FINAL
SUMMARY REPORT

Peer Review of
Technical Guidance on Selecting Species for Landscape Scale Conservation

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REGION 6 OFFICE
US FISH AND WILDLIFE SERVICE

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Prepared for:

U.S. Fish & Wildlife Service
Headquarters

4401 North Fairfax Drive
Arlington, Virginia 22203

Prepared by:

AMEC Environment & Infrastructure, Inc.
1819 Denver West Drive
Suite 100
Golden, CO 80401

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Executive Summary

In 2012, the U.S. Fish & Wildlife Service (Service) committed to using Strategic Habitat Conservation (SHC) as an approach to address the challenges of the 21st century. As part of implementing that commitment, the Service distributed a version of the draft *Technical Guidance on Selecting Species for Design of Landscape Scale Conservation* (Technical Guidance) as a practical step in the biological planning component of the SHC approach. Five external peer reviewers have completed a formal, independent, external scientific peer review of the latest draft Technical Guidance. The panel was tasked specifically to review the scientific information in the Technical Guidance and its practical application to conservation management.

The external peer reviewers generally agreed that the Technical Guidance is missing key elements and does a poor job of providing scientific support for many of the statements made within it, although one reviewer was not as critical as the others. Generally, all reviewers recommended additional, more detailed discussion of the different types of surrogates (species and otherwise) and their uses, along with associated discussion of their advantages and disadvantages, evidence for success, and associated monitoring requirements. There was disagreement among the reviewers about whether or not climate change was well-integrated within the document. Every reviewer included specific recommendations and they were all generally along the same lines, although some reviewers recommended more significant revisions than other reviewers. The overall message from the external peer reviewers was that the document needs significant revision, including better organization, more focus, and better discussion and inclusion of the scientific literature.

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1.0 Background

In July 2012, the Director of the U.S. Fish & Wildlife Service (Service) sent a message to all employees discussing the Service's commitment to Strategic Habitat Conservation (SHC) as an approach to address the challenges of the 21st century. In concert with that message, the Service distributed a version of the draft *Technical Guidance on Selecting Species for Design of Landscape Scale Conservation* (Technical Guidance) as a practical step in the biological planning component of the SHC approach. All employees were encouraged to submit comments on the Technical Guidance and attend discussion sessions throughout each region. There was a significant response and additional information and suggestions improved the draft Technical Guidance. States, tribes, and non-government organizations were also provided the draft Technical Guidance and their comments and suggestions were considered in subsequent revisions. Comments were received through March 2013, followed by further revisions to the draft Technical Guidance by a team composed of state fish and wildlife agency and Service representatives.

Given the long-term conservation implications of the Technical Guidance, and its influential information, it required a formal, external, independent scientific peer review before implementation. If the Technical Guidance does not include the best science and analyses, any decisions or conservation actions based on this Technical Guidance may be less effective in the long-term conservation of fish, wildlife and plants at a landscape-scale.

The purpose of this review is to provide a formal, independent, external scientific peer review of the Service's draft Technical Guidance as part of the biological planning component of SHC.

2.0 Peer Reviewers

Peer reviewers were tasked to review the scientific information in the Technical Guidance and its practical application to conservation management. The peer reviewers reviewed the scientific integrity of the recommended guidance, the validity of the arguments made for its application, the interpretation of the science cited in the guidance in support of using surrogate species, and its ability to enhance the design and success of landscape-scale conservation. The review was limited to the information and analysis in the Technical Guidance only, and did not include a review of the SHC policy, but did consider the Technical Guidance's application within the framework of SHC. Additionally, the reviewers evaluated whether the surrogate species concepts described by the guidance document are supported by the scientific literature and are likely to provide the landscape-scale conservation objectives described.

The selection of peer reviewers followed the guidance provided in the Office of Management and Budget's *Final Information Quality Bulletin on Peer Review* (OMB Bulletin; December 16, 2004) to ensure scientific integrity of the peer review. Appropriate expertise and an appropriate balance of that expertise was identified for this peer review panel during the process of identifying potential reviewers. Panelists with expertise in large-scale conservation planning and landscape ecology were essential for this peer review. Additional expertise in zoology, botany, aquatic systems, community ecology, paleoecology and/or evolutionary biology was also appropriate. All peer reviewers were provided the language from the OMB Bulletin (2004) with regard to independence and conflicts of interest and any potential issues were identified and evaluated during the selection of the panelists, both with respect to both the Service and the report under peer review. To maintain the independence and objectivity of the peer review, a number was randomly assigned to each peer reviewer and all references in this report are to that number.

The five peer reviewers all have experience with large-scale conservation planning and/or landscape ecology and with peer reviews of scientific publications. The reviewers are all independent of the Service, have not taken an advocacy position with respect to this topic, and have no conflicts of interest. The resumes for the peer reviewers are presented in Appendix B and the reviewers consist of:

- Stephanie Januchowski-Hartley, PhD from University of Wisconsin at Madison;
- Joshua Lawler, PhD from University of Washington (Seattle);
- Dennis Murphy, PhD from University of Nevada at Reno;
- Maile Neel, PhD from University of Maryland; and
- James Thorne, PhD from University of California at Davis.

3.0 Summary of Peer Reviewer Responses

The peer reviewers considered and responded to the Charge to the Panel, a total of eight questions, provided by the Service. The following section summarizes their responses to each question, with their full responses provided in Appendix A. Table 1 below provides a summary of whether a reviewer provided a response to a question and the total pages provided by the reviewer.

Table 1: Summary of Reviewer Responses by Question

Peer Reviewer	Question								Included Line Comments[1]	Total Pages[2]
	1	2	3	4	5	6	7	8		
Reviewer 1	✓	✓	✓	✓	✓	✓	✓	✓	Yes	4
Reviewer 2	✓	✓	✓	✓	✓	✓	✓	✓	Yes	6
Reviewer 3	✓	✓	✓	✓	✓	✓	✓	✓	Yes	11
Reviewer 4	✓	✓	✓	✓	✓	✓	✓	✓	Yes	4
Reviewer 5	✓	✓	✓	✓	✓	✓	✓	✓	No	12

[1] Line specific comments provided by the reviewer and included in compiled 'Track Changes' version of the draft Technical Guidance as well as Line Comments spreadsheet (in Appendix A).
[2] Total pages of the reviewers' response, not including line-specific comments.

The summaries provided below are brief synopses of the complete responses provided in Appendix A. Much additional detail is provided in the individual responses provided in Appendix A. A compiled list of all references provided by the reviewers is provided under Question 7.

Question 1

Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?

- Reviewer 1: The concepts are clearly laid out but it is not clear if plants are included or not included in this document.

- Reviewer 2: While some elements of the Technical Guidance are clearly stated, there is room for improvement to streamline the content and clarify the scientific foundation of the Technical Guidance. 1) Throughout the document there is a need for more evidence-based support for many statements that are made about surrogates and surrogate species more specifically. 2) While the document provides definitions for particular terminology, there remain a variety of words that are not defined, or for which examples are not provided. 3) There are many sweeping statements without references.

- Reviewer 3: Unlike the SHC Handbook, the Technical Guidance returns to a species-centric approach. Although the assumption of using surrogate species as a means to implement SHC is clearly stated, the scientific support for it is not provided in the main document. Because the document never progressed beyond generalities, it is hard to evaluate the underlying science supporting surrogate species. The document is primarily focused on general considerations for landscape level planning writ large and then suggests surrogate species as the only approach for doing landscape planning. Surrogate species do not even come up until page 21 of 33 pages. The literature regarding surrogate species is not really reviewed until Appendix B.

- Reviewer 4: The bulk of the document does not deal with the scientific foundation for the use of surrogates. Perhaps the greatest shortcomings of the document are that it 1) does not stress enough that the use of surrogates will have uncertain results, and 2) although the document does stress that to determine whether or not surrogates are working, one will need to actually monitor more than just the surrogate species, it provides no guidance on how to do this. A more thorough discussion of the evidence for the effectiveness of the three different types of surrogates is needed.

- Reviewer 5: A lack of clarity and logic attends the draft guidelines from start to finish. A clear and concise statement of the explicit purpose(s) of the draft Technical Guidance in the preface and introduction is absent. The general rationale for the use of surrogates in conservation planning at larger spatial scales is made in the draft Technical Guidance with reason and logic. And, fair argument is made in the guidance document (and the foundational *Strategic Habitat Conservation* documents) that at larger landscape scales surrogates or proxies will inevitably need to be relied upon to inform management decisions and as management targets. The technical guidelines on surrogates are limited to a description and defense of that conceptual assertion. But, surrogates should only be used where they offer an indispensible service; where direct measures of programmatic targets cannot be made readily. The surrogate guidance should describe circumstances wherein surrogates are an appropriate default approach in conservation planning and assessment, and, importantly, where they are not. The roughly written rationale for the surrogate approach, which is selective in its assessment of materials that support the use of the approach, is at the same time vague about how the approach might be actually implemented and unclear how the approach can and should be supported by best available science.

Question 2

Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.

- Reviewer 1: For the most part, but the presentation of ecoregions is weak and two key papers are missing.

- Reviewer 2: Yes. In general scientifically sound conclusions are drawn based on the scientific information presented in the document. It does need to be emphasized in the document that while surrogate methods might continue to be used, and methods are continually being developed to better use surrogate species, there remains a general lack of evidence to support the underlying principle that focal species confer protection to co-occurring species facing similar threats.

- Reviewer 3: This is a somewhat difficult question to answer because rather than reaching a conclusion, the Technical Guidance starts from a premise that does not appear to be well supported based on the scientific literature.

- Reviewer 4: The bulk of the document does not present science and then draw conclusions from the scientific evidence. The bulk of the document (with the exception of Appendix B) provides a framework of sorts and steps that one would take to select surrogate species. Most of this framework and the steps laid out are reasonable given the science. The way that the surrogate approaches are presented, categorized, and described is confusing at best. The surrogate approaches are arguably the centerpiece of the guidance document but they are placed in an appendix. Three types of surrogate approaches are described, although they are really three uses for surrogates, not types of approaches. The bulk of the document really focuses on the use of surrogates as indicators of population condition of target species—however, three different surrogate approaches are discussed. The rest of the document needs to be broadened in scope OR it should focus on indicator species only and merely mention the other surrogate types in passing. The main text does not allude to any shortcomings of the surrogate approaches nor to the fact that there is more or less evidence for the successful use of the different surrogate types.

- Reviewer 5: Not dissimilar to the available literature, the Technical Guidance does not actually draw “scientific” conclusions from available “scientific” information. The standing literature on surrogates is better viewed as best professional judgment by conservation biologists organized to convey thoughtful considerations useful to management planners. There is technical information in the Technical Guidance, but not much in the way of direct findings drawn from studies informed by exercising the scientific method. An extensive literature on the use of surrogates (including indicators and a number of other applications of proxies to meet specific conservation goals) is reasonably represented in the cited literature, but the several studies that have actually attempted to put the surrogate approach to the test or critically addressed the need for surrogates to be subject to validation procedures are not cited. Each of those studies comes with warnings regarding implications of the inherent discordance in responses of surrogates and target species of conservation concern. The analytical studies of surrogates can be viewed as rather negative regarding the potential effectiveness of surrogates, especially species, in representing species diversity at larger landscape scales or biodiversity more generally. The more analytic treatments of the surrogate concept are consistent in their message – surrogate responses to environmental stressors are unlikely to reflect accurately those of the conservation target(s), the use of surrogates should be a default response when no opportunity exists for direct measure of the targeted species (or other desired resources or resource conditions), and if a surrogate is to be used in conservation planning, its potential effectiveness and efficacy in the intended application should be confirmed through a validation procedure. The most glaring absence in the Technical Guidance is a descriptive pathway that articulates clearly 1) the reasoning behind the selection of a surrogate, 2) linking demographic responses of surrogate species to the extent and condition of habitats or landscape areas of concern, and 3) describing the uncertainties that accompany the relationship between the status and trends of the surrogate and those of the conservation targets.

Question 3

Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?

- Reviewer 1: There should be an example of how a community or non-profit group might initiate these types of efforts. This is especially true if Landscape Conservation Cooperatives (LCCs) are expected to be part of or lead these efforts.

- Reviewer 2: While there were examples provided as to how surrogates have been used, there is not any clear line of evidence that indicates that surrogate approaches have been implemented and proven successful by monitoring or for delivering viable populations of all the species in any system. The Technical Guidance will be more helpful if there was a specific subsection under each presentation of existing Surrogate Species Approaches (as presented in Appendix B) that is titled "*Evidence"* or *"Evidence of Success*".

- Reviewer 3: No, there are not sufficient examples of how surrogates have been successfully used to monitor population-level responses. There is some evidence in the literature that broadly ranging surrogate species can be used to represent other species in the context of reserve selection. But there is no indication in the literature that population sizes, trajectories, or responses of one species will reflect another species. Table 1 is presented as providing an example of one surrogate approach, but there are many issues with this example that illustrate the problems with the lack of clarity and logic of the Technical Guidance in general.

- Reviewer 4: Appendix B does provide several examples of cases in which surrogates have been used. However, there is limited to no discussion of how successful these uses have been. The two hypothetical examples in Appendices C and D are a good attempt to demonstrate the process outlined in the document. However, because they are hypothetical, they are a little less useful than they would be if they were real case studies.

- Reviewer 5: No the Technical Guidance does not provide sufficient or informative examples. But, it might be argued that no examples actually exist.

Question 4

Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Guidance to help achieve better results?

- Reviewer 1: There is little evidence that the long-term monitoring required for adaptive management and/or use of surrogate species has or is actually occurring. Additional discussion of what the monitoring and associated timelines might look like is merited.

- Reviewer 2: I am unable to comment on this based on the Technical Guidance. The Technical Guidance does not provide the information necessary to determine if the use of surrogate species will provide meaningful indices of population-level response.

- Reviewer 3: As described in the appendices, the proposed application of surrogate species does not save time, effort, or funding and in the end will not provide meaningful indices of population responses. Using surrogate approaches is likely to make the resulting information on individual species less informative and straightforward and the approaches preclude a synthetic analysis of a landscape in a way that is more likely to represent conditions necessary to ensure the landscape is functional for all species. If surrogate species are going to be used, the means of monitoring needs to be improved if the results of the conservation efforts are going to have any hope of being meaningful. The cost and difficulty of demographic monitoring is underestimated or understated.

- Reviewer 4: The process described for selecting species is well-reasoned and defensible. The inclusion of climate change considerations is well done and appropriate. The main text needs to emphasize that surrogates don't always work. The main text needs to describe how to test to see if the surrogates being used are effective. In addition, the review of the performance of each type of surrogate was somewhat superficial. There should be enough literature to conduct a formal meta-analysis of the evidence for the utility of each of the different types of surrogates. A formal meta-analysis would be ideal, but even an informal, but thorough, survey of the literature would be worthwhile.

- Reviewer 5: If surrogate species as described in the Technical Guidance "provide meaningful indices," they will do so by coincidence. The guidance makes no attempt to engage demographic issues for species of conservation interest either as targets or surrogates.

Question 5

Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?

- Reviewer 1: Yes.

- Reviewer 2: Yes. It would be beneficial if this information was more central to the document, including methods used and evidence of success.

- Reviewer 3: The discussion of the likely pitfalls of surrogate species was fair to poor. Much of the core literature on surrogate species was cited. However, a number of important publications demonstrating limitations and inadequacies of surrogate approaches are conspicuously absent. Of particular importance in the context of population abundance and trajectories is the evidence that abundances across species are not representative or correlated. And although some literature regarding shortcomings of surrogate approaches is discussed, the knowledge of the inadequacies appears to have no bearing on the intent to proceed with using surrogates regardless.

- Reviewer 4: Although the document does discuss some of the shortcomings of the different approaches, these discussions are somewhat superficial. The document would benefit from a thorough review and summary of the literature on how successful tests of the different surrogate approaches have been. See response to Question 4.

- Reviewer 5: To be consistent with the scientific literature on surrogates, the draft Technical Guidance should be frank about the shortcomings of surrogate approaches and applications. The use of surrogates in landscape-level conservation is a default from direct measure, and not the first choice in management and monitoring. Overlaying multiple surrogates and surrogate measures, with attending uncertainties as to the ability of each to reflect the status and trajectories of desired ecosystem, community, and species phenomena, does not enhance landscape conservation.

Question 6

Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.

- Reviewer 1: For the most part, but six citations are missing from the text. Most importantly, some of the basis of this approach comes out of systematic conservation planning, which is not recognized. A few paragraphs to set some context will prove helpful as this guidance is used.

- Reviewer 2: Yes, the analyses and conclusions were based upon the best available science with regards to surrogate species. However, explicit discussion of the use of species groups (essentially coarse-filter surrogates) and their limitations in conservation planning when setting targets for the representation of species would be valuable.

- Reviewer 3: There are two ways in which the Technical Guidance does not incorporate the best available science. First, although the document is supposed to be about surrogate species, more than half the body of the text is about landscape level conservation planning in general. Second, given that a surrogate species approach has been chosen, the intent stated in the Draft Technical Guidance is to use population abundances and trajectories of one species to represent the species of conservation interest that is/are the indirect target(s). There is no scientific evidence to support use of surrogate species for this purpose. Based on the scientific literature, surrogate species at best can be used when there is spatial overlap in distributions and protecting habitat for one wide ranging species in a reserve network includes the distribution of other species.

- Reviewer 4: The literature that is cited is appropriate and many of the important papers on the topics in question have been cited.

- Reviewer 5: Despite citations of useful references, which include observations and findings that fairly might be described as included in the “best available science regarding to the use of surrogate species,” the guidelines stop short of explaining how that information is used in selecting and employing surrogates in support of conservation efforts. The Technical Guidance does not offer direction on how relevant information is used to decide whether a conservation policy or management action informed by a potential surrogate will adequately service the conservation needs of a target species, habitat, or geographic area – where best available science would actually be applied.

Question 7

Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.

- Reviewer 1: Six additional citations.
- Reviewer 2: Six additional citations.
- Reviewer 3: More than 23 additional citations.
- Reviewer 4: Overall the literature review was lacking. There are likely hundreds of papers that could be relevant to the discussion on the use and success of surrogates. Although I would not expect even half of them to be cited here, I would have expected a more thorough and systematic review of the literature. In particular, there are a few papers that have used analytical approaches to assess the characteristics of successful surrogates for locating conservation areas that could be cited. In addition, there was no mention of the many papers that explore the relative utility of non-species surrogates for selecting conservation areas. Two specific citations are included.
- Reviewer 5: Fifteen additional citations.

The following is a compiled list of more than 50 references provided by all reviewers. A few references were suggested by multiple reviewers.

Bachand, M., S. Pellerin, S.D. Cote, M. Moretti, M. De Caceres, P.M. Brousseau, C. Cloutier, C. Hebert, E. Cardinal, J.L. Martin, and M. Poulin. 2014. Species indicators of ecosystem recovery after reducing large herbivore density: Comparing taxa and testing species combinations. Ecological Indicators 38: 12-19.

Baguette, M., and V.M. Stevens. 2013. Predicting minimum area requirements of butterflies using life-history traits. Journal of Insect Conservation 17: 645-652.

Banks, J.E., A.S. Ackleh and J.D. Stark. 2010. The use of surrogate species in risk assessment: using life history data to safeguard against false negatives. Risk Analysis 30: 175-182.

Branton, M., and J.S. Richardson. 2011. Assessing the value of the umbrella-species concept for conservation planning with meta-analysis. Conservation Biology 25: 9-20.

Brooks, T.M., R.A. Mittermeier, G.A.B. da Fonseca, J. Gerlach, M. Hoffman, J.F. Lamoreux, C.G. Mittermeier, J.D. Pilgrim, and A.S.L. Rodriques. 2006. Global biodiversity conservation priorities. Science 313: 58-61.

Buchanan, R.A., J.R. Skalski, and A.E. Giorgi. 2010. Evaluating surrogacy of hatchery releases for the performance of wild yearling Chinook salmon from the Snake River Basin. North American Journal of Fisheries Management 30: 1258-1269.

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Che-Castaldo, J.P. and M.C. Neel. 2012. Testing surrogacy assumptions: Can threatened and endangered plants be grouped by biological similarity and abundances? *PLoS One* 7: e51659.

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Eglington, S.M., D.G. Noble, and R.J. Fuller. 2012. A meta-analysis of spatial relationships in species richness across taxa: Birds as indicators of wider biodiversity in temperate regions. Journal for Nature Conservation 20: 301-309.

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Fahrig, L., J. Baudry, L. Brotons, F.G. Burel, T.O. Crist, R.J. Fuller, C. Sirami, G.M. Siriwardena, and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters 14: 101-112.

Fattorini, S., R.L.H. Dennis, and L.M. Cook. 2011. Conserving organisms over large regions requires multi-taxa indicators: One taxon's diversity-vacant area is another taxon's diversity zone. Biological Conservation 144: 1690-1701.

Fleishman, E. and D.D. Murphy. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. Conservation Biology 23: 1109-1116.

Groves, C., D. Jensen, L. Valutis, K. Redford, M. Shaffer, J. Scott, J. Baumgartner, J. Higgins, M. Beck, and M. Anderson. 2002. Planning for biodiversity conservation: putting conservation science into practice. BioScience 52(6): 499-512.

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Hermoso, V., S.R. Januchowski-Hartley and R.L. Pressey. 2013. When the suit does not fit biodiversity: loose surrogates compromise the achievement of conservation goals. Biological Conservation 159: 197-205.

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Januchowski-Hartley, S.R., V. Hermoso, R.L. Pressey, S. Linke, J. Kool, R.G. Pearson, B.J. Pusey, and J. VanDerWal. 2011. Coarse-filter surrogates do not represent freshwater fish diversity at a regional scale in Queensland, Australia. Biological Conservation 144: 2499-2511

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11: 849-856.

Landres, P.B. 1992. Ecological indicators: panacea or liability? In: DH McKenzie, DE Hyatt, and VJ McDonald (eds) Ecological Indicators, Vol. 2. Elsevier Applied Science, London, pp. 1295-1318.

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Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature 405: 243-253.

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Reside, A.E., J. VanDerWal, B.L. Phillips, L.P. Shoo, D.F. Rosauer, B. Anderson, J. Welbergen, C. Moirtz, S. Ferrier, T. Harwood, K. Williams, B. Mackey, S. Hugh, and S. Williams. 2013. Climate change refugia for terrestrial biodiversity: Defining areas that promote species persistence and ecosystem resilience in the face of global climate change. National Climate Change Adaptation Research Facility. Available at http://www.nccarf.edu.au/publications/climate-change-refugia-terrestrial-biodiversity.

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Schindler, S., H. von Wehrden, K. Poirazidis, T. Wrbka, and V. Kati. 2013. Multiscale performance of landscape metrics as indicators of species richness of plants, insects and vertebrates. Ecological Indicators 31: 41-48.

Schwenk, W.S., and T.M. Donovan. 2011. A multispecies framework for landscape conservation planning. Conservation Biology 25: 1010-1021.

Thorne, J.H., D. Cameron, and J.F. Quinn. 2006. A conservation design for the central coast of California and the evaluation of mountain lion as an umbrella species. Natural Areas Journal 26: 137-148.

Tulloch, A., H.P. Possingham, and K. Wilson. 2011. Wise selection of an indicator for monitoring the success of management actions. Biological Conservation 144: 141-154.

