | Primarily green forest with multiple spots of red and/or gray trees across the catchment. Spots show evidence of two or more years of subsequent mortality. The increasing magnitude of these spots is assessed with a 2.25, 2.5, and 2.75 rating. |
| 3–4 | severe (active outbreak) | Primarily red forest where spots of red and gray trees have coalesced across the catchment. A catchment may display a varying degree of coalescing spots ranging from initial coalescence, category 3, to increasing coalescence that is assessed with a 3.25, 3.5, 3.75, and 4 rating, where essentially the entire whitebark pine overstory is red. |
| 5.1–5.4 | residual forest | Residual forest where a catchment may contain a varying degree of remaining green forest after a mountain pine beetle attack. This variation is captured with a 5.1–5.4 rating where virtually the entire whitebark pine overstory is dead and gray. These mortality intensity values are equivalent to those found in the 1–4 categories (i.e., a 5.35 rating is equal to a 3.5 at the end of the outbreak cycle). Rating of 5.*x* pertains to a residual forest, as opposed to a 1–4 that indicates the red-attack stage. |

variable for kriging. Therefore, the final polygon-based mortality map consisted of a combination of sampled catchments that included both active and post-outbreak conditions (0–5.4) and non-sampled catchments that consisted of mortality intensity values (0–4). A recognized limitation of this approach was that, by using mortality intensity ratings only, the timing of post-outbreak condition for non-sampled catchments is not captured with the resulting interpolated mortality surface.

*Precision and accuracy assessment.*—Manual classification of MPB-caused mortality is inherently subjective because of observer variability that directly influences the repeatability (precision) of the resulting classifications. The precision of our classification method was assessed by randomly selecting a total of 465 aerial photos (10% of total photos), and then having two observers independently classify mortality by major mortality level (0, 1, 2, 3, 4, 5) in each photo. Cohen's kappa statistic (0–1) was used to measure agreement between the observers' classifications because it is more robust and conservative than the overall error rate (Congalton 1991). The accuracy of the LAS method was assessed by using a GIS viewshed analysis along roadways that access whitebark pine forests to identify and map a total of 300 potential ground-based classification viewpoints. Each of these ground verification viewpoints was physically visited, and an independent on-the-ground mortality classification was conducted and compared to the aerial photo-based classification. Cohen's kappa statistic was once again used to measure agreement between the on-the-ground and photo-based classifications.

## RESULTS

The LAS whitebark pine mortality assessment results are contained in three data formats: (1) aerial oblique photographs (KML point files with associated photo "pop-ups"), (2) look-at point mortality maps, and (3) polygon (catchment-level) mortality maps.

### *Oblique aerial photographs*

The aerial perspective obtained from the LAS overflights provided an unobstructed view of the forest overstory that allowed for effective aerial photo-documentation of whitebark pine mortality. A total of 4653 oblique aerial photos were determined to be high enough quality for accurate mortality assessment. These photos were widely distributed along 8673 km of predetermined flight lines, covering all 22 major mountain ranges of the GYE. This extensive photo inventory documented whitebark pine mortality that was more severe and widespread than indicated from either previous modeling research or the USDA Forest Service Aerial Detection (Fig. 4). The higher than anticipated mortality emphasized the need for developing a comprehensive whitebark pine conservation strategy.

In an effort to aid resource managers in the development of such a strategy, the 4653 classified photos were processed to produce a KML file that allowed forest condition to be effectively evaluated in a spatially explicit three-dimensional context within Google Earth (Supplement). The resulting KML file provided a photographic record of whitebark pine condition for the GYE at a time (summer 2009) when the ecosystem was experiencing a MPB disturbance of historically unprecedented proportions, and established a base-line to evaluate both future

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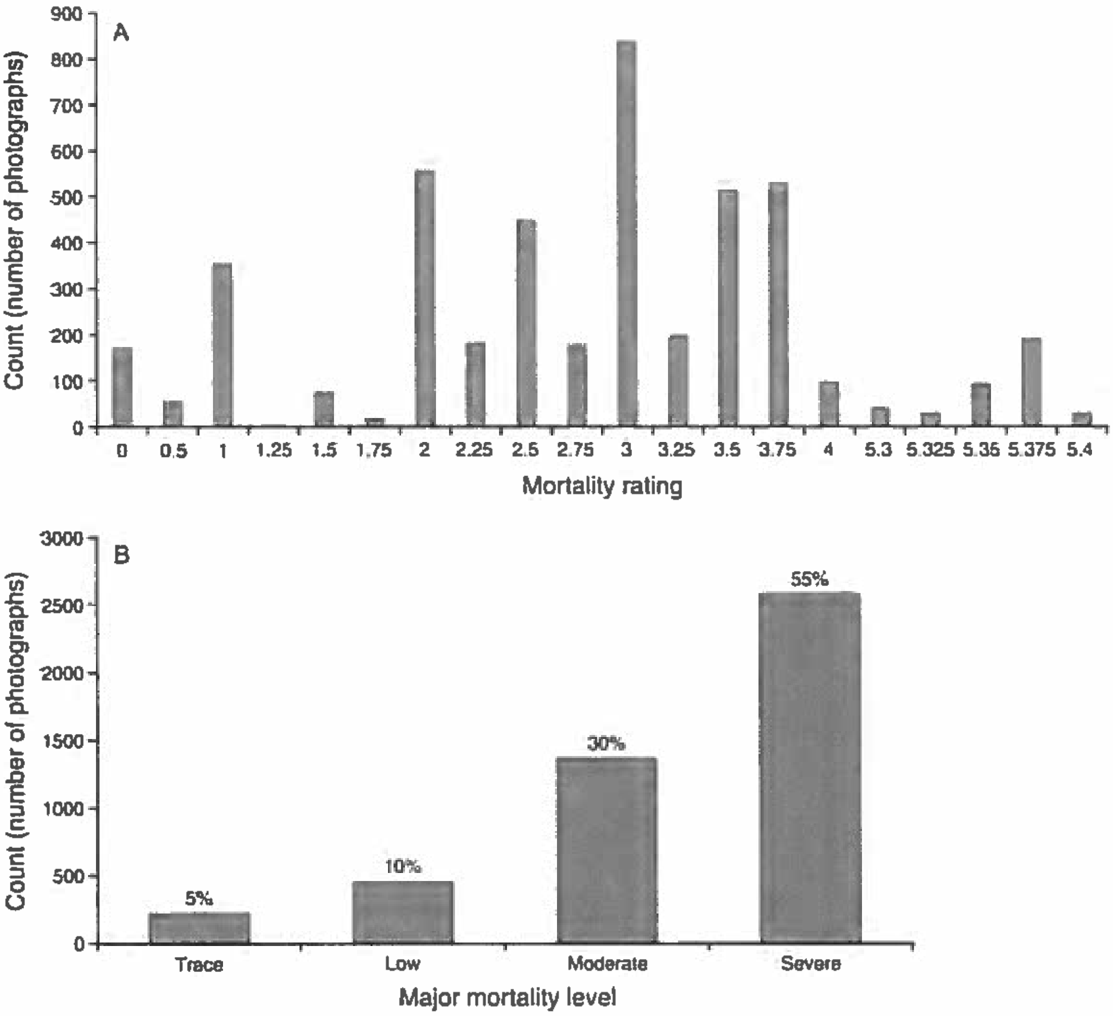


FIG. 4. (A) Frequency distribution of classified aerial photos ($n = 4653$ in total) by mortality rating: 0–0.75 represents trace level of mortality, 1–1.75 represents the occasional spot mortality, 2–2.75 represents multiple-spot mortality, 3–3.75 represents coalesced mortality, and 4 represents the removal of virtually all whitebark pine overstory. Residual forest ratings of 5.1–5.4 indicate a decreasing amount of green trees remaining after a mountain pine beetle attack, and a rating of 5.4 indicates a forest where essentially the entire whitebark pine overstory has been removed and turned gray. The residual forest ratings are equal in mortality intensity to the red-attack categories 1–4 (i.e., 5.5 is equivalent to 3.5 in mortality intensity). (B) Frequency distribution of classified aerial photos ($n = 4653$) with mortality ratings grouped into major mortality levels: trace level of mortality (0–0.75); low mortality (1–1.75); moderate mortality (2–2.75); and severe mortality (3–4 and 5.3–5.4). The percentage of the total for each level is shown above the bars.

outbreaks and potential regeneration/recovery of whitebark pine forests.

*Look-at point-based mortality map*

The look-at point-based mortality map showed the specific ground location of each photo and the corresponding mortality rating (0–5.4) and revealed clusters of mortality indicating strong autocorrelation (i.e., areas closer together are more likely to have the same level of mortality than those far apart; Fig. 5). The spatial scale of the mortality pattern exhibited by the point-based mortality assessment supports the hypothesis that outbreaks resulted from a simultaneous release of resident low-level MPB populations rather than an invasion of outside sources. Additionally, the clustered point mortality pattern provides an indication of the temporal sequence of disturbance, with orange and red indicating either a building or peak outbreak, and gray indicating post-outbreak/residual forest. From this temporal pattern, the epicenter of the disturbance is apparently the east-central portion of Yellowstone National Park and the northwest part of the GYE. Throughout the entire GYE, all look-at points documenting residual (gray attack) forests were classified with severe (5.3 or greater) ratings, indicating that the current MPB infestations are consistently progressing to an outbreak stage before ending.

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### *Catchment level mortality map*

The GIS analysis revealed that the project's 4653 look-at points intersected with 3185 of the total 4862 catchments (73% by area). Another 657 catchments (6% by area) were identified as wildfire-dominated mortality and were excluded from the MPB-caused mortality analysis. For the remaining 1677 catchments (21% by area), a mortality surface was interpolated using kriging (Appendix E).

Kriging was determined to be appropriate based on the results of the Global Moran's *I* statistic and Ripley's *K* function. Computed values for the Global Moran's *I* statistic, which evaluated whether the mortality pattern expressed was clustered, dispersed, or random, indicated a statistically significant tendency toward clustering with a positive Moran's *I* index of 0.61. The Ripley's *K* function also indicated that the mortality look-at point data exhibited strong spatial dependence (feature clustering) over the entire GYE whitebark pine distribution. These results show strong spatial autocorrelation, so the data is appropriate for interpolation using kriging.

The photo-inventoried and interpolated catchment-level mortality data were combined to generate GYE-wide spatial mortality data. Similar to the point-based analysis, the catchment-level data revealed widespread moderate-to-severe whitebark pine mortality across the vast majority (82%) of the GYE (Fig. 6). The catchment-level mortality map delineated the spatial patterns of mortality and revealed widespread, severe ongoing, and post-outbreak whitebark pine mortality across the GYE distribution (Fig. 7). These foundation and keystone forests with severe ongoing or severe post-outbreak mortality are tending towards "functionally extinct," meaning they are no longer capable of providing the important ecosystem services they once did. Since GYE resource managers have determined that heavily impacted catchments are good candidates for restoration efforts, and less impacted areas are most suitable for preservation, the catchment-level mortality map identifies many opportunities for restoration across the GYE, but far fewer opportunities for preservation. Additionally, the catchment-level forest mortality corresponds to mircoclimate patterns (lower mortality in colder catchments and higher mortality in warmer catchments), thus supporting the assertion that the proliferation of MPB in the subalpine zone of the GYE is climate-warming driven.

### *Precision and accuracy assessment*

Landis and Koch (1977) provide the following kappa ranges for strength of agreement: poor (0.00), slight (>0.00–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–1.00). The observed kappa statistic with linear weighting was 0.86, indicating almost perfect agreement between the MPBM Rating System classifications given by two independent, highly experienced observers to the 465 aerial photos (10% of total photos).

Of the 300 potential on-the-ground classification viewpoints that were identified and mapped, we found that 275 (or 91%) of these were easily accessible and provided an unobstructed view. These viewpoints allowed an effective comparison between mortality classifications based on aerial photos and observed on-the-ground classifications. From our viewpoints, the mortality conditions for 481 catchments (or 10% of the 4862 total LAS-surveyed catchments) were assessed by major mortality level (0, 1, 2, 3, 4, 5) resulting in the on-the-ground classification of roughly 12% of the GYE whitebark pine distribution (Appendix F). Once again the kappa statistic was used to quantify the degree of agreement between the mortality classifications of the aerial photographs compared to the on-the-ground classifications. The observed kappa statistic with linear weighting was 0.82, indicating a high level of agreement between on-the-ground classifications and those based on oblique aerial photos.

## Discussion

### *LAS summary*

The extensive inventory of classified geo-tagged photos, spatial data sets, and mortality maps resulting from the LAS project provided important spatially explicit mortality information for the conservation of this foundation and keystone species. Results from this work have already provided resource managers with a useful tool for planning and implementing conservation strategies, and have provided a baseline of whitebark pine forest condition that can be used as a reference point to evaluate either the recovery or loss of whitebark pine forests following an unprecedented disturbance. LAS is a new approach to assessing MPB impact in whitebark pine forests that addresses limitations to previous methods like the ADS and satellite image analysis.

Similar to LAS, the ADS method utilizes low-level flights to map forest damage. In contrast to ADS, the LAS approach was designed to specifically measure the cumulative ecological impact of MPB on whitebark pine rather than seasonal mortality. As such, the traditional ADS approach is limited to documenting current red trees that result from successful beetle attack just the previous summer, and as a result, an individual year's survey does not represent a cumulative mortality estimate. Also, since not every area is flown every year, it is not possible to estimate cumulative mortality by simply summing year-to-year mortality. Additionally, the LAS approach provides a spatially accurate permanent photographic record of forest condition that can be externally evaluated (Supplement). In contrast, ADS observers use either digital or paper maps, typically 1:100 000-scale, upon which they hand sketch forest damage by drawing points and polygons attributed by damage type, defoliation intensity, or number of dead

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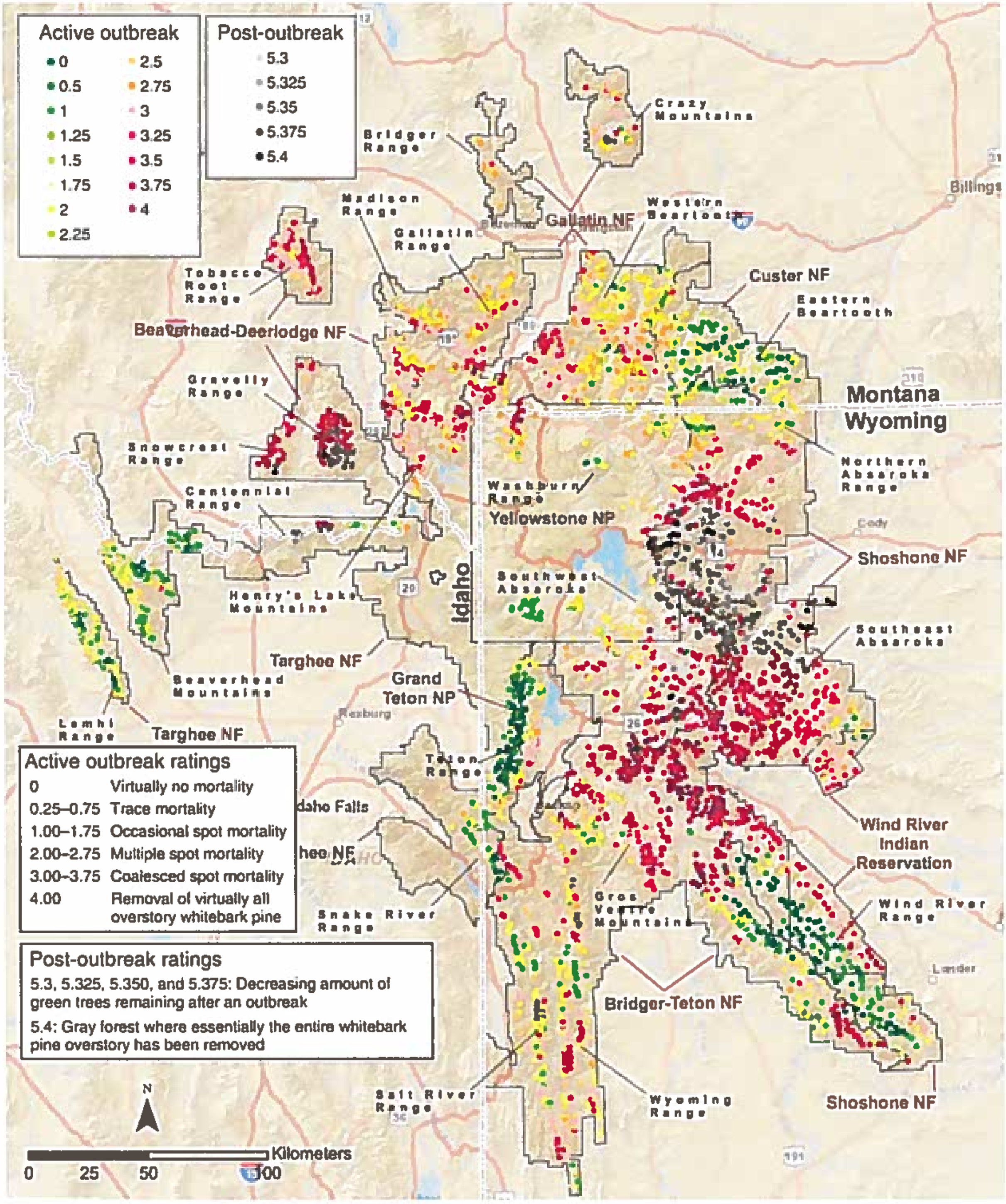


FIG. 5. GYE-wide, point-based, whitebark pine mortality map. The map displays the location and associated rating (0–5.4) with fraction categories (in steps of 0.25) of all project oblique aerial photos ($n = 4653$). Areas of severe mortality, shown as clusters of points with shades of red and gray, indicate outbreak levels of MPB populations. Areas of moderate mortality, shown as clusters of points with shades of orange and yellow, indicate MPB populations that are in the initiating phase of the outbreak cycle. Healthy forests (points with shades of green) were clustered in the Wind River Range, the West slope of the Teton Range, and the Eastern Beartooth Plateau, indicating areas that, at least for the present, remain fully functioning whitebark pine forests. These areas of refuge from MPB outbreaks, at least for the time being, correspond to locations that have colder microclimates.

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**EXHIBIT F**

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

In Response Reply to:
FWS/AES/PM0052

SEP 25 2015

Mr. Virgil Moore, Director
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P.O. Box 25
Boise, Idaho 83707

Mr. Jeff Hagener, Director
Montana Fish, Wildlife & Parks
P.O. Box 200701
Helena, Montana 59620-0701

Mr. Scott Talbot, Director
Wyoming Game and Fish Dept.
5400 Bishop Boulevard
Cheyenne, Wyoming 82006

Dear Directors:

Thank you for your letter dated August 28th regarding our on-going discussions on the potential delisting of the Greater Yellowstone Ecosystem (GYE) grizzly bear population.

As you know, since the date of your letter, we have had two additional meetings on this topic. The first occurred between our respective staff as well as staff from the National Park Service (NPS), U.S. Forest Service (USFS) and U.S. Geological Survey (USGS) on September 9 and 10. The second was the meeting that the four of us had, along with both NPS and USFS, at the Association of Fish and Wildlife Agencies (AFWA) annual meeting on September 14. Based on those two meetings, I believe we have a mutually understood process that will allow the Service to proceed with a proposed delisting proposal as follows:

- We have agreed to manage to at least within the confidence intervals associated with the long term average grizzly bear population within the GYE. The long term average population is calculated from 2002 to 2014[1].
- We have agreed that Chao2 represents the best available science for determining allowable mortality in order to manage for the long-term average population.
- We have agreed to a revised Demographic Monitoring Area (DMA) of 19,279 square miles. This will be the area in which mortality will be managed. Outside of the DMA, mortalities will not be applied to mortality levels outlined below.

[1] The model averaged Chao2 estimate from 2002 to 2014 is 674 bears with a 95% confidence interval of 600 to 747.

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- We have agreed to a revised Demographic Monitoring Area (DMA) of 19,279 square miles. This will be the area in which mortality will be managed. Outside of the DMA, mortalities will not be applied to mortality levels outlined below.

- We have agreed to the following mortality limits for females and males based on the annual results of the model-averaged Chao2 population estimate:

    - Below 600: no discretionary mortality would be allowed unless necessary to address human safety issues
    - Between 600-673: mortality limits will be less than 7.6% for adult females and 15% for adult males
    - At 674: mortality limits will be 7.6% for adult females and 15% for adult males
    - Between 675-747: mortality limits will not exceed 9% for adult females and 20% for adult males
    - Greater than 747: mortality limits will not exceed 10% for adult females and 22% for adult males

- We have established a timeline and associated action items (to include review and agreement by all parties) to both the Recovery Criteria and the Conservation Strategy that we believe will allow us to publish a proposed delisting rule prior to the end of 2015.

- States have agreed to consider additional regulatory mechanisms that will be part of individual state management plans/regulations and referenced in the rule that will implement the Conservation Strategy. We look forward to continuing to work with you on this issue.

- States have agreed to meet annually with the federal land management agencies to discuss managed mortality in and around federal lands.

Like you, we believe that the recovery of the GYE grizzly bear population represents a tremendous conservation success story based on more than 30 years of collaboration between state and federal partners. We look forward to continuing to work with you on this great achievement.

Sincerely,

DIRECTOR

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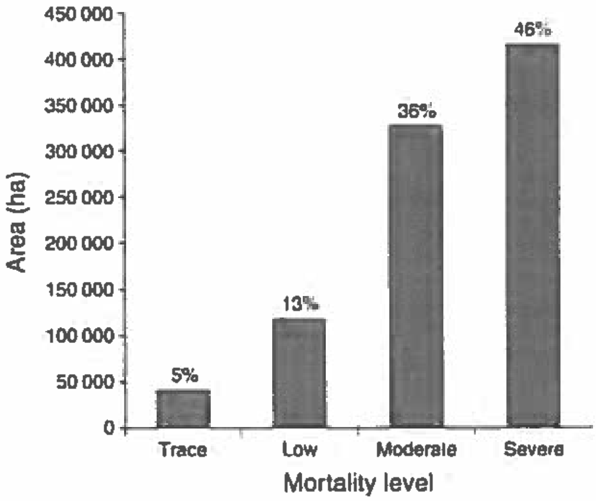


FIG. 6. Area calculations for small-catchment-level mortality ($n$ = 894 774 ha total). Mortality ratings are grouped into major mortality levels: trace level of mortality (0–0.75), low mortality (1–1.75), moderate mortality (2–2.75), and severe mortality (3–4 and 5.3–5.4). The percentage of the total for each level is shown above the bars.

trees (McConnell et al. 2000). There is no convenient way for an independent observer to evaluate mortality classification from these maps. Moreover, ADS provides little information regarding what the residual stands "look like" following an outbreak; so even in areas where annual mortality levels have been recorded, it is difficult to determine the amount of live overstory whitebark pine remaining to assess recovery potential (Schwandt and Kegley 2008). Notwithstanding the limitations of annual ADS data, the method provided useful information on mortality trends that generally corroborated our LAS data.

Many remote-sensing studies have focused on detecting the red-attack stage of MPB outbreaks using satellite imagery with resolutions ranging from medium to very fine (Wulder et al. 2006*a*). Franklin et al. (2003), Skakun et al. (2003), and Wulder et al. (2006*b*) used Landsat imagery (30-m resolution) to achieve red-attack detection accuracies of 67–78%. Coops et al. (2006), White et al. (2005), Hicke and Logan (2009), and Wulder et al. (2008) used high-resolution imagery (2–4 m) and reported red-attack detection accuracies of 71–93%, while Meddens et al. (2011) reported that even finer resolution does not necessarily lead to better detection accuracy and found that 2.4-m resolution imagery provided the most accurate detection in lodgepole pine forests. The high classification accuracies make high-resolution satellite imagery a promising tool for assessing MPB-caused forest mortality. However, at the present time, non-archive high-resolution satellite imagery is cost prohibitive for large landscapes such as the GYE.

The high cost of acquiring current high-resolution imagery has made Landsat-based approaches the standard for GYE-wide mortality assessments. In 2008, the Remote Sensing Application Center (RSAC) used Landsat satellite imagery to detect canopy change in all conifer forests, using scenes from 2000, 2007, and 2008 across ~90% of the GYE (Goetz at el. 2009). Results indicate that 79% of the whitebark pine zone in the GYE showed some level of canopy change, and 27% showed "moderate" or "high" canopy change. This canopy change assessment did not provide information specific to mortality levels (i.e., amount dead or alive); rather it showed canopy change that was assumed to be related to mortality. While providing useful information, this satellite image analysis has inherent limitations. The 30-m Landsat resolution was too coarse to discern individual whitebark pine crowns or small clusters of affected trees and gray-attack detection was not possible. As discussed in the second paragraph of the *Discussion*, information on gray-attack locations can be important for assessing cumulative mortality, success of conservation efforts, and calculating MPB spread (Wulder et al. 2006*a*). At the present time, only expensive fine-resolution (0.5–2.4 m) multispectral imagery can detect the gray stage of forest mortality (Dennison et al. 2010, Meddens et al. 2011).

LAS, of course, has its own limitations, most notably the time and expense of training observers to categorize outbreak levels from photography, the labor-intensive step of orienting photos to look-at points, and the subjective nature of manually classifying MPB-caused mortality. Despite the respective identified limitations of the LAS, ADS, and satellite image analysis approaches, each method provides useful complementary information, and when used in aggregate, these methods can provide a more complete picture of whitebark pine decline in the GYE and connections with climate drivers. For example, Jewett et al. (2011) used a time series of nine images from 1999–2008 of Landsat satellite imagery to monitor whitebark pine mortality in the core of the GYE. Mortality patterns were analyzed with respect to monthly climate variations over the nine-year period. Historical high-resolution imagery available on Google Earth was used to confirm a relationship between visible red-attack whitebark pine stands and negative Landsat-derived "enhanced wetness difference index" (EWDI) values. Their results support our findings and indicate that drier and warmer climates are correlated with increased whitebark pine mortality, potentially due to increased mountain pine beetle activity.

### *Outbreak patterns: potential refugia*

Of the 22 major mountain ranges in the GYE, our results identified some that were less impacted than others. We hypothesize that these less impacted mountain ranges may be more resistant to climate change than others, and therefore, may be more likely to avoid MPB impacts for the near future. The two areas most likely to provide effective refugia for whitebark pine are the

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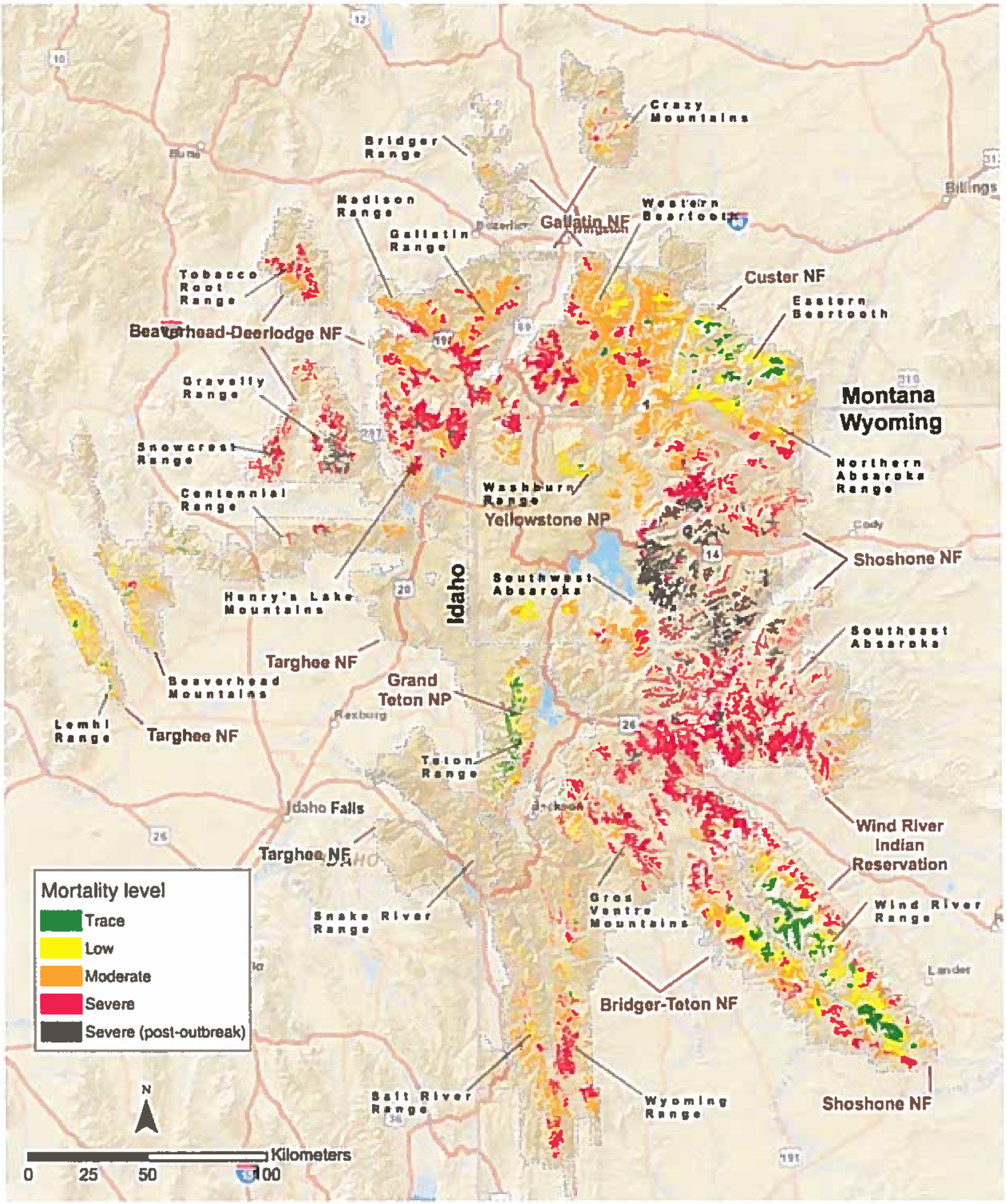


FIG. 7. GYE-wide whitebark pine distribution catchment-level mortality map. The map displays mortality ratings of all 4862 catchments (3185, or 79% by area, were photo-inventoried, and the remaining 1677, or 21%, were interpolated). Mortality ratings are grouped into major mortality levels: trace level of mortality (0–0.75, green), low mortality (1–1.75, yellow), moderate mortality (2–2.75, orange), severe mortality (3–4, red), and severe post-outbreak (5.3–5.4, gray). Catchments with severe ongoing and severe post-outbreak mortality levels dominate the map, indicating widespread decline and collapse of this foundation and keystone species in these areas.

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central core of the Wind River Range in Wyoming and the Beartooth Plateau in Montana.

The Wind River Range's resistance to climate warming may result from being the highest mountain range in the GYE and having one of the most complex glacial systems in the contiguous U.S. Rocky Mountains (Holmes and Moss 1955). The moderating influence of high-mountains, permanent snow and ice may have resulted in a local climate that remains too harsh for development of outbreak MPB populations. However, this moderating influence may be short lived because glaciers in the Wind Rivers, like in Glacier National Park, are shrinking at a historically unprecedented rate. Thompson (2009) found a 42% decrease in the volume of glaciers in the Wind River Range between 1966 and 2006. Once the remaining permanent snow and ice is lost from these glaciers, we anticipate increased likelihood of a threshold event that will dramatically improve thermal habitat for MPB, and a concurrent increased outbreak potential.

The Beartooth Plateau is perhaps an even more promising refuge than the Wind River Range. The Beartooth Plateau is the largest contiguous area above 3000 m in the U.S. Rocky Mountains (Turiano 2003). This large, high plateau is extremely cold, with particularly long winters (Locke 1989). The combination of high elevation, cold temperature, and a short growing season has resulted in a vast expanse of dwarf/Krummholz whitebark pine forests. The long-term survival of the species likely resides in the Krummholtz growth form found throughout the ecosystem near tree line, because it is too small for beetles to attack, and because, over time, it is capable of assuming an upright growth form under more moderate climate conditions. Nevertheless, even these krummholz tree islands are susceptible to white pine blister rust and are already being impacted by this introduced pathogen (Resler and Tomback 2008).

### *Outbreak patterns: distribution across the landscape*

LAS aerial photos consistently captured two different microclimate-driven patterns of MPB-caused mortality: (1) Higher intensity outbreaks tended to occur on the southern aspects (warmer and drier aspects) when compared to nearby northern aspects (colder and wetter aspects), and (2) mid-slope rather than lower-slope whitebark pine habitats were the first to become vulnerable to MPB.

The aspect-related mortality pattern is intuitive and suggests that the warmer microclimate on southern slopes allows the beetles to thrive in these sites first before spreading to cooler northern aspects (Logan et al. 2010). This mortality pattern is also apparent in areas where the outbreak cycle was further progressed, where southern-aspect red trees have already faded to gray and northern-aspect green trees have just turned red (Appendix G).

Conversely, the mid-slope mortality pattern (Appendix H) is counterintuitive because the MPB outbreak in whitebark pine is primarily driven by a warming climate and elevation lapse-rate models would predict that the lowest elevation habitat should be the first to become warm enough to support outbreak populations. We hypothesize that cold air pooling from temperature inversions, typical winter weather in these high mountain valleys, combined with lack of summer heat at the higher elevations are responsible for this counterintuitive phenomenon. The net effect is high winter MPB mortality in the cold valleys and insufficient thermal energy to complete an entire life cycle in one year at higher elevations. Further research could test this hypothesis and place results within a meaningful management context, such as identifying areas on the landscape that serve an "early-warning" function for impending outbreaks.

## Conclusions

Results from our work indicate that the scope and severity of the current MPB outbreak in GYE whitebark pine are far beyond the episodic events of the historical past. The levels of ecosystem-wide forest mortality we found are more intensive and widespread than expected through model prediction (see footnote 7) or previously documented by ADS. We conclude that the LAS methodology we have developed adds a new dimension to evaluating the impact of increased MPB activity in whitebark pine. This technology has the potential for evaluating MPB activity in other whitebark pine habitats, as well as being more generally applicable for evaluating other ecological disturbances.

The documented mortality is alarming for a number of reasons. First, there are no signs that the climate change-induced conditions that have allowed the MPB to flourish will abate any time soon. It therefore appears likely that whitebark pine mortality will continue until the species has largely been removed from the GYE (U.S. Fish and Wildlife Service 2011). Second, indicators of the future health of the species, primarily seed production, recruitment, and regeneration, are being greatly reduced by the combined and synergistic effects of white pine blister rust and MPBs. Third, because whitebark pine is an exceptionally slow-growing species, and cone crops are not generally produced until 80 to 120 years of age (McCaughey and Tomback 2001), even under the best case scenario, the recovery of the species will likely take several centuries. Finally, future recovery of the species is in jeopardy because whitebark pine largely depends upon the Clark's Nutcracker for seed dispersal, whereas the Clark's Nutcracker, a facultative mutualist, will abandon subalpine forests during periods of cone shortages (McKinney et al. 2009); therefore, heavily impacted forests could be left with little means to regenerate. These results indicate a greater impact than previously was generally recognized or appreciated

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(Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee 2011; see footnote 6).

Resource managers are concerned and are beginning to respond to the whitebark pine crisis. A whitebark pine conservation strategy that includes preservation and restoration options, utilizing data from this project, has been developed (Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee 2011; see footnote 6). Forest treatment proposals also are being formulated and implemented. We have two general concerns about the impending management responses: (1) The rapid, climate change-induced, alteration of high-elevation ecosystems is not being considered sufficiently under the current adaptive management strategies, and (2) almost everything we know about managing MPBs comes from experience in lodgepole pine forests, and the ecological functionality of MPB in whitebark pine is radically different from that in lodgepole pine.

Our results support an urgent need for more research and an improved interplay between research and management. A prospective, rather than reactive, management view is needed in order to respond to the climate change-driven collapse of the whitebark pine ecosystem. In addition, managers must recognize that responses that make sense in lodgepole pine forests may be ineffective, or even counterproductive and detrimental, in whitebark pine forests.

Raising the plight of this important ecosystem in the public consciousness has been an important contribution of our work. Whitebark pine loss in the GYE has not received the attention of the general public largely because it is not a commercial species, due to a lack of timber value, and because of the habitats it occupies, which typically are among the highest, most rugged, and most remote habitats on the continent. It is below the public's radar screen simply because most people do not venture into these places. Of the >.5 million visitors to Yellowstone National Park in 2010, only 6902 backcountry permits (required for backcountry camping) were issued, involving 20 105 visitors, or ~0.5% of all visitors. Though this number does not tell us the exact number of people who venture into Yellowstone's whitebark pine habitat each year, it gives us some indication of the proportion of visitors who explore the more remote regions where the park's whitebark pine is located. Even for those visitors that do experience whitebark pine forests, few may recognize the reasons behind the devastation. Many visitors mistakenly assume fire to be the culprit, due to the immense and long-lasting public education program revolving around the 1988 fires. When compared to the 1988 fires, the area severely impacted by MPB in whitebark pine (~416 000 ha) already nearly equals the total area that was impacted by the 1988 Yellowstone fires (445 000 ha) ecosystem wide. Additionally, much of the 1988 fires burned in lodgepole pine forests that are supremely adapted to large-scale fire disturbance. The ecological impact of MPB in whitebark is a vastly different phenomenon that has the potential for regime shift in a sensitive and important ecosystem (Logan et al. 2010). Information provided by our LAS work highlights these massive impacts, potentially keeping whitebark pine forests from becoming another of the "places that no one knew," and perhaps even more optimistically, spurring action to formulate a truly strategic, systems-level management response.

## Acknowledgments

We thank the GYCC Whitebark Pine Subcommittee, USDA Forest Service Forest Health Protection, and the Natural Resources Defense Council (NRDC) for generous support. We thank Bruce Gordon of Eco-Flight for piloting the overflights; Adam Clark, Paul Petersen, and Jerry Hughes of GEO/Graphics, for GIS support; Dena Adler and Colin Peacock for assisting in data collection; Louisa Willcox, Nancy Bockino, Liz Davy, and Steve Munson for their support throughout the project; and the Utah State University, Watershed Sciences Department for providing support during the revision process. Reviewer comments from Whitney Leonard and two anonymous reviewers significantly improved a previous version of the manuscript; however, any errors in fact or interpretation remain our own.

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## Supplemental Material

### Appendix A

Figure showing Greater Yellowstone Ecosystem (GYE) whitebark pine distribution contained in either national parks or designated wilderness (*Ecological Archives* A023-021-A1).

### Appendix B

Figure showing 2009 LAS flight lines (*Ecological Archives* A023-021-A2).

### Appendix C

Figure delineating catchment boundary within mountainous region of the GYE (*Ecological Archives* A023-021-A3).

### Appendix D

Mountain pine beetle-caused mortality rating system (*Ecological Archives* A023-021-A4).

### Appendix E

GYE-wide whitebark pine catchment map (*Ecological Archives* A023-021-A5).

### Appendix F

Figure showing whitebark pine mortality ground verification (*Ecological Archives* A023-021-A6).

### Appendix G

Figure showing aspect-related mortality pattern (*Ecological Archives* A023-021-A7).

### Appendix H

Figure showing mid-slope mortality pattern (*Ecological Archives* A023-021-A8).

### Supplement

Google Earth file (.kml) containing a "pop-up" aerial oblique image and numeric (0–5.4) mortality rating based on the mountain pine beetle mortality (MPBM) rating system for all "look-at points" used and referenced in this study (see Fig. 5 in main text) (*Ecological Archives* A023-021-S1).

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X-2

**Chris Servheen**

**From:** Chris Servheen
**Sent:** Friday, March 09, 2012 1:25 PM
**To:** mark_haroldson@usgs.gov; Mark Bruscino; Steve_Cain@nps.gov; Kerry_Gunther@nps.gov; dtyers@fs.fed.us; Frey, Kevin; bryan.aber@idfg.idaho.gov; 'daryl.meints@idfg.idaho.gov'
**Subject:** FW: 3 options for consideration

Guys,
I had a conference call with the IGBC leadership (Harv Forsgren and Scott Talbot) and briefed them on our discussions over the past few days. I requested that IGBC have a conference call to discuss the 3 options we reviewed and our recommendation for option #2. They agreed and wanted a summary of these for circulation to IGBC members so they were up to speed before the call. Here is what I sent Ellen Davis who will send this to the IGBC members. I wanted you to be aware of this as I am sure each of you will be asked by your IGBC members to explain more about this.
Chris

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"If there are no dogs in heaven, then when I die I want to go where they went." - Will Rogers

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**From:** Chris Servheen
**Sent:** Friday, March 09, 2012 1:16 PM
**To:** 'Davis, Ellen -FS'
**Subject:** 3 options for consideration

Ellen,
Here are the 3 options for consideration on the IGBC conference call: Please stress to IGBC members that this discussion document is NOT to be shared with others outside of IGBC. It is an IGBC-only discussion document.

We had a meeting over the past 2 days of the Yellowstone agency science team partners. After extensive discussion on what we now know, I proposed that we have 3 options on how to move forward on a possible new proposed delisting rule for the Yellowstone ecosystem given the 9th circuit decision on WBP:

1) Move forward now to write a new proposed rule with the information we currently have on declines in WBP and the stabilization of the grizzly population in the 2002-2011 time period.
**Pros:** We could maintain the Conservation Strategy commitment by the partner agencies while waiting for the process to proceed with hopes of legal success.
**Cons:** Low probability of legal success. Loosing again on delisting would doom the interagency partnership.



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2) Wait 18-24 months to write a new proposed rule and in the interim time period develop a comprehensive synthesis of all the existing data on the relationship between Yellowstone grizzly bear dynamics and health, and changes in WBP and other foods. Use this synthesis to inform the decision on a new proposed rule and the quality and scientific depth of a new proposed rule. If a new proposed rule was indicated, it would be published in late 2013 or early 2014.
   **Pros:** This approach would improve the new proposed rule and certainly improve the probability of legal success. We could maintain the Conservation Strategy commitment by the partner agencies while waiting for the process to proceed with hopes of legal success.
   **Cons:** Increased fragility of the patience of the partner agencies and the public with a delay. There is a possibility that the results would indicate grizzly population decline which could make a new proposed rule unlikely.
3) Abandon any hope of delisting due to the uncertainty of the legal system. Mange the population as listed with maximum management flexibility. There would be little concern about maintaining mortality limits since there was no chance of delisting anyway.
   **Pros:** No investment in the process of a new proposed rule and the resulting legal complications. Emphasis would shift to the NCDE delisting process.
   **Cons;** The interagency partnership implementing the Conservation Strategy would dissolve. The Conservation Strategy would be abandoned by the USFS and NPS as it specifically says that its implementation is tiered to delisted status. The result of the abandonment of the Conservation Strategy would be a serious erosion of grizzly habitat and mortality management because there would no longer be limits on new road development, new site development, and new livestock allotments. Such actions would again be allowed on public lands and only subject to Section 7. Since no individual development would jeopardize the population, all such developments would be allowed and habitat quality would decline. Mortalities would increase since the reason mortalities are limited now is to adhere to the Conservation Strategy demographic criteria. The interagency partnership built to maintain a recovered population would very likely dissolve.

We discussed these alternatives at length and the end result was that the science team partners of all Yellowstone management agencies were united in recommending alternative #2. USGS agreed to lead production of this synthesis document in #2.

Chris

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http://www.fws.gov/whitenosesyndrome/

"If there are no dogs in heaven, then when I die I want to go where they went." - Will Rogers



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Comments CS

# GRIZZLY BEARS AND WHITEBARK PINE IN THE GREATER YELLOWSTONE ECOSYSTEM

## PROJECT OUTLINE

## INTERAGENCY GRIZZLY BEAR STUDY TEAM

1) **Whitebark Pine Ecology**
   a. **Whitebark pine status and trends in the GYE**
      *i.* Leads: Kristin Legg (NPS-IM), Kathy Irvine (USGS-NOROCK), Dan Tyres (USFS).
      *ii.* Status and timeline: in progress, ms. submission by 1 Mar 2013.
      *iii.* Funding: IM project funded through FY12; additional funding desired for USFS project Beartooth Mtns. ($15,000 for 2012 WBP transects data collection and completion of analysis and write-up for 1990-2012 or $7,500 only for analysis and write-up of 1990-2011 data). ✓Check fully funded FWS
      *iv.* Products: peer-reviewed paper(s).
   b. **Future status of whitebark pine (literature review focused on rust resistance, MPB trend predictions, climate change)**
      *i.* Lead: Mahalovich (USFS). Sulfur isotopes Also?
      *ii.* Status and timeline: August 2013 ?
      *iii.* Funding: need unknown re: Cluch?
      *iv.* Products: chapter for synthesis document
   c. **Brown bear diets and stone pines (literature review)**
      *i.* Lead: Gunther (with Cain, van Manen) John Molloy w/assistance Maybe John
      *ii.* Status and timeline: August 2013
      *iii.* Funding: not required
      *iv.* Products: chapter for synthesis document
2) **Ecological plasticity of grizzly bears in the Greater Yellowstone Ecosystem**
   a. **Diet, resource use, home ranges, and body condition**
      ***i. Grizzly bear diets in the GYE: alternative foods in a temporally and spatially variable landscape.***
         1. Lead: Schwartz (with Podruzny, others?)
         2. Status and timeline: 1 manuscript submitted (Fortin et al.), 1 manuscript in progress (Podruzny et al.) carcass use
         3. Funding: additional funding for Schwartz we will pay

in areas in $N_2$ over time

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4. Products: Diet items from isotope manuscript in progress. Food items use from site visits, 1 manuscript submitted (Fortin et al.), 1 manuscript in progress (Podruzny et al.)

ii. ***Grizzly bear use of large ungulates identified from GPS location clusters: trends related to ungulate numbers, wolves, and whitebark pine decline***

1. Lead: Ebinger (with Haroldson, van Manen, P.J. White? Gunther, and D. Smith?)
2. Status and timeline: in progress, ms. submission by 1 Mar 2013
3. Funding: additional funding for Ebinger
4. Product: peer-reviewed paper

iii. ***Grizzly bear use of whitebark pine stands and trends in the face of whitebark pine decline (discrete choice analysis)***

1. Lead: van Manen (with Ebinger, Haroldson)
2. Status and timeline: in progress, ms. submission by 1 Mar 2013
3. Funding: additional funding for Ebinger
4. Product: peer-reviewed paper

iv. ***Indices of grizzly bear home-range size in the GYE: patterns and trends related to variable foods and population increases***

1. Lead: Bjornlie (with Haroldson, Thompson, van Manen)
2. Status and timeline: in progress, ms submission by 1 March 2013
3. Funding: not required
4. Product: peer reviewed paper

v. ***Grizzly bear body condition (% fat) in a changing landscape: Are grizzly bears in the GYE getting what they need in the face of increasing bear densities and changing food resources?***

1. Lead: Haroldson (with van Manen, Bjornlie, Thompson)
2. Status and timeline: in progress, ms submission by 1 March 2013
3. Funding: not required
4. Product: peer reviewed paper

***b.*** **Population Demographics**



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i. ***Recent trends in grizzly bear vital rates and population growth in the GYE: can we distinguish density versus whitebark pine effects?***
   1. Lead: van Manen (with Haroldson, Bjornlie, Thompson, G. White)
   2. Status and timeline: in progress, ms. submission by 1 Mar 2013
   3. Funding: additional funding for G. White.
   4. Product: peer-reviewed paper(s)

ii. ***Predictors of fall mortalities: what drives numbers of fall grizzly bear mortalities in the GYE (population size, range expansion, whitebark pine cone abundance, other factors, or combination of these factors)?***
   1. Lead: Haroldson (with van Manen, Higgs)
   2. Status and timeline: in progress, ms. submission by 1 Mar 2013
   3. Funding: additional funding for Higgs.
   4. Product: peer-reviewed paper(s)

3) **Synthesis Analysis and Final Report**
   a. **Lead: van Manen (with entire IGBST)**
   b. **Timeline: Start 1 March 2013; completion 31 October 2013**
   c. **Final report to FWS**
   d. **Preliminary report outline**
      i. ***Executive Summary***
      ii. ***Introduction***
      iii. ***Whitebark pine in the GYE***
         1. ***Whitebark pine ecology***
         2. ***Whitebark pine status and trend***
         3. ***Future of whitebark pine in the GYE***
      iv. ***Grizzly bears and whitebark pine decline in the GYE: synthesis of research findings***
         1. ***Individual level***
         2. ***Population level***



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v. ***Management Implications***

vi. ***Conclusions***

**Other items from 'WBP strawman':**

-Density dependence and WBP (?): *Note: to be addressed in discussion of Synthesis Report*

-Contrast GYE with other ecosystems (?) *Note: could be addressed in synthesis report*

Density regulation effects including what happens with high population density and high densities of males and how this would change population structure and survival by age class.

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*Research Article*

# Density Dependence, Whitebark Pine, and Vital Rates of Grizzly Bears

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**ABSTRACT** Understanding factors influencing changes in population trajectory is important for effective wildlife management, particularly for populations of conservation concern. Annual population growth of the grizzly bear (*Ursus arctos*) population in the Greater Yellowstone Ecosystem, USA has slowed from 4.2–7.6% during 1983–2001 to 0.3–2.2% during 2002–2011. Substantial changes in availability of a key food source and bear population density have occurred. Whitebark pine (*Pinus albicaulis*), the seeds of which are a valuable but variable fall food for grizzly bears, has experienced substantial mortality primarily due to a mountain pine beetle (*Dendroctonus ponderosae*) outbreak that started in the early 2000s. Positive growth rates of grizzly bears have resulted in populations reaching high densities in some areas and have contributed to continued range expansion. We tested research hypotheses to examine if changes in vital rates detected during the past decade were more associated with whitebark pine decline or, alternatively, increasing grizzly bear density. We focused our assessment on known-fate data to estimate survival of cubs-of-the-year (cubs), yearlings, and independent bears (≥2 yrs), and reproductive transition of females from having no offspring to having cubs. We used spatially and temporally explicit indices for grizzly bear density and whitebark pine mortality as individual covariates. Models indicated moderate support for an increase in survival of independent male bears over 1983–2012, whereas independent female survival did not change. Cub survival, yearling survival, and reproductive transition from no offspring to cubs all changed during the 30-year study period, with lower rates evident during the last 10–15 years. Cub survival and reproductive transition were negatively associated with an index of grizzly bear density, indicating greater declines where bear densities were higher. Our analyses did not support a similar relationship for the index of whitebark pine mortality. The results of our study support the interpretation that slowing of population growth during the last decade was associated more with increasing grizzly bear density than the decline in whitebark pine. Grizzly bear density and its potential effect on vital rates and population trajectory warrant consideration for management of the grizzly bear population in the Greater Yellowstone Ecosystem. Published 2015. This article is a U.S. Government work and is in the public domain in the USA.

**KEY WORDS** demographic change, density dependence, Greater Yellowstone Ecosystem, grizzly bear, *Ursus arctos*, vital rates, whitebark pine decline.

The trajectory of a wildlife population is the collective manifestation of vital rates (e.g., survival and fecundity), which are broadly governed by the life-history characteristics of a species (Cole 1954). Changes in the population trajectory are a direct consequence of variation in age-specific vital rates, which, in turn, are influenced by a combination of ecological processes (Caughley 1977). Given sufficient time, population growth progresses most wildlife populations toward a relatively steady density through the interaction between population processes and available resources, with environmental variation superimposing random fluctuations over time (Caughley and Sinclair 1994:54). Populations are ultimately limited by availability or access to non-consumable (e.g., space, nest sites) or consumable resources (Caughley and Sinclair

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1994). Understanding these relationships and how they influence the population trajectory can be insightful for wildlife managers and has important implications for mortality management. An informed management response to a reduction in population growth would be different if a change in trajectory was caused primarily by a decline in food resources versus a population experiencing density-dependent effects indicative of a population reaching carrying capacity.

Concepts related to population limitation and regulation have garnered particular interest from brown bear (*Ursus arctos*) managers as bear densities have increased in several recovering populations in Europe and the continental United States over the past 3 decades (Schwartz et al. 2006*d*, Kindberg et al. 2011, Mace et al. 2012, Chapron et al. 2014). McLellan (1994) suggested that food availability is likely the ultimate factor limiting brown bear populations but argued that this is a function of social behavior influencing access to food resources and level of energy expenditure in most instances, rather than a limitation of food biomass itself. Similarly, Miller et al. (2003) indicated that differences in body mass among Alaskan brown bear populations were most parsimoniously explained by each population's proximity to carrying capacity rather than differences in their habitat quality. Zedrosser et al. (2006) reported that body size of adult female brown bears was positively associated with abundance and availability of food, but that it may be constrained by competition for food at greater population densities. Density may influence vital rates directly through mechanisms such as infanticide by adult males (Swenson et al. 1997, Wielgus and Bunnell 2000). Miller et al. (2003) suggested that variation in cub survival and litter size was mostly influenced by proximity to carrying capacity, with some additional influence from environmental variation and stochastic events.

When a population is nearing carrying capacity, regulatory mechanisms are expected to affect vital rates and population growth. When that same population also experiences a change in abundance of food resources, it is difficult to isolate which factors may be affecting population growth most. However, when individual-level data on resource loss and population density are available, the relative strength of association with changing vital rates would be indicative of factors that may be acting more strongly on a particular population. Such studies require substantial, longitudinal datasets. Recent changes in the population trajectory of the grizzly bear population in the Greater Yellowstone Ecosystem (GYE) provided a unique opportunity to investigate these relationships. During 1983–2001, the estimated annual rate of population growth (λ) was between 4.2% and 7.6% (Harris et al. 2006) but declined to between 0.3% and 2.2% based on 2002–2011 data (Interagency Grizzly Bear Study Team [IGBST] 2012:34). Independent from these population projections, annual estimated numbers of unique females with cubs-of-the-year (cubs; Knight et al. 1995, Keating et al. 2002) corroborated a change in the population trajectory. Change-point analyses indicated this likely occurred around 2001 (M. Higgs, Montana State University, unpublished data).

One hypothesis for the slowing of population growth is based on substantial decline of an annually variable, high-calorie fall food source for grizzly bears, seeds of whitebark pine (*Pinus albicaulis*). Previous studies have reported associations between annual whitebark pine cone production and survival of independent bears (Haroldson et al. 2006), fecundity (no. F cubs/breeding-age F/yr; Schwartz et al. 2006*a*), movements (Blanchard and Knight 1991), and frequency of management actions (Mattson et al. 1992, Blanchard and Knight 1995, Gunther et al. 2004). Starting in the early 2000s, whitebark pine experienced widespread mortality primarily from mountain pine beetle (*Dendroctonus ponderosae*) infestations and, to a lesser degree, from fire and white pine blister rust (*Cronartium ribicola*) infection (Gibson 2007). Based on monitoring transects established in the GYE as part of the Interagency Whitebark Pine Monitoring Program, an estimated 27% (95% CI = 18–36%) of whitebark pine trees >1.4 m tall (all age classes) died during 2008–2013 (Greater Yellowstone Whitebark Pine Monitoring Working Group 2014). Observed cumulative mortality was 37% for trees >10 cm and ≤30 cm diameter at breast height (DBH) and 72% for trees >30 cm DBH. By 2013, 72% of 176 monitored transects had evidence of beetle infestation (Greater Yellowstone Whitebark Pine Monitoring Working Group 2014). On transects monitored annually for whitebark pine cone production (Blanchard 1990), 75% of 190 mature, cone-bearing sample trees died between 2002 and 2014, with most mortality occurring prior to 2010 (Haroldson 2014).

Given that the grizzly bear population in the GYE experienced robust growth from the early 1980s through late 1990s, an alternative hypothesis for slowing population growth among grizzly bears in the GYE is that population density factors may be affecting vital rates. Eberhardt (1977, 2002), for example, hypothesized that population regulation in long-lived vertebrates is largely a function of density-dependent survival among younger age classes (i.e., cub and yearling survival for grizzly bears), which may be followed by changes in reproductive rates and, finally, adult survival.

There is substantial spatial heterogeneity within the GYE with respect to whitebark pine mortality and grizzly bear density (Bjornlie et al. 2014*b*). Therefore, we sought to obtain inference regarding how spatial and temporal variation in whitebark pine decline and grizzly bear density were associated with grizzly bear survival and reproductive parameters. If resource effects from whitebark pine mortality were more influential, we hypothesized that a decline in these vital rates would be greatest among those bears that resided in areas where mortality of whitebark pine was high. Alternatively, if population density effects were more influential, we predicted that vital rates would decrease as relative density of grizzly bears increased spatially and temporally among individuals.

## STUDY AREA

Our study area comprised occupied grizzly bear range in the GYE (50,280 km$^2$ by 2010; Bjornlie et al. 2014*a*) and included Yellowstone National Park, Grand Teton National

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Park, portions of 5 adjacent national forests, and state and private lands in Montana, Wyoming, and Idaho. The GYE consists of a high-elevation plateau surrounded by 14 mountain ranges with elevations >2,130 m, and contains the headwaters of 3 continental-scale rivers. Summers are short and most average annual precipitation (50.8 cm) falls as snow. Vegetation transitions from low-elevation grasslands through conifer forests at mid-elevations, reaching alpine tundra around 2,900 m. Within occupied grizzly bear range, the area of mapped whitebark pine is approximately 7,090 $km^2$ (14%; Landenburger et al. 2008) within a narrow elevation range of 2,500–3,060 m (Mahalovich 2013). Detailed descriptions of the geography, climate, and vegetation appear in Mattson et al. (1991) and Schwartz et al. (2006*c*).

## METHODS

### Capture and Handling

We used similar procedures for collection and analysis of demographic data as documented by Schwartz et al. (2006*d*) but extended the dataset from 1983–2001 to 1983–2012. We used culvert (i.e., box traps) or Aldrich leg-hold snares to capture bears (Blanchard 1985). Since 1997, bear capture and handling procedures were reviewed and approved by the Animal Care and Use Committee of the United States Geological Survey; procedures conformed to the Animal Welfare Act, and to United States government principles for use and care of vertebrate animals in testing, research, and training. Grizzly bear captures were conducted under United States Fish and Wildlife Service Endangered Species Permit (Section [i] C and D of the grizzly bear 4[d] rule, 50 CFR17.40 [b]) and additional research permits for the national park units and 3 states. We livecaptured bears in frontcountry (road access) and backcountry (no road access) settings within and outside national parks and wilderness areas. Except for dependent offspring, we fitted captured grizzly bears with radio transmitters (very high frequency [VHF] or global positioning system [GPS]; Telonics, Inc., Mesa, AZ). Adults were radiocollared, whereas independent subadults were instrumented with expandable collars, collars with programmable releases, glue-on transmitters, or ear transmitters. When we fitted radio collars on bears, we used a biodegradable canvas spacer to ensure collar drop. All transmitters were equipped with a motion sensor that reduced pulse rate if stationary for 4–5 hours, allowing for detection of mortalities and shed collars.

### Analyses

Key determinants of bear population dynamics are survival of adult females, cubs, and yearlings, and reproductive output. Therefore, we examined the following parameters to test our hypotheses: 1) independent bear survival (≥2 years old; known-fate model), 2) cub and yearling survival (nest survival model for daily survival), and 3) reproductive transition probability of females (multi-state live-encounter model of transition from no offspring to cubs).

*Independent survival.*—We typically began telemetry monitoring of independent bears in early April and concluded in late November but did not routinely monitor bears intensively during the denning season. We conducted telemetry flights every 7–14 days to determine bear status (i.e., alive, dead). Upon receiving a stationary mortality signal, we investigated potential bear mortalities within 2 weeks. We classified fates as unresolved in those instances where no collar or carcass was found, or certainty of the individual's fate was unknown.

We estimated survival of independent bears by following the known-fate procedures of Haroldson et al. (2006) in Program MARK (White and Burnham 1999). We coded bears as either alive, dead, or censored each month. An individual's encounter history began the month and year it was first captured and concluded the month and year it was censored or died. During the active season (Apr–Nov), we considered a bear alive during a gap in telemetry data if we knew it was alive before and after the data gap. If the gap exceeded 60 days during the active season, we censored bears for the appropriate months. We classified bears as alive during the denning months if they were alive the previous October or November and they emerged from dens wearing a functional radio collar. We censored bears with unknown fates (Haroldson et al. 2006). We used the results of Schwartz et al. (2010) to develop a base model to estimate survival of independent-aged bears and included capture status (research or management [conflict] bear), sex, quadratic function of age (age + $age^2$), proportion of locations in secure habitat (areas ≥4.05 ha that were >500 m from open or gated roads; U.S. Fish and Wildlife Service 2007), proportion of locations in developed areas, and season (denning vs. active).

*Dependent young survival.*—We defined dependent offspring as bears in their first (cub) and second year (yearling) of life because they remain with their mothers during these periods. We determined their fate from visual observations of family groups during ground monitoring or aerial telemetry flights of radio-collared females. We were able to document mortality in a few instances, but in all other cases, we assumed that cubs or yearlings died when they were no longer observed with their mother or when their mother died. We followed procedures of Schwartz et al. (2006*b*) to estimate cub and yearling survival using the nest survival model of Dinsmore et al. (2002) in Program MARK. Encounter histories were based on 3 dates: 1) the first date a female with young was seen (day $i$), 2) the last date young were known to be present with their mother (day $j$), and 3) the last date the mother was monitored (day $k$). For young that survived the monitoring interval, day $k$ equaled day $j$. In cases where dependent offspring died, $k$ was the first date of observation of the mother without young.

We estimated survival of dependent offspring for 3 time periods. The first period represented the cub stage and spanned the period between the date of our first observation of a litter of cubs following den emergence in spring (22 Apr) and the date of our last cub observation prior to den entry (18 Nov; 211 days). The second period was winter denning, which was from 19 November to 17 April (150 days). The third period represented the yearling stage and spanned the

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dates of our first and last observations of a litter of yearlings (18 Apr to 3 Nov; 199 days). We estimated daily survival rates (DSR) for each time period. For the entire cub period, we calculated the survival rate as $DSR_{cub}^{211}$, whereas survival for the yearling (yrl) period was based on $DSR_{yrl}^{199}$.

Survival of individual offspring within a litter may not be independent, which may lead to overdispersed data that can bias the variance of estimates, although not the estimates themselves (Schmutz et al. 1995). Therefore, we used a data bootstrap procedure similar to the analyses of Bishop et al. (2008) by bootstrapping on unique litters, but used bootstrapping to perform model selection rather than estimation of the amount of overdispersion. We used simulation procedures in Program MARK to obtain model estimates for each of 5,000 bootstrap resamples of unique litters. We used the 5,000 resamples to calculate median beta coefficients.

*Reproductive transition.*—We used the method of Schwartz and White (2008) to estimate the likelihood that a radio-marked female ≥3 years old would transition between different reproductive states based on visual observations from telemetry flights. At least 2 consecutive years of observations are required to document a reproductive transition. In any given year, a female may be in one of the following states: no young (N), with cubs (C), with yearlings (Y), or with 2 year olds (T), resulting in 10 potential reproductive transitions that are biologically feasible (Schwartz and White 2008). For our analysis, we were primarily interested in the transition from no offspring in 1 year to cubs the following year (i.e., N to C). For females with no offspring, the only alternative transition is to no offspring again, thus, this transition provides an effective measure of how reproduction may be affected by population density or whitebark pine decline. We used the multi-state model in Program MARK that assumes first-order Markovian transitions (i.e., the next transition is conditional on the current state only) to estimate transition rates. Fecundity varies by age because of reproductive maturation and senescence, a relationship closely fit by a quadratic curve, so we included age ($age + age^2$) of individual females in our base model for the N to C transition (Schwartz and White 2008).

*Testing for time trend.*—To determine if changes in vital rates over time were associated with grizzly bear density or whitebark pine mortality, it was important to fit a covariate for time trend to each model to detect whether vital rates changed and, if so, when and how they changed. We tested 8 temporal covariates to capture plausible scenarios of vital rate changes (Supplementary Fig. S1), including a linear trend ($T_{lin}$), 4 quadratic splines (starting in 1983 [$T_{q1983}$], 1991 [$T_{q1991}$], 1996 [$T_{q1996}$], and 2001 [$T_{q2001}$], respectively; value range = 0.001–0.900), 2 sigmoidal trends (inflection points around 1995 [$T_{sig1}$] and 2000 [$T_{sig2}$], respectively; value range = 0–1.0), and a binary covariate ($T_{period}$) that split the 30-year study period into 1983–2001 and 2002–2012, the second representing the period of slowed population growth documented by IGBST (2012). We also included a model with no time trend in each analysis. We determined which temporal covariate had the most support based on the global model for each vital rate using Akaike's Information Criterion with a second-order correction for small sample size ($AIC_c$; Hurvich and Tsai 1989, Burnham and Anderson 2002). We used the most supported temporal covariate to develop a model set for hypothesis testing.

*Hypothesis testing.*—We examined whether changes in vital rates over time were associated with either whitebark pine decline or grizzly bear density. To do so, we assigned covariate values to the encounter histories of individually marked bears based on annual, spatially explicit indices of whitebark pine decline and grizzly bear density. Potential effectiveness of the indices as covariates was contingent on detecting variation through space and time.

We derived the grizzly bear density index (Bjornlie et al. 2014*b*) using capture, telemetry, and life-history data for 870 bears involved in >1,800 captures during 1975–2012. We spatially reconstructed individual bears' extent of use, as represented in a lifetime activity range, and temporally extruded these activity ranges each year from the age of independence (≥2 years of age) through the known or estimated year of death. The lifetime activity range was defined by the mean lifetime activity radius of telemetry locations, collected approximately every 10–14 days during the active season, from the center of activity (Bjornlie et al. 2014*b*; $\gamma_{male} = 24.3$ km, $\gamma_{female} = 12.8$ km; based on 80th percentile to exclude outliers). We restricted data to known-aged individuals (cementum annuli aging) that were captured for research or management purposes. We explicitly accounted for any management bears that established a new range after transport by recalculating their activity centers. We overlaid each lifetime activity range on a grid of 14- × 14-km cells (196 $km^2$), approximating the annual home-range size of female bears (IGBST, unpublished data). For each grid cell, the density index in a given year was the sum of proportional overlap of all lifetime activity ranges for bears present during that year (Bjornlie et al. 2014*b*). We assumed lifetime activity-range estimates were representative of years prior to first capture. Grid cells that were completely covered by an activity range received a value of 1 for that individual. For cells partially covered by an activity range, the contribution to the density index was based on its proportional coverage. Our derivation of this index has several caveats. First, the density index is based on bears that were captured and although capture effort is distributed spatially and temporally throughout the ecosystem, differences in capture effort may cause biases. Therefore, we tested if the density index was correlated with capture effort (1996–2012) by evaluating the correlation between the change in capture effort (cumulative no. trapnights of current and preceding years/grid cell) and change in bear density at the grid-cell level. The large extent of the study grid resulted in many uninformative cells with zero density and zero capture effort and we excluded them from this evaluation. Furthermore, 29% of cells with non-zero cumulative density values for the time series were cells where there was no capture influence (i.e., capture index = 0) for the entire time period. These cells were not solvable in terms of correlations and were excluded. Of the remaining cells ($n = 250$), we

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detected little correlation between the rate of change of the cumulative capture index and that of the density index: the distribution of correlation coefficients for these 250 cells approached a normal distribution with a mean near 0 ($\bar{x} = 0.07; \sigma = 0.28$; Bjornlie et al. 2014*b*). The second caveat is that the initial and ending years from 1975 to 2012 underestimated density relative to the middle years of this period. This is unavoidable because we could not include bears that might have been captured prior to 1975 and forecast into the future, nor bears that might be captured in the future (i.e., post-2012) and back-cast to the present. The average age of first capture is approximately 5 years so this time lag was not a concern for the starting year of 1983 because of capture effort during 1975–1982. However, for the ending years, underestimation of the density index started around 2007. Therefore, we ended the density index in 2006 and used autoregressive integrated moving average ARIMA (1,1,1) forecasting. We accounted for drift (i.e., $d > 0$) and based projections on the previous 5 years of density information (2002–2006) to project trends forward from 2007 through 2012 on a cell-by-cell basis (i.e., 960 time-series projections). We validated the density index using data from standardized observation flights conducted twice annually by IGBST since 1998 in 28 Bear Observation Areas (BOAs). All independent-aged bears (≥2 years old) were counted individually. For females with offspring, we only counted the mother. Using BOAs as the sampling unit, we calculated correlation coefficients to test if bear observation rates were positively associated with the density index. We ended the period for validation in 2006 because of the aforementioned time lag for sampling bears. For the 1998–2006 period, the mean density index was positively correlated with mean log-transformed counts of bear groups/hour/1,000 $km^2$ within BOAs ($r = 0.725$, $P < 0.001$, $n = 28$; Bjornlie et al. 2014*b*). Assuming that changes in observation rates over time are a product of the number of bears in BOAs, these results support the efficacy of the index to track relative changes in bear density. Over time, the bear density index showed an expanding pattern due to population expansion and increasing index values in core areas of the ecosystem, reflecting increasing bear density (Supplementary Fig. S2). Additional details on the development and evaluation of this index are provided by Bjornlie et al. (2014*b*).

With the exception of a single year (2009; Macfarlane et al. 2013), no annual data existed to derive an individual covariate of whitebark pine decline. Therefore, we developed a spatially explicit, annual index of whitebark pine mortality. Normalized Difference Vegetation Index (NDVI) data derived from MODIS satellite imagery (250-m resolution) have been effectively used to model insect-induced tree mortality (Verbesselt et al. 2009) so we developed a similar approach to estimate change in healthy whitebark pine canopy. Our area of analysis followed an existing whitebark pine distribution map (Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee 2011) that was also used by Macfarlane et al. (2013), which included mixed and pure stands. Whitebark pine in the GYE is most commonly found with lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*) as associates, and occurs as a climax species in pure stands only on the most exposed sites (Arno and Hoff 1989). Whitebark pine cones are indehiscent and grizzly bears obtain >90% of seeds by raiding red squirrel (*Tamiasciurus hudsonicus*) cone caches (Kendall 1983, Mattson and Reinhart 1997). Greatest red squirrel densities occur in mixed, mature conifer stands, where food supply is more consistent (Mattson and Reinhart 1994, Podruzny et al. 1999). Within mapped whitebark pine, we selected pixels with ≥50% canopy cover (2001 National Land Cover Database; Homer et al. 2007) to ensure that we measured changes for pixels that were mostly forested. For each year, we used 5 composite scenes (16 days each; late Jul through mid-Oct) to calculate a weighted mean annual value of NDVI for each grid cell. We weighted each pixel using the 16-bit binary coded Quality Assurance (QA) science datasets (SDS) included in the MODIS products (Solano et al. 2010). Using the Vegetation Indices (VI) pixel reliability parameter (bits 2–5 of the QA-SDS dataset), we converted the 11 classes of binary data to an interval-scaled (range = 1–11) weighting factor for each pixel in each composite scene. Because our primary interest was to detect mortality of whitebark pine rather than inter-annual variation in reflectance from other sources (e.g., precipitation), we used a robust piecewise constant signal denoising algorithm (Little and Jones 2011) to reduce annual variation. Finally, using 2000 as the reference year, we calculated change in the reflectance value of each grid cell for each year. We used 2000 as the reference year because the most recent outbreak of mountain pine beetle began in 1999–2000 with peak beetle activity around 2009 (Mahalovich 2013). Consequently, 2001 was the first year during which this index showed negative values among sampled bears. Several sources of uncertainty likely were propagated in this index, as is common with remote sensing data (Lechner et al. 2012). Among the 3 sources of uncertainty addressed by Lechner et al. (2012; classification scheme uncertainty, spatial scale, classification error), our index was least sensitive to classification scheme uncertainty because we used continuous NDVI data, rather than discrete classes. Regarding spatial scale, uncertainty associated with the index at the observation scale of a pixel decreased substantially as we aggregated pixel values to our analysis scale of a lifetime activity range (Bian and Butler 1999), as described subsequently. We could not quantify classification error because it was not feasible to groundtruth this retrospective index because of the dynamic changes that have occurred in whitebark pine stands. Therefore, we used 2009 data from Macfarlane et al. (2013) to qualitatively assess our index (Supplementary Fig. S3). Besides reflecting the effects of mountain pine beetle, our index also detected changes due to other sources of mortality, such as forest fires. The index showed fine-scale, gradual changes in whitebark pine stands for many areas, likely reflecting a spreading pattern of local outbreaks of mountain pine beetle, with a few areas showing larger-scale, abrupt changes indicative of forest fires (Supplementary Fig. S3).

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To measure the indices for bear density and whitebark pine mortality as a covariate value for each bear, we first estimated lifetime centers of activity of individual bears. We calculated the mean activity radius for females and males and then applied that distance to each individual's activity center to measure the mean annual value of each index based on grid cells within that area. We proportionally adjusted the weight for grid cells that fell on the perimeter. Additionally, for the index of whitebark pine mortality, we weighted the index according to the proportion of whitebark pine cover type (Landenburger et al. 2008) for cells with >50% tree cover (Homer et al. 2007) available for each bear. In other words, severe mortality and high proportion of the whitebark pine cover type combined to produce the lowest indices, indicative of the most severe decline. Conversely, values were close to 0 for bears with little whitebark pine in their activity range and varied only slightly with change in whitebark pine cover.

We developed a suite of models to test our research hypotheses using $AIC_c$. For each vital rate, our model set included a base model as previously described, a model with the top-supported temporal covariate only, and models with either the index of bear density or the index of whitebark pine mortality. Finally, to test each vital rate with grizzly bear density or whitebark pine mortality changing as a function of the temporal covariate, we included models with interaction terms for 1) the temporal covariate and grizzly bear density index and 2) the temporal covariate and whitebark pine index. For survival of independent bears, we also included a term for sex. Because cub and yearling survival were based on bootstrapping, we performed model selection using the median $AIC_c$ and $\Delta AIC_c$ values based on the 5,000 resamples of each model. We used model averaging to graphically show relevant relationships of estimated vital rates and model covariates. In testing our research hypotheses, our focus was on the relationships represented by the model parameters, rather than estimation of each vital rate. Vital rate estimates from our analyses are not fully comparable with those provided by Schwartz et al. (2006*d*) and IGBST (2012) because we used model averaging, different covariates, and data from a different time period.

## RESULTS

The indices for grizzly bear density and whitebark pine mortality showed considerable variation among individual bears (grizzly bear density index: $\bar{x} = 13.9$, $SD = 5.6$, range = 0–29.2; index of whitebark pine mortality: $\bar{x} = -0.022$, $SD = 0.050$, range = −0.380–0 [more negative numbers reflect greater mortality]) through time (Fig. 1). The mean annual density index for sampled bears increased from approximately 9 early in the study period to over 16 toward the end, with a concomitant increase in variation (Fig. 1A). The whitebark pine index indicated that the number of bears affected and the extent of whitebark pine loss increased rapidly after the year 2000, with annual means ranging from −0.070 to 0 (Fig. 1B). Among sampled bears, we found little evidence of a correlation between these 2 indices for the entire time period ($r = -0.048$, $P = 0.039$, $n = 1{,}872$), or after the year 2000, the period of whitebark

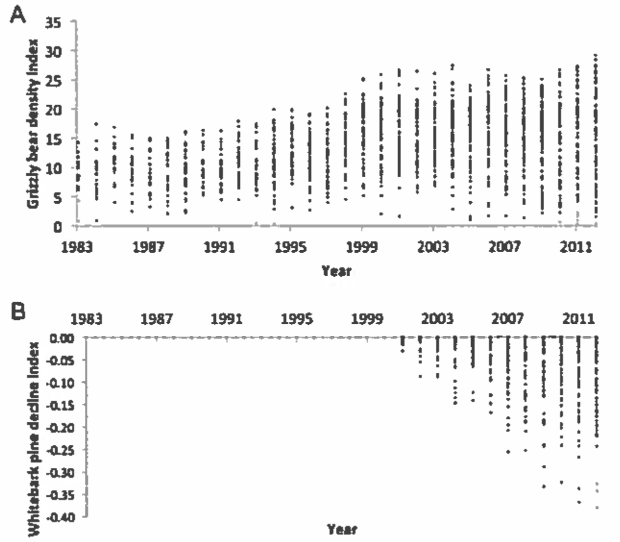


**Figure 1.** Mean index values for (A) grizzly bear density and (B) whitebark pine mortality associated with lifetime activity ranges of independent-aged (≥2 years) grizzly bears sampled in the Greater Yellowstone Ecosystem, USA, 1983–2012.

pine decline ($r = 0.098$, $P = 0.001$, $n = 1{,}063$). Thus, these indices provided useful measures of local changes experienced by individual bears over time and across a wide gradient of conditions in the GYE.

Our analysis of survival of independent bears was based on 1,872 annual encounter histories of 645 individual bears. Among the 8 temporal covariates we tested, period ($T_{period}$; 1983–2001 vs. 2002–2012) had the most support ($AIC_c = 1{,}128.62$; $AIC_c$ weight [$w_i$] = 0.54; Supplementary Table S1); the second and third most supported models were based on no time trend and a quadratic trend, but both had much less support ($\Delta AIC_c = 2.40$, $w_i = 0.16$ and $\Delta AIC_c = 3.34$, $w_i = 0.10$, respectively). Therefore, we used $T_{period}$ as the temporal covariate to test our hypotheses. We did not fit an interaction term for this covariate because the interaction was inherent in the whitebark pine covariate: statistical support for the whitebark pine covariate would indicate it occurred during the latter period of 2002–2012. The model with $T_{period}$ ($\hat{\beta} = 0.847$, 95% CI = 0.297–1.398), sex ($\hat{\beta} = 0.467$, 95% CI = −0.040–0.973), and $T_{period} \times$ sex interaction ($\hat{\beta} = -0.690$, 95% CI = −1.468–0.089; Supplementary Table S2) had the most support ($w_i = 0.34$; model A5; Table 1), followed by a model ($\Delta AIC_c = 1.05$, $w_i = 0.20$; model A2; Table 1) with sex ($\hat{\beta} = 0.183$, 95% CI = −0.204–0.569; Supplementary Table S2) and $T_{period}$ only ($\hat{\beta} = 0.522$, 95% CI = 0.128–0.916; Supplementary Table S2). There was some evidence of greater survival during the 2002–2012 period, primarily among males (Fig. 2). We detected little support for an association of independent bear survival with the indices for grizzly bear density or whitebark pine mortality or their interaction with period ($\Delta AIC_c > 1.90$; Table 1).

We used 326 encounter histories for offspring of 116 females to estimate survival for the cub and yearling periods;

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**Table 1.** Model-selection results to test association of 4 vital rates of grizzly bears with time trends, spatially and temporally explicit indices of whitebark pine mortality (WbPmort) and grizzly bear density (GBdensity), and their interactions, Greater Yellowstone Ecosystem, USA, 1983–2012. We examined the following parameters: survival of independent-aged grizzly bears (≥2 yrs), survival of cubs-of-the-year (cub) and yearlings (yrl), and reproductive transition from no offspring to cubs.

| Model no. and model description | $AIC_c$[a] | $\Delta AIC_c$[b] | $w_i$[c] | $K$[d] | Dev[e] |
|---|---|---|---|---|---|
| Independent survival[f] | | | | | |
| A5 {base + sex + $T_{period}$ + sex × $T_{period}$} | 1,128.04 | 0.00 | 0.34 | 10 | 1,108.02 |
| A2 {base + sex + $T_{period}$} | 1,129.08 | 1.05 | 0.20 | 9 | 1,111.07 |
| A6 {base + sex + $T_{period}$ + GBdensity} | 1,129.93 | 1.90 | 0.13 | 10 | 1,109.91 |
| A7 {base + sex + $T_{period}$ + WbPmort} | 1,130.20 | 2.16 | 0.12 | 10 | 1,110.18 |
| A8 {base + sex + $T_{period}$ + GBdensity + $T_{period}$ × GBdensity} | 1,130.56 | 2.52 | 0.10 | 11 | 1,108.53 |
| A4 {base + sex + WbPmort} | 1,131.81 | 3.77 | 0.05 | 9 | 1,113.80 |
| A3 {base + sex + GBdensity} | 1,132.81 | 4.77 | 0.03 | 9 | 1,114.79 |
| A1 {base + sex} | 1,133.97 | 5.93 | 0.02 | 8 | 1,117.96 |
| Cub and yearling survival[g] | | | | | |
| B7 {cub(GBdensity + $T_{q2001}$ + GBdensity × $T_{q2001}$), yrl(GBdensity + $T_{sig1}$ + GBdensity × $T_{sig1}$)} | 697.42 (53.84)[h] | 0.00 (4.14)[h] | 0.95[i] | 8 | 681.42 (53.84)[h] |
| B5 {cub(GBdensity + $T_{q2001}$), yrl(GBdensity + $T_{sig1}$)} | 705.75 (53.03) | 7.59 (9.40) | 0.02 | 6 | 693.75 (53.03) |
| B8 {cub(WbPmort + $T_{q2001}$ + WbPmort × $T_{q2001}$), yrl(WbPmort + $T_{sig1}$ + WbPmort × $T_{sig1}$)} | 705.76 (53.50) | 7.68 (10.49) | 0.02 | 8 | 691.37 (53.54) |
| B6 {cub(WbPmort + $T_{q2001}$), yrl(WbPmort + $T_{sig1}$)} | 708.83 (53.42) | 10.74 (10.76) | <0.01 | 6 | 696.83 (53.42) |
| B2 {cub($T_{q2001}$), yrl($T_{sig1}$)} | 710.44 (52.94) | 12.23 (12.13) | <0.01 | 4 | 702.44 (52.94) |
| B3 {cub(GBdensity), yrl(GBdensity)} | 725.95 (53.64) | 28.70 (14.34) | <0.01 | 4 | 717.95 (53.64) |
| B4 {cub(WbPmort), yrl(WbPmort)} | 732.18 (53.12) | 34.26 (17.76) | <0.01 | 4 | 724.18 (53.12) |
| B1 {cub(.), yrl(.)} | 733.30 (53.27) | 35.70 (17.77) | <0.01 | 2 | 729.30 (53.27) |
| Reproductive transition from no offspring to cubs[j] | | | | | |
| C7 {base + $T_{sig1}$ + GBdensity + $T_{sig1}$ × GBdensity} | 6,196.19 | 0.00 | 0.44 | 13 | 6,169.26 |
| C1 {base} | 6,198.08 | 1.89 | 0.17 | 10 | 6,177.53 |
| C2 {base + $T_{sig1}$} | 6,198.79 | 2.61 | 0.12 | 11 | 6,176.13 |
| C3 {base + GBdensity} | 6,199.78 | 3.60 | 0.07 | 11 | 6,177.12 |
| C4 {base + WbPmort} | 6,199.99 | 3.80 | 0.07 | 11 | 6,177.32 |
| C6 {base + $T_{sig1}$ + WbPmort} | 6,200.07 | 3.88 | 0.06 | 12 | 6,175.28 |
| C5 {base + $T_{sig1}$ + GBdensity} | 6,200.90 | 4.71 | 0.04 | 12 | 6,176.11 |
| C8 {base + $T_{sig1}$ + WbPmort + $T_{sig1}$ × WbPmort} | 6,201.84 | 5.66 | 0.03 | 13 | 6,174.92 |

[a] Akaike's Information Criterion adjusted for small sample size.
[b] Difference in $AIC_c$ compared with lowest $AIC_c$ model.
[c] $AIC_c$ model weight.
[d] No. model parameters.
[e] Model deviance.
[f] Base model was modified from Schwartz et al. (2010) and included trap status (research or management bear), age, $age^2$, secure habitat, developed area, and season (denning vs. active); time trend modeled as a binary variable ($T_{period}$; 1983–2001 [period 1] vs. 2002–2012 [period 2]).
[g] Time trend for cubs and yearlings modeled as quadratic spline starting in 2001 ($T_{q2001}$) and sigmoidal function ($T_{sig1}$), respectively.
[h] Median value based on 5,000 bootstrap resamples; standard deviation in parentheses.
[i] $AIC_c$ weights based on median $\Delta AIC_c$ values of the 8 models from the 5,000 resamples.
[j] Base model included age and $age^2$ for the transition of no young to cubs; time trend modeled as a sigmoidal function ($T_{sig1}$).



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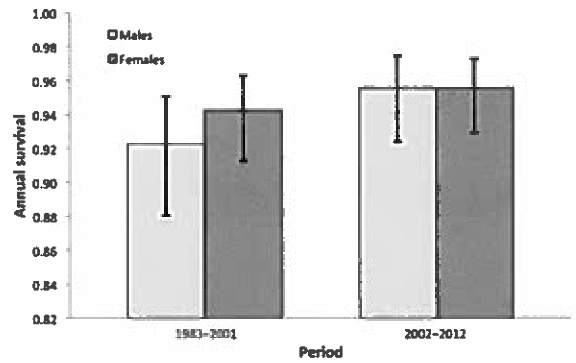


**Figure 2.** Predicted annual survival and 95% confidence intervals (vertical lines) of independent-aged (≥2 years) grizzly bears in the Greater Yellowstone Ecosystem, USA, by period (1983–2001 and 2002–2012). Predictions based on model-averaged estimates. Covariate values in the base model were set at their mean (age = 8.4 years [M and F], proportion of locations in secure habitat = 0.82, proportion of locations in developed area = 0.13).

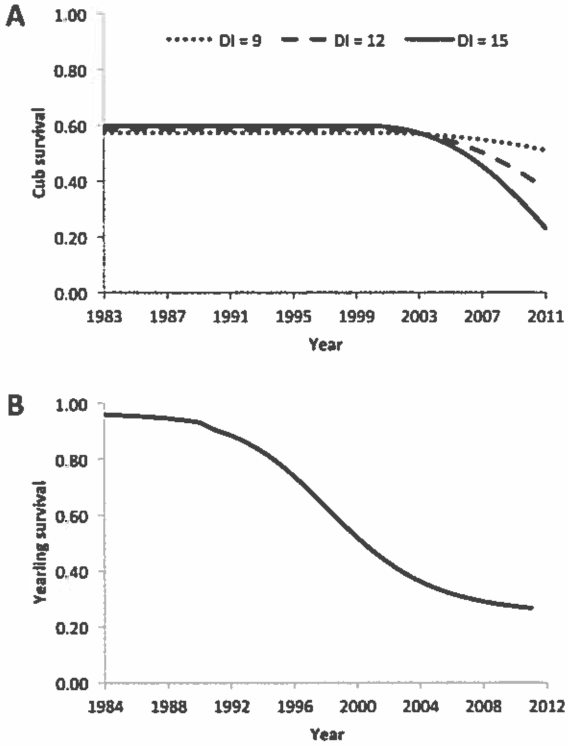


**Figure 3.** Predicted survival rate of grizzly bear cubs-of-the-year (cub) and yearlings, Greater Yellowstone Ecosystem, USA, 1983–2012. Predictions based on model-averaged estimates. (A) Survival rate during 211-day cub period and grizzly bear density index (DI). Time trend was based on quadratic spline starting in 2001. The 3 levels of the grizzly bear density index (*DI* = 9, 12, or 15) reflect range of density conditions experienced by sampled bears during the study period, with generally greater values as the study period progressed. We set the covariate value for the index of whitebark pine mortality at a value of −0.04. (B) Survival rate during 199-day yearling period. Time trend was based on sigmoidal function. We set the covariate for bear density at a value of 12 and the covariate for the index of whitebark pine mortality at a value of −0.04, approximating conditions experienced by sampled bears during the early 2000s.

118 of these records represented mortalities. Time trend analyses for cub survival indicated the best fit for quadratic models, with most support for a quadratic time trend starting in 2001 ($T_{q2001}$; $AIC_c = 741.60$; $w_i = 0.41$; Supplementary Table S1), followed by a quadratic time trend starting in 1996 ($T_{q1996}$; $\Delta AIC_c = 1.09$; $w_i = 0.24$). We chose $T_{q2001}$ as our temporal covariate. For yearling survival, the best fit was evident for a sigmoidal time trend over the study period ($T_{sig1}$; $AIC_c = 746.08$; $w_i = 0.64$; Supplementary Table S1), followed by a model with the second sigmoidal function ($T_{sig2}$; $\Delta AIC_c = 3.37$; $w_i = 0.12$). Therefore, we applied $T_{sig1}$ to the yearling period to develop our model set for hypothesis testing. Results of the 5,000 bootstrap resamples indicated greatest support for a model that included the time trends, bear density index, and their interactions (median $AIC_c = 697.42$; $w_i = 0.95$; model B7; Table 1). For cub survival, parameter estimates for the bear density index (median $\hat{\beta} = 0.014$, 95% CI = −0.047–0.075) and time trend (median $\hat{\beta} = 10.189$, 95% CI = −8.721–29.099) had confidence intervals that overlapped 0, but there was evidence of a $T_{q2001}$ × bear density interaction (median $\hat{\beta} = -1.242$, 95% CI = −2.227 to −0.256; Supplementary Table S2). Model-averaged estimates of cub survival showed the effect of the interaction, with a decline of cub survival starting in 2001 and more so in areas with greater index values for bear density (Fig. 3A). For yearling survival, parameter estimates did not indicate an interaction effect for $T_{sig1}$ × bear density (median $\hat{\beta} = 0.388$, 95% CI = −0.165 to 0.941), although there was some evidence of a decline in yearling survival based on the time trend covariate $T_{sig1}$ (median $\hat{\beta} = -7.089$, 95% CI = −14.327 to 0.150; Model B7, Supplementary Table S2). Model-averaged estimates of yearling survival indicated this decline occurred during the 1990s (Fig. 3B). The model with whitebark pine, time trend, and their interaction was the third-ranked model but had little support (median $\Delta AIC_c = 7.68$; $w_i = 0.02$; model B8; Table 1); only the parameter estimates for time trend did not bound 0 in the 95% confidence intervals (cubs: median $\hat{\beta} = -14.328$, 95% CI = −20.935 to −7.720; yearlings: median $\hat{\beta} = -2.101$, 95% CI = −3.802 to −0.399; Supplementary Table S2). The evidence ratio between the equivalent, competing models with temporal interactions ($E_{B7,B8}$) was 46.6 in favor of the model based on the grizzly bear density index (B7) versus the whitebark pine index (B8; Table 1).

Finally, we estimated reproductive transitions based on 185 encounter histories of 156 females (377 transitions, of which 199, 101, 58, and 19 started in the N, C, Y, and T states, respectively). Among the temporal covariates we tested, the sigmoidal time trend $T_{sig1}$ had slightly more support ($AIC_c = 6{,}196.86$; $w_i = 0.28$; Supplementary Table S1) than the binary covariate of $T_{period}$ ($\Delta AIC_c = 0.16$, $w_i = 0.25$) and $T_{sig2}$ ($\Delta AIC_c = 0.80$, $w_i = 0.18$). Therefore, we used $T_{sig1}$ as the temporal covariate to test our hypothesis. The most supported model had an $AIC_c$ weight of 0.44 (model C7; Table 1) and included $T_{sig1}$ ($\hat{\beta} = 3.048$, 95% CI = 0.080–6.017), grizzly bear density index ($\hat{\beta} = 0.257$, 95% CI = 0.045–0.468), and their interaction ($\hat{\beta} = -0.321$, 95% CI = −0.570 to −0.072; Supplementary Table S2). The



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second- and third-ranked models had less support ($\Delta AIC_c = 1.89$, $w_i = 0.17$ [model C1] and $\Delta AIC_c = 2.61$, $w_i = 0.12$ [model C2], respectively; Table 1) and contained the base model and the covariate for $T_{sig1}$ ($\hat{\beta} = -0.580$, 95% CI = −1.544–0.384), respectively (Supplementary Table S2). Based on the 2 competing models with the temporal interactions (models C7 and C8; Table 1), the evidence ratio $E_{C7,C8}$ indicated 16.9 times greater support for a grizzly bear density association with transition probability compared with the index for whitebark pine mortality. Model-averaged estimates showed the probability of reproductive transition from no offspring to cubs declined during the 1990s, which was more pronounced in areas with greater population densities (Fig. 4).

## DISCUSSION

The vital rate that generally has most influence on the population trajectory in grizzly bear populations is survivorship of adult females, followed by reproductive rates and juvenile survival (Eberhardt et al. 1994, Garshelis et al. 2005, Harris et al. 2006). However, as Mitchell et al. (2009) reported for American black bears (*Ursus americanus*), high variance of juvenile survival and recruitment may have a greater influence on variation of population growth than adult female survival (Harris et al. 2011). In the GYE, survival of independent-aged females was high and did not change during the study period and thus did not contribute to slowing of population growth. Survival of dependent-aged bears declined, however, and was negatively associated with population density, particularly for cubs (Fig. 3A). Decline in cub survival was evident beginning in the early 2000s and was associated more strongly with increasing grizzly bear density than reduced availability of whitebark pine. Cub survival is a

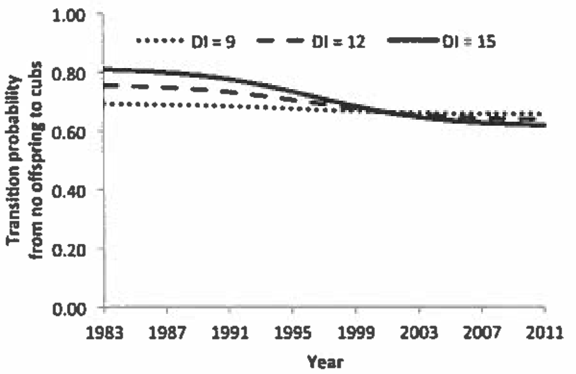


**Figure 4.** Predicted probability of reproductive transition of female grizzly bears from having no offspring to having cubs-of-the-year (cub) and relationship with grizzly bear density index (DI), Greater Yellowstone Ecosystem, USA, 1983–2012. Predictions based on model-averaged estimates. Time trend was based on sigmoidal function. The 3 levels of the grizzly bear density index (*DI* = 9, 12, or 15) reflect range of density conditions experienced by sampled bears during the study period, with generally greater values as the study period progressed. We set the covariate for age at the mean value for sampled females (8.4 years). We set the covariate value for the index of whitebark pine mortality at −0.04, approximating conditions experienced by sampled bears during the early 2000s.

potential density-dependent factor contributing to population regulation among bear populations and we explore 2 potential causes for the grizzly bear population in Yellowstone: intraspecific killing and interference competition.

Intraspecific killing may function as a density-dependent effect on cub survival, although different biological mechanisms have been proposed (Miller 1990, Swenson et al. 2001, Wielgus et al. 2001, Miller et al. 2003, McLellan 2005). McLellan (1994) reported 57 cases of intraspecific killing of brown bears, and cubs were the victim in 44% of instances, followed by adult females (12%), several of which were killed while protecting their cubs. The latter was documented ($n = 2$) for the first time in areas with high bear densities in Yellowstone National Park in May 2012 (IGBST, unpublished data). For the GYE, we hypothesize that a connection exists between increased survival of independent-aged males (Fig. 2; IGBST 2012) and increased mortality of cubs as a function of bear density during the last decade of the study period (Fig. 3A). Indeed, most of our observations of males killing cubs have occurred in recent years (IGBST, unpublished data).

A second, density-related cause for lower survival among dependent-aged (i.e., cubs and yearlings) bears may be interference competition. As population density increases, interference competition has the potential to constrain the feeding efficiency of some individuals, particularly subordinate individuals such as juveniles (Rutten et al. 2010, López-Bao et al. 2011). Breed et al. (2013) suggested that reduced foraging efficiency of young-of-the-year gray seals (*Halichoerus grypus*) in Nova Scotia, Canada resulted in reduced survival at greater densities, which likely explained the slowing of population growth they observed. Unlike exploitation competition, when food supplies are depleted with increasing population density, interference competition can arise even when food is plentiful, as Gende and Quinn (2004) demonstrated for brown bears on Chichagof Island, Alaska. At the extreme, interference competition can cause starvation among less-competitive individuals even in the absence of food depletion (Goss-Custard et al. 2001). If conspecifics are potentially predatory, as in brown bears, increased vigilance may further affect foraging efficiencies at higher population densities, as generally observed in predator-prey systems (St. Juliana et al. 2011). There is ample evidence for interference competition among brown bear populations. Although McLellan (1994) identified food as the ultimate factor limiting brown bear populations, he noted that bear consumption rarely reduces food biomass to levels where foraging efficiency is compromised. Instead, he suggested that foraging is more likely impaired at high densities by social behaviors such as displacement, increased vigilance, and increased energy expenditure from social stress. Older bears, particularly adult males, are usually dominant at productive feeding sites by virtue of their larger body size. Subordinate juveniles and females with dependent young may avoid areas used by adult males and several authors have suggested this serves to reduce the risk of intraspecific predation (Wielgus and Bunnell 1994, Mattson and Reinhart 1995, Ben-David et al. 2004, Rode et al. 2006).

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Such avoidance can incur a nutritional cost. Nevin and Gilbert (2005), for example, found that females with cubs reduced energy intake by 37% when selecting sub-optimal habitats in a salmon-rich environment. Similarly, Steyaert et al. (2013) suggested a food-for-safety trade-off exists among female brown bears with cubs in Sweden that may have its origins in avoiding intraspecific predation.

Our study was not designed to determine whether population density acted more directly (i.e., intraspecific killing) or indirectly (i.e., interference competition) on cub survival. We speculate both processes may play a role in the GYE but only have supporting evidence for intraspecific killing based on investigations of mortality (IGBST, unpublished data). We lack the ability to directly assess the nutritional costs of interference competition on cub body condition because we rarely captured females with cubs and avoided handling them when we did. However, percent body fat of females exerts a strong influence on body condition of newborns (Robbins et al. 2012) and thus provides a useful indicator of this effect. Although data presented in Schwartz et al. (2014) indicated a possible decline in percent body fat among fall captures of adult females during 2007–2010, additional data and analyses since that time provided no evidence of a decline in percent body fat during the period of whitebark pine decline (IGBST 2013:19–20).

Yearling survival also declined, but this decline was not explicitly associated with whitebark pine mortality or population density. The decline in yearling survival began during the 1990s and thus prior to the onset of whitebark pine decline. Cubs tend to be more susceptible to intraspecific killing than yearlings (McLellan 1994), which may explain why we did not observe an interaction for the change in yearling survival with bear density. However, power to detect an interaction effect may have been limited by the smaller number of records contributing to estimation of yearling survival compared with cub survival.

Our study provided moderate evidence that the probability of reproductive transition from no offspring to cubs declined during the 1990s, prior to whitebark pine decline, and that this decline was greater in areas with higher bear densities (Fig. 4). The increase in adult female densities where survival is high may be linked with reproductive suppression through interference competition within female hierarchies (Gende and Quinn 2004, Støen et al. 2006). As discussed previously, a greater number of adult males due to their increased survival since the early 2000s may also have contributed to interference competition.

The changes we observed in survival of dependent young and reproductive transition are consistent with the documented slowing of estimated annual population growth since the early 2000s (IGBST 2012). Lower cub survival, in particular, may have been an important contributor to reduced population growth. The observed reduction in cub survival from an estimated $0.64 \pm 0.087$ (SE) during 1983–2001 to $0.55 \pm 0.064$ during 2002–2011 (IGBST 2012) would have reduced annual population growth, from 1.076 to 1.049. A study of Scandinavian brown bears similarly demonstrated that an observed difference in cub survival ($S_0$), between 2 study areas with ($S_0 = 0.85–1.00$) and without ($S_0 = 0.58–0.61$) harvesting of adult males, could reduce annual population growth from 1.18 to 1.14 (Swenson et al. 1997). Recent analyses on that same population further indicated relatively high elasticity of the cub survival parameter on population growth (Gosselin et al. 2015).

Density-dependent changes in life-history traits are more likely to occur when populations are near carrying capacity (Caughley 1977; Fowler 1981*a*,*b*) and the research of Miller et al. (2003) supports this notion for brown bears. Our findings are consistent with Schwartz et al. (2006*b*), who predicted based on 1983–2001 data that population density may influence cub and yearling survival as density reaches carrying capacity in different portions of the GYE, such as inside Yellowstone National Park. Of course, population changes mediated by density may be linked with food resources and carrying capacity of the environment (Miller 1990). Thus, there is the possibility that decline of whitebark pine and other resources (e.g., cutthroat trout [*Oncorhynchus clarkii*] around Yellowstone Lake; Haroldson et al. 2005, Teisberg et al. 2014) reduced carrying capacity, which, through increased exploitation competition for high-energy foods, could have reduced cub survival and reproductive transitions in a density-dependent fashion. This effect would be difficult to separate from that of interference competition we discussed previously. If bears were responding to a decline in carrying capacity, however, we would have expected home-range size and movements to have increased (McLoughlin et al. 2000), bears to have relied on lower-energy food resources (McLellan 2011), and body condition to have declined as a consequence (Rode et al. 2001, Robbins et al. 2004, Zedrosser et al. 2006). To date, there is little support for these conditions in the Yellowstone Ecosystem: female home ranges have decreased in size and are less variable in areas with greater bear densities (Bjornlie et al. 2014*b*), daily movement rates and daily activity radii have not changed for either sex during fall (Costello et al. 2014), bears continue to use high-quality foods (Fortin et al. 2013), and body mass has not declined (Schwartz et al. 2014). As we discussed previously, percent body fat among adult females has not declined since the early 2000s (IGBST 2013, Schwartz et al. 2014) and, regardless, this effect would be consistent with either interference or exploitation competition and would not explain the changes in vital rates that occurred much earlier than the declines in foods. Current evidence indicates bears showed a functional response to declines in whitebark pine (Costello et al. 2014) and cutthroat trout (Fortin et al. 2013) and compensated for the loss of these particular foods through diet shifts (Schwartz et al. 2014).

Previous studies linking grizzly bear survival rates to production of whitebark pine seeds largely attributed the effect to a behavioral response to the annual variation in this food. When seed production was high, bears were more likely to use high elevations where the potential for human-caused mortality was lower (Mattson et al. 1992, Blanchard and Knight 1995). Haroldson et al. (2006) also detected this

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effect in their models and estimated that annual survival among non-conflict bears was 0.947, 0.957, and 0.965 after years with median whitebark pine cone counts of 0 (no crop), 7.5 (average), and 15 (high), respectively; a greater effect was observed among conflict bears with corresponding survival rates of 0.818, 0.850, and 0.874, respectively. This annual variation is not inconsistent with a long-term, stable trend in survival, as we observed among independent bears. In fact, recent analyses indicate annual cone production is still associated with the annual frequency of grizzly bear mortalities during 2000–2012 (IGBST 2013:24). Even heavily affected stands may contain surviving trees that produce cone crops and grizzly bear use of whitebark pine seeds in such stands has been observed (Orozco and Miles 2013), although Costello et al. (2014) detected a downward trend in fall selection of whitebark pine habitats during 2000–2012. Thus, on an annual basis, good whitebark pine cone production may still have a positive effect on survival of independent bears. However, we found no evidence of a longer term downward trend in survival of independent bears associated with the decline of this food.

Similar to our results, previous studies have not shown that annual variation in whitebark pine cone production was a strong correlate for cub and yearling survival (Schwartz et al. 2006*b*). Schwartz et al. (2006*a*) observed an association between fecundity and the annual index of whitebark pine cone production; however, they detected a much stronger relationship with an index of minimum population size than whitebark pine cone production, which supports our findings and interpretation that bear density is associated with long-term changes in reproduction.

Data from our study support the hypothesis that slowing of population growth of grizzly bears in the GYE is a function of increasing grizzly bear density rather than the decline of a high-calorie fall food resource, whitebark pine. This interpretation is reinforced by recent findings of Gosselin et al. (2015), who suggested that the behavior of individuals and social biology of brown bears can have pronounced effects on population growth. Although multiple lines of evidence support the interpretation of a bear density effect, alternative explanations exist beyond the ones we explored here. First, cub and yearling survival may have declined because of reduced body condition unrelated to whitebark pine or bear density. However, as we mentioned previously, a decline in female body condition would likely be a precursor to decline in offspring condition and we have not observed a decline in female percent body fat. Second, with the reintroduction of gray wolves (*Canis lupus*) in 1995–1996, we cannot dismiss the potential role of wolf predation on cubs and yearlings but with only 4 incidents observed since 2001 (Gunther and Smith 2004; IGBST, unpublished data), we do not regard this as a substantial source of cub or yearling mortality and have no empirical evidence to support this hypothesis. Finally, as with any study, sampling variation could have affected our results, but this could only explain our findings if there was a distinct trend in sampling variation over the course of our study, for which we have no evidence.

## MANAGEMENT IMPLICATIONS

Our study findings corroborate those of Bjornlie et al. (2014*b*), who reported evidence of an inverse relationship between home-range size and the index of grizzly bear population density; they did not observe a relationship between home-range size and availability of live whitebark pine stands. Combined, these studies provide evidence that grizzly bear density may become an increasingly important factor to consider for management of the grizzly bear population in the GYE. The potential role of increased male survival may be of particular interest for mortality management, but further study is needed. Our results suggest that this population is near or at carrying capacity and managers should not expect population growth rates similar to those observed during the 1980s and 1990s in core areas of the population. In fact, consideration should be given to the possibility that the population may start exhibiting fluctuations around a long-term mean. Such oscillations could include short periods of population increases or decreases, which may only be distinguished from sustained increasing or decreasing trends with continued, long-term monitoring. Current monitoring protocols should be sufficient to detect different population trajectories (Harris et al. 2007), but further investigation may be desired to identify additional scenarios and whether new population monitoring approaches may be more effective to adaptively manage the grizzly bear population in the GYE.

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*Associate Editor: Jamie Sanderlin.*

## SUPPORTING INFORMATION

Supporting information may be found in the online version of this article at the publisher's website.

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**November 8, 2013 For information contact Gregg Losinski at 208-390-0635**

# AGENCY REPORTS AT MEETING PRESENT UNANIMOUSLY GOOD NEWS ABOUT YELLOWSTONE ECOSYSTEM GRIZZLY BEAR RECOVERY

**BOZEMAN** – Managers from the state, tribal, and federal agencies responsible for recovery of the grizzly bear in the Yellowstone Ecosystem heard good news at their recent meeting in Bozeman, Montana. Despite being a poor cone production year for the already beleaguered whitebark pine trees (WBP), managers heard reports of surprisingly few conflicts between humans and grizzly bears, even though a record count of 58 unduplicated females with cubs were observed in the ecosystem this year. Especially promising was that a female with cub was documented in each of the 18 bear management units used to keep track of the bear population.

In addition to reports of minimal conflicts from all of the states and national parks, managers also heard a report on the annual population status from the Interagency Grizzly Bear Study Team (IGBST). Utilizing existing statistical methods the population estimate for the Yellowstone Ecosystem in 2013 is 629. Because grizzly bears have yet to enter their dens for hibernation, all of the information presented regarding conflicts was labeled as "Draft," but current data shows 25 known grizzly mortalities recorded so far, which represents less than half the mortalities in 2012.

The IGBST also presented a synthesis of information on the effects of changes in bear foods on the health of the Yellowstone grizzly population. The IGBST had been tasked in the spring of 2012 to do this work so the YES managers would have the best available information on which to make a recommendation to the USFWS on whether a new proposed delisting rule should be prepared or not.

According to van Manen, "Our extensive analysis of existing research and monitoring has shown us that grizzly bears are resilient and resourceful in the face of changing food resources." Additionally he said, "Our findings indicate that the decline in WBP due mostly to mountain pine beetles is not a major threat to the future of the Yellowstone grizzly bear population. Data show the observed slowing of population growth since 2002 is a result of increased grizzly bear population density and resulting declines in subadult survival."

The food synthesis research was presented to the YES members who then voted to conditionally support the findings, pending completion of a final section of the report and having all the research peer reviewed and published in professional journals. The IGBST will be presenting the same information to the IGBC at their December meeting in Missoula, Montana. Both the Yes and the IGBC will make recommendations of the United States Fish & Wildlife Service (USFWS), the agency responsible for deciding on whether a new proposed rule proposing to again delist Yellowstone bears would be developed and published for public

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comment. USFWS will likely make a final decision in late December or early January on whether to produce a new proposed rule or not.

According to Recovery Coordinator Chris Servheen, "If delisting were to occur it wouldn't be until later in 2014." Careful monitoring and management would continue if delisting were to occur. According to van Manen, "Our team will continue to monitor how grizzly bears respond over time and keep a close eye on the thresholds established to ensure a sustainable population."

To learn more about grizzly bear recovery visit: www.igbconline.org. To view reports by the IGBST regarding the Yellowstone grizzly bear population visit: http://www.nrmsc.usgs.gov/research/igbsthome

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County of Park

PARK COUNTY WYOMING
*ORGANIZED 1911*

ORIGINAL PARK COUNTY COURTHOUSE
CODY, WYOMING
*COMPLETED 1912*

October 26, 2015

Daniel Ashe
Director, U.S. Fish and Wildlife Service
1849 C Street NW
Washington, D.C. 20240

Dear Director Ashe:

Please find enclosed a Resolution signed October 20, 2015 by the Board of County Commissioners, Park County, Wyoming, encouraging the USFWS to move forward with all due haste in proposing a rule to delist the grizzly bear in the Greater Yellowstone Area.

Park County, Wyoming comprises much of the GYA, including the northern half of Yellowstone Park. Since 1975, residents of Park County have learned how to successfully share habitat with the grizzly bear both in the backcountry and the front-country. The bear's recovery can be credited in no small part to this social willingness to see the grizzly bear expand its territory and grow its population.

However, in visiting with our constituents, we are sensing a significant waning of this tolerance under the current federal ESA listing regime. The State of Wyoming Game and Fish Department has provided the bulk of on-the-ground management for the bear in much of the GYA. They are a competent and enlightened wildlife agency and have every ability to continue their good work and successfully manage a delisted population. We believe management by this competent Wyoming agency will be important in maintaining social acceptance of the bear by area residents.

It is essentially unanimous among wildlife managers that the grizzly bear is recovered. We encourage you, with all due haste, to propose a rule to delist the grizzly bear in the GYA and let the Wyoming Game and Fish Department apply its science and management protocols in ensuring that this impressive wildlife species remains a part of the landscape in co-habitation with a supportive human presence.

BOARD OF COUNTY COMMISSIONERS
PARK COUNTY, WYOMING

Joseph E. Tilden, Chairman

Lee Livingston, Vice Chairman

Tim A. French, Commissioner

Loren Grosskopf, Commissioner

Bucky Hall, Commissioner

encl: Park County Resolution # 2015-052

cc: President Barack Obama
Sally Jewell. Secretary. U.S. Dept. of the Interior
Matt Mead. Governor. State of Wyoming
Jessica Crowder. Policy Advisor. Office of Governor Matt Mead
Scott Talbott. Director. WY Game and Fish Department
Pete Obermueller. Executive Director. Wyoming County Commissioners Association

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# RESOLUTION # 2015-052

**TITLE: ENCOURAGING DELISTING OF GRIZZLY BEAR IN PARK COUNTY AND THE GREATER YELLOWSTONE AREA**

**WHEREAS,** the grizzly bear in Park County is listed as a threatened species under the Endangered Species Act (ESA) having been first listed by the United States Fish and Wildlife Service (USFWS) in 1975. Since that time the grizzly population in what is described as the Greater Yellowstone Area (GYA) has risen dramatically reaching, according to credible estimates, approximately five times their numbers at the time of the original listing; and

**WHEREAS,** as populations have risen, grizzly bears have expanded their territory into areas where they have been absent for a century. Much of this area is now inhabited by humans where, through the legitimate exercise of property rights, the land is now occupied by farms, ranches and residential properties. This human development will not be reversed. Thus, humans and bears will continue to live together on the same landscape for the foreseeable future. In Park County, people have learned to adapt to the bear's presence. However, many landowners and outdoor enthusiasts have lost patience with the lack of flexibility in managing conflict problems under the current federal ESA listing regime; and

**WHEREAS,** most experts agree that the bear's increased population over the last four decades has resulted in the grizzly bear approaching, meeting or exceeding its carrying capacity in core recovery areas including but not limited to Yellowstone Park. Increased bear numbers is the most likely reason for the bear's expansion into new territory, according to credible experts. The argument that the population is stagnant or falling and that the bears are simply moving out of core areas into new habitat, is not consistent with distribution studies and other on-the-ground observations. Bears remain healthy in core areas and have, in the case of some females, decreased the size of their home ranges in response to increased population density. This decrease in home range size in core areas argues against the theory that grizzly bears are vacating those core areas; and

**WHEREAS,** this Board notes its own significant and long-term experience traveling in the Greater Yellowstone Area backcountry. While grizzly sightings by Board members and/or their employees over the past several decades may be considered anecdotal and not scientifically reliable, these sightings in fact track population estimates and distribution patterns recognized by experts. This Board deems its own voluminous sightings and experiences with grizzly bears to be credible evidence in support of this Resolution; and

**WHEREAS,** good science and new technologies have assisted in monitoring the health of individual grizzly bears and of the population overall. Based on the current health of the population along with management systems and habitat protections now in place, experts agree the long-term recovery of the grizzly bear is secure. All targets that have been set through the years for grizzly bear recovery are being met and have been met for many years. The bear's ability to adapt to changes in the environment and food sources ensures that recovery goals will continue to be met.

While the digestive system of a grizzly bear is essentially carnivorous, grizzlies are successful omnivores as well. Their historic distribution indicates the bear's adaptive flexibility in food habits. Recent scholarly examination by the International Grizzly Bear Study Team (IGBST) continues to document this flexibility and demonstrates, for example, that while whitebark pine nuts are an important food source during late summer and fall for some grizzlies, depending on their home ranges, bears captured and sampled show similar body fat conditions in years of good pine nut production as compared with years of poor pine nut production.

Among other things, grizzly bears eat ground squirrels, ungulates, carrion, insects, grasses, clover, roots, bulbs, tubers, fungi, tree cambium, berries, nuts, fish and moths. As it concerns fish, recent reductions of lake trout in Yellowstone Lake through netting and other programs has led to improvements in the Yellowstone cutthroat trout population. As numbers of lake trout drop it is expected that cutthroat will increase. Successful reduction of lake trout in Yellowstone Lake constitutes a substantial effort in time, money and manpower that will have a positive effect on restoration of the grizzly's important cutthroat food source as well as having a positive effect on the natural environment overall and recreational opportunities within that environment. This Board applauds the efforts of those involved and encourages their continued work.

**WHEREAS,** the Wyoming Game and Fish Department (WGFD) has been actively involved in managing grizzly bears throughout the time of its listing under the ESA. The WGFD currently provides the bulk of on-the-ground management for grizzlies and is in large part responsible for gains in grizzly bear recovery, yet the WGFD lacks full administrative management authority. The WGFD believes the grizzly bear is recovered and that the bear should be managed by Wyoming along with the rest of Wyoming's wildlife. The WGFD has extensive knowledge and experience in managing this and other sensitive species and has adequate planning in place for future management of grizzlies including limited hunting opportunities; and

**WHEREAS,** the WGFD and other agencies have captured a multitude of bears over the years. Agencies typically extract DNA samples with each capture. Results of DNA sampling have not raised significant concerns among experts regarding genetic diversity. Furthermore, with increases in grizzly bear populations and expansion of ranges in the GYA and North Continental Divide population in Montana, experts state that the likelihood of male bears naturally finding their way between the population groups has increased. While the GYA grizzly bear is often referred to as an "island" population, the GYA is a *large* island with widely distributed bears. The population's size and distribution within the GYA are sufficient to provide adequate genetic flow in maintaining a recovered population. Those bears' genetic diversity has not significantly changed over the last century. The WGFD has studied this diversity utilizing the most current genetic science and is competent to continue their studies and provide management options which could include translocation from other populations to address any lack of genetic diversity should that ever occur in the future; and

**WHEREAS,** an endangered species is one that is "in danger of extinction throughout all or a significant portion of its range." A threatened species is one that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Clearly, based on the science applied in monitoring grizzly bears over the years, the grizzly bear in Park County and the Greater Yellowstone Area is *not* in danger of extinction nor likely to be in danger of extinction in the foreseeable future. The population is robust and has expanded its territory; and

**WHEREAS,** we agree with the general sentiment of Wyoming Governor Matt Mead that the continued expenditure of funds and manpower directed toward a recovered population of grizzly bears undermines the possibility for recovery of species that may actually be threatened;

**NOW THEREFORE BE IT RESOLVED** that the Park County Board of County Commissioners strongly encourages the United States Fish and Wildlife Service to move forward with all due haste in proposing a rule to delist the grizzly bear in the Greater Yellowstone Area including Park County.