Tulloch, A.I.T., I. Chades, and H.P. Possingham. 2013. Accounting for complementarity to maximize monitoring power for species management. Conservation Biology 27: 988-999.

Vera, P., M. Sasa, S.I. Encabo, E. Barba, E.J. Belda, and J.S. Monros. 2011. Land use and biodiversity congruences at local scale: applications to conservation strategies. Biodiversity and Conservation 20: 1287-1317.

Wenger, S.J. 2008. Use of surrogates to predict the stressor response of imperiled species. Conservation Biology 22: 1564-1571.

Wesner, J.S., and M.C. Belk. 2012. Habitat relationships among biodiversity indicators and co-occurring species in a freshwater fish community. Animal Conservation 15: 445-456.

Question 8

Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.

- Reviewer 1: The surrogate approach described here is similar to approaches described for focal species. There are a few new elements, but nothing divergent.

- Reviewer 2: Yes. One could use coarse-filter surrogates or processes, use of planning for refugia, and/or use methods based on modeling individual species. These are all points that were touched on in the document, but that were not given adequate discussion.

- Reviewer 3: To identify surrogate species, the Technical Guidance recommends that for each species the range and habitat extent is mapped, life history attributes are compiled, hypothesized limiting ecological factors are known, and threats are identified. If all that is done for each species, it is more straightforward and defensible to plan for each species simultaneously using standard decision support tools rather than to choose a subset of species and hope they represent the others. Using habitat and landscape characteristics as surrogate conservation targets provides another outstanding alternative to an umbrella species approach that is conspicuously absent from the Technical Guidance. It is not clear why surrogate species are being promoted to the exclusion of other scientifically supported landscape conservation approaches. An alternative approach that is much more transparent, straightforward, and defensible relative to the scientific literature is provided.

- Reviewer 4: One major alternative would be ecosystem-based management. Instead of using sets of species as surrogates for other species or for the condition of the ecosystems on which they depend, one could manage the ecosystems themselves. This alternative has some of the same pitfalls as the surrogate species approaches, but in some cases, it may be a more direct method of managing for species of concern than managing surrogates for those species. The most effective approach may be some combination of ecosystem-based management and the use of surrogate species for monitoring or management purposes.

- Reviewer 5: No other ready means of meeting the purposes outlined in SHC documents is available. However, in linking overarching programmatic descriptors to the prospective surrogates tool, the Technical Guidance does little beyond stating why the surrogate approach is heuristically satisfying, and what distributional, ecological, life history, and other characteristics that potentially affect the effectiveness of a surrogate in action.

Other Comments

- Reviewer 1: Track changes comments included in the draft Technical Guidance.

- Reviewer 2: One element of the document that I found difficult was the dual integration of using an Adaptive Management Framework and using surrogate species in conservation planning. A clear presentation of how the use of surrogate species fits within the Adaptive Management Framework would benefit the reader. Another element is the lack of clarity relating to the relationship of environmental surrogates and groups of species to the approach described in the document, particularly relative to single focal species. The boxes on climate change are strangely placed and a section dedicated to the potential implications of future change (including climate change) might be more helpful. Track changes comments included in the draft Technical Guidance.

- Reviewer 3: The Technical Guidance could benefit from increased clarity in many places. It is unclear what species are to be managed using surrogate approaches. No specific procedures or tools are identified. There are fundamental contradictions in different sections. It is not clear what range of spatial scales is anticipated. It would have been helpful for all literature to have been cited in one place in the document rather than separately in the main body and the appendices. There is a clear but implicit taxonomic bias towards birds and large mammals. Line number comments included.

- Reviewer 4: Line number comments included.

- Reviewer 5: This review is made challenging because the draft Technical Guidance does not in a recognizable sense of the word offer "guidelines." The basic conservation approach, to which the surrogate policy is to be applied, is reasonably well described in *Strategic Habitat Conservation* (SHC) documents, and is recapitulated in the draft Technical Guidance. The guidelines offer a persuasive argument for the need to use surrogate species and measures in planning and assessment at larger spatial scales, where diverse ecological communities exist and species of concern are many. But, when it comes to actually "selecting a surrogate approach and the surrogate species associated with that approach" the guidelines default to guidance akin to saying -- just do it. It is not clear why the expanded list of ten process steps for selecting surrogate species put forward in *Draft guidance on selecting species for design of landscape-scale conservation* (dated July 2012 – see pages 9-18, available at http://www.fws.gov/landscape-conservation/pdf/DraftTechnicalGuidanceJuly2012.pdf) – is not used. Even that expanded list falls short of articulating the necessary (obligatory) steps in the design of a conservation program expected to meet explicit programmatic goals and objectives – and needing to use surrogates to facilitate and enhance program effectiveness, efficacy, and accountability. The Technical Guidance should acknowledge that parsing a large, landscape scale conservation challenge into its operational elements is necessary before tools, like surrogates, which may be used in implementing and assessing a conservation plan, can be addressed.

4.0 Overall Summary for Each Reviewer

Reviewer 1

The Technical Guidance generally covers the material associated with surrogate species, with some missing elements and various areas that need additional clarification. A key missing element was an explicit discussion of integrating with regional (i.e., municipal, county, LCC) level efforts already underway for conservation planning or occurring somewhat independently of federal agencies. The biggest weakness is that there is limited evidence to show that either adaptive management or surrogate species approaches have the long-term monitoring follow through to be successful, which is not so much with the document with those management approaches. And associated with that is the lack of discussion in the Technical Guidance about how to successfully accomplish that necessary monitoring.

Reviewer 2

The Technical Guidance needs to be reorganized, in particular with Appendix B being included in the main document, and additional citations and are needed throughout to substantiate statements. Additional discussion is needed relating to evidence of successful use of surrogate approaches, as well as how to best use surrogate approaches. As with all the reviewers, a major concern is the lack of evidence of surrogates being used successfully, in particular using the focal species approach, which is the primary one discussed in the Technical Guidance. As with Reviewer 3, Reviewer 2 suggested that methods based on modeling individual species distributions are now common and provide frameworks like systematic conservation planning and spatial prioritizations to allow planners to use tools like Marxan and Zonation to guide their decisions based on the distributions of individual species rather than on groups of species or surrogates groups based on environmental classifications. Using these approaches allows planners to make decisions at landscape, regional and national scales that are cost-effective and that adequately represent all species of interest. Providing a clear adaptive management framework and how exactly the surrogate approach fits into that framework would greatly strengthen the Technical Guidance.

Reviewer 3

The Technical Guidance is intended to support the SHC program overall, but it does not do a good job of showing how it does that or even doing that in a way consistent with existing documents on the SHC program. The Technical Guidance does not provide any context for how or why surrogates fit into SHC as a whole. There is little scientific support for many of the statements in the document and the document is often unclear, vague, or contradictory. There is also a lack of detail about how to actually implement a surrogate species approach, assuming one were appropriate to use. As the process is described in the Technical Guidance, it would also appear that using surrogate species would be no less time or data intensive than just analyzing/monitoring all species of conservation interest. There are other approaches to landscape-scale conservation that are more transparent, more straightforward and more scientifically defensible.

Reviewer 4

The Technical Guidance does not provide a firm scientific foundation for the use of surrogates or examine the scientific evidence in detail, with the exception of Appendix B. The document would be more useful if it: 1) emphasized the material in Appendix B in the main text, 2) provided a better organized description of the surrogate approaches, 3) included a more comprehensive and systematic review of the literature on surrogates (e.g., perhaps a meta-analysis), 4) provided more evidence for the successful use of surrogates (particularly exploring when they have worked and when they have not), and 5) included guidance on how to test surrogates to see if they work. Additionally, the document would benefit from being refocused to either only address the type of surrogate that seems to be most emphasized in the document (the use of species as surrogates for population processes or status of other species) or to broaden the focus of the entire document. Finally, ecosystem-based management may be a viable alternative to this approach, although the most effective approach is likely a combination of surrogate and ecosystem approaches.

Reviewer 5

The Technical Guidance provides little in the way of actual guidance on how, why or when to use surrogate approaches nor how it fits into the larger SHC program. The Technical Guidance should provide a clear set of steps/process and how those associated with surrogate species fit into a larger conservation planning process. There are earlier (2012) documents from the Service on surrogate species and landscape-scale conservation that provide a start but those elements are not included in this draft Technical Guidance. There is no clear purpose to the Technical Guidance, little to no justification for many of the statements in the Technical Guidance, and little to no evaluation of the existing scientific literature on the topic of surrogate species.

5.0 Conclusions and Recommendations

Overall reviewers 2, 3, 4 and 5 all agree that the Technical Guidance is missing key elements and does a poor job of providing scientific support for many of the statements made within it. Also, generally, all reviewers recommended that additional, more detailed discussion of the different types of surrogates (species and otherwise) and their uses was necessary, along with associated discussion of their advantages and disadvantages, evidence for success, and associated monitoring requirements. Four reviewers felt Appendix B should have been integrated into the main text. At least three reviewers had problems with Table 1. There was disagreement among the reviewers about whether or not climate change was well-integrated within the document.

Every reviewer included specific recommendations and they were all generally along the same lines, although some reviewers recommended more significant revisions than other reviewers. The overall message from the reviewers was that the document needs significant revision, including better organization, more focus, and better discussion and inclusion of the scientific literature.

APPENDIX A

Complete Individual Responses

Peer Review of

Technical Guidance on Selecting Species for Landscape Scale Conservation

U.S. Fish & Wildlife Service

Reviewer 1 Response to the Charge to the Panel

1. *Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?*

Yes, the concepts are clearly laid out. However, the taxonomic groups that are addressed by the approach is not clearly set in the beginning, in that plants are neither explicitly included or excluded in the introduction section. There are varying statements through the course of the document that lead one to believe these could be included, could be included as habitat components, or are not included. I think it would make sense to be more explicit about how they are being treated given the objectives of the document.

2. *Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.*

For the most part, yes. I think you should include the concept of redundancy around line 197. Also, for a national audience, I think the USFS Eco-regional mapping, based off of Bailey's ecoregions should be mentioned around line 327 (http://www.fs.fed.us/rm/ecoregions/). And systematic conservation planning (Margules & Pressey 2000; Brooks et al 2006) are foundation papers that seem to be missing.

3. *Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?*

I think an example that portrays how community or non-profit groups might initiate such an exercise, with the subsequent involvement of federal agencies, would be helpful. In California there are a number of community-driven and county government-level conservation efforts. The guidance manual is silent on this front. Providing either a scenario, or listing out how these groups can engage and lead such efforts under the 'additional considerations' section at the end of the document is needed. This is particularly true if the LCCs are to carry this program, since this is often the audience that they need to engage for landscape-level conservation efforts (because the federal lands are much easier to decide what to do with).

Added for Clarification:

I mention that there are community-driven and county level conservation efforts, but did not mean to imply that they are using surrogate species for monitoring. So, what I meant was for the authors to consider describing how such an approach might be useable for groups beyond the FWS.

In California, county/federal efforts include Habitat Conservation Plans and California Natural Community Conservation Plans (https://www.dfg.ca.gov/habcon/nccp/). In some cases these plans take a long time to develop and communities have pushed the process, such as in Orange County, where mitigation for transportation projects was seen as opportunity to obtain conservation lands, and a round table approach to identifying which lands to pursue was used (https://www.dfg.ca.gov/habcon/nccp/status/OrangeTransport/).

There are other conservation efforts that are either outside federal guidance altogether, or that represent consortia of groups that seek to implement conservation and restoration of other lands. An example of nonprofit groups are land trusts, which typically function at the county or smaller level (e.g. Santa Cruz County Conservation Blueprint http://www.landtrustsantacruz.org/blueprint/). An example of a consortium is the Conservation Lands Network in the Bay area, which was developed with over 30 groups, and a peer-review process headed by non-profits, but with many agencies participating (http://www.bayarealands.org/explorer/).

The point is that these types of localized efforts do not yet typically have the use of surrogate species for monitoring on their radar. In some cases groups are using umbrella species for modeling the location of desired conservation lands, and there are instances of land purchases and easements justified by this approach. However, follow-up monitoring, particularly for easements, is typically weak if done at all. Therefore, to help these groups engage with the idea that using surrogates for monitoring, a hypothetical example would be useful. I guess if a real example were needed, then mountain lions in southern California might be appropriate. Some corridors have at least been identified, and some cats in two studies that I am aware of have been collared and data are being used to determine where/what habitats the cats are typically using (and where they are getting into trouble).

4. *Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Technical Guidance to help achieve better results?*

I remain to be convinced that the large amount of work to successfully conduct either adaptive management or surrogate species will actually be completed in the field due to costs and effort required being typically higher than funding available. I am aware of few, if any, adaptive management efforts that really follow through over the years required. This is, indeed, part of the motivation to move to more landscape-centered conservation efforts. I think the framework laid out here is okay, and aims are admirable. It might be good to include cautionary language about what the work required to complete the monitoring might look like, and what the timelines of those efforts might be.

5. *Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?*

Yes. I think this part of the document is well done.

6. *Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.*

For the most part this is well done. I'm including 5 or 6 citations (see comments in text about where to put them) that could amplify. I think some of the basis for this approach comes out of systematic conservation planning, which is not recognized. So Margules & Pressey 2000 is a key citation. Also the US GAP analysis program is another 'root' here. It might be helpful to flesh out more of the 'Where did this approach come from? How did it evolve?' to help people set thing in context. You have a new approach, but it definitely is informed by things that come before. I realize you don't want to go too far afield, but I think a couple paragraphs that help to set some context might later prove to be very useful.

7. *Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.*

Brooks, T.M., R.A. Mittermeier, G.A.B. da Fonseca, J. Gerlach, M. Hoffman, J.F. Lamoreux, C.G. Mittermeier, J.D. Pilgrim, and A.S.L. Rodriques. 2006. Global biodiversity conservation priorities. Science 313 (5783): 58-61. doi: 10.1126/science.1127609

Epps, C.W., B.M. Mutayoba, L. Gwin and J.S. Brashares. 2011. An empirical evaluation of the African elephant as a focal species for connectivity planning in East Africa. Diversity and Distributions 17: 603–612. doi: 10.1111/j.1472-4642.2011.00773.x

Huber, P., J.H. Thorne, and S. Greco. 2010. Boundaries make a difference: the effects of spatial and temporal parameters on conservation planning. Professional Geographer 62:1-17.

Lewandowski, A.S., R.F. Noss, and D.R. Parsons. 2010. The Effectiveness of Surrogate Taxa for the Representation of Biodiversity. Conservation Biology 24: 1367–1377. doi: 10.1111/j.1523-1739.2010.01513.x

Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature 405: 243-253. doi: 10.1038/35012251

Thorne, J.H., D. Cameron, and J.F. Quinn. 2006. A conservation design for the central coast of California and the evaluation of mountain lion as an umbrella species. Natural Areas Journal 26:137-148.

8. *Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.*

Well, the use of focal species in many of the ways described is pretty similar to surrogates. The addition of climate refugia and or physical site characteristics is new. So there are some new things here, but it is not as though attempts to do this have not been attempted. Biodiversity hotspots themselves are a sort of surrogate.

9. *Any other comments?*

Please see comments in the margins and edits using ‘track changes’.

Thank you for the opportunity to review this interesting work.

Reviewer 2 Response to the Charge to the Panel

1. *Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?*

While some elements of the Technical Guidance are clearly stated, there is room for improvement to streamline the content and make the scientific foundation of the Technical Guidance more clear. There are several key ways I could see this being improved:

a) Throughout the document there is a need for more evidence-based support for many statements that are made about surrogates and surrogate species more specifically. For example, Page 17, on determining the geographical scale to use for particular management questions, while there might not be standards for selecting the scale at which to carryout management there are published studies that apply to the points laid out for which references should be given. This is the case throughout the text, and I have done my best to highlight specifically where in the text evidence or references are needed.

   In addition, a lot of the evidence or examples that are the foundation of this technical document are tucked away in the Appendices. Appendix B is critical as it presents the different types of surrogate species commonly used. Before reaching Appendix B the technical guidelines appeared quite vague in the main text. Therefore, it would be useful both to the reader and the end user if much of the material tucked away in Appendix B were brought forward and presented explicitly in the Introduction of Surrogate Species. Without explicitly stating what types of surrogate species have been used and are commonly used now both in the literature and in practice, it makes it very hard for the reader to believe these are technical guidelines. The meat of the document is buried in Appendix B and would greatly improve the logic of the document by bringing it out at the start rather than having it hidden away. Without doing this, readers/users could get frustrated and find the technical document hard to follow. This could be improved by moving specific examples of *Surrogate Species* to the specific section on this topic, and moving examples of methods that have been used to the respective section on *Selecting the Surrogate Approach and Surrogate Species* would also significantly improve the logic and flow of information in the Technical Guidance.

b) While the document provides definitions for particular terminology, there remain a variety of words that are not defined, or for which examples are not provided. Descriptions of areas, such as landscapes or ecoregions and the potential sizes for such areas should be provided to the reader up front as this gives the reader an idea of the types of areas being considered. Given that this is meant to be technical guidance that type of information would be useful. *For example*, it is stated in the document that surrogates work best for landscape and ecoregional scales, but then goes on to say that this approach is less effective for regional scales, but no context or examples are provided to the reader. It would really benefit the reader/user to have a brief description of what these areas are and to provide links to papers that support these points. Consideration should be given to provide sizes, even a range of sizes, and explicit examples of where surrogates have worked at particular scales.

c) There are many sweeping statements without references. I have highlighted many of these throughout the text; primarily in the main text. I also gave examples of existing literature that could be used to support some of the sweeping statements, but in other instances the authors need to use the existing literature from which they took the statements and reference them properly. There are numerous cases where statements are made that have clearly been said before in literature, but for which no citations are provided. This must be remedied in order for the document to be sound.

2. *Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.*

Yes. In general scientifically sound conclusions are drawn based on the scientific information presented in the document. I have highlighted in track changes, in the document itself, several instances where some clarity could be given to particular points.

It needs to be reemphasized in the document that while surrogate methods might continue to be used, and methods are continually being developed to better use surrogate species (e.g., Nicholson et al. (2013)), there remains a general lack of evidence to support the underlying principle that focal species confer protection to co-occurring species facing similar threats (see Nicholson et al. (2013) and references therein**).**

3. *Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?*

While there were examples provided as to how surrogates have been used, I don't believe there is any clear line of evidence that indicates that surrogate approaches have been implemented and successful for monitoring or for delivering viable populations of all the species in any system.

Examples were given to show that surrogate methods have been developed and even implemented; there is a need to follow that up with evidence or measures that the method actually helps sustain or recover viable populations of all the species in a system. While this is not a direct weakness of the Technical Guidance *per se*, it stems from a weakness in existing studies to demonstrate the capacity of a set of focal species to ensure the viability of other species.

It could also help the reader/user if there was a specific subsection under each presentation of existing Surrogate Species Approaches (as presented in Appendix B) that is titled "*Evidence"* or *"Evidence of Success*" that gives explicit lines of evidence of a surrogate approach being implemented for monitoring, and it actually being shown to ensure the viability of other species than the surrogate species. The only study I am aware of that has indirectly shown this to date is Nicholson et al. (2013). I have provided a reference for this paper below.

4. *Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Technical Guidance to help achieve better results?*

I am unable to comment on this based on the Technical Guidance. I don't believe that the Technical Guidance provides the information necessary to determine if the use of surrogate species will provide meaningful indices of population-level response. This would require studies that evaluate the effectiveness of actions implemented based on the use of surrogates to determine whether there were sufficient population-responses from non-surrogate species. See Nicholson et al. (2013) for an example study that actually quantifies that a reserve system minimized the expected loss of the focal species and the expected loss in a larger set of 10 species.

5. *Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?*

Yes. For the most part the pitfalls and shortcomings of using surrogate species are adequately covered. It would still be beneficial to make this information more front and center in the document, along with the types of methods used. It would also be helpful for the user/reader if a specific section were included about evidence of these approaches working once implemented, or of studies that have showed that the use of surrogate species is effective in minimizing population declines or in population recovery of other targeted species.

6. *Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.*

Yes, to the best of my knowledge the analyses and conclusions were based upon the best available science with regards to surrogate species. However, I actually would define the use of species groups, as referenced by Wiens et al. (2008), as coarse-filter surrogates, and in this case there is a deeper literature on the ineffectiveness of coarse-filter groups of species for representing species. I have provided references to these papers below. It could be valuable to consider the limitations of using coarse-filter species approaches in conservation planning when setting targets for the representation of species. See Hermoso et al. (2013) and Januchowski-Hartley et al. (2011) and papers referenced within.

7. *Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.*

Yes.

Nicholson, E., D.B. Lindenmayer, K. Frank, and H.P. Possingham. 2013. Testing the focal species approach to making conservation decision for species persistence. Diversity and Distributions 19: 530-540.

Hermoso, V., S.R. Januchowski-Hartley and R.L. Pressey. 2013. When the suit does not fit biodiversity: loose surrogates compromise the achievement of conservation goals. Biological Conservation 159: 197-205.

Januchowski-Hartley, S.R., V. Hermoso, R.L. Pressey, S. Linke, J. Kool, R.G. Pearson, B.J. Pusey, and J. VanDerWal. 2011. Coarse-filter surrogates do not represent freshwater fish diversity at a regional scale in Queensland, Australia. Biological Conservation 144: 2499-2511.

8. *Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.*

Yes.

One could use coarse-filter surrogates (based on species or environmental factors) or processes, and consider the use of planning for refugia. These are all points that were touched on in the document, but that were not given adequate discussion. Planning for the protection of refugia is a fairly new concept, but there are emerging papers on the topic (see for example: Reside et al. (2013)).

Reside, A.E., J. VanDerWal, B.L. Phillips, L.P. Shoo, D.F. Rosauer, B. Anderson, J. Welbergen, C. Moirtz, S. Ferrier, T. Harwood, K. Williams, B. Mackey, S. Hugh, and S. Williams. 2013. Climate change refugia for terrestrial biodiversity: Defining areas that promote species persistence and ecosystem resilience in the face of global climate change. National Climate Change Adaptation Research Facility. Available at http://www.nccarf.edu.au/publications/climate-change-refugia-terrestrial-biodiversity.

The use of coarse-filter surrogates in conservation planning show mixed results in terms of the representation of species in final conservation plans based on surrogates alone (see for example Januchowski-Hartley et al. (2011)).

Methods based on modeling individual species distributions are now common in the literature as data to do so have become available. In this way frameworks like systematic conservation planning and spatial prioritizations allow planners to use tools like Marxan and Zonation to guide their decisions based on the distributions of individual species rather than on groups of species or surrogates groups based on environmental classifications (see Moilanen et al. (2009)). Using these approaches allows planners to make decisions at landscape, regional and national scales that are cost-effective and that adequately represent all species of interest.

See for example:

Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature 405: 243-253.

Moilanen, A., K.A. Wilson and H.P. Possingham. 2009. Spatial conservation prioritization: quantitative methods and computational tools. Oxford University Press, Oxford, United Kingdom. 304 pages.

9. Any other comments?

Yes. I have contributed additional feedback in comments boxes in the Technical Guidance document. In addition, one element of the document that I found difficult was the dual integration of using an Adaptive Management Framework and trying to unfold the Technical Guidance for using surrogate species in conservation planning. It would benefit the reader to present the idea of the adaptive management concept more clearly in the Introduction and to consider presenting an existing (or modification of) figure (see below) that breaks down the Adaptive Management process so that the reader can understand the logic of linking this Technical Guidance to Adaptive Management.