**BOARD OF COUNTY COMMISSIONERS**
**PARK COUNTY, WYOMING**

Joseph E. Tilden, Chairman

Lee Livingston, Vice Chairman

Tim A. French, Commissioner

Loren Grosskopf, Commissioner

Bucky Hall, Commissioner

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# Angry talk won't solve wolf, griz issues

GUEST SHOT

*Matt Mead and Dan Ashe*

Todd Wilkinson, in an opinion published last Nov. 4 in the Jackson Hole News&Guide ("Mead can't deny the bear, lobo economics") ascribes to us thinking, motivations, philosophies and disagreements on wildlife conservation that do not exist. Undeniably, we face challenges of staggering scope and complexity, challenges we cannot solve alone. That is why the U.S. Fish and Wildlife Service and the state of Wyoming have chosen to work together, which benefits the people and the resources we are entrusted to serve.

It is true that we differ in some regards about the management of wolves, grizzly bears and other wildlife protected by the Endangered Species Act. We also differ on whether we are making satisfactory progress in delisting them once we agree the species are recovered. That is to be expected given the differing mandates and authorities under which we operate. However, we agree that Yellowstone grizzly bears and Rocky Mountain grey wolves are recovered.

In all our agreements and disagreements, neither of us has known the other to be anything but genuine in his concern for these species and respectful of their place and value in the ecosystem and economy. In fact, we agree with Mr. Wilkinson that wolves, grizzly bears and other wildlife are important to the economy of Wyoming and the West and that they make this a special place for residents and visitors. To be clear, where we have disagreements they are tactical, not strategic, and they have never prevented us from finding common ground.

We have made progress on wolves and grizzly bears by focusing on areas where we can agree and on finding solutions that work for both people and wildlife. That is made easier because we hold a common vision — that of a Wyoming and the West, where diverse, abundant wildlife populations share the landscape with the people who live here. We understood early in our working relationship that if we wanted to realize that vision we needed to make a place for wildlife while also keeping working families on the land. We needed to understand and reduce conflicts between people and wildlife. Conservation, at its heart, is about the relationship of people to wildlife and the land they share.

Pretending that the views and concerns of residents do not matter is a recipe for division and disaster. Working together at the local, state and federal level, we have largely succeeded because we endeavored to understand and address those concerns, not because we have dismissed these legitimate concerns as "pervasive, irrational and socially reinforced hatred" that will only die with the people who hold those views, as Mr. Wilkinson describes it.

The future of species and the spaces they need will not be met by belittling, divisive or angry speech. It takes the courage of conviction and the extending of a hand in friendship while recognizing that the person on the other side of the handshake has strong opinions and beliefs. It takes strength of character and a willingness to listen to others. Listening may not dislodge those opinions and beliefs, but it can light a path to progress.

The relationship built by the U.S. Fish and Wildlife Service and the state of Wyoming is strong and will outlast our terms of office. It has already produced other successes, the largest of which is the effort to conserve the greater sage grouse before Endangered Species Act protection was required.

When we speak about the Endangered Species Act we may have differing opinions about its future. More importantly, we agree that the law needs to and can work better. We can set aside rhetoric and set a course to find and listen to diverse and reasoned voices. One of us is using his position and influence within the Western Governors' Association to host such a dialogue. The other is supporting that effort as the best chance to find bipartisan consensus and possible improvements to the law.

Good public service, as distinct from good public spectacle, is best conducted with unclenched fists. We have succeeded in that endeavor while maintaining our core convictions and integrity.

Grizzly bears, gray wolves, greater sage grouse and other resources are the beneficiaries.

*Gov. Matt Mead is a Teton County native and the brother of News&Guide columnist Brad Mead. Dan Ashe is the director of the U.S. Fish and Wildlife Service.*

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Message from the President Advisory Council

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# Advisory Council

**EXHIBIT H**

A.C. Smid, Bear Trust International President, has extensive management experience as a business owner and consultant, and has successfully helped other nonprofit organizations focus their vision and activities toward refining and achieving their goals. Because of his intense love of the outdoors and personal knowledge of wildlife and habitat, combined with his professional background, Smid was approached with the idea of forming a nonprofit organization dedicated to wild bear conservation.

The Bear Trust came into existence following more than a year of intense discussions and numerous meetings with wildlife experts, bear researchers, conservation interests, grassroots organizations, private citizens and potential donors. Once the need for the organization was established, it was incorporated in Montana and received its 501(c)(3) designation.

Those who have been instrumental in creating the organization and helping design the program structure, and who are members of the Bear Trust Advisory Council include:

- Jack Ward Thomas, Ph.D., currently the Boone and Crockett Club Professor of Wildlife Conservation at the University of Montana and formerly U.S.D.A. Forest Service - Chief (1993-1996);
- John J. Craighead, Ph.D., of the Craighead Wildlife-Wildlands Institute, and Derek Craighead of Beringia South, who have engaged in extensive bear research throughout the Rocky Mountain area and Alaska;
- Robert W. Munson, co-founder and President Emeritus of the Rocky Mountain Elk Foundation and current Executive Director of the Theodore Roosevelt Conservation Alliance;
- Christopher Servheen, Ph.D., Grizzly Bear Recovery Coordinator, USFWS and Co-chair, IUCN/SSC Bear Specialist Group;
- Daniel Pletscher, Ph.D., Director of the Wildlife Biology Program at the University of Montana; and
- Robert L. Bailey, President of Robert Bailey Incorporated, a leading design firm specializing in branding, marketing, and web site development.

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EXHIBIT J

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March 20, 2006

Dr. Christopher Servheen
Grizzly Bear Recovery Coordinator
U.S. Fish and Wildlife Service
University Hall 309
University of Montana
Missoula, MT 59812

Dear Dr. Servheen:

We, the undersigned scientists, write to express our opposition to the U.S. Fish and Wildlife Service proposal to remove the Yellowstone grizzly bear population from the list of threatened and endangered species under the Endangered Species Act. See 70 Fed. Reg. 69854-69884 (November 17, 2005). The Yellowstone grizzly bear population faces significant threats to recovery because of its small size, significant annual fluctuations in mortality rates, inadequate habitat protections, major threats to key foods, genetic risks, and proposed additional human-caused bear mortalities.

Population Size: An isolated grizzly bear population of 500-600 bears is not a biologically recovered bear population. In order to withstand regional-scale stochastic events and to provide for genetic diversity, a population of 2,000-3,000 bears is needed. The grizzly bears are currently listed as a threatened species throughout the lower-48 states. Recovery efforts should focus on reconnecting Yellowstone-area bears to bears in the Glacier Park/Bob Marshall area and a stable population in central Idaho in order to achieve metapopulation dynamics and promote long-term recovery.

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Significant Fluctuations in Annual Mortality Rates: Small populations of bears tend to experience significant variation in annual mortality rates and are likely to decline and go extinct. In the Yellowstone grizzly bear population, this anticipated annual variation in bear mortalities is exacerbated by increased bear-human conflicts and mortalities in years when whitebark pine seed cones in remote, high-altitude areas are not abundant. Managers need to provide further protections to minimize mortality for Yellowstone bears to buffer this added extinction risk.

Inadequate Habitat Protections: Habitat protection is essential to maintain, restore, and recover populations of endangered species. Long-term protection of essential grizzly bear habitat after the proposed delisting of the Yellowstone grizzly population has not been assured. Many lands currently occupied by Yellowstone-area grizzlies receive no protections under the delisting proposal because they are outside of the designated recovery zone. Lands necessary to connect Yellowstone bears to other populations are not protected. Even within the recovery zone, necessary restrictions on roadbuilding and habitat destruction rely on an enforcement mechanism—U.S. Forest Service National Forest Plans—that a recent Bush administration rulemaking has declared "nonbinding." Thus, necessary habitat protections to achieve recovery or even maintain current population levels are not in place. During bad food years there will be nowhere else for grizzlies to go; managers need to allow for alternative habitat and food sources.

Major Threats to Key Foods: The Yellowstone grizzly bears feed heavily on four key foods. All of these key grizzly bear foods are already currently in decline or face significant threats to their distribution and abundance. Whitebark pine, the keystone food source, is declining in many portions of the Yellowstone area due to mountain pine beetles, white pine blister rust, and global warming. Yellowstone cutthroat trout have been reduced due to the introduction of lake trout in

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Yellowstone Lake. Army cutworm moths may suffer declines due to various agricultural practices. Ungulate populations may be reduced by factors such as the spread of chronic wasting disease or various management practices. The uncertainty of the continued abundance and distribution of these key bear foods poses threats to the Yellowstone bear population.

Genetic Risks: A small population faces extinction risks arising from loss of genetic variation that may prove essential to the population's long-term survival. The Yellowstone grizzly bear population has effectively been isolated for more than seventy years. The FWS has estimated that the population may have been reduced to roughly 200 bears in the 1970s. Currently, the genetic effective population size ($N_e$) is about 125 bears; much lower than the general scientific consensus of 500 or more for long-term persistence. DNA studies have documented that Yellowstone bears' genetic material is not as diverse as those of other grizzly bear populations in the lower-48 states. Because of concerns about the loss of genetic diversity, the FWS has stated that it will continue to monitor the genetic make-up of the Yellowstone grizzly population, and will relocate two bears every ten years to address genetic concerns. The ESA requires recovery of endangered populations in the wild; the Yellowstone grizzly bear population must be large enough to survive in the wild without chronic augmentation to address genetic concerns. In addition, if the Yellowstone population truly is a Distinct Population Segment due to unique genetic characteristics as the FWS claims, then introducing genes from other populations will destroy that uniqueness.

Proposed Additional Human-Caused Bear Mortalities: In addition to the serious threats that Yellowstone bears face even with the full protections of the ESA, a delisted bear population would be subject to intentional additional bear mortalities associated with proposed hunting seasons. For a relatively small population, any additional deliberate human-caused mortalities will have significant population impacts.

We, the undersigned scientists believe that there are many reasons that the Yellowstone grizzly bear population is not biologically recovered and should not be removed from the list of threatened and endangered species.

Sincerely,*

Lance Craighead
on behalf of the
Craighead Environmental
Research Institute
and the listed scientists


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continued in petition file...

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**EXHIBIT K**

May 5, 2016

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TOTAL = 66

Re: FWS-R6-ES-2016-0042; Greater Yellowstone Ecosystem Grizzly Bears

Dear Secretary Jewell and Director Ashe:

We, the undersigned scientific experts, are writing to express our strong opposition to the proposal by the U.S. Fish and Wildlife Service (FWS) to remove the grizzly bears (*Ursus arctos horribilis*) living in the Greater Yellowstone Ecosystem (GYE) from protection as a threatened species under the Endangered Species Act (ESA),[1] leading to Northern Rockies states' commencement of an unsustainable trophy-hunting[2] season on GYE grizzly bears, which continue to be imperiled by resource declines, including habitat and dietary staple losses.

**GYE grizzly bears are not recovered.** Before 1800, approximately 50,000 grizzly bears roamed the lower 48 states between Canada and Mexico.[3] After European settlement, humans heavily persecuted grizzly bears to near eradication.[4] Today, wild grizzly bears number fewer than 1,700 individuals in the lower 48 states[5] - while FWS claims that there are 700 grizzly bears in the GYE,[6] this is a contested figure.[7] Grizzly bears have not recovered across a significant portion of their range, and thus they are not recovered and should not be delisted.

**Trophy hunting grizzly bears would further jeopardize their persistence.** Pursuant to a tri-state memo, Northern Rockies states have allocated bears for the purposes of "discretionary mortality available for regulated harvest" within the Demographic Monitoring Area (DMA)[8] as follows: Wyoming would authorize hunting for 58% of the bear quota, Montana 34% and Idaho 8%.[9] The number of grizzly bears states will permit for trophy hunting is unknown. While Wyoming has issued a draft grizzly bear management plan, it would inadequately protect GYE grizzly bears in the absence of a federal ESA listing because it gives broad discretion to the Wyoming Game Commission to set the manner of take (e.g., baiting, hounding, trapping, stalking), bag limits, seasons, sex ratios and age limits for grizzly bear hunting.[10] How Idaho or Montana will permit grizzly bear hunting is also currently unknown. Under this veil of uncertainty, the FWS is rushing to close the public comment period (ignoring reasonable requests for a deadline extension justified by the voluminous documents released by FWS) in order to rapidly delist grizzly bears for what appear to be more political than scientific reasons. Such action conflicts with the ESA requirement to make listing decisions solely on the basis of the best scientific evidence available and to seek meaningful public comment on listing decisions.

**Grizzly bears face multiple threats to persistence** including the loss of their primary food resources. Currently, whitebark pine seeds, native cutthroat trout, huckleberries, army cutworm moths, elk and bison are either declining and/or are expected to decline in the foreseeable future as a result of habitat loss, climate change, drought, invasive species and other anthropogenic causes. Traditionally, whitebark pine seeds have provided a core dietary staple for grizzly bears. Yet, the whitebark pine, a species the FWS agrees warrants federal protection, is in decline because of a variety of problems.[11] Another key source of sustenance, the cutthroat trout, has stopped spawning in all tributaries of Yellowstone Lake.[12] Army cutworm moths, a staple for grizzly bears since the late 1990's, could likely disappear because they nectar on tundra flowers, which are highly vulnerable to global warming. Added to these threats to the sustainability of the GYE grizzly bear population, Yellowstone's Jackson and Northern Range elk herds and its Central Range bison herd are all in decline.[13] Because of warming summer temperatures and drought severity since 2005,[14] berries have become largely unavailable to grizzly bears. These food failures—whitebark pine, cutthroat trout, huckleberries—have caused grizzly bears to switch to a more meat-based diet, including domestic livestock. As a result, bears have been in conflict with humans, leading to record numbers of lethal actions taken against them.[15] This additive mortality harms their persistence.[16] Furthermore, biologists have noted that grizzly bear cub production has declined[17]—perhaps because of more predation on cubs by wolves and other bears as a result of their new dependence upon a meat-based diet, which puts them into greater proximity with other predators, resulting in deadly strife on grizzly bear cubs.

The loss of flora and fauna upon which grizzly bears depend in Yellowstone and Grand Teton national parks, in part, explains why grizzly bears are dispersing in greater numbers from park lands to national forests lands, which are grazed by public lands permittees, to search for food. Because of ubiquitous livestock outside of park lands, record numbers of grizzly bears have had lethal encounters.[18]

Worse, if grizzly bears are delisted, the GYE bears who already live or disperse outside of the DMA's artificial boundary will not be counted toward states' population objectives and will likely be subject to persecution. Yet, these dispersing individuals are vital for providing connections between other populations, maintaining *genetic diversity* and preventing *genetic drift* and *inbreeding depression.*[19]

While the conclusions of certain studies upon which the FWS relies suggest that grizzly bears have reached their carrying capacity, there is ample support for an alternative theory that bears have lost their historic dietary staples and are now turning to both native and domestic ungulates, putting them in closer proximity to humans, wolves and/or other bears.[20] While this shift is occurring it is impossible to predict whether and when the GYE grizzly bear population might reach "carrying capacity". FWS is not scientifically justified in concluding with certainty that the GYE population has reached long-term stability and is therefore secure for the foreseeable future. There is far too much uncertainty reflected in the current science to justify such a conclusion; rather, the best available science and the precautionary principle demands continued federal monitoring of this vulnerable population, which will only happen with continued ESA protection.

**The public highly values grizzly bears.** In 2015, Yellowstone received 4.1 million visits and Grand Teton had 4.6 million contributing $890 million to Wyoming's gateway communities, and $1.1 billion to Wyoming's overall economy. These figures greatly outweigh revenues generated by either Wyoming's livestock or hunting industries.[21] Grizzly bears, in the human economy, are worth far more alive than dead.

For all of these reasons, we urge you not to remove grizzly bears from protections under the ESA. Now is the time to redouble grizzly bear conservation efforts, not decrease them.

Signed:

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**References:**

[1] 81 Fed. Sup. 1374 (3/11/16): https://www.gpo.gov/fdsys/pkg/FR-2016-03-11/pdf/2016-05167.pdf
[2] *Trophy hunting* is the practice of killing or pursuing with the intent to kill a grizzly bear (or other wild animal) where the primary motivation is to obtain the animal for display, in whole or in part, or for bragging rights. The Associated Press obtained and released a leaked (12-4-2015) "Memorandum of Agreement Regarding the Management and Allocation of Discretionary Mortality of Grizzly Bears in the Greater Yellowstone Area.
[3] http://www.fws.gov/mountain-prairie/es/grizzlyBear.php
[4] Schwartz, C. C., S. D. Miller, M. A. Haroldson. 2003. Grizzly Bear (Ursus arctos) in Wild Mammals of North America: Biology, Management, and Conservation. Johns Hopkins University Press, Baltimore, Maryland.
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[6] http://www.nps.gov/yell/learn/nature/gbearinfo.htm
[7] Doak, D.F. and K. Cutler. 2014. Re-Evaluating Evidence for Past Population Trends and Predicted Dynamics of Yellowstone Grizzly Bears. Conservation Letters 7(3)313-322. David Mattson, "Http://Www.Grizzlytimes.Org/#!Honest-Science/C1ch8".
[8] The DMA is the geographic area where state wildlife agencies will monitor the grizzly bear population. The FWS's Rule also calls it the Primary Conservation Area.
[9] Virgil Moore, M. Jeff Hagener, and Scott Talbott, "Final Draft 12-4-2015: Memorandum of Agreement Regarding the Management and Allocation of Discretionary Mortality of Grizzly Bears in the Greater Yellowstone Area," *AP Story at: http://bigstory.ap.org/article/a4738ff1a2c14920b0c45063302d5c4e/apnewsbreak-states-divvy-yellowstone-area-grizzly-hunt*, (2016).
[10] Wyoming's House Joint Resolution on gray wolves and grizzly bears characterizes both with unbridled animosity: gisweb.state.wy.us/2016/bills/HJ0004.pdf. Wyoming Game and Fish Department, "Draft Wyoming Grizzly Bear Management Plan," *https://wgfd.wyo.gov/WGFD/media/content/Wildlife/Hot%20Topics/FINAL-DRAFT-GB-Mgmt-Plan-3-15-16.pdf*, (2016).
[11] The FWS writes: "Threats to the whitebark pine include habitat loss and mortality from white pine blister rust, mountain pine beetle, catastrophic fire and fire suppression, environmental effects resulting from climate change, and the inadequacy of existing regulatory mechanisms." http://www.fws.gov/mountain-prairie/species/plants/whitebarkpine/
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[13] D. D. Bjornlie et al., "Whitebark Pine, Population Density, and Home-Range Size of Grizzly Bears in the Greater Yellowstone Ecosystem," *Plos One* 9, no. 2 (2014); C. M. Costello et al., "Influence of Whitebark Pine Decline on Fall Habitat Use and Movements of Grizzly Bears in the Greater Yellowstone Ecosystem," *Ecology and Evolution* 4, no. 10 (2014); F. T. van Manen et al., "Density Dependence, Whitebark Pine, and Vital Rates of Grizzly Bears," *Journal of Wildlife Management* 80, no. 2 (2016).

[14] Bjornlie et al., "Whitebark Pine, Population Density, and Home-Range Size of Grizzly Bears in the Greater Yellowstone Ecosystem; Costello et al., "Influence of Whitebark Pine Decline on Fall Habitat Use and Movements of Grizzly Bears in the Greater Yellowstone Ecosystem; van Manen et al., "Density Dependence, Whitebark Pine, and Vital Rates of Grizzly Bears."

[15] Figure 8 of Wyoming's plan shows that since 1990 an increasing trajectory in both self defense and management removals of grizzly bears. Wyoming Game and Fish Department, "Draft Wyoming Grizzly Bear Management Plan."

[16] Because of human-bear conflicts over domestic livestock and hunter-killed ungulates, significantly more bears have been killed since 2005 compared to the period 1990-2004. See: IGBST's grizzly bear mortality data base: http://www.nrmsc.usgs.gov/science/igbst/mort.

[17] van Manen et al., "Density Dependence, Whitebark Pine, and Vital Rates of Grizzly Bears."

[18] See: IGBST's grizzly bear mortality data base: http://www.nrmsc.usgs.gov/science/igbst/mort.

[19] *Genetic diversity* increases a species' chances of long-term survival because negative traits (such as inbreeding) become widespread within a population when that population is left to reproduce only with its own members. *Genetic drift* refers to a populations' loss of genes, making a population less vital, more disease prone, and unable to overcome natural disasters. L. S. Mills and F. W. Allendorf, "The One-Migrant-Per-Generation Rule in Conservation and Management," *Conservation Biology* 10, no. 6 (1996).

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**EXHIBIT L**

# Grizzly Sardine Can Blues

**December 17, 2015**

**David Mattson**


We can't support any more bears. We've got bears coming out of our ears. We've reached carrying capacity. Such is the purported state of grizzly bears in Yellowstone.

Sound familiar? It should. For those of you who have been paying attention to the rhetoric voiced by agency spokespeople during the last few years, you will have heard the refrain about too many bears in too little space over and over again. In fact, this claim undergirds much of the argument made by the US Fish & Wildlife Service (FWS) and state wildlife managers for removing ESA protections from Yellowstone's grizzlies (which is to say, "delist" them). Just a few weeks ago, in a conversation with environmentalists, FWS Director Dan Ashe emphasized that "the Yellowstone ecosystem just can't hold any more bears." Frank van Manen, leader of the Interagency Grizzly Bear Study Team (IGBST) put it another way: "we are packing more sardines in the sardine can."

If you were inclined to defer to the agency experts, you would probably heave a sigh and say, "well, I guess we just need to move ahead with delisting Yellowstone's grizzly bears. We've reached carrying capacity." In fact, that is the outcome that the agency experts probably hope for and expect.

Well…I would argue that there is cause to question the experts in this instance. In fact, there is an increasing and to my mind wholly justified tendency for the public to question experts, especially when there is reason to suspect that they are politically motivated. And there is ample evidence for political motivations behind what we are hearing from spokespeople for all of the agencies involved in managing Yellowstone's grizzly bears, including the government's scientists (for more on this follow this link and this link).

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**Unpacking the Sardine Can**

To start, it is worth unpacking the concept of "carrying capacity" given that this term is being bandied about with such abandon by government scientists and managers. To listen to van Manen you would think that the number of grizzlies able to live in the Yellowstone ecosystem (i.e., "carrying capacity") is a static food-related attribute of the land contained within a fixed box. Hence the sardine metaphor.

The truth could hardly be more different. Even accepting the notion of fixed boundaries, within those bounds the food-related capacity of any given acre varies from month to month and year to year. In fact, we've seen a long-term and sustained decline in the availability of high-quality foods that has almost certainly caused a decline in the intrinsic food-related capacity of Yellowstone's core habitat to sustain grizzlies. Cutthroat trout have nearly disappeared; whitebark pine has been substantially reduced; and elk herds have declined, some dramatically. That's three of the four legs of the food stool that has supported Yellowstone's grizzly bears (the fourth leg is army cutworm moths). All of the evidence belies any claims, implicit or otherwise, that food-related carrying capacity is static. If anything, the sardine can has shrunk in size.

More importantly, carrying capacity is determined not only by the food-driven rate at which females produce cubs, but also by the rate at which grizzly bears of all description die. So, mortality is a major part of the equation. And guess what causes most deaths of adult grizzlies in Yellowstone? People do. So our lethality to bears is a big part of the carrying capacity equation. Which comes down to our collective attitudes and behaviors, and the extent to which they translate into dead bears. More on this a little later.

And the rate at which young bears (i.e., cubs and yearlings) die also matters. As it turns out, death rates of cubs and yearlings have increased substantially of late, primarily due to "natural" causes—including bears killing bears. Again, to listen to van Manen you would think that young bears in Yellowstone are dying in increasing numbers simply because of increasing densities of adult grizzlies, likening these adults to a bunch of equally lethal pinballs bouncing around according to some random Brownian motion in a fixed space. Too many damn sardines. More on this a little later as well.

The notion of fixed boundaries to an immutable box is a final major fallacy in the government's "carrying capacity" argument. The capacity of Yellowstone's ecosystem to support grizzlies is determined not only by the per acre abundance of foods and the unit area lethality of the landscape, but also by the extent of the area within which bears can live and contribute to the larger population. And clearly, this extent has increased substantially over time. We have grizzlies living in roughly twice the area we had them in the 1970s. Moreover, there have been multiple analyses, by government and independent scientists alike, showing that there is ample habitat with natural foods sufficient to support grizzly bears in places where grizzlies have not yet established themselves: the southern Wind River Range, the Palisades area, the Centennials, and more.

**A Social Sardine Can?**



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And, yet, the FWS and their minions claim that the box is fixed, invoking yet another pseudo-idea, that of "social carrying capacity." More to the point, the FWS claims that there is no more space for grizzlies in Yellowstone because "people" will not accept them anywhere else. So now we have gone from the simplistic static, food-based, box of van Manen's to a concept fielded by the FWS that begins to grapple, at least on the face of it, with the aspect of carrying capacity that relates to human attitudes and lethality.

But who are these "people" anyway, and who queried them, how? As it turns out, "people" amount to ranchers, outfitters, and others with enough political clout to bully not only state wildlife managers, but also the FWS. As a result, "social carrying capacity" has been defined by a few regressive energy executive as well as some sheep and cattle ranchers who don't want to live with grizzlies, not by the people whom the agencies are supposed to be serving under the rubric of the public trust. "Social carrying capacity" turns out to be a convenient political ruse, not any sort of on-the-ground reality determined by the attitudes, choices, and behaviors of a wide range of relevant people. In fact, the sardine can could be a whole lot bigger.

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### The Density Ruse

So, let's return briefly to the density issue, which is closely tied to the notion of carrying capacity and blithely invoked to explain rising deaths of young bears. Have grizzly bear densities actually increased, as van Manen claims? And, if so, are high densities the reason for increasing death rates among young bears? Well, the answers are No, and Probably Not. As it turns out, the Yellowstone grizzly bear population has not increased to any extent during the last 15 years. It may have even been declining since 2007 (see some info on all of this here and here). At the same time, the distribution of this population has increased by over 40%. Ergo, density axiomatically decreased—not increased. Which debars a connection between deaths of cubs and yearlings and densities of adults, as such. More likely, cubs and yearlings are dying in greater numbers because their moms have turned increasingly to eating meat (including livestock) to compensate for losses of whitebark pine and cutthroat trout. And meat-eating is an incredibly hazardous undertaking for any bear, especially those with vulnerable young (for more information follow this link).

Putting this all together, we have a narrative being promoted by our government officials that is based on a simple-minded, poorly conceived, and highly-politicized notion of this thing called carrying capacity. Moreover, the government narrative is at odds with the best available evidence. All of this politicized spin being billed under the rubric of "science" is clearly designed to support the agenda of delisting Yellowstone's grizzly bears.

### Out of the Sardine Can

In fact, what we have is a picture altogether different from that being painted by government managers and scientists. We have a box with highly fungible and potentially much expandable boundaries within which we have experienced major declines in food-related carrying capacity, but within which, also, we've increased carrying capacity attributable to major beneficial changes in human attitudes and behaviors—related to increased sanitation, other controls on human foods, and reductions in livestock. Bear densities have declined, at the same time that distributions have expanded and grizzlies have turned to eating alternative foods, many of which are concentrated on the peripheries of the current ecosystem. This is not a sardine can being crowded by ever greater numbers of sardines.

But perhaps the most important point is one that features us—and what goes on between our ears. History has shown that perhaps the most important determinant of the numbers of grizzly bears that can live in any given area is our behaviors. In turn rooted in our worldviews; how we see ourselves in relation to the world and to the creatures in it. There is no doubt that our European ancestors saw no place for grizzlies in the world. And they proved it by killing 99% of all grizzlies in 98% of all the places they once lived. But we are not our ancestors.

We have the chance to create a world where grizzlies and people coexist in places where we probably can't even imagine it is possible. But, believe me, it is possible. Grizzlies have proven that they can tolerate us and live among humans with few problems. The famous mother grizzly of Pilgrim Creek, bear #399, is one among many that has proven the point (for some more information on her see this Christian Science Monitor article). It comes down to us, and the grace and compassion we can bring to coexisting with grizzly bears.

Director Ashe and Dr. van Manen are wrong. We can have more grizzly bears in Yellowstone. And we should have.

## Food Fight: the Debate Over Grizzly Bear Foods

**By Dr David Mattson**

In 2009, federal endangered species protections were restored for the Yellowstone grizzly bear population in response to a court ruling that found that the government had failed to evaluate the effects of the collapse of whitebark pine, a key staple for the population. In 2013, the Interagency Grizzly Bear Study Team (IGBST) issued a report, "Response of Yellowstone grizzly bears to changes in food resources: a synthesis", that concluded that whitebark pine was not essential for recovery of the Yellowstone grizzly bear. The IGBST is currently publishing a series of related papers designed to pave the way toward another delisting rule.

This report has serious conceptual and other problems that show evidence of a political agenda, rather than a fair objective analysis of the science to serve the broader public interest. All of the publications that eventually presented the material covered in the Synthesis report suffer from the same flaw. The Report also flatly contradicts an overwhelming body of earlier government science showing the importance of whitebark pine to the health of the Yellowstone population, and it fails to come to grips with its own more recent data showing that, in response, bears are turning more to meat – with increasingly lethal results. The Report furthermore suggests that since bears are omnivores, all foods are interchangeable; in other words, a salad is the same as a steak dinner. This palliative clearly fails at face value.

The adamant refusal over the last two decades by the government to allow its underlying data to be seen by outside parties is especially disturbing, especially given that taxpayers footed the bill. The solutions to the problems of the report, discussed below, include releasing all raw data for outside scrutiny, an independent outside review of the science, and a fundamental reform of the governance process to reflect the broader public trust.

"Response of Yellowstone grizzly bears to changes in food resources: a synthesis": Rebuttal by Dr. David Mattson

The appraisal of this Report was shaped by fundamental precepts related to the public trust. The scientists who undertook and reported the research in the Report and the managers who facilitated, funded, and hastened this work are all directly or indirectly financially supported by tax payers. This means they hold a special obligation to the public to undertake, report, and apply science in a neutral and non-partisan manner. This holds especially for the USGS scientists and USFWS managers who work directly for the public and are more directly public trustees and spokespeople. Put another way, government scientists and managers who promulgate science that is distorted by a partisan agenda betray the public trust. Evidence of partisan and politicized science should be of concern to anyone who cares about good governance and a healthy democracy.

Strong evidence of a partisan political agenda need not be evidence of deliberate intent or malfeasance. No doubt the scientists who undertook the reported research think of themselves as "objective" scientists. In fact, several of them have publicly strongly asserted the case. The notion of being "objective" is a core part of most scientists' identity. But the insidious aspect of this self-narrative is that it is invariably self-deceptive. All humans, including scientists, are slaved to their subjectivities and especially prey to bias when they fail to reflect deeply and instead bind themselves to a deceptive narrative of "objectivity" and surround themselves with a community of others who

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share, either explicitly or implicitly, a common normative purpose. "Group think" is one common outcome. By all of the evidence, such was the case with the scientists and managers involved in producing the Report.

The following comments are organized under broad themes, beginning with those of greater and over-arching importance and ending with a sampler of more detailed problems that, by and large, ground the main points.

The reported research is poorly conceptualized and inattentive to important system dynamics

This problem deeply taints and permeates all of the reported research and manifests in three fundamental ways:

**(1) The Report does not offer a coherent and well-articulated framework for understanding bear responses to dietary changes.** Perhaps the best way to illustrate this point is by offering a conceptual frame that is, in fact, not only useful but also vital to structuring research questions and interpretations. Diet and feeding behaviors will affect bears in two fundamental ways: (i) nutritionally and (ii) by affecting hazards; i.e., the likelihood of dying. The first effect is self-evident. The net energetic benefit and fat content of foods are especially important to female condition and reproduction. Less fat and less energy gain will decrease reproductive rates—both the likelihood of reproducing and the number of cubs produced. The second effect pertains to whether use of different foods brings bears more frequently into hazardous conditions or not. This happens when use of a food brings bears more often near potential predators, especially ones that are highly lethal. Insofar as adult Yellowstone's grizzlies are concerned, humans are far-and-away the most lethal predators, especially humans who are armed and intolerant—notably many hunters and livestock producers. Insofar as cubs and yearlings are concerned, wolves and other adult bears are additional hazards.

In this context, it is worth assessing Yellowstone's bear foods in terms of potential nutritional benefits and relative hazards. Cutthroat trout, army cutworm moths, ungulates, and whitebark pine seeds have been energetically the richest and most abundant bear foods in the Yellowstone ecosystem. Moreover, moths, pine seeds, and ungulates during fall are a rich source of fat. On this basis, moths and fall ungulates are energetically good replacements for whitebark pine seeds—assuming that the abundance and distributions of these foods are comparable.

Insofar as hazards are concerned, any food that tends to be distributed in areas or in ways that reduce exposure to humans, wolves, and other adult bears is a superior food. There is no doubt that whitebark pine seeds have been the safest food for females and their cubs to consume. Moths are remote from humans, but tend to concentrate bears near each other. By contrast, meat is indisputably the most hazardous food for of all ages and both sexes to eat, especially when consumption of meat increases exposure of cubs and yearlings to wolves and other bears—as with the scavenging of larger carcasses—or to armed intolerant people—as with scavenging of guts piles and other remains left by hunters, and with depredation or scavenging of livestock.

Parenthetically, the Report's authors conflate farness from roads with the hazards of foraging. Hence, the awkwardness of the authors asserting that bears do not forage in less safe areas (i.e., nearer roads) in the absence of whitebark pine seeds, while at the same time presenting results showing that more bears die during poor seed crops and that more bears concentrate near roadsides. Some foods (e.g., yampa, pocket gophers) do bring bears nearer people, but often under circumstances where the involved people are not particularly lethal—as in Yellowstone Park. On the other hand, meat can draw bears into highly lethal circumstances, not uncommonly involving gut piles and livestock, in areas that are greater than 500m from a road.

In summary, whitebark pine seeds indisputably have been the safest and nutritionally most beneficial food for Yellowstone's female grizzlies, and the turn to eating more meat has probably yielded comparable energetic returns, but with substantially increased hazards to the bears. Thus, one would not expect any dramatic downturn in body condition or cub production with loss of whitebark pine, but, rather, an increase in mortality among cubs and yearlings everywhere and among adults outside of the National Parks where adults are exposed to livestock producers and big game hunters.

Which is exactly the result of the research presented in the Report. Nonetheless, the Report's authors leave readers with the impression that loss of whitebark pine has been of no consequence to Yellowstone's grizzly bears. Moreover, the reported research does not in any way address trends in meat resources, elk and bison in particular, nor other major trends in Yellowstone's grizzly bear habitat which would almost certainly affect the behaviors and vital rates investigated by the Report's scientists; which leads to the next point.

But before moving on it is worth emphasizing a critical conclusion: despite its advertised purpose, this Report offers a remarkably simple-minded and even incoherent framework for, in fact, understanding bear responses to dietary changes. Moreover, this lack of coherency allows for and even encourages post hoc arguments and interpretations that accommodate a partisan representation of the research results. This is, quite simply, shoddy science which cannot be remedied by any amount of statistical gimcrackery.

**(2) The Report does not explicitly consider the effects of other on-going trends in Yellowstone's grizzly bear foods and habitat.** It is in some ways remarkable the extent to which the Report's scientists bounded their consideration of environmental effects. Despite reference, when convenient, to the diversity of Yellowstone's grizzly bear diet, with emphasis on moths, cutthroat trout, ungulate meat, and whitebark pine seeds as being energetically the most important, virtually all of the reported research explicitly considers only changes in whitebark pine seeds. Change in abundance of whitebark pine is then competed with the effects of a variety of different time periods and an index of density to explain changes in behaviors and vital rates. Period.

This circumscription of effects considered by the Report's authors is bizarre in light of demonstrable trends in Yellowstone's grizzly bear habitat (Figures 1-7; appended). Just as a sampler, the period (1983) 1989-1999 saw the advent and increasing use of moths and moth sites, peak abundance of elk and the central Yellowstone bison populations, abundant spawning cutthroat trout, slightly elevated growing season temperatures, and comparatively wet growing seasons. The period 2000-2004 saw not only the beginning of the decline of whitebark pine, but also intermediate-sized cone crops, the beginning of the decline of elk populations, major declines in cutthroat trout, and a period of exceptionally severe drought. Finally, by contrast, the period 2007-2012 saw nigh on to catastrophic declines of some elk populations, whitebark pine seeds, and cutthroat trout, highly variable but warm growing seasons, intermediate levels of drought, increased numbers of bears on moth sites, and (on average) increased cone crops on the whitebark pine trees that had survived. Which begs the question: Why did the Report's authors not explicitly consider any of these other habitat effects (but see comments on the partisan nature of the science below)?

All of these other habitat changes are correlated with time. This translates into a critical short-coming in virtually all of the reported research. All of these other habitat changes are subsumed in the putative effects of the various time periods that the Report's authors employ or in the index of density, which is also correlated with time. Which leads to the concluding point of this section: time period and "density dependence" are essentially meaningless as explanations for anything.

**(3) The Report deploys concepts that are essentially meaningless as alternate explanations for behaviors and vital rates.** Time period, in and of itself, is self-evidently without any meaning other than as a surrogate for other things that might be going on. This is, in fact, how time period is employed in their analyses by the Report's authors. But they then arbitrarily delimit what time period means, without any consideration given to the many other substantial habitat changes afoot (Figures 1-7). All of the other habitat effects are subsumed within, undifferentiated and unacknowledged. At best this could be considered a result of thoughtlessness and lack of sophistication.

Likewise, several particularly thoughtful scientists have remarked that "density" is not a mechanism, but, rather, a surrogate for interactions of animals with each other and with other species organized in space and around resources. Increasing densities of bears (assuming such has been the case) do not somehow automatically result in bears spontaneously dropping dead or failing to give birth. A good share of the "effects" of density on birth and death rates are a result of real interactions with other bears and with other species such as wolves and people, strongly influenced by the extent to which there is scramble competition for foods or accessing foods affects hazards (see above). More specifically, it is likely that the decline in cub and yearling survival is less a consequence of density, as such, and more a consequence of increasing reliance by female bears on meat, where cubs and yearlings are at greater risk of death from other bears, wolves, and humans.

As a final note on the density concept, the Report's authors deploy the term as if density-dependent effects have been amply demonstrated for bears in multiple areas. However, the only research they (repeatedly) reference was undertaken in Sweden in habitat that was (by all indications) relatively static and in which human lethality was better controlled than in the Yellowstone ecosystem, which would allow for greater attribution of demographic effects to social interactions of bears, as such (i.e., "density"). This key contextual difference essentially debars any relevance to the highly dynamic conditions of Yellowstone's grizzly bear habitat. But the Report's authors do not anywhere note this critical consideration.

As a bottom line, the substitution of "density" and abstract time periods by the Report's authors for the host of other environmental effects afoot, and their related assertions about the putative effects of these non-factors is disingenuous, thoughtless...and shoddy science.

## There are other issues with the report

The extent to which the reported research substitutes pseudo-variables for a number of important habitat dynamics alone precludes giving much credence to any of what the Report (and derivative publications) offers. In addition, any substantive appraisal depends, at a minimum, on access to the full manuscripts and details of methods and, better yet, on access to the data that were used. However there are issues with the research and the Report, even taking the results at face value.

**(1) There are major problems with the interpretation of research results by the Report's authors.** As noted above, some of the reported research provides support for an alternative coherent story—not articulated by the Report's authors—about what has happened during the last 10-15 years with behavior and demography of Yellowstone's grizzly bears. Use of whitebark pine has apparently declined along with selection for whitebark pine habitats, but with continuing effects of whitebark pine seed crop size on frequency of roadside feeding and levels of mortality both within and outside the recovery zone, at the same time that grizzlies have increasing turned to eating meat with accompanying increases in cub and yearling mortality. This story is consistent with other data not presented in the Report: of mounting depredation and conflicts with livestock producers especially to the southeast of the ecosystem and of a long term trend toward proportionately increasing conflicts with hunters. There has also been a symmetrical proportional increase in number of grizzly bear deaths linked to livestock and hunters along with substantial increases in absolute numbers of grizzlies dying. This increasing mortality coupled with longer-term declines in recruitment would readily explain the stalling if not decrease in the Yellowstone grizzly population. This is a compelling account supported by the available evidence, yet the authors of the Report give such an interpretation no credence whatsoever in their apparent rush to conclude that whitebark pine has had no effect on the Yellowstone grizzly bear population.

By contrast, all of the evidence offered by the authors that might be considered at odds with the alternate interpretation offered here is either highly suspect, extraneous, or deeply contradictory. For example, the authors' claim that, when whitebark pine is less abundant, bears do not forage in more hazardous environments, is at odds with the turn to eating more meat, continued increases in bear mortality, increasing conflict with hunters and livestock producers, and the stalling (if not decline) of the population. None of these contradictions are adequately explained by the authors, which compounds the problem noted before of the erroneous equation of remoteness from roads with the hazards of using different foods. The analysis of vital rates is rendered more or less meaningless by use of time period (and, by implication, density) as an explanatory variable (see above) and fails to reconcile the described changes in reproductive and survival rates with the flattening if not decline in population growth. At best the authors imply (but don't state outright) that reduced cub and yearling survival resulted in slower population growth—while at the same time making the contradictory case that adult female survival was the more critical phenomenon. Moreover, it is unclear why the authors chose to focus on (in effect) reproductive interval rather than litter size when previous research has shown litter size to be more sensitive to availability of whitebark pine seed crop size. Finally, results of the home-range-size and movements analyses only relate very weakly and indirectly to the issues of diet, hazards, and vital rates.

Of relevance here as well, the Report's authors fail to reconcile their results with the large body of previous research showing major effects of whitebark pine on behavior and demography of Yellowstone's grizzly bears. As the authors note, this previous research demonstrated substantial effects of whitebark pine on distributions of bears, conflict with humans, use of alternate foods, and reproductive and survival rates. On the one hand the Report's authors seem to claim that consumption of meat has fully compensated demographically and otherwise for loss of whitebark pine, but then fail to present any direct evidence of a meat effect on either reproduction or survival, while at the same time presenting evidence of continuing effects of whitebark pine on levels of mortality. The authors also fail to address previously-documented differences in distributions of various sex, age, and reproductive classes of bears relative to humans in response to other bears and variations in whitebark pine seed crops. It is unclear whether the analysis of habitat use addressed these sex-age distinctions and, whether, as previously found, there was evidence of differential distributions relative to people. Instead, the authors make blanket statements about "bears."

Perhaps the most egregious short-coming of the interpretation offered by the Report's authors is in their treatment of diet variation and diversity. The Report's authors frequently imply, or even state outright that, because grizzly bear diets vary in time and space, there are few if any demographic implications of this variation. In other words, according to this account, it doesn't matter, demographically, what Yellowstone's grizzly bears eat. This is nonsense. Clearly, any bear you encounter will have eaten something to stay alive, but this does not mean the bear will be as productive or as likely to stay alive if the consumed foods have less energetic benefit, less fat content, and engender greater hazards while being used. Moreover, there is ample evidence of diet quality translating into sometimes substantial differences in densities of bear populations. Just because some bear(s) will eat false truffles, biscuitroots, yampa roots, berries, or pocket gophers during some years or seasons does not mean it is faring as well as when it was eating trout, pine seeds, moths, or ungulate meat. The treatment of diet diversity by the Report's authors is truly bemusing and leaves one groping for an explanation, with ignorance being unlikely, and the blind pursuit of a partisan agenda the more probable cause.

The take home message here is: the Report's authors clearly offered ad hoc interpretations that served the purpose of reaching foregone conclusions shaped by a political agenda (see below). And, as noted above, this biased interpretation was abetted by the authors' failure to articulate and adhere to a comprehensive and insightful conceptualization of the research problem and the investigated system.

**(2) There are additional potential problems with explanatory variables.** There are potentially many issues with the analyses undertaken by the Report's authors, but lack of access to a full account of the data and methods precludes any definitive commentary. However, the Report does present enough information to flag several potential problems.

Insofar as the analysis of whitebark pine habitat use is concerned, there are two potentially major issues. One is evident in the map of whitebark pine distribution that the Report provides. Quite simply, it is not accurate, especially in failing to depict whitebark pine at lower elevations (down to 7900-8000') on the central and Madison Plateaus, the very areas where the Report's authors claim that whitebark pine is absent. We know that mature seed-producing whitebark pine occur in these areas...because the grizzly bears have shown us. During years of very large pine seed crops, as occurred during 1978-1979, virtually every radio-marked grizzly bear in all parts of the ecosystem, including western parts, was consuming whitebark pine seeds, not uncommonly from red squirrel middens located under an isolated stand of whitebark pine on a rocky outcropping in a forest otherwise comprised of lodgepole pine. This error of omission calls into question claims made by the authors regarding "absence" of whitebark pine distribution in a substantial percentage of Yellowstone grizzly bear ranges. Their statements are simply not true.

The second potential issue with the authors' analysis of selection for whitebark pine habitats has to do with how these habitats were defined. Previous research has shown that strongest selection for whitebark pine habitats by grizzly bears occurs at lower elevations where whitebark pine is intermixed with other tree species, and where red squirrels are abundant. By contrast, grizzlies have been shown to select against higher-elevation stands of pure or near-pure whitebark pine. The implication here is that, if the author's pooled high and low elevation whitebark pine habitats, they would mask important differences in selection and underestimate selection for the most critical of whitebark pine habitats. They may have made such a distinction, but the Report fails to provide this

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information—which is emblematic of the problems associated with releasing such politically sensitive research in such a hasty and only partially described manner.

Finally, without being comprehensive, there is reason to be concerned about the veracity of the bear density index used by the Report's authors. The performance of this index is critical because of the extent to which it is invoked as an explanatory variable. Given the Report's description, this index appears to be fundamentally driven by the number of bears trapped in a given 14 x 14 km area. Systematic time-specific adjustments were apparently then made using population-averaged survival rates to derive time-specific density estimates. The concern, then, is whether trapping effort is random with respect to density. The authors provide no evidence of this but instead assert that trapping effort was somehow "representative." Given the importance placed on this metric, such assertions are not sufficient and, indeed, there is no evidence that trapping effort within the Yellowstone ecosystem has been anything close to random—or even systematic.

The Report's authors claim to have confirmed their index of bear density through correlation with an "independent" measure of grizzly bear distribution: number of bear observed during hour of flight reckoned for 1000 km2 area. This test only has merit to the extent that the two measures are, in fact, independent. The authors provide no evidence that this is so. By contrast, it could be the case that trapping effort tended to gravitate toward where more bears had been seen during aerial oversights. It's hard to know, which is to say, this is a particularly pointed instance where lack of access to data and a detailed description of methods preclude meaningful assessment of science that is driving a critically important management decision.

**(3) The analysis of body fat is suspect.** The structure and conceptualization of the updated analysis of body fat presented in the Report is highly suspect. There are several issues. For one, the authors yet again conflate time period with a tacit control for all things other than loss of whitebark pine, assuming that they then have the ability to isolate a whitebark pine-related effect, which, as indicated above, is not the case. Interpretation of any results between or among time periods is confounded by a number of environmental factors that were not considered in the analysis. Moreover, the author's fail to consider the fact that average cone production increased by roughly 1.6 times on surviving trees during the 2008-2013 period compared to the 2000-2004 period, which would have masked the effects of tree mortality.

Another factor is that the sample size is small enough to preclude any statistical power; i.e., the ability to detect differences. This is relevant to interpretation of the effects plots presented on page 20 of the Report, where, by visual inspection, one can see a lessening of seasonal body fat accumulation during the 2008-2013 period compared to the 2000-2004 period and a tendency for younger bears sampled during poor seed crops years to fall below the central tendency during the earlier period as well—yet none of the effects were apparently detected statistically. Another related concern is whether the small sample of bears is representative of the population at large, especially in consumption of various foods. There is good reason to suspect that the sample is not, indeed, representative (or random) given that consumption of foods probably does not vary independently of the likelihood that a bear will be captured, especially for management purposes and probably even by researchers.

**The reported research is motivated and framed by a political agenda**

Many of the otherwise bewildering short-comings of the Report's science are explicable when understood as a political endeavor. The reported research was clearly motivated by and shaped to address and rebut rulings by the federal District Court of Montana and Ninth Circuit Court of Appeals. These rulings focused on the USFWS's failure to consider loss of whitebark pine during an earlier effort to delist Yellowstone's grizzly bear population. The USFWS unsuccessfully tried to argue that the Yellowstone grizzly bear population was increasing, apparently without end, without any effects of whitebark pine loss, and with "density-dependence" as the only likely effect on vital rates. After its losses, the USFWS clearly set out to prove its case with the help of USGS scientists by setting up a dueling dichotomy of effects attributable to density versus whitebark pine. The limited conceptualization and structure of the USGS analysis thus becomes explicable: it was dictated by the political agenda of the USFWS in reaction to its losses in court.

The political nature of the reported science is further evident in the highly unusual departure from USGS's Fundamental Science Practices. This code rather unequivocally mandates that all USGS research undergo internal and external peer and other bureau reviews before being publicly released. The Report's Disclaimer (page ii) signifies what would in other contexts be a major infraction of this USGS policy; which clearly signals that approval for release was obtained at the highest levels of the USGS, probably at the request of those at the highest levels of the USFWS. Which begs the question, why? Why the hurry to get such a report on the streets, even in violation of the spirit and intent of USGS Fundamental Science Practices?

The answer to this somewhat rhetorical question is pretty straight-forward: the USFWS is clearly set on beginning the delisting process for Yellowstone's grizzly bear population during 2014 and needed the science to be available to managers of the Interagency Grizzly Bear Committee (IGBC) so as to set the stage for a vote by this body in support of delisting; which has, in fact, happened. If the science remained "unreported," such a vote would have to wait upon the next round of IGBC meetings, which would delay the move to delist.

Put another way, the political nature of the reported science is equally evident in the remarkable lack of genuine curiosity exhibited by the Report's authors regarding what is actually going on with Yellowstone's grizzly bears and their habitat. There was no indication that the authors really wanted to understand how all of the moving pieces in Yellowstone's world was affecting both the current and future prospects of the grizzly bear population. By contrast, what was clearly evident was an interest in a highly limited political framing of the research followed by a partisan interpretation that would allow the USFWS to claim in court that Yellowstone's grizzly bears were unaffected by loss of whitebark pine.

All of this is a betrayal of the public trust. Yellowstone grizzly bear researchers and managers are paid annual salaries totaling millions of dollars to inquire honestly and skillfully into the ecology and demography of the bear population, and then to present those results in a way that gives due regard to uncertainties and risks. There is a tempo to this case that signifies a profound lack of due deliberation on the part of scientists and managers. The glut of science described in the Report is clearly being hastily promulgated without regard for the quality of review or open scientific debate.

**Concluding thoughts**

There are perhaps two robust conclusions that can be drawn from the Report. First is that the federal government can bury us with shoddy science if it devotes its resources to the task. Second is that the

Report is the result primarily of a political rather than scientific process. Which is not to say that the involved scientists think of themselves as being partisan or political. Some of the potential reasons for this seeming paradox are covered in the Introduction. This Report is more than anything else a striking example of what one can get when a business model of scientific practice is coupled with a monopoly on data, amplified by a highly inflamed political context and enmeshment in a set of cultural preferences.

USGS has constructed a model of its scientific enterprise that is informed by corporate America, that is, of providing a "service" to customers or clients. The service is science, and most of it is paid for by customers, who, under this model, happen to be primarily other Bureaus within the federal government. USGS scientists, such as those who produced this report, are beholden to "serve" their fellow Bureau customers, the aegis of which includes contractual monetary arrangements. In this case, the primary "customer" is the USFWS. Moreover, representatives of the USFWS are and were deeply involved in shaping the science in the Report along with its delivery.

The results are insidious. The USGS science might have turned out different than it did if the USFWS and other involved "customers" were in fact neutral arbiters of the public interest. However, there is ample evidence that the USFWS and other government bureaus pursue their own special interests, and that professionals within these bureaus pursue special interests of their own. Thus you see agencies acting in ways that reflect their budgetary concerns, political relations with Congress, cozy relations with entities that they supposedly regulate, or just simply the ego demands of professionals within. Without going into details, it seems safe to assume that all of this applies to the USGS, the USFWS, and relations between them.

Compound this by involving state wildlife agency biologists and managers in not only executing the science, but also in shaping the science agenda. This has been very much the case with the science described in the Report. The states are involved in two ways: 1) as members of the Interagency Grizzly Bear Committee, which is also considered to be a USGS "customer," and 2) as active participants in the research, both collecting and analyzing data. The problem with the states is that they have considerable vested interests in delisting. The wildlife management agencies of Wyoming, Idaho, and Montana have made no bones about their great desire to delist Yellowstone's grizzly bears so that they can take over management and institute a sport hunt. And state agencies are hardly paragons of representative governance. Rather, there is ample evidence showing they are a despotic institution designed to serve the interests of a minority of sport hunters.

Finally, add in the especially problematic monopolistic arrangements of Yellowstone's grizzly bear science. Under terms of the ESA the USFWS has final permitting authority over what science can get done with Yellowstone's grizzly bear, and almost invariably the permitted science is executed by the USGS Interagency Grizzly Bear Study Team and scientists whom they invite to participate. Period. Thus, you have a monopoly of permitted inquiry. On top of this, there is only one data set for Yellowstone's (currently) threatened grizzly bear population; so only one set of scientists who are part of a closed community, in service of "customers" who have considerable vested interests, inquiring into a single data set that is essentially unavailable to anyone else. This is a sure fire recipe for all sorts of politically-informed bias to insinuate itself into the process of scientific inquiry. **Hence, the Report.**

Figure 1. Annual elk population estimates for the Yellowstone northern elk population (a) and the Firehole-Madison elk population (b)

Figure 2. Annual estimates of calf:cow ratios for Yellowstone region elk populations, Montana and adjacent Wyoming (a) and other Wyoming populations (b) from Middleton et al. (2013)

Figure 3. Number of spawning cutthroat trout counted in front country streams (gray line) and in Clear Creek (blue line) (a), and index of bear activity along front country streams (b) tributary to Yellowstone Lake.

Figure 4. Annual growing season temperatures (a) and annual Palmer Drought Index (b), both averaged for April-August in upper Yellowstone climate region. The heavy red line is a 3-year moving average.

Figure 5. Annual estimates of number of moth sites used by grizzly bears in the Yellowstone ecosystem (top green line) as well as total numbers of bears observed on moth sites (bottom gray line).

Figure 6. Average number of cones counted on whitebark pine trees on fixed transects (gray dots and line) with 3-year moving average (green line. The cone crop averages for 2000-2004 and 2008-2012 are also shown.

Figure 7. Annual bison population estimates for Yellowstone National Park herds.

## Agency Spin: Government claims about Yellowstone's grizzly bears... and the rest of the story

***Following is a summary of the key claims of being made by government scientists and managers, and a response. The length of the piece is due to the complexity of the issues presented here. There is a clear pattern of bias in both what is presented and how its presented by government officials. This bias is unambiguously supportive of delisting the Yellowstone grizzly bear population with disregard for important environmental trends and scientific uncertainties. When such bias is exhibited by public servants, it is nothing less than a betrayal of the public trust.***

Another key point pertains to the quality of science being done by government scientists. There is a lack of conceptual sophistication in both the design and interpretation of the analyses that have been undertaken. Correspondingly, there is a seeming pattern of substituting statistical gimcrackery for conceptual depth and substance. In part, this may be a reflection of the blinders unconsciously adopted when doing science within an echo chamber shared by those who are present by invitation only and who are voicing a similar political agenda. Which is to say, the patterns of bias and scientific practice evident in this case are probably not wholly a result of deliberate malfeasance, but rather evidence of "group think", which is a common hazard when science is monopolized by a chosen handful.

This points to the pitfalls of any monopoly over science, as is currently the case with research being done by Yellowstone's grizzly bear scientists. The only cure is for the monopoly to be broken. One primary means of doing so is to make all data freely available to any researcher with an interest in it and, moreover, provide them with resources to undertake independent inquiry and analysis.

**CLAIM 1:** ***The Yellowstone grizzly bear population is large, has steadily grown in size, has correspondingly expanded its range, and meets or exceeds demographic recovery criteria. The population is therefore ready to be delisted.***

**The rest of the story:** Population size and trend are a poor basis for making judgments about current status and future prospects of the Yellowstone population. Population size and trend are notoriously insensitive to deteriorating habitat conditions because of often long lags in demographic responses and because population trend is intrinsically a snapshot of the past—a look in the rearview mirror. However large the population might be, and however fast it might have grown, tells us nothing about the unfolding present and impending future.

This matters because none of the unfolding trends in Yellowstone's grizzly bear habitat is positive (see response to CLAIMS 2 and 3). Whitebark pine and cutthroat trout have been or will soon be lost as major food sources. Meat, one of the other four abundant high-quality foods, poses substantial hazards for any bear that consumes it (see response to CLAIM 2). Moreover, elk, which have been a major source of meat for Yellowstone grizzlies, have undergone substantial population declines in the north, east, and west. The southern elk population that winters in the Jackson Hole area is furthermore scheduled for major reductions to combat the threat of Chronic Wasting Disease. The only one of the four major foods that continues to be abundant is army cutworm moths, but even this food is projected to diminish as its alpine habitats are lost to climate warming.

**CLAIM 2:** ***Yellowstone grizzly bears have compensated for loss of whitebark pine and cutthroat trout by eating more meat. Loss of whitebark pine has had little impact on the population.***

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**The rest of the story:** Yellowstone grizzly bears appear to be eating more meat now compared to in the past, probably as a compensatory response to loss of whitebark pine and cutthroat trout. The greatest shift in diet has apparently occurred among female grizzlies, which is not surprising given the greater extent to which they relied on whitebark pine seeds in the past. On average, females ate twice as many pine seeds as did males.

However, this turn to meat is problematic. Consumption of meat is much more hazardous for Yellowstone grizzlies compared to consumption of virtually any other food aside from human garbage. Recent fairly dramatic increases in consumption of livestock on the periphery of the ecosystem has resulted in increased conflict with humans and resulting increased killing of the involved bears. This has been especially evident in the east and southeast in places such as the upper Green River drainage. Moreover, increased consumption of elk poses hazards for both cubs and adult bears. Increasing scavenging of hunter kills has resulted in increasing conflicts and resulting hunter-caused mortality. Cubs of females that use meat also tend to die at a higher rate, primarily because of more frequent contact with especially adult males—and even wolves. Adult males have historically been much more oriented toward eating meat and will sometimes kill cubs if given a chance. This continues to be the case.

Put another way, increased consumption of meat by Yellowstone grizzlies is not auspicious, either now or looking to the future. Recent declines in cub and yearling survival are consistent with the increased hazards posed to young bears when their moms seek out meat in competition with adult males and wolves. The lack of support given by federal and state agencies for dissemination of husbandry practices that foster coexistence with bears does not bode well on the livestock front, especially after delisting. Moreover, declines in elk populations that have been largely driven by worsening habitat conditions are likely to continue as drought becomes part of the new normal. Continuing demand for sport hunting opportunities coupled with effects of both wolf and grizzly bear predation will almost certainly worsen conditions for elk.

**CLAIM 3:** ***The fact that Yellowstone grizzly bears are as fat now as in the past is further evidence that loss of whitebark pine has not been detrimental.***

**The rest of the story:** This statement is both deliberately misleading (if not an outright falsehood) and misses the larger point insofar as dietary shifts are concerned. Regarding the falsehood, a decline in body fat among adult females has, in fact, been documented by Schwartz et al. (2013). This decline among females, in contrast to what was found for males, is exactly what we would expect with loss of pine seeds and the greater historic reliance on pine seeds among females compared to males. Interestingly, government scientists present evidence of worsening body condition among females and then go on to dismiss this result by invoking small sample sizes, which is a classic case of political spin and, moreover, spin that survived peer review (see response to CLAIM 10 below).

Insofar as the more important aspect of dietary shifts is concerned: consequences manifest both nutritionally and in the risks of death associated with using alternate foods. Meat is a high-quality food and, nutritionally, every bit as beneficial as pine seeds. This holds especially for the composition of elk and bison carcasses during the fall when fat content is as high as or higher than that of pine seeds. Triumphant (and misrepresentative) proclamations regarding body condition completely miss the question of hazards. And there is no doubt that eating meat is much more hazardous than eating pine seeds, especially for females and their cubs (see response to CLAIM 2).



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Finally, a more recent decline in body fat among females is consistent with asynchrony relative to loss of whitebark pine. As noted below in the response to CLAIM 4, females were probably shifting more to meat during the 1990s in response to losses of whitebark from the 1988 fires and from blister rust. But these earlier shifts occurred during a time when bison populations in central Yellowstone Park and elk populations everywhere in the ecosystem were at an all-time high. However since especially the mid-2000s these ungulate populations have declined dramatically, which, along with further losses of whitebark pine to bark beetles, matches the decline in body fat documented by Schwartz et al. (2013).

**CLAIM 4:** ***Even with losses of whitebark pine, there is still strong evidence that whitebark pine seed crops continue to have spatial and temporal effects on vital rates of Yellowstone grizzly bears as well as levels of contact and conflict between humans and bears.***

**The rest of the story:** This is not necessarily a claim to be questioned but, rather, a claim to be placed in context. Losses of whitebark pine have been uneven in time and space . Moreover, death of mature whitebark pine has been mitigated by a near two-fold increase in cone production by the remaining trees, by all indications driven by progressive warming of the climate since 1970. However this boost in cone production is temporary and only delays the inevitable losses of mature trees meted out by proximal factors such as disease, insects, and competition, but ultimately driven by climate warming (see response to CLAIM 10 below). The somewhat artificial increase in cone production is just one of potentially many factors introducing lag effects in the response of grizzly bear birth and death rates to deteriorating habitat conditions (see response to CLAIM 1). All of this means that an effect of whitebark pine cone crop size has persisted and will persist for a while yet, but masking an overall negative trajectory.

But the more important point pertains to contradictions in the scientific results being presented by government scientists and managers. Although, on the one hand, there seems to be a drive to dismiss the importance of whitebark pine, on the other, there seems to be no denial of the historic and on-going effects of whitebark pine seed availability on critical facets of demography and human-bear conflict. This schizophrenia can be plausibly interpreted as a tension between the partisan imperative to support delisting and some measure of adherence to scientific integrity, at least among government scientists (see concluding comments).

**CLAIM 5:** ***Grizzly bears are omnivores and will adjust to loss of foods simply by eating something else. This is evident in the shift to meat and the increased consumption of false truffles. Moreover, grizzlies in Yellowstone are known to have eaten more than 200 different foods.***

**The rest of the story:** This claim is disingenuous at best and outright dishonest at worst. First are the factual problems. Not all foods are equal either in terms of abundance or quality. A figurative stalk of celery is not equal to a figurative steak; and there are huge differences in the nutritional and energetic quality of the foods available to Yellowstone grizzlies. With the exception of meat, none of the foods being eaten in compensation (for example, roots and mushrooms) are close to the quality of the foods being lost (whitebark pine seeds and cutthroat trout). Moreover, we know that quality and quantity of foods manifests in potentially huge differences in grizzly bear densities. So food quality and quantity matter! Any grizzly bear that we find alive will, by definition, have eaten something, but that tells us nothing about implications for the population. As a final note on this point, the increased consumption of false truffles by government scientists was only documented for bears in the core of the ecosystem and without any indication whether this food was energetically or demographically beneficial. This stands in contrast to the tacit implication that bears everywhere are eating truffles and that this food is somehow fully compensatory for lost foods.

Second are the representational problems. A critical feature of any food is not just its nutritional quality but also, and perhaps more importantly, the hazards associated with eating it, especially whether it brings bears into conflict with people. This facet of food is amply evident in the consumption of meat (see response to CLAIM 2) but also applies to other foods, such as some roots, that often occur at lower elevations in habitats nearer where people live and recreate. Insofar as the "greater than 200 different foods" claim is concerned: a list such as the referenced one based on taxonomic distinctions made by humans has essentially no relevance to bears. Foods need to be understood in functional rather than taxonomic terms when it comes to bear foraging. For example, from a bear's perspective, a grass is a grass, with differences arising primarily from plant architecture and changes in fiber content as the growing season progresses. Yet people interested in inflating a list of "foods" could generate 40-50 "types" if they differentiated taxonomic genera and species, and even more yet if they differentiated subspecies.

As a bottom line, claims of omnivory and associated inflated lists of potential "foods" are spurious and misleading when it comes to the current and future plight of Yellowstone grizzly bears. This point is so transparently evident that one has to wonder what motivates scientists making this claim: Ignorance? Duplicity? Perhaps Group Think? (see concluding comments)

**CLAIM 6:** ***Grizzly bears are also benefiting from wolves because a number of bears have adopted the strategy of appropriating wolf kills throughout the bears' active season.***

**The rest of the story:** There is, indeed, ample evidence of grizzly bears usurping and benefiting from wolf kills. But the key fact virtually never disclosed by government scientists is that virtually all of the bears benefiting from wolf kills are males—predominantly adult males. There are very few records of females, especially females with cubs, appropriating a wolf kill, and in the few instances where this has been recorded, the females have put their cubs at risk from both wolves and from other bears (see response to CLAIM 2). In fact, it is more likely that wolves have been detrimental to female grizzlies rather than the opposite. Females historically obtained most of their meat during the spring by scavenging on winter-killed ungulate carcasses. Given the propensity of wolves to kill vulnerable elk (i.e., the young and the old), there are, all else equal, predictably fewer of these animals available to succumb to the rigors of winter and show up as carrion during spring, to the benefit of female grizzlies. And spring carrion is a comparatively safe meat for females to eat because it is often scattered abundantly across the landscape in smaller packages, which predictably results in smaller odds of encountering other grizzlies. At a population level all of this matters because it is females, not males, that are the reproductive engines of a bear population—the segment that ultimately determines whether a population grows or declines.

**CLAIM 7:** ***Current estimates of population trend have accounted for sightability and effort bias associated with use of unduplicated females with cubs-of-the-year (COY) to index population size.Recent critiques by Doak and Cutler (2013) are wrong.***

**Another perspective:** It seems inconceivable that current methods for estimating population size and trend based on both the Chao2 (past) and Mark-resight (current) techniques can adequately account for sightability biases introduced by major changes in observer effort and bear behaviors over the last 25 years. This is not only the result presented by Doak and Cutler in their 2013 paper, but also a result to be found in the very publications invoked by government scientists to justify their adopted methods.. Government scientists also claim that they have increased efforts to fine females with cubs-of-the-year simply because the population has spread so widely, implying that the effort to search any given area has remained constant. This is quite simply wrong. If you contrast the increase search effort with the increase in distribution of the grizzly bear population, it turns out that search effort has doubled.

From another perspective, the issue of bias in methods in not best addressed through assertions in the scientific literature, especially when in the form of argumentative dismissals by those privileged with monopolistic access to the data. A far better approach, both scientifically and managerially, would be to take a precautionary stance in the face of uncertainty and controversy and to release the data for independent check and inquiry. The current approach adopted by the government is poor science, poor management, and amply evident of a biased partisan agenda.

**CLAIM 8:** ***The leveling of population trajectory and changes in demography of the Yellowstone grizzly bear population have occurred because the population has reached carrying capacity, not because of loss of whitebark pine.***

**The rest of the story:** This is another claim that begs the question of motivation and sophistication on the part of government scientists and managers. The most obvious point to be made is that carrying capacity is axiomatically a function of food quality and quantity. Carrying capacity, as a concept, cannot be divorced from what is happening with whitebark pine and cutthroat trout. In other words, the distinction between an effect of carrying capacity (i.e., density dependent effects) and an effect of, say, losing whitebark pine is a false one. Yet such a false distinction—a straw man—does provide government scientists the opportunity to "demonstrate" that whitebark pine loss has been of no consequence if they can pin demographic changes to some spurious temporal and spatial distinctions amplified by use of data that is not available for external review.

In particular, government scientists have claimed that declines in cub and yearling survival predated major losses of whitebark pine "beginning in the mid to late 2000s" and so must have occurred because of "density dependent" effects. To be clear, "density dependent" is just a fancy way of invoking either worsening female body condition (which has occurred [see above]) or decreased survival because of increased exposure to hazards; for example, of cubs to male bears at carcasses. So the turn to meat is plausibly what government scientists are calling a "density dependent effect," which could be better understood as compensation among females for losing whitebark pine. And whitebark pine was being lost in substantial amounts to white pine blister rust as early as the mid-1990s followed by the advent of major losses to bark beetles around 2003. Prior to this, even, there had been substantial losses of whitebark pine in the core of the ecosystem to the fires of 1988, with demonstrable declines in consumption of whitebark pine seeds by Yellowstone's grizzly bears. Given the greater average reliance of females on whitebark pine seeds, we would expect females to be more sensitive to these early losses, manifest in early compensatory shifts to eating meat. The bottom line is: changes in birth and death rates and resulting population trajectory are readily attributable to loss of whitebark pine, not some abstract and unspecified "density dependent" mechanism.

Another straight-forward inconsistency in government claims regarding "density effects" follows from the simple fact that, even by the government's own data, the Yellowstone grizzly bear population has not grown since the early 2000s at the same time that distribution has increased substantially. This begs the question: how can overall density increase at the same time that the same numbers of bears are spread out over a larger area? Axiomatically, density has to decrease, which means that supposed increase in density has not occurred, meaning that density, as such, cannot be a major cause of the stalling in population growth.

A final note regarding this claim: It could be that the population has leveled or even declined simply because of high grizzly bear mortality since 2006, without invoking any "density-dependent" mechanisms. Mortality limits for adult males and/or adult females have been violated during 5 out of the last 7 years, with a record 56 bears known to have been killed during 2012. Government scientists claim that limits have been so conservative that there would be no population effects even with violation, but this assumes that the methods used to estimate size and trend of the population—and from which limits are derived—are reliable. As noted in response to CLAIM 7, there is much doubt about the reliability of methods and estimates, enough so to debar any confident claims about true mortality limits and the population-level effects of violations.

**CLAIM 9:** ***Whitebark pine is genetically adaptable and so will likely fare well with climate change. Moreover, blister rust resistance has increased in selected stock from 11% to 22%. This augurs well for the future of whitebark pine and grizzly bears in the Yellowstone ecosystem.***

**The rest of the story:** Whitebark pine currently is distributed in a well-defined climate envelope typified by cold and relatively dry conditions. There is also evidence that competition with lower elevation early successional tree species such as lodgepole pine and Douglas-fir limits the downslope distribution of whitebark pine. The claim that whitebark pine, a very long-lived species with correspondingly long generation lengths, can somehow genetically adapt to extremely rapid climate change and in a way that defies current demonstrable climatic limits as well as relations with lower-elevation competitors is, not to be impolite, ludicrous. What is even more ludicrous is claiming that somehow this rapid adaptive response, even assisted by geneticists and tree orchards, can also accommodate novel highly lethal insects and pathogens, of which the insects (bark beetles) are clearly abetted by warming climatic conditions. Even if climate-adapted and blister rust-resistant whitebark pine were to be engineered through advanced genetic techniques, planting enough trees to make a difference ecosystem-wide would require essentially unlimited budgets and, once established, the trees at maturity would still be fodder for bark beetles. Furthermore, each new mutation of blister rust (a predictable event) would necessitate yet another generation of expensive genetic engineering and propagation.

Whatever happens to whitebark pine, we have ample evidence that responses of grizzly bears to food availability, including whitebark pine seeds, are non-linear and subject to threshold effects. Below a certain abundance level you see little use; above a certain abundance level you see dramatically increased use. The implications are that, even if whitebark pine persists and increases in abundance, it will still be so diminished that consumption of whitebark pine seeds by Yellowstone grizzly bears will never recover to anywhere near former levels.

**CLAIM 10:** ***All of our science has been peer reviewed, which means that it is a sound basis for making decisions for management of Yellowstone's grizzly bears, including potential delisting.***

**The rest of the story:** It would be nice if peer review worked as well as the government scientists and managers claim it works. Their narrative strongly implies that peer review insures the absence of error and a partisan agenda; that is to say, normative bias. Yet the ample research on peer review and its effects shows that peer review does a remarkably poor job of detecting and correcting errors and of filtering out partisan research. Several studies have shown that error detection is about what you would expect at random. By contrast, peer review has been shown to discourage creativity and insure obedience to ruling scientific paradigms and those who are affiliated with those paradigms. Put succinctly, peer review does little to guarantee that the current crop of Yellowstone grizzly bear science is a reliable and non-partisan basis for making important decisions—such as delisting the population.

By contrast, what has been shown to be an effective means of correcting and advancing our knowledge of grizzly bears (and all manner of other things) is independent inquiry into the same topics, using the same data if needed. The contingency of access to the same data becomes all the more relevant when there is only one population and one data set, the topic is symbolically charged, and the science is highly contested—as is the case with Yellowstone's grizzly bear population. Under these conditions a monopoly on the data is tantamount to betrayal of the public trust. Yellowstone's grizzly bear scientists and managers have publicly voiced their resistance to disclosing data to anyone other than those whom they invite in, which could be construed as betrayal of their responsibility as public trustees.

# The Grizzly Numbers Game

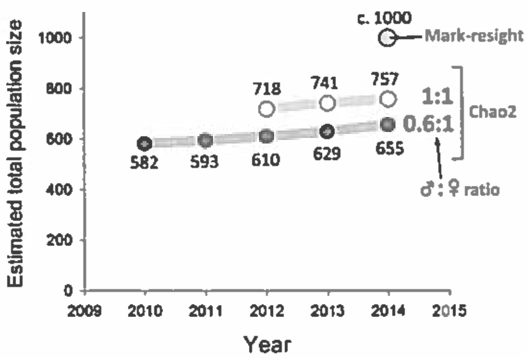
*In the media, the government bandies confusing and contradictory information on the size and trend of the Yellowstone grizzly bear population. This page tries to help people make sense of what they hear in the media, and explains where the various estimates come from and the problems with the methods used.*

*Dr. Mattson concludes that there is no evidence of a population increase in the last 15 years. All of the claimed "increases" have been a result of changing methods, rather than a real increase in the size of the population. All population estimates are based on estimated numbers of females with cubs of the year (COY) and the estimated fraction of other age/sex classes of bears. There are two basic methods used in Yellowstone: Chao 2 and Mark-resight. The first gives a lower estimate than the second.*

*Dr. Mattson shows how trends that show increases in bear numbers since 1998 mirror search effort and high sightability of grizzly bears on treeless alpine slopes while feeding on moths. He concludes that any "putative" increases in population are almost certainly spurious.*

The public has been hearing lots of confusing information during the last five years about size and trend of the Yellowstone grizzly bear population. In one newspaper article or agency meeting they will hear that the population has not increased for roughly 15 years. In the next article or meeting they will hear that the estimated size of the population has increased from the 580 or so to something around 750. In the next article, yet, they will hear the USFWS Recovery Coordinator or someone from the state of Wyoming say that there are anywhere between 1000 and 1200 bears in the population. No wonder people are confused. The primary purpose of this page is to help people make sense of what they are hearing. Inevitably, though, this process of clarification also points to what seems like a delibrate strategy of disinformation on the part of agency representatives. To put it simply, there is no evidence of a population increase during the last 15 years. All of the "increases" have been a result of changing methods--which amounts to no real increase in size of the population at all.

The graph at left summarizes all of the population estimates that have been bandied about by agency spokespeople during the last five years. Each dot (and number) represents an annual estimate; and each color (dark gray, white, and light gray) represents an estimate derived by a different method or set of inputs.

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All methods are driven basically by multiplying the estimated number of individual females with cubs-of-the-year (COY) in the population by various factors that presumably account for numbers of other sex and age classes of bears. In other words, all population estimates are based on estimated numbers of females with COY and the estimated fraction of that segment relative to other segments of the population.

There are two basic methods for taking the number of females with COY that are observed and, from that, estimating the numbers of this cohort that were missed. Adding the observed and "missed" numbers together gives you the total females with COY for the year, which is then multiplied to account for males, non-reproductive females, and dependent young in the population. One of the adjustment methods used by the agencies is called "Chao2" and another is called "mark-resight." The first produces a lower estimate of the total compared to the second.

The Chao2 method has been vigorously defended by agency spokespeople, and the Interagency Grizzly Bear Study Team baldly claims in its annual reports that this method "accounts for individual sighting heterogeneity" to generate an unbiased estimate. But, at the same time, these same scientists say that the method produces low estimates, and that the mark-resight method is less biased. It is hard to make sense of these contradictions. Moreover, as was covered by The Trend Game, there has been some pretty compelling research showing that Chao2-based estimates of population size produce spurious estimates of population trend, primarily because this method does not correct for heterogeneity (i.e., differences) in sightability of bears from one year to the next, and is strongly affected by how much effort researchers expend trying to find bears and by the kinds of activities that bears are engaged in.

So...what's up with the numbers in the graph above? The white and dark dots show estimates of total population size based on use of the Chao2 method to adjust underlying numbers of females with COY. The single light gray dot represents a presumed estimate based on the mark-resight method. Problem is, this higher estimate has not been officially published by the IGBST and is based solely on claims made in public by the USFWS and state of Wyoming. But this high number is clearly based on mark-resight.

What about the difference between the higher and lower series of estimates based on the Chao2 method? Put simply, the higher estimates (>700) were derived by using a larger multiplier to account for males in the population. These estimates assume that there is one male for every female in the population older than the age of 2 (a 1:1 sex ratio). The lower Chao2 estimates assume that there is 1.7 females for every male in the population (a 0.6:1 sex ratio). So, depending on how many males you think are out there, you can easily add 100 bears to your estimate of total population size.

So, which of the of the Chao2-based series of estimates should you put credence in? Well, probably neither. I also wouldn't believe the mark-resight estimate. It, as well as the higher Chao2 estimate, are based on a presumed increase in survival of males in the ecosystem (the 1:1 ratio of males to females), which defies logic and contradicts the data. Numbers of known dead bears--including males--have increased since 2007 at a far more rapid rate than has any putative increase in the population (see Conflicts & Mortalities). Moreover, when it comes to conservation of this population, it is numbers of females that matter, not males. Any addition of

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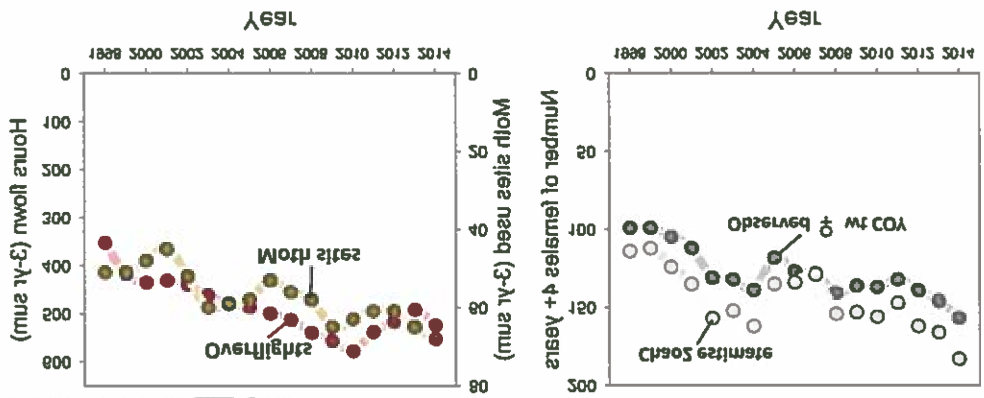
males to the population estimate, no matter how credible, is somewhat irrelevant. Any hunter (or rancher, for that matter) knows this.

BOTTOM LINE: None of these differences in estimated population size generated by use of different methods or inputs amounts to a real increase. At least according to the agencies, they all presumably adjust for "bias" of one sort or another. Put another way, if we have 750 bears now, we probably had 750 bears or so in the early 2000s. If we have 1000 bears now, we probably had roughly that many more than a decade a go. And so on.

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But there is one more issue that needs to be addressed here, essentially recapping the argument made in The Trend Game. You could look at the annual estimates of total population size in the graph at the top of this page and conclude that there probably has been an increase in the population, from either (roughly) 582 to 655 or from 718 to 757 (depending on whether you give credence to additional male bears).

Well, actually, no. Remember that these estimates are all based on sightings of females with COY adjusted using the Chao2 method. Remember, also, that this method is biased, unreliable, and affected by agency search efforts and bear behaviors, especially highly sightabile activities such as feeding on alpine moth aggregations.

With this in mind, it is worth looking at trends in observed females with COY and total numbers of this cohort derived from the Chao2 method (both immediately top right) relative to search effort and bear use of moth sites (immediately top left). As was shown by The Trend Game for a longer period of time, search effort and moth site use have both continued to increase, even after both phenomena presumably stabilized (or so claim the agencies) in the mid-1990s. Notice how trends in numbers of observed and estimated total numbers of females with COY mirrors effort and sightability. In other words, any putative "increases" in population size are almost certainly spurious. Moreover, the more reliable mark-resight method does not yield the same results (see The Trend Game), which is why some agency spokespeople probably continue to feature the Chao2 method. Mark-resight yields a higher population estimate, but Chao2 produces a higher population trend. I guess you can't have it both ways.

And so the game goes...



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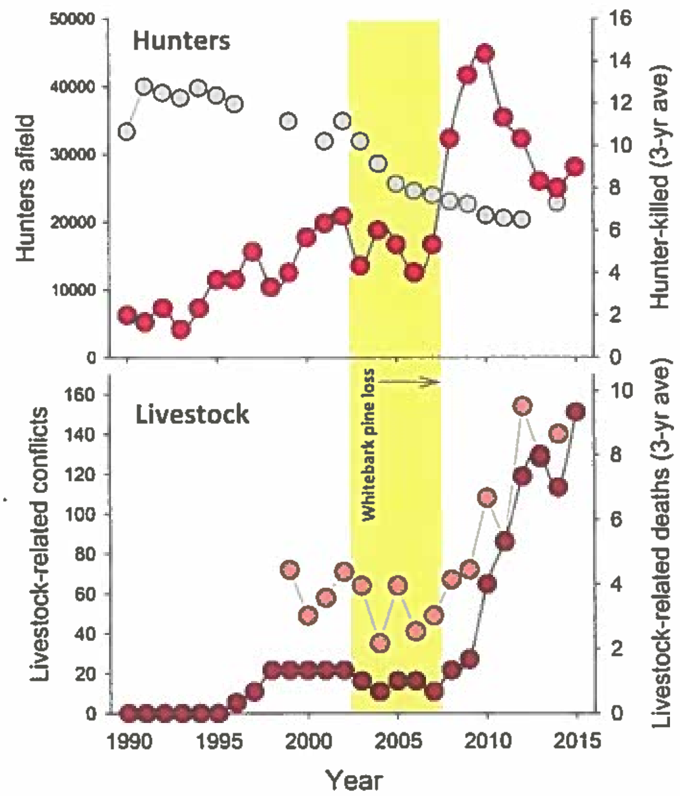
# Livestock and hunter-related mortalities

# 1990-2015

*The public has been swamped with misinformation about the growth of the Yellowstone grizzly bear population during the last decade, with some agency officials claiming a doubling of the population in the last handful of years. Using a 3-year running average of the most reliable estimates of females with cubs of the year (based on the Mark-Resight method), Interagency Grizzly Bear Study Team data shows that the population shows the population has not increased since around 2002, and has probably declined since 2007, which was the end of period when most of the whitebark pine forests died in the Yellowstone ecosystem.*

*In contrast, grizzly bear mortalities have increased dramatically since roughly 2000, far in excess of anything that can be explained by changes in population size. The most important trend is the substantial increase in mortality that followed hard on the heels of when we lost most whitebark pine in the ecosystem. Grizzly bear conflicts with livestock producers and hunters have surged dramatically since the loss of whitebark pine, which his consistent with a turn by many bears to eating more meat in compensation for loss of pine seeds and cutthroat trout. The increase in hunter-related mortalities has occurred despite a substantial decline in hunters afield. This belies claims on the part of agency personnel that hunters are "behaving better" than in the past.*

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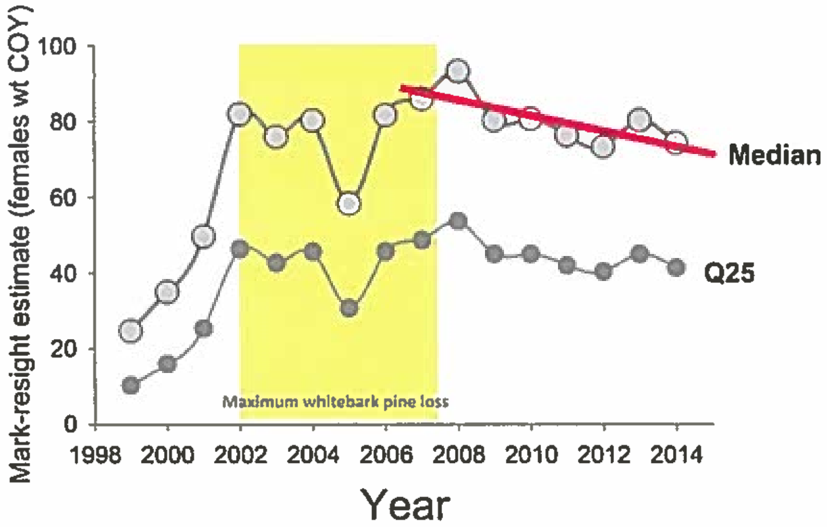
The graph above shows trends in hunter and livestock-related conflicts and mortalities in the Greater Yellowstone Ecosystem, expressed as 3 year averages, up to Oct. 20, 2015. The top graph shows hunter-caused mortalities, with number of hunters afield in grey. The bottom graph shows livestock conflicts (pink) and mortalities (maroon). The yellow vertical bar denotes the period of maximum loss of whitebark pine from mountain pine beetles. Bottom line: grizzly bear conflicts with hunters and livestock producers over meat have surged dramatically since loss of whitebark pine, which is consistent with a turn by many bears to eating more meat in compensation for loss of pine seeds...and cutthroat trout. Note that the increase in hunter-caused mortalities has occurred despite a substantial declines in numbers of hunters afield. This belies claims on the part of agency spokespeople that hunters are "behaving better" than in the past. (The data were compiled by Dr. David Mattson from annual reports of the Interagency Grizzly Bear Study Team.)

## Population growth

### 1999-2014

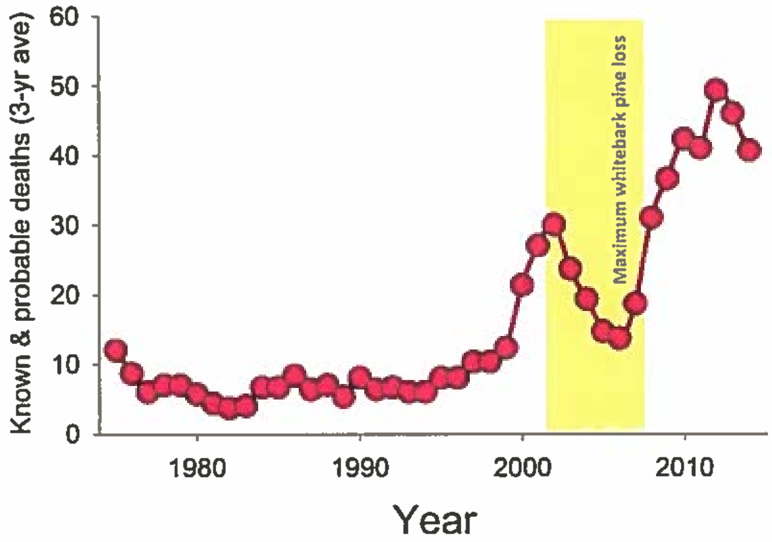



The public has been swamped with misinformation about growth of the Yellowstone grizzly bear population during the last decade, with some agency representatives claiming a doubling of the population during the last handful of years. The graph above shows a 3-year running average of the most reliable estimates (medians and the lower quantile of the estimate) for numbers of females with cubs-of-the-year in the population. Given a 3-year interval between litters, a three year average captures a baseline for numbers of reproductive females, which is relevant because estimates of this cohort undergird all estimates of total population size for the population (the details are beyond what can be treated here).

Bottom line: The population has not increased since around 2002 and has probably declined since 2007, which benchmarks the end of the interval during which we lost most of the cone-producing whitebark pine trees in the Yellowstone ecosystem. The red line is fitted to the data and suggests that we have been losing around 2 females with COY per year, net, since 2007. The trend line is statistically significant (P = 0.027, r2 = 0.54, for those who pay attention to such things).

## Total known & probable mortality

## 1975-2014




Trends in total mortality are consistent with estimated trends in population size. The graph immediately above shows a 3-year running average of total known and probable bear deaths in the Yellowstone ecosytem (see immediately above for the rationale behind use of a 3-year running average). The dominate trend since roughly 2000 has been a dramatic upsurge, far in excess of anything that can be explained by changes in population size. In fact, the population has been static since roughly 2002 (see above). The most important trend is the substantial increase that has followed hard on the heals of when we lost most whitebark pine in the ecosystem. Last year (2014) wasn't bad insofar as mortality was concerned, at least compared to the years before. But this year (2015; the data are not shown) will almost certainly reinforce the dominant trend towards increasing numbers of dead bears.

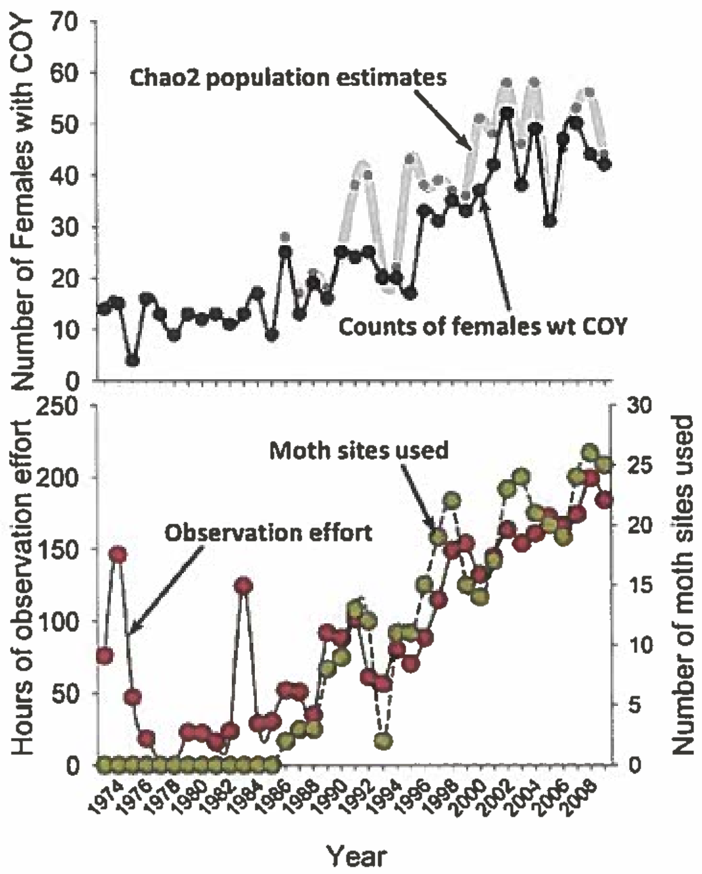
# Biases in Counting Bears, or the 'Trend Game'

See The Trend Game-2 for more on the Trend Game. ATTACHED pp 32-35

*Agency representatives consistently claim that the Yellowstone grizzly bear population grew 4-7% per year between 1980 and 2000, and continue to grow by as much as 2% per year. Is this true?*

*No. The claimed increases can be explained by agency efforts to find bears that quadrupled, even quintupled, since the 1980's. At the same time, bears became much easier to see from the air, as they found a new food source, army cutworm moths, on treeless alpine slopes, starting in the mid-1980's. Bears engaged in this activity are almost certain to be seen, and more bears are relying on moths in the wake of whitebark pine and trout loss. Dr. Dan Doak and Kerry Cutler have conclusively shown that trends in the counts of females with cubs of the year almost exactly mirror search effort and sightability (as indicated by bears on moth sites).*

*Dr. Mattson compiled the first comprehensive collection of estimates for size of the Yellowstone population, going back to the 1950's. He concludes that while the population has increased in size between 1970 and 2000, it doubled, rather than tripled or quadrupled as claimed by representatives of federal and state management agencies. And this modest increase occurred only with 40 years of ESA protections – which begs the question of how quickly might those gains might be lost after protections are removed, especially with the current negative habitat trends?*

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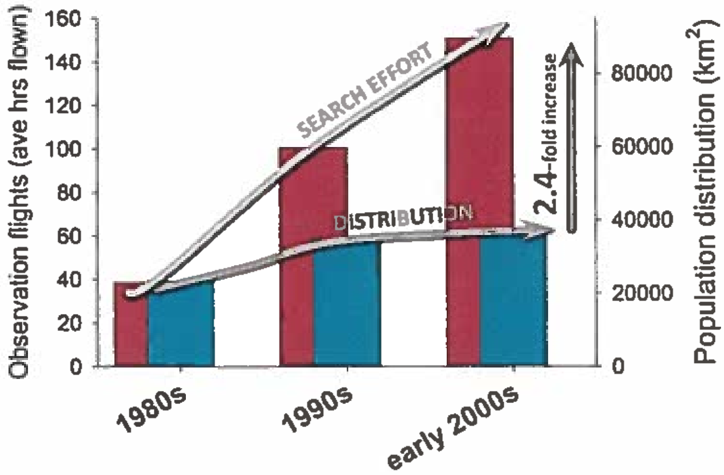
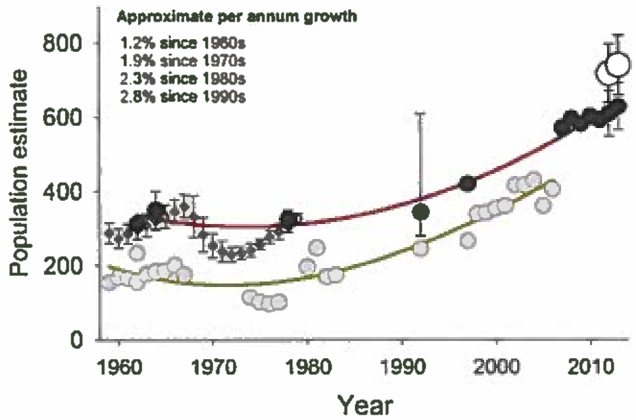



**These graphs show the data games being played by government officials to overstate increases in the Yellowstone grizzly bear population** so as to, in turn, justify delisting. It is important to remember that these games are being played at taxpayer expense and have real, life and death consequences for threatened grizzly bears. These graphs are based on data of the Interagency Grizzly Bear Study Team. In this page, we tell "the rest of the story".

**Representatives of state and federal agencies consistently claim that the Yellowstone grizzly bear population grew at 4-7% per year between roughly 1980 and 2000, and continues to grow by as much as 2% per year.** Most of these claims are based on trend lines fit to annual estimates of numbers of bears in the population, either total or limited to reproductive females. This latter cohort is particularly relevant because all estimates of total population size are obtained (essentially) by multiplying numbers of females seen with cubs by the various fractions of other types of bears estimated to be in the population (see The Numbers Game). So all population estimates are driven by the numbers of females with cubs-of-the-year (COY) observed each year.

The black dots in the graph at top left show the numbers of individual females with COY seen in the Yellowstone ecosystem each year going back to 1973. The gray dots represent an adjustment that presumably accounts for additional females with COY that went undetected. This adjustment is done by an arcane statisical method called "Chao2." Bottom line: the trend in females with COY is the primary basis for claims of dramatic and even on-going increases in the Yellowstone grizzly bear population.

**But let's look at the bottom graph above. It shows the effort made by agency biologists to find grizzlies (the burgundy dots), represented by total numbers of hours spent each year in aerial overflights.** This graph also shows (in green dots) the number of sites used by grizzlies to excavate army cutworm moths. This matters because (1) bears engaged in this alpine activity are almost certain to be seen (unlike bears engaged in other activities) and (2) almost all of the bears on the eastern side of the ecosystem feed on moths these days. The bottom line: efforts to find bears have quadrupled, even quintupled, since the 1980s; and at the same time bears have become much easier to see.

**Putting this all together:** Notice how trends in counts of females with COY almost exactly mirror search effort and sightability (as indicated by moth site use). Could it be that trends in counts of females with COY have been simply an artifact? Dan Doak and Kerry Cutler have pretty conclusively shown, in fact, that the observed trend is probably spurious; that all of the "increases" could be an artifact of effort and sightability (see Doak and Cutlers' original paper). The agencies tried to dismiss the Doak and Cutler critique primarily (it seems) on the basis of author biomass rather than cogency of arguments (see Doak and Cutlers' rebuttal of their rebuttal). Regardless, the two graphs above seem to be pretty compelling. No amount of statistical gimcrackery could possibly correct for the amount of bias introduced by such changes in search effort and sightability.

It is illustrative to look at some of the arguments used by agency representatives to defend their use of trends in observed females with COY as a basis for, in turn, inferring trends in the overall population. For example, **they claim that an increase in aerial effort is simply a consequence of the fact that the distribution of the population has increased.** The tacit claim here is that effort per unit area has remained constant.

**Is that claim true? In a word: No.**

The graph at right shows the extent of the population's distribution (turquoise bars) and level of aerial search effort (burgundy bars) averaged by decade. As you can see, relative to the 1980's baseline, search effort increased roughly 2.4 times as much as did distribution of the grizzly bear population. In other words, agency biologists were searching any given 100 square miles roughly 2.4 times as intensively during the 2000's as they did in the 1980's. If you look harder for bears that are easier to see...you will see more bears. And there is no amount of statistical gimcrackery that can fix the problem.

**So, if the primary method used by the agencies to monitor trend is pretty much bunk, do we have any idea of what has been happening?** As shown on the The Numbers Game, a recently adopted and more reliable method (mark-resight) suggests that population trend has been flat since the early 2000s, and probably declining since 2007.

In addition, the graph at left shows all of the estimates of population size that have been made for Yellowstone's grizzly bears, going back to the 1950s. The black dots show estimates of total population size; the gray triangles, estimates of total population size based on a simulation model; and the gray dots, estimates of minimum population size (i.e., the minimum number of bears thought to be in the population). The two large white dots represent recent increased estimates of total population size generated solely by adding more male bears to the counts (see The Numbers Game). But, sorry lads, more males really don't matter that much from a population standpoint. And, an important point: estimates of total and minimum population size are apples and oranges and cannot be legtimiately compared (see immediately below).

**So, what is the take-away? The population almost certainly increased in size between roughly 1970 and 2000, but at a much slower rate than the 4-7% trumpeted by agency representatives.** Depending on the time period, the rate of increase was probably much closer to 2-3% per annum, about half the advertised rate. Interestingly, this is quite close to what Doak and Cutler came up with, as well as Pease and Mattson in their 1999 paper.

**Agency representatives are fond of saying that the population roughly tripled or even quadrupled in size since it was given ESA protections in 1974,** claiming that it "increased from around 200 bears to around 750 (or even 1000) these days." The only way you can come up with such figures is by comparing minimum population estimates around 1970 with total populations estimates more recently (see the comment above). **This is disingenuous at best. More likely, the population roughly doubled in size, which is good news, but nothing close to the exaggerated claims made by the states and USFWS.** And this modest increase occurrred only after 40 years of hard work under full protection of the Endangered Species Act. Which begs the question, how quickly might these gains be reversed when protections are removed, especially with the number of negative habitat trends that we now have afoot?

## Matching Models with pre-set conclusions, or 'Trend Gaming 2'

*Dr. David Mattson shows how the government plays games with model selection and choosing time spans for which trend is modeled to show the most inflated view of the population possible – not the most accurate and unbiased view.*

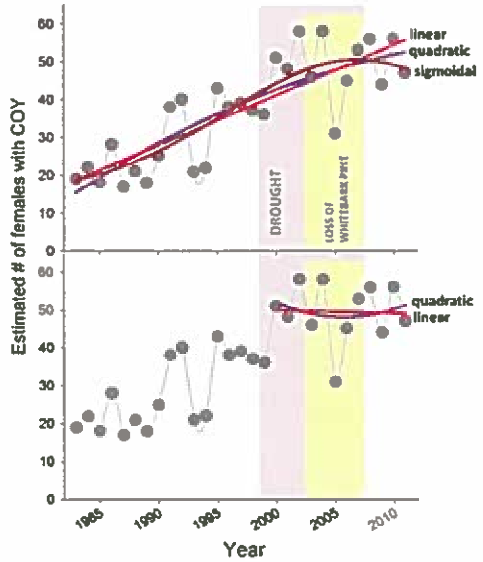
*he government's selection of a linear or quadratic models that they tether back to 1983 ensures little sensitivity to unfolding conditions of drought and climate change (and related loss of whitebark pine and cutthroat trout) that started during the late 1990s. This approach to estimating trend does not pick up on the dramatic changes that occurred after the 1988 fires and again after the millennial drought that began in about 1998. In fact, data from the Interagency Grizzly Bear Study Team itself show a growth rate of -2% between 2002 and 2012, which is the time frame that should be considered to be maximally sensitive to unfolding conditions.*

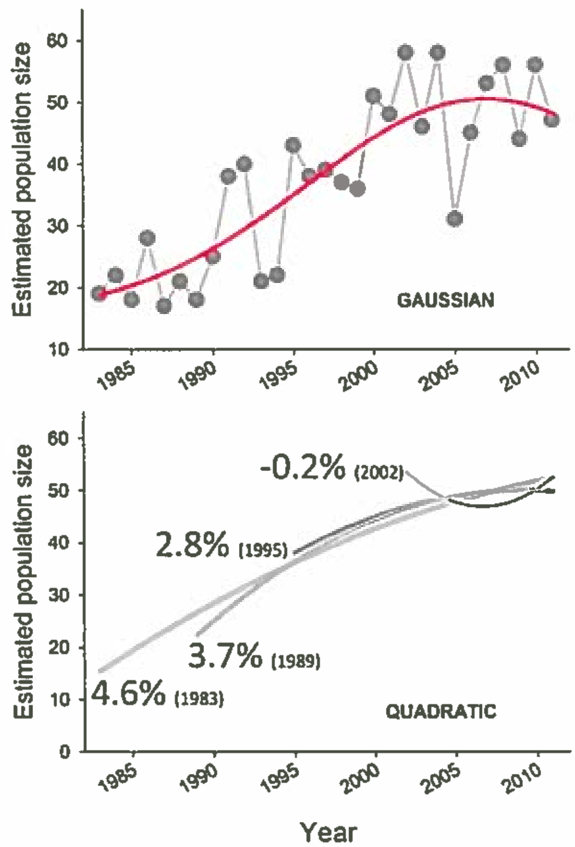
*Dr. Mattson concludes that all efforts of government scientists to estimate trend for the Yellowstone population are enslaved to the past, and that agency scientists are fixedly gazing in the rear view mirror at the same time that the management landscape is dramatically changing. Moreover, population trends are intrinsically insensitive to habitat changes because of lag in the response of populations to changes in the productivity or the lethality of the environment.*

*As important, the recent uptick of the population during the last 20 years or so should be seen against of the backdrop of recent extinctions, which amounts to population declines of around -6% per year during the last 150 years. An increase of a few hundred bears over 40 years hardly registers in the context of the loss of 98,000-99,000 bears during the previous century or so. To call this uptick "recovery" is a stretch.*

**Another trick in this Trend Game has to do with the kind of model chosen to describe (or fit) the population trend and the time span for which trend is modeled.**

**Depending upon the chosen model and time period, you can come up with dramatically different results.** Again, as with Trend Game 1 (link), the game being played by government officials is to select models and time frames to inflate population increases so as to justify delisting. At the expense of taxpayers who footed the bill, and the lives of grizzly bears.




The graphs at left contribute to illustrating these points. The gray dots are numbers of individual females grizzly bears with cubs-of-the-year (COY) observed each year in the Yellowstone ecosystem. These counts undergird all estimates of population size (see The Numbers Game for more on this). The different colored lines represent different trends fit using different models (the top graph) or a different time period (the bottom graph). The USFWS has chosen to fit trend going back to 1983. The current model used by the Interagency Grizzly Bear Study Team (IGBST) for fitting trend is a quadratic model. This model has a second negative term that, if deemed significant, would (so claims the IGBST) indicate a population decline following a long-term population increase.

So, key points? The graph at top shows that detection of a downturn in the population during recent years depends a lot on what model you assume is appropriate. A sigmoidal model would strongly suggest a downturn, even tethered to 1983, whereas a linear model would virtually never indicate negative growth. Moreoever, if, instead of tethering our trend line to 1983, we only fit more recent (and relevant data), we get essentially no growth. And that using a measure of trend (counts of females with COY) that is strongly biased high (see The Trend Game-1).

The graphs to the right expand upon the importance of time frame for estimating population growth rate and trend. The top graph essentially reiterates the data shown in the figure immediately above, but with only the sigmoidal trend line shown. **But the bottom graph is where the action is.**

The graph at bottom right shows trend lines that were all fit using a quadratic model, with each of the four lines fit to a different time period: 1983-2012; 1989-2012; 1995-2012; and 2002-2012. The numbers attached to each curvaceous line are estimates of population growth rate derived for the corresponding period. The point here is that you can get estimates of population growth rate that range from near 5% to near 0% simply by considering a different period of time; and this using the same method (quadratic) and the same dataset.

So, which statistical model and which period of time are appropriate? You could argue that the answer to these questions depends upon the result that you want to generate. If you want to ensure that you have a high estimated rate of growth and little sensitivity to current trends, then tether your estimate back to 1983 and use a linear or quadratic model. On the other hand, if you want to be maximally sensitive to unfolding conditions, only consider the most recent years (e.g., 2002-2012). **It hardly seems like coincidence that the USFWS and IGBST chose to answer these key questions in a way that supported inflated claims of population growth** (see The Trend Game-1) **and minimized sensitivity to current problematic trends** (see Conflicts & Mortalities). **And that they would also compound this by relying on a method for generating trend data that would yield estimates that were biased high** (see The Trend Game-1).

**One final observation:** All of the efforts by government scientists to estimate trend for the Yellowstone population are slaved to the past. Moreover, population trends are intrinsically insensitive to habitat change because of lags in the response of populations to changes in the productivity or lethality of the environment (see Lag Effects). The government's trend estimates based on the Chao2 method are anchored as far back as 1983. Trend estimates based on the mark-resight method are anchored at 1997. And trend estimates based on underlying estimates of birth and death rates obtained from trapped and radio-marked bears average data going back at least 6-10 years. All of these retrospective methods are profoundly insensitive to the rapidly unfolding conditions that we now face in Yellowstone, including sharp increases in bear mortality during recent years. Agency scientists and managers are fixedly gazing in the rear-view mirror at the same time that the management landscape is dramatically changing. It would be like



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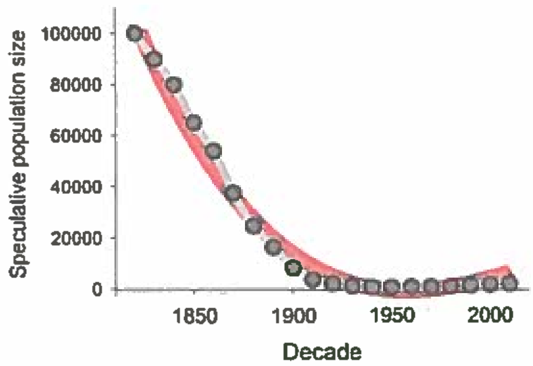
driving a car with the seat and stearing wheel placed looking backward, driving down a straight stretch of road, and assuming that everything ahead was like where you had been when, in fact, you were approaching a sharp corner along the edge of a cliff. It's a misguided way to manage any population, much less one that is at risk.

**And turning all of this on its head,** if you go back far enough--say 200 years--the trend for grizzly bear populations in the contiguous US is in stark contrast to trends being generated by the agencies for the last 30 years or so. The figure to the right shows a more-or-less speculative reconstruction of grizzly bear population trends between roughly 1820 and the present. The starting point is a commonly accepted estimate of 100,000 for all of the grizzlies in the western US at the time of first substantive contact with Europeans. The subsequent trend is fit to known extirpations dates (follow this link to a web page that provides details).

### Grizzly Bear Population Trends 1820-present




**The bottom line? if you look back far enough, the dominant theme remains one of massive extirpations typified by a trend of -6% per year sustained over >150 years. A loss of roughly 98,000-99,000 bears. Framed this way, increases in remnant grizzly bear populations from roughly 900 at the time they were given ESA protections in the early 1970s to a purported 1900 during the last decade hardly register. it is a bit of a stretch to call such a small uptick "recovery."**

**EXHIBIT M**

# Hunting to Scare Grizzlies?

**January 13, 2016**

**David Mattson**

Kill grizzly bears to make them afraid of humans. This idea has gotten a lot of air time in recent years as one of several justifications for removing endangered species act (ESA) protections for Yellowstone's grizzlies, most recently in a January 10th editorial by the Editorial Board of the Bozeman Chronicle. Delisting (another term for removing ESA protections) would clear the way for a sport hunt managed by the states of Wyoming, Montana, and Idaho, which are currently squabbling over a share of the sport kill in anticipation of devolution of authority from the federal government to them.

The idea of instilling fear in grizzlies through a hunt is emotionally charged because there have been several bear-caused human fatalities in the Yellowstone region during the last few years. The media, of course, has duly sensationalized each death. So the idea is to have sport hunters kill grizzlies to teach them to fear people. As a result, there will be fewer bear attacks. People will be safer. To borrow a phrase from Valerius Geist, a proponent of hunting bears, people will have "freedom of the woods." Hmm. Well…

Although some people obviously consider hunting to be a self-evident guarantor of human safety, there is, in fact, little or no empirical support for this proposition. There is essentially no evidence that a sport hunt instils fear in grizzlies. The proposition also defies logic and everything that we otherwise know about grizzly bears. If nothing else, how can a dead bear learn anything? A point that has been made by many others besides me.

Having made my assertion, I should probably elaborate, noting, though, that a thorough review of the evidence (or lack thereof) would probably bore you, the reader, to tears. Which means that I will confine myself to a (relatively) brief and necessarily cursory overview. So put on your seat belt and send me your questions if you want more detail.

## Grizzly Bear Fundamentals

The first point to be made is that grizzly bears exist at a baseline characterized by a greater tendency to respond aggressively to perceived threats compared to other bear species. Steve Herrero, a Canadian behavioral ecologist, was the first to speculate that this aggressiveness was rooted in the evolutionary history of grizzlies. Grizzlies (AKA brown bears) evolved in open environments where safety depended on standing your ground and intimidating or beating back any threat. (You can find more on the formative evolutionary environments of grizzlies by following this link and this link).

Even so, grizzlies can exhibit a high degree of tolerance for humans and other bears that might otherwise be viewed as threats. You can see this in coastal environments where bears have become highly socialized and tolerant of each other because of frequent interactions with conspecifics concentrated around salmon spawning streams. Or among bears that have interacted enough with benign humans to internalize a less fear-based response—a process known as "habitation."

So, a couple of key points are worth making at this juncture: First, grizzlies seem to be hard-wired genetically to deal with perceived threats aggressively. Second, and perhaps more importantly, grizzlies can become less reactive to people, not as a result of heightened fear, but rather as a result of the opposite. These fundamentals alone call into question the logic of using hunting to increase human safety. Killing grizzlies (and, as I address later, we've done a lot of that even with ESA protections) is unlikely to rewire the genetic underpinnings of their behavior; and less fear rather than more is probably going to make people safer, especially if we continue to reduce the number of circumstances (e.g., garbage around human residences or hunters near freshly-killed elk) that allow people to do things that trigger aggressive responses from even the most tolerant bears. More on that a little later.

## Welcome to the Vacuum

Another important point to make up front is that we know virtually nothing about the behavioral and motivational responses of bears to hunting, certainly little that is grounded in research. The closest we come is a study out of Scandinavia showing that hunted brown bears increased their night-time activity, with little obvious relevance to whether humans were thereby safer. A coarse-grained review by Jon Swenson, a Scandinavian bear researcher (and, for a while, a Montana biologist), suggested that hunted European brown bears might be more wary, but that this possible behavioral response was trumped by whether food was available near people. Bears were likely to seek out food regardless of whether they were hunted or not, which goes back to my point immediately above about garbage and hunter-generated carrion.

By contrast, we know quite a bit about the negative and often unintended consequences of selectively hunting adult males of various carnivore species. Insofar as livestock depredation and other conflicts are concerned—including the type that could lead to human injury—we tend to get more rather than fewer. This is because adolescent males tend to gravitate to areas where the dominant resident males have been removed by hunters. And adolescent male bears are notoriously prone to push human boundaries. Moreover, sport hunting tends to disrupt the social order of bear populations, which often results in more cub-killing by males and, with that, unexpected and sometimes problematic population declines.

So, a couple more points: There is little or no direct evidence that bears become warier with hunting, and certainly no evidence that people become safer. On the other hand, conflicts with people can paradoxically increase, along with unanticipated declines in bear populations. So, again, not a compelling case for the benefits of sport hunting.

**The Immediate Circumstances of Attacks**

At this point I return to Steve Herrero, who has spent essentially his entire professional career looking at the immediate circumstances of bear attacks, with emphasis on behaviors of the involved people and bears. His research shows that most attacks by grizzlies happened because people were moving quietly (or sometimes rapidly) through the woods, or because the bears were lured to the vicinity of people by food. The former set of circumstances led to surprise encounters. Adult females with cubs almost invariably responded aggressively to protect their young. On the food front, when grizzlies spent more time around people the odds mounted of us doing something stupid (or unintentionally risky), or of bears simply getting curious. So, surprise encounters and foods that attract grizzlies are prominent drivers of risk. And, again, foods were typically in the form of garbage or the remains of elk and moose that hunters had recently killed. Only rarely did Steve find that outright predation was a factor, typically as night attacks on people camping in tents.

This comports with what we know of circumstances surrounding the bear attacks that have occurred around Yellowstone. Several people have been injured or even killed because they were moving quietly through the woods (sometimes jogging), surprising a female that then defended her cubs, or a bear that defended a carcass, or, in the case of some hunters, just simply a bear that defended its personal space. But surprise encounters are a central theme. Then there were the few night attacks on people in tents, probably (or, in one instance, almost certainly) by bears that were in the habit of checking out campgrounds for food. So, the food factor. And then there were the odd-balls, such as the botanist killed by an enraged boar grizzly recovering from being trapped and drugged (again, a surprise encounter), or the photographer killed by a frantic female that he had pushed beyond endurance. In this latter case, the stupidity factor.

So, given these concrete circumstances, what can be deduced about prospects for increasing human safety by hunting grizzlies? Well…unless you kill most bears, you are not going to substantially reduce the chance of surprise encounters. Nor, as I noted earlier, are you going to eliminate the hard-wired tendency for grizzlies to defend themselves from a perceived threat when surprised, especially when guarding cubs or food. Hunting also does not deal with the availability of foods near people. And we would be foolish to expect that grizzlies will be less motivated to procure food because we are hunting them. Obtaining food is another hard-wired drive for bears, especially during the late summer and fall when they are putting on fat to get through hibernation. And hunting does not address the stupidity factor.

As a bottom line, when looking at the reasons why people get injured by grizzlies, I am hard-pressed to divine how hunting will increase human safety. Unless, perhaps, we kill most of the grizzly bears in and around Yellowstone, as our European ancestors did.

**And We've Already Run the Experiment**

On top of this, we've already run the experiment and found no evidence that it has worked. Which is to say, we've functionally been hunting Yellowstone's grizzlies for years, complete with gunshots, blood, gory remains, and lots of associated human scent and sign. Think, for example, of all the grizzlies that have been killed by big game hunters during surprise encounters or in conflicts over hunter-killed elk—increasingly. Or by ranchers and other people in defense of life-and-property. Functionally this is probably little different from a sport hunt, except in the heads and on the balance-sheets of wildlife managers. We've essentially been hunting grizzlies in Yellowstone, without any evidence that it has affected human safety one way or another.

**And What About Yellowstone Park?**

And then there is Yellowstone National Park, where a substantial proportion of the bear attacks and resulting human fatalities have occurred. There will not be a sport hunt in the Park, even with a delisted grizzly bear population. So, even assuming the unlikely--that hunting would cause bears to avoid us because they are more fearful, how will this effect be propagated through over 2 million acres in the core of the ecosystem? From hunted bears on the periphery, which will presumable be killed by humans at a higher rate compared to protected bears living in the core--in Yellowstone Park? In the face of a resulting net movement of bears outward rather than inward? Unlikely.

**But We Probably Can Make Bears Fear Us Even More**

At this point I've run much of the gauntlet of evidence and found little or no support for the idea that human safety can be enhanced by sport hunting. At least the traditional kind of sport hunting that focuses on killing trophy-worthy adult males, with little overt selection for bears known to be involved in conflicts with humans.

But there is a kind of hunting that probably could have an effect, and to understand this potential we need to look at what we know about relations among bears. More specifically, bears fear other bears, more than they probably fear humans. And there are reasons for this.