Presenting such a figure would also allow the Technical Guidance document to unfold in a logical way that aligns with the framework, at the moment that is not the case in some areas and it makes it difficult to see how the flow of information with regards to surrogate species fits with the Adaptive Management Framework.

In addition, there are two points in the text about the importance of considering climate change when evaluating surrogate species. In this way the document is somewhat confusing in that it clearly states it is aimed at the identification of "surrogate species", but there are elements about the importance of environmental surrogates (such as refugia) and about the importance of groups of species as opposed to a single focal species, which seems to suggest the use of alternative methods to surrogate species. This is fine, but to provide clarity to the readers it would be really helpful to acknowledge and unpack these different approaches in more detail, as well as better recognizing the published limitations of all suggested approaches.

It would also help to give consideration to where the boxes on climate change are placed. For example, to me it would be logical to have a section at the end of the introduction or methods on selecting surrogates that is dedicated to the potential implications of future changes and what this could mean for making decisions based on surrogates. Unpacking the potential benefit of using refugia and how to identify such areas is also needed if there is going to be reference to the idea of using it in the planning process. There is a growing literature on the complexities of what defines refugia and how we quantify it that should be given some consideration if this is to remain in the text.

Reviewer 3 Response to the Charge to the Panel

1. *Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?*

According to the preface, the Technical Guidance document is intended to support implementation of Strategic Habitat Conservation (SHC) as envisioned in the 2006 Report of the National Ecological Assessment Team. However, the recommendations in the Technical Guidance are in stark contrast to the approaches suggested by the SHC document. That document is forward looking and includes conservation approaches that are well supported in the current conservation biology literature. Specifically, the SHC document recommends developing and prioritizing conservation objectives based on landscape level analyses that link the biology of species to habitat and landscape characteristics, and both species and habitat/landscape characteristics to threats to species persistence. The SHC mentions potential use of surrogate species only in Sub-Element 1.2 on page 14 as one means of setting conservation priorities. The focus is on conservation in a landscape context and spatial analyses are emphasized. The Technical Guidance returns to a species-centric approach, retreating from the more holistic landscape analysis approach. Landscape analysis is mentioned in passing in the Technical Guidance, but it is not an underlying, pervasive philosophical framework. It is not clear why the Service has now chosen the one narrow method of surrogate species to promote as a primary way forward for meeting the vision of SHC.

On page 7 lines 136-138, the authors state their underlying assumption that by "carrying out management strategies that produce ecological conditions favored by a smaller set of species, the needs of a larger number of species will also be met." Although the assumption is clearly stated, the scientific support for it is not provided in the main document. There is no discussion of why a surrogate species approach was selected over all other possible approaches to implement SHC. The document never progressed beyond generalities and thus it is hard to evaluate the underlying science supporting surrogate species – it was difficult to understand what that science was. The document is primarily focused on general considerations for landscape level planning writ large and then suggests surrogate species as the only approach for doing landscape planning. Surrogate species do not even come up until page 21 of 33 pages. The literature regarding surrogate species is not really reviewed until Appendix B.

The Technical Guidance document is also too vague to be of practical value in implementation. The main body of the document does not provide any more specific suggestions for implementation of landscape conservation than were already provided in the SHC document; in fact it is even less specific than the SHC document in many respects. For example, when surrogate approaches are finally mentioned on page 22 (lines 421), the guidance suggests three approaches exist, but no details are given in terms of defining the three categories of approach. The details are not provided until Appendix B. And when they are given, there is one method for selecting areas for conservation (umbrella and landscape species) and one method for selecting species for monitoring (indicator species).

Given that the surrogate species approach was chosen as the means of implementing SHC, I was expecting the Technical Guidance to provide detailed, specific instructions on selecting surrogate species and setting goals and objectives for those species. The process by which surrogates would be selected is not described clearly in the main body of the document. Rather the main body focuses on broad generalities and platitudes (the dynamic nature of landscapes, science excellence, transparency, logic and consistency, etc.). Much of the discussion and recommended considerations in the Technical Guidance are much broader and more general than surrogate species applications. For example, all of the overarching considerations from page 12-20 are important for landscape scale conservation, but they say little specifically about surrogate species. The topic of Box 1 is climate change considerations for landscape conservation planning. Thus, the considerations go far beyond surrogate species approaches and it is hard to see how much of the text prior to page 21 clarifies how to implement a surrogate species approach. It is only the Appendices that speak specifically to surrogate species. The examples in Appendixes C and D provide relatively clear descriptions of suggested processes in two hypothetical example cases. What I understand from the text of the main document is that

1) All species of concern will be identified.
2) Surrogate species will be selected for each species of concern.
3) Population objectives (stated as mean ±SE) for the surrogates will be selected and meeting those objectives will be considered to indicate population viability of the species of concern. It is not clear if population goals are also set for the species that are really of interest.

Elaborations on this apparently streamlined process in Appendixes B, C, and D illustrate that a surrogate species approach is not likely to be less time consuming, data intensive or cumbersome than addressing each species. First, extensive information on each species is required to determine which species are likely to be represented by a particular surrogate. The recommended procedure is to compile information on the distribution and life history traits of each species. From this information lists of similar species are grouped together under as many surrogates as are needed to represent the species of concern. Once surrogates are selected the Technical Guidance suggests monitoring of all or most species to ensure that the demographic responses of surrogate and non-target species are in fact responding in the same manner.

2. *Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.*

This is a somewhat difficult question to answer because rather than reaching a conclusion, the Technical Guidance starts from a premise that does not appear to be well supported based on the scientific literature. Added for Clarification: See answer to Question 1 for additional explanation.

3. *Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?*

No, there are not sufficient examples of how surrogates have been successfully used to monitor population-level responses. This is a fundamental flaw of the suggested approach. There is some evidence that broadly ranging surrogate species can be used in the context of reserve selection. In this way, sufficient amounts and configurations of habitat are conserved to also conserve habitats of other non-target species. But there is no indication in the literature that population sizes, trajectories, or responses of one species will reflect another species. Because there can be orders of magnitude differences in responses of different populations in the same species (Brook et al. 2008; Zeigler et al. 2013) there is no reason to anticipate one species being a proxy for another.

Table 1 provides examples of one surrogate approach – but none of these examples include setting population objectives for surrogates that then are assumed to reflect population abundances or trajectories of the species of conservation interest. It also provides many examples of issues with the clarity and logic of the Technical Guidance document. Despite noting the importance of not confusing different surrogate approaches in the text, the authors confuse the approaches in the table as detailed below:

- The surrogate approaches of umbrella species and landscape species are confounded – they are defined as different things in Appendix B, but are lumped here. I believe the authors are saying landscape species can be considered a particular type of umbrella species, but there are other types as well.
- The Reza et al. 2013 paper that is cited is an exercise in which habitat suitability for 9 large mammals is assessed separately and then the individual suitability scores are combined into one index value that combines suitability for those mammal species. The species are called umbrella species but their ability to function as umbrellas for other species is not assessed – in fact the authors state that they simply assume the index will be useful. Thus this paper is not an example of the umbrella method working. So the term umbrella species in this chosen example does not demonstrate the ability for population abundances or trajectories of these species to reflect those of other species.
- The Florida Closing the Gap program goes far beyond an umbrella species approach (they use the term focal specie). Beyond 44 focal vertebrate species they include mapped habitat for important globally endangered species of plants and rare animal and plant communities.
- Syrbe et al. 2013 uses landscape structure to assess delivery of ecosystem services. It is not a surrogate species approach. I think the Reza et al. citation that is in the Examples column is supposed to be at this point in the Source column
- The Heneberg 2012 citation is a great example of confusion regarding surrogate species that the Technical Guidance authors advocate guarding against. Heneberg calls the sand martin a flagship species, but it is used in the paper as an indicator species (an indicator of particular soil characteristics that are also important to hymenoptera) and is listed in the table as an example of an umbrella or landscape species.

- The text suggests that primary and original sources of literature be used for making recommendations or decisions and then uses a text book for a citation for the Northern Spotted Owl.

4. *Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Technical Guidance to help achieve better results?*

The proposed application of surrogate species does not save time, effort, or funding and in the end will not provide meaningful indices of population responses. By the time practitioners follow the protocol/procedures suggested in Appendices B, C, and D, they would have been able to address each species of interest directly with much greater transparency and precision.

Using surrogate approaches is likely to make the resulting information on individual species less informative and straightforward and they preclude a synthetic analysis of a landscape in a way that is more likely to represent conditions necessary to ensure the landscape is functional for all species.

If surrogate species are going to be used, the means of monitoring needs to be improved if the results of the conservation efforts are going to have any hope of being meaningful. The document only vaguely refers to monitoring demographic characteristics of both the surrogates and the other species. The cost and difficulty of demographic monitoring is underestimated or understated: "You will need to monitor population viability of the surrogate species and, maybe to a lesser extent, all of the species that the surrogate is intended to protect, at least initially, to test efficacy of the approach." Given the difficulty of getting accurate population estimates of even one species (e.g., Kendall et al. 2009) the practicality of demographic monitoring for population viability for all surrogate species and species of interest is low. The fact that the monitoring workload is not reduced due to the need to confirm that population abundances of surrogates are representing the species of interest further demonstrates that the surrogate approach does not reduce cost or workload. It would be much more straightforward to manage and monitor the species of interest from the outset.

5. *Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?*

The discussion of the likely pitfalls of surrogate species was fair to poor. Much of the core literature on surrogate species was cited. However, a number of important publications demonstrating limitations and inadequacies of surrogate approaches are conspicuously absent (Cushman et al. 2010; Murphy et al. 2011; Hoare et al. 2012, 2013; Mysak & Horsak 2014). Of particular importance in context of the reliance on population abundance and trajectories is the evidence that abundances across species are not representative or correlated (e.g., Cushman et al. 2010) is not discussed. Thus, the crux of the logic in the Technical Guidance logic that population goals (e.g., abundance and trajectories) for surrogate species will represent other species that are not directly managed or monitored is not supported. Even if presence of one species might be spatially represented by a surrogate (which many studies show is not the case), population levels or trajectories for a surrogate will say nothing about the population status of the other species of conservation interest. And although some literature regarding shortcomings of surrogate approaches is discussed, the knowledge of the inadequacies appears to have no bearing on the intent to proceed with using surrogates regardless. In that regard, it is difficult to see that the guidance follows logically from the published scientific evidence. Additional relevant literature that is not cited is suggested in 7 below.

6. *Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.*

There are two ways in which the Technical Guidance does not incorporate the best available science. First, although the document is supposed to be about surrogate species, more than half the body of the text is generally about landscape level conservation planning in general. Given that, much of the broader literature on landscape conservation approaches is absent – specifically I am referring to species complementarity reserve selection approaches using decision support software tools (e.g., Ball & Possingham 2000) and approaches that select landscape features or environmental gradients (e.g., Malcolm & ReVelle 2002; Rouget et al. 2003; Malcolm & ReVelle 2005b, a; Moilanen 2005; Moilanen et al. 2005; Lindenmayer et al. 2014; Rickbeil et al. 2014). No justification for eliminating those methods and focusing only on surrogate species is provided.

Second, given that a surrogate species approach has been chosen, the intent stated in the Draft Technical Guidance is to use population abundances and trajectories of one species to represent the species of conservation interest that is/are the indirect target(s). There is no scientific evidence to support use of surrogate species for this purpose. As mentioned above, existing scientific evidence is quite to the contrary. For example, different species of birds do not have similar trajectories (Cushman et al. 2010; Hoare et al. 2012; Cruz et al. 2013; Hoare et al. 2013) and even different populations of the same species can differ by orders of magnitude (Brook et al. 2008; Zeigler et al. 2013). I could find only one example of highly correlated demographic responses across species and it was from a very particular situation in which five island dwelling lizards all responded positively to removal of mammalian predators (Monks et al. 2014). Thus, the assumption that population abundances, responses, and trajectories of surrogate species will mirror those of other species is not warranted by any scientific data. This concern is magnified when the taxonomic and ecological differences between the surrogate and species of concern are greater. In the examples in Appendixes C and D, it is suggested that the 30 plant species of concern will be adequately protected if bears and mountain lions are managed. This assumption is common among vertebrate biologists but has no scientific justification.

Based on the scientific literature, surrogate species at best can be used when there is spatial overlap in distributions and protecting habitat for one wide ranging species in a reserve network includes the distribution of other species (i.e., conservation of habitat for on species 'represents' the target species in a reserve network). Much of the research evaluating sufficiency of surrogates for this use has focused on overlaps in species ranges (the Technical Guidance refers to this as "Biodiversity Indicators"). Surrogate approaches have been found problematic even for this application in that species do not overlap sufficiently or the overlap that does exist may not include optimal habitat for the target species (Saetersdal & Gjerde 2011; de Andrade et al. 2014; Di Minin & Moilanen 2014; Mysak & Horsak 2014) or the areal extent of habitat to ensure inclusion of non-target species is too high to be practical.

7. *Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.*

In addition to the citations in other responses, the following papers are conspicuously absent from the Technical Guidance:

Bachand, M., S. Pellerin, S. D. Cote, M. Moretti, M. De Caceres, P. M. Brousseau, C. Cloutier, C. Hebert, E. Cardinal, J. L. Martin, and M. Poulin. 2014. Species indicators of ecosystem recovery after reducing large herbivore density: Comparing taxa and testing species combinations. Ecological Indicators 38:12-19.

Branton, M., and J. S. Richardson. 2011. Assessing the value of the umbrella-species concept for conservation planning with meta-analysis. Conservation Biology 25:9-20.

Che-Castaldo, J.P. and M.C. Neel. 2012. Testing surrogacy assumptions: Can threatened and endangered plants be grouped by biological similarity and abundances? PLoS One 7: e51659.

Eglington, S. M., D. G. Noble, and R. J. Fuller. 2012. A meta-analysis of spatial relationships in species richness across taxa: Birds as indicators of wider biodiversity in temperate regions. Journal for Nature Conservation 20:301-309.

Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O. Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena, and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters 14:101-112.

Fattorini, S., R. L. H. Dennis, and L. M. Cook. 2011. Conserving organisms over large regions requires multi-taxa indicators: One taxon's diversity-vacant area is another taxon's diversity zone. Biological Conservation 144:1690-1701.

Heink, U., and I. Kowarik. 2010a. What are indicators? On the definition of indicators in ecology and environmental planning. Ecological Indicators 10:584-593.

Heink, U., and I. Kowarik. 2010b. What criteria should be used to select biodiversity indicators? Biodiversity and Conservation 19:3769-3797.

Isasi-Catala, E. 2011. Indicators, umbrellas, flagships, and keystone species concepts: Use and abuse in conservation ecology. Interciencia 36:31-38.

Lawler, J. J., and D. White. 2008. Assessing the mechanisms behind successful surrogates for biodiversity in conservation planning. Animal Conservation 11:270-280.

Lawler, J. J., D. White, and L. L. Master. 2003. Integrating representation and vulnerability: Two approaches for prioritizing areas for conservation. Ecological Applications 13:1762-1772.

Lindenmayer, D. B., P. S. Barton, P. W. Lane, M. J. Westgate, L. McBurney, D. Blair, P. Gibbons, and G. E. Likens. 2014. An empirical assessment and comparison of species-based and habitat-based surrogates: A case study of forest vertebrates and large old trees. Plos One 9.

Mellin, C., S. Delean, J. Caley, G. Edgar, M. Meekan, R. Pitcher, R. Przeslawski, A. Williams, and C. Bradshaw. 2011. Effectiveness of Biological Surrogates for Predicting Patterns of Marine Biodiversity: A Global Meta-Analysis. Plos One 6.

Murphy, D. D., P. S. Weiland, and K. W. Cummins. 2011. A critical assessment of the use of surrogate species in conservation planning in the Sacramento-San Joaquin Delta, California (USA). Conservation Biology 25:873-878.

Noon, B. R., L. L. Bailey, T. D. Sisk, and K. S. McKelvey. 2012. Efficient species-level monitoring at the landscape scale. Conservation Biology 26:432-441.

Schindler, S., H. von Wehrden, K. Poirazidis, T. Wrbka, and V. Kati. 2013. Multiscale performance of landscape metrics as indicators of species richness of plants, insects and vertebrates. Ecological Indicators 31:41-48.

Schwenk, W. S., and T. M. Donovan. 2011. A multispecies framework for landscape conservation planning. Conservation Biology 25:1010-1021.

Tulloch, A., H. P. Possingham, and K. Wilson. 2011. Wise selection of an indicator for monitoring the success of management actions. Biological Conservation 144:141-154.

Tulloch, A. I. T., I. Chades, and H. P. Possingham. 2013. Accounting for complementarity to maximize monitoring power for species management. Conservation Biology 27:988-999.

Vera, P., M. Sasa, S. I. Encabo, E. Barba, E. J. Belda, and J. S. Monros. 2011. Land use and biodiversity congruences at local scale: applications to conservation strategies. Biodiversity and Conservation 20:1287-1317.

Wesner, J. S., and M. C. Belk. 2012. Habitat relationships among biodiversity indicators and co-occurring species in a freshwater fish community. Animal Conservation 15:445-456.

There is a comment in the Guidance that there is no way to assess the necessary size of a landscape (Page 17 Line 300). Minimum viable habitat area analysis can provide insight into the minimum size of a landscape needed to maintain particular species. This is only one factor that goes into choosing a landscape for conservation analysis and planning, but it does provide guidance.

Baguette, M., and V. M. Stevens. 2013. Predicting minimum area requirements of butterflies using life-history traits. Journal of Insect Conservation 17:645-652.

Dardanelli, S., M. L. Nores, and M. Nores. 2006. Minimum area requirements of breeding birds in fragmented woodland of Central Argentina. Diversity and Distributions 12:687-693.

Pe'er, G., M. A. Tsianou, K. W. Franz, Y. G. Matsinos, A. D. Mazaris, D. Storch, L. Kopsova, J. Verboom, M. Baguette, V. M. Stevens, and K. Henle. 2014. Toward better application of minimum area requirements in conservation planning. Biological Conservation 170:92-102.

8. *Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.*

To identify surrogate species, the Technical Guidance recommends that for each species the range and habitat extent is mapped, life history attributes are compiled, hypothesized limiting ecological factors are known, and threats are identified. If all that is done for each species, it is more straightforward and defensible to plan for each species simultaneously using standard decision support tools such as MARXAN or MARZONE (Ball & Possingham 2000) than to choose a subset of species and hope they represent the others. Spatial analysis based on species complementarity could identify deficiencies in current protected areas as well as the range of options available for overcoming those deficiencies by explicitly representing each species or the landscape elements on which it depends. Landscape pattern analysis of the resulting alternative networks can be used to assess connectivity. Such an analysis can also show how distributions of limiting factors and extrinsic threats interact across all species and thus facilitate or impede conservation across 'functional landscapes'.

Using habitat and landscape characteristics as surrogate conservation targets provides another outstanding alternative to an umbrella species approach that is conspicuously absent from the Technical Guidance. As mentioned above, it is not clear why surrogate species are being promoted to the exclusion of other scientifically supported landscape conservation approaches.

An alternative approach that is much more transparent, straightforward, and defensible relative to the scientific literature and would use the same data that are indicated as necessary in Appendixes C and D would be as follows:

1) Identify all species of planning concern (trust species and others deemed critical)
2) Map current and, if possible, future predicted ranges and occupied habitat.
3) Identify naturally limiting factors (e.g., key habitat requirements such as soil requirements for narrowly endemic plants, nest cavities in larger trees, roost sites in caves, etc.).
4) Identify extrinsic threats to the limiting factors.
5) Map land use (current and if possible projected) including mapping areas protected and managed for biodiversity.
6) Assess amount of range and occupied habitat for each species that is in protected/managed status versus that is vulnerable to loss.
7) Develop conservation objectives for each species. These can include numbers of populations, numbers of individuals, connectivity among populations, amounts of

habitat, spatial distribution of habitat, extent of range, etc. The chosen levels will be normative decisions, but once chosen they provide transparent, and measurable conservation objectives.

8) Identify and map key landscape or habitat features that are needed to support all of the species (e.g., amount and spatial distribution of habitat, successional stages of particular habitats, soil types and characteristics, elevation gradients, water temperature gradients, salinity gradients, etc.).
9) Conduct multi-species conservation planning analysis to identify key sites that need to be acquired or managed to represent all species to the desired level. Include an analysis and selection of landscape elements that are critical as limiting factors for species. There are now decades of experience with this process from the Nature Conservancy's ecoregional planning efforts which have been completed for most if not all ecoregions of North America using a combination of coarse filter and fine filter planning and site selection.
10) Monitor and Adapt.

9. Any other comments?

The Technical Guidance could benefit from increased clarity in many places. For example, it is unclear what species are to be managed using surrogate approaches. The SHC states that priority species for management are federal trust species (page 14 in the SHC). The SHC then states that the species of conservation concern will need to be prioritized because there are too many to address individually. In the body of the Technical Guidance, endangered species and migratory birds of management concern are specifically mentioned as being trust species. In the definitions in Appendix A, I finally found what I think is a complete list of trust species categories. However, in the Technical Guidance, it is stated that threatened and endangered species have specific regulatory requirements that preclude surrogate approaches. Greater clarity is needed regarding which species are potentially going to be managed based on surrogates. If there are not really many species that can be managed with surrogate species, why go through the effort for such an indirect approach?

Due to use of vague, poorly defined terms and concepts, there would be no way to objectively determine if the guidance had been followed. If I were an agency biologist tasked with implementing this planning approach, I would have difficulty knowing how to proceed.

No specific procedures or tools are identified. For example, on page 24 starting at line 457, the text indicates that decision support tools are available but none are identified or discussed. The "conceptual or quantitative models generating ranks or "best fits"" and "multivariate methods" noted are equally as vague.

There are fundamental contradictions in the Technical Guidance. In a few places, it vaguely refers to the importance of habitat in supporting species, but then in one climate change box (Box 1) the case is made that vegetation communities are artificial constructs that will become disassembled under altered climate regimes. In Box 6, the environmental features such as geophysical settings are argued to be better surrogates than species or communities. But these sorts of surrogates are not considered at all in the Technical Guidance.

[Note: The comments from here until citations are also included in the 'Track Changes' version of the Technical Guidance.]

Page 23 Line 452 – What are *greater demands*? More specific/restricted habitat requirements? Highly specialized species would seem less likely to provide surrogacy for other species. Or does greater demands mean broader requirements? Such species may not be as sensitive to change as more restricted species.

It is not clear what range of spatial scales is anticipated. Although there is a need for flexibility in the application of SHC to different spatial scales it would be helpful if some idea of the scale was provided. Different conservation approaches are most relevant and feasible at different scales. For example, if one is planning at an ecoregional scale, it is likely most appropriate to ensure that habitat of all species of interest is represented in sufficient amount and configuration. If one is planning at a watershed scale, it is more likely that site specific habitat management projects will be developed. Thus, greater clarity is needed regarding the intended scale and applications and the differences among them. As it is now, the document potentially confounds systematic conservation planning at the ecoregions scale with watershed level planning of site specific habitat management scale without ever being specific about either. There is some perceived 'surrogate' zone', a scale at which use of surrogates is appropriate but it is unclear what the spatial scale is. My naïve assumption prior to reading the Technical Guidance was that SHC would be focused on planning for each of the Landscape Conservation Cooperatives. However, the term 'ecoregional' scale was used several times, and the Landscape Conservation Cooperatives were mentioned only in passing as potential sources of lists of species of conservation interest.