For example, there is ample evidence that fear motivates adolescent bears and females with young cubs to exert themselves to avoid other adults, even to the extent of spending more time near people. In fact, we can unintentionally serve as shields of sorts for bears that are seeking protection from aggressors of their own species. There are several reasons for all of this. Adolescents are often chased by solitary adults, and on occasion, probably thrashed to within inches of their lives…sometimes even killed. Likewise, cubs can be killed during encounters with adult grizzlies other than their mother, a phenomenon known as infanticide. All of this entails unpleasant experiences and interactions that happen on a relatively frequent basis, which fosters learning and even generalization of experiences.

So, what does this have to do with how we might hunt Yellowstone's grizzlies, with the objective of engendering fear of humans? It seems pretty obvious. You selectively hunt and kill cubs--but leave the mothers alive. And you trap bears, with an emphasis on adolescents, club them to within inches of their lives, and then let them go. And do this repeatedly and for as many bears as possible.

Having suggested such an approach, I find the prospect disgusting. But, then, I am sure there are some hunters out there that would relish the prospect of killing cubs and torturing trapped bears. The same hunters that have done something similar with wolves and coyotes. But the backlash from the broader public would be predictable, dooming such a hunting strategy to an early demise. Moreover, not unlike abused dogs, abused bears might, in fact, be even readier to attack a human should a surprise encounter happen.

Still, if the issue really is just simply about making grizzlies fear us… Or is the ardent promotion of sport hunting really about something else?

**Concluding Thoughts**

Take the case of Terry Schramm, a self-styled cowboy from Pennsylvania working for self-styled out-of-state ranchers who own the Walton Ranch in Jackson Hole. Or the legislator-rancher Albert Sommers who raises cows in the Upper Green River of Wyoming thanks to heavy subsidies by environmentalists (in the form of a $1 million plus conservation easement), by the federal government (in the form of well-below-market-price grazing fees), and by the state of Wyoming (in the form of generous compensation for any cows that he claims are lost to predators). In a recent Wyofile article, both of these icons of the modern west explicitly or implicitly suggested that their fraught lives would be a lot less problematic if there were many fewer grizzlies in a lot fewer places.

The fundamental idea here is to kill grizzlies. The more the better, by whatever means, including sport hunting. My point being that many of those who promote hunting as a means of increasing human safety are probably using the argument simply as cover for getting rid of grizzly bears that they see as an inconvenience or an affront to their personal ideologies.

Without having the space here to elaborate, I will leave you with a related thought. Perhaps those promoting the sport hunting of grizzlies are doing so viscerally, out of a place of fear and a derivative need to dominate and subjugate anything that subjectively threatens them. A dark place. A place that gives rise to the logic of owning lots of guns and affirming self through the act of killing—especially beings such as grizzly bears that somehow impart a sense of potency. Or that the habit of killing is so deeply ingrained personally and institutionally that it is impossible for most hunters and wildlife managers to conceive of wildlife management in any terms other than hunting. Possibly? Certainly not from a place informed by an objective and thorough examination of the evidence.

**EXHIBIT N**



HOUSE BILL NO. HB0018

Wolves and grizzly bears-limited state action.

Sponsored by: Select Federal Natural Resource Management Committee

A BILL

for

AN ACT relating to game and fish; prohibiting law enforcement from assisting the federal government in investigating, arresting and prosecuting persons taking or injuring gray wolves or grizzly bears as specified; providing exceptions; and providing for an effective date.

*Be It Enacted by the Legislature of the State of Wyoming:*

**Section 1.** W.S. 23-3-310 is created to read:

**23-3-310. Gray wolf and grizzly bear investigations and assistance prohibited.**

(a) No game and fish personnel or Wyoming law enforcement officer shall assist any official, agent or employee of the United States government in the investigation, arrest or prosecution of any person who takes or causes injury of a gray wolf or grizzly bear in the state, if the animal is a species listed as experimental nonessential population, endangered species or threatened species in the state.

(b) Nothing in this section shall prohibit game and fish personnel or Wyoming law enforcement officers from:

(i) Enforcing or complying with any provision of federal or state law other than those identified in subsection (a) of this section;

(ii) Responding to civil process;

(iii) Taking any action to facilitate the delisting of the gray wolf or grizzly bear under the Endangered Species Act;

(iv) Working with any official, agent or employee of the United States government in an effort to



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reduce the number of gray wolves or grizzly bears in any area in the state.

**Section 2.** This act is effective immediately upon completion of all acts necessary for a bill to become law as provided by Article 4, Section 8 of the Wyoming Constitution.

(END)



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**EXHIBIT O**

# Grizzly Times

## The Grizzly Bear Moth-Eating Jig

**April 14, 2016**

**David Mattson**

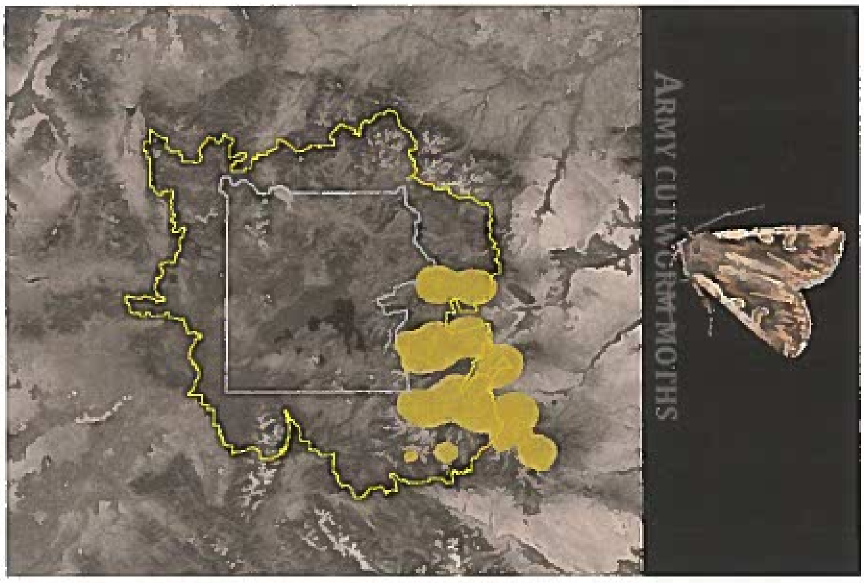
*Public domain photo by the US Geological Survey*

Back in 1955, a year after I was born, John Chapman published a paper in the journal Ecology describing a peculiar feeding activity by bears in the Mission Mountains of western Montana. Grizzlies and black bears were both rummaging through alpine talus fields—eating something. As it turned out, they were slurping up both ladybird beetles and army cutworm moths that had concentrated there during the summer to either aestivate or to feed on nectar of high-elevation flowers. Twenty plus years later John Craighead and his colleagues described grizzly bears gobbling up cutworm moths from under overturned talus rock in alpine reaches of the Scapegoat Mountains roughly 50 miles east of the Missions. Barring a few published descriptions by early mountaineers, these were the first and—for a while—the only written descriptions of bears feeding on cutworm moths.

In the late 1970s and early 1980s, when I first started working for the Interagency Grizzly Bear Study Team (IGBST), the Missions, Scapegoats, and their resident grizzlies seemed pretty remote and exotic, albeit only about 250 miles away as the crow flies from where I was working in the Yellowstone ecosystem. The idea that grizzlies in Yellowstone might feed on cutworm moths seemed equally strange and exotic. In fact, if anyone had asked me in 1985 if bears in Yellowstone ate moths I would have said "nope, no evidence of it at all," and this after having covered over 1000 miles by shanks mare each of the previous six years in this ecosystem. But one year later I would be proven wrong.

In July of 1986 the IGBST's veteran pilot, Dave Stradley, located a radio-collared grizzly camped on a talus slope straddling an alpine divide in the Absaroka Mountains east of Yellowstone Park. It seemed odd. Next year the same bear camped in the same location. Moreover other radio-collared bears were found camped on yet other remote talus slopes in the same area. This anomaly catalyzed an expedition to find out what the heck was going on, consisting of myself, Bart Schleyer, Carrie Hunt, and Kurt Inberg. Carrie and Kurt were employees of Wyoming Game & Fish at the time. What we found were multiple grizzlies on the site where our collared bear had first been located during 1986, all rummaging through alpine talus, feeding on slithering masses of cutworm moths. The same phenomenon was documented on three more sites during 1987 and 1988 thanks to strenuous efforts by IGBST field crews that included Gerry Green, Jamie Jonkel, Dan Reinhart, and Doug Dunbar.

Since then, ever more grizzlies have been found on ever more alpine sites gobbling up cutworm moths—a total of 31 now. All of the sites are above 10,000' elevation, all in the Absaroka Mountains east and southeast of Yellowstone Park (see the map immediately below). Anymore, it is probably not too much of a stretch to claim that the majority of the bears in this part of the ecosystem spend the majority of their time between mid-July and mid-September on these exceedingly remote moth sites eating moths gathered to feed on nectar of alpine flowers. The moths feed primarily during nighttime, dawn, and dusk, and spend the remainder of the day in the chilly cracks and crevices of angular rocks accumulated on talus slopes, which is where the bears find them. Why congregate like this in a cold microenvironment if you are moth? Who knows, but I suspect it has something to do with avoidance of predators and parasites—barring bears.

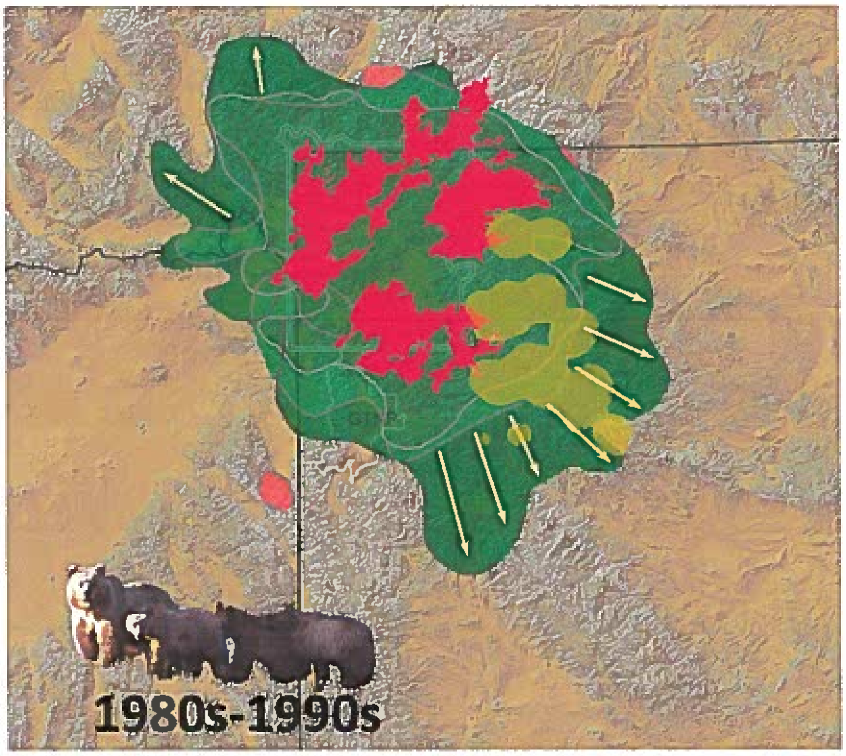



*The moth sites in this map are encompassed by the yellowish-green blobs, with reference to the boundary of Yellowstone National Park (the gray line) and the Primary Conservation Area (PCA) for Yellowstone's grizzly bears (yellow line). There are three take-away points: first, all of the moth sites are in the Absaroka Mountains on the east side of the ecosystem; second, all of the sites are outside of the Park; and, third, some moth sites are outside of the PCA.*

Since the early 1990s the phenomenon of grizzly bears eating moths in Yellowstone has been pretty thoroughly documented thanks to an initial research publication in 1991, successive papers by Steve and Marilyn French (in 1994) and Sean O'Brien (in 1998), and annual updates in the IGBST's Annual Reports. Of even greater import, bears eating moths in the remote and startlingly beautiful alpine haunts of Yellowstone has captured the public imagination, aided and abetted by the efforts of several enterprising and sometimes intrusive film crews, most notably from BBC. Their footage has probably been seen by millions of people worldwide thanks to being aired as part of the BBC series *Planet Earth.*

I could wrap things up here and leave this simply as an interesting bit of history. But I can't help think of larger ramifications for Yellowstone's grizzly bears, our current approaches to research and management, and a pending move by the US Fish & Wildlife Service (USFWS) to remove Endangered Species Act (ESA) protections for this bear population. Making these kinds of connections seems to be my plight.

As it turns out, the burgeoning use of moth sites by Yellowstone's grizzly bears probably explains much of the major increase in their distribution to the east and southeast that occurred between the mid-1980s and 2000. The match between where we find moth sites and where the greatest expansion occurred is uncanny. Remember, too, that this period was on the heels of the 1988 wildfires that killed nearly 30% of cone-producing whitebark pine in the core of the ecosystem (whitebark pine is another key source of bear food). The map below shows details of all this.




*Here the moth sites are superimposed on the distribution of Yellowstone's grizzly bears, represented by the green shading, with the beige arrows denoting areas of major increase in distribution between the 1980s and 1990s. The red represents areas burned during the epic wildfires of 1988. There are two takeaway points: first, the largest increase in distribution was in the direction of the newly-discovered moth sites; and, two, these increases also occurred after the 1988 fires had taken out roughly 30% of the whitebark pine in the core of the ecosystem.*

Coincidentally, dramatic increases in grizzly bear activity on moth sites have also contributed to inflated estimates of growth for the Yellowstone grizzly bear population. Bears on moth sites are almost certain to be seen by airborne researchers and managers out looking for females with cubs-of-the-year (COY) at their side. By contrast, bears engaged in virtually any other kind of feeding activity are likely to be seen only 1%...at most only 40% of the time... when somebody flies over. Which is to say, grizzlies have, in the net, become one heck of a lot easier to see in the last couple of decades, at the same time that managers and researchers have quadrupled their efforts to find bears. Given that sightings of females with COY are the foundation of all estimates of population trend, these estimates have correspondingly been inflated upward—because of increased search effort, but also by the increased ease of sighting females with COY on moth sites. Perhaps an unintended consequence? Maybe not.

Less positively for Yellowstone grizzlies, their expansion into Wyoming in apparent pursuit of moths has taken them deeper into cow country. Not surprisingly, a considerable portion of the increasing number of conflicts between grizzlies and ranchers over cattle (another nutritious bear food) in the Yellowstone ecosystem is concentrated not too far downslope from a number of moth sites. So, perhaps paradoxically, increasing exploitation by grizzlies of a food in some of the most remote parts of the ecosystem (that is, moths) has probably contributed to a substantial increase in the numbers of bears dying downslope and down-elevation in retaliation for predation on livestock.

And having expanded well inside the frontier of regressive Wyoming politics and attitudes, the arrangements proposed by the US Fish & Wildlife Service as part of a package for removing ESA protections from Yellowstone's grizzly bears would leave some of the moth-eating grizzlies high and dry outside the zone of meaningful protections, and the rest exposed to the potential excesses of Wyoming Game & Fish Department's post-ESA management. Wyoming is frothing at the mouth to institute a sport hunt, and there is going to be no easier bear for a hunter to find (albeit a little difficult to reach) than one camped on a moth site. The Department also seems dedicated to the proposition of reducing grizzly bear densities on the ecosystem periphery, which coincides with the areas containing all of the moth sites—this as part of a putative strategy for reducing levels of livestock depredation. The net prospects for moth-eating grizzly bears are not good. And, as I pointed out a little earlier, these moth-eaters comprise a substantial portion of the total Yellowstone grizzly bear population.

In light of all this, it only makes sense to expand the Primary Conservation Area out to include all of the known moth sites, and then protect these sites and a substantial surrounding area from any sport hunting. Better yet, don't hunt delisted grizzlies. And, even better yet, don't remove ESA protections and, instead, prioritize the protection of these grizzly bears that are otherwise at the edge of all protections, and the most exposed of all to thuggish enclaves of Wyoming citizenry.

But, I have one more thought that arises from the grizzly bear x moth phenomenon. As I noted before, the emergence of moth-eating by Yellowstone's grizzly bears was a complete surprise for me. And I've continued to be surprised by all sorts of things that I never could have imagined: the 1988 Yellowstone wildfires; the near-extirpation of cutthroat trout in Yellowstone Lake by climate change and predation by an illegally introduced predator; the widespread losses of whitebark pine to an unprecedented bark beetle outbreak driven by a warming climate; massive declines in virtually all of the ecosystem's elk herds, also driven in part by climate change; the emergence of Chronic Wasting Disease as a threat to larger mammals in the ecosystem; and more… The theme here is surprise and, barring cutworm moths, all of the surprises have so far been (more or less) really unpleasant.

The take away? Perhaps humility is in order for our federal and state wildlife managers—humility and caution. As is, I see little evidence of either in the USFWS's rush to remove ESA protections, Wyoming Game & Fish's eager embrace of lethal grizzly bear management, or the cocky attitudes of the current crop of IGBST researchers. What to do? I don't know exactly, other than sure as Hell don't turn the keys to the car over to Wyoming any time in the near future.

**EXHIBIT I**

# Grizzly Times

## Partisan Scientists in Public Service II: The Strange Case of the Interagency Grizzly Bear Study Team (continued)

**April 7, 2016**

**David Mattson**

*Another grizzly being collared to then be follered (undated IGBST photo)*

Last week I painted a picture of corrupted science behind the current push to remove Endangered Species Act (ESA) protections from Yellowstone's grizzly bears. On the face of it, there are other possible interpretations. But what makes the case for corruption particularly compelling is the extent to which this scientific endeavor is beset by a perfect storm of influences that in combination virtually guarantee subversion of the entire undertaking—even with participating scientists who have the best of intentions.

### The ingredients of corruption

Any useful explanation of my claim necessarily starts with some basic observations about the human condition. Most fundamentally, all people are captive to their subjectivity, which axiomatically debars any of us from being truly "objective." With that, we are prey to bias. This fundamental psychological truth makes us additionally prey to a phenomenon called "groupthink," which arises when we surround ourselves with like-minded people who reinforce our prejudices and perspectives. Most of us are also notoriously vulnerable, directly or indirectly, to the sway of money, which becomes all the more potent when we are subsumed in a system that rewards us for bringing money in the door. Finally, given all of these powerful bias-inducing forces, science only truly progresses—or produces "reliable" results—when done under circumstances of the utmost transparency and openness, including ample provision for the attempted independent replication (or refutation) of any research results.

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With these basics in mind, it is pretty easy to compile a list of hugely problematic circumstances that beset the government scientists producing the information being used by the US Fish & Wildlife Service (USFWS) and regional state politicians to advance the agenda of delisting Yellowstone's grizzly bears. Seven toxic ingredients…

***1. Self-delusion***: Every Interagency Grizzly Bear Study Team (IGBST) scientist that I've known, past or present, has at some time publicly claimed that they are "objective"—sometimes fervently and defensively so. As often as not, they also claim that they merely "let the data speak for themselves." And I truly believe that they truly believe what they say. This certainly holds for the current IGBST Leader, Frank van Manen, as well as his predecessor, Chuck Schwartz.

But putting beliefs aside, whenever I hear anyone make such claims red flags go up. Rather than providing reassurance, I typically end up being convinced instead that the person making such assertions has little self-reflective capacity—which is a big problem. I contend that the only way any of us can attain even some measure of objectivity is by being acutely aware of the inevitable biases that arise from our immersion in subjectivity. Without such awareness, I suspect that people such as Frank and Chuck are (or were) all the more vulnerable to the biasing forces that pervade their professional practice. And, in fact, "confirmation bias" in research is such a widespread phenomenon that it has spawned its own body of scientific literature.

***2. Groupthink***: Put succinctly, the IGBST's scientists and their invited collaborators are pretty much holed up in a private clubhouse with guns pointed outward ready to blast away at anyone who questions their science. A recent critique of the IGBST's primary method for monitoring Yellowstone's grizzly bear population by Dan Doak and Kerry Cutler was met with a putative rebuttal by the IGBST that, at least to my eye, relied more on the cumulative biomass of authors than on any particularly cogent arguments. Doak and Cutler's rebuttal of their rebuttal was aptly entitled "Doth Protest too Much."

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The point of all this being that the IGBST and its helpmates have existed for years in a sort of echo chamber, which is perfect recipe for "groupthink" typified by conformity and an inability to imagine alternatives. In fact, sociologists who study scientists have long noted the prevalence of groupthink among research teams or lineages, most compellingly Thomas Kuhn in his work on scientific paradigms. Of relevance here, I see ample evidence of entrenched groupthink among the IGBST's research group, made all the more problematic by the aggressively defensive response of this cabal to any perceived threat to their scientific hegemony and the deliberate exclusion of any public critics.

***3. Monopoly***: Under normal circumstances a research team afflicted by groupthink and populated by scientists prey to delusions of objectivity wouldn't be a particularly big problem for the advancement of our collective understanding of the world. But this holds true only when all who might be interested have free access to the same physical system (as in physics or chemistry) or, in the absence of opportunities for exact replication, have unimpeded access to the same data, which holds for most wildlife field studies, including those of relevance to Yellowstone's grizzly bears. Or put another way, any kind of monopoly on inquiry is antithetical to scientific integrity and the production of reliable information. Period. (The literature substantiating this basis point is beyond summary, but see Philip Kitcher's 2002 book for an interesting perspective).

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In the case of Yellowstone's grizzly bears, the IGBST maintains a stranglehold on virtually all of the relevant data (Fischman and Meretsky provide context and background on this). There is only one Yellowstone grizzly bear population, only one dataset of direct relevance to management of these bears, and only one research team privileged with access to it. And this monopoly doesn't exist by chance. The IGBST's scientists, aided by the USFWS, have fought tooth and nail to maintain this monopoly and, in the one instance where a Freedom-of-Information-Act (FOIA) request forced them to disgorge some data, they have since worked hard, politically, to dismiss the resulting science. Even more egregiously, the current IGBST Leader, Frank van Manen, publicly stated that he needed to perpetuate a monopoly to advance his career (follow this youtube link). Mind you, all of the data as well as Frank himself are paid for with taxpayer dollars. A monopoly is a huge problem.

***4. Lack of replication***: I invoked replication immediately above, and I did so because replication of research, or the opposite (lack of replication) is the foundation of any scientific progress—or reliable information. And attempted replication is best undertaken by an independent team of preferably cantankerous and critical scientists, or at least scientists who have a burning desire to genuinely understand how the world works. Peer review is sometimes invoked as THE cornerstone of science, but it isn't (more on that immediately following). Independent attempts at replication are.

In the case of Yellowstone's grizzly bears, where you have messy data collected under messy field conditions, this amounts to independent analysis that deploys alternative models and statistical methods given that modeling is the only means by which useful insight into environmental change—e.g., loss of whitebark pine—can be achieved. But there are numerous possible models parameterized by a number of possible statistical methods, and none are "correct." In fact, different models will give you different results, even using the same data and asking the same question. Illustrative of this, a recent article in *Science* featured what happened when 29 research teams were given the same dataset and asked to determine whether a particular effect was "significant," not unlike loss of whitebark pine. You got essentially 29 different answers, ranging from non-significant, to slightly significant, to highly significant. In application to any complex system, there are multiple possible models and multiple possible outcomes and, in any situation that is contested and consequential, as many of these models and results as possible need to be on the table for consideration.

My point? The deliberately perpetuated monopoly that I described above debars replication, diverse analytic perspectives and, with that, any reliable science.

***5. Politicization of peer review***: But what about peer review? This question matters because the USFWS, the IGBST, and its parent organization, the US Geological Survey (USGS), constantly assert that peer review is not only the cornerstone, but also the guarantee of quality science (for example...). In other words, invocation of peer review is a primary means by which these invested federal agencies skirt the monopoly issue in the case of Yellowstone's grizzly bears.

Don't worry about independent inquiry; we've got the bases covered with peer review—as an article of faith. And so on. But do they?

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As it turns out, the research on peer review shows that it guarantees nothing (the literature on this is vast, but see these two emblematic papers). The best that any half-way objective person can say for peer review is something similar to what Winston Churchill said about democracy: "Democracy is the worst form of government, except for all the others." Hardly reassuring. One could say that peer review serves roughly four functions: censorship; improvement; maintenance of identity; and political advantage. On the censorship front, peer review works just about as good as flipping a coin for detecting and excluding egregious errors. Insofar as identity is concerned, it clearly constitutes a cleansing ritual that helps sustain the self-ascribed elite status of most scientists. It works perhaps best as a means of improving scientific endeavors and products. But in the case of Yellowstone's grizzlies, it is clear that peer review is used primarily for political purposes by the involved bureaucracies, primarily by making inflated claims for its efficacy as a basis for maintaining control over scientific inquiry, and, with that, advancing the delisting agenda.

***6. Corrupting money***: Almost all scientists scramble for money to do research, which holds for IGBST scientists as well. They have their salaries more-or-less covered by agency budgets, but rely on outside money to hire consultants, recruit other outside help, and execute many field studies. But with money comes the potential for often tacit corruption, especially when the research is highly politicized, the money fronted by an entity with a vested interest, and where there is explicit provision for this party to have a seat at the table when shaping research questions and vetting research results—all of which holds true for the post-2007-litigation science produced by the IGBST. Chris Servheen of the USFWS ponied up most of the taxpayer dollars to support this research, along with a mandate to target the whitebark pine issue at the heart of the Courts' 2009-2011 rulings, and a timeline for cranking out the science in support of a delisting rule prior to the 2016 elections (for example, see the IGBST study plan which explicitly targeted whitebark pine and was signed off on by Servheen). Moreover, email traffic obtained through a FOIA shows that Dr. Servheen was deeply involved in crafting, reviewing, and flogging this science. As I described last week, Recovery Coordinator Servheen is hardly a neutral civil servant. At a minimum, he pretends to play legislative politics.

***7. Business models of science***: And if this weren't bad enough, the IGBST's federal scientists are subsumed in an agency—the USGS—that has adopted a business model of science. Which means what? For one, those (such as the USFWS's Chris Servheen) who pony up money for USGS scientists are referred to as "customers." This implies that the IGBST is producing a product to satisfy the customer, which is, in fact, a highly prioritized outcome in the USGS. Amazingly enough, the USGS sends out questionnaires to "customers" asking whether they are satisfied, which is to say, asking whether the science served their purposes? (For example, follow this link). In a case such as Yellowstone's grizzly bears, all of this predictably amplifies the corruptive potential attached to the money that the IGBST received in recent years from the USFWS, which, like all government bureaus, has its special interest agendas.

EXCERPTS ATTACHED

Perhaps for some readers who are sold out heart and soul to the capitalist model of everything, the notion of a business model is prima facie a good thing. But it is actually a bad thing when, in fact, the "customer" of a federal science agency is (as it should be) that amorphous blob of people called "the public," and where the ultimate purpose being served is fulfillment of the public trust, not the expectations of a privileged few (see this recent insightful paper by Adrian Treves on the public trust doctrine with reference to predators such as grizzlies).

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**What to do? Some recommendations**

What to do about all of this? Perhaps seven antidotes for seven toxic ingredients…

First, without intending to sound flip, I would recommend that leaders of the USGS, and most members of Congress for that matter, go back and take a civics course, and perhaps even bother to read some of the original texts authored by Adam Smith. A little Max Weber might not hurt either. And then they should root out the corruptive business model—"pay to play"—that has taken hold in the USGS and other federal government bureaus.

Second, the monopoly that plagues Yellowstone's grizzly bear science absolutely needs to be broken; which means that all of the data, bar none, should be made freely available to scientists and citizens for multiple independent inquiries. The argument advanced by the USFWS that these data need to be sequestered to protect Yellowstone's grizzlies from poachers should be recognized as the ruse it is.

Third, the move to delist Yellowstone's grizzly bears should be put on hold until there is, in fact, some modicum of reliable science upon which to base deliberations. As is, I would argue that there is none to be had, for all of the reasons listed here.

Fourth, it might not hurt for the current crop of IGBST scientists and their compadres to sit through a class or two devoted to social-psychology and, better yet, the sociology and philosophy of science. There is clearly a knowledge deficit on this front.

Fifth, it also might not hurt for all of the involved scientists to dig into the research that has focused on the efficacy (or inefficacy) of peer review, the critical importance of replication, and the problems of model-based inquiry into messy data. The current naiveté and faith-based approaches to scientific practice are, quite frankly, staggering.

Sixth, it might improve matters if some of those in the USFWS who have overstepped the bounds of ethical behavior were appropriately chastised for their overreach. Clearly, people as high as Dan Ashe and as low as Chris Servheen don't have a good grip on what is and is not appropriate behavior for a civil servant in an administrative agency. Perhaps clearing house might be in order.

Finally, seventh, I strongly recommend humility and caution on the part of those managing and studying Yellowstone's grizzly bears. No matter how good our science, we will always be dealing with a huge amount of uncertainty rooted in the massive global changes afoot.

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LETTER

# Re-Evaluating Evidence for Past Population Trends and Predicted Dynamics of Yellowstone Grizzly Bears

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## Abstract

Sampling effort and demographic assumptions may powerfully shape conclusions about the status of endangered species. We re-examined data sets that suggest recent increases, and hence relative safety from future extinction, of the grizzly bear population inhabiting the Greater Yellowstone Ecosystem (GYE), one of the best studied large carnivore populations in the world. We find that inadequate attention to increasing observation effort and also to the life history characteristics of bears is likely to have substantially influenced past analyses of the population's trajectory. We conclude that the GYE grizzly has probably increased far less than generally believed, but also that past analyses have been too inaccurate to allow any firm conclusions about the dynamics or status of this population. The problems we illustrate here apply to many other threatened species and suggest the need for more careful consideration of observation processes that can shape our perceptions of species' history and status.

## Introduction

Throughout the world, large predators have been disproportionately impacted by human land-use changes and direct persecution. In addition, many large predators are thought to be of particular importance in structuring their ecological communities (Terborgh & Estes 2010). Together, these patterns have generated a focus on the recovery and maintenance of predator populations. The grizzly bears (*Ursus arctos horribilis*) living in the Greater Yellowstone Ecosystem (GYE) form a small and isolated population of large carnivores, but is widely believed to have rebounded in numbers and to now be relatively safe from extinction. Partly because of its ecological importance, and partly because of the controversy surrounding efforts by the government to remove the population from protection under the U.S. Endangered Species Act (and efforts by other groups to oppose this decision), the Yellowstone grizzly population has been the focus of intense scientific study for over 40 years, with efforts to delist the population dating back to 1999 (Wilkinson 1998; Primm & Murray 2005), and continuing to the present (in 2011 a federal judge rejected the latest delisting attempt).

Here, we examine the evidence that this population has been increasing in numbers and is relatively safe from extinction. In particular, we re-examine the use of two data sets at the core of the arguments about the population's status, past and present: demographic rate estimates from 1983 to 2001, and relative density estimates from 1973 to the present. The second of these two data sets is one of the most commonly used examples in the literature on count-based population viability analysis (e.g., Dennis *et al.* 1991; Dennis & Taper 1994; Morris & Doak 2002; Lindley 2003; Buonaccorsi & Staudenmayer 2009).

Our results cast doubt on the assertion that this population underwent a sharp increase from 1980 to 1995 and has recently stabilized in numbers, or even continued to increase (Harris *et al.* 2007, Eberhardt & Breiwick 2010). Beyond addressing the status of this population, our results illustrate how shifts in the observation process can alter the perception of population viability and risk. As

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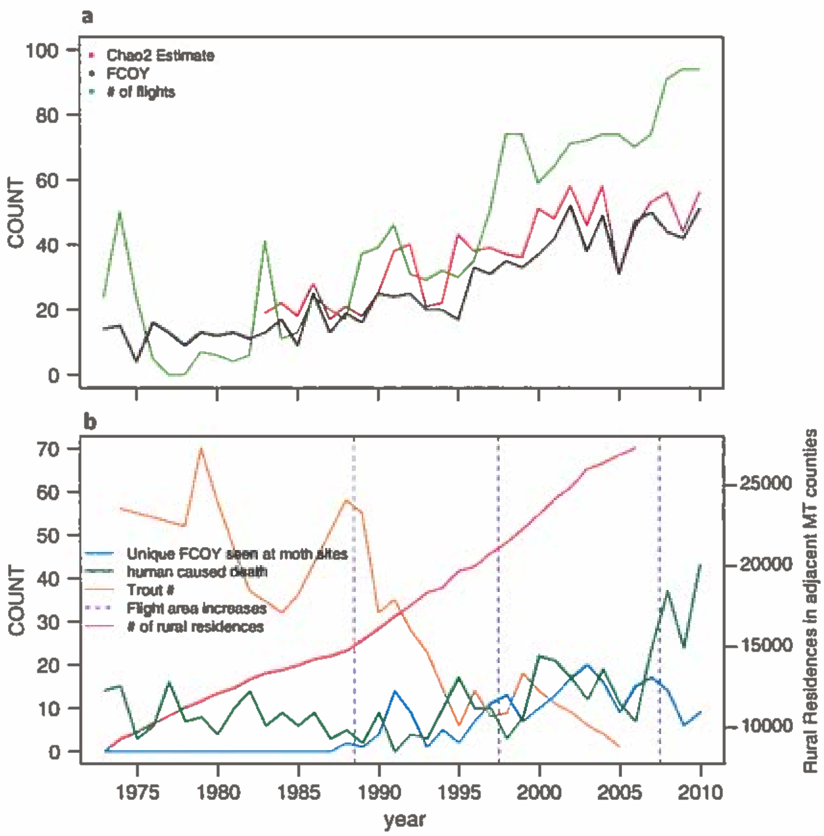


**Figure 1** Trends in bear sightings and several important variables influencing observations as well as population dynamics. (A) Numbers of unduplicated females with cubs of the year (Fcoy), Chao2 estimates based on the Fcoy numbers, and the number of observation flights flown to spot bears each year. (B) Trends in the numbers of Fcoy seen at moth sites, known human-caused bear mortalities, the number of rural residences in the GYE (Gude *et al.* 2006), and the number of migrating cutthroat trout at Clear Creek (count × $10^3$, Koel *et al.* 2005). Shifts in the flight search areas are also indicated.

species become rare, or are proposed to be recovered, it is common for formal and informal observation effort to change substantially, and our results caution that unless these changes are carefully analyzed (e.g., Boyd 2010; Kery *et al.* 2010; Senyatso *et al.* 2013), they can result in substantial misunderstanding of a population's history and hence safety from future extirpation.

## Background

Over the last 50 years, many changes have taken place in the GYE that are likely to influence grizzly populations and multiple shifts in the knowledge and monitoring of grizzlies have also occurred. Some of these changes are illustrated in Figure 1 (also see Appendix S1). The changes most likely to influence our study questions are increasing effort searching for bears each year, increasing bear use of feeding sites where they are easily seen, as well as human recognition of these sites (in particular, high-elevation moth aggregations, which have been increasingly used by bears since 1981 and were first recognized as feeding sites in 1986; Mattson *et al.* 1991), and three trends almost certain to negatively impact bears: loss of trout runs, ongoing collapse of white-bark pines (both important food sources), and increasing rural development.

Virtually, all data on the dynamics of the GYE population come from the ongoing work of the Interagency Grizzly Bear Study Team (IGBST). The first data set we consider comprises annual estimates of minimum population numbers, used to infer trends in population size. These surveys, which estimate unique (= "unduplicated") females with cubs of the year (Fcoy), were initiated in 1973 and are ongoing. Grizzlies do not reproduce every year and thus on average Fcoy represents ~33% of all adult females and ~27% of the entire bear

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population (Eberhardt & Knight 1996). Several factors could complicate interpretation of these population estimates (Mattson 1997; Boyce *et al.* 2001; Keating *et al.* 2002; Cherry *et al.* 2007). Key among these are: increases in standardized sampling effort over time (Figure 1); the use of both standardized and nonstandardized sampling to estimate Fcoy each year; increasing knowledge of places with high sightability of bears; changing food and habitat use patterns; and the shifting range of bears and also of search effort (see Appendix S1 for more on these issues).

Recognizing that there are multiple problems with Fcoy as an estimator of relative population size, the IGBST has more recently used the Chao2 estimator (Chao 1989; Wilson & Collins 1992; Keating *et al.* 2002; Cherry *et al.* 2007). Chao2 is one of a widely used family of population size (or species richness) estimators that use the frequencies of observations (how many times each individuals is seen within a sampling period) to estimate unobserved individuals. Chao2 uses the relative frequencies of Fcoy seen once versus twice in a season to estimate the numbers of Fcoy present but not observed. While Chao2 was adopted in response to concerns that differences in sightability of bears, as well as variation in observation effort, were affecting Fcoy estimates, it is nonetheless sensitive to heterogeneity in sighting probabilities, as well as the amount of effort that is expended for the observation process each year (Keating *et al.* 2002; Cherry *et al.* 2007). Nonetheless, even the most recent IGBST analyses (IGBST 2012), which suggest moving away from the Chao2 estimator, do not question the history of population growth that is based on the Fcoy and Chao2 metrics.

The second major data set relevant to our questions are estimates of demographic rates. Since the 1970s, the IGBST has been collaring bears to estimate the vital rates of the population. These include age of first reproduction, litter size, breeding probability, interbirth interval, and survival of different age and sex classes in the population. The IGBST has used these estimates for deterministic calculations of the GYE grizzly bear population growth rate (e.g., Harris *et al.* 2007), arriving at annual population growth rates as high or higher than those indicated by trends in Fcoy and Chao2.

## Methods and results

### Relative population size estimates

A key potential failure of the Chao2 estimator as an accurate representation of relative population sizes through time results from the changing intensity of observation effort, and potential changes in the sightability of bears due to dietary shifts and a nonrandom search regimen. Of particular concern, is the confounding of observation effort and estimated bear numbers (Figure 1). The correlation between observation hours and Fcoy is high ($r^2 = 0.717$; Figure 2A), suggesting that the apparent rise in bear numbers could be a direct consequence of increased sampling effort (and also, potentially, increasing efficacy of observation, as noted above; see also Boyce *et al.* 2001). At the same time, the ratio of Chao2 to Fcoy has remained steady over time, suggesting that this estimator may not successfully correct for shifts in observation effort or other changes (Figure 2B).

We conducted several simulations to explore the performance of Chao2 and in particular to determine whether it can provide accurate assessments of population trends with shifting observation and sightability parameters. These simulations are similar to those conducted by Keating *et al.* (2002) and Cherry *et al.* (2007), but we take a more mechanistic approach that explicitly simulates the observation process, based on a distribution of sightabilities of Fcoy. These $P_{obs}$ values, the probabilities of a bear being seen per hour of observation, can be characterized by a beta distribution. We obtain our baseline estimates of this distribution from the data in Keating *et al.*'s (2002) Table 5, which shows the full frequency distribution of sightings over 16 years, and the number of observation flight hours per year. Using MCMC methods and assuming that the observed frequencies follow a censored beta distribution, we obtained maximum likelihood estimates of the beta parameters a and b (0.4416015 and 50.40902), resulting in a mean hourly sightability of 0.00868429 observations/hour, and a CV in sightability of 1.483754 (code used for this and all other analyses is included in Appendix S1). This mean and CV are similar to those used by simulations by Keating *et al.* (2002) and Cherry *et al.* (2007). While these estimates can only be made for the quantified search effort and cannot be viewed as definitive (Link 2003), they should give a reasonable estimate of the total probability of sighting a bear if quantified search effort is related to total probability of a sighting, as it appears to be (Figure 2).

Next, we simulated different scenarios of changing or constant observation effort, sightability parameters, and actual bear numbers, generating series of Fcoy and Chao2 estimates to compare with the observed values in these estimators over time. First, with the population held constant at $n = 50$, we varied the CV of sightabilities, while holding mean sightability constant (Figure 3a). The Chao2 estimator is positively related to the CV of sightability, and is actually more sensitive to changing variance in sightability than are Fcoy values. This sensitivity persists over a range of population sizes (Figure 3b). We conducted similar analyses for mean sightabilities: Chao2 estimates also rise as the mean sightability of bears increases (Figure 4).

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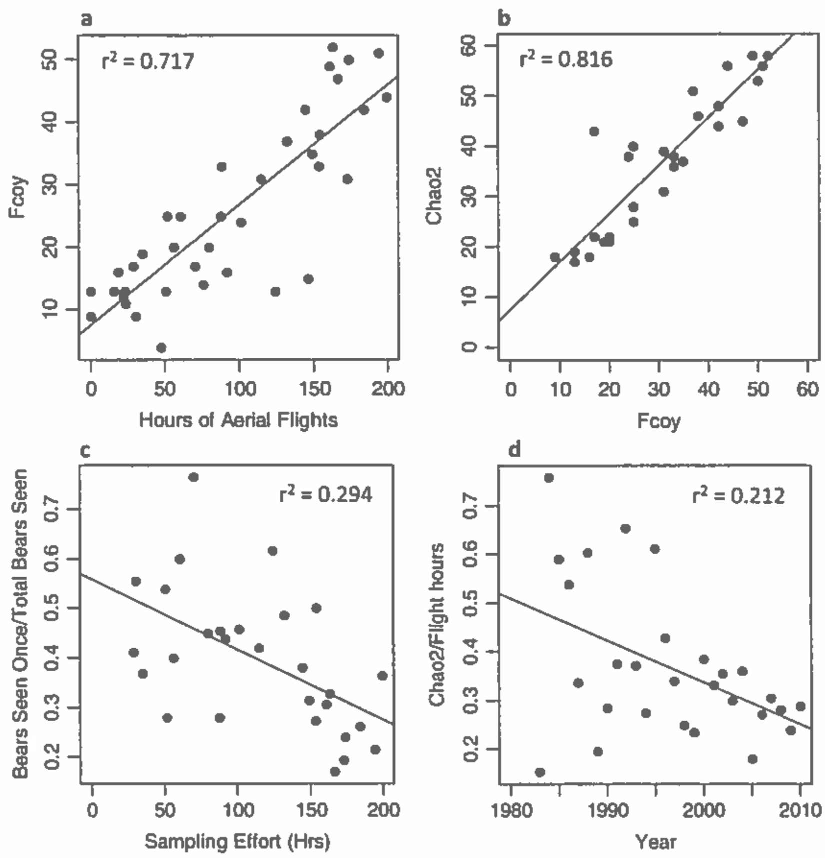


**Figure 2** Relationships between two population estimators, (A) Fcoy and Chao2, and search effort. Fcoy counts have risen linearly with hours of formal observation effort. (B) Chao2 population estimates and simple Fcoy estimates show a simple linear relationship. Linear regressions of Chao2 on Fcoy and either year or flight hours show no effects of time or observation effort, suggesting that the Chao2 estimator does not correct for shifting observation effort or sightability of bears. (C) Increased sampling effort over time decreases the number of bears seen only once, suggesting that formal observation effort does affect sighting frequencies and is thus a reasonable proxy for overall observation effort. (D) The ratio of Chao2 to search hours has significantly declined through time, consistent with search efforts having risen far faster than any population growth. High scatter in this ratio in early years, and a much more consistent relationship more recently, also suggest alterations in search efficiency or sightability. Pearson's $r^2$ correlations are shown for each relationship. Data from 1973 to 2010 on Fcoy and flight hours and from 1983 to 2010 for Chao2.

Changes over time in the mean or variance of bear sightabilities appear likely, but are impossible to quantify with our data. However, the formal search effort for bears has definitely increased. To examine how this rising effort could influence population estimates, we simulated observation of a constant population of $n = 70$ (to giving roughly the observed Chao2 value in 1986) using the observation flight hours reported for each year from 1983 to 2010. Comparison with the actual Chao2 calculated for each year shows how similar this 20-year trend is to one driven solely by changes in observation effort (Figure 5), and that the confidence envelope of simulated values encompasses nearly all observed Chao2 values. Most early Chao2 values are somewhat lower than the median simulated values, while later observations are often somewhat higher, but residuals from a regression of real Chao2 on simulated medians are not significantly related to year ($P = 0.366$). While the exact number of real Fcoy each year has obviously not remained constant (due to variable number of females reproducing and many other demographic processes), much of the apparent increasing trend in bear numbers during this time period can be parsimoniously explained as a result of increasing search effort.

Other data also support this interpretation. In particular, an objection to our analysis could be that formal observation effort is only part of the observation process used to count Fcoy, and that the increases in both Fcoy

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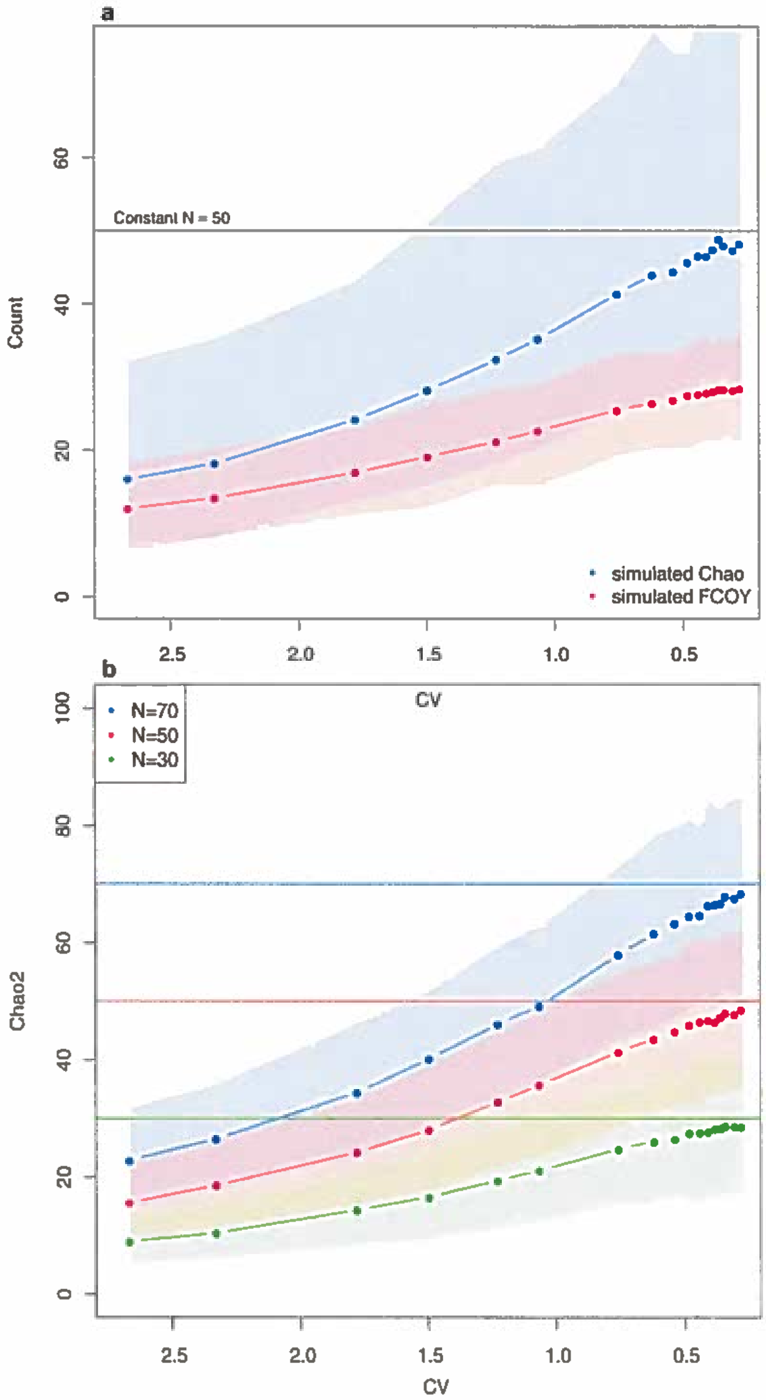


**Figure 3** Changes in the heterogeneity of sightability (CV) of bears, such as changes in flight routes or food availability may induce, result in large shifts in Chao2 estimates of bear numbers. We increased the CV by increasing the variance of sightabilities, while keeping both mean sightability of bears and search effort (100 hours) constant. (A) With a constant 50 Fcoy in the population, rising CV in sightabilities results in increased Fcoy and Chao2 estimates, with larger shifts in Chao2 estimates than in simple Fcoy estimates. (B) Effects of CV in sightability on Chao2 estimates are similar in magnitude across a range of real population numbers. All means and shaded 95% confidence limits are based on 1,000 iterations at each parameter value.

and observation hours are simply a coincidence. However, if flight hours did not drive patterns in the mean probability of being observed each year, there should be no relationship between the relative number of bears seen once, twice, or >2 times and formal observation effort. However, the fraction of bears with single observations has fallen with increasing effort (Figure 2c). This is not a pattern expected if numbers were increasing but observation effort had no effect on the probability of a bear being seen each year. Finally, Fcoy/search

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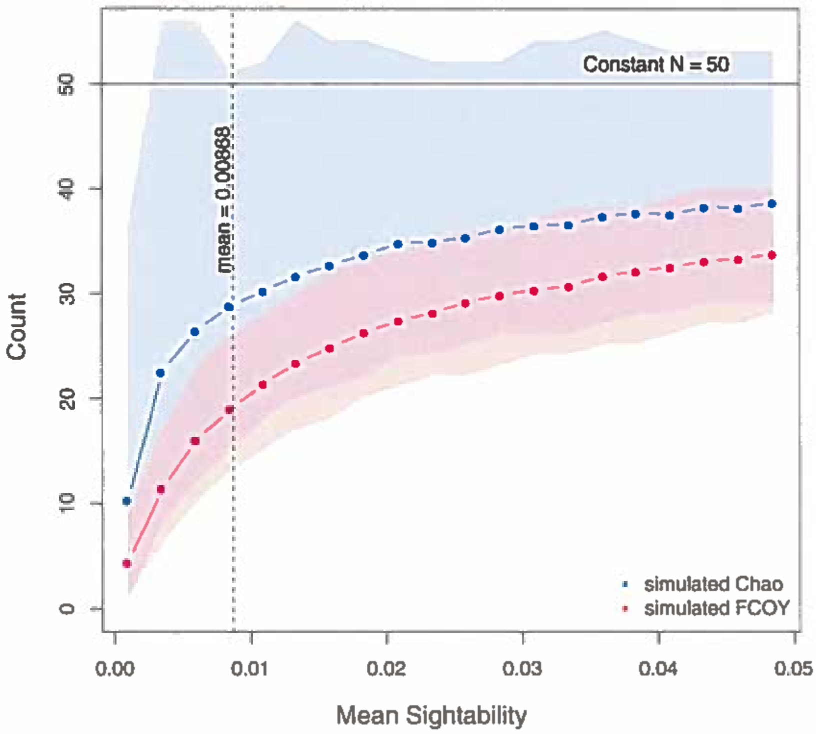


**Figure 4** Changes in mean sightability alter both Fcoy and Chao2 estimates of population size. With a constant population number and constant CV in sightability, increasing mean sightability leads to rising estimated population sizes. Chao2 shows essentially identical sensitivity to mean sightability as does Fcoy. All simulations assume 100 search hours. The means and shaded 95% confidence limits are based on 1,000 iterations at each parameter setting. The mean sightability indicated by the dotted line is the value estimated from the data in Keating *et al.* 2002 (see main text for further explanation).

hours and Chao2/search hours both decline over time (Figure 2d; $P = 0.0517$ and $P = 0.0138$, respectively). These ratios (essentially catch-per-unit-effort) should increase with population increases and decrease with increasing search effort. While modest increases in population size, accompanied by larger increases in search effort, could lead to decreasing Chao2/search hours, the significant declines in this ratio are concordant with our simulations of the estimation process, which suggest that little or no population growth is needed to explain the observed trends in Fcoy or Chao2. The declining variability in these ratios over time also suggests temporal shifts in either the observation process or bear sightabilities.

Finding that Chao2 is not a robust estimator of relative or absolute numbers, we also explored the use of two alternative estimators. Simulation tests of the Second-Order Sample Coverage estimator (SC2 in Keating *et al.* 2002) showed that it was not appreciably better than Chao2. Similarly, with the relatively small numbers and high variance in sightability that characterize the GYE grizzly population, the methods described by Mao (2007) and Mao & You (2009) are not reliable. These results are not surprising, given Link's (2003) findings regarding the nonidentifiability of population sizes from any estimators based on analysis of frequencies, in the absence of other information to ground the analysis.

## Demographic analyses

Past use of demographic data for this population have also indicated a rapidly growing population (Harris *et al.* 2007, based on results in Schwartz *et al.* 2006a [Haroldson *et al.* 2006; Schwartz *et al.* 2006b, c]: but see Pease & Mattson 1999). Harris *et al.* calculate best estimates of mean annual population growth rate from 1983 to 2002 of between 1.07 and 1.04. However, these estimates assume that there is no reproductive or survival senescence of bears until they reach age 30, the maximum lifespan. This is a reasonable use of estimated demographic rates if either: (1) there really is no senescence or (2) a random sample of adult bears that represent the true age distribution was used to calculate the mean adult survival and fecundity rates. There is clear evidence for both



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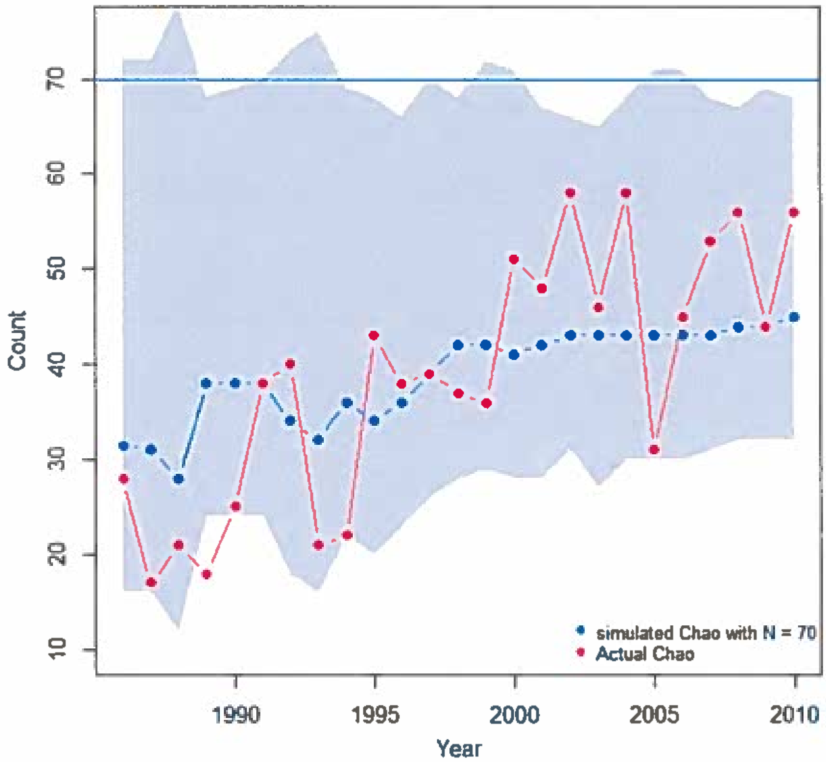


**Figure 5** Actual increases in search effort are predicted to result in increasing estimated bear numbers that parallel trends seen in Chao2 estimates for the real population. We calculated simulated Chao2 values by sampling from a constant population with $n = 70$ and using the actual hours of search flights flown in each year. All simulations assume constant mean and CV of sightability as estimated from data in Keating *et al.* 2002 (see text). The medians and shaded 95% confidence limits are based on 1,000 iterations at each parameter value.

reproductive and survival senescence in grizzlies, including the GYE population (Schwartz *et al.* 2003; Johnson *et al.* 2004; see Appendix S1), and the survival rates estimated for collared bears suggest that they do not come from a representative sample of ages. Harris *et al.*'s mean adult female survival estimates of 0.922 and 0.950 would result in 10% or 24% of adult bears surviving to age 30, and between 25% and 42% dying past the age of 20. From 1975 to 1994, the oldest female death observed was at age 24, and only two female deaths of greater than age 20 were observed (Boyce *et al.* 2001). While a similar, simple assessment of the plausibility of the single adult fecundity values used in past analyses is not possible, these too appear to poorly match what is known about age-specific fecundity patterns (see Appendix S1).

To correct for the exclusion of senescence from past demographic models, we constructed models with estimates of annual fecundity and adult, cub and yearly survival from 1983 to 2001 from Haroldson *et al.* (2006), Keating *et al.* (2002), and Harris *et al.* (2007) and including either no senescence, a correction for survival senescence beyond age 20, or corrections for both survival and reproductive senescence. In these simulations, we either used adult survival rate estimates that assumed missing bears had died, or that censored these individuals (see Appendix S1).

Starting with an adult female population of size 57 and at the first year's stable age distribution, we simulated the size of the bear population through time. With no inclusion of senescence effects, models with high adult survival predict growth rates even greater than those shown by the Chao2 estimates, while models using low adult survival predict roughly the growth seen in Chao2 numbers (Figure 6). However, inclusion of senescence results in considerably lower growth rates. If both reproductive and survival senescence are included in the model, we arrive at predictions of somewhat lower or extremely little growth from 1983 to 2002.