From an organizational standpoint, it would have been helpful for all literature to have been cited in one place in the document rather than separately in the main body and the appendices.

There are many cases in which the text needs more careful editing. A few examples are noted below.

- Page 3 Line 49 – 50 – Can a surrogate species be a measurable objective?
- Page 5 Lines 89-91 – This sentence does not read correctly.
- Page 8 Line 160 – The literature is not 'exhaustive'. Perhaps extensive?
- Page 9 - The text box is redundant with the text and is not needed.
- Page 21 - The actions required to select a surrogate approach and surrogate species are given and include selecting the surrogate approaches (line 403) and selecting surrogate species (line 406). The actions are redundant with the goal.

- Page 22 Line 420 – States that "most conservation researcher identify 3 categories of surrogates" but then only two papers are cited. It would be safer to say something like, "We concur with (citations) in recognizing three categories of surrogate species."

- Page 22 Line 428 – The sentence starting "In most cases…" seems to have the logic reversed. Selection of surrogate species should not define the important landscape conditions needed for other species. The needs of the other species should determine the needed conditions.

- Page 23 Lines 436-438. Plural singular disagreement on line 438.

- Page 24 Line 474 – sentence is too vague. What criteria? How developed? This whole document is supposed to tell specifically how to develop such criteria. More specifics are needed.

- Page 46 Line 376– The definition of a biological objective begins, "A concise, measurable (SMART) statement...". But **SMART** includes specific, measurable, achievable, results-oriented, and time-relevant. So if you say something is a measurable (SMART) statement, it is, **measurable**, specific, **measurable**, achievable, results-oriented, and time-relevant statement and thus it is redundant.

Citations

Ball, I. R., and H. Possingham. 2000. MARXAN (V1.8.2): Marine reserve design using spatially explicit annealing, a manual.

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Cushman, S. A., K. S. McKelvey, B. R. Noon, and K. McGarigal. 2010. Use of abundance of one species as a surrogate for abundance of others. Conservation Biology **24**:830-840.

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Malcolm, S. A., and C. ReVelle. 2005a. Models for preserving species diversity with backup coverage. Environmental Modeling & Assessment **10**:99-105.

Malcolm, S. A., and C. ReVelle. 2005b. Representational success: A new paradigm for achieving species protection by reserve site selection. Environmental Modeling & Assessment **10**:341-348.

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Saetersdal, M., and I. Gjerde. 2011. Prioritising conservation areas using species surrogate measures: consistent with ecological theory? Journal of Applied Ecology **48**:1236-1240.

Zeigler, S. L., J. P. Che-Castaldo, and M. C. Neel. 2013. Actual and potential use of population viability analysis in recovery of plant species listed under the U.S. Endangered Species Act. Conservation Biology.

Reviewer 4 Response to the Charge to the Panel

1. *Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?*

The bulk of the document does not deal with the scientific foundation for the use of surrogates. What discussion there is of this topic is in Appendix B. Perhaps the greatest shortcoming of the document that I see is that it 1) does not stress enough that the use of surrogates will have uncertain results (sometimes surrogates will work and sometimes they won't), and 2) although the document does stress that to determine whether or not surrogates are working, one will need to actually monitor more than just the surrogate species, it provides no guidance on how to do this. Will it require long-term monitoring of all other species (hopefully not), some other species, sporadic and limited monitoring of a small number of targets? How are these decisions to be made?

In addition, I think that a more thorough discussion of the evidence for the effectiveness of the three different types of surrogates is needed (see my response to #4 below as well as my specific comments).

2. *Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.*

Again, this is a bit tricky to answer. The bulk of the document does not present science and then draw conclusions from the scientific evidence. The bulk of the document (with the exception of Appendix B) provides a framework of sorts and steps that one would take to select surrogate species. I do believe that most of this framework and the steps laid out are reasonable given the science. That said, I did have a bit of trouble with several specific statements (see my specific comments under #9 below) and with the way that the surrogates were presented in general.

I found the way that the surrogate approaches are presented, categorized, and described to be confusing at best. First, the surrogate approaches are arguably the centerpiece of the guidance document. However, they have been placed in an appendix. This is odd and I suspect it will make using the document difficult. Second, three types of surrogate approaches are described (although I would argue that these are three uses for surrogates, not types of approaches). It would be more useful to just list the types of surrogates and their uses (e.g., umbrellas and their uses [which I believe are broader than defined in the document], indicators and their uses, focal species and their uses, and flagships and their uses).

I also struggled a bit with the issue that the bulk of the document really focuses on the use of surrogates as indicators of population condition of target species (this is reinforced by the wording of question #4 below)—however, three different surrogate approaches are discussed. I think the rest of the document needs to be broadened in scope OR it should focus on indicator species only and merely mention the other surrogate types in passing.

Finally—and this point is related to my response to #1 and #4—the main text does not allude to any shortcomings of the surrogate approaches nor to the fact that there is more or less evidence for the successful use of the different surrogate types. The shortcomings are listed in Appendix B, but the document still gives the overall impression that these three approaches are all useful and they should all be used. However, as I discuss in my response to question #4 below, I think there is much less evidence for the successful use of surrogates for selecting conservation areas than there is for using surrogates to monitor environmental changes—but perhaps I am wrong.

3. *Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?*

Appendix B does provide several examples of cases in which surrogates have been used. However, for the most part, there is no discussion of how successful these uses have been. It would be good to have examples of where surrogates have been used successfully and where they have failed.

The two hypothetical examples in Appendices C and D are a good attempt to demonstrate the process outlined in the document. However, because they are hypothetical, they are a little less useful than they would be if they were real examples. If these two examples were instead case studies that demonstrated the use of surrogates in the real situations, they would be more informative.

4. *Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Technical Guidance to help achieve better results?*

This is an excellent question. I think the process described for selecting species is well-reasoned and defensible. The inclusion of climate change considerations is well done and appropriate. As stated above, I do think the document—and particularly the main text—needs to emphasize that surrogates don't always work (most of my experience with surrogates is with conservation planning and that literature is replete with examples in which surrogates fail when used to identify areas to protect). The main text of the document needs to describe how to test to see if the surrogates being used are effective. This is where guidance would be particularly useful. Testing surrogates is the only real way to know whether or not they will work in a given situation. However, as I mentioned in my response to question #1, guidance will be needed on how to test surrogates with limited time and funding.

In addition, I felt like the review of the performance of each type of surrogate was somewhat superficial. There should be enough literature to conduct a formal meta-analysis of the evidence for the utility of each of the different types of surrogates. Do they work? Appendix B merely contains some citations for papers that claim they work and others that claim they don't. It would be useful to see a formal survey of the literature—how often do tests of the different types of surrogates result in positive conclusions? A formal meta-analysis would be ideal, but even an informal, but thorough, survey of the literature would be worthwhile. I suspect (and this is just my hypothesis) that one would find that surrogates for conservation planning (site selection) often fail—but perhaps there are some characteristics of good surrogates that could be reported (there are several papers that have tried to identify characteristics of good surrogates with exhaustive modeling exercises). I suspect that indicators of environmental condition are often successful and that perhaps indicators of responses to management are mixed. Finally, I suspect that the success of flagships is also variable. Knowing how variable—given a full evaluation of the literature—the outcomes of each of these approaches is, would be very valuable and would provide good guidance for potential users.

5. *Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?*

Although the document does discuss some of the shortcomings of the different approaches, these discussions are somewhat superficial. The document would benefit from a thorough review and summary of the literature on how successful tests of the different surrogate approaches have been. As discussed in my response to question #4, this is one place where the document could be substantially improved.

6. *Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.*

To the best of my knowledge, the literature that is cited is appropriate and many of the important papers on the topics in question have been cited. I do, however, think that the report could draw on more (not necessarily better) science to assess the efficacy of the different surrogate approaches. See my comments above.

7. *Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.*

I would guess that there are likely hundreds of papers that have attempted to test surrogates for selecting conservation sites. And, I suspect that there is more than one recent review paper that has summarized the findings of these papers. Caro's book (2010) may have the synthetic summary that I was expecting to be reported on in this document, but if not, there are likely other recent papers that have thoroughly reviewed this literature. There are also at least a few papers that have used analytical approaches to assess the characteristics of successful surrogates for locating conservation areas, e.g.,

Manne, L.L. and P.H. Williams. 2003. Building indicator groups based on species characteristics can improve conservation planning. Animal Conservation 6: 291-297.

Lawler, J.J. and D. White. 2008. Assessing the mechanisms behind successful surrogates for biodiversity in conservation planning. Animal Conservation 11: 270-280.

There are also many papers that explore the relative utility of non-species surrogates for selecting conservation areas. This literature has not been mentioned—papers by Faith and Walker, Araújo, and others.

Although I am less familiar with the literature on the other two types of surrogates, I suspect there are plenty of papers that test their efficacy as well. A thorough review of these papers and a reporting on the findings would greatly increase the value of this guidance document.

8. *Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.*

One major alternative would be ecosystem-based management. Instead of using sets of species as surrogates for other species or for the condition of the ecosystems on which the species depend, one could manage the ecosystems themselves. There is a large body of literature on this subject. It has some of the same pitfalls as the surrogate species approaches, but in some cases, it may be a more direct method of managing for species of concern than managing surrogates for those species. The most effective approach may be some combination of ecosystem-based management and the use of surrogate species for monitoring or management purposes.

9. *Any other comments?*

I have included specific, line-by-line comments below. [Note: These are also incorporated into the 'Track Changes' version of the Technical Guidance.]

Line 69. Change "global warming" to "climate change." The challenges faced are not just those posed by increasing global temperatures but rather by a wide range of climatic and climate related changes.

Line 123. I would argue that conservationists (with a few exceptions) have not generally worked on "population growth" per se. They have definitely looked at the effects of population growth at increasingly larger scales. I would suggest changing this to "land-use change."

Line 126. I would argue that one can identify limiting factors at both finer and broader scales—although I know the traditional description of hierarchy theory would agree with the phrasing here. Perhaps a citation would cover it. I am not so sure that the definition in the glossary agrees with the one associated with hierarchy theory—thus there may be a mismatch and my initial reaction may be appropriate.

Line 146. This is awkward. I believe the text here is supposed to say that landscape or ecological scales can be considered to be the “surrogate zone”. A second issue is that Wiens et al. (2008) don’t actually tie the surrogate zone to a particular size area (see their figure 4).

Line 195. Perhaps it goes without saying, but I would think effectiveness (not just cost-effectiveness) would be a criterion here.

Line 214. Table 1. Umbrella species surrogates are described in Appendix B, but “Landscape” surrogates are not. What are these? A table like this could be quite useful if it were to have multiple rows listing many conservation goals (or management goals). In my comments about Appendix B, I have a similar comment—it would useful to see a full mapping of conservation goals to surrogate types.

Line 223. This is a bit awkward. I don’t think a method has a goal—rather a method or approach can be used to attain a goal.

Line 262. I would say this consideration should be made when selecting the species, not after.

General. The integration of climate change into the document has been nicely done.

Line 295. I would state that this is the definition of landscape that is being used in this document—not that it is a widely accepted definition of landscape. In the field of landscape ecology—a more general definition is often used that refers only to heterogeneity and pattern, and not to spatial scale. In fact on line 321 it seems like what are being referred to as landscapes are actually biomes or ecoregions. Although I realize the term landscape may be used differently in the Service than it is in the scientific literature, it would be better to be consistent. See definitions provided by Wiens or Turner.

Line 331. This section doesn’t actually give much guidance on how to select a time horizon. For example, what are the ecological and sociological considerations that should be taken into account? How does climate change affect the planning horizon?

Line 420. As I mention in my comments on Appendix B, somewhere it would be good to discuss what the surrogate species are surrogates for. Surrogate species will be surrogates for different things given the different approaches.

Line 421. I would call these “categories of approaches” uses of surrogate species. Would species that are monitored to assess the general condition of other species fall into category 2? I think so, given the definition in Appendix B, but that definition seems to be limited to investigating the effects of management activities or to using the species as surrogates for some environmental condition.

Line 448. Isn’t the most important criterion that the surrogate is representative of other species—with respect to how it responds to stressors, what habitat it needs, etc. Perhaps this is what is captured by the 4th bullet? However, this seems to be the biggest hurdle to successfully using surrogates.

Line 463. Some examples of these or at least some citations would be useful.

Line 465. Again, more detail is needed here. Please provide an example of how one would use a multivariate approach to select species.

Line 498. However, as defined in Appendix B—the three surrogate approaches are used for very different purposes (selecting conservation areas, assessing environmental condition or effects of management action, and building public support). Occasionally, one might be doing more than one of these things, but it seems like often, one would be focused on a single objective and a single approach.

Appendix B. This appendix is definitely needed (in fact I think its contents should be moved to the main text), but it is rather confusing and poorly organized. First, there is not a clear distinction between the approaches and their uses. This Appendix needs to start with a list of the approaches. It would also be nice to see a list of applications – perhaps these could be in a table together so the reader could clearly see which approaches were appropriate for which applications. I would also prefer that the following subsections (A., B., and C.) be organized by either the approach or the use. The appendix seems to make the statement that each approach is tied to a specific use. I think that is true to some degree, but as I note below, I don't see this as necessarily being the case. Why not make the subheadings A. Umbrella Species, B. Indicator species, and C. Flagship species.

Appendix B. Line 1140. This section is titled "Species to help define areas of conservation significance" and it is dedicated to umbrella and Lambeck's focal species. But this section also implied that these approaches can be used for selecting management areas and (see caption of Figure 1) for developing conservation plans (management plans I assume?). Also, wouldn't the indicator approach when applied to biodiversity (as described in section B) also fit in section A because it is used to define areas of conservation significance?

Appendix B. Line 1144. I believe (and I may be wrong) that a major piece of Lambeck's "focal species" concept was that one identified the species that were most sensitive to certain stressors (such as habitat fragmentation). This makes this approach quite different from the basic umbrella approach.

Appendix B. Line 1231. Again, the title of section A is confusing here. I have been reading this section expecting that umbrella species can be used to identify lands that if protected, would provide habitat for a much larger number of species.

Appendix B. Line 1230. It would be good to provide some examples of tests of the concept. See DeNormandie and Edwards (2002), for some good examples of when the umbrella concept has failed.

Appendix B. Line 1249. This line implied that the purpose of umbrella species is to "determine the vital components of functioning ecosystems". First, I don't necessarily agree with this. Second, if that is indeed one of the functions, why has it not been mentioned much earlier in this section?

Appendix B. Line 1255. This section on "indicator" species makes me realize that it might be good to discuss what surrogate species can be used as surrogates for (e.g., for environmental conditions, for the presence of other species, for the health of other species, for ecosystem function, etc.). This is not explicitly discussed anywhere.

Appendix B. Line 1326. I am still confused as to how this differs from some of the uses of umbrella species listed above in Section A. Also, biodiversity indicators, at least for reserve selection, don't seem to work all that well—with some exceptions (lots of papers could be cited here). I imagine that they would work even less well for assessing the impact of some action on biodiversity—is there evidence that they work well for this?

Appendix B. Line 1391. Is a Flagship species or an iconic species as you have defined them really a surrogate? What are they a surrogate for? This needs to be defined. I think they are a surrogate in the public eye for entire ecosystems, biomes, or biodiversity in general.

Appendix B. Line 1461. This section makes it sound like flagships and icons are NOT surrogates. If they are surrogates for ecosystems, biodiversity, etc… then one of the assumptions is that protecting or managing them will be beneficial to these other targets. If they are not surrogates for these things, what are they surrogates for? I understand that they are communication and education tools, but that does not make them surrogates. Why are they surrogates and for what are they surrogates?

Appendix B. Line 1474. What does this report say? Summarize it here in a sentence or two.

Appendix A. Line 484. This is not a definition of "conservation challenge." What is a conservation challenge?

Appendix A. Line 894. I would not define an ecosystem as a community. The latter has a specific ecological definition and using the term here could be confusing.

Appendix A. Line 1006. It would be good to specify how "representative species" differ from surrogate species.

Appendix C and D. It is unclear why these two examples should differ. The first sentence of each states the goal of the effort, but I do not see how they are different. Appendix D states "Region A of the USFWS and States B and C agree to use a surrogate species approach to develop a conservation design for Landscape X, so that it will function to support self-sustaining populations of plants, fish and wildlife, for the continuing benefit of society" and Appendix E states "Region A of the USFWS and States B and C agree use a subset of species to provide a simplified framework for planning landscape-scale conservation for Landscape X" The introductions to these two examples need to be much clearer about what the goals are and why they differ.

Reviewer 5 Response to the Charge to the Panel

This review is made challenging because the draft Technical Guidance does not in a recognizable sense of the word offer "guidelines." A reader might expect from guidelines a how-to manual, a step-down instructional guide, a helpmate to implement agency intent, maybe directions from the agency that could assist one in meeting program expectations. The draft Technical Guidance does not offer directions, operating instructions, or a programmatic road map in any sense.

The basic conservation approach, to which the surrogate policy is to be applied, is reasonably well described in *Strategic Habitat Conservation* (SHC) documents, and is recapitulated in the draft Technical Guidance. The guidelines offer a persuasive argument for the need to use surrogate species and measures in planning and assessment at larger spatial scales, where diverse ecological communities exist and species of concern are many. But, when it comes to actually "selecting a surrogate approach and the surrogate species associated with that approach" the guidelines default to guidance akin to saying -- just do it. They offer the following steps as guiding implementation of a surrogate approach.

- *Define the Conservation Goal and Challenges*
- *Select the Surrogate Approach(es)*
- *Establish Surrogate Species Selection Criteria*
- *Employ Available Decision Support Tools for Selecting Species*
- *Select Surrogate Species*
- *Develop Biological Objectives*

This list of surrogate program steps is unacceptably spare; and really it's not clear why the expanded list of ten process steps for selecting surrogate species put forward in an previous presentation by FWS -- *Draft guidance on selecting species for design of landscape-scale conservation* (dated July 2012 – see pages 9-18) – is not used.

http://www.fws.gov/landscape-conservation/pdf/DraftTechnicalGuidanceJuly2012.pdf

Even that expanded list falls short of articulating the necessary (obligatory) steps in the design of a conservation program expected to meet explicit programmatic goals and objectives – and needing to use surrogates to facilitate and enhance program effectiveness, efficacy, and accountability.

Surrogates are tools used to promote and service conservation goals and objectives. The identification of conservation goals and objectives is just the first step of several that precede selecting a "surrogate approach." The Technical Guidance should acknowledge that parsing a large, landscape scale conservation challenge into its operational elements is necessary before tools, like surrogates, which may be used in implementing and assessing a conservation plan, can be addressed. Before the need for surrogates can be ascertained, the multiple steps to a management plan need to be articulated. They include, but are not limited to: 1) stating the purpose and goals for the conservation plan, 2) articulating ecological (including species) objectives for resources management, 3) building a management decision-support capability, 4) developing management-focused conceptual models that describe how the natural systems being conserved operate, 5) compiling and assessing available information that will help guide management decisions, 6) constructing and refining hypotheses regarding how the ecological system(s) of concern operate and identifying uncertainties that will be addressed through adaptive management, 7) confronting and selecting from among existing and alternative (conservation) management actions that planners believe will benefit desired species and other ecosystem attributes, 8) selecting management action(s) for implementation, 9) identifying performance measures, and 10) designing monitoring scheme(s). The first eight demanding steps should precede, or at least accompany, the decision to use surrogates in conservation planning and assessments of program performance -- as management targets, or more frequently, as indicators or proxies in monitoring. Steps 2, 4, 5, and 6 establish the need for surrogates in a conservation program (including a program established to meet the intent of "strategic habitat conservation"); steps 9 and 10 employ surrogates when they are found to be needed.

The draft Technical Guidance on surrogates would benefit greatly from combining the steps from the FWS 2012 "guidance" with the sequence of steps listed above. That would produce a structured approach to strategic habitat conservation, and allow ready identification of the elements (or steps) that could benefit from application of surrogate species or measures. In turn, the draft Technical Guidance could describe (in limited detail) how surrogates contribute to the design of a large-scale conservation plan, the plan's (presumably adaptive) management agenda, and its monitoring schemes by identifying the specific requirements for and application of surrogates at each step of the multiple-step SHC planning and implementation process.

1. *Is the scientific foundation of the Technical Guidance clearly stated and logical? If not, please identify the specific methods and assumptions that are unclear or illogical and how it can be strengthened?*

A lack of clarity and logic attends the draft guidelines from start to finish. Absent a clear and concise statement of the explicit purpose(s) of the draft Technical Guidance in the preface and introduction -- the first three pages of the draft Technical Guidance state that the FWS envisions a number of laudable attributes for the Strategic Habitat Conservation (SHC) policy and the following pages document assertions about the value of surrogates -- a dozen pages into the document it is unclear what the intent of the draft technical guidelines is at all. At the point at which the document makes its own technical (scientific?) assertions regarding surrogates, it is not clear whether those points even matter. The Technical Guidance states that "*at a landscape, or ecoregional scale, the surrogate approach may be a practical way to model the complexity of the system and ensure many species and other key ecological features benefit from conservation activities*" (page 7). Model the complexity of the system? Well, that is not true. But, the guidelines state elsewhere that "*surrogates, rather, are a tool to be used to help attain the landscape conditions needed to support the species of conservation interest at the desired levels*" (page 8). Now that is true. Surrogates are tools used to facilitate management and monitoring where species of conservation interest are too numerous and/or difficult to measure. That statement belongs on page one with a clear description of how the "guidance" that follows provides a template for employing surrogates to assist in meeting conservation goals in landscape-level conservation planning efforts.

It is not a rhetorical question to ask what should be expected from "Technical Guidance"? One finds the words recommendations, instruction, direction, suggestion, rule, principle, measure, procedure, and other terms as ostensible synonyms for "guidelines," indicating that rather wide latitude should be given to this document; but it is reasonable to state that the draft Technical Guidance for review should be expected to provide some level direction or instruction in the employ of surrogates directly or by example; but they do not offer a glimpse of procedural guidance. Surrogates may be useful, even indispensible tools, in carrying forth conservation planning and implementing management, but the Technical Guidance document does little more than tell the reader that they can be useful and in a number of conservation planning contexts.

These guidelines are surely an appropriate vehicle by which the FWS should justify the explicit assertion that inferences drawn from the status of and trends in surrogates can usefully represent the status and trends of biological diversity at larger spatial scales. The guidelines should present a means by which data from and analyses involving fitness-related parameters can be used to validate the surrogate or surrogates selected to serve as proxies for some dimension of ecological health of an ecosystem, communities, or one or more species.

The general rationale for the use of surrogates in conservation planning at larger spatial scales is made in the draft Technical Guidance with reason and logic. And, fair argument is made in the guidance document (and the foundational *Strategic Habitat Conservation* documents) that at larger landscape scales surrogates or proxies will inevitably need to be relied upon to inform management decisions and as management targets. The guidelines draw support from several publications to make that defensible point. The technical guidelines on surrogates are limited to a description and defense of that conceptual assertion. But, a similarly acknowledged point made in many publications is given scant attention. Surrogates should only be used where they offer an indispensible service; where direct measures of programmatic targets cannot be made readily. The surrogate guidance should describe circumstances wherein surrogates are an appropriate default approach in conservation planning and assessment, and, importantly, where they are not.

The roughly written rationale for the surrogate approach, which is selective in its assessment of materials that support the use of the approach, is at the same time vague about how the approach might be actually implemented and unclear how the approach can and should be supported by best available science.

As discussed below, the technical challenge facing managers attempting to implement the surrogates approach in a program that facilitates "landscape-level conservation planning and implementation with a tractable number of species" (as described in question 7 below) rests in the development of a "validation procedure." For the Technical Guidance to guide implementation of the surrogate approach they need to draw from a US Fish & Wildlife Service presentation dated November 2012 (both that FWS presentation and the previous one cited offer clearer and more helpful guidance regarding SHC and surrogates than does the current draft Technical Guidance) --

http://www.fws.gov/mountain-prairie/science/documents/SSpecies%20Presentation%20Nov_5_2012.pdf

It seems essential that the Technical Guidance describes how conservation planners and managers "test the conceptual 'linkage' between the surrogate species and the species it represents, and not the management practices," "design the monitoring to test effectiveness of the approach," and "develop expected outcomes for both the surrogate species and the represented species" (see step 10 on slide 20). They currently don't. The Strategic Habitat Conservation Conceptual Diagram (slide 21) in the service's presentation parses the SHC into 12 activities, at least six of which are technically challenging, require data and analysis, and could use surrogate species and other surrogate measures. The cycle in the figure belies the impression given in appendices C and D that selecting-the-surrogates activities might largely involve an ad hoc vetting of lists of species.

The Technical Guidance does make some clear statements at the outset that are logical but simply not true. Among them –

A. *This document provides technical guidance for selecting and using* surrogate species *as measurable biological objectives in landscape conservation planning and management (page 1).* The document does not, but could and should, provide technical guidance for "using surrogate species." In its draft form it describes the merits of surrogates, several characteristics of effective surrogates, and a number of other attributes of a surrogates approach, but a surrogate selection process or implementation guidance for a program that uses surrogates is not in the guidelines.

B. *This guide also describes how to identify and choose among different surrogate species approaches, discusses advantages, limitations, and conservation applications of those approaches, and offers assistance in developing an adaptive approach (page 1).* The document offers criteria that might serve as a basis for identifying and choosing among approaches, but it does not in fact provide a guide to how such activities can be defensibly and successfully carried out; nor does it demonstrably provide "assistance in developing an adaptive approach." How to implement the intentions of the surrogate approach in the context of Strategic Conservation Planning is left to surmise, because the subsequent statement in the draft technical guidelines is not true. *The Strategic Habitat Conservation Handbook… provides details on the concepts and application of the technical elements of Strategic Habitat Conservation (page 4).* Yes, the Handbook explains the concepts behind the conservation strategy; but, no, it does not "provide details" on, or more appropriately guidance in, implementing or applying its "technical elements." Actual programmatic criteria for and implementation rules or procedures to realize SHC apparently do not yet exist (at least they are not available in any of the readily available programmatic documents). This point is important; if the means of implementing the intent of SHC has not yet been well articulated, then the surrogate (approach) tool in the conservation planning toolbox cannot find its use.

C. *Focal species are one type of surrogate species; this guide examines current scientific thinking on the use of a broader suite of surrogate species approaches and makes* *recommendations for when and how they can be used in Strategic Habitat Conservation (page 5).* The draft guidelines do not adequately nor comprehensively reflect "current scientific thinking," nor do they comport themselves consistent with that thinking, nor do they meet the stated "how they can be used" descriptor. How surrogate species can be "used" requires essential missing guidance that includes description of the demographic criteria upon which surrogate species selection can be based, the explicit purposes to which the surrogate will be used to inform management or monitoring, and a number of other salient technical elements essential to surrogate selection, implementation of surrogate-based management actions, and monitoring using surrogates species and measures.

2. *Do the authors of the Technical Guidance draw reasonable and scientifically sound conclusions from the scientific information presented in the document? Are there instances in the Technical Guidance where a different but equally reasonable and scientifically sound scientific conclusion might be drawn that differs from the conclusion drawn by the Service? If any instances are found where that is the case, please provide the specifics of that situation.*

Not dissimilar to the available literature, the Technical Guidance does not actually draw "scientific" conclusions from available "scientific" information. The standing literature on surrogates is better viewed as best professional judgment by conservation biologists organized to convey thoughtful considerations useful to management planners. There is technical information in the Technical Guidance, but not much in the way of direct findings drawn from studies informed by exercising the scientific method. An extensive literature on the use of surrogates (including indicators and a number of other applications of proxies to meet specific conservation goals) is reasonably represented in cited literature in the draft guidelines, but the several studies that have actually attempted to put the surrogate approach to the test or critically addressed the need for surrogates to be subject to validation procedures are not cited -- see

Caro, T., J. Eadie and A. Sih. 2005. *Use of substitute species in conservation biology.* Conservation Biology 19:1821-1826;

Wenger, S.J. 2008. *Use of surrogates to predict the stressor response of imperiled species.* Conservation Biology 22:1564-1571; and

Cushman, S.A., K.S. McKelvey, B.R. Noon, and K. McGarigal. 2010. *Use of abundance of one species as a surrogate for abundance of others.* Conservation Biology 24:830-840.

Each of those studies comes with warnings regarding implications of the inherent discordance in responses of surrogates and target species (including multiple species) of conservation concern. The analytical studies of surrogates can be viewed as rather negative regarding the potential effectiveness of surrogates, especially species, in representing species diversity at larger landscape scales or biodiversity more generally.

The draft guidelines draw from the literature warnings regarding the need to be conservative in the application of surrogates in conservation planning – "*surrogate species approaches need* *empirical evidence to demonstrate successful practical application; effective use of surrogate species requires precise and consistent use of concepts; the suitability of any particular surrogate species approach (e.g., umbrella, indicator, flagship) depends on the specific conservation goals/objectives of the application; and implementation of surrogate species approaches should involve stakeholders and land-use planners and include socioeconomic considerations"* (Page 8). In fact the more analytic treatments of the surrogate concept (including the several that attempt to engage data) are consistent in their message – surrogate responses to environmental stressors are unlikely to reflect accurately those of the conservation target(s), the use of surrogates should be a default response when no opportunity exists for direct measure of the targeted species (or other desired resources or resource conditions), and if a surrogate is to be used in conservation planning, its potential effectiveness and efficacy in the intended application should be confirmed through a (rigorous) validation procedure.

The draft Technical Guidance might consider Murphy and Weiland's (2014) message drawn from the contemporary literature on surrogates (and other proxies); they state – "[s]cholars have raised doubts regarding whether the assumption that information could be derived from surrogate species and measures, and used to substitute for information from a species that is actually targeted for conservation action is able to hold up in practice" (see, for example, Caro 2010). Murphy et al. (2011) warn that the "surrogate species concept does not have universal application and must be applied prudently" and note that the parsimonious conclusion from more than two decades of direct and retrospective studies is that at best weak concordance can be expected between the demographic responses of surrogates and listed species that are targeted by management actions. Landres et al. (1988) explored the premise that "an organism that responds to relevant environmental conditions in a manner similar to a target species, for which data are too difficult, inconvenient, or expensive to gather" could have reliable application in the U.S. Forest Service's "management indicator species" approach to land use planning, and concluded that the use of surrogates "fails on conceptual and empirical grounds." Lambeck (1997) warned that critical assessment of available data must be undertaken to ascertain whether the use of surrogates is necessary, justified, or logistically possible. Caro and O'Doherty (1999) offer that objective criteria from which surrogates are chosen need to be explicitly specified. Lindenmayer et al. (2002) observe that a surrogate-based approach to conservation planning is "data intensive and demands detailed information".

The most glaring absence in the Technical Guidance is a descriptive pathway that uses reliable knowledge and scientifically acceptable techniques to articulate clearly 1) the reasoning behind the selection of a surrogate, including describing the similarities in responses by the surrogate and target species, habitat, or conservation area to the same environmental phenomena, 2) linking demographic responses of surrogate species to the extent and condition of habitats or landscape areas of concern, and 3) describing the uncertainties that accompany the relationship between the status and trends of the surrogate and those of the conservation targets under common circumstances.

3. *Does the Technical Guidance provide sufficient examples of how surrogates have been successfully used to monitor population-level responses by agencies with mandates, goals, and programs similar to ours (FWS)?*

No the Technical Guidance does not provide sufficient or informative examples. But, it might be argued that no examples actually exist. If the Service believes that examples do exist they should be included, with salient details documented. The two appendices C and D purport to show "hypothetical examples of biological planning to select surrogate species," but these "examples" in substance and detail fall short of serving as models that parties looking for guidance in the application of surrogates in conservation planning can use.

Added for Clarification:

I'm not sure where in the document examples are offered. There is the strangely orphaned Table 1, which is not referenced in the narrative text. While I can't make any match of columns in the table, the presence of Meffe and Carroll (1997) suggests that the references don't constitute well-articulated examples – that citation is a textbook.

Under the header "Species to help define areas of conservation significance" are lines 1220-1226 (Appendix B, bullet #6), which assert "that this approach has been used to help design landscapes capable of supporting self-sustaining species populations," followed by 14 citations, but that does seem to engage the original question relative to "*sufficient examples of how surrogates have successfully been used*." If these citations are examples, then they should be presented as described in the next paragraph.

If the guidelines are going to point to examples of successful application of surrogates in landscape-level conservation efforts, then the document should identify the specific individual efforts, should describe how surrogates are used and to meet what specific goals, should draw from the cited material (or original documentation) evidence of the claimed "success," and should explain how the approach taken to identify the surrogates employed and their application has led to project "success." Otherwise readers of the guidelines are best informed by the observation that – when it comes to the use of surrogates in large–scale conservation planning, the jury is very much still out. Few examples of explicit applications of surrogates are in action, and none have actually run long enough for their performance to be ruled successful.

On a related point, the assertion in the draft Technical Guidance that -- "*most conservation researchers (*Caro 2010*;* Brock and Atkinson 2013*) identify 3 major categories of surrogate species approaches:*

1. *Selecting species to define areas of conservation interest;*
2. *Selecting species to document effects of environmental or management conditions; and/or*
3. *Selecting species to engender public support (page 21)*"

-- really garbles the central direction that the technical guidelines should take and steers the "surrogate" presentation further off the track. Yes, surrogates can be used to "document effects of environmental or management conditions" (although the terms in that pair of "conditions" effectively produce a non-sequitur). But, no, surrogates are not used to define areas of conservation interest; that makes no sense. Actual conservation targets, not surrogates, define areas of conservation interest. And, no, the surrogate species "concept" does not (or at least should not) be part of the selling of SHC. If charismatic species reside in the an area that will enjoy SHC, and a public relations initiative is warranted, then sell the species or resources that will sell the program, the conserved lands, and the management efforts. It is unclear how the central purpose of the surrogate approach pertains in eliciting public support for SHC. The categories above confuse the surrogate concept.

4. *Will the use of surrogate species, as described by the Technical Guidance, provide meaningful indices of population-level responses of sufficient resolution for priority species (species of conservation interest) at proper spatial and temporal scales? If not, are there changes that could be made to the Guidance to help achieve better results?*

If surrogate species as described in the Technical Guidance "provide meaningful indices," they will do so by coincidence. The guidance makes no attempt to engage demographic issues for species of conservation interest either as targets or surrogates. But it should; it needs to. In the draft surrogates rule (described below under question 5) the FWS similarly offered itself no guidance regarding species responses "at proper spatial and temporal scales," an essential element in SHC planning and in a surrogates approach to implementing the ESA. Murphy and Weiland (2014), drawing in part from Caro et al. (2005), suggest that should the FWS in its application of surrogates under sections 7 and 9 of the ESA desire to defend its use of surrogates as being based on "the best available scientific information" the FWS should promulgate several steps. Those steps can be made applicable to SHC and the surrogate guidance as follows. A SHC planning effort should --

A. Provide an explanation of the reasons why the direct assessment of a conservation area or target species cannot be measured and assessed. The justification for surrogate use should explicitly differentiate between ecological characteristics of the target species, its habitat, or a conservation area that impede data collection thereby making rigorous assessment not possible, and any logistical and practical challenges that present impediments to or inconveniences in surveys or sampling efforts.

B. Apply a structured, deductive process to match a prospective surrogate with the listed species, habitat, or conservation area employing available demographic and geographic information, inferences from other species, and experiences from conservation planning efforts elsewhere that have successfully or unsuccessfully engaged surrogate approaches.

C. Present a clear description of similarities and differences between the likely responses of the surrogate and the target species, habitat, or conservation area to salient environmental phenomena, along with identifying any uncertainties that may manifest as different responses to environmental stressors. This is the point at which the causal nexus between the surrogate and conservation target is acknowledged and critically examined. It may frequently be necessary to describe how data regarding the surrogate must be adjusted in order to allow for its use in the context of adaptive management and/or monitoring.

D. Articulate a means by which post-determination implementation and monitoring will be designed, using adaptive management to explore continuously the relationship and ecological relatedness between the surrogate and the targeted species, its habitat, or the conservation area, and the responses of both to environmental stressors that threaten or endanger them.

Should the technical guidance instruct practitioners to carry forth the steps above, the answer to the question above then would potentially be affirmative.

5. *Does the Technical Guidance do an adequate job of identifying potential pitfalls and shortcomings of the use of surrogate species?*

If the SHC program actually counts on this following statement being true, a pitfall surely awaits -- *Using a combination of surrogate approaches, and multiple species within approaches, increases the power of a surrogate approach to achieve landscape conservation (*Brock and Atkinson 2013*), as long as the criteria used and the reasons for selection of the surrogate are clearly articulated (page 25).* The power of the approach? What can that mean? The strength of any conservation plan rests its ability to understand and measure directly ecosystem processes, ecological community structure and function, the responses of targeted species of concern. Overlaying multiple surrogates and surrogate measures, with attending uncertainties as to the ability of each to reflect the status and trajectories of desired ecosystem, community, and species phenomena, does not enhance landscape conservation. The use of surrogates in landscape-level conservation is a default from direct measure, and not the first choice in management and monitoring.

To be consistent with the scientific literature on surrogates, the draft Technical Guidance should be frank about the shortcomings of surrogate approaches and applications. The FWS should repeat the burst of honesty about surrogates that it offered up six months ago. In a proposed rule issued in November of last year (Fish and Wildlife Service and National Marine Fisheries Service [2013] Incidental Take Statements, Proposed Rule, Federal Register 78:54,437-54,442) FWS identified eight cases in which the federal courts have overruled the agency involving the uncritical application of surrogate species or surrogate measures in implementation of the federal Endangered Species Act. It would seem that the guidelines would serve resource managers well if they provided guidance that would assist planners in avoiding surrogate applications that were found to be "scientifically" indefensible (arbitrary and capricious) in application under the ESA.

6. *Does the Technical Guidance base its interpretations, analyses and conclusions upon the best available science regarding the use of surrogate species? If any instances are found where the best available science was not used, please provide the specifics of each situation.*

Despite citations of useful references, which include observations and findings that fairly might be described as included in the "best available science regarding to the use of surrogate species," the guidelines stop short of explaining how that information is used in selecting and employing surrogates in support of conservation efforts. For example, the draft guidelines offer the accurate observation that "*once species of conservation interest have been identified, key aspects about each species should be summarized. This information should include, but is not limited to 1) life history traits, 2) habitat requirements for each life history stage, 3) limiting factors, 4) current range, and any existing projections associated with the selected planning horizon, 5) spatial requirements for a viable population (e.g., area, connectivity, configuration), 6) population objectives, if established, and 7) existing conservation and/or monitoring programs*." One or more of those "factors" may be in common between a conservation target and a candidate surrogate, maybe several factors. The Technical Guidance does not offer direction on how such information is used to decide whether a conservation policy or management action informed by a potential surrogate will adequately service the conservation needs of a target species, habitat, or geographic area – where best available science would actually be applied.

7. *Are there any significant peer-reviewed scientific papers that the Technical Guidance omits from consideration that would enhance the scientific quality of the document? Please identify any such papers.*

Banks, JE, AS Ackleh and JD Stark. 2010. The use of surrogate species in risk assessment: using life history data to safeguard against false negatives. Risk Analysis 30: 175-182.

Buchanan, R.A., J.R. Skalski, and A.E. Giorgi. 2010. Evaluating surrogacy of hatchery releases for the performance of wild yearling Chinook salmon from the Snake River Basin. North American Journal of Fisheries Management 30: 1258-1269.

Caro, T, J Eadie and A Sih. 2005. Use of substitute species in conservation biology. Conservation Biology 19:1821-1826.

Fleishman, E and DD Murphy. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. Conservation Biology 23:1109-1116.

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11:849-856.

Landres, P.B. 1992. Ecological indicators: panacea or liability? In: DH McKenzie, DE Hyatt, and VJ McDonald (eds) Ecological Indicators, Vol. 2. Elsevier Applied Science, London, pp. 1295-1318.

Landres, PB, J Verner and JW Thomas. 1988. Ecological uses of vertebrate indicator species: a critique. Conservation Biology 2:316-328.

Lindenmayer, DB, AD Manning, PL Smith, HP Possingham, J Fischer, I Oliver and MA McCarthy. 2002. The focal-species approach and landscape restoration: a critique. Conservation Biology 16:338-345.

Murphy, D.D. and P.S. Weiland. 2014. The use of surrogates in implementation of the federal Endangered Species Act – proposed fixes to a proposed rule. Journal of Environmental Studies and Science. [On line.]

Murphy, DD, PS Weiland and KW Cummins. 2011. A critical assessment of the use of surrogate species in conservation planning in the Sacramento-San Joaquin Delta, California (U.S.A.). Conservation Biology 25: 873-878.

Rowland, MM, MJ Wisdom, LH Suring and CW Meinke. 2006. Greater Sage Grouse as an umbrella species for sagebrush-associated vertebrates. Biological Conservation 129: 323-339.

Wenger, SJ. 2008. Use of surrogates to predict the stressor response of imperiled species. Conservation Biology 22: 1564-1571.

The draft guidelines would benefit from guidance derived from a growing literature on structured decision-making. It is reasonable to assert that SHC will only gain its intended traction when it is rigorously implemented in an adaptive management framework. A growing literature describes adaptive management, supported by structured decision-making, in terms and programmatic approaches that provide explicit process steps and activities that accommodate a surrogates approach – thereby placing the surrogate tool in an actual toolbox. FWS should consider these and many citations therein.

Diefenderfer et al. 2011. A levels-of-evidence approach for assessing cumulative ecosystem response to estuary and river restoration. Ecological Restoration 29: 112-134.

Murphy, D.D. and P.S. Weiland. 2014. Science and structured decision-making: fulfilling the promise of adaptive management. Journal of Environmental Studies and Science. [Online.]

8. *Given the reasons that the Service has outlined for the use of surrogate species (landscape-level conservation planning and implementation with a tractable number of species) are there other established methods for achieving these ends that do not involve the use of surrogate species? If so, please describe.*

No other ready means of meeting the purposes outlined in SHC documents is available. The Technical Guidance states that "*Strategic Habitat Conservation (Figure 1) relies on an adaptive management framework to identify the information, management actions, and monitoring needed to achieve conservation goals effectively and efficiently" (page 4)* and indicates that the program will use "*scientific information and predictive models to link work at project scales to conservation achievements on broader scales, such as landscapes, watersheds, major ecoregions, and entire species ranges" (page 5).* Both of these intents could be well served by an effective surrogates approach. However, in linking these overarching programmatic descriptors to the prospective surrogates tool, the Technical Guidance does little beyond stating why the surrogate approach is heuristically satisfying, and what distributional, ecological, life history, and other characteristics that potentially affect the effectiveness of a surrogate in action. One might reasonably expect surrogate guidelines to at least start to describe the "scientific information" and offer a categorical accounting of the "predictive models" that will be used in SHC planning and might employ the surrogate approach to good outcomes. If guidelines cannot or will not do that, then, the guidelines should give several well-articulated examples of where scientific information and predictive models have successfully been employed.

Added for Clarification:

No, there is not an obvious method for assessing the effectiveness and efficacy of "*landscape-level conservation planning and implementation with a tractable number of species*" beyond the use of surrogates, proxies, and indicators.

9. Any other comments?

See preface to the responses to the Charge to the Panel

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	*The comment refers to:* Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
1	Preface	3	49	This document	I believe FWS typographic standards are one space after periods. And paragraphs have space between, not 1st line indent
2	Preface	3	50	measurable biological objectives	Reviewer 3: Can a surrogate species be a measurable objective?
3	Preface	3	55	single surrogate approach	Reviewer 2: But it does prescribe the use of surrogate species rather than the use of environmental or process based surrogates. If that is not that case then more clarity is needed to be clear that surrogate methods other than the use of species have and continue to be used and evaluated in the conservation literature.
4	Intro	3	59	Fish and	I believe the standards are that this should always be an "&"
5	Intro	3	60	fish and wildlife	Reviewer 1: What about plants?
6	Intro	4	69	global warming	Reviewer 4: Change "global warming" to "climate change." The challenges faced are not just those posed by increasing global temperatures but rather by a wide range of climatic and climate related changes.
7	Intro	4	73	(Bottrill et al. 2006)	Reviewer 2: This is a very specific case study based on five NGOs in Kenya. I don't believe referencing that study here is adequate or representative.
8	Intro	4	90	systems and	Reviewer 1: Should this be "ecosystems with"?
9	Intro	5	89	Explicitly linking the work of individual programs and field stations to sustaining species, populations, and natural communities as parts of whole systems and their ecological functions and processes	Reviewer 3: This sentence does not read correctly.
10	Intro	5	93	achievements	Reviewer 1: May be more appropriate as "endeavours"?
11	Intro	5	92	Using scientific information and predictive models to link work at project scales to conservation achievements on broader scales, such as landscapes, watersheds, major ecoregions, and entire species ranges	Reviewer 2: what is a project scale, and how is the link between that and the broader scale made?
12	Intro	5	96	sustainable fish and wildlife populations and/or the habitat conditions that support them	Reviewer 2: Is this meant to be an example of an objective or of biology? Either way this isn't clear and is not a good example of a measurable objective.
13	Intro	5	109	Focal species are one type of surrogate species; this guide examines current scientific thinking on the use of a broader suite of surrogate species approaches and makes recommendations for when and how they can be used in Strategic Habitat Conservation.	Reviewer 2: It would be a significant benefit to the reader and users of this document if there is an explicit statement about the different kinds of surrogate approaches. For example it is implied later in the text that environmental factors and processes can be used as surrogates. There is a need for an explicit statement about the different surrogate approaches that this document is meant to encompass, at the moment that remains unclear, and it makes it difficult to determine
14	Intro to SS	6	121	Surrogate Species	Reviewer 2: There are some inconsistencies throughout the text that make the focus on surrogate species unclear. There is a lot of discussion about surrogate groups, which arguably are coarse-filter methods; and there is reference to the importance of environmental factors such as climate change and the identification of refugia (areas of stable environment) (an entire box is devoted to this topic). So while I appreciate that it is preferred to focus on surrogate species, there seems to be some inconsistency in the text that can lead the reader astray. Perhaps have a very clear paragraph about the additional surrogate approaches that will be touched on in the docment is necessary either here or above in the opening of the document.
15	Intro to SS	6	124	human population growth	Reviewer 4: I would argue that conservationists (with a few exceptions) have not generally worked on "population growth" per se. They have definitely looked at the effects of population growth at increasingly larger scales. I would suggest changing this to "land-use change."
16	Intro to SS	6	125	When conservation is planned for and carried out at larger scales, it is often easier to detect ecological patterns and population dynamics than when it is conducted within smaller geographic units	Reviewer 4: I would argue that one can identify limiting factors at both finer and broader scales—although I know the traditional description of hierarchy theory would agree with the phrasing here. Perhaps a citation would cover it. I am not so sure that the definition in the glossary agrees with the one associated with hierarchy theory—thus there may be a mismatch and my initial reaction may be appropriate.
17	Intro to SS	6	127	Working at larger scales improves the ability of conservationists to address limiting factors and achieve long-term benefits to species of plants and animals	Reviewer 2: This requires a reference.
18	Intro to SS	6	130	, it is impractical to plan and implement conservation for all species and their habitat requirements at larger landscape scales	Reviewer 2: This is incorrect. There are 1,000s of papers on the planning and implementation of actions based on conservation planning assessments aimed at maximizing the representation of as many species as possible.
19	Intro to SS	7	137	A surrogate species approach assumes that by carrying out management strategies that produce ecological conditions favored by a smaller set of species, the needs of a larger number of species will also be met	Reviewer 2: Reference needed.
20	Intro to SS	7	146	practical way to model the complexity	Reviewer 2: Surrogates aren't used to model complexity. What does this mean exactly?