## Discussion

Confidence in the recent growth and hence health of the GYE grizzle population has largely rested on Fcoy estimates, and their correction via the Chao2 estimator,

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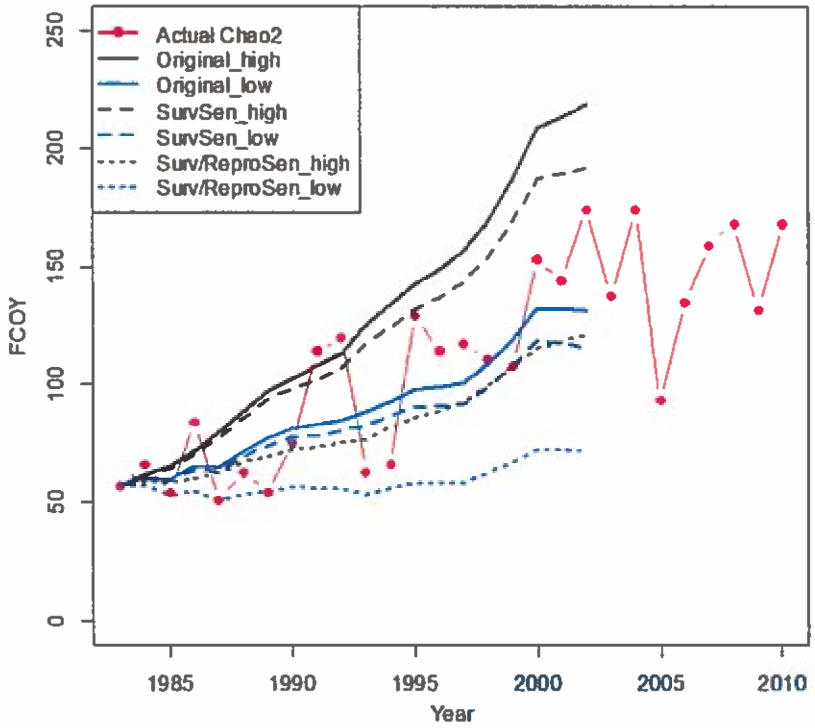


**Figure 6** Predicted population trends through time, using different demographic assumptions. Three sets of results are plotted: (A) predicted trends using either high or low adult survival rates, without incorporation of senescence (Original_high and Original_low lines); (B) predicted trends using either high or low adult survival rates, with incorporation of survival senescence (SurvSen_high and SurvSen_low lines); and (C) predicted trends using either high or low adult survival rates, with incorporation of both reproductive and survival senescence (Surv/ReproSen_high and Surv/ReproSen_low lines). For the simulated numbers in each scenario, the mean and variance of the log(lambda) values are (respectively): {0.0708, 0.00074}, {0.0439, 0.00135}, {0.0595, 0.00080}, {0.0336, 0.00140}, {0.0345, 0.00044}, and {0.0078, 0.00168}. For the empirical Chao2 estimator over the same period, the mean and variance are {0.0587, 0.10230}. All simulations were started with adult female numbers equal to three times the observed number of Fcoy in 1983 and all age classes at the stable age distribution for this year. Three times the actual Chao2 estimates, plotted in red, are shown for comparison to demographic predictions, for which we plot the predicted number of adult females each year. While Chao2 estimates are plotted up to 2010, we only had survival and reproductive estimates from 1983 to 2001 for demographic predictions.

as well as on the corroborating evidence from demographic rates. In all studies, we found that use the Fcoy or Chao2 grizzly data set authors take published estimates of these numbers at face value, as stable estimators of relative numbers. Even the most recent discussion of population trend data has accepted the basic narrative of long-term growth of this population, even while, in some cases, concluding that new ways to estimate numbers are needed (Eberhardt & Breiwick 2010; IGBST 2012). Our results suggest the need to re-evaluate these apparent trends. We find that a plausible and parsimonious explanation for most or all of the rise in Fcoy estimates is rising search effort, along with possible shifts in the mean and variance in sightability of bears, and that the Chao2 estimator does not meaningfully correct these issues. Similarly, we show that the approach taken in past demographic analyses of ignoring senescence has likely resulted in overly high population growth estimates, and that incorporation of senescence patterns known for grizzlies results in substantially lower growth estimates for the recent past. These results suggest that a re-evaluation of the acceptable mortality limits for bears is also needed.

Three recommendations follow from our work. First, one of several methods should be used to re-evaluate the last several decades of data on bear numbers, and to do so with explicit treatment of the rapidly changing observation effort. The most reasonable approach would be to analyze only the data collected on standardized observation flights, so that effort could be treated clearly in the estimation of relative numbers. Dealing with the shifting observability of bears is more problematic, but even if this issue cannot be fully resolved, the overwhelming effects of effort could be dealt with in such a reanalysis.

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Second, demographic rates should be re-estimated with acknowledgment of senescence effects. Given that senescence is well-known in bears, and that past work has used GYE data for the estimation of both reproductive and survival senescence, it is puzzling that these effects have not been included in past estimates of population growth rates. Verbal arguments that senescence is relatively unimportant (e.g., Schwartz *et al.* 2003) only make sense if age-representative samples of bears are used to estimate all pooled adult rates, which does not seem likely, given that average adult survival estimates suggest large fractions of adults living the maximum age of 30.

Finally, our results suggest that we actually know very little about the past trends of this population, and hence about their likely future fate, especially with rapid declines in multiple food resources and increases in opportunities for human conflicts (Figure 1). While our most basic conclusion is that we cannot confidently assess the past or future trends of this population without further and more careful work, our analyses show that trends in Fcoy and Chao2 are consistent with a population that has grown little, or perhaps not at all, in the recent past, but also that was higher in the past than was realized. In a nonchanging landscape, this might imply considerable safety from future extinction. However, with rapidly accelerating impacts, the flattening Chao2 estimates over the last decade, even as search effort has continued to increase, are consistent with a population that may now be, in fact, declining.

Our basic conclusion is that the perceived dynamics of this population rest on overly simplified uses of the basic data sets available. While the GYE grizzlies have been intensively studied, lack of attention to basic issues of wildlife data analysis (accounting for observation effort and realistic treatment of life history patterns) are likely to have resulted in misunderstandings of the data collected, systematic bias in the inferences about the dynamics of this population, and overconfidence in apparent trends. Given the widespread use of the Chao and related estimators in many other contexts, our work also suggests that caution is needed in interpreting patterns in these statistics in studies of either population numbers or species richness.

More generally, these results highlight the need to carefully consider shifting observation processes for species of conservation concern. Changing knowledge of a species, increasing attention to its plight, or shifts in individual behaviors in the face of habitat changes can all alter the observation process, with nontrivial effects on estimated population viability (e.g., Hernandez-Manrique *et al.* 2013). In different situations, these changes might lead to the perception of greater or less risk than is real, compounding other problems of implementing necessary management interventions (Martin *et al.* 2012). While a great deal of careful attention has been paid to the observation process in many areas of wildlife and conservation biology (Bellemain *et al.* 2005; Olea & Mateo-Tomas 2011; Chaudhary *et al.* 2012), this is not always the case, especially with very rare species. Our work highlights that in many circumstances more care is needed in making inferences about population trends, especially when these results are being used in a direct policy context (Mace *et al.* 2010).

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## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

**Appendix S1.** Re-evaluating evidence for past population trends and predicted dynamics of Yellowstone grizzly bears.

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# Van Manen *et al.*, Doth Protest too Much: New Analyses of the Yellowstone Grizzly Population Confirm the Need to Reevaluate Past Population Trends

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**Keywords**
Ursus; Yellowstone; senescence; grizzly bear; demography.

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Grizzly bears are an essential part of healthy, fully functioning ecosystems in western North America. Understanding how grizzlies have responded through time to management and habitat changes is therefore key to understanding and protecting not only this one species, but also entire ecosystems. Our purpose in examining Yellowstone grizzly population growth (Doak and Cutler 2013; henceforth D&C) was to evaluate the potential for problems with analyses that underlie the perceived rate of increase of this population. By doing so, we hoped to prompt members of the IGBST, who control the data sets on this population, to test for and deal with these potential issues. It is therefore disappointing that, in our view, van Manen *et al.* (2014; henceforth VMEA) focus mostly on refuting details in our specific methods—criticisms that we find largely without merit and respond to in detail in Appendix S1—rather than on the larger substance of these concerns.

Two aspects of VMEA's article are particularly puzzling. First, they concentrate on refuting many of the particular simulations that we explicitly presented as examples of general issues. VMAE show, for example, that one particular simulation of observation effort effects does not *completely* explain the full rise in Chao2 estimates of population size (i.e., it explains only up to 77% of estimated annual growth: Appendix S1). VMAE's analysis does not invalidate that observer bias can be a significant effect and is a distraction from the general problem being addressed.

More importantly, there is a perplexing inconsistency between VMEA's blanket rejection of our concerns and the largely confirming results presented on senescence effects in VMEA's manuscript, and on estimation of population growth from survey data by three of these same authors in Higgs *et al.* 2013. VMEA suggest that their models show that senescence has trivial impacts on population growth estimates; in fact, their results show that incorporating senescence sharply reduces previously estimated population growth from 1983 to 2001 (see Appendix S1). Higgs *et al.* (2013), an excellent effort to improve analysis of this population, is exactly the type of approach we support, and is predicated on dealing with many of the observation issues that also motivated our

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work. This study shows that there is so much uncertainty in population estimates that inferences about population trends are extremely weak. This is precisely our basic conclusion. The only serious difference between our view and theirs is that they only look forward in time, but their results reinforce our view that past population changes inferred from less sophisticated analyses must also be reexamined.

We stand by our concerns over what the Yellowstone grizzly data really can and do tell us about this population. As with many conservation controversies, the most productive way forward would be collaborative examination of alternative interpretations of the data by all parties. Alternative, a National Academy of Sciences review, or reanalysis of the various contended issues by some other independent team with access to all of the data, would go a long way towards promoting the best conservation assessment of this population.

## Supporting Information

Additional Supporting Information, including extensive text responding to VMEA's arguments, as well as the following tables and figures, may be found in the online version of this article at the publisher's web site:

**Table S1:** Correlations between different explanatory variables that could be used to explain changes in Chao2 estimates through time. These results are for data from 1986 through 2010, the years for which we have search area data with which to conduct the search effort corrections that VMEA make. Area-adjusted search hours indicate the corrected search effort advocated by VMEA, while BOA-corrected search hours uses the correction we describe in the SI text.

**Table S2:** Explanatory power from regressions of log(Chao2) values on different independent factors. In all cases, the slope of the regression was significant.

**Table S3:** Comparing results of different demographic models that do and do not include senescence. This table is based on the comparisons shown in van Manen et al. 2014, but corrects errors and emphasizes the correspondence of the different models in predicted population growth rates.

**Figure S1:** Comparison of different relative survival curves from different sources. All curves show survival relative to the highest age-specific annual survival rate. Boyce et al. (2001) give parameters for 4 models of age dependent survival (numbers refer to the table of Boyce et al. giving parameters for each survival curve), while Johnson et al. (2004) give two models. Finally, we plot the high survival curve of VMEA. All previous survival curves are in close agreement, and the one D&C used (Boyce 9) is one of the most optimistic regarding low senescence. VMEA's survival curve is quite different from any preceding estimate, and also does not match the observed age distribution of monitored bears (Figure S2)

**Figure S2:** Comparison of the expected distribution of ages of adult female bears, from VMEA's 'high survival' survival curve (VMEA Figure 5) and the age distribution of monitored bears (VMEA Figure S2). The age distribution given by VMEA in their Figure S2 are for bears sampled over 28 years, making it difficult to adjust expected age distributions to account for population growth. We therefore present three expected age distributions, all based on VMEA's 'high survival' survival curve: A assumes no population growth, B assumes a lambda of 1.05, and C assumes a lambda of 1.027. The latter two assumptions correspond to VMEA's predicted growth rates with high and low survival rates (see Table S3). While VMEA claim that there is no sign of biased sampling of different ages of bears, comparison of the any of the distributions predicted by their survival curve and the ages sampled indicates that there is, in fact, a significant bias towards sampling younger bears. Older bears are either under-sampled, or this survival curve over-estimates survival into older age groups. We do not compare the monitored bear ages to the low survival curve because VMEA do not give any numerical or graphical information on this survival curve in their article.

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# Endangered Species Information: Access and Control

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## Endangered Species Information: Access and Control

Robert L. Fischman* & Vicky J. Meretsky**

### I. Introduction

In his keynote contribution to this special issue of the Washburn Law Journal, Professor Sax spotlights restoration and the ways the Endangered Species Act ("ESA")[1] promotes new forms of collaborative governance to manage ecosystems. All of the changes that he documents, from multi-agency watershed councils to habitat conservation planning, will require better and more prompt information to succeed. Indeed, one of the greatest challenges to the effectiveness of administrative innovation is our poor understanding of the precise relationships between human activities, such as forest practices or residential development, and species recovery.

Adaptive management itself, which almost everyone agrees is a key element in Sax's "new age of environmental restoration," is information intensive.[2] Adaptive management responds to dynamic ecological characteristics by "[r]ecognizing that every land management practice is an experiment with an uncertain outcome."[3] In adaptive management, authorized activities are coordinated and monitored to determine their effects on species or other resources of concern.[4] The information gained then feeds back "to adjust management in a desirable direction."[5]

One of the fundamental needs of the new age of environmental restoration, therefore, will be more effective use of existing informa-

* Professor, Indiana University School of Law–Bloomington; Senior Research Scholar, Yale Law School (2001). I am grateful to Myrl Duncan for the invitation to contribute to this symposium. I wish to thank Beth Cate, Fred Cate, Patrick Parenteau, and Craig Pease for generously

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sharing their insightful thoughts and work on this topic. An Indiana University School of Law summer research grant and the Yale Law School supported this work.

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1. 16 U.S.C. §§ 1531-1544 (1999).

2. Joseph L. Sax, The New Age of Environmental Restoration, 41 WASHBURN L.J. 1 (2001). Professor Sax uses the term adaptive management in describing the ESA "no surprises policy." Id. at 5.

3. Reed F. Noss, Some Principles of Conservation Biology, As They Apply to Environmental Law, 69 CHI.-KENT L. REV. 893, 907. Adaptive management is based on feedback from continual management experimentation.

4. See generally KAI N. LEE, COMPASS & GYROSCOPE: INTEGRATING SCIENCE AND POLITICS FOR THE ENVIRONMENT (1993); C.J. WALTERS, ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES (1986). The U.S. Fish and Wildlife Service provides a helpful bibliography of relevant adaptive management literature in Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, 65 Fed. Reg. 35242, 35256-57 (2000).

5. Id. See also Tim W. Clark et al., Synthesis, in ENDANGERED SPECIES RECOVERY: FINDING THE LESSONS, IMPROVING THE PROCESS 417, 425 (Tim W. Clark et al. eds., 1994).





tion and more research to create new information.[6] More effective use of existing information will often require widespread, early, and rapid disclosure of research results. More research will require greater funding. The lack of good data on endangered species and poor access to existing data is symptomatic of a larger failure to employ adaptive management.[7] This is especially true for endangered species,[8] where failure to use current and accurate information can compromise species' chances for recovery.[9] For instance, lack of monitoring and assessment information about grizzly bears throughout the 1980s and the 1990s impeded recovery.[10] Poor experimental design and poor access to data flow, in large part, from the neglect of the empirical research component of management decisions. This article focuses on access and control of information as an indicator of the gap between adaptive management theory and actual agency practice.

Outside of medicine, publication of scientific research generally proceeds at a pace not dictated by a strong sense of urgency. The traditional understanding of scientists is that data are not released until the researcher is ready to publish. Scientists may guard their data

6. See Erica Fleishman, Moving Scientific Review Beyond Academia, 15 CONSERVATION BIOLOGY 547 (2001) ("We will not achieve our conservation mission unless research is executed, results disseminated, and management actions initiated at a rapid pace."); Tim W. Clark et al., supra note 7, at 420.

7. Richard P. Reading & Brian J. Miller, The Black-footed Ferret Recovery Program: Unmasking Professional and Organizational Weaknesses, in ENDANGERED SPECIES RECOVERY: FINDING THE LESSONS, IMPROVING THE PROCESS 73, 88-90 (Tim W. Clark et al. eds., 1994); U.S. GENERAL ACCOUNTING OFFICE, FOREST SERVICE DECISION-MAKING: A FRAMEWORK FOR IMPROVING PERFORMANCE 41-45 (1997) (GAO/RCED-97-71).

8. The ESA protects two different categories of species, threatened and endangered, that suffer serious risk of extinction. 16 U.S.C. § 1532(6), (20) (1999). However, for the purposes of this article, we will use the term "endangered species" broadly to include any species receiving the special protection of the ESA. Another, more technical term, "listed species," also refers to both categories of species. Though some threatened animals enjoy less protection than endangered animals under the ESA, generally the issues we discuss in this article apply equally to both. Threatened and endangered plants, on the other hand, are largely unprotected from nonfederal activities and not subject to the ESA permits discussed in this article.

9. Currently, 1244 species in the United States are listed under the ESA. U.S. FISH & WILDLIFE SERV., THREATENED AND ENDANGERED SPECIES SYSTEM (TESS), http://ecos.fws.gov/tess/html/boxscore.html (last visited Sept. 7, 2001). A species does not receive protection under the ESA until either the U.S. Fish and Wildlife Service or the National Marine Fisheries Service lists it through notice and comment rulemaking. 16 U.S.C. § 1533(a). Unfortunately, by the time species receive protection under the ESA, their populations are generally so small that recovery is an extraordinarily difficult task and many habitat management alternatives are foreclosed.

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David S. Wilcove et al., What Exactly Is an Endangered Species? An Analysis of the U.S. Endangered Species List: 1985-1991, 7 CONSERVATION BIOLOGY 87, 92 (1993). Once a population level falls below a certain threshold, an "extinction vortex" pulls the species inexorably toward extinction. Leah R. Gerber et al., Measuring Success in Conservation, 88 AM. SCIENTIST 316, 323 (2000).

10. David J. Mattson & John J. Craighead, The Yellowstone Grizzly Bear Recovery Program, in ENDANGERED SPECIES RECOVERY: FINDING THE LESSONS, IMPROVING THE PROCESS 101, 112-25 (Tim W. Clark et al. eds., 1994). Agency actions that harmed grizzly populations often went unchallenged because there was no mechanism to force the agency to disclose supporting data (which did not exist). Id.



to avoid being preempted (or, "scooped"[11]), by other scientists publishing an interpretation of the data first. This corresponds to a tradition that regards analysis or treatment of a data set as justifying only one publication. Adaptive management for species recovery will require a shift in the professional culture of conservation biologists to view the access and disclosure customs in their field more from the perspective of medicine and less from the perspective of the life sciences in which many of them were trained.

In addition to the rapid responses often needed to recover endangered species, most research in conservation biology is also distinguished by a dependence on government resources. The funding for research; the scientific permits allowing researchers to collect, harass, or harm animals; the permission for access to public lands; and the regulation controlling activities to ensure continued existence of imperiled species all point to the pervasive public interest in the resulting information. This public claim for access countervails the customary control researchers exert over data they collect.

In his recent book, Playing Darts with a Rembrandt,[12] Professor Sax examined the problem of access and control in the context of cultural treasures, not biological ones. We use the occasion of this special issue to extend a bridge between Professor Sax's book and his "new age of environmental restoration." Section II of this article discusses the peculiar challenges of information access and control for endangered species recovery. It highlights the need for avenues of disclosure of data outside of the scientific peer-review process. Section III describes the legal framework for facilitating this disclosure. Though the Freedom of Information Act, the "Shelby Amendment" as interpreted by the Office of Management and Budget, and general principles of administrative law compel some public access to information about endangered species, it is the ESA itself that best supports reforms to ensure prompt information disclosure. Section IV concludes this article with recommendations, principally for reforms to the ESA scientific permitting program, that will promote timely and easy access to endangered species data without sacrificing the rewards for conducting original research.

Results of complex analyses and long-term, cumulative studies legitimately require time to complete, and are perhaps best handled through peer-review publication. But short-term research results, year-to-year monitoring data, and assessments of methods, despite being easier to prepare, are often far less accessible. The ESA conserva-

11. JOSEPH L. SAX, PLAYING DARTS WITH A REMBRANDT 168 (1999) (quoting Stephen A. Kaufman, THE COMPREHENSIVE ARAMAIC LEXICON (Hebrew Union College, Cincinnati, Ohio) Feb. 1992, at 5).

12. Joseph L. Sax, Playing Darts with a Rembrandt (1999).

tion and permitting provisions should require prompt availability of this information, which is often overlooked in formal scholarly publication. Rapid release of data would permit better monitoring of endangered species recovery; better dissemination and evaluation of conservation techniques; better communication between cooperating entities; and better-informed participation by outside researchers, oversight groups, and other stakeholders.

In some circumstances, disclosure of data would provide information that would enable people to determine the precise location of individuals in a population of an endangered species. To protect those individuals from harm, statutory reform should allow narrowly drafted exceptions to the general rule of open access. Unfortunately, broad exceptions tempt agencies and other decision-makers to shield their programs from criticism. As grizzly bear management illustrates, any risk that location data might be used for poaching must be balanced against the risk to the species from the lack of any adaptive correction of poor management through outside review.[13]

## II. Conservation Biology and the Problems of Information Disclosure

In all fields of experimental science there exists a tension between the desire to control data in order to reap the customary reward of first publication, and the desire to disseminate data that will contribute to the timely advancement of knowledge and the refinement of theory. Traditional notions of ownership emerging from human labor, and sustaining incentives for commitment to an arduous experimental project, bolster the researcher's proprietary interest in controlling analysis of experimental data.[14] Pervasive federal funding of scientific research supports disclosure as part of the public's return on an investment.

In general, professional consensus, not formal rules enforceable through the legal system, balances these competing interests. As Professor Sax has shown, some fields, such as archeology and papyrology (the study of ancient documents written on papyrus), employ strict customs of proprietary rights for researchers who discover or secure possession of sites or scrolls.[15] In these fields, colleagues may wait for decades before researchers release data or documents.

In the natural sciences, disclosure of raw or intermediate data is also a problem.[16] The peer-review process of scholarly publication

13. Mattson & Craighead, supra note 10, at 112-25.
14. Sax, supra note 12, at 174-75; John Locke, Second Treatise of Government § 27 (1698).
15. Sax, supra note 12, at 165-78.
16. Id. at 174.

generally mediates conflicts that arise in science.[17] But, conservation biology presents two special complications that disrupt the customary balance in science between a researcher's expectation of first publication and obligation to share information. First, and most importantly, conservation biology, like medicine, is a mission-oriented science.[18]

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Therefore, it is not simply the advancement of the abstract ideal of scientific understanding that researchers serve. It is also the protection and restoration of biological diversity. In experiments or studies involving species on the brink of extinction (and, adaptive management makes most conservation projects experiments), researchers may need to disclose preliminary or intermediate information to meet the urgent needs of recovery. Researchers may further need to abort an experiment when it jeopardizes the well-being of a species. In this respect, also, conservation biology is like medicine, which requires a researcher to end the experiment (or inform the distinctly affected subject) if, during the course of research, doctors discover some unexpected adverse effect (or some distinct problem, e.g., a malignant tumor, in a particular subject).[19]

Second, conservation biology's central (though not entire) aim, the prevention of extinction, coincides with a controversial law and pervasive public control. The ESA imposes special obligations on federal agencies and general restrictions on all persons pertaining to species listed by the Fish and Wildlife Service ("FWS") or the National Marine Fisheries Service ("NMFS") (together, "the Services"). Therefore, federal regulation entangles many conservation biology experiments or studies, which often also involve field work on public lands. Moreover, federal agencies have duties to recovery listed species that may be fulfilled only through better understanding of conservation biology. Researchers need the Services' (and land management agencies') permission to conduct many experiments or observations; and, the Services (and land management agencies) need researchers to provide guidance on meeting legal requirements. Both needs in this relationship between scientists and agencies create additional tensions over the control and disclosure of information.

The traditional reliance on peer-reviewed publication, the gold standard of academic standing and the advancement of knowledge, is inadequate to meet the pressing challenges of ecological restoration. This is not to say that peer review has no value in conservation biol-

17. See generally NAT'L RESEARCH COUNCIL, IMPROVING RESEARCH THROUGH PEER REVIEW (1987); Steven J. Rothman, A Review of Peer Review, 48 PHYSICS TODAY 124 (Sept. 1995).
18. Michael Soul' e, What is Conservation Biology?, 35 BIOSCIENCE 727 (1985).
19. See, e.g., Lawrence K. Altman, Volunteer in Asthma Study Dies After Inhaling Drug, N.Y. TIMES, June 15, 2001, at A16; Gina Kolata, Parkinson's Research Is Set Back By Failure of Fetal Cell Implants, N.Y. TIMES, Mar. 8, 2001, at A1.

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ogy. To the contrary, it is a crucial process for establishing uniformity, credibility, and continuity in the development of theory and knowledge, as it is in other sciences.[20] Though full disclosure of data is rarely included in academic journals, often some of the data are presented. And, scientists increasingly turn to the internet "web" to supplement publications with databases. Still, peer review alone has failed to provide the information necessary to succeed in environmental restoration.

One reason why traditional scholarly publication does not provide adequate access to data is that much information about endangered species comes from management activities that lack any explicit research component. Adaptive management's insistence on regular assessment and readjustment is widely accepted in theory but seldom applied in practice.[21] Without research objectives, management programs generally lack publication goals and may not even produce unpublished (or, "in-house") reports.[22] Where an agency or contractor does produce reports, they may be quietly shelved, particularly if they do not support agency policy. The variable speed of production and level of detail of these sources of information leave researchers and managers with an inconsistent and incomplete grasp of the health of a species. Also, a management program without research objectives will likely yield information that falls short of good scientific experimental design standards.

However, even where explicit research leads to a traditional peerreviewed publication, the information disclosed may still be inadequate to meet the needs of adaptive management for environmental restoration. First, peer review is a slow process. The current issue of Conservation Biology, the flagship peer-reviewed publication for the scientific discipline that concerns itself most directly with ecological restoration, contains articles that have waited up to twenty-six months between submission and publication.[23] The editor of the journal detects a "simmering crisis" over the disparity between the conservation need for prompt publication and the time required for peer review.[24]

20. See NAT'L RESEARCH COUNCIL, supra note 17.
21. C.S. Holling & Gary K. Meffe, Command and Control and the Pathology of Natural Resource Management, 10 CONSERVATION BIOLOGY 328 (1996). For examples, see supra note 7.
22. These reports are sometimes categorized as "gray literature." Laura H. Watchman et al., Science and Uncertainty in Habitat Conservation Planning, 89 AMERICAN SCIENTIST 351, 353 (2001).
23. See, e.g., Richard T. Kazmaier et al., Effects of Grazing on the Demography and Growth of the Texas Tortoise, 15 CONSERVATION BIOLOGY 1091 (2001) (twenty-six months); M.A. McCarthy et al., Testing the Accuracy of Population Viability Analysis, 15 CONSERVATION BIOLOGY 1030 (2001) (twenty-five months); David W. Crumpacker et al., Implications of Climatic Warming for Conservation of Native Trees and Shrubs in Florida, 15 CONSERVATION BIOLOGY 1008 (2001) (twenty-three months).
24. Gary K. Meffe, Crisis in a Crisis Discipline, 15 CONSERVATION BIOLOGY 303 (2001).

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In addition, scientists may delay preparation of submissions for years while they gather data over time or attend to other duties.

Second, even when published, the information contained in peerreviewed articles may not be complete enough to offer guidance for management. Publications rarely include discussion of problems and failures, leaving managers and subsequent researchers inefficiently solving the same problems and stumbling over the same errors.[25] For instance, the designs in neither the black-footed ferret nor the California condor recovery programs enabled information to be collected that could assess the relative risks of different animal release techniques, despite the strong likelihood that techniques differ in effectiveness.[26]

Information may not be available because no one has the time to write it up, because it is in a report that does not circulate, or because it is held up in the peer-review process. Alternatively, information may be withheld intentionally because of a reluctance (particularly among those who seldom write for a scientific audience) to submit to the sometimes-withering criticism of the peer-review process or to shield a program from close examination in order to secure continued funding.[27]

For instance, the California condor recovery program began releasing Andean condors to the wild in 1989, and California condors in 1992. The FWS conducted the first release efforts, in southern California, and continues to oversee releases in that area. The Ventana Wilderness Society and the Peregrine Fund conducted subsequent release efforts in central California and in northern Arizona, respectively. These two nonprofit organizations published informal notes from the field at weekly or monthly intervals at public web sites, and the FWS produced an irregularly published newsletter which began as a quarterly but slowed as longer intervals separated each issue. The FWS has not published a newsletter on the condor release program since December, 2000. In twelve years, no participant published, and the FWS did not perform, an analysis of the results of the release program. Not until a group of scientists (including a coauthor of this article) working from outside the recovery program acquired and analyzed the data did it become clear that lack of oversight had permitted poor study design to persist for years, and that mortality rates strongly indicated a need to address threats such as lead poisoning. A

25. Id.; D.G. Kleiman et al., Improving the Evaluation of Conservation Programs, 14 CONSERVATION BIOLOGY 356 (2000).

26. Vicky J. Meretsky et al., Demography of the California Condor: Implications for Reestablishment, 14 CONSERVATION BIOLOGY 957 (2000); Richard P. Reading & Brian J. Miller, supra note 7, at 89-90.

27. K.H. Redford & A. Tabor, Writing the Wrongs: Developing a Safe-Fail Culture in Conservation, 14 CONSERVATION BIOLOGY 1567 (2000).



properly designed adaptive management program would have required far more timely analysis of available data and the opportunity for independent review of study design and results. Third-party review does not guarantee action–the FWS still has not acted to reduce lead availability to condors in release areas–however, outside pressure is far stronger now that the issue and its implications have been raised in a public forum.

## III. LEGAL CONSTRAINTS ON ACCESS AND CONTROL OF ENDANGERED SPECIES INFORMATION

A number of legal mechanisms are available for securing access to information about endangered species. However, each has its limitations. The Freedom of Information Act ("FOIA") is simultaneously too broad and not broad enough. On one hand, it fails (outside of national parks) to protect precise location data that aid poachers and others seeking to harm endangered species. Even well-intentioned trackers, such as wildlife photographers, may incidentally harass endangered animals. In this respect, FOIA provides too much access. Indeed, in extreme cases, FOIA discourages agencies from acquiring some location data for fear of being forced to disclose them. On the other hand, FOIA mandates disclosure only of agency records and thus offers no access to information outside of government. And, disclosure under FOIA can be burdensome and protracted. Although the statute mandates prompt time frames for an agency response to an inquiry, these deadlines are frequently not met.[28]

The Office of Management and Budget ("OMB") by establishing disclosure conditions for federal research grants under the Shelby Amendment, augments somewhat the administrative requirements for information access. Still, the OMB conditions rely on some form of publication, even if only a reference by an agency making a decision, to trigger disclosure. Therefore, the OMB rules seldom help disseminate preliminary data. Even aside from the special OMB requirements, general principles of administrative law sometimes compel the disclosure of private research data when they are central to an agency rulemaking. However, in order to employ administrative law to compel agencies to acquire and disclose endangered species data, one

28. Though FOIA requires agencies to respond to record requests in twenty days, 5 U.S.C. § 522(a)(6)(A) (1989), agencies are notoriously dilatory in their compliance. In a typical example, the Department of the Interior did not respond with a partial disclosure of data on grizzly bears requested on January 5, 1999 for more than five months, until May 14, 1999. Plaintiff's Memorandum of Law in Support of His Motion for Summary Judgment and in Opposition to Defendant's Motion for Summary Judgment, Pease v. Babbitt, No. 1:99-CV-113, at 6 (July 29, 1999).



needs both a final agency action and a meaningful standard of review to overcome deference to agency managerial decisions.

Just as the special characteristics of environmental restoration create special problems for access and control of information, the special duties of the ESA create distinct legal footholds for improving information sharing. Species recovery is an affirmative requirement for all agencies, and the Services have specific obligations to advance species conservation.[29] Therefore, the Services and agencies managing habitat need monitoring of the status of endangered species. Because much endangered species research involves some risk of harm, injury, or harassment of individual endangered animals, scientists need permits from the Services to conduct their work. This section concludes with our recommendations for conditioning these permits on periodic reporting to ensure access to information while allowing researchers to retain some control. The Services should use the reporting condition also in negotiating a range of cooperative agreements that deal with meeting the obligations of the ESA.

## A. The Freedom of Information Act

Data and other information contained in federal agency records are subject to the disclosure provisions of FOIA.[30] Upon receipt of a request for information, an agency must disclose any records (which include electronic data, maps, photos, and recordings) that are responsive. FOIA does not require that an agency conduct investigations to answer a public query, or even that an agency retain information. The agency must disclose only whatever records it might currently have that contain relevant information. In deciding whether a document is an agency record for the purposes of mandatory FOIA disclosure, courts consider whether the document is: 1) in the agency's control, 2) generated within the agency, 3) placed into the agency's files, or 4) used by the agency for any purpose.[31]

FOIA requires an agency to comply with requests only if they reasonably describe records. A request that is overly broad or vague may be unreasonable. This does not mean that a requester must identify



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a particular record. A requester who clearly and specifically describes his or her needs is entitled to records that fulfill those needs.
A rule of thumb is that the request must be specific enough to permit a professional employee who is familiar with the subject matter to locate the record in a reasonable period of time.

29. The ESA defines conservation to mean recovery of endangered species to the point where they no longer need the special protections of the ESA. 16 U.S.C. § 1532(3).
30. 5 U.S.C. § 552.
31. Kissinger v. Reporters Comm. for Freedom of the Press, 445 U.S. 136, 157 (1980). See generally ALFRED C. AMAN, JR. & WILLIAM T. MAYTON, ADMINISTRATIVE LAW § 17.3.1 (1993).

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FOIA carves out nine exceptions to the general rule of mandatory disclosure. One exception, that federal natural resources agencies had used until recently to withhold information concerning endangered species, is for internal agency matters the disclosure of which would risk circumvention of a legal requirement.[32] The typical materials protected from disclosure under this exception are law enforcement manuals, guidelines and studies (particularly ones that relate to an agency's security vulnerability). By extension, the Forest Service argued that Mexican spotted owl and goshawk nest site information disclosure would make protection of the sites more burdensome. Presumably, public disclosure of the nest locations would direct people wishing to harass the birds to the most sensitive places. However, in 1997, two federal courts of appeals rejected this position of the Forest Service that nest site information should be exempt under the internal agency matters exception.[33] Under FOIA, maps pinpointing nest and bird locations are subject to the general disclosure rule.
Though, under a different exception, agencies may redact analyses and interpretations in reports to protect the government's deliberative process, this exception does not protect purely factual information related to the policy process.[34] This exception may protect scientific reports that interpret technical data insofar as the opinion of an expert reflects a deliberative phase of policy making. It may even protect parts of pre-decisional documents that select certain facts out of a larger body of data. Raw data, however, generally remain subject to the mandatory disclosure policy of FOIA.
Another noteworthy exception from mandatory disclosure under FOIA is for matters specifically exempt from disclosure by a statute that either provides no discretion to disclose or that establishes particular criteria for withholding.[35] For instance, the Archaeological Resources Protection Act of 1979 ("ARPA")[36] prohibits release of information concerning the nature and location of protected archeological resources unless the relevant agency official determines that disclosure would further the purposes of ARPA and create no risk of harm to the resources.
Strangely, though many of the same concerns about illegal removal of or harm to protected resources apply to endangered species conservation,[37] there is no analogous provision in the ESA triggering

32. 5 U.S.C. § 552(b)(2).
33. Maricopa Audubon Soc'y v. U.S. Forest Serv., 108 F.3d 1082 (9th Cir. 1997); Audubon Soc'y v. U.S. Forest Serv., 104 F.3d 1201 (10th Cir. 1997).
34. 5 U.S.C. § 552(b)(5).
35. Id. at § 552(b)(3).



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36. 16 U.S.C. §§ 470aa-470ll (1994).
37. See, e.g., NAT'L RESEARCH COUNCIL, COMM. FOR A STUDY ON PROMOTING ACCESS TO SCIENCE AND TECHNOLOGY DATA FOR THE PUBLIC INTEREST, A QUEST FOR BALANCE: PRI\
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an exception from mandatory disclosure under FOIA for sensitive information, such as nesting or denning sites.[38] In a partial effort to respond to this lacuna in endangered species law, Congress, in 1998 legislation primarily dealing with national park concession policy but also addressing research needs, enacted a provision allowing the National Park Service to withhold information concerning the "nature and specific location of a National Park System resource which is endangered, threatened, rare, or commercially valuable . . . ."[39] The statute provides criteria for releasing this information that is similar to ARPA standards:

(1) disclosure of the information would further the purposes of the unit of the National Park System in which the resource . . . is located and would not create an unreasonable risk of harm . . . ; and
(2) disclosure is consistent with other applicable laws protecting the resource . . . .[40]

While the need for statutory protection of precise location information that would jeopardize endangered species is clear after the 1997 Audubon cases,[41] this new Park Service legislation goes too far. With no guidance on how to interpret its terms, the legislation excludes from disclosure not only precise location data but also information concerning the "nature" of an endangered species. This broad authority, unfortunately, is an invitation for agencies to withhold whatever national park endangered species information might cause embarrassment or contradict desired outcomes. Moreover, if read broadly, the statute might allow the Park Service to withhold information whenever it finds that disclosure would fail to "further the purposes of the unit."[42] Such insulation from outside criticism would weaken adaptive management for environmental restoration. While disclosing certain information may increase the risk of harm to some endangered species, this must be balanced against the serious risk to

VATE RIGHTS AND THE PUBLIC INTEREST IN SCIENCE AND TECHNOLOGY DATABASES 12 (1999) (statement of Barbara Ryan, Assoc. Director for Operations, U.S. Geological Survey: "publication of endangered species data sometimes results in further harm to the species at the hands of those who wish to possess rare commodities").
38. Like the 1979 ARPA, the 1973 ESA post-dates the 1966 FOIA, Pub. L. No. 89-487, 80 Stat. 250.
39. National Park Omnibus Management Act of 1998, Pub. L. No. 105-391, § 207, 112 Stat. 3501 (1998) (codified at 16 U.S.C. § 5837 (1999)). The legislative history of the statute is dominated by discussion of concession management. There is nothing enlightening in the legislative history to aid in the interpretation of the provision dealing with information disclosure. See, e.g., H. REP. No. 105-767 (1998); S. REP. No. 105-202 (1998).
40. 16 U.S.C. § 5837.
41. See supra note 33 and accompanying text.
42. Such an extreme interpretation, however, would push the boundaries of what constitutes "particular criteria" for withholding information. See Am. Jewish Cong. v. Kreps, 574 F.2d 624, 628-29 (D.C. Cir. 1978) (requiring a precise formula whereby an agency may determine whether disclosure would pose the hazard that Congress foresaw).
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recovery of excluding timely, external review of natural resource management decisions.[43]

The Interior Department has relied on a broad interpretation of this Park Service provision to withhold data about grizzly bear behavior



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from at least one academic scientist interested in evaluating the effects of current federal land management practices.[44] Professor Craig Pease sought historical location data on grizzly bears to determine how the bruins become habituated to humans, which is a behavior that ultimately leads to a doubling of the mortality rate for the bears.[45] Grizzly bear recovery is one of the most politically charged endangered species issues.[46] Professor Pease's collaborator, David Mattson, had his office files removed, computer documents deleted, his mail screened, and his travel budget slashed by his superiors while serving as a field ecologist for the Yellowstone Interagency Grizzly Bear Study Team because of his criticism of the federal government's approach to bear recovery.[47] Although the Interior Department may have exercised reasonable caution in withholding current location data for existing bears, its categorical denial of historic information on all bears, whether alive or dead, illustrates the temptation toward secrecy that discretionary control of data engenders. Knowing the historic roaming patterns of grizzly bears through their enormous range would not enable poachers to pinpoint their locations in the manner that release of current owl nest sites would. Probably the Interior Department interpreted its new authority broadly to avoid the risk of criticism of its intention to remove the grizzly bear from the list of protected species under the ESA.[48] The Department justifies broad, exclusive control over the location data, in part, by asserting the classic science counterweight to disclosure: that government scientists should have the first opportunity to analyze the data before releasing it to others.[49]

So, with some narrow exceptions (e.g., for certain Park System resources), when a federal agency itself, such as FWS, conducts re-

43. Tim W. Clark et al., supra note 5, at 425.
44. Pease v. Babbitt, Civ. No. 1:99-CV-113 (Sept. 20, 1999).
45. Plaintiff's Memorandum of Law in Support of His Motion for Summary Judgment and in Opposition to Defendant's Motion for Summary Judgment, Pease v. Babbitt, No. 1:99-CV-113, at 3 (July 29, 1999).
46. See, e.g., Todd Wilkinson, Grizzly War, HIGH COUNTRY NEWS, Nov. 9, 1998; Emily Miller, Trouble for Grizzly Bear Recovery Plan, HIGH COUNTRY NEWS, Aug. 14, 1997.
47. Wilkinson, supra note 46. The suppression of Mattson and his data is also noted in FREDERICK WAGNER, WILDLIFE POLICIES IN THE NATIONAL PARKS 103 (1995); Oversight Hearing Before the Subcomm. on National Parks and Public Lands of the House Comm. on Resources, 105th Cong. 34 (1997) (testimony of Dean Wagner).
48. Semiannual Regulatory Agenda, 64 Fed. Reg. 64482, 64521-22 (1999) (including de-listing of grizzly bear as an expected long-term regulatory action).
49. Defendant's Memorandum in Opposition to Plaintiff's Cross-Motion for Summary Judgment, Pease v. Babbitt, No. 1:99-CV-113, at 12 (Aug. 12, 1999). This justification, however, has no basis in FOIA.



search, the public generally has access to the information generated through FOIA. When a federal agency acquires (e.g., through a condition in a research permit) endangered species data gathered by others, then the public usually has access to the records under FOIA. However, scientists working for universities and other non-profit institutions, who conduct most conservation biology studies, frequently do not operate under permits with species reporting requirements. What obligation do these scientists outside of the agencies have to disclose information? Some legal obligation may arise from strings attached to federal research awards.

B. The OMB Disclosure Requirements Under the
Shelby Amendment

The principle that "what the federal government funds, the public is entitled to see" may be fair, but the actual law is considerably less expansive and more complicated. In 1998, Congress sought to ensure that "all data produced" from federal awards of grants be available to the public through the procedures established under FOIA.[50] Buried on page 496 of a 920-page omnibus appropriations bill, the provision, commonly called the "Shelby Amendment," delegates implementation to the OMB through the administrative requirements for federal grants and agreements with non-profit organizations (including universities).

In 1999, the OMB published the new disclosure requirements.[51]

In promulgating its interpretation of the legislation, the OMB purported to balance three goals: 1) the advancement of the public interest in widely available information, 2) the maintenance of the traditional scientific process to ensure that research may continue to progress, and 3) the establishment of practical implementation procedures for public access. The most significant concern of the scientific community with the new disclosure condition of federal funding was that researchers would be forced to work in a "fishbowl" that would unveil data and research methods prematurely. The OMB responded to this concern by stressing that the disclosure requirements would protect the confidentiality of data while research is ongoing.[52]

The OMB requirements clarify that the federal government has the right to obtain and use data produced under an award. Such data would then be subject to FOIA. However, if the federal government

50. Omnibus Consolidated and Emergency Supplemental Appropriations Act, 1999, Pub. L. No. 105-277, 112 Stat. 2681-495 (1998).

51. OMB Circular A-110, Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations, 64 Fed. Reg. 54926 (1999).

52. Id. at 54927.



itself fails to act to obtain the data, the OMB interprets the 1998 legislation to obligate awardees to respond to a FOIA request for "research data relating to published research findings produced under an award that were used by the Federal Government in developing an agency action that has the force and effect of law . . . ."[53] The OMB materials define research data as "recorded factual material commonly accepted in the scientific community as necessary to validate research findings," and specifically exclude "preliminary analyses, drafts of scientific papers, plans for future research, peer-reviews, or communications with colleagues."[54] The OMB requirements bind all federally funded research, even if the federal support is a small proportion of the total research budget. As "faith-based" social programs are now discovering, federal strings come attached to the very first (even if the only) dollar of government money.

The key action triggering disclosure under the OMB requirements is publication. Unless the data requested by a member of the public (including a fellow scientist) are published, researchers have no obligation to disclose. Absent publication, data are unavailable unless:

1) a federal agency obtains them, 2) some other obligation (e.g., in a permit or cooperative agreement) requires disclosure, or 3) the researcher volunteers them. For the purposes of the OMB requirements, data are considered published not only when they appear in a peer-reviewed scientific or technical journal. Data are also considered published when a "[f]ederal agency publicly and officially cites the research findings in support of an agency action that has the force and effect of law."[55]

The question of what constitutes "an action that has the force and effect of law"[56] is one that will likely generate some conflict in the coming years. The OMB interpretive material states that a rule (such as an ESA listing or delisting decision) or an administrative order (such as the issuance of a permit) falls within the meaning of the key phrase. In contrast, agency guidance documents fall outside of the agency actions that trigger publication under the OMB requirements.[57] On which side of the divide does an endangered species recovery plan fall?

The recovery plan, an ESA requirement for all protected species,[58] contains three elements. First, each plan contains a description

53. Id. at 54930.
54. Id. This exclusion parallels FOIA disclosure exception for deliberative material. See supra note 34 and accompanying text.
55. Id. (emphasis added).
56. Id.
57. Id. at 54929.
58. 16 U.S.C. § 1533(f) (1999). A single recovery plan may cover several species linked by common habitat or threat. As of February 20, 2001, 975 species had approved recovery plans.

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of "site-specific management actions" necessary for recovery.[59] These actions are divided into three priority levels: urgent tasks necessary to prevent extinction, tasks that forestall significant further decline, and long-term tasks required for full recovery. Second, the plan must provide "objective, measurable criteria" for determining when the species has recovered.[60] Third, the plan includes estimates of the time and money required to meet recovery and intermediate goals that lead toward recovery.[61] Good monitoring information is necessary to implement all three of these elements, but especially the second.

The Services do not regard the plans as binding, and courts generally have refused to compel implementation of plans.[62] In this narrow sense, then, the recovery plan does not have the force and effect of law because it is mere guidance.[63] From this perspective, the recovery plan does not trigger "publication" for information disclosure under the OMB requirements. However, courts will require the Services to prepare adequate plans. For instance, courts have remanded recovery plans to the FWS for failure to provide objective, measurable criteria for recovery that addressed the factors on which the listings were based.[64] In this respect, courts treat the recovery plan like the environmental impact statement under the National Environmental Policy Act:[65] courts will compel agencies to prepare the document, and to rewrite the document if its content does not meet the statutory criteria; however, courts will not compel agencies to implement the provisions discussed in the document. So, if "an action that has the force



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and effect of law" corresponds to "agency actions" under the Administrative Procedure Act ("APA") that are subject to judicial review,[66] then studies cited in recovery plans do trigger the OMB requirements for disclosure. As illustrated below, the APA itself will compel agencies to include information supporting "agency actions" in the public

U.S. FISH & WILDLIFE SERV., THREATENED AND ENDANGERED SPECIES SYSTEM BOX SCORE, http://ecos.fws.gov/tess/html/boxscore.html (last visited July 10, 2001).
59. 16 U.S.C. § 1533(f)(1)(B)(i).
60. Id. at § 1533(f)(1)(B)(ii).
61. Id. at § 1533(f)(1)(B)(iii).
62. See, e.g., Nat'l Wildlife Fed'n v. Nat'l Park Serv., 669 F. Supp. 384 (D. Wyo. 1987). Federico Cheever, The Road to Recovery: A New Way of Thinking About the Endangered Species Act, 23 ECOLOGY L.Q. 1, 26, 58-59 (1996). But see Sierra Club v. Lujan, No. MO-91-CA-069, 36 Envt'l Rep. Cas. (BNA) 1533, 1541, 1993 WL 151353, at *8 (W.D. Tex. Feb. 1, 1993), appeal dismissed, Sierra Club v. Babbitt, 995 F.2d 571 (5th Cir. 1993) (requiring the FWS to develop and implement a recovery plan).
63. Fund for Animals v. Rice, 85 F.3d 535, 547 (11th Cir. 1996) (recovery plan is "for guidance purposes only"); Defenders of Wildlife v. Lujan, 792 F. Supp. 834, 835 (D.D.C. 1992) (recovery plan is not an "action document"). See Federico Cheever, Recovery Planning, the Courts, and the Endangered Species Act, 16 NAT. RESOURCES & ENV'T 106, 109 (2001).
64. See, e.g., Defenders of Wildlife v. Babbitt, 130 F. Supp. 2d 121, 133-34 (D.D.C. 2001) (remand of Sonoran pronghorn plan); Fund for Animals v. Babbitt, 903 F. Supp. 96, 110-14 (D.D.C. 1995), opinion amended by 967 F. Supp. 6 (D.D.C. 1997) (remand of grizzly bear recovery plan). See Cheever, supra note 63, at 109-10.
65. 42 U.S.C. §§ 4321-4345 (1989).
66. 5 U.S.C. §§ 551(13), 702 (1989).



administrative record.[67] The better interpretation of the OMB rule would compel disclosure for at least those agency decisions, such as adoption of a recovery plan, subject to the judicial review requirements of a contemporaneous agency record containing the supportive information.

C. Disclosure Under the ESA

The ESA is the legal cornerstone for environmental recovery. As Aldo Leopold famously observed, "to keep every cog and wheel is the first precaution of intelligent tinkering."[68] Species are essential elements of our diverse ecosystems. Because the ESA imposes relatively stringent duties on scientists and agencies, it provides specific authority to put into practice the general principles of information disclosure. In particular, the federal government's duty to recover species, and the scientists' obligation to secure permits to engage in research that impacts endangered species, require improved access to data.

1. Listing

At least with respect to agency rulemaking, the OMB requirements are not an abrupt departure from existing administrative law. For instance, in a celebrated 1994 decision, a federal court found the FWS listing of the coastal California gnatcatcher to violate the ESA and APA[69] because the public administrative record did not contain the underlying raw data supporting a disputed scientific paper.[70] In the gnatcatcher controversy, the listing of the subspecies hinged on whether its geographic range extended southward to thirty degrees, north, latitude, in which case it qualified for protection under the ESA, or whether its geographic range extended southward to twentyfive degrees, north, latitude, in which case its range included populations sufficient to preclude listing. In 1988, Dr. Jonathan Atwood of the Manomet Bird Observatory prepared a report in which he interpreted



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his field data describing variations in California gnatcatcher morphology to establish the more southerly boundary to the subspecies' range. After peer review of the paper, Dr. Atwood revised his conclusions in 1990 to establish the southern boundary at thirty degrees. Based partly on Atwood's revised paper, in 1993 the FWS

67. Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 419-20 (1971); see infra notes 69-80 and accompanying text.

68. ALDO LEOPOLD, A SAND COUNTY ALMANAC WITH OTHER ESSAYS ON CONSERVATION FROM ROUND RIVER 177 (Oxford Univ. Press 1966) (1949) (The Round River).

69. Relevant provisions include 5 U.S.C. §§ 553, 701, 702, and 706.

70. Endangered Species Comm. of the Bldg. Indus. Ass'n of Southern Cal. v. Babbitt, 852 F. Supp. 32 (D.D.C. 1994).



listed the coastal Californian gnatcatcher to receive protection under the ESA as a subspecies.[71]

During the comment period for the proposed listing, the future plaintiffs in the litigation, including the local builders' trade association, made requests for the raw data to both the FWS and to Atwood himself. In the listing, the FWS had reviewed only the scientist's reports, not the raw data. Since the federal agency had not reviewed the raw data in making its determination, they were not agency records. Therefore, the FWS did not disclose them. Atwood himself refused to disclose the information to the future plaintiffs because he believed that they were on "some sort of statistical 'witch hunt'."[72]

The court found the listing to be illegal because the trade association had not been able to review and comment on the raw field data, which played an important role in determining the range of the subspecies. The court cited the general principle of administrative law that when an agency relies on data to craft a rule, it generally must provide those data for public review.[73] In this case, the federal government argued that it did not rely on the raw data, as such, but instead relied on scientific reports based on the data. The court viewed this claim skeptically.

In addition, the ESA requires that listing decisions be based solely on the "best scientific and commercial data available."[74] Though some courts have allowed agencies to rely on reports interpreting data rather than the data themselves, the gnatcatcher court distinguished the litigation at issue because the Atwood reports were highly disputed.[75] When a controversy surrounds interpretation of data in a report, the court concluded, the law requires that the data be disclosed for public review. In making this finding, the court distinguished the legal process from scientific peer review, which (according to an American Ornithological Union statement in the record) does not usually require an ornithologist to provide the underlying raw data to support a scientific paper.

The outcome of the gnatcatcher case is consistent with the current requirements of the OMB. However, it is important to note that there was no question that the data involved in the controversy were final, not preliminary. Atwood had published his papers, and they had undergone traditional peer review. The much more difficult case faced today by people interested in monitoring species conservation

71. Under the ESA, "species" protected may be biological species, subspecies, or any distinct population segment of vertebrates that interbreeds when mature. 16 U.S.C. § 1532(16).

72. 852 F. Supp. at 34.
73. Id. at 36.
74. 16 U.S.C. § 1533(b)(1)(A).
75. 852 F. Supp. at 37.



efforts is access to data that researchers claim is preliminary. The only ESA circumstance where a court has compelled release of preliminary information involved the FWS listing of the Bruneau Hot Springs snail as an endangered species.[76] The court found that a "provisional" U.S. Geological Survey report did not merely supplement or confirm existing data.[77] Instead it "provided the only scientific information on the cause of the decline in spring flows," which destroyed the snail habitat.[78] Therefore, the Service should have given the public an opportunity to review and comment on the report.

However, in the absence of some final agency action reviewable under the terms of the APA,[79] we currently lack a mechanism for compelling access to unpublished species information. Federal agencies argue that disclosure of grizzly bear data would be premature until the data are published at some indeterminate time in the future, likely when a delisting rule is published and critics face a brief period in which to comment.[80] At that point, useful outside scientific scrutiny will be difficult, given the unpredictable and brief time frame.

It is also important to note that the FWS used the Atwood conclusion to support a notice and comment rulemaking, a relatively involved administrative process. Even preparation of a recovery plan requires a supporting administrative record.[81] The more difficult case faced today involves administrative actions that are less formal, such as management decisions about where, when, and how to close roads or release birds. Though the broadly applicable principles of FOIA and the OMB requirements for federally funded research leave these issues open to debate, the ESA itself provides additional law promoting disclosure where listed species are involved.

2. Other ESA Duties and the Need for Reporting Requirements in Permits

The ESA imposes an affirmative, but nonspecific duty on federal agencies to contribute to the recovery of listed species. Although courts consistently hold that the duty to conserve requires some action, or some reason why the agency has not acted, they seldom set

76. Idaho Farm Bureau Fed'n v. Babbitt, 53 F.3d 1392 (9th Cir. 1995) (remanding the endangered species listing decision for the Bruneau Hot Springs snail).
77. Id. at 1402.
78. Id. at 1403.
79. 5 U.S.C. § 551(13) (1989) (defining "agency action" as "a rule, order, license, sanction, relief, or the equivalent or denial thereof, or failure to act"); 5 U.S.C. § 702 (providing judicial review for "agency action").
80. The administrative procedure for delisting parallels the one for listing. 16 U.S.C. § 1533(c)(2). For a thorough analysis of delisting issues, see Holly Doremus, Delisting Endangered Species: An Aspirational Goal, Not a Realistic Expectation, 30 ENVTL. L. REP. 10434 (2000). The comment period for proposed delistings may be as brief as forty-five to sixty days.
81. See supra note 64.



out precisely what it requires or rely on it as the sole basis for overturning an agency's decision.[82] In order to explain how they are meeting this duty, the agencies need information on the relationship



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between their programs/actions and the effects on the listed species. This duty, then, creates a federal demand to generate or acquire records containing conservation biology data. In this section, we recommend that agencies modify ESA permits and cooperative agreements to require periodic monitoring or reports. This will provide the agencies and the public alike with better information on how well agencies are meeting their ESA recovery duties. Most researchers already operate under permits and agreements, which provide a vehicle for advancing the public interest in species recovery.

Other, more specific, requirements of the ESA strengthen the case for better central reporting of endangered species information. As discussed in section III(B), above, the Services have special responsibilities to develop recovery plans for listed species.[83] Among other things, the plans include "site-specific management actions" necessary for recovery and "objective, measurable criteria" for determining when the species has recovered.[84] A separate provision of the ESA prohibits federal agencies (including the Services) from authorizing any activity (or issuing a permit) that is likely to jeopardize the continued existence of a listed species. It is difficult to fathom how agencies can fulfill these duties without improved information and review.

The broadest proscriptions of the ESA apply to everybody and ban a wide range of activities that injure, harm, harass, wound, trap, capture or collect individual endangered animals.[85] Harm includes "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering."[86] Research on and management of endangered species often involves manipulation of habitat or close examination that might run afoul of these ESA prohibitions.

However, the Services issue permits to allow these otherwise prohibited activities for "scientific purposes or to enhance the propaga-

82. Robert L. Fischman & Mark S. Squillace, Environmental Decisionmaking: NEPA and the Endangered Species Act 175-76 (3d ed. 2000); J.B. Ruhl, Section 7(a)(1) of the "New" Endangered Species Act: Rediscovering and Redefining the Untapped Power of Federal Agencies' Duty to Conserve Species, 25 Envtl. L. 1107 (1995). But see Sierra Club v. Glickman, 156 F.3d 606, 615 (5th Cir. 1998) (holding that the U.S. Department of Agriculture violated the affirmative conservation duty by failing to develop an organized program for utilizing its authorities for the conservation of listed species dependent on the Edwards Aquifer in Texas).

83. See supra notes 58-63 and accompanying text.

84. 16 U.S.C. § 1533(f)(1)(B)(i)-(ii).

85. Id. at §§ 1532(19), 1539(a).

86. 50 C.F.R. § 17.3 (2000).

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tion or survival" of listed species.[87] This science and enhancement permit is a close cousin of the better-known incidental take permit, described in Professor Sax's article.[88] However, the science and enhancement permit does not require a habitat conservation plan, the most controversial and burdensome element of an incidental take permit. Other than specifying that the permitted activities should be "for scientific purposes or to enhance the propagation or survival of the affected species,"[89] the statute contains no special requirements for the content of the permit. Most research involving listed species requires this science/enhancement permit. The ESA grants broad authority to the Services to condition a research permit on terms to promote recovery of the species.[90] As with all permitting decisions, the issuance of a science/enhancement permit requires the Service to comply with the ESA requirement to ensure that any action authorized does not jeopardize the continued existence of an endangered species or adversely modify critical habitat.[91]

In order to prevent jeopardy and contribute to recovery, the Services need information on the status of listed species, the efforts underway to recover them, the likely impact of proposed activities on listed species, and the cumulative impacts of other ongoing or proposed activities. In an effort to make the most of existing research, the Services ought to condition research permits on periodic reporting of collected data. Reports should include observations of conditions that may warrant further investigation by the agency (e.g., possible illegal activities, or problems outside the expertise of the researcher that might require other expert opinion or research); assessments of monitoring, research, or management techniques employed; and results relevant to conservation of the species.

Permits to discharge or emit otherwise prohibited pollutants commonly contain reporting conditions to allow the regulating agencies and the public to monitor the environment.[92] For research permits under the ESA, the fit between specified data reporting and the per-

87. 16 U.S.C. § 1539(a)(1)(A).
88. Sax, supra note 2, at 5.
89. 16 U.S.C. § 1539(a)(1)(A).
90. Id. at § 1539(a)(2)(B). The science permit program receives little outside scrutiny and there is a wide variation from region to region in how the Services implement it. For instance, in FWS Region 2 (the Southwest Region), researchers fill out Form 3-200, Federal Fish and Wildlife License/Permit Application, to obtain their own individual permit. The FWS cannot grant the permit until it publishes notice of the application to provide opportunity for public comment under 16 U.S.C. § 1539(a)(2)(B). In FWS Region 6 (the Mountain-Prairie Region), the regional director holds a scientific permit and researchers request status as subpermitees without the need to apply for individual permits.
91. 16 U.S.C. § 1536(a)(2).
92. See, e.g., 33 U.S.C. § 1342(a)(2) (1987) (NPDES permit conditions on data and information collection and reporting); 40 C.F.R. § 122.41(h) (2000) (duty of permitee to provide information); id. at § 122.41(l) (reporting requirements, including periodic discharge monitoring reports in permits).