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	The comment refers to: Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
21	Intro to SS	7	145	At a landscape, or ecoregional scale, the surrogate approach may be a practical way to model the complexity of the system and ensure many species and other key ecological features benefit from conservation activities	Reviewer 4: This is awkward. I believe the text here is supposed to say that landscape or ecological scales can be considered to be the “surrogate zone”. A second issue is that Wiens et al. (2008) don’t actually tie the surrogate zone to a particular size area (see their figure 4).
22	Intro to SS	7	148	At much larger geographic scales such as regional or continental levels	Reviewer 2: What is the difference between an ecoregion and a region? There needs to be clear definitions and sizes provided if this is a technical document.
23	Intro to SS	8	158	Wiens et al. 2008.	Suggest removing “can” from “Can consider each species individually”
24	Intro to SS	8	161	exhaustive	Reviewer 3: The literature is not ‘exhaustive’. Perhaps extensive?
25	Intro to SS	8	160	surrogate species in conservation planning is exhaustive	Reviewer 2: It is actually not exhaustive, and most recent studies highlight that the message that emerges from studies is ambiguous.
26	Intro to SS	9	175	all have limitations	Reviewer 2: These limitations should be unpacked here rather than being tucked away in the Appendix. There are a diversity of limitations associated with the approach. One of the greatest being that studies are equivocal as to whether focal species approaches work (see Nicholson et al. 2013).
27	Intro to SS	9	182	It is critical	Reviewer 3: The text box is redundant with the text and is not needed.
28	Intro to SS	10	195	number of priorities	Reviewer 4: Perhaps it goes without saying, but I would think effectiveness (not just cost-effectiveness) would be a criterion here.
29	Intro to SS	10	194	With cooperative planning at the landscape scale, there is often more than one goal and a number of priorities that need to be addressed.	Reviewer 2: Reference needed.
30	Intro to SS	10	197	urgency	Reviewer 1: And redundancy?
31	Intro to SS	10	196	Factors to be considered should include cost-effectiveness, risk, uncertainty, spatial and temporal scale, and urgency	Reviewer 2: Reference needed.
32	Intro to SS	10	198	A surrogate species approach should be used only when, due to budget limitations or other constraints, it is more likely to conserve a large number of species than alternative approaches that attempt to address each species individually.	Reviewer 1: I can think of situations where the surrogate approach might be the preferable starting point, to which other things are added. In other words, that large cores and corridors can be identified at landscape scale with a surrogate, but that by itself this is not sufficient. It is, nevertheless a good way to start evaluating the landscape.
33	Intro to SS	12	215	Table 1.	Reviewer 4: Umbrella species surrogates are described in Appendix B, but “Landscape” surrogates are not. What are these? A table like this could be quite useful if it were to have multiple rows listing many conservation goals (or management goals). In my comments about Appendix B, I have a similar comment—it would useful to see a full mapping of conservation goals to surrogate types.
34	Intro to SS	12	215	Land-scape	Reviewer 2: It would help to have landscape species surrogate rather than just landscape here. Otherwise it seems that the focus is on landscape characteristics rather than species.
35	Bio Plan	12	223	objective elaborates on a goal	Reviewer 4: This is a bit awkward. I don’t think a method has a goal—rather a method or approach can be used to attain a goal.
36	Bio Plan	12	224	The goal of the surrogate species method, as described in this document, is the conservation of functional landscapes capable of supporting self-sustaining populations of fish, wildlife, and plants for the continuing benefit of society.	Reviewer 2: This is not a quantifiable goal. How do you measure the conservation of all of these things? It would help to present the goal prior to this point and to also revise this goal to be quantifiable. I don’t see how you will ever be able to quantify this.
37	Bio Plan	13	241	any	Reviewer 1: This word is problematic. Using climate change as example, we don’t know what all changes might be. I think the sentence is strong enough without this word. Conversely, I think it’s ok further down in the pp.
38	Bio Plan	14	262	Logic and consistency.	Reviewer 4: I would say this consideration should be made when selecting the species, not after.
39	Bio Plan	14	268	, testing ecological models (conceptual or other) for the landscape	Reviewer 1: This is a bit vague, I see what is wanted here, but perhaps needs a citation with (e.g.***)
40	Bio Plan	16	Box 1	change.	Reviewer 1: Overly simplistic. Changes in biology can be: phenological, demographic, biogeographic, and indirect (e.g. disease outbreaks, changes in fire frequency). These can lead to turnover in community composition.
41	Bio Plan	16	Box 1	Box 1.	Reviewer 2: This seems out of place; while I agree that climate change is important when planning, I am not sure if this is the right place to bring this in. Also, it would seem that land use change would be equally as important of a consideration and also quantifiable at this scale; more easily than climate change.
42	Bio Plan	17	293	Although much information exists concerning the concept of landscapes, landscape-scale conservation, and landscape ecology	Reviewer 4: I would state that this is the definition of landscape that is being used in this document—not that it is a widely accepted definition of landscape. In the field of landscape ecology—a more general definition is often used that refers only to heterogeneity and pattern, and not to spatial scale. In fact on line 321 it seems like what are being referred to as landscapes are actually biomes or ecoregions. Although I realize the term landscape may be used differently in the Service than it is in the scientific literature, it would be better to be consistent. See definitions provided by Wiens or Turner.

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	The comment refers to: Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
43	Bio Plan	18	308	(See Figure Two)	Reviewer 2: I don't find Figure 2 helpful in terms of determining whether a surrogate will be effective or not. There is a dense literature on the effectiveness of surrogate species. There is a need for evidence and explicit examples that demonstrate the scale at which surrogates have been shown to be effective, and if possible, for which species this has been shown.
44	Bio Plan	19	321	and funding sources.	Reviewer 2: It would be helpful to provide references to support these points (i.e., each bullet in the list); otherwise they could have just been chosen randomly.
45	Bio Plan	19	322	Omernik Ecoregion	The EPA/CEC has updated this classification system. May want to update this reference to the CEC 1997 reference at least and the website http://www.epa.gov/wed/pages/ecoregions.htm
46	Bio Plan	19	323	system (Omernik 1987)	Reviewer 1: This seems insufficient guidance. If this is intended for a national audience, then there are the Bailey ecoregions, and the work done by US Forest Service (http://www.fs.fed.us/rm/ecoregions/). If international then there are numerous additional considerations including previously defined global conservation priorities, including Margules & Pressy (Nature 2000) and Brooks et al. 2006 (Science).
47	Bio Plan	19	322	Absent other suitable geographic schemes, first consider using the Omernik Ecoregion classification system (Omernik 1987) to promote connectivity among selected landscapes. Geographic boundaries may need to be adjusted to maximize effectiveness based on insights gained as the process unfolds (e.g., during the selection of surrogate species).	Reviewer 2: These ecoregions are framed for terrestrial species; what is the suggestion then for freshwater dependent species? Arguably hydrological units such as those developed by USGS for their watershed boundary dataset would be the most useful units as they scale with eachother and would allow the end user to chose between different hydrological scales. See here: http://water.usgs.gov/GIS/huc.html
48	Bio Plan	19	326	Critical Participants:	Reviewer 2: Arguably participants should also include those who have alternative objectives that could have negative influence on the success of the program.
49	Bio Plan	19	332	Temporal Scale:	Reviewer 4: This section doesn't actually give much guidance on how to select a time horizon. For example, what are the ecological and sociological considerations that should be taken into account? How does climate change affect the planning horizon?
50	Bio Plan	19	334	Furthermore, since this is part of an adaptive management process	Reviewer 2: The vein of adaptive management doesn't run clearly through the document. It would be helpful to present a figure of the adaptive management process front and center for the reader and to then unfold the elements that should be given consideration as they they go through this process.
51	Bio Plan	20	360	Conservation of many of these species may ultimately be addressed through efforts devoted to surrogate species chosen later in the process. However, it is important to clearly define all species of conservation interest first, since the conservation challenges and desired outcomes identified for the landscape are related to this larger group of species, not	Reviewer 2: Could these species act as surrogates as well? Given their high profile and in some cases large ranges they could arguably be surrogates themselves. It would be helpful to provide guidance on that here.
52	Bio Plan	21	364	The surrogates, rather, are a tool to be used to help attain the landscape conditions needed to support the species of conservation interest at the desired levels. Once species of conservation interest have been identified, key aspects about each species should be summarized. This information should include, but is not limited to:	Reviewer 2: This could also be used to determine if the species of conservation interest could act as surrogates, is that what is being suggested here? If so it needs to be made more clear. Also, as this is a technical document it would really help the reader to have specific references to turn to that provide evidence for these criteria being used, and whether or not they are effective.
53	Bio Plan	21	375	Characterization of the Landscape:	Reviewer 2: A statement needs to be made that in some cases data on many of these factors is not likely to be available. Then perhaps a suggestion about what to do if such data aren't available and if decisions should be made based on best available data.
54	Selecting	22	396	To identify the best-fitting surrogate approach(es) and corresponding surrogate species, it is vital to clearly define how they will be used to help achieve conditions on the landscape needed to support the species of conservation interest. Each surrogate approach and set of surrogate species selected will be unique to the conservation goals and challenges for a given landscape.	Reviewer 2: Overarching question. Why is there a need for surrogate species if you are interested in a particular species of interest? Surely the first question should be does that species itself act as a surrogate for archiving conservation outcomes for other species. If it doesn't then the question should be should whether we focus effort on other species that would provide benefit to the species of conservation interest as well as other species.
55	Selecting	22	402	Define the Conservation Goal and Challenges	Reviewer 2: It was stated above that goals need to be stated beforehand. Why are we now restating goals here?
56	Selecting	22	403	Select the Surrogate Approach(es)	Reviewer 3: The actions required to select a surrogate approach and surrogate species are given and include selecting the surrogate approaches (line 403) and selecting surrogate species (line 406). The actions are redundant with the goal.
57	Selecting	22	409	Under the Strategic Habitat Conservation framework, the goal is conservation of populations of fish and wildlife and the ecological functions that sustain them (U.S. Fish and Wildlife Service and U.S. Geological Survey. 2006). In this guide, that goal has been re-stated as "functional landscapes supporting self-sustaining populations of fish, and wildlife and plants for the continuing benefit of society." For the purposes of selecting a surrogate approach, this can be simplified as "sustainable populations of species of conservation interest."	Reviewer 1: This is much more explicit than the wording in the introduction. Suggest that some of this be stated up top, in addition to here. My comments on inclusion of plants at the beginning could possibly be ignored if this language is more explicit from the beginning.

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	The comment refers to:			Original Text	Reviewer's Comment
	Section	Original Page #	Original Line #		
58	Selecting	23	414	"sustainable populations of species of conservation interest."	Reviewer 2: This is not a quantifiable goal. It could be if you knew the existing population size and aimed to maintain x% or the entire population; which would need to be explicitly stated.
59	Selecting	23	416	These conservation challenges help define the components of the landscape needed to support those species, and help in the selection of the surrogate approach and the surrogate species. Although not measurable, these challenges help clarify expected achievements.	Reviewer 2: Again. The challenges could be measureable, and why not give consideration to measuring the challenges in such a way that informs the planning and implementation process. Arguably if there are challenges that can't be measured that should be a red flag in the adaptive management process.
60	Selecting	23	420	Select the Surrogate Approach:	Reviewer 2: The selection of the surrogate approach should be dependent on the objective at hand.
61	Selecting	23	420	Most conservation researchers	Reviewer 3: States that "most conservation researcher identify 3 categories of surrogates" but then only two papers are cited. It would be safer to say something like, "We concur with (citations) in recognizing three categories of surrogate species."
62	Selecting	23	421	surrogate species approaches	Reviewer 4: As I mention in my comments on Appendix B, somewhere it would be good to discuss what the surrogate species are surrogates for. Surrogate species will be surrogates for different things given the different approaches. I would call these "categories of approaches" uses of surrogate species. Would species that are monitored to assess the general condition of other species fall into category 2? I think so, given the definition in Appendix B, but that definition seems to be limited to investigating the effects of management activities or to using the species as surrogates for some environmental condition.
63	Selecting	23	421	species approaches:	Reviewer 1: I think there is another- which are umbrella species. These can be used to define the area of conservation interest. However, they are also assumed to be representative of the habitat needs for other species. While these are similar, they are not the same. See Thorne et al. 2006; and subsequent that cite including Epps et al. 2011 & Lewandowski et al. 2010; So, suggest changing to 4, and include umbrella species here.
64	Selecting	23	428	In most cases the surrogate approaches selected for Strategic Habitat Conservation will help define landscape conditions such as habitats, features, and processes needed to support species of conservation interest	Reviewer 3: The sentence starting "In most cases…" seems to have the logic reversed. Selection of surrogate species should not define the important landscape conditions needed for other species. The needs of the other species should determine the needed conditions.
65	Selecting	24	436	Species Selection Criteria:	Reviewer 2: It would be valuable to the reader if the information presented were divided up in each section by the different surrogate approaches that could be considered.
66	Selecting	24	438	The next step is to establish surrogate species selection criteria that are specific to the surrogate approach selected and to the way surrogates species	Reviewer 3: Plural singular disagreement on line 438
67	Selecting	24	436	The next step is to establish surrogate species selection criteria that are specific to the surrogate approach selected and to the way surrogates species will be used to help address the conservation challenges on the landscape	Reviewer 2: References are need here. Also, as stated before, it would be more useful to the reader if the elements in Appendix B are unpacked in a way that is digestable for the reader. It would also help to have that information front and center as this is a technical document and any specific details are needed to make an informed decision about what are the best practices available.
68	Selecting	24	446	Criteria for selecting surrogate species	Reviewer 4: Isn't the most important criterion that the surrogate is representative of other species—with respect to how it responds to stressors, what habitat it needs, etc. Perhaps this is what is captured by the 4th bullet? However, this seems to be the biggest hurdle to successfully using surrogates.
69	Selecting	24	447	surrogate species may	Reviewer 2: It is stated consistently that environmental elements or processes could act as surrogates, however there is also the consistent reference to "surrogate species". Perhaps it is most accurate to not use surrogate species as a catch all phrase and rather use surrogate approach or just surrogate.
70	Selecting	24	448	population objectives	Reviewer 2: What is a population objective? This needs to be explained better.
71	Selecting	24	448	If not, that species cannot be used as a surrogate.	Reviewer 1: This is a rather final statement. Is it possible to rephrase to indicate more work needed before it can be used? Or that it is not optimal?
72	Selecting	24	452	demands are equal or greater	Reviewer 3: What are greater demands? More specific/restricted habitat requirements? Highly specialized species would seem less likely to provide surrogacy for other species. Or does greater demands mean broader requirements? Such species may not be as sensitive to change as more restricted species.
73	Selecting	25	456	Decision Support Tools for Selecting Species	Reviewer 2: Again here it is suggesting that only species would be used as surrogates but it has been stated before that surrogates could be environmental elements or processes. There needs to be consistency in the document. There needs to be much greater detail about how these approaches unfold. How does one use multivariate statistics to identify groups that are likely to be most representative? If this is an approach that is being suggested, it would also help to have more than one reference used throughout the document. While it supports the idea of surrogacy that reference alone does not unpack how multivariate methods could be used to identify groups of surrogates nor does it interrogate the effectiveness of using such groups to make management decisions.

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	*The comment refers to:* Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
74	Selecting	25	457	Decision support tools	Reviewer 2: Multivariate statistics are not a decision support tool. It would benefit the reader to provide explicit examples of these tools. It is otherwise impossible to understand or distinguish from this paragraph what those tools might be. The use of metapopulation models has also been shown to be effective at identifying focal species (see Nicholson et al. 2013).
75	Selecting	25	462	Conceptual or quantitative models	Reviewer 4: Some examples of these or at least some citations would be useful.
76	Selecting	25	462	Conceptual or quantitative models generating ranks or "best fits" by combining criteria with data inputs from landscape assessment and species of conservation interest;	Reviewer 2: Please provide a reference for this and give more detail as to how this is done. Also, to my knowledge this is a set of decision rules not a decision support tool.
77	Selecting	25	464	Multivariate statistical methods	Reviewer 4: Again, more detail is needed here. Please provide an example of how one would use a multivariate approach to select species.
78	Selecting	25	466	Select Surrogate Species:	Reviewer 2: This section requires more information and evidence, including references to other methods and approaches that have been shown to work for selecting focal species.
79	Selecting	25	474	Several migratory bird species might be eliminated as potential surrogates either because there are limited data available for them or because they are too costly to monitor effectively	Reviewer 3: sentence is too vague. What criteria? How developed? This whole document is supposed to tell specifically how to develop such criteria. More specifics are needed.
80	Selecting	26	486	established selection criteria	Reviewer 2: What would the selection criteria be? It is really important given that this is a technical document to give more explicit examples.
81	Selecting	26	497	combination of surrogate approaches	Reviewer 4: However, as defined in Appendix B—the three surrogate approaches are used for very different purposes (selecting conservation areas, assessing environmental condition or effects of management action, and building public support). Occasionally, one might be doing more than one of these things, but it seems like often, one would be focused on a single objective and a single approach.
82	Selecting	27	Box 6	Box 6.	Reviewer 2: Just with the previous box on climate change, this is out of place. Why is this box here? It seems that the issue of climate change deserves greater attention, and unpacking the potential value of using refugia as a surrogate of important areas for conservation action also requires more discussion.
83	Selecting	27	Box 6	Selecting Surrogate Species	Reviewer 2: All of the text in this box requires support from references as this is by no means the first time this has been said. There is extensive literature in the last 5 years about the potential importance of protecting refugia in the landscape and what it means for the retention of species in the landscape under climate change. In addition, terminology like refugia should be defined just as other terms used throughout the document that might not always be known to the reader.
84	Selecting	27	503	provide a more robust biological foundation for conservation planning.	Reviewer 1: Although, there would come a point where the use of more traditionally labeled 'focal species" would equal the number of surrogates. So this assertion is less "new" than perhaps the authors are suggesting.
85	Selecting	27	501	In most situations, for one surrogate approach, suites of surrogates species (Sanderson et al. 2002) based on multiple criteria (Lambeck 1997; Fleishman et al. 2000; Sanderson et al. 2002; Seddon and Leech 2008) provide a more robust biological foundation for conservation planning.	Reviewer 2: Some of these references are applicable to number 4 as well. For example, Fleischman et al. 2000 specifically identify methods for the selection of umbrella species.
86	Selecting	28	506	. Develop Outcome-based Biological Objectives	Reviewer 2: The objective should be established prior to the selection of surrogates. Without knowing the objective at hand, how can assessments of surrogates be conducted? This step should be combined with Step 3 and 4 and come before the selection of surrogate species. This Step (6) should help guide the criteria used to identify surrogate species and there is text in this Step 6 that describe methods and ways that people and groups have used in the past to select surrogate species, and so complements and strengthens the weaker presentation of methods in Step 4.
87	Selecting	28	506	6. Develop Outcome-based Biological Objectives:	Reviewer 1: This section 6 is a nice review of different approaches to outcome-based biological objectives. However, it reads very much as out of a straight conservation manual. I think you need to tie the three approaches back to the surrogate approach. This could be done by setting a little more context at the beginning of section (just above the 3 examples), or by adding a paragraph after the three examples that discusses whether or not there are any differences to consider when using surrogates instead of multiple species.
88	Selecting	28	513	Population objectives can be expressed as abundance, trend, vital rates and/or other measurable indices of a species' population status (Andres et al. 2012).	Reviewer 2: See Nicholson et al. 2013 for an interesting approach using metapopulation model to estimate extinction risk

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	*The comment refers to:* Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
89	Selecting	28	517	For example, most waterfowl species are represented by the North American Waterfowl Management Plan population objectives (North American Waterfowl Management Plan, Plan Steering Committee. 2012). These objectives are based on duck population levels measured in the 1970s, a time when these populations were considered to be at desirable levels (i.e., provide adequate harvest). Partners in Flight (Rich et al. 2005) generally set objectives for landbirds based on population numbers measured at the beginning of the Breeding Bird Survey in the mid-1960s.	Reviewer 2: This is a great example. However, where was the approach shown to be effective? It would benefit the reader to know if there is evidence that such baseline methods are useful.
90	Selecting	29	531	This ensures that compatible population objectives for shared surrogate species on different landscapes can be “rolled-up” to meaningful measures at the national or continental scales, a step necessary to enhance the ability for assessing progress toward range-wide objectives and stated conservation goals.	Reviewer 1: Suggest to split this sentence into 2. There are many terms/jargon that allow for several different interpretations.
91	Species	32	598	Species Requiring Individual Attention	Reviewer 2: This section should be above and is something I had noted as being needed, seeing it here makes me feel better about the potential/consideration of using species of conservation importance as surrogates as well. I think that this text would be most valuable in the “Selecting the Surrogate Approach and Surrogate Species” section above. Moving it there would improve the flow of thought as readers are likely to wonder why species of conservation importance couldn’t be used as surrogates.
92	Species	32	616	sustain this species.	Reviewer 1: We expect diseases and pathogens to become more prevelant under climate change. This is already being seen in many forest pests. Perhaps add a sentence to this section suggesting this phenomenon will become more prevalent.
93	Species	33	620	Species of Greatest Conservation Need	this is not the first time this term comes up. the link should be with the first use.
94	Conclusion	35	644	In the 21st Century, the conservation community is faced with unprecedented environmental, socio-economic, and fiscal resource challenges	Reviewer 2: Reference needed.
95	Conclusion	35	647	It is necessary to work at ecologically meaningful scales, across boundaries and borders, and throughout the ranges of these species, while actively collaborating with other individuals and organizations that have a stake in the conservation of wildlife and their habitats.	Reviewer 2: Again reference needed. This paper by Groves says essentially the same thing. Groves, C., D. Jensen, L. Valutis, K. Redford, M. Shaffer, J. Scott, J. Baumgartner, J. Higgins, M. Beck, and M. Anderson. 2002. Planning for biodiversity conservation: putting conservation science into practice. BioScience 52(6):499-512.
96	Conclusion	35	652	A strong biological foundation allows us to move forward with confidence that our conservation activities are grounded in scientific planning, that decisions, theories, and thought processes are well-documented and transparent, and that we can learn from the results of our actions and be held accountable for them	Reviewer 2: This has surely been said in existing adaptive management literature, please provide an adequate citation to support this statement.
97	Conclusion	35	656	This document also acknowledges that the science of surrogate species is evolving. Therefore, following the adaptive management framework	Reviewer 2: To me the document has not done a good job of linking these two elements, and I have noted several ways this could be improved.
98	App A	41	847	Conservation Challenge	Reviewer 4: This is not a definition of “conservation challenge.” What is a conservation challenge?
99	App A	43	892	Ecosystem	Reviewer 4: I would not define an ecosystem as a community. The latter has a specific ecological definition and using the term here could be confusing.
100	App A	46	955	Landscape Species	Reviewer 2: Landscape species are not clearly highlighted in the document text. This actually led me astray in my reading of Table 1 as I had found myself thinking the reference to landscape surrogate in the table implied the use of environmental factors rather than landscape species. Make this explicit in the table and bringing in more discussion around the types of surrogate species used would really help the reader in the opening part of the document.
101	App A	47	986	, measurable (SMART)	Reviewer 3: The definition of a biological objective begins, “A concise, measurable (SMART) statement...”. But SMART includes specific, measurable, achievable, results-oriented, and time-relevant. So if you say something is a measurable (SMART) statement, it is, measurable, specific, measurable, achievable, results-oriented, and time-relevant statement and thus it is redundant.
102	App A	48	1005	Representative Species	Reviewer 4: It would be good to specify how “representative species” differ from surrogate species.
103	App B	53	1099	Appendix B	Reviewer 2: Appendix B should be integrated better within the text and used to highlight the limitations of approaches and complexities associated with different types of surrogate approaches. Given that this a technical document, It would seem to benefit the reader more if these elements were integrated into the make document rather than here.

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	*The comment refers to:* Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
104	App B	53	1099	Appendix B	Reviewer 4: This appendix is definitely needed (in fact I think its contents should be moved to the main text), but it is rather confusing and poorly organized. First, there is not a clear distinction between the approaches and their uses. This Appendix needs to start with a list of the approaches. It would also be nice to see a list of applications – perhaps these could be in a table together so the reader could clearly see which approaches were appropriate for which applications. I would also prefer that the following subsections (A., B., and C.) be organized by either the approach or the use. The appendix seems to make the statement that each approach is tied to a specific use. I think that is true to some degree, but as I note below, I don't see this as necessarily being the case. Why not make the subheadings A. Umbrella Species, B. Indicator species, and C. Flagship species?
105	App B	54	1139	Species to help define areas of conservation significance	Reviewer 4: This section is titled "Species to help define areas of conservation significance" and it is dedicated to umbrella and Lambeck's focal species. But this section also implied that these approaches can be used for selecting management areas and (see caption of Figure 1) for developing conservation plans (management plans I assume?). Also, wouldn't the indicator approach when applied to biodiversity (as described in section B) also fit in section A because it is used to define areas of conservation significance?
106	App B	54	1145	"focal species	Reviewer 4: I believe (and I may be wrong) that a major piece of Lambeck's "focal species" concept was that one identified the species that were most sensitive to certain stressors (such as habitat fragmentation). This makes this approach quite different from the basic umbrella approach.
107	App B	57	1189	this approach	Reviewer 2: Which approach?
108	App B	57	1199	Intended Outcome	Reviewer 2: Again I think that this text is redundant with the section on Selecting Surrogate Species and it would actually be more helpful to the reader if the core of this information were moved to the main text and any redundancy be removed. For example, this list is already provided in the main text so doesn't really need to be presented here again.
109	App B	58	1228	Drawbacks	Reviewer 2: Again text like this is really critical in a document aimed as a technical guideline, and consideration should be given to moving this to the main text so that the users of the document can readily see the drawbacks and strengths of different approaches as has been shown in existing literature.
110	App B	58	1229	Many criticisms	Reviewer 4: It would be good to provide some examples of tests of the concept. See DeNormandie and Edwards (2002), for some good examples of when the umbrella concept has failed.
111	App B	58	1230	"umbrella species"	Reviewer 4: Again, the title of section A is confusing here. I have been reading this section expecting that umbrella species can be used to identify lands that if protected, would provide habitat for a much larger number of species.
112	App B	59	1248	the vital components	Reviewer 4: This line implied that the purpose of umbrella species is to "determine the vital components of functioning ecosystems". First, I don't necessarily agree with this. Second, if that is indeed one of the functions, why has it not been mentioned much earlier in this section?
113	App B	59	1255	types of surrogate species approaches	Reviewer 4: This section on "indicator" species makes me realize that it might be good to discuss what surrogate species can be used as surrogates for (e.g., for environmental conditions, for the presence of other species, for the health of other species, for ecosystem function, etc.). This is not explicitly discussed anywhere.
114	App B	62	1325	D. Biodiversity Indicators	Reviewer 4: I am still confused as to how this differs from some of the uses of umbrella species listed above in Section A. Also, biodiversity indicators, at least for reserve selection, don't seem to work all that well—with some exceptions (lots of papers could be cited here). I imagine that they would work even less well for assessing the impact of some action on biodiversity—is there evidence that they work well for this?
115	App B	64	1362	Ayesha citation	Missing citation
116	App B	65	1391	Flagship or iconic species	Reviewer 4: Is a Flagship species or an iconic species as you have defined them really a surrogate? What are they a surrogate for? This needs to be defined. I think they are a surrogate in the public eye for entire ecosystems, biomes, or biodiversity in general.
117	App B	68	1459	Species used as flagships	Reviewer 4: This section makes it sound like flagships and icons are NOT surrogates. If they are surrogates for ecosystems, biodiversity, etc… then one of the assumptions is that protecting or managing them will be beneficial to these other targets. If they are not surrogates for these things, what are they surrogates for? I understand that they are communication and education tools, but that does not make them surrogates. Why are they surrogates and for what are they surrogates?
118	App B	68	1473	survey commissioned	Reviewer 4: What does this report say? Summarize it here in a sentence or two.

Reviewer's Comment Matrix
Peer Review of Draft Technical Guidance for Surrogate Species

Comment #	*The comment refers to:* Section	Original Page #	Original Line #	Original Text	Reviewer's Comment
119	App B	68	1475	Keystone species	Reviewer 2: Again, this type of information, at least to me as a reader, would be most useful in the main text, if not in full at least in summary form to provide me the reader with an understanding of different species surrogates and their limitations.
120	App C	74	1694	Appendix C	Reviewer 4: . It is unclear why these two examples should differ. The first sentence of each states the goal of the effort, but I do not see how they are different. Appendix D states "Region A of the USFWS and States B and C agree to use a surrogate species approach to develop a conservation design for Landscape X, so that it will function to support self-sustaining populations of plants, fish and wildlife, for the continuing benefit of society" and Appendix E states "Region A of the USFWS and States B and C agree use a subset of species to provide a simplified framework for planning landscape-scale conservation for Landscape X" The introductions to these two examples need to be much clearer about what the goals are and why they differ.
121	App C	77	1772	demanding.	Reviewer 1: This appears to be the same graphic used previously. For a publication, you might consider re-doing this image to fit the scenario?
122	App D	83	1933	A data and document management tool is developed to track all of the information considered and the associated decisions.	Reviewer 1: This represents a lot of capacity. It's ok for a scenario, but perhaps some modification to the language in this sentence such as, "Seed funding permitted development of a data and document management tool, to track…".
123	App E	88	2114	Additional Considerations	Reviewer 1: I think you are missing language about how non-governmental groups can engage in this process. In fact, many NGOs (and other government bodies not mentioned here such as county conservation efforts). If there is not language in the book about the preferred way that these bodies can move forward, then there is a risk that they will operate independently.

Comment Response Matrix - Reviewer Responses
Draft Summary Report on Peer Review of Technical Guidance for Surrogate Species

The comment refers to: Comment #	Reviewer #	Question #	USFWS Comment on Individual Reviews	Response from Reviewer
1	1	3	Specific example of the organization and surrogate species approach	I mention that there are community-driven and county level conservation efforts, but did not mean to imply that those are using surrogate species for monitoring. So, what I meant was for the authors to consider describing how such an approach might be useable for groups beyond the US FWS. In California, county/federal efforts include Habitat Conservation Plans and California Natural Community Conservation Plans (https://www.dfg.ca.gov/habcon/nccp/). In some cases these plans take a long time to develop and communities have pushed the process, such as in Orange County, where mitigation for transportation projects was seen as opportunity to obtain conservation lands, and a round table approach to identifying which lands to pursue was used. (https://www.dfg.ca.gov/habcon/nccp/status/OrangeTransport/). There are other conservation efforts that are either outside federal guidance altogether, or that represent consortiums of groups that seek to implement conservation & restoration of other lands. An example of a nonprofit group class are land trusts, which typically function at the county or smaller level (e.g. Santa Cruz County Conservation Blueprint (http://www.landtrustsantacruz.org/blueprint/). An example of the consortium is the Conservation Lands Network in the Bay area, which was developed with over 30 groups, and peer-review process headed by non-profits, but with many agencies participating (http://www.bayarealands.org/explorer/). The point is that these types of localized efforts do not yet typically have the use of surrogate species for monitoring on their radar. In some cases groups are using umbrella species for modeling the location of desired conservation lands, and there are instances of land purchases and easements justified by this approach. However, follow-up monitoring, particularly for easements, is typically weak if done at all. Therefore, to help these groups engage with the idea that using surrogates for monitoring, a hypothetical example would be useful. I guess if a real example were needed, then mountain lions in southern California might be appropriate. Some corridors have at least been identified, and some cats in 2 studies that I am aware of have been collared and data being used to determine where/what habitats the cats are typically using (and where they are getting into trouble).
2	2	1	Not clear if all undefined terms and needed examples are identified by the reviewer in comment 1b	I was highlighting the need for them to define particular terminology, because there were a variety of words that are not defined. It is their responsibility to define terms and all examples as part of the revision process.
3	3	2	Rationale and examples are given in the preceding comment; this assumption needs clarification	See answer to Question 1 for additional explanation.

Comment Response Matrix - Reviewer Responses
Draft Summary Report on Peer Review of Technical Guidance for Surrogate Species

The comment refers to: Comment #	Reviewer #	Question #	USFWS Comment on Individual Reviews	Response from Reviewer
4	3	6	(2nd paragraph) Not clear that commenter's stated intent of guidance actually occurs in the document; requires clarification	A question was raised as to where I read that "the intent stated in the Draft Technical Guidance is to use population abundances and trajectories of one species to represent the species of conservation interest…" The Service indicates that if I took this as a premise of the guidance that I had misinterpreted or misread document. They then indicate that the guidance includes multiple surrogate approaches beyond just surrogate species and they provide guidance for more than one surrogate species approach. First, I did read the document to be about surrogate species. The title, "Technical Guidance on Selecting Species for Landscape Scale Conservation," was the first indication that it was about species, not all surrogate approaches. The first sentence in the STG, "This document provides technical guidance for selecting and using surrogate species as measurable biological objectives in landscape conservation planning and management," further indicated that the guidance focused on surrogate species. I see in Box 6 that there is a statement that "Conservation planning surrogates can be species or other features of the environment, like geophysical settings." I agree that the document does not prescribe a single surrogate species approach. Yet it is overwhelmingly focused on the premise that population abundance and trajectories of the surrogate reflect those of the species of interest. Although different methods of selecting species are described the text reads such that population abundance and trajectories are the measures of interest. Examples supporting this impression are given below. Section 6 (Developing Outcome-based Biological Objectives) focuses specifically on population objectives that " can be expressed as abundance, trend, vital rates and/or other measurable indices of a species' population status…" It is true that multiple methods of setting population objectives are provided – but all objectives for the surrogates are framed as population objectives. Appendix B compares different surrogate species approaches and then in the monitoring section for umbrella species states "You will need to monitor population viability of the surrogate species and, maybe to a lesser extent, all of the species that the surrogate is intended to protect, at least initially, to test efficacy of the approach." The monitoring section for indicator species also emphasizes poulations: "You will need to monitor population trends and demographies of the indicator over time in relationship to anticipated stressors. Also need to monitor the species or landscape attribute represented by the surrogate to test whether the indicator is in fact acting as a surrogate (if this relationship has already been verified in the literature, then monitoring to test this assumption might not need to be as intensive)." I agree that the section on flagship species does not focus on population abundances or trajectories. In Appendix C, line 1799, the STG states: "Black bear – most demanding of area and connectivity of this landscape, managing for viable populations of black bear will accommodate the area and connectivity needs of: deer, elk, owls, breeding habitat for migratory birds, salamanders, ferns, butterflies, …" Lines 1995-1998 state, "Once the surrogate species have been selected, associated population objectives are also needed to define the scope of subsequent conservation efforts, and subsequently measure progress. For Landscape X, a series of expert panels is convened to define the following associated population objectives for each surrogate species within Landscape X…(table of population values given)"
5	4		No comments	n/a
6	5	3	Why and how do the examples indicated fall short?	What examples exactly? I'm not sure where in the document examples are offered. There is the strangely orphaned Table 1, which is not referenced in the narrative text. While I can't make any match of columns in the table, the presence of Meffe and Carroll (1997) suggests that the references don't constitute well-articulated examples – that citation is a textbook. Under the header "Species to help define areas of conservation significance" are lines 1220-1226 (Appendix B, bullet #6), which assert "that this approach has been used to help design landscapes capable of supporting self-sustaining species populations," followed by 14 citations, but that does seem to engage the original question relative to "sufficient examples of how surrogates have successfully been used." If these citations are examples, then they should be presented as described in the next paragraph. If the guidelines are going to point to examples of successful application of surrogates in landscape-level conservation efforts, then the document should identify the specific individual efforts, should describe how surrogates are used and to meet what specific goals, should draw from the cited material (or original documentation) evidence of the claimed "success," and should explain how the approach taken to identify the surrogates employed and their application has led to project "success." Otherwise readers of the guidelines are best informed by the observation that – when it comes to the use of surrogates in large–scale conservation planning, the jury is very much still out. Few examples of explicit applications of surrogates are in action, and none have actually run long enough for their performance to be ruled successful.

Comment Response Matrix - Reviewer Responses
Draft Summary Report on Peer Review of Technical Guidance for Surrogate Species

The comment refers to:				
Comment #	**Reviewer #**	**Question #**	**USFWS Comment on Individual Reviews**	**Response from Reviewer**
7	5	8	Answered the question relative to SHC and not Surrogate Species	Perhaps I didn't understand the meaning of the original question, but when the query asks what alternatives to surrogates are available or directly "are there other established methods for achieving these ends that do not involve the use of surrogate species," the answer to the question perforce should address programmatic needs/applications, not the surrogate approach. So I guess I'll default by stating, no, there is not an obvious method for assessing the effectiveness and efficacy of "landscape-level conservation planning and implementation with a tractable number of species" beyond the use of surrogates, proxies, and indicators. That noted, the guidelines take on real importance, therefore need to explain in step-down procedures how candidate surrogates should be selected, how provisional surrogates should be selected from among them (including validating the surrogates that are selected), how to design a sampling scheme in support of monitoring using surrogates, how to appraise the success of the effort, and the many more steps necessary to effectively link a proxy-based approach to a successful landscape-level conservation program.

APPENDIX B

Reviewer's Resumes (Alphabetical)

Peer Review of
Technical Guidance on Selecting Species for Landscape Scale Conservation

U.S. Fish & Wildlife Service

STEPHANIE RENEE JANUCHOWSKI-HARTLEY, PHD
Center for Limnology, University of Wisconsin-Madison
Email: stephierenee@gmail.com

Enthusiastic Conservation Scientist with a diversity of skills acquired from a wide range of demanding roles. Ten years of experience within the academic and conservation sectors, and now seeking the next challenging opportunity to conduct high quality research and make an effective contribution to biodiversity conservation by generating tools and methods to inform decision making and policy.

HIGHLIGHTS OF QUALIFICATIONS

- Strong funding record ~ $200,000 USD secured as an early career researcher.
- Excellent publication record for an early-career researcher: 14 peer-reviewed journal publications (8 as lead author).
- Active member of the conservation community: organizer and participant of topical working groups and an active student mentor.
- Successful collaborative research and up-take of research by conservation practitioners, including local, regional and national government agencies and NGOs.

RESEARCH EXPERIENCE (selected)

Postdoctoral Research Associate 2012-present
Evaluating global conservation priorities for freshwater biodiversity
Center for Limnology, University of Wisconsin-Madison, USA

Postdoctoral Research Associate 2011-2012
Reestablishing connectivity between the Great Lakes and their tributaries
Center for Limnology, University of Wisconsin-Madison, USA

Principal Investigator 2011-2013
Collaborating across boundaries
Reef Catchments (Mackay Whitsunday Isaac) Limited, Mackay, Queensland, Australia

Research Assistant 2010-2011
Planning and evaluating environmental flows in the Murray-Darling Basin
Australian Rivers Institute, Griffith University, Douglas, Queensland, Australia

RESEARCH GRANTS AND AWARDS (selected)

Collaboration across Boundaries (Reef Catchments Ltd)	$32400*	2012
Environmental Flows (Dept. SEWPC)	$19000*	2011
Collaboration across Boundaries (JCU)	$9900*	2010
James Cook University and Griffith University	$8800*	2010
ARC Research Network for Earth Systems Science	$13600*	2010
Weed prioritization (Qld. Dept. of Primary Industries)	$33000*	2009
Postdoctoral scholarship (JCU – 3 years)	$75000*	2009
Research Experience for Undergraduates (NSF)	$20000**	2006

PI on all listed grants and awards; * Australian Dollars/ ** US Dollars

EDUCATION

Doctor of Philosophy 2008-2011
Centre of Excellence for Coral Reef Studies, James Cook University
Thesis: Advancing systematic conservation planning for freshwater ecosystems

Master of Science 2004-2006
Biology and Natural Resources Management, Grand Valley State University
Thesis: Explaining koala occurrence at multiple ecological scales in Ballarat, Victoria, Australia

Bachelor of Science 2000-2003

Biology and Natural Resources Management, Grand Valley State University

WORKING GROUPS

Global Biodiversity Outlook 4 Scenario Assessment, Vancouver, CA 02/2014
Global Biodiversity Outlook 4 Scenario Assessment, Cambridge, UK 09/2013
IUCN Identifying Key Biodiversity Areas Thresholds, Rome, IT 12/2013
Conservation Opportunity Workshop, Stradbroke Island, AU 04/2013
Great Lakes Aquatic Connectivity Working Group 2011-2013
Society for Conservation Biology's Freshwater Working Group Board Member 2010-2013

ORGANIZING COMMITTEES

Chair: *Enhancing freshwater conservation efforts at broad spatial scales* 05/2013
Society for Freshwater Science Annual Meeting, Jacksonville, FL, USA
Chair: *Global Freshwater Biodiversity* 12/2012
WWF, Washington D.C., USA (2012)
President: ARC Centre of Excellence for Coral Reef Studies Student Group 2010-2011

TEACHING AND MENTORING (selected)

University of Wisconsin-Madison, Guest Lecturer Fish Ecology 2013
University of Wisconsin-Madison, Undergraduate Student Mentor 2012-present
University of Wisconsin-Madison, Guest Lecturer Environmental Toxicology 2012
James Cook University, Academic Tutor, Introduction to GIS 2008
Nulloo Yumbah Indigenous Learning Centre, Academic Tutor 2007
Grand Valley State University, Introductory Biology Lab Tutor 2005

ACADEMIC REVIEWER (selected)

Biological Conservation; Conservation Letters; Conservation Biology; Diversity and Distributions; Environmental Management; International Journal of Geographical Information Science; Journal of Environmental Management; PLoS One

SOCIAL MEDIA AND OUTREACH

Webpage: www.livingfreshwaters.com
Twitter: @ConnectedWaters and Facebook: https://www.facebook.com/connectedwaters

SPECIFIC SKILLS

Programming languages: R, MatLab, Python
GIS packages: ArcGIS 9x and 10x, GRASS
Spatial software: RivEx, Marxan
MS Office packages including Access and Excel
Fieldwork: >5 years of experience in remote regions (Caribbean, Australia, Eastern Europe)
Wildlife identification: Broad background in natural history (esp. birds, fishes)
Languages: English, German, Spanish

PEER REVIEWED PUBLICATIONS

Martinuzzi, S., **Januchowski-Hartley, S.R.**, Pracheil, B.M., McIntyre, P.B., Plantinga, A.J., Lewis, D.J., and Radeloff, V.C. (2014) Threats and opportunities for freshwater conservation under future land use change scenarios in the United States. Global Change Biology 20: 113-124.

Hermoso, V., **Januchowski-Hartley, S.R.** and Pressey, B. (2013) When the suit does not fit

biodiversity: loose surrogates compromise the achievement of conservation goals. Biological Conservation 159: 197-205.

Januchowski-Hartley, S.R., McIntyre, P.B., Diebel, M., Doran, P.J., Infante, D.M., Joseph, C. and Allan, J.D. (2013) Restoring aquatic ecosystem connectivity requires expanding barrier inventories. Frontiers in Ecology and the Environment 4: 211-217.

Visconti, P., Di Marco, M., Álvarez-Romero, J.G., **Januchowski-Hartley, S.R.**, Pressey, R.L., Weeks, R. and Rondinini, C. (2013) Effects of errors and gaps in spatial data sets on assessment of conservation progress. Conservation Biology 27: 1000-1010.

Januchowski, S.R., Moon, K., Stoeckl, N. and Gray, S. (2012) Social factors and private benefits influence landholders' riverine restoration priorities in tropical Australia. Journal of Environmental Management 110: 20-26.

Foale, S., Cohen, P., **Januchowski-Hartley, S.R.**, Wenger, A. and Macintyre, M. (2011) Tenure and taboos: origins and implications for fisheries in the Pacific. Fish and Fisheries 12: 357-369.

Hermoso, V., **Januchowski-Hartley, S.R.**, Linke, S. and Possingham, H.P. (2011) Reference vs. present-day condition: early planning decision influence the achievement of conservation objectives. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 500-509.

Januchowski-Hartley, S.R., Pearson, R.G., Puschendorf, R. and Rayner, T. (2011) Fresh waters and fish diversity: distribution, protection and disturbance in tropical Australia. PlosOne 6. DOI: 10.137/journal.pone.0025846.

Januchowski-Hartley, S.R., Hermoso, V., Pressey, R.L., Linke, S., Kool, J., Pearson, R.G. and Pusey, B. (2011) Coarse-filter surrogates do not represent freshwater fish diversity at a regional scale. Biological Conservation 144: 2499-2511.

Januchowski-Hartley, S.R., VanDerWal, J. and Sydes, D. (2011) Effective control of invasive species: building evidence for management of the tropical invasive macrophyte olive hymenachne (*Hymenachne amplexicaulis)*. Environmental Management 48: 568-576.