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mit purpose is much tighter because the very purpose of the permit often is to collect information. Though the research may harm a species in the short-run, we allow it to continue because we believe it will benefit recovery in the long term. Access to research information can secure that long-term benefit.

It is long past time for the Services to promote more assertively the public conservation interest through permit conditions on scientific and enhancement permits. The reporting requirements we recommend here would also improve incidental take permits, which need better documentation of monitoring and of implementation of takes and mitigation.[93] The details of the timing and content requirements may be tailored by the Services to particular circumstances, but reports should allow responsible review of activities at least annually.

The Services themselves should meet this reporting requirement where they directly engage in monitoring, management, enhancement and scientific activities. Moreover, the Services should incorporate reporting conditions into cooperative agreements with states, universities, and nonprofit organizations. These agreements are important existing tools with which the Services coordinate species management, habitat enhancement, and research. Safe harbor agreements[94] and conservation agreements,[95] two relatively recent innovations in the ESA program, likewise must include regular information disclosure. Permits and agreements should also require quick notification of unanticipated adverse impacts to endangered species, as is already the case with incidental take statements attached to biological opinions issued by the Services as a result of formal consultation.[96] These re-

93. PETER KAREIVA ET AL., USING SCIENCE IN HABITAT CONSERVATION PLANS 3-4 (1999), available at http://www.nceas.ucsb.edu/projects/hcp (summarized in Frances James, Lessons Learned from a Study of Habitat Conservation Planning, 49 BIOSCIENCE 871 (1999)). While the FWS disagreed with the report's conclusions about the lack of biological information, it has recently amended its HCP handbook to provide for measurable biological objectives, incorporate adaptive management, and develop better monitoring. U.S. FISH & WILDLIFE SERV., U.S. FISH AND WILDLIFE SERVICE'S RESPONSE TO AIBS/NCEAS'S STUDY USING SCIENCE IN HABITAT CONSERVATION PLANS, available at http://endangered.fws.gov/hcp/response.htm (last visited Sept. 21, 2000); Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, 65 Fed. Reg 35242 (June 1, 2000) (to be codified at 50 C.F.R. parts 13 and 17).

94. Safe harbor agreements allow a landowner to enhance habitat in exchange for a shield from liability for its subsequent destruction. See Safe Harbor Agreements and Candidate Conservation Agreements with Assurances, 64 Fed. Reg. 32706 (June 17, 1999). See also J.B. Ruhl, Who Needs Congress? An Agenda for Administrative Reform of the Endangered Species Act, 6 N.Y.U. ENVTL. L.J. 367 (1998).

95. Conservation agreements may defer listing of species in exchange for conservation actions. See id.; Robert L. Fischman, Endangered Species Conservation: What Should We Expect of Federal Agencies?, 13 PUB. LAND L. REV. 1 (1992); Announcement of Final Policy for Candidate Conservation Agreements with Assurances, 64 Fed. Reg. 32726 (June 17, 1999).

96. Formal consultation is the process by which agencies, including the Services themselves, meet their duty to ensure that actions authorized, funded and carried out by them do not jeopardize the continued existence of endangered species or adversely modify critical habitat. 16 U.S.C. § 1536 (1999).



porting requirements would provide the Services with information they are already bound to collect.

Scientists currently benefit from internet web sites that post ongoing information about field or captive programs in support of endangered species recovery.[97] Furthermore, written reports are often already required by state agencies that issue permits,[98] by the National Park Service and other federal agencies for research on their lands,[99] and by funding sources as well. Annual reports do not impede the simultaneous preparation of manuscripts for publication; indeed, they might encourage it. Annual reports would not need to contain the kinds of advanced analysis and synthesis associated with full-blown, peer-reviewed publications. Researchers can provide appropriate caveats to deflect overly enthusiastic interpretation of results and to educate readers regarding the uncertainties. A display of reports on a web site would provide a central location to facilitate work by researchers, resource managers, educators, students, and the general public. Though mechanisms to protect precise location data for species vulnerable to persecution would need to be a part of any system of access, these need not greatly reduce the available information.

## IV. CONCLUSION

Our current, haphazard approach to endangered species research provides too little information. Peer-reviewed publication is a traditional and essential method of dispersing information; and, in the contentious and passionate atmosphere that surrounds endangered species, peer review can be an important tool for careful evaluation of methods and results. But, peer review also demands hopeful patience without providing any guarantee that desired data will appear. Moreover, exactly those programs that may be most in need of review–resource management without explicit research components–have the least exposure to it.

97. In the case of the Meretsky et al., research, discussed supra note 26 and accompanying text, web sites supported by the Peregrine Fund and Ventana Wilderness Society were excellent sources of information on dates and suspected or confirmed causes of mortality; and numbers, ages and sexes of released birds. See, e.g., VENTANA WILDERNESS SOC'Y, CONDOR REINTRODUCTION: NOTES FROM THE FIELD, http://www.ventanaws.org/fldnotes.htm; PEREGRINE FUND: NOTES FROM THE FIELD, http://www.peregrinefund.org/notes_condor.html#notes from the field. The U.S. Fish and Wildlife Service maintains a web page on which it posts recovery plans. U.S. FISH & WILDLIFE SERV., THE ENDANGERED SPECIES PROGRAM, http://endangered.fws.gov/recovery/recplans/index.htm. The volume and usefulness of web-based information vary widely from agency to agency, but access is generally increasing.

98. See, e.g., ARIZ. ADMIN. CODE R12-4-418(G) (2001) (requiring a written report at the end of the term of each "scientific collecting permit"); UTAH ADMIN. CODE R657-3-16 (2001) (requiring a report for "collection, importation, transportation, and possession of zoological animals" permits). One of the coauthors has engaged in scientific research under permits requiring reports in the following states: Arizona, Indiana, Utah.

99. See, e.g., NAT'L PARK SERV., RESEARCH PERMIT AND REPORTING SYSTEM, http://science.nature.nps.gov/servlet/Prmt_PubIndex.

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Annual reports are not reviews, but they can provide informal opportunities for outside comment, which is far more useful as a course correction for adaptive management than a post mortem.[100] If annual reports can provide a less threatening forum for comment, the result may be improved evaluations during formal review. This will eventually reduce resistence to the whole process. Impartial, periodic review of management efforts is imperative for successful recovery.[101] Proprietary reluctance to share widely endangered species information is in neither our own best interests nor in the species' best interests. Annual reporting requirements in exchange for permission to study the public's biological treasures is a fair balance between access and control. Such a requirement would provide a venue for reporting minor insights and advances that might otherwise go unpublished. Centrally and promptly available internet web reports can benefit listed species, individual researchers, and the conservation effort; and, they would be much harder to ignore than reports whose existence is less well known.

Because the Services will bear the brunt of collecting and posting the reports, they will need additional budget monies and personnel to prepare their own reports and assemble the rest. However, unlike recent budget battles over funding the ESA listing program, increased efficiency, sounder science, and public information have widespread support irrespective of party or environmental affiliation.[102] Increased demand for ready access to public information grows every day, and technology facilitates compliance with information responsibilities to endangered species far more easily now than ever before.[103]

The inability of agencies to withhold precise data for current nesting, denning, and other relatively static locations outside of the national

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parks cannot be so easily remedied with an administrative initiative. Congress must provide a narrowly drawn exception to the general disclosure rule of FOIA for this information where it pinpoints endangered species under circumstances where access would

100. See, e.g., D.G. Kleiman et al., Improving the Evaluation of Conservation Programs, 14 Conservation Biology 356 (2000).

101. Clark et al., supra note 5, at 425.

102. For instance, the portion of the National Park Omnibus Management Act of 1998, supra note 41, designed "to encourage the publication and dissemination of information derived from studies in the National Park System," 16 U.S.C. § 5931(5) (1999), and to "assure the full and proper utilization of results of scientific study for park management decisions," 16 U.S.C. § 5936, received strong support from both Senator Craig Thomas (a Wyoming Republican generally hostile to environmental protection measures) and Charles Clusen, Senior Policy Analyst for the Natural Resources Defense Council. Hearings on S. 1693 Before the Subcomm. on National Parks, Historic Preservation and Recreation of the Senate Comm. on Energy and Natural Resources, 105th Cong. (1998).

103. In the pollution control field, annual reporting of toxic releases has spurred important preventive measures to improve environmental quality. See Bradley C. Karkkainen, Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?, 89 Geo. L.J. 257 (2001).

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risk jeopardy to the species. The lesson of the 1998 Park Service legislation is that where Congress provides agencies with broader discretion to withhold information, they will insulate less sensitive data from public scrutiny. This secrecy may ultimately be more harmful to the recovery effort than the loss of several animals to poachers.

None of us likes annual physical exams, but we admit the usefulness of the information, and, more grudgingly, the chance to have our complacency regarding our health shaken a bit. A required annual physical for our endangered species, delivered by those who work with them, or whose work affects them, is in everyone's best interests. The "new age of environmental restoration" demands it.



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SERIES

# Peer review: a flawed process at the heart of science and journals

Richard Smith

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*Richard Smith was editor of the* BMJ *and chief executive of the BMJ Publishing Group for 13 years. In his last year at the journal he retreated to a 15th century palazzo in Venice to write a book. The book will be published by RSM Press [www.rsmpress.co.uk], and this is the second in a series of extracts that will be published in the* JRSM.

Peer review is at the heart of the processes of not just medical journals but of all of science. It is the method by which grants are allocated, papers published, academics promoted, and Nobel prizes won. Yet it is hard to define. It has until recently been unstudied. And its defects are easier to identify than its attributes. Yet it shows no sign of going away. Famously, it is compared with democracy: a system full of problems but the least worst we have.

When something is peer reviewed it is in some sense blessed. Even journalists recognize this. When the *BMJ* published a highly controversial paper that argued that a new 'disease', female sexual dysfunction, was in some ways being created by pharmaceutical companies, a friend who is a journalist was very excited—not least because reporting it gave him a chance to get sex onto the front page of a highly respectable but somewhat priggish newspaper (the *Financial Times*). 'But,' the news editor wanted to know, 'was this paper peer reviewed?'. The implication was that if it had been it was good enough for the front page and if it had not been it was not. Well, had it been? I had read it much more carefully than I read many papers and had asked the author, who happened to be a journalist, to revise the paper and produce more evidence. But this was not peer review, even though I was a peer of the author and had reviewed the paper. Or was it? (I told my friend that it had not been peer reviewed, but it was too late to pull the story from the front page.)

## WHAT IS PEER REVIEW?

My point is that peer review is impossible to define in operational terms (an operational definition is one whereby if 50 of us looked at the same process we could all agree most of the time whether or not it was peer review). Peer review is thus like poetry, love, or justice. But it is something to do with a grant application or a paper being scrutinized by a third party—who is neither the author nor the person making a judgement on whether a grant should be given or a paper published. But who is a peer? Somebody doing exactly the same kind of research (in which case he or she is probably a direct competitor)? Somebody in the same discipline? Somebody who is an expert on methodology? And what is review? Somebody saying 'The paper looks all right to me', which is sadly what peer review sometimes seems to be. Or somebody pouring all over the paper, asking for raw data, repeating analyses, checking all the references, and making detailed suggestions for improvement? Such a review is vanishingly rare.

What is clear is that the forms of peer review are protean. Probably the systems of every journal and every grant giving body are different in at least some detail; and some systems are very different. There may even be some journals using the following classic system. The editor looks at the title of the paper and sends it to two friends whom the editor thinks know something about the subject. If both advise publication the editor sends it to the printers. If both advise against publication the editor rejects the paper. If the reviewers disagree the editor sends it to a third reviewer and does whatever he or she advises. This pastiche—which is not far from systems I have seen used—is little better than tossing a coin, because the level of agreement between reviewers on whether a paper should be published is little better than you'd expect by chance.[1]

That is why Robbie Fox, the great 20th century editor of the *Lancet*, who was no admirer of peer review, wondered whether anybody would notice if he were to swap the piles marked 'publish' and 'reject'. He also joked that the *Lancet* had a system of throwing a pile of papers down the stairs and publishing those that reached the bottom. When I was editor of the *BMJ* I was challenged by two of the cleverest researchers in Britain to publish an issue of the journal comprised only of papers that had failed peer review and see if anybody noticed. I wrote back 'How do you know I haven't already done it?'

## DOES PEER REVIEW 'WORK' AND WHAT IS IT FOR?

But does peer review 'work' at all? A systematic review of all the available evidence on peer review concluded that

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'the practice of peer review is based on faith in its effects, rather than on facts'.[2] But the answer to the question on whether peer review works depends on the question 'What is peer review for?'.

One answer is that it is a method to select the best grant applications for funding and the best papers to publish in a journal. It is hard to test this aim because there is no agreed definition of what constitutes a good paper or a good research proposal. Plus what is peer review to be tested against? Chance? Or a much simpler process? Stephen Lock when editor of the *BMJ* conducted a study in which he alone decided which of a consecutive series of papers submitted to the journal he would publish. He then let the papers go through the usual process. There was little difference between the papers he chose and those selected after the full process of peer review.[1] This small study suggests that perhaps you do not need an elaborate process. Maybe a lone editor, thoroughly familiar with what the journal wants and knowledgeable about research methods, would be enough. But it would be a bold journal that stepped aside from the sacred path of peer review.

Another answer to the question of what is peer review for is that it is to improve the quality of papers published or research proposals that are funded. The systematic review found little evidence to support this, but again such studies are hampered by the lack of an agreed definition of a good study or a good research proposal.

Peer review might also be useful for detecting errors or fraud. At the *BMJ* we did several studies where we inserted major errors into papers that we then sent to many reviewers.[3,4] Nobody ever spotted all of the errors. Some reviewers did not spot any, and most reviewers spotted only about a quarter. Peer review sometimes picks up fraud by chance, but generally it is not a reliable method for detecting fraud because it works on trust. A major question, which I will return to, is whether peer review and journals should cease to work on trust.

## THE DEFECTS OF PEER REVIEW

So we have little evidence on the effectiveness of peer review, but we have considerable evidence on its defects. In addition to being poor at detecting gross defects and almost useless for detecting fraud it is slow, expensive, profligate of academic time, highly subjective, something of a lottery, prone to bias, and easily abused.

### Slow and expensive

Many journals, even in the age of the internet, take more than a year to review and publish a paper. It is hard to get good data on the cost of peer review, particularly because reviewers are often not paid (the same, come to that, is true of many editors). Yet there is a substantial 'opportunity cost', as economists call it, in that the time spent reviewing could be spent doing something more productive—like original research. I estimate that the average cost of peer review per paper for the *BMJ* (remembering that the journal rejected 60% without external review) was of the order of £100, whereas the cost of a paper that made it right though the system was closer to £1000.

The cost of peer review has become important because of the open access movement, which hopes to make research freely available to everybody. With the current publishing model peer review is usually 'free' to authors, and publishers make their money by charging institutions to access the material. One open access model is that authors will pay for peer review and the cost of posting their article on a website. So those offering or proposing this system have had to come up with a figure—which is currently between \$500–\$2500 per article. Those promoting the open access system calculate that at the moment the academic community pays about \$5000 for access to a peer reviewed paper. (The \$5000 is obviously paying for much more than peer review: it includes other editorial costs, distribution costs—expensive with paper—and a big chunk of profit for the publisher.) So there may be substantial financial gains to be had by academics if the model for publishing science changes.

There is an obvious irony in people charging for a process that is not proved to be effective, but that is how much the scientific community values its faith in peer review.

### Inconsistent

People have a great many fantasies about peer review, and one of the most powerful is that it is a highly objective, reliable, and consistent process. I regularly received letters from authors who were upset that the *BMJ* rejected their paper and then published what they thought to be a much inferior paper on the same subject. Always they saw something underhand. They found it hard to accept that peer review is a subjective and, therefore, inconsistent process. But it is probably unreasonable to expect it to be objective and consistent. If I ask people to rank painters like Titian, Tintoretto, Bellini, Carpaccio, and Veronese, I would never expect them to come up with the same order. A scientific study submitted to a medical journal may not be as complex a work as a Tintoretto altarpiece, but it is complex. Inevitably people will take different views on its strengths, weaknesses, and importance.

So, the evidence is that if reviewers are asked to give an opinion on whether or not a paper should be published they agree only slightly more than they would be expected to agree by chance. (I am conscious that this evidence conflicts with the study of Stephen Lock showing that he alone and

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the whole *BMJ* peer review process tended to reach the same decision on which papers should be published. The explanation may be that being the editor who had designed the *BMJ* process and appointed the editors and reviewers it was not surprising that they were fashioned in his image and made similar decisions.)

Sometimes the inconsistency can be laughable. Here is an example of two reviewers commenting on the same papers.

> Reviewer A: 'I found this paper an extremely muddled paper with a large number of deficits'

> Reviewer B: 'It is written in a clear style and would be understood by any reader'.

This—perhaps inevitable—inconsistency can make peer review something of a lottery. You submit a study to a journal. It enters a system that is effectively a black box, and then a more or less sensible answer comes out at the other end. The black box is like the roulette wheel, and the prizes and the losses can be big. For an academic, publication in a major journal like *Nature* or *Cell* is to win the jackpot.

## Bias

The evidence on whether there is bias in peer review against certain sorts of authors is conflicting, but there is strong evidence of bias against women in the process of awarding grants.[5] The most famous piece of evidence on bias against authors comes from a study by DP Peters and SJ Ceci.[6] They took 12 studies that came from prestigious institutions that had already been published in psychology journals. They retyped the papers, made minor changes to the titles, abstracts, and introductions but changed the authors' names and institutions. They invented institutions with names like the Tri-Valley Center for Human Potential. The papers were then resubmitted to the journals that had first published them. In only three cases did the journals realize that they had already published the paper, and eight of the remaining nine were rejected—not because of lack of originality but because of poor quality. Peters and Ceci concluded that this was evidence of bias against authors from less prestigious institutions.

This is known as the Mathew effect: 'To those who have, shall be given; to those who have not shall be taken away even the little that they have'. I remember feeling the effect strongly when as a young editor I had to consider a paper submitted to the *BMJ* by Karl Popper.[7] I was unimpressed and thought we should reject the paper. But we could not. The power of the name was too strong. So we published, and time has shown we were right to do so. The paper argued that we should pay much more attention to error in medicine, about 20 years before many papers appeared arguing the same.

The editorial peer review process has been strongly biased against 'negative studies', i.e. studies that find an intervention does not work. It is also clear that authors often do not even bother to write up such studies. This matters because it biases the information base of medicine. It is easy to see why journals would be biased against negative studies. Journalistic values come into play. Who wants to read that a new treatment does not work? That's boring.

We became very conscious of this bias at the *BMJ*; we always tried to concentrate not on the results of a study we were considering but on the question it was asking. If the question is important and the answer valid, then it must not matter whether the answer is positive or negative. I fear, however, that bias is not so easily abolished and persists.

The *Lancet* has tried to get round the problem by agreeing to consider the protocols (plans) for studies yet to be done.[8] If it thinks the protocol sound and if the protocol is followed, the *Lancet* will publish the final results regardless of whether they are positive or negative. Such a system also has the advantage of stopping resources being spent on poor studies. The main disadvantage is that it increases the sum of peer reviewing—because most protocols will need to be reviewed in order to get funding to perform the study.

## Abuse of peer review

There are several ways to abuse the process of peer review. You can steal ideas and present them as your own, or produce an unjustly harsh review to block or at least slow down the publication of the ideas of a competitor. These have all happened. Drummond Rennie tells the story of a paper he sent, when deputy editor of the *New England Journal of Medicine*, for review to Vijay Soman.[9] Having produced a critical review of the paper, Soman copied some of the paragraphs and submitted it to another journal, the *American Journal of Medicine*. This journal, by coincidence, sent it for review to the boss of the author of the plagiarized paper. She realized that she had been plagiarized and objected strongly. She threatened to denounce Soman but was advised against it. Eventually, however, Soman was discovered to have invented data and patients, and left the country. Rennie learnt a lesson that he never subsequently forgot but which medical authorities seem reluctant to accept: those who behave dishonestly in one way are likely to do so in other ways as well.

## HOW TO IMPROVE PEER REVIEW?

The most important question with peer review is not whether to abandon it, but how to improve it. Many ideas



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have been advanced to do so, and an increasing number have been tested experimentally. The options include: standardizing procedures; opening up the process; blinding reviewers to the identity of authors; reviewing protocols; training reviewers; being more rigorous in selecting and deselecting reviewers; using electronic review; rewarding reviewers; providing detailed feedback to reviewers; using more checklists; or creating professional review agencies. It might be, however, that the best response would be to adopt a very quick and light form of peer review—and then let the broader world critique the paper or even perhaps rank it in the way that Amazon asks users to rank books and CDs.

I hope that it will not seem too indulgent if I describe the far from finished journey of the *BMJ* to try and improve peer review. We tried as we went to conduct experiments rather than simply introduce changes.

The most important step on the journey was realizing that peer review could be studied just like anything else. This was the idea of Stephen Lock, my predecessor as editor, together with Drummond Rennie and John Bailar. At the time it was a radical idea, and still seems radical to some—rather like conducting experiments with God or love.

### Blinding reviewers to the identity of authors

The next important step was hearing the results of a randomized trial that showed that blinding reviewers to the identity of authors improved the quality of reviews (as measured by a validated instrument).[10] This trial, which was conducted by Bob McNutt, A T Evans, and Bob and Suzanne Fletcher, was important not only for its results but because it provided an experimental design for investigating peer review. Studies where you intervene and experiment allow more confident conclusions than studies where you observe without intervening.

This trial was repeated on a larger scale by the *BMJ* and by a group in the USA who conducted the study in many different journals.[11,12] Neither study found that blinding reviewers improved the quality of reviews. These studies also showed that such blinding is difficult to achieve (because many studies include internal clues on authorship), and that reviewers could identify the authors in about a quarter to a third of cases. But even when the results were analysed by looking at only those cases where blinding was successful there was no evidence of improved quality of the review.

### Opening up peer review

At this point we at the *BMJ* thought that we would change direction dramatically and begin to open up the process. We hoped that increasing the accountability would improve the quality of review. We began by conducting a randomized trial of open review (meaning that the authors but not readers knew the identity of the reviewers) against traditional review.[13] It had no effect on the quality of reviewers' opinions. They were neither better nor worse. We went ahead and introduced the system routinely on ethical grounds: such important judgements should be open and acountable unless there were compelling reasons why they could not be—and there were not.

Our next step was to conduct a trial of our current open system against a system whereby every document associated with peer review, together with the names of everybody involved, was posted on the *BMJ*'s website when the paper was published. Once again this intervention had no effect on the quality of the opinion. We thus planned to make posting peer review documents the next stage in opening up our peer review process, but that has not yet happened—partly because the results of the trial have not yet been published and partly because this step required various technical developments.

The final step was, in my mind, to open up the whole process and conduct it in real time on the web in front of the eyes of anybody interested. Peer review would then be transformed from a black box into an open scientific discourse. Often I found the discourse around a study was a lot more interesting than the study itself. Now that I have left I am not sure if this system will be introduced.

### Training reviewers

The *BMJ* also experimented with another possible way to improve peer review—by training reviewers.[4] It is perhaps extraordinary that there has been no formal training for such an important job. Reviewers learnt either by trial and error (without, it has to be said, very good feedback), or by working with an experienced reviewer (who might unfortunately be experienced but not very good).

Our randomized trial of training reviewers had three arms: one group got nothing; one group had a day's face-to-face training plus a CD-rom of the training; and the third group got just the CD-rom. The overall result was that training made little difference.[4] The groups that had training did show some evidence of improvement relative to those who had no training, but we did not think that the difference was big enough to be meaningful. We cannot conclude from this that longer or better training would not be helpful. A problem with our study was that most of the reviewers had been reviewing for a long time. 'Old dogs cannot be taught new tricks', but the possibility remains that younger ones could.

## TRUST IN SCIENCE AND PEER REVIEW

One difficult question is whether peer review should continue to operate on trust. Some have made small steps



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beyond into the world of audit. The Food and Drug Administration in the USA reserves the right to go and look at the records and raw data of those who produce studies that are used in applications for new drugs to receive licences. Sometimes it does so. Some journals, including the *BMJ*, make it a condition of submission that the editors can ask for the raw data behind a study. We did so once or twice, only to discover that reviewing raw data is difficult, expensive, and time consuming. I cannot see journals moving beyond trust in any major way unless the whole scientific enterprise moves in that direction.

## CONCLUSION

So peer review is a flawed process, full of easily identified defects with little evidence that it works. Nevertheless, it is likely to remain central to science and journals because there is no obvious alternative, and scientists and editors have a continuing belief in peer review. How odd that science should be rooted in belief.

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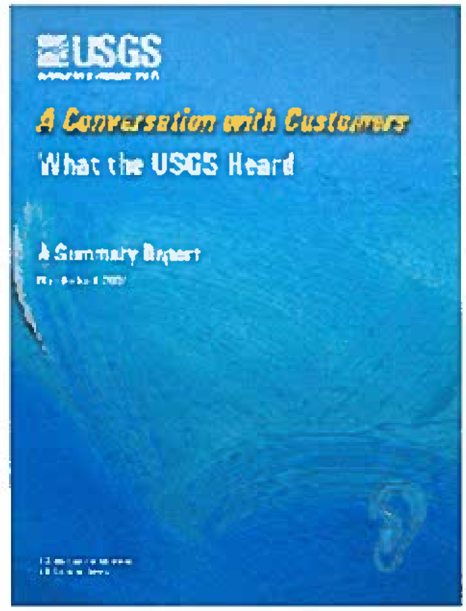
## Conversation with Customers: What the USGS Heard
## 2000 Customer Listening Session



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## Note from the Director

Dear Customer:

I would like to thank all of the customers who participated in our listening sessions. The many insightful comments and suggestions have provided much food for thought within the organization. We are committed to serving the needs of our customers, and we can only respond to those needs when they are expressed needs, not needs that we perceive on our own or in a vacuum without input from our customers. We appreciate the time that each of you took from your busy schedules to meet with us. Subsequent to the ***Conversation with Customers***, I have had the opportunity to meet on several occasions with customers who attended, as well as other customers who were not a part of our listening sessions. At each of those meetings, the thoughts expressed and the quality of the dialog have reinforced for me the importance of staying in touch -- and in tune -- with those whose needs and interests we are here to serve. Thank you again for your participation. If you have had some additional thoughts, or if new issues have arisen that you would like to communicate to us, the email address, conversation@usgs.gov, remains available to you.

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Charles G. Groat
Director

*************************

# Future Science Directions

In listening to its customers, the USGS heard an endorsement of the future science directions that it had set forth -- but that endorsement poses significant challenges, in that each of the directions is in itself a major effort for which customers see extensive science needs. While it was reassuring to hear the widespread endorsement of the science directions that the USGS sees in its future, it was also sobering to realize the breadth to which the science reaches and the incredible demands that need to be met to serve society's needs.

The future science directions that had been used as the framework for the listening sessions were heard in the conversations of every one of our customers. The majority of them spoke to more than one of these directions as being "right on track," raising issues that needed to be addressed or questions that needed to be answered. The fact that many customers endorsed more than one of these topics -- and showed us linkages between them -- tells us that these are the "right track" for our science.

In refining our science directions, we have kept the same major themes and have only modified them slightly, to focus chiefly on earthquakes, rather than the broad spectrum of "hazards," and folding flood concerns into "rivers." Additionally, although there is not a separate direction for "environment and human health," issues related to this topic are dealt with in the context of several of the future science directions. Similarly, while "living resources" is not a stand-alone future science direction, the biological issues that were identified by many of our customers are incorporated into the other science directions and, in a sense, embody the reaction of many customers that living resources should be looked at not as a discrete direction but rather as part of every aspect of our scientific investigations.

Customers also agreed that the challenges have never been greater for linking societal and policy questions with scientifically based answers. Many stressed the need to have science, technology, and information in all of their rich linkages employed in the development of sound management decisions and effective public policy.

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# Predators and the public trust

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ABSTRACT

Many democratic governments recognize a duty to conserve environmental resources, including wild animals, as a public trust for current and future citizens. These public trust principles have informed two centuries of U.S.A. Supreme Court decisions and environmental laws worldwide. Nevertheless numerous populations of large-bodied, mammalian carnivores (predators) were eradicated in the 20th century. Environmental movements and strict legal protections have fostered predator recoveries across the U.S.A. and Europe since the 1970s. Now subnational jurisdictions are regaining management authority from central governments for their predator subpopulations. Will the history of local eradication repeat or will these jurisdictions adopt public trust thinking and their obligation to broad public interests over narrower ones? We review the role of public trust principles in the restoration and preservation of controversial species. In so doing we argue for the essential roles of scientists from many disciplines concerned with biological diversity and its conservation. We look beyond species endangerment to future generations' interests in sustainability, particularly non-consumptive uses. Although our conclusions apply to all wild organisms, we focus on predators because of the particular challenges they pose for government trustees, trust managers, and society. Gray wolves *Canis lupus* L. deserve particular attention, because detailed information and abundant policy debates across regions have exposed four important challenges for preserving predators in the face of interest group hostility. One challenge is uncertainty and varied interpretations about public trustees' responsibilities for wildlife, which have created a mosaic of policies across jurisdictions. We explore how such mosaics have merits and drawbacks for biodiversity. The other three challenges to conserving wildlife as public trust assets are illuminated by the biology of predators and the interacting behavioural ecologies of humans and predators. The scientific community has not reached consensus on sustainable levels of human-caused mortality for many predator populations. This challenge includes both genuine conceptual uncertainty and exploitation of scientific debate for political gain. Second, human intolerance for predators exposes value conflicts about preferences for some wildlife over others and balancing majority rule with the protection of minorities in a democracy. We examine how differences between traditional assumptions and scientific studies of interactions between people and predators impede evidence-based policy. Even if the prior challenges can be overcome, well-reasoned policy on wild animals faces a greater challenge than other environmental assets because animals and humans change behaviour in response to each other in the short term. These coupled, dynamic responses exacerbate clashes between uses that deplete wildlife and uses that enhance or preserve wildlife. Viewed in this way, environmental assets demand sophisticated, careful accounting by disinterested trustees who can both understand the multidisciplinary scientific measurements of relative costs and benefits among competing uses, and justly balance the needs of all beneficiaries including future generations. Without public trust principles, future trustees will seldom prevail against narrow, powerful, and undemocratic interests. Without conservation informed by public trust thinking predator populations will face repeated cycles of eradication and recovery. Our conclusions have implications for the many subfields of the biological sciences that address environmental trust assets from the atmosphere to aquifers.

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*Key words*: *Canis lupus*, carnivore, ecosystem services, endangered species, environmental law, lethal management, policy, sustainability, wolf.

CONTENTS



## I. INTRODUCTION

The fundamental principle of the public trust and our starting premise is that just, democratic governments must preserve environmental components as assets held in trust for current and future generations. The governments of at least 22 countries accept some legal responsibilities for environmental conservation as some form of trust to benefit their citizens, although the contours and details vary markedly across jurisdictions (see Fig. 1; Sand, 2004; Blumm & Guthrie, 2012; Sagarin & Turnipseed, 2012). Public trust principles have ancient roots in many cultures, although 19th century courts and 20th century legal scholarship in the U.S.A. played a seminal role in their modern expressions (Sand, 2004; Blumm & Guthrie, 2012; Hare & Blossey, 2014). Despite a long history of recognizing a public trust doctrine (PTD) that includes wildlife as assets (see online Appendix S1 for glossary of terms and case law history), U.S.A. federal and state governments allowed, or actively pursued, the eradication of terrestrial, mammalian, large-bodied, carnivores (predators hereafter) including grizzly bears *Ursus arctos* L., mountain lions *Puma concolor* L. and gray and red wolves *C. rufus* Audubon & Bachman, 1851. Since the 1970s, several large carnivore species have recolonized portions of North America and Europe (Mech, 1995; Eberhardt & Breiwick, 2010; LaRue *et al.*, 2012; Chapron *et al.*, 2014). The future of predator recoveries depends on whether governments embrace and fulfil their trust responsibilities (Bruskotter, Enzler & Treves, 2011, 2012). Even today, the fates of numerous predator species worldwide depend on a complex mix of laws and social norms superimposed on the behavioural ecology of sympatric predators and people (see Sections IV–VI). Here we examine the persistent challenges humanity faces in conserving predators. In parallel, we explore the many obstacles to upholding a public trust. The one illuminates the other. Thus we translate legal instruments and multidisciplinary science to connect biological scientists to policy-makers and legal scholars concerned with environmental conservation. In Section II, we interweave varied perspectives on the U.S.A. PTD with federal and state duties recognized for wildlife conservation, to illustrate the challenges of centralized and decentralized authority for environmental trust assets such as predators. In Section III, we recount the volatile history of U.S.A. policy on predators with a focus on gray wolves, to place current predator conservation in historical context and illuminate a neglected public trust. In Section IV, we examine the lack of scientific consensus on sustainable mortality within predator populations and its consequences for efforts to preserve predators as trust assets. In Section V, we review evidence about human tolerance and intolerance for predators to illustrate two competing hypotheses for predator extirpation and the attendant interventions needed to avoid future extirpation. In Section VI, we review predator behavioural biology and the challenges it poses in attempting to balance consumptive and non-consumptive uses. Finally, in Section VII we recommend steps to implement public trust principles for predator conservation by any government. Throughout, we follow Hare & Blossey (2014) when referring to public trust thinking or principles generally, and we follow Blumm



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& Guthrie (2012) when we refer specifically to a PTD in a particular jurisdiction. Appendix S1 presents a glossary of PTD and legal terms.

## II. VISIONS OF THE PUBLIC TRUST MEET MOSAICS OF GOVERNMENTAL RESPONSIBILITIES

Although public trust thinking has roots dating back millennia (Sand, 2004), our modern recognition of the PTD began with a few U.S.A. court cases in the early 19th Century. U.S.A. and state Supreme Courts ruled that the 1776 American Revolution made the people sovereign and held the union of states responsible for many, if not all, environmental assets. These include wildlife. One landmark U.S.A. Supreme Court case in particular (Illinois Central Railroad Company, 1892, hereafter Illinois Central) clearly articulated how the public interest in waters and lands represented a permanent trust encompassing diverse environmental resources, which obligated the government to limit private property rights, commercial uses, and grants of environmental assets (see online Appendix S1). The PTD articulated by Illinois Central (1892) is still cited today and featured prominently in the U.S.A. revival of public trust thinking in the 1970s. Some claim that other countries have recently surpassed the U.S.A. in extending and enforcing public trust principles (Blumm & Guthrie, 2012). Certainly E.U. case law positions governments as trustees of the public interest in the environment including wildlife (see online Appendix S1). The international revival is widely credited by recent authors (Hare & Blossey, 2014; Wood, 2014*a*) to the writings and teachings of Judge Joseph Sax (Sax, 1970, 1971, 1980–1981).

### (1) A historical, democratic vision of the public trust doctrine (PTD)

Reviewing U.S.A. federal and state case law, Sax articulated a coherent vision of the environmental public trust as an evolving doctrine that was responsive to changing societal needs and whose paramount role was to preserve public, environmental assets for future generations and defend society from undemocratic allocations of environmental assets. We define undemocratic allocations as those that reflect tyranny of minority or majority, or are otherwise illegal or unjust. Sax (1970) urged courts to protect and prioritize the broadest public interest in environmental resources, even if diffuse and difficult to measure,

> '... when [ignorance] is joined with the courts' strong feeling that *diffuse public uses are both poorly represented and, by their nature, difficult to measure*, judicial wariness is inevitably enhanced ... And if the relevant facts are unknown and yet legislatures and administrative agencies show eagerness to go forward, the courts are only reinforced in their overall suspicion that they are dealing with governmental responsiveness to pressures imposed by *powerful but excessively narrow interests*.' (emphasis added, Sax, 1970, pp. 564–565)

For our purposes, 'diffuse' uses of wildlife would be inconspicuous, dispersed in space or time, or affecting individual wild animals subtly (e.g. wildlife watching, aesthetics and reverence). Sax's (1970) formulation and those of recent writers in his tradition (Horner, 2000; Sand, 2004; Hare & Blossey, 2014) differ from narrower views of the PTD that prioritize consumptive uses – especially hunting (NAM Technical Review, 2010). We detail similarities and contrasts between the two perspectives in Section III. Several U.S.A. state and local governments recognize and protect diffuse uses for wildlife in their constitutions, statutes, and mission statements (e.g. Michigan Constitution Article IV Section 52, 1963; Wisconsin Statutes & Annotations § 29.011-1; Alaskan Constitution, Article VIII Section 3). Several countries have recognized a fundamental, diffuse use as the right to a healthy environment (Blumm & Guthrie, 2012), e.g. Norway's 2014 Constitution states, 'Every person has a right to an environment that is conducive to health and to a natural environment whose productivity and diversity are maintained' (Norway 2014 Constitution, Article 112).

In the U.S.A., despite widespread recognition of the legitimacy of diffuse uses, many observers have noted that U.S.A. citizens' diffuse uses of wildlife tend to be under-represented by environmental resource agencies and often under-studied by wildlife researchers (Gill, 1996; Rutberg, 2001; Dunkley & Cattet, 2003; Way & Bruskotter, 2011). The pro-hunting values in U.S.A. society associated with the widespread neglect of diffuse uses are generating a lively debate today (Clark & Milloy, 2014).

Sax's (1970, 1980–1981) revival of the call to defend the broadest public interest and diffuse uses was not simply aspirational. It had a U.S.A. Supreme Court basis and it had practical consequences manifested in state courts since 1972. State courts paved the way for an expansive PTD addressing a broad array of environmental assets (see online Appendix S1). New Jersey case law led the way since Arnold (1821) and Martin (1842). One hundred and fifty years later, the New Jersey Supreme Court held, 'The public trust doctrine, like all common law principles, should not be considered fixed or static, but should be molded and extended to meet changing conditions and needs of the public it was created to benefit.' (Borough of Neptune City, 1972, p. 54). Sax (1980–1981) framed the PTD explicitly as evolutionary not revolutionary, protecting customary uses but allowing for change in societal priorities and cultural uses. The California Supreme Court decision on Mono Lake (National Audubon Society, 1983) followed that lead but set precedents that simultaneously clarified, extended, and constrained the PTD (Blumm & Guthrie, 2012). Probably the most significant extension was not the geographic one that extended the water trust beyond navigable waters, but that which extended the PTD to protect newer, non-traditional uses of the waters. The limits placed on the PTD by the Mono Lake decision are equally notable. In addition to U.S.A. Constitutional limits (see online Appendix S1), the California Supreme Court



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set a precedent that allocation of the water in Mono Lake should reflect customary and newer uses of those waters, but limited by the paramount public interest in that water. In ruling, 'The state has an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible' (National Audubon Society, 1983, note 14), the California Supreme Court obligated the state to protect water if feasible. Because the definition of feasible, 'Capable of being done, accomplished or carried out; possible, practicable' (Oxford English Dictionary, 2013), does not consider cost except at a hypothetical extreme that exceeds that possible for a State, the feasibility of protecting water presumably is limited mainly by the technologies, skills, and knowledge of the times. That put the public interest in water above any economic concerns (Sax, 1980–1981; Blumm & Guthrie, 2012). It also seemed to place technical and scientific assessments of feasibility in a central role for determining the scope of preservation of waters. The preceding two court cases on the PTD protected society's self-determination about acceptable uses rather than enshrining any particular uses.

Pondering the role of the government trustee led Sax to consider the sometimes-conflicting, relative roles of the three branches of U.S.A. government (executive, legislative, and judicial). Sax (1970) admonished the courts to balance the legislative and executive branches of U.S.A. government, which most often allocate benefits,

> 'When a claim is made on behalf of diffuse public uses, courts take the first step in the process by *withdrawing the usual presumption that all relevant issues have been adequately considered and resolved* by routine statutory and administrative processes. That first step is tantamount to a court's acceptance of jurisdiction.' (emphasis added, Sax, 1970, p. 561)

In his vision, the judiciary checks executive or legislative allocations of trust assets, such as permitting and privatizing, by using democratic doctrines and constitutional provisions that protect minorities and diffuse uses (Sax, 1970, 1980–1981). Later observers noted that the judiciary faces dynamic tensions with regard to interpreting or rewriting law (Wood, 2014*a*). On the one hand, courts may counter tyranny of the majority to protect minority interests (e.g. protecting the rights of trappers to pursue their customary uses of wildlife) no matter how unpopular they may be (Reiter, Brunson & Schmidt, 1999). On the other hand, the U.S.A. judiciary should counter the majority only by interpreting the law, constitution, and regulation, not by rewriting these expressions of majority rule. An opponent of judicial activism has characterized court efforts to rewrite law as fuelling a

> 'developing clash in liberal ideology between furthering individual rights of security and dignity, bound up in notions of private property protection, and supporting environmental protection and resource preservation goals, inevitably dependent on intrusive governmental programs designed to longer-term collectivist goals' (Lazarus, 1986, p. 633).

The tension between judicial activism and passivism plays out differently under PTD than under more common administrative law. Under more common administrative law, courts defer to administrative agencies whereas courts that are asked to consider PTD may be more liable to scrutinize agency decisions without deference. Hence some assert that the U.S.A. PTD relied unduly 'on a proenvironmental judicial bias' (Lazarus, 1986, p. 692). On the other hand, Sax (1980–1981) argued the PTD imposed a pro-democratic bias and he expressed strong views on undemocratic decisions by administrative agencies,

> '...many – if not most — of the depredations of public resources are brought about by public authorities who have received the permission of the state to proceed with their schemes... [courts] can assure that decisions made by mere administrative bodies are not allowed to impair trust interests in the absence of explicit, fully considered legislative judgments.' (Sax, 1980–1981, pp. 186, 194)

Sax was highly alert to undemocratic allocation and excessive use by current interest groups, but he did not write extensively about intergenerational equity, which we view as fundamental to public trust principles. President Theodore Roosevelt (1858–1919), was particularly eloquent on this theme,

> 'Defenders of the short-sighted men who in their greed and selfishness will, if permitted, rob our country of half its charm by their reckless extermination of all useful and beautiful wild things sometimes seek to champion them by saying that "the game belongs to the people." So it does; and not merely to the people now alive, but to the unborn people. The "greatest good for the greatest number" applies to the number within the womb of time, compared to which those now alive form but an insignificant fraction. Our duty to the whole, including the unborn generations, bids us to restrain an unprincipled present-day minority from wasting the heritage of these unborn generations. The movement for the conservation of wildlife and the larger movement for the conservation of all our natural resources are essentially democratic in spirit, purpose, and method.' (Roosevelt, 1916, Chapter 10, passage 25)

Few advocates for children have pursued legal claims for intergenerational equity and the few cases brought to U.S.A. courts have not succeeded so far (e.g. atmospheric trust litigation in Wood, 2014*a*). Nevertheless, many legal scholars in Sax's tradition view intergenerational equity as fundamental to PTD (Sagarin & Turnipseed, 2012; Hare & Blossey, 2014). The rise of conservation sciences and sustainability sciences have made it practical to quantify the 'insignificant fraction' of users and in some cases predict the extermination, referenced by Roosevelt (1916) above. The need to account completely, transparently and scientifically for environmental asset preservation and use leads us to turn back to Sax's vision because he envisioned accountability to the broad public interest as a critical prerequisite for just allocation of environmental assets,



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'The courts properly evince reluctance to approve decisions based upon ignorance... One product of such judicial reluctance is an incentive for decision-making agencies to begin seeking *careful and sophisticated measurements of the benefits and costs involved in resource allocations*. To the extent that judicial hesitancy cautions the agencies against making such allocations without better information on the public record, the courts are deterring ventures into the unknown.' (emphasis added, Sax, 1970, p. 564–565)

Sax's warning about 'ventures into the unknown' lives on in mandates to use the 'best scientific data available' [Endangered Species Act of 1973, 16 U.S.A. Congress (hereafter USC) § 1531] and E.U. laws requiring 'relevant and reliable scientific information' and 'necessary research and scientific work' (Habitats Directive, 1992). Norway's 2014 amended Constitution Article 112 grants. '... citizens are entitled to information on the state of the natural environment and on the effects of any encroachment on nature that is planned or carried out.' Hawaii's Court of Appeals went further and authorized the use of the precautionary principle to protect trust assets when conclusive scientific proof of harmful use was absent (Water Use Permit Applications, 2000; see online Appendix S1). A 2011 U.S.A. presidential order warned against ventures into the unknown, requiring regulation to be transparent, accountable, and based on the best available science (see online Appendix S1; Obama, 2011).

Thus far we have described four fundamental principles of any PTD. The first pair of principles is that PTDs must evolve with changing societal uses of assets while preserving the principal of the asset for future generations (Illinois Central, 1892; Borough of Neptune City, 1972; National Audubon Society, 1983). Also, the allocation of public trust assets to current users should be accounted transparently and completely, while also being subject to judicial review or challenges by beneficiaries to ward against undemocratic allocations (see online Appendix S1). These powerful principles appear simple but they set a high standard for trustees (Sax, 1980–1981; Sand, 2004; Klass, 2006; Blumm & Guthrie, 2012; Hare & Blossey, 2014).

Later legal scholars have proposed an even higher standard. Some see public trust principles including a fiduciary obligation similar to that of a financial or charitable trust (Scott, 1999; Horner, 2000; Wood, 2014*a*). Trusts require prudent management to preserve the principal, favouring asset growth over expenditure, to allow future generations to choose their own uses as well as continuous, scientific, and transparent accounting before allocating assets to current beneficiaries (Horner, 2000; Hare & Blossey, 2014; Wood, 2014*a*). Several U.S.A. state courts have taken steps in this direction (see online Appendix S1). The role of scientific evidence in accounting for the trust assets becomes clearer when one considers a fiduciary obligation. Therefore much of our review addresses how biological scientists and conservation scientists from many disciplines might support fiduciary accounting for wildlife trusts.

Neither Sax (1970) nor we are making the positivist claim that scientific evidence will settle debates that are fundamentally about values (Clark & Milloy, 2014). Rather Sax (1970) implicitly acknowledged that all the governments that recognize a PTD have already decided to measure environmental assets so they can be shared, preserved, and monitored. Whether measuring, preserving, or allocating assets is right or wrong is beyond our scope, so we direct the reader to treatments of balancing private and public interests (Lazarus, 1986; Lasswell & McDougal, 1992; Wood, 2014*a*). In practice, predators and other wildlife have been and will continue to be allocated for preservation or use, so we are concerned with scientific evidence about the effectiveness of trustees and the balance of interventions they select. Using reason to find balance between competing claims for our common interests can be assisted greatly by sciences and allied disciplines such as bioethics and political ecology.

### (2) A confusing mosaic of U.S.A. PTDs

Even if visions of the public trust were clear, in practice, many U.S.A. governmental responsibilities for wildlife are a confusing mosaic (Fig. 1A). Although many states followed National Audubon Society (1983) in adjudicating water trust issues (Scanlan, 2000; Blumm *et al.*, 2014), precedents for wildlife trusts, especially for terrestrial species, have not been articulated so clearly (Blumm & Paulsen, 2013; Blumm *et al.*, 2014). A minimum standard for wildlife conservation was set by U.S.A. federal court rulings that confirmed the authority and responsibility of states to 'preserve', 'protect', 'manage', 'conserve', and 'regulate the exploitation' of wild animals to avoid impairment of the public interest (see online Appendix S1). We encompass all these state duties generally with the term 'preserve', to capture the principle of leaving intact the principal of the trust for the next generation and avoiding impairment of the trust. Although the U.S.A. federal wildlife PTD (wildlife trust hereafter) is ambiguous or absent and only a matter of U.S.A. state law (see online Appendix S1), the federal Endangered Species Act of 1973 (ESA) is widely recognized as a powerful instrument to prevent extinction (Norris, 2004). Recent judicial interpretations have strengthened the linkages between the PTD and ESA, as we make explicit in Section III. To begin, the U.S.A. Congress enacting the ESA found diverse customary uses and benefits of wildlife for all citizens,

'...fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people... for the benefit of all citizens...The Secretary shall ...give priority to ...particularly those species that are, or may be, in conflict with construction or other development projects or other forms of economic activity;' (16 USC § 1531, Sec. 2(3)(5) and 4(f)(1)(A)).

The ESA thereby prioritized preservation over any development or economic activity, generating political vitriol as no other environmental act in U.S.A. history (Plater, 2004; The New York Times Editorial Board, 2015). Prioritizing



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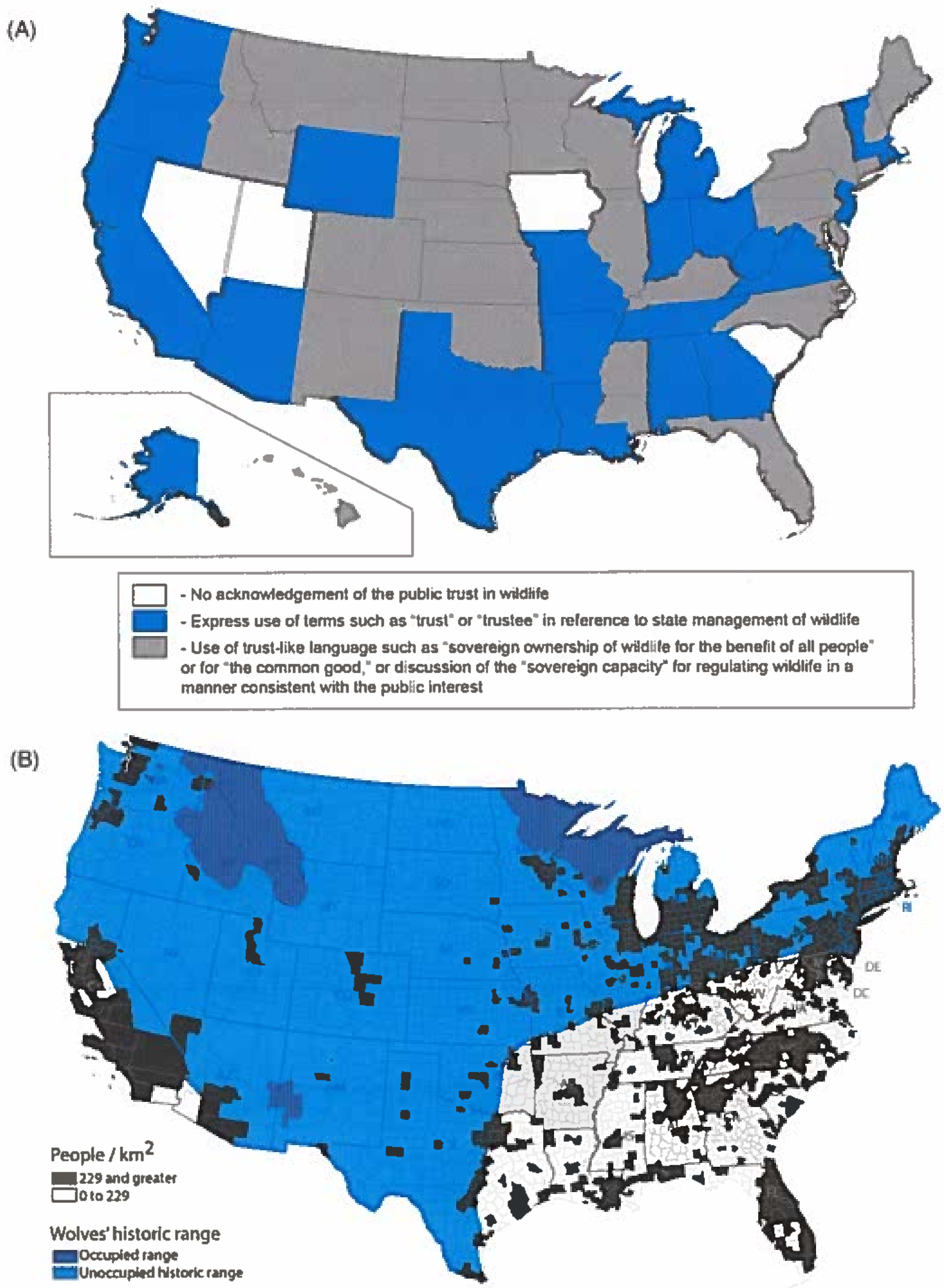


**Fig. 1.** (A) Three categories of state public trust doctrine (PTD) in the U.S.A. following Blumm & Paulsen (2013). (B) Historic range of the gray wolf reproduced from Bruskotter *et al.* (2013).

preservation above allocations of assets is central to public trust thinking because of intergenerational equity.

Beyond the ESA, the U.S.A. federal government played a national, coordinating role in environmental protection starting in the 1960s when several Congressional Acts established cooperative federalism, within which the federal government set the standards and states responded (Plater, 2004; Klass, 2006). The U.S.A. Supreme Court recently opined that setting state trustees' responsibilities is a matter of state law for all three branches (PPL Montana, 2012). This does not exclude a possible challenge that a state does not meet some minimum, federal standard of wildlife trusteeship, but the legal test for terrestrial wildlife has yet to be made to our knowledge. U.S.A. federal regulation such as the

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ESA led states to enact their own regulatory statutes and build their own wildlife agencies to meet or exceed federal standards for wildlife regulation. The results were wildlife trusts that vary from state to state (Fig. 1A) including states with none (Blumm *et al.*, 2014). Further complicating the interstate mosaic are federal and tribal jurisdictions within states, which may have their own trust obligations and serve as co-trustees (e.g. Sanders, 2013; Wood, 2014*b*).

Blumm & Paulsen (2013) reviewed state constitutions, laws, and regulations for assertions that wildlife is a public trust asset or state assertions using 'public trust-like language to describe management of wild animals' (Blumm & Paulsen, 2013, Section IV.B). Twenty-two U.S.A. states used the words 'trust' or 'trustee', to describe management of wildlife (Fig. 1A). Another 22 states used other PTD language 'such as sovereign ownership of wildlife for "the benefit of all people" or for "the common good", or discussion of the "sovereign capacity" for regulating wildlife in a manner consistent with the public interest' (Fig. 1A). The remaining states either had less articulated versions of the public trust in wildlife (Iowa, Delaware, and Nebraska), or did not acknowledge it at all (Nevada, South Carolina, and Utah) (Blumm & Paulsen, 2013, Section IV.B). Interpretations of the PTD also vary within states over time (Horner, 2000; Klass, 2006; Redmond, 2009; Blumm *et al.*, 2014). Although one can visualize the mosaic based on legal language (Fig. 1A), in practice, some states may not uphold those duties recognized in legal language.

One measure of the strength of a state PTD is whether citizens can challenge the government's allocations. As of 2006, only 2 states had the strongest form of PTD in which constitutional rights to trust assets were established, and 15 others mentioned such rights in statutes but limited accountability of the trustee (Klass, 2006).

In sum, governmental responsibilities to conserve wildlife have been subject to variable, state-level, democratic processes producing a mosaic of wildlife conservation responsibilities. The U.S.A. wildlife trust is also murky because of narrow influences on administrative agencies.

### (3) Agency capture and public trustees

Asset allocation readily becomes undemocratic when special interests capture the administrative agencies, or capture the constitutive process, defined as the rules governing wildlife agency decision-making (Lasswell & McDougal, 1992; Clark & Milloy, 2014). Prukop & Regan (2005, p. 375–376, cited on p. 20 in Chapter 9 of Clark & Milloy, 2014), writing for the U.S. Association of Fish and Wildlife Agencies noted many problems with the constitutive process in current U.S.A. wildlife management. Clark & Milloy (2014) comprehensively examined the constitutive process in predator policy and science in the western U.S.A., and concluded, '... the decision process needs to be made more open to everyone, more factual about the entire context,... more focused on achieving common interests ... Recurring weaknesses [include] expert biases, ... "benefit leakage", intelligence failures and delays, ... inappropriate organizational arrangements, insensitivity of decision makers to valid and appropriate criticism ... ' (Clark & Milloy, 2014, p. 21 in Chapter 9). Indeed, the majority of U.S.A. states assigned trust responsibilities to individuals selected for experience working within an interest group or affinity with consumptive users of wildlife (Gill, 1996; Horner, 2000; Clark & Milloy, 2014; Hare & Blossey, 2014). Agency capture will be facilitated if trustees are selected for their affinity to narrow interests. The government trustees responsible for allocation of benefits from wildlife are vulnerable to individual corruption or agency capture by financial inducement or political patronage. Scanlan (2000) described the many forms of trustee abdication associated with agency capture that led to degradation of trust assets,

> '... the regulators entrusted with the duty to implement the [water trust] are restricted from acting to the full extent allowed by the court... [by] inability to deny permits, a perceived dependence on local district attorneys to prosecute violations, understaffing, and pressure from supervisors and politicians to... degrade trust resources' (Scanlan, 2000, p. 139).

Appointing trust managers or trustee agencies with affinity to special interests clashes with recommendations for selecting fiduciary or charitable trustees based on independence, integrity, expertise with trusts or beneficiaries, comprehensive knowledge of uses, and accountability to challenges by beneficiaries (e.g. U.S. Uniform Code of Trusts http://uniformlaws.org/ActSummary.aspx?title=Trust%20 Code, accessed September 2014). The general standard of care holds trustees to 'manifest the care, skill, prudence and diligence of an ordinary prudent man engaged in similar business affairs' (Bogert & Bogert, 1993, p. 167). An ordinary and prudent man is determined by an objective standard (Scott, 1999, p. 143), which favours preservation of the trust principal over expenditures, so must refrain from maximizing disbursements of benefits in favour of optimizing preservation of future benefits (Scott, 1999; Sagarin & Turnipseed, 2012, p. 145). Besides a duty prudently to apply that expertise, a trustee also has a duty to solicit sound advice, and keep good records of the assets (Scott, 1999, p. 144).

As a result of the disparity between recommendations about public trustees and current practices in hiring and appointing wildlife trustees, North American wildlife agencies are facing criticism from those that do not align with hunting, trapping, and angling interests (Clark & Milloy, 2014). The same may hold for the E.U., whose Commission recently endorsed management guidelines from the Large Carnivore Initiative for Europe (Linnell, Salvatori & Boitani, 2008) as best-management practices despite the guidelines including an unsubstantiated claim that hunting is permitted for species listed under Annex IV of the Habitats Directive (1992) see also Michanek (2012). In the U.S.A., accusations of agency capture have focused on the North American Model (NAM) which arose in the 1990s (Geist, Mahoney & Organ, 2001) as promoting hunting, trapping, and angling as the purpose of wildlife management. In 2010, a document on the NAM, published by four professional societies allied to governmental fish and wildlife agencies, identified the 'Democracy of hunting' as one of seven principles of the NAM and commensurate with the PTD (NAM Technical Review, 2010). The principle of Democracy of hunting has been thoroughly examined by Clark & Milloy (2014) who concluded, 'The [principle] that we recommend be changed is the idea of the "democracy of hunting."... these are special interests.' (p. 366–367). Problems of agency capture are particularly important for predator conservation under the NAM, because '...at various times and places, the [NAM] has been used to justify extermination of large carnivores for purposes such as increasing populations of ungulate game species' (Clark & Milloy, 2014, p. 294–295, citing Robinson, 2005; see also Bruskotter *et al.*, 2013). Raising a special interest credo of 'Democracy of Hunting' to a level commensurate with the PTD (NAM Technical Review, 2010, p. 10 Synopsis) has perpetuated and reinforced an illegitimate view of the U.S.A. and Canadian wildlife trusts.

### (4) An illegitimate view of wildlife trusts

The writings of Sax (1970) and successive generations, many of whom were practicing lawyers or law professors (Horner, 2000; Wood, 2009, 2014*a*; Blumm & Guthrie, 2012; Hare & Blossey, 2014) have elaborated a legitimate 'broad public interest view' of the PTD supported by case law and other legal instruments. By contrast, the NAM has been advocated by professionals in fish and wildlife management (NAM Technical Review, 2010) and espouses seven principles including the 'Democracy of hunting' or 'Hunting opportunity for all', depending upon the specific articulation (NAM Technical Review, 2010). This 'pro-hunting view' canonizes regulated public hunting of wildlife as *the* purpose of wildlife management, and hunters as privileged beneficiaries of the trust in wildlife (Geist *et al.*, 2001; Clark & Milloy, 2014, pp. 366–367). The broad public interest view and this more recent pro-hunting view differ on the following three points that bear on our topic: (*i*) changes in societal values are comfortably accommodated in the PTD (broad public interest view) rather than threatening it (pro-hunting view); (*ii*) the benefits of wildlife are shared equitably by all members of current and future generations regardless of their awareness, uses, value systems, or fees they have paid (broad public interest view) *versus* an asymmetrical share with priority given to hunting, trapping, and angling (pro-hunting view); and (*iii*) wildlife differs from other environmental assets because some interest groups seek eradication, it responds to people's actions and policy interventions and *vice versa* (this review) *versus* wildlife differ because they pose liabilities (pro-hunting view).

The first point of difference (changing societal values) is illustrated well by the following,

> 'The underpinnings of the PTD and the future relevance and successful application of the [NAM] may be *at risk due to recent changes in society, government policies, and case law... Several significant threats have been identified that directly or indirectly erode or challenge the PTD* in North America... These threats undermine existing state, provincial, and federal laws, as well as governmental policies and programs. Moreover, they inhibit sound conservation practices for fish and wildlife resources...' (emphasis added, NAM Technical Review, 2010, p. 10).

Proponents of the pro-hunting view perceive threats to the entire institutional and legal framework of fish and wildlife management in North America. The authors name the perceived threats, '... inappropriately claiming ownership of wildlife as private property; unregulated commercial sale of live wildlife; *prohibitions on access to and use of wildlife; personal liability issues; and a value system oriented toward animal rights*' (emphasis added, NAM Technical Review, 2010, p. 10).

The synopsis of the pro-hunting view of the PTD quoted above identifies a value system (the animal rights movement) and a legally recognized concern (personal liability), and therefore the organizations espousing both, as existential threats to democratic institutions and the PTD itself. That identification is illegitimate. It not only demonizes legally recognized interests but pits government agencies against citizens who advocate for such interests and concerns. In this way, the pro-hunting view of the PTD attempts to turn government trustees and trust managers against a subset of legally recognized interests. By contrast, the broad public interest view of the PTD recognizes all legal interests and provides a guide to how to balance their claims on public trust assets (Hare & Blossey, 2014). The changes in society, policy, and law that the authors mistrust are not a concern for the legitimate broad public interest view of the PTD because its underpinnings (state and federal constitutions, laws, and common law) need no protection from democratic expressions of social change. If the pro-hunting view were simply an articulation of a special interest agenda, we would not devote text to this critique. But it is the statement of appointed trust managers who should even-handedly consider all legally recognized interests in wildlife (Scott 1999). If adopted legally, the pro-hunting view of the PTD and the NAM would prevent future citizens from recognizing animal rights or personal liability concerns. Although the NAM Technical Review (2010) reprinted Roosevelt's (1916) quotation as we did in Section II, the authors missed the significance of his eloquent articulation of intergenerational equity.

Furthermore, the NAM Technical Review (2010) warns about 'prohibitions on access to and use of wildlife' above, which at face value are required elements of the PTD (Illinois Central, 1892; see online Appendix S1). Prohibitions on access and take are encoded in federal and state laws and rules (e.g. restrictions on the timing, location, and method for hunting). The authors specify more clearly what they mean later, '... the public is having an increasingly difficult time gaining entry to hunt or trap on private property or reach tracts of public land' (p. 17, NAM Technical Review, 2010). Vucetich, Bruskotter & Nelson (2015) point out that



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support for wildlife conservation does not depend on hunting and trapping access. Therefore the NAM Technical Review (2010) epitomizes agency capture by narrow special interests.

Although some of the pro-hunting authors of the NAM Technical Review (2010) recently struck a more inclusive note (Decker *et al.*, 2013; Organ *et al.*, 2014), the later authors also exposed a further difference relating to the public interest in preserving wildlife in the face of private interests. The broad public interest view sees wildlife damages, whether to private property or public interests, as inevitable consequences of the public interest in preserving wildlife assets (Bruskotter *et al.*, 2011, 2012). Damage by wildlife is therefore similar to preserving rivers as assets that occasionally flood private property and restoring natural fire regimes that occasionally burn private property. Nevertheless all native wildlife, as with all rivers, provides benefits to some citizens and unpredictable benefits to future generations. The pro-hunting view sees some wildlife as liabilities,

> '...some species have rebounded from scarcity to become *socially overabundant* in particular contexts. While it may not be possible to have a financial trust with 'too much money,' it is possible to have too many individuals of a wildlife trust species within certain contexts, such as those wherein the wildlife have extensive negative impacts on ecosystems and humans. This can result in their status ***becoming a liability rather than an asset. Controlling the negative impacts*** of overabundant populations...' (emphasis added, Organ *et al.*, 2014, p. 412).

A liability is a debt, pecuniary obligation, responsibility, answerable by law or equity (Oxford English Dictionary, 2013). Reframing a public trust asset as a liability is neither useful nor consistent with the broad public interest view of the PTD that environmental assets are benefits. Although democratic societies can self-determine the optimal level of an environmental asset, the mandate for intergenerational equity sets priority on preservation over any private interest that currently holds a wildlife population as 'socially overabundant'. The challenge as the above authors correctly note arises when a democratic society determines that an environmental asset is harming the public interest because of its over-abundance. The State of Louisiana struck a balanced note in American Waste and Pollution Control (1993) (see online Appendix S1) when the Appeals Court held that trustees might diminish the principal of a public trust asset after diligent, fair, careful, transparent measurement of all costs and benefits to the public interest. We are not aware of any trust managers that have undertaken such diligent accounting before reducing predator populations and some state trustees have clearly not respected such principles (e.g. see online Appendix S2).

The terms liability and socially overabundant may foster intolerance, particularly for predators. If left unchecked, intolerance can lead to impairment of the asset by poaching and also lethal management (Sections IV and V). The broad public interest view acknowledges that the public interest in environmental assets can infringe on other public interests and on private interests (see Section VI and online Appendix S1). That is not new to wildlife. Water trust assets frequently impose costs on riparian landowners (Scanlan, 2000). The costs are imposed by the public interest in preserving the asset (navigable waterways) not imposed by the asset itself (water). Riparian owners are not entitled to block waterways (i.e. impair the public interest) because they perceive waterways in a negative light, e.g. as over-abundant. Likewise a private interest should not destroy wildlife because it perceives a cost. Sometimes private interests may merit compensation for wildlife 'takings' (Doremus, 1999); wildlife damage has been adjudicated using takings law (Thompson, 1997). Nevertheless, the public interests are inalienable so private rights do not include destruction of the asset, as established in Illinois Central (1892) (see online Appendix S1). Therefore liability is not a concept in the PTD, and it has limited application in wildlife takings case law (Thompson, 1997). The differences between wildlife and other environmental assets do not lie in their threats to private interests. Instead the difference lies in how wild animals and people respond to each other and how some narrow interests promote eradication of controversial wildlife.

Wild animals and people typically respond with aversion (if harmed) and attraction (if helped). Few, if any, other environmental assets respond to policy or human behaviour, which changes the compatibility of various uses (Section VI). The problem with framing wildlife as liabilities is illustrated by the authors' leap of logic to advocating 'controlling negative impacts of overabundant populations' (Organ *et al.*, 2014, p. 412). In traditional wildlife contexts in English-speaking countries, control means killing (Boumez, 1989; Allen & Sparkes, 2001; Berger, 2006), especially when joined to the phrase 'overabundant populations'. Even if that phrase was meant to include non-lethal methods, a mindset of controlling wildlife skips the rational chain of cause and effect that would lead a trustee to ask if complaints relate to real or perceived costs, and if real, whether the property was adequately protected from a public asset, the wildlife. A mindset that all wildlife are assets held in trust for current or future generations leads one down a more prudent route of examining alternatives to depleting the asset. In sum, the pro-hunting view in 2014 still prioritized lethal uses of wildlife and remains out of line with public trust thinking until it disavows its narrow preference for lethal management and consumptive uses. We conclude the pro-hunting view of the PTD and its over-arching NAM has failed to guide trust managers (e.g. wildlife agencies; Smith, 2011) in adopting a broad public interest view of the PTD.

The vagaries of majority values in particular jurisdictions, legislative processes, case laws, and administrative agency rules create legitimate mosaics of wildlife trusts. Murkiness arises from narrow interests capturing governmental allocations and even the trust managers. These mosaics and murkiness are not unique to the U.S.A. (see fig. 1 in Sagarin & Turnipseed, 2012). E.U. Member States are trustees of European environmental protections and their interpretations of that trust responsibility may vary (López-Bao *et al.*, 2015; see online Appendix S1). Member States' interpretations of their own trustee responsibilities



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toward predators protected by E.U. law are being adjudicated as we write (Epstein, 2013; Epstein & Darpö, 2013; Chapron, 2014). The full contours of wildlife trusts are rarely clear within a country and neighbouring countries often have very different obligations for wildlife (Blumm & Guthrie, 2012). Geographically variable interpretations and enforcements of the PTD may have advantages and disadvantages for wildlife populations. Mosaics varying in environmental protection can potentially provide refuges for imperilled species, or act as sinks, if one jurisdiction's policies are more or less protective than those of its neighbours. Thus trustee failure may not be irrevocable for a subpopulation of wildlife. A drawback may be that a mosaic of interpretations can hamper collective action if different jurisdictions cannot align policies or transboundary activities Historically many predator subpopulations were driven extinct in many regions but persisted in a few. They have only recently begun to recolonize. That volatile history of predator conservation and the legal and policy instruments that now exist are well illuminated by the case of the gray wolf.

## III. THE VOLATILE HISTORY OF U.S.A. PREDATOR POLICY WITH A FOCUS ON GRAY WOLVES

Despite explicit trust obligations for wildlife articulated by the U.S.A. Supreme Court in Geer (1896) and other cases (see online Appendix S1), both state governments and the federal government continued to enact policies that jeopardized entire populations of various species during the past century (Wilcove *et al.*, 1998; Estes *et al.*, 2011). Globally, extirpations of predators resulted from the destruction and modification of habitat, direct competition with people over space and resources, commercial extraction, culturally perpetuated antagonisms, or political scape-goating, all of which might have been abetted by governmental neglect (Knight, 2000; Pereira, Navarro & Martins, 2012; Chapron & Lopez-Bao, 2014; Ripple *et al.*, 2014; Treves & Bruskotter, 2014). Numerous populations of predators including felids, ursids, and canids were extirpated across the U.S.A. and Europe in the mid-20th century (Woodroffe, 2000; Chapron *et al.*, 2014). For example, two U.S.A. federal agencies eradicated gray wolves in National Parks and National Forests (Bangs & Fritts, 1996; Smith, Peterson & Houston, 2003), and many states used bounties to eradicate cougars or wolves (Thiel, 1993; Riley, Nesslage & Maurer, 2004). Indeed, bounties on coyotes are still in use (Bartel & Brunson, 2003).

Nevertheless, predator recoveries began in the 1970s in the U.S.A. and the 1980s in Europe. Two legal instruments are largely credited with these recoveries; the U.S.A. ESA of 1973 (Plater, 2004) and the international Bern Convention of 1979 followed by the Habitats Directive of the European Union (Epstein, 2013), which protect most large carnivore populations (Habitats Directive, 1992, Annexes II, IV, and V). The Habitats Directive (1992) requires that Member States contribute to reach and maintain a favourable conservation status for all listed species, and in particular constrains governments from permitting local disturbance or disappearance of species listed in Annexes II and IV (European Commission, 2006; Michanek, 2012; Epstein & Darpö, 2013). Similarly, the ESA prohibits the 'take' (e.g. killing, harm, capture, pursuit) of listed species, which includes transforming habitat determined to be 'critical', thus providing at least temporary federal authority over state wildlife species listed under the law (Freyfogle & Goble, 2009). Many populations of predators (e.g. gray wolves, grizzlies in the conterminous U.S.A. states) were listed shortly after the ESA's passage, and 40 years later, several U.S.A. states and local jurisdictions are preparing for, or have recently regained, management authority (delisting) for their predator subpopulations. The process of listing and delisting has not been smooth.

When determining the listing status of a species, the U.S.A. Fish and Wildlife Service (USFWS) must examine five 'threat factors' defined by the ESA (16 USC § 1533(a)(1)). A species can be removed from ESA protection (or 'delisted') when the threats that led a species to be listed are sufficiently mitigated that the species no longer meets the definition of either a 'threatened' or 'endangered' species (Vucetich, Nelson & Phillips, 2006). Yet delisting is not the end of USFWS authority under the ESA. The ESA requires the USFWS to monitor a delisted species for a minimum of 5 years (16 USC § 1531 Sec. 4(g); USFWS, 2006). Among U.S.A. predators listed under the ESA, only subpopulations of the gray wolf have been delisted due to recovery, although these actions have been controversial and federal courts recently reversed two such determinations. At least seven federal court cases involved wolves in the last 12 years (http://ecos.fws.gov/tess_public/pub/delistingReport.jsp). To understand the implications for predator conservation under the U.S.A. PTD, we examine the history of wolf policy in greater detail.

Wolves in the conterminous 48 states declined to a few hundred animals in a small portion of northeastern Minnesota and on tiny Isle Royale, Michigan by the 1960s (Mech, 1995). Non-conterminous Alaska retained a population estimated in the thousands across a wide area, but controversies over wolf policy surfaced there as well (Fitzgerald, 2009). The USFWS took authority for all non-Alaskan gray wolves in 1978 and soon after for the Mexican subspecies *C. l. baileyi* and the red wolf *C. rufus*, and began work on plans to recover all three predators. Recovery efforts took different approaches in different regions of the U.S.A. Gray wolves were reintroduced to Yellowstone National Park and parts of central Idaho during the mid-1990s, and considered for reintroduction elsewhere (Bangs & Fritts, 1996). In the western Great Lakes states, wolf recovery efforts involved protecting naturally recolonizing wolf populations from excessive mortality (Wydeven, Van Deelen & Heske, 2009*a*). Efforts to recover the Mexican gray wolf and the red wolf also involved reintroductions; however, in both of these cases, the source animals for reintroductions were captive-bred for release (Bangs & Fritts, 1996; Parsons, 1998). Those efforts testify to the desperate straits of some predators and to the force of the enabling statute.



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By 2009, gray wolf subpopulations totalled several thousand animals in five states with tendrils beginning to extend and establish into states adjacent to recovery areas (Fig. 1B). Between 2005 and 2013, the USFWS proposed delisting two noncontiguous, regional populations of gray wolves and then the whole species (http://www.fws.gov/midwest/wolf/). Several commentators voiced the opinion that recovery was complete, based primarily on wolf population size (Wydeven, Van Deelen & Heske, 2009*b*; Mech, 2013), whereas other scientists disagreed in part or entirely; citing, for example, lack of geographic representation across the species' historic range and assertions that USFWS failed to use the best available science (Carroll *et al.*, 2010; Bruskotter *et al.*, 2013; Bergstrom, 2014; NCEAS, 2014). Citing these and other issues, federal courts have consistently ruled that alleged recovery of wolves was insufficient to satisfy the ESA requirements. A series of federal court decisions between 2005 and 2014 restored federal protections for wolves (http://www.fws.gov/home/wolfrecovery/). Federal courts did not agree with USFWS determinations that gray wolves had recovered sufficiently to delist; or in narrower challenges, did not agree that the USFWS could issue permits for states to kill wolves in hopes of preventing livestock attacks (Refsnider, 2009). In 2011, a Congressional budget rider side-stepped ESA protections and an ongoing federal lawsuit about gray wolves in the Northern Rocky Mountains (Treves & Bruskotter, 2011). A Congressional budget rider had previously been used to side-step ESA protections and permit timber sales in the habitat of the spotted owl (*Strix occidentalis* De Vesey 1860) (Plater, 2004). Because of years of political conflict over wolves and USFWS' inability to win in federal court, Treves & Bruskotter (2011) proposed three compromise scenarios that reduced legal take of wolves for at least 5 years, while balancing competing public interests and the resulting power struggle between states and federal governments. One scenario proposed down-listing wolves to 'threatened' status under the ESA, which allows more flexibility in state-initiated removal of wolves (16 USC § 1531 Sec. 4d permits) while preventing controversial public hunting seasons. Two years later, the USFWS proposed removing federal protections nationwide (USFWS, 2013) and then lost two more lawsuits addressing regional subpopulations (Defenders of Wildlife, 2014; Humane Society of the U.S. (HSUS), 2014).

### (1) The courts' perspectives

The two most recent U.S.A. federal court decisions comprehensively analysed the USFWS' delisting determinations for gray wolves in Wyoming and for the Western Great Lakes (WGL) region, respectively (Defenders of Wildlife, 2014; HSUS, 2014). In so doing, federal judges clarified important passages in the ESA and instructed the USFWS on future determinations. Their clarifications and instructions echoed principles of the public trust albeit implicitly. The echoes will reverberate for many other predators, if not other wildlife.

In the Wyoming case, the court held that, 'Wyoming's statutory and regulatory regime is legally inadequate under the ESA ... ' (Defenders of Wildlife, 2014, p. 206) because Wyoming's plan lacked protections for wolves throughout the vast majority of the state. Throughout state lands, wolves could be killed for any purpose. The plan also classified wolves as a game animal in areas adjacent to Yellowstone and Grand Teton National Parks. In the court's view, this policy threatened the capacity of Wyoming to meet minimum federal recovery goals (100 wolves in 10 packs). From the standpoint of public trust thinking, the Wyoming plan allowed the state to deplete the trust asset on state lands, impede recolonization from the federal source lands, and potentially diminish the sources by attracting wolves into hunting zones (*sensu* Loveridge *et al.*, 2007). It also contained an unenforceable promise to stop depleting. The judge spent 10 pages clarifying the significance of the ESA mandate that delisting proceed only if the USFWS finds, 'adequacy of existing regulatory mechanisms' (16 USC. § 1533(a)(1)(D)). The court held that '[USFWS] cannot rely solely on an unenforceable promise as a basis to delist a species ... ' (Defenders of Wildlife, 2014, p. 208), and agreed with a prior federal court that,

> 'Absent some method of enforcing compliance, protection of a species can never be assured. Voluntary actions, like those planned in the future, are necessarily speculative ... Therefore, voluntary or future conservation efforts by a state should be given no weight in the listing decision.' (Oregon Natural Resources Council, 1998, p. 1155)

The court's decision evoked three elements of Sax's (1970) vision. He called for judicial scrutiny of decisions to allocate trust assets. The first element was the federal one restoring authority for wolves to a government that had helped to extirpate them. The second was Wyoming's allocation to any person wishing to kill a wolf on State lands. The third element was the lack of sophisticated and transparent accounting within Wyoming's' proposed regulatory mechanisms accepted by USFWS. A few months later, another federal court ruling evoked public trust principles for wolves.

On 19 December 2014, a federal court overturned the USFWS' decision to delist wolves in the WGL (HSUS, 2014). The judge issued a detailed, 111-page decision that examined the Congressional record and the language of the ESA, prior USFWS policy, and prior court precedents. The court reminded the USFWS that delisting determinations must consider all of the range of the listed species and could not delist a species that remained threatened or endangered throughout 'all or a significant portion of its range' (HSUS, 2014, p. 78). The court required – as had a prior federal court – the USFWS to explain why territory that was part of a species' historical range but no longer occupied by that species, fell outside a significant portion of the species' range (Fig. 1B). The USFWS instead focused on the species' conservation status within its current range (HSUS, 2014). That court also criticized the USFWS for approving inadequate regulatory protections for wolves, singling out Minnesota. Nor had Wisconsin and Michigan escaped scientific criticisms of their regulatory mechanisms



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(Vucetich *et al.*, 2013; Treves *et al.*, 2014; see online Appendix S2). The judge ruled that the USFWS failed to explain why mortality factors did not combine or interact to create a clear threat to the species (HSUS, 2014). These concerns echo Sax's (1970) admonition to agencies on clear and sophisticated measurements of costs and benefits as well as the public trust principle that citizens of all states are trust beneficiaries. Clearly federal judges did not agree with the federal administrative agency making determinations about endangered species but were larger issues at stake?

The debate over wolves has raised serious questions about U.S.A. federal wildlife trust obligations. For one, the court rulings suggest state management of wildlife is subject to federal court review, despite wildlife trusts lodging initially in the states (see online Appendix S1). Furthermore, the historic range of wildlife was scrutinized by the court in HSUS (2014), which evokes the trust duties of governments far beyond current range. In 2015, 8 states contained wolves, leaving approximately 29 that once hosted wolves (Fig. 1B). U.S.A. citizens living outside the wolf range in 2015 had little or no opportunity to benefit from the asset not only because of the need to travel to a range state but also because lethal management appears to make wolves shy of people (Section VI). The number of states in which wolves might recolonize is partly a value judgment for society, and partly depends on the uncontrollable movements of wild wolves. But the ESA phrase 'a significant portion of range' would seem to be more than the current range of ~22% of all states in the historic range (Fig. 1B). Moreover citizens of historic range now depleted of wolves might ask whether their state abrogated its duty under the wildlife trust. Given the U.S.A. wildlife trust is a benefit for current and future citizens can citizens of one state challenge another state's wildlife management? Can citizens challenge their own state's failure to promote recovery of native wildlife? Tests of these and other unanswered questions may be forthcoming if wolves continue to be managed without public trust thinking.

### (2) Predator litigation will recur

The U.S.A. court rulings affirmed the importance of sophisticated, careful measurements of costs and benefits (e.g. mortality, range expansion, regulatory mechanisms) before allocating a public trust asset. Scientists and their advocates have been scrutinizing agency decisions, particularly for the ESA with its mandate for use of the best available science. Both courts emphasized the affirmative duty of enforceable protection measures and adequate regulations for delisted species. The decisions also confirmed the rights of citizens to challenge the trustees. Each effort by USFWS to relax wolf protections met legal resistance under the civil suit provision (16 USC § 1531 Sec. 11(g)), which allows any citizen to challenge the federal government's actions or inactions under the ESA. By 19 December 2014, the USFWS had won none of the civil suits on wolves. Federal court setbacks to the USFWS do not mean ESA protections will persist forever. The U.S.A. Congress in 2015 has again drafted bills to delist wolves by decree including immunity from judicial review as in 2011 (Treves & Bruskotter, 2011; The New York Times Editorial Board, 2015). More court challenges relating to predators should be expected.

We expect more legal challenges for several reasons. The first reason is that lethal management interests have captured many agencies and otherwise dominate the process for decision-making about wildlife in the U.S.A. (Section II; Clark & Milloy, 2014). Lacking a strong voice in the policy-making process 'pro-predator' interests turn to the courts. Also, the 'pro-wolf' plaintiffs' successes described above may inspire further efforts because numerous national interest groups have expressed concern over the sustainability of state policies on wolves and other predators (Grandy, 2008; Male & Li, 2010). State courts will also probably see wolf litigation. Minnesota and Wisconsin courts already ruled against plaintiffs in two pro-wolf lawsuits pertaining to public wolf-hunting seasons (Center for Biological Diversity, 2013; Wisconsin Federated Humane Societies, 2013). Both of these lawsuits addressed wolf hunting regulations. Neither invoked the PTD forcefully. That omission may reflect the uncertain contours of state trust responsibilities for wildlife (Section II).

If U.S.A. nationwide wolf delisting proceeds, at least 29 additional states would be affected because they contained the historic range of wolves (Fig. 1B). Of 22 states that use the words 'trust' or 'trustee' to describe management of wildlife (Blumm & Paulsen, 2013, Section IV.B), 5 host breeding wolves: Alaska, Michigan, Oregon, Washington, and Wyoming. Another 22 states use other PTD language (Blumm & Paulsen, 2013, Section IV.B) and 4 of those host breeding wolves: Idaho, Minnesota, Montana, and Wisconsin (Fig. 1A, B). If plaintiffs choose to file suits against states that eradicated their wolves to compel them to restore wolves, another 14 states might see lawsuits (Fig. 1A, B). Some states with few or no breeding wolves have already accepted responsibilities to preserve wolves. For example, the states of Illinois, Oregon, Washington, and California listed wolves recently. Predator litigation might echo Sax's (1970) concerns about 'ventures into the unknown' and challenge state plans for lethal management, because there is currently little scientific consensus about sustainable mortality of predators.

## IV. HUMAN-CAUSED MORTALITY IN PREDATOR POPULATIONS

Effective trustees must impose regulatory authority to prevent over-use of wild animals. Identifying unsustainable use or threats to populations is a traditional area of interest in conservation and wildlife management. Lately attention has focused keenly on human-caused mortality in predator populations. That interest reflects appreciation that human-caused mortality provoked or significantly contributed to past predator extinctions or species extinctions including the Falklands wolf (*Dusicyon australis* Kerr, 1792), sea mink (*Neovison macrodon* Prentis, 1903), giant fossa (*Cryptoprocta spelea* Grandidier, 1902), and Tasmanian thylacine (*Thylacinus cynocephalus* Harris, 1808)



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among other national subpopulations eradicated (IUCN Red List http://www.iucnredlist.org accessed 31 August 2015). Determining sustainable levels of human-caused mortality demands that managers understand the effects of vehicle collisions, poaching, legal take (government culling or permitted hunting), etc., together with variability in birth and mortality factors that affect census and effective (breeding) population size.

Models of sustainable mortality for several predator populations suggest total mortality rates higher than 15–30% would be unsustainable (Adams *et al.*, 2008; Chapron *et al.*, 2008; Vucetich, 2012). The models seem supported by empirical estimates showing that various population recoveries have been slowed or reversed by mortality rates of 19–37% or human-caused mortality of 14–32% (Woodroffe & Frank, 2005; Goodrich *et al.*, 2008; Creel & Rotella, 2010; Smith *et al.*, 2010; Liberg *et al.*, 2012; Vucetich, 2012; Artelle *et al.*, 2013). Therefore the addition of a few percentage points of human-cause mortality can drive a predator population decline. Prudent governments following public trust principles should avoid additional uses that deplete the principal of the trust asset, as we noted in Section II.

### (1) Lack of scientific consensus on sustainable, human-caused mortality

Setting sustainable quotas for hunting or fishing is fundamental to regulating exploitation. Yet a recent commentary on scientific understanding of population dynamics concluded that the field remains under-developed because non-linear dynamics, time-lags, and regime shifts are poorly understood (Oro, 2013). In part, typical management tactics, such as setting future quotas by past reported take (Logan & Sweanor, 2001) may augment the volatility of wildlife populations and lead to crashes (Fryxell *et al.*, 2010; Bischof *et al.*, 2012; Artelle *et al.*, 2013). Furthermore, predator populations are even less well understood than most hunted species (e.g. waterfowl or ungulates). Predators experience local mortality sinks and super-additive mortality due to breeding failure, infanticide, or social group dissolution (Swenson *et al.*, 1997; Loveridge *et al.*, 2007; Brainerd *et al.*, 2008; Andreasen *et al.*, 2012; Doak & Cutler, 2014). Sinks and super-additive mortality may deplete broader regions than the sites affected by predator-killing. As a result the science behind sustainable use of predators remains contentious and unsettled, even for gray wolves, one of the best-studied predators globally.

Recently concerns about jeopardizing two U.S.A. wolf populations arose because six states moved to reduce their wolf populations substantially by regulated hunting and other legal killing (Bergstrom *et al.*, 2009; Bruskotter *et al.*, 2013; Treves *et al.*, 2014). All but one of the states managed populations of <1000 animals and several states implemented relatively large quotas (20–34%) by global standards (Creel & Rotella, 2010). The latter authors triggered a scientific debate about sustainable mortality that remains unresolved. Examining the same population of wolves, three teams of scientists investigated the relationship between the observed rates of human-caused mortality and growth of wolf populations in the Northern Rocky Mountains (NRM) from 1999 to 2009 (Creel & Rotella, 2010; Gude *et al.*, 2012; Vucetich, 2012). In a federal review of one NRM state's wolf management plan, Vucetich (2012) evaluated and replicated the other two teams' analyses after correspondence with each. He found a 26% disparity in their estimates of sustainable levels of human-caused mortality and inconsistency of methods. Estimating human-caused mortality rates that a wolf population might sustain without declining, Creel & Rotella (2010) estimated <22%, whereas Gude *et al.* (2012) estimated <48%. The former was consistent with three prior reviews and estimates of 14–30% for a wider set of North American wolf populations (Fuller, Mech & Cochrane, 2003; Vucetich, 2012). Vucetich (2012) found that both teams' notations and calculations were different, non-standard, and did not account for error in the measurement of human-caused mortality. Vucetich (2012) predicted that isolated NRM wolves were more vulnerable than other populations surrounded by contiguous source populations, suggesting that prudent wolf-managers should aim for the lower values in the range of mortalities. He also found evidence to support a prior observation of accelerating declines in wolf populations (Adams *et al.*, 2008). For 37 North American wolf populations, declines were best described by a downward sloping curve (depensatory mortality); that implies accelerating declines for each increment in human-caused mortality, a pattern not well explained by current theory (Vucetich, 2012). The major component of human-caused mortality in many carnivore populations is poaching, which is also not well understood yet.

### (2) The nascent science of poaching

Poaching (illegal killing or capture of wildlife) is a major source of human-caused mortality in predator populations. Estimates of poaching as a percentage of all mortalities (relative risk) ranged from 24–75% across regions and predator species (Fuller *et al.*, 2003; Andren *et al.*, 2006; Chapron *et al.*, 2008). As a percentage of predator populations (hazard), poaching accounted for 6% of NRM wolves in and around a vast protected area (Smith *et al.*, 2010); 15% in Scandinavia's mixed-use landscape (Liberg *et al.*, 2012); 34% of Amur tigers *Panthera tigris* L. in four high-poaching years across a mixed-use landscape (Goodrich *et al.*, 2008); and 11–30% of wolverines *Gulo gulo* L. in mixed-use northern Scandinavia (Persson, Ericsson & Segerstrom, 2009). Therefore, poaching represents a major mortality factor for predators, which is often underestimated (Gavin, Solomon & Blank, 2010; Liberg *et al.*, 2012) (see online Appendix S2). Poaching is difficult to quantify accurately because poachers have strong incentives to conceal evidence. In the best scientific study available, two thirds of poaching of Scandinavian wolves remained undetected by direct observation (Liberg *et al.*, 2012).

Counterintuitively, a commonly proposed remedy for poaching is to legalize killing *via* regulated hunting or government-regulated culling (Mincher, 2002; Refsnider, 2009), despite the scientific uncertainties described above. At



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present, the only systematic study of the relationship between poaching rate and hunting rate showed no relationship among four subpopulations of European lynx (*Lynx lynx* L.; Andren *et al.*, 2006); the subpopulation with the highest hunting rate had the second highest poaching rate and the lowest hunting rate had the highest poaching rate. A meta-analysis of many more populations would be useful to help resolve this issue.

Under these conditions, prudent government trustees managing populations of predators that face high poaching should prioritize understanding and preventing poaching. Because illegal uses detract directly from all other legal uses, anti-poaching interventions seem high priority for every prudent predator trust manager. Public trust thinking suggests illegal uses should be counted directly against any other uses that deplete the resource. But the difficulty of accounting for illegal uses may lead trustees to turn a blind eye to illegal killing.

Hopeful fixes for poaching have been proposed, such as increasing government-sponsored culling or regulated harvest, Indeed, the USFWS asserted in federal court that permitting states to kill wolves perceived as problems would reduce poaching (Refsnider, 2009). That prediction was examined for wolf-culling in Wisconsin (Olson *et al.*, 2014). Although the authors concluded that more culling led to less poaching, their analysis did not account properly for within-year and between-year time series that affect observed poaching and culling patterns. Other scientists have proposed a more subtle benefit of legalizing predator-killing. Legalizing predator-killing might raise tolerance and inhibit poaching among those that benefit from predator-hunting (Ericsson & Heberlein, 2003; Heberlein, 2008; Refsnider, 2009). In 2007, when the USFWS proposed removing federal protections for grizzly bears, the agency claimed that hunting promoted '... tolerance for grizzly bear recovery' (USFWS, 2007, p. 14784), but acknowledged that, 'there is no scientific literature documenting that delisting would or could build ... tolerance for grizzly bears' (USFWS, 2007, p. 14902). Some evidence suggests that approval for poaching or intentions to poach increase when other forms of predator-killing are legalized (Treves & Bruskotter, 2014). Therefore public trust thinking would demand a clear understanding of poaching, intolerance, and proposed interventions for either.

## V. HUMAN ATTITUDES TO PREDATORS

A prudent trustee will want to understand how the beneficiaries perceive the asset lest they use it illegally or disdain the benefits. When the beneficiaries are legion, such understanding demands the most sophisticated and clear methods from social science. Decades of research since the 1970s show that majorities of residents within and without predator range care about predators and how they are managed (Kellert, 1985; Williams, Ericsson & Heberlein, 2002; Dressel, Sandström & Ericsson, 2014). The prevailing view of attitudes to predators is that society today accepts predators more than in most of the 20th century, and in part, changing attitudes allowed predator recolonization (e.g. Schanning, 2009). In this view, the environmental decades of the 1960s and 1970s in the U.S.A. and Europe reflected a sea change in individual attitudes to predators across broad regions and many sectors of society. The claim is reasonable and straightforward but discounts the pervasive, positive icons associated with predators in western and non-western cultures (Knight, 2000; David, 2009). The nearly complete lack of quantitative data on attitudes of the average citizen before 1970 has hampered scientific examination of the prevailing view (Kellert, 1985; Schanning, 2009). One alternative hypothesis is that powerful but narrow interest groups have long pushed for predator eradication, independent of individual attitudes in the broader public. Because legislation can both lead and follow public opinion, it seems plausible that the power elites that shaped predator policy in the past have changed recently and may do so again. To elucidate these competing hypotheses, we review research on attitudes to predators.

Most research on attitudes to predators has been conducted on gray wolves. An early meta-analysis of 37 data sets spanning 1972–2000 showed attitudes towards wolves correlated negatively with age, rural residence, and agricultural occupation; and positively with education, income, and living outside wolf range (Williams *et al.*, 2002; see for Europe more recently, Dressel *et al.*, 2014). People active near wolves expressed more negative attitudes than those more insulated by distance, livelihoods, or pro-wolf world-views (Naughton-Treves, Grossberg & Treves, 2003; Karlsson & Sjöström, 2007; Heberlein & Ericsson, 2008; Shelley, Treves & Naughton-Treves, 2011). Recent reviews confirmed that attitudes to wolves were more positive outside wolf range than inside it, both in the U.S.A. and in Europe (Bruskotter *et al.*, 2013; Dressel *et al.*, 2014). Furthermore, negative attitudes tended to increase with time within wolf range (Majic & Bath, 2010; Treves, Naughton-Treves & Shelley, 2013; Dressel *et al.*, 2014), although the causes of change are not clear because individual experience did not seem to predict longitudinal change in individual attitudes (Treves *et al.*, 2013). Negative messages – media emphasizing negative aspects of wolf recovery (Houston, Bruskotter & Fan, 2010) and political rhetoric (Bruskotter, 2013; Bruskotter *et al.*, 2013), largely unleavened by positive messaging – might have reduced tolerance for wolves among sympatric residents of wolf range (Treves & Bruskotter, 2014). Expansion of lethal management may also have diminished the perceived value of wolves (Treves *et al.*, 2013). Inaugural implementation of one season of permitted wolf-hunting in 2012 was associated with an average decrease in individual tolerance for wolves among male residents of Wisconsin's wolf range (Hogberg *et al.*, 2015). Likewise, an unpublished report on Montana residents' self-reported recollections of their own attitudes suggested a wolf-hunt did not change tolerance for wolves, although it did improve attitudes towards wolf managers (Lewis *et al.*, 2012). Yet attitudes are mainly relevant to



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trustees to the extent that attitudes shape beneficiaries' expectations about the balance of use and preservation.

Attitudes may ultimately manifest in a variety of individual behaviours that can directly and indirectly influence predators and conservation outcomes. Direct behaviours may include poaching or protective stewardship among others. Indirect behaviours may include communications and contributions for or against policies for predator conservation. Therefore attitudes to poaching, preservation, and legal uses are of particular interest.

The mechanisms that facilitate predator-poaching and the motives behind such behaviour have only recently been studied. The traditional view that poaching is driven by retaliation for livelihood losses is inconsistent with evidence that wealthier individuals are more involved in and intent on jaguar poaching (Marchini & Macdonald, 2012; see also Browne-Nuñez *et al.*, 2015, for wolves). Therefore, the causes of poaching reflect complex social patterns beyond simple retaliation for economic losses caused by predators and other wildlife. Individual fear, direct financial incentives, pathological behaviour, beliefs that predator-killing is beneficial for game conservation or property protection, or identity group norms and values that attach status or rewards to illegal behaviour, all may lead an individual with opportunity to poach into that action (Marchini & Macdonald, 2012; Kahler, Roloff & Gore, 2013; Sharmaa *et al.*, 2014; Browne-Nuñez *et al.*, 2015). Poaching may be encouraged by scapegoating, downgrading the value of predators, or beliefs that poaching is a common or acceptable behaviour unlikely to be punished (St. John *et al.*, 2012; Chapron & Lopez-Bao, 2014; Treves & Bruskotter, 2014). Poachers also sometimes justify their crimes by citing deficient knowledge of the rules, or corruption and other unfairness in systems of wildlife allocation (Gore, Ratsimbazafy & Lute, 2013). Consistent with empirical findings in other social psychological studies of sensitive behaviours, St. John *et al.* (2012) documented that respondents inclined to poach predators believed their behaviour and intentions were in the majority. If would-be poachers who only have intentions to behave illegally are encouraged to act by other illegal actions, then the result could be propagation of predator poaching through a social network. Social norms are often resistant to policy interventions because members of identity groups gain status by defying outgroups, which often include law enforcement (Kinzig *et al.*, 2013; Lute & Gore, 2014). These findings suggest that policy interventions designed to increase acceptance of predators should be evaluated scientifically and informed by recent social science (Dickman, Marchini & Manfredo, 2013; Treves & Bruskotter, 2014). If poaching is caused by this complex interplay of psychological and social factors, policy interventions that hope to reduce poaching will need to integrate more sophisticated measurements using a mix of quantitative and qualitative social scientific methods (Browne-Nuñez *et al.*, 2015). Because illegal uses of predators are poorly understood, remedies for poaching are on uncertain ground.

Practitioners and scientists commonly assume that intolerance for predators leads to retaliation because people perceive threats to human safety and livelihoods. Therefore, it is reasoned, reductions in predator populations can reduce perceived threats associated with the species and thereby improve acceptance. But hazard-acceptance theory predicts acceptance of risks such as predators is influenced by the benefits as well as the costs of the hazard; both cross-sectional and experimental tests support the theory for predators (Slagle *et al.*, 2013; Bruskotter & Wilson, 2014). Furthermore, indirect anti-poaching interventions such as financial incentives may have to reach potential poachers not just the individuals who express intolerance for predators; indirect interventions may have to be paired with a direct anti-poaching interventions in any case (Persson, Rauset & Chapron, 2015). Yet, the path to better understanding of poaching will be uphill if the alternative hypothesis we proposed above finds support. If intolerant interest groups exert their power by capturing agencies, media, and constitutive processes, then measuring the attitudes of the more-readily accessed public may not shed much light on actions that oppose predator preservation. Successful and prudent trust asset preservation under these conditions may demand that trustees be separated from the asset managers who are exposed to many pressures from those they regulate and with whom they interact. Full treatment of the separation of powers between trustees and trust managers is beyond our scope but that deep reflection has begun (Scott, 1999; Horner, 2000; Smith, 2011; Hare & Blossey, 2014). Even if predator managers grapple successfully with the scientific uncertainties and the political obstacles to preserving predator populations, independent trustees may still face genuine conceptual challenges in balancing alternative uses of predators.

## VI. BALANCING COMPETING USES OF PREDATORS WITH COMPLEX BEHAVIOURAL ECOLOGY

The public expresses a variety of legally recognized uses and interests in predators. People observe, feed, track, and discuss them, in addition to hunting, trapping, and retaliating for property losses. In principle, the PTD protects all legally recognized interests against infringement by any of the others. Therefore depletion of the asset requires scrutiny, following Illinois Central (1892) in the U.S.A. and other countries' constitutional provisions (Blumm & Guthrie, 2012; see online Appendix S1). The nature of any infringement between uses will necessarily be influenced by the behavioural ecology of predators and humans.

### (1) Lethal and non-lethal customary uses

Because most people are urban residents and that trend is continuing worldwide, the majority will probably never use predators by killing them (Treves & Martin, 2011;



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Bruskotter *et al.*, 2013). Even within an urbanizing world, diffuse uses of predators continue. For example, the Anishinaabe (Ojibwe) value the gray wolf above other animals http://www.ojibwe.org/home/about_anish.html (David, 2009; Shelley *et al.*, 2011). Diverse groups of people appreciate the wolf aesthetically in art or in wildlife-watching (Duffield, Neher & Patterson, 2008). For example, the Swedish Association of Ecotourism Industries complained in 2013 to the Swedish government that the decision to eliminate wolf packs in a licensed hunt would jeopardize the profitability of eco-tourism companies (see also Center for Biological Diversity, 2013; Collins, 2013). Organized non-consumptive users may perceive infringement by consumptive users such as predator-hunters although data on this infringement are sparse at present. Consumptive uses bear a special burden when one employs public trust thinking. Intergenerational equity demands that one prioritize preservation of the principal of the asset for future generations. Whether this goal is achieved by legally recognizing the intrinsic value of environmental assets (i.e. independent from current human uses) or by requiring trustees to advocate explicitly for future generations remains debated. Regardless, current generations should not decide how future citizens should preserve or use the assets. Setting aside this argument about intrinsic value and intergenerational equity, we turn to the adjudication of conflicts between current uses of predators.

Similar to how courts may play counter-majoritarian roles to protect minority interests, the government trustees that allocate wildlife resources should not be swayed unduly by the popularity of certain uses. The test for a trustee adjudicating between uses should rather be whether the trustee has recognized and successfully balanced the diverse public interests in predators, especially the diffuse uses (Sax, 1970).

Although hunters are a minority in the U.S., E.U., and likely most industrialized countries (Pergams & Zaradic, 2008; see also http://www.face.eu/about-us/members/across-europe/census-of-the-number-of-hunters-in-europe-september-2010 accessed April 2015), majorities in most regions support regulated hunting with variable bounds on its purposes, methods, locations, and sustainability (Reiter *et al.*, 1999; Treves & Martin, 2011). Nevertheless, neither the number participating, nor the popularity of a particular use, should dictate strongly how a trustee allocates wildlife to beneficiaries. Because future generations inherit the asset in perpetuity, without substantial impairment, the allocation to current users that deplete the asset is an incremental addition to 'impairment', which must always be less than 'substantial' (Illinois Central, 1892). In the following sections, we explain why diffuse uses would receive preferential treatment under the U.S.A. Supreme Court's interpretation of the PTD (see online Appendix S1).

Generally public trust thinking would view non-consumptive uses as more prudent uses of a trust asset because they rarely deplete the asset. Certainly some diffuse uses deplete the asset. For example, tourism can harm wildlife, although rarely to the point of mortality (e.g. Dunstone & O'Sullivan, 1996; Treves & Brandon, 2005). On the other hand, some diffuse uses of wildlife may enhance the asset by increasing others' access or enjoyment. For example, if feeding, creating refuges, restoring habitat, etc. were measurably enhancing the benefits for other users, the activity might be seen as highly preferred to taking wildlife or otherwise depleting the asset. Given the possibility of harming or depleting wildlife, trustees should look more cautiously at lethal uses than has been traditional under North American wildlife management (Section III). Trustees held to a fiduciary trust standard would likely suspend lethal uses until uncertainty and scientific controversy about sustainability are deemed minor (Section IV). However the PTD recognizes customary uses, which include hunting, so outright bans on predator-killing seem unlikely. Therefore balancing lethal and non-lethal uses of predators will remain important.

Balancing lethal and non-lethal uses is not straightforward. Advocates often claim a broad public interest in killing predators. Similar statutory claims exist. For example, the ESA allows proactive killing of wild animals before human injury occurs as an exception to prohibitions on take, when wild animals 'constitute a demonstrable but non-immediate threat to human safety' (http://www.fws.gov/policy/library/2002/02fr1494.html accessed 31 August 2015 citing 50 CFR1 § 17.31). The ESA also accommodates predator-killing as a conservation practice, '... predator control, protection of habitat and food supply, or other conservation practices ...' (16 USC § 1531 Sec. 4(b)). Indeed state and federal agencies have long cited the protection of listed species, as well as health and human safety reasons, to kill small numbers of listed predators, including entire wolf packs. However the most frequent and widespread reason governments give to kill predators is to protect wild game or domestic animals and other property (Doremus, 1999; Treves, 2009). There are three problems with this justification as a broad public interest.

First, protection of property is a private interest in most cases. U.S.A. federal courts have repeatedly rejected the notion that the government is responsible for takings that result from the actions of wild animals (Thompson, 1997). Reintroduced wild animals are more often subject to lethal intervention though (Doremus, 1999). Second, justifying killing predators to prevent property damage erects a false dichotomy, '... "Environment or healthy human economics. You cannot have both." This classic false dichotomy of an inexorable tradeoff is a powerful and seductive mind-framing which serves to undercut environmental regulation generally' (Plater, 2004, p. 303). A recent review of that question concluded, 'an increase in stringency of environmental policies does not harm productivity growth' (The Economist, 2015). Treves, Wallace & White (2009*b*) provided evidence for why there is always more than one intervention to resolve human–wildlife conflicts, one that addresses the outcomes of encounters between people and wildlife, and another that addresses how people perceive such encounters. Thus lethal



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management should be viewed as a candidate intervention, not the only option. Indeed, physical intervention directed at wildlife, should always be juxtaposed with other interventions that influence human perceptions or behaviour (Treves *et al.*, 2006). A prudent trustee should be aware of and weigh alternatives on their merits as well as their effect on preservation and other legal uses. Third, experts worldwide agree that non-selective killing of predators typically does not prevent property losses (Knowlton, Gese & Jaeger, 1999; Greentree *et al.*, 2000; Bartel & Brunson, 2003; Donnelly & Woodroffe, 2012; Vial & Donnelly, 2012; Krofel, Cerne & Jerina, 2011), except for the extreme of local eradication or extremely high mortality for long periods over large geographic areas, which is incompatible with public trust thinking. Even moderately selective killing has a poor record of preventing predator damages (Knowlton *et al.*, 1999; Greentree *et al.*, 2000; Peebles *et al.*, 2013; McManus *et al.*, 2015; Wielgus & Peebles, 2014; Krofel *et al.*, in press). The allegedly most effective techniques for eliminating confirmed culprit predators thus far documented include the following: shooting lions *Panthera leo* L. over a carcass within 24 h of a kill (Woodroffe & Frank, 2005) or acoustic mimicry of coyotes *Canis latrans* Say, 1823, followed by shooting those that arrive to investigate the caller (Sacks, Blejwas & Jaeger, 1999; Mitchell, Jaeger & Barrett, 2004). Neither has been subjected to experimental comparisons with non-lethal methods (reviewed in McManus *et al.*, 2015). The shortage of evidence for the effectiveness of killing predators to protect property or human safety should induce hesitancy among trustees to provide for this use. Under a fiduciary standard, trustees presented with evidence of inefficacy or counter-productive effects (Wielgus & Peebles, 2014) might prohibit the practice as a precaution. Finally, killing predators to protect private property is an unlikely public interest, but falls under the more general legal issue of 'takings' that often regulates conflicts between public interests and private title (Section II). If one cannot demonstrate a broad public interest in killing predators, then predator-killing becomes a competing, private use without priority.

Adopting public trust thinking sheds a different light on permit fees and payments for private uses of public assets. In the U.S.A., those seeking a pragmatic remedy to the status quo of preferential treatment of hunters in allocation of wildlife assets have argued that non-consumptive users should pay equivalent taxes and fees for bird feeders, binoculars, tripods, etc. as hunters pay for ammunition, permits, etc. Public trust thinking would suggest that taxes and fees are levied for uses that deplete the asset or infringe on other protected public interests. Uses that do not deplete or even enhance the asset should be encouraged not taxed, in this view. Legally recognized private uses must be balanced with other legal uses. However, predator behavioural ecology complicates the search for balance between depleting and non-depleting uses.

### (2) Predators as atypical game species

First and foremost, predators occur at lower densities than virtually all other game species such as white-tailed deer *Odocoileus virginianus* Zimmerman 1780, elk *Cervus elaphus* L., and moose *Alces americanus* Clinton 1882 in North America. For example, estimates for Algonquin Park and North Central Minnesota spanned the range of wolf densities relative to ungulate prey at 97 and 617 ungulates per wolf, respectively (Fuller *et al.*, 2003). Sparseness by itself argues against widespread killing of many predators if one wishes to protect other uses.

Second, sparseness of predators is partly maintained by territoriality within and among species. Predators defend territories more aggressively than most animals (Palomares & Caro, 1989; Wrangham, Gittleman & Chapman, 1993). For example wolves kill interloping dogs (Olson *et al.*, 2015), coyotes (Arjo & Pletscher, 1999; Switalski, 2003), and conspecifics (Smith *et al.*, 2010). Many predators defend year-round territories to exclude competitors and neighbours from vast areas (Gittleman, 1989). When gregarious predators defend territories cooperatively, the size of the cooperating group influences success in territorial defence (Packer *et al.*, 1988; McComb, Packer & Pusey, 1994). Therefore human uses that deplete individuals essential to cooperative defence may lead to the collapse of territorial defences (Whitman *et al.*, 2004; Brainerd *et al.*, 2008; Borg *et al.*, 2014). If neighbouring territorial residents take over vacated territories without permitting new immigrants to do so, the local density may diminish for some time. For example, established packs of wolves occasionally took over neighbouring territories that were vacated after human-caused depletions (Bradley *et al.*, 2008; Brainerd *et al.*, 2008). Depleted territories near to protected source populations refill more quickly than isolated territories (Adams *et al.*, 2008). As a result of strict defence of territories and background sparseness, local predator densities may increase only slightly when populations grow (Fuller *et al.*, 2003; Cubaynes *et al.*, 2014; Kittle *et al.*, 2015). In sum, for many predator populations, depleting a group of predators may not result in rapid replenishment for other users (lethal or not).

Third, and unlike typical game species, deaths of essential members (e.g. breeders) in cooperative groups of predators can destabilize social structures for long periods. For example, many wolf packs that lost a breeding adult disbanded and others did not reproduce for one or more years afterwards; rates of disbanding and reproductive failure increased when both breeders died (Brainerd *et al.*, 2008; Borg *et al.*, 2014). Removal of resident African lions often resulted in infanticide, injuries to lionesses, and long-lasting instability of prides (Packer *et al.*, 1988; Whitman *et al.*, 2004). Infanticide has been detected in solitary predators as well. For solitary species, the effects of infanticide and other social instability on population dynamics of small or hunted populations remain uncertain and controversial (Swenson *et al.*, 1997; Logan & Sweanor, 2001; Packer *et al.*, 2010; Peebles *et al.*, 2013). Social disruptions and reproductive failure would presumably rise in frequency as lethal uses intensify.

Fourth, predator behaviour and spatial ecology may also challenge zoning schemes commonly used by managers to separate different uses. Long-range movements can make



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hunting zones a drain on adjacent non-hunting zones for many predators (Woodroffe & Ginsberg, 1998; Loveridge *et al.*, 2007). Predators may make long-lasting, long-distance, extra-territorial forays, often followed by returns to their source ranges. For example, ~25% of radio-collared Wisconsin wolves made long-range, extra-territorial movements lasting 1 month or more (Treves *et al.*, 2009*a*) and 25% of such movements were detected at least once out-of-state. Also predator populations experiencing high levels of human-caused mortality travelled or bred further from settlements and roads (Mladenoff *et al.*, 2009; Theuerkauf, 2009; Ordiz, Bischof & Swenson, 2013). Researchers on foot using telemetry had difficulty seeing radio-collared wolves or brown bears in areas of human use or past persecution (Theuerkauf *et al.*, 2003; Karlsson, Eriksson & Liberg, 2007; Zedrosser *et al.*, 2011). Therefore, people may not be able to use predators for feeding, viewing, or stalking, if those predators are fearful of humans.

In sum, uses of predators that deplete the asset have the potential to reduce the success of later users over large areas for years. Although the quality and quantity of predator population depletion by human use is still genuinely debated, the conclusion that lethal use needs prudent and precautionary management has been made repeatedly for many predators (Whitman *et al.*, 2004; Balme *et al.*, 2010; Artelle *et al.*, 2013). Yet concerns have lately risen that government agencies are failing to apply the precautionary principle and prudent interventions (Bruskotter *et al.*, 2013; Chapron *et al.*, 2013; Vucetich *et al.*, 2013; Artelle *et al.*, 2014). We end this review with recommendations for prudent trustees to adopt precautionary management that prioritizes preservation of predators as trust assets.

## VII. CONCLUSIONS

(1) Traditional wildlife conservation in the U.S.A. and western Europe, and particularly predator conservation, has been dominated by a constitutive process that favoured hunting and other forms of lethal management. Those traditions often led to abdication of governmental trust duties and eradication of predators over vast areas, contrary to public trust principles. However recolonization by several species of predators since the 1970s suggests that stronger public trust doctrines can prevent renewed cycles of eradication.

(2) In Section II and Appendix S1, we described the modern codification and vision of the environmental public trust. We distinguished and rejected a variant that expressed preference for narrow, lethal uses of wildlife. Public trust thinking demands disinterested trustees that take a broad public interest approach to allocating environmental assets to current and future generations, while keeping up to date with evolving legal and societal recognition of new and customary uses and accounting transparently and scientifically for the assets and their uses. A logical but idealized form of the public trust that holds governments to a fiduciary standard for environmental assets would demand stronger preservation by non-extractive use predominantly, 'prudent man' standards for allocations, and the strictest accounting standards involving the best available science. Improving trustee effectiveness will require equitable partnerships between trustees and scientists who are as insulated as possible from political and financial incentives for undemocratic allocations. Those partnerships must avoid the political misuse of scientific evidence and eliminate the current conflicts of interest inherent to agency capture by narrow interests. Governance reforms that address constitutive rules are needed in the U.S.A. and beyond to enforce the broad public interest in the environment.

(3) In Section III, we reviewed variable expressions of PTDs across jurisdictions and the abdication of trust duties for many predators in many U.S.A. states. We examined recent legal decisions that incorporated public trust principles for wolf preservation. In the U.S.A., we identified uncertain, legal application of the PTD and power struggles between the federal and state governments that together make a fiduciary trust for wildlife unlikely in the near future.

(4) In Sections IV–VI, we reviewed the essential role of scientific evidence from multiple disciplines in assisting a public trustee to account for predators transparently and quantitatively. We refined the oft-repeated call for interdisciplinarity in conservation sciences by explaining how scientific uncertainty often revolves around understanding and balancing legal and illegal uses by humans. That balance will require a sophisticated understanding of human cognition and action, wildlife behavioural ecology, and the sustainability of human uses that deplete the assets, as well as multiple criteria for evaluating the effectiveness of policy interventions.

(5) In Section IV, we reviewed genuine conceptual uncertainty about the sustainability of human-caused mortality. In Sections IV and V, we reviewed poaching research and the consequences of policy interventions for people's attitudes to predators and behaviour toward predators. In Section VI, we reviewed several aspects of behavioural ecology among sympatric humans and predators, which can complicate the trustees' tasks of balancing competing uses. To avoid tyrannies of the minorities or majorities who may demand depletion of unpopular, native wildlife, we recommend that trustees use the most prudent principles of scientific evaluation, precaution, and intergenerational equity to balance competing uses. We explain how lethal uses of predators need immediate scientific scrutiny to justify their proposed contribution to the public interest.

(6) We recommend public trust principles be applied to the appointment of trustees, separation of powers between trust managers (wildlife agencies) and trustee decision-makers, and judicial oversight and intervention when executive or legislative branches abdicate their trust obligations. Judges should not hesitate to review agency



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decisions if given evidence of mismanagement, unscientific accounting, or undemocratic decisions. The judiciary should not hesitate to examine scientific facts, using independent scientists it selects itself rather than the litigants' experts. Deference to agencies risks capture of the judiciary by narrow interests. Delegates of the government should adhere to the same legal standards of trust duties as the government. Universities with enforceable academic freedom will be essential in the face of political pressures to submerge or distort scientific findings. Without such reforms, public trust in science may dwindle and the credibility of scientific evidence in policy debates and legal proceedings may erode further. Regardless we expect predator policy will remain controversial and continue to test public trust in government.

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## X. SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article.

**Appendix S1.** PTD case law, wildlife trusts and a glossary of PTD terms.

**Appendix S2.** Allocating predators without regard to the public trust.

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