Januchowski-Hartley, S.R., Visconti, P. and Pressey, R.L. (2011) A systematic approach for prioritizing multiple management actions for invasive species. Biological Invasions 13: 1241-1253.

Januchowski, S.R., Pressey, R.L., VanDerWal, J. and Edwards, A. (2010) Characterizing surface model error and associated costs. International Journal of Geographical Information Science 24: 1327-1347.

Januchowski, S.R., McAlpine, C.A., Callaghan, J.G., Griffin, C.B., Mitchell, D., Lunney, D. and Bowen, M. (2008) Importance of managing wildlife at multiple-scales in fragmented landscapes: Implications for koalas (*Phascolarctos cinereus*) in Ballarat, Victoria, Australia. Ecological Management and Restoration 9: 134-142.

Smith, R.G., Gross, K.L. and **Januchowski, S.R.** (2005) Earthworms and weed seed distribution in annual crops. Agriculture, Ecosystems and Environment 108: 363-367.

PEER REVIEWED ARTICLES IN REVIEW

Hermoso, V., **Januchowski-Hartley S.R.** and Linke, S. (In Review) Rethinking the conservation value of ecological connectivity in a modified world. Conservation Letters

Januchowski-Hartley, S.R., Diebel, M., Doran, J. and McIntyre, P.B. (Major Revisions) Modelling road culvert passability for migratory fishes. Diversity and Distributions

Moon, K., Adams, V., **Januchowski-Hartley, S.R.**, Polyakov, M. Biggs, D. Game, E., Mills, M., Knight, A. and Raymond, C. (In Review). The theory of conservation opportunity. Conservation Biology.

TECHNICAL REPORTS

Januchowski-Hartley, S.R. and Moon, K. (2013) The role of ecosystem services and landscape values in riverine conservation programs. Internal report: Reef Catchments Mackay Whitsunday Isaac Ltd., Mackay, Queensland, Australia.

Linke, S., McMahon, J., **Januchowski-Hartley, S.R.**, Olley, J., Turak, E., Blakey, R., Watts, M. and Possingham, H. (2011) Testing the waters: optimizing environmental water allocations. Australian Department of Environment, Water, Heritage and the Arts, Canberra, Australia.

Januchowski-Hartley, S.R. and Moon, K. (2011) Gregory river healthy waterways project: collaborating across boundaries. Reef Catchments Mackay Whitsunday Ltd., Mackay, Queensland, Australia.

VanDerWal, J., Falconi, L., **Januchowski**, **S.R.**, Shoo, L. and Storlie, C. (2011) SDMTools: species distribution modelling tools: Tools for processing data associated with species distribution modeling exercises. http://rforge.net/SDMTools/index.html

Januchowski, S.R. and Visconti, P. (2009) Identifying on-ground management priorities for the control of olive hymenachne (*Hymenachne amplexicaulis)*: a pilot study with Cassowary Coast Regional Council, Tully, Queensland, Australia.

BOOK CHAPTERS

Ban, N.C., **Januchowski-Hartley, S.R.**, Alvarez-Romero, J., Mills, M., Pressey, R.L., Linke, S. and de Freitas, D. (2013) Marine and freshwater conservation planning: from representation to persistence, In: *Shaping the Future: Conservation Planning from the bottom up - a practical guide for the 21st century* (eds. Craighead L and Convis C). ESRI Press Redlands, California.

Hermoso, V., Linke, S., **Januchowski-Hartley, S.R.** and Kennard, M. (In Review) Freshwater Conservation Planning, In: *Conservation of Freshwater Fishes* (eds. Closs G, Krosek M Olden J). Cambridge University Press.

McIntyre, P.B., Reidy Liermann, C., Childress, E., Hamann, E.J., Hogan, J.D., **Januchowski-Hartley, S.R.**, Koning, A.A., Neeson, T.M., Oele, D.L. and Pracheil, B.M. (In Review) Conservation of migratory fishes in freshwater ecosystems, In: *Conservation of Freshwater Fishes* (eds. Closs G, Krosek M Olden J). Cambridge University Press.

OTHER PUBLICATIONS

Patricio, H.C. and **Januchowski-Hartley, S.** (2014) Tackling giants: getting the most out of working groups for freshwater fish conservation. Newsletter of the IUCN/SSC/WI Freshwater Fish Specialist Group. Issue 4, March 2014.

CONFERENCES AND PRESENTATIONS (selected)

International Congress for Conservation Biology Meeting, Baltimore, Maryland, USA (2013)
Januchowski-Hartley S.R., Moon K. and Hermoso, V. *The role of landscape values and ecosystem services in riverine conservation opportunity assessments on private lands*.

Society for Freshwater Science Meeting, Jacksonville, Florida, USA (2013)
Januchowski-Hartley S.R., McIntyre P.B., Abell R., Darwall W.R., Dudgeon D., Gessner M.O., Harrison I., Lehner B., Petry P. and Revenga, C. *Global Distribution and Conservation of Riverine Biodiversity*.

American Fisheries Society Meeting, Minneapolis-St Paul, Minnesota, USA (2012)
Januchowski-Hartley S.R., Pracheil B.M., McIntyre P.B. and Diebel M. *Establishing priorities: The importance of connections and costs in broad-scale freshwater conservation*.
Januchowski-Hartley, S.R., McIntyre, P.B., Diebel, M., Doran, P.J. and Infante, D. *Development of a comprehensive instream barrier dataset for the Great Lakes Basin.*

Discovery Challenge Symposium, Madison, Wisconsin, USA (2012)
Januchowski-Hartley S.R., McIntyre P.B., Diebel M. and Doran P.J. *Reconnecting the Great Lakes and their tributaries to benefit nature and people*.

Invited Speaker: Australian Rivers Institute, Griffith University, Queensland, Australia (2012)
Januchowski-Hartley, S.R. *Determining local to global priorities for freshwater conservation*.

Joshua J. Lawler

School of Environmental and Forest Sciences, University of Washington
Box 352100, Seattle, Washington 98195-2100
phone: (206) 685-4367, e-mail: jlawler@u.washington.edu
http://depts.washington.edu/landecol/

CURRENT POSITIONS

Associate Professor, School of Forest Resources, University of Washington (2010-)
Global Health and Climate Change Fellow, University of Washington (2010-)
Denman Professor of Sustainable Resource Sciences (2013-)

EDUCATION

Ph.D. in Ecology, Utah State University (2000)
M.S. in Wildlife Ecology, Utah State University (1997)
A.B. in Biology and Environmental Studies, Bowdoin College (1993)

RECENT POSITIONS

Assistant Professor, School of Forest Resources, University of Washington (2007-2010)
David H. Smith Postdoctoral Fellow, Department of Zoology, Oregon State University (2004-2006)
Effects of climate change on species distributions and conservation planning
National Research Council Associate, at U.S. Environmental Protection Agency (2001-2003)
Methods for prioritizing areas for the conservation of biodiversity
Postdoctoral Fellow, Margaret Chase Smith Center, University of Maine (2000)
Biotic and economic effects of acid deposition on Maine lakes

GRANTS AND FELLOWSHIPS (since 2001)

USGS, co-PI (2013-2014)	$48,175
Bureau of Land Management, co-PI (2013-2018)	$33,000
U.S. DoD, SERDP, lead-PI (2013-2016)	$372,500
Wilburforce Foundation, co-PI (2013-2016)	$469,730 (SEFS $217,730)
USGS Northwest Climate Science Center, sole-PI (2012-2014)	$177,859
Wilburforce Foundation, sole-PI (2012-2013)	$40,000
Stanford University (US DoD), co-PI (2011-2013)	$228,118
Yale University (DDCF, Wilburforce, Kresge), sole-PI (2012)	$85,946
National Wildlife Federation, sole-PI (2011-2012)	$20,000
Environment Canada, sole-PI (2011-2012)	$35,000
Fish and Wildlife Service, NP-LCC, lead-PI (2011-2012)	$72,915
Fish and Wildlife Service, GN-LCC, lead-PI (2011-2012)	$95,000
David and Lucile Packard Foundation, lead-PI (2011-2013)	$165,000
National Center for Ecological Analysis and Synthesis, co-PI (2010-2011)	$65,625
National Parks Service, lead-PI (2011)	$17,993
U.S. EPA, Renewal Act (PRIA 2) Partnership, sole-PI (2011-2012)	$100,000
U.S. DoD, SERDP, lead-PI (2011-2015)	$1,245,805
USGS/ NPS, lead-PI (2011-2013)	$236,405 (SEFS $117,889)

USGS National Climate Change and Wildlife Science Center, co-PI (2009-11)	$826,842 (SEFS $195,656)
New Mexico Chapter of The Nature Conservancy, co-PI (2009)	$18,670
USGS/ NPS, lead-PI (2009-2011)	$99,649
National Parks Service, co-PI (2008-2010)	$93,000
National Science Foundation, co-PI (2008-2011)	$1,242,625 (SEFS $341,035)
Washington Chapter of the Nature Conservancy, lead-PI (2008-2010)	$100,000
Resource Innovations, University of Oregon, lead-PI (2008)	$5,000
U.S. EPA STAR, co-PI (2008-2011)	$588,275 (SEFS $148,015)
The Nature Conservancy, lead-PI (2007-2008)	$139,815
Washington Department of Fish and Wildlife, lead-PI (2007)	$5,000
U.S. DoD, SERDP, sole-PI (2007-2011)	$768,000
The Nature Conservancy, fellowship (2004-2006)	$155,000
U.S. EPA Research Grant (2003-2004)	$29,500
National Research Council, Associateship (2001- 2003)	$169,000

AWARDS

Aldo Leopold Leadership Program Fellow (2013)
Kavli Fellow, U.S. National Academy of Sciences (2013)
School of Environmental and Forest Sciences, UW, Exemplary Research Funding Award (2013)
School of Environmental and Forest Sciences, UW, Graduate Student Support Award (2012)
Project of the Year, Strategic Environmental Research and Development Program (2011)
Secretary of the Interior, Conservation Partners Award (2011)
School of Forest Resources, University of Washington, Exemplary Service Award (2011)
School of Forest Resources, University of Washington, Graduate Student Support Award (2011)
College of Forest Resource, University of Washington, Exemplary Research Funding Award (2009)
College of Forest Resource, University of Washington, Exemplary Service Award (2008)
College of Forest Resource, University of Washington, Exemplary Research Funding Award (2008)
Graduate Student Mentor Award, Dept. Fisheries and Wildlife, Utah State University (1999)
Best Student Presentation, Annual Meeting of the Utah Chapter of the Wildlife Society (1999)
Terri Lynn Steel Award, College of Natural Resources, Utah State University (1998)
Student Membership Award, Cooper Ornithological Society (1996-1997)
Presidential Fellowship, Utah State University (1994-1995)

PUBLICATIONS (69 TOTAL)

Lawler, **J. J.**, D. Lewis, E. Nelson, A. J. Plantinga, S. Polasky, J. C. Withey, D. P. Helmers, S. Martinuzzi, D. Pennington, V. C. Radeloff. *In Press.* Projected land-use change impacts on ecosystem services in the U.S. *Proceedings of the National Academy of Sciences, USA.*

Schumaker, N. H., A. Brookes, J. R. Dunk, B. Woodbridge, J. A. Heinrichs, **J. J. Lawler**, C. Carroll, D. LaPlante. *In press*. Mapping sources, sinks, and connectivity using a simulation model of northern spotted owls. *Landscape Ecology.*

Wilsey, C. B., **J. J. Lawler**, D. Cimprich, and N. H. Schumaker. *In Press.* Dependence of the endangered black-capped vireo on sustained cowbird management. *Conservation Biology*.

Lawrence, D. J., B. Stewart-Koster, J. D. Olden, A. S. Ruesch, C. E. Torgersen, **J. J. Lawler**, D. P. Butcher, J. K. Crown. *In Press.* The interactive effects of climate change, riparian management, and a non-native predator on stream-rearing salmon. *Ecological Applications.*

Lankford, A. J., L. K. Svancara, **J. J. Lawler**, K Vierling. 2014. Comparison of Climate Change Vulnerability Assessments for Wildlife. *Wildlife Society Bulletin.* Doi: 10.1002/wsb.399.

Ibáñez, I., J. M. Diez, L. P. Miller, J. D. Olden, C. J. B. Sorte, D. M. Blumenthal, B. A. Bradley, C. M. D'Antonio, J. S. Dukes, R. Early, E. D. Grosholz, and **J. J. Lawler**. 2014. Integrated assessment of biological invasions. *Ecological Applications* 24: 25-37.

Stein, B. A., A. Staudt, M. S. Cross, N. S. Dubois, C. Enquist, R. Griffis, L. J. Hansen, J. J. Hellmann, **J. J. Lawler**, E. J. Nelson, A. Pairis. 2013. Preparing for and managing change: climate adaptation for biodiversity and ecosystems. *Frontiers in Ecology and the Environment* 11: 502-510.

M. D. Staudinger, S. L. Carter, M. S. Cross, N. S. Dubois, J. E. Duffy, C. Enquist, R. Griffis, J. J. Hellmann, **J. J. Lawler**, J. O'Leary, S. A. Morrison, L. Sneddon, B. A. Stein, L. M. Thompson, and W. Turner. 2013. Biodiversity in a changing climate: a synthesis of current and projected trends in the United States. *Frontiers in Ecology and the Environment* 11: 465-473.

Lawler. J. J., A. Ruesch, J. D. Olden, B. H. McRae. 2013. Projected climate-driven faunal movement routes. *Ecology Letters* 16: 1014-1022.

Wilsey, C. B., **J. J. Lawler**, E. P. Maurer, D. McKenzie, P. A. Townsend, R. Gwozdz, J. A. Freund, K. Hagmann, and K. M. Hutten. 2013. Tools for assessing climate impacts on fish and wildlife. *Journal of Fish and Wildlife Management* 4: 220-241.

Lawler, J. J., B. Spencer, J. D. Olden, S.-H. Kim, C. Lowe, S. Bolton. B. M. Beamon, L. Thompson, and J. G. Voss. 2013. Mitigation and adaptation strategies. *In*: R. Pielke, Sr., K. Suding, and T. Seastedt, Editors. *Climate Vulnerability: Understanding and Addressing Threats to Essential Resources*, *Volume 5, Ecosystem Function*. Elsevier Inc. Academic Press.

Nuñez, T. A., **J. J. Lawler**, B. H. McRae, D. J. Pierce, M. B. Krosby, D. M. Kavanagh, P. H. Sigleton, and J. J. Tewksbury. 2013. Connectivity planning to address climate change. *Conservation Biology* 27: 407-416.

Lawler, J. J., C. A. Schloss, A. K. Ettinger. 2013. Climate change: anticipating and adapting to the impacts on terrestrial species. *In*: S. A. Levin (ed.). *Encyclopedia of Biodiversity,* second edition, Volume 2, pp100-114, Academic Press, Waltham, MA.

Cross, M. S., J. A. Hilty, G. M. Tabor, **J. J. Lawler**, L. J. Graumlich, J. Berger. 2012. From connect-the-dots to dynamic networks: Maintaining and restoring connectivity as a strategy to address climate change impacts on wildlife. *In*: J. Brodie, E. Post, D. Doak, eds. *Conserving wildlife populations in a changing climate*. Chicago University Press.

Lawler, J. J., H. D. Safford, and E. H. Girvetz. 2012. Martens and fishers in a changing climate. *In*: K. B. Aubry, Editors. *Biology and Conservation of Martens, Sables, and Fishers: a New Synthesis*. Cornell University Press.

Ruesch, A. S., C. E. Torgersen, **J. J. Lawler**, J. D. Olden, E. E. Peterson, C. J. Volk, D. J. Lawrence. 2012. Projected climate-induced habitat loss for salmonids in the John Day River network, Oregon, USA. *Conservation Biology* 26: 873-882.

Withey, J. C., **J. J. Lawler**, S. Polasky, A. J. Plantinga, E. J. Nelson, P. Kareiva, C. B. Wilsey, C. A. Schloss, T. Nogeire, A. Ruesch, J. Ramos Jr., and W. Reid. 2012. Maximizing return on conservation investment in the conterminous U.S. *Ecology Letters* 15: 1249-1256.

Diez, J. M., C. M. D'Antonio, J. S. Dukes, E. D. Grosholz, J. D. Olden, C. J. B. Sorte, D. M. Blumenthal, B. A. Bradley, R. Early, I. Ibáñez, S. J. Jones, **J. J. Lawler**, and L. P. Miller. 2012. Will extreme climatic events facilitate biological invasions? *Frontiers in Ecology and the Environment* 10: 249-257.

Schloss, C. A., T. A. Nuñez, and **J. J. Lawler**. 2012. Dispersal will limit ability of mammals to track climate change in the Western Hemisphere. *Proceedings of the National Academy of Sciences, U.S.A.* 109: 8606-8611.

Krosby, M., J. Hoffman, **J. J. Lawler**, and B. H. McRae. 2012. Integrating climate change into conservation planning in Washington State, and the Pacific Northwest. *In*: C. C. Chester, J. A. Hilty, and M. S. Cross, Editors. *Climate and Conservation: Landscape and Seascape Science, Planning, and Action.* Island Press.

Cross, M. S., E. S. Zavaleta, D. Bachelet, M. Brooks, C. A. F. Enquist, E. Fleishman, L. Graumlich, C. Groves, L. Hannah, L. Hansen, G. Hayward, M. Koopman, **J. J. Lawler**, J. Malcolm, J. Nordgren, B. Petersen, E. L. Rowland, D. Scott, S. Shafer, R. Shaw, J. Weaver, and G.M. Tabor. 2012. The adaptation for conservation targets (ACT) framework: a tool for incorporating climate change into natural resource management. *Environmental Management* 50: 341-351.

Trombulak, S. C., R. F. Baldwin, **J. J. Lawler**, J. Cymerman-Hepinstall, and M. A. Anderson. 2012. Landscape-scale conservation planning for climate change in the Northern Appalachian/Acadian ecoregion. *In*: C. C. Chester, J. A. Hilty, and M. S. Cross, Editors. *Climate and Conservation: Landscape and Seascape Science, Planning, and Action.* Island Press.

Radeloff, V. C., E. Nelson, A. J. Plantinga, D. J. Lewis, D. Helmers, **J. J. Lawler**, J. C. Withey, F. Beaudry, S. Martinuzzi, V. Butsic, E. Lonsdorf, D. White, and S. Polasky. 2012. Economic-based projections of future land use in the conterminous U.S. under alternative economic policy scenarios *Ecological Applications* 22: 1036-1049.

Wilsey, C., **J. J. Lawler**, and D. Cimprich. 2012. Performance of habitat suitability models for the endangered black-capped vireo built with remotely-sensed data. *Remote Sensing of Environment* 119: 35-42.

Bradley, B. A., D. M. Blumenthal, R. I. Early, E. D. Grosholz, **J. J. Lawler**, L. P. Miller, C. J. B. Sorte, C. M. D'Antonio, J. M. Diez, J. S. Dukes, I. Ibanez, and J. D. Olden. 2012. Global change, global trade, and the next wave of plant invasions. *Frontiers in Ecology and the Environment* 10: 20-28.

Schloss, C. A., **J. J. Lawler**, E. R. Larson, H. L. Papendick M. J. Case, D. M. Evans, J. H. DeLap, J.G.R. Langdon, S. A. Hall, and B. H. McRae. 2011. Systematic conservation planning in the face of climate change: bet-hedging on the Columbia Plateau. *PLoS ONE* 6: e28788.

Kostyack, J., **J. J. Lawler**, D. D. Goble, J. D. Olden, and J. M. Scott. 2011. Beyond reserves and corridors: policy solutions to facilitate the movement of plants and animals in a changing climate. *BioScience* 61: 713-719.

Lawler, J. J. 2011. *News and Views:* Conservation at any cost. *Nature Climate Change* 1: 350-351.

Lawler, J. J., E. Nelson, M. Conte, S. L. Shafer, D. Ennaanay, and G. Mendoza. 2011. Modeling the impacts of climate change on ecosystem services. *In*: P. M. Kareiva, T. H. Ricketts, G. C. Daily, H. Tallis, and S. Polasky, Editors. *The Theory and Practice of Ecosystem Service Valuation*. Oxford University Press.

Bancroft, B. A., B. A. Han, C. L. Searle, L. M. Biga, D. H. Olson, L. B. Kats, **J. J. Lawler**, and A. R. Blaustein. 2011. Species-level correlates of susceptibility to the pathogenic amphibian fungus *Batrachochytrium dendrobatidis* in the United States. *Biodiversity and Conservation* 20: 1911-1920.

Blaustein, A.R., C. Searle, B.A. Bancroft and **J. Lawler**. 2011. Amphibian population declines and climate change. *In:* J. Belant and E. Beever Eds. *Ecological Consequences of Climate Change: Mechanisms, Conservation, and Management*. Taylor & Francis Publishing.

Lawler, J. J., and J. D. Olden. 2011. Reframing the debate over assisted colonization. *Frontiers in Ecology and the Environment* 9: 569-574.

Olden, J. D., M. J. Kennard, **J. J. Lawler**, N. L. Poff. 2011. Challenges and opportunities in implementing managed relocation for conservation of freshwater species. *Conservation Biology* 25: 40-47.

Lawler, J. J., Y.F. Wiersma, and F. Huettmann. 2011. Designing predictive models for increased utility: using species distribution models for conservation planning and ecological forecasting. *In*: Drew, A., Y. F. Wiersma, and F. Huettmann, Editors. *Predictive Modeling in Landscape Ecology*. Springer Press.

Jantarasami, L. C., **J. J. Lawler**, and C. W. Thomas. 2010. Institutional barriers to climate-change adaptation in U.S. national parks and forests. *Ecology and Society.* 15(4): 33.

Lawler, J. J., J. A. Hepinstall-Cymerman. 2010. Conservation planning in a changing climate: assessing the impacts of potential range shifts on a reserve network. *In*: R. Baldwin and S. C. Trombulak, Editors. *Multi-scale Conservation Planning*. Springer-Verlag.

Blaustein, A. R., S. C. Walls, B. A. Bancroft, **J. J. Lawler**, C. L. Searle, and S. S. Gervasi. 2010. Direct and indirect effects of climate change on amphibian populations. *Diversity* 2: 281-313.

Lawler, J. J., S. L. Shafer, B. A. Bancroft, and A. R. Blaustein. 2010. Projected climate impacts for the amphibians of the western hemisphere. *Conservation Biology* 24: 38-50.

Belant, J. L., E. A. Beever, J. E. Gross, and **J. J. Lawler**. 2010. Introduction: special section: ecological responses to contemporary climate change within species, communities, and ecosystems. *Conservation Biology* 24: 7-9.

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(Faculty of 1000 selected article)

Girvetz, E., C. Zganjar, G. T. Raber, E. P. Maurer, P. Kareiva, and **J. J. Lawler**. 2009. Applied climate-change analysis: the Climate Wizard tool. *PLoS ONE* 4(12): e8320. doi:10.1371/journal.pone.0008320

West, J. M., S. H. Julius, P. Kareiva, C. Enquist, A. E. Johnson, **J. J. Lawler**, B. Petersen, and E. R. Shaw. 2009. U.S. Natural resources and climate change: concepts and approaches for management adaptation. *Environmental Management* 44: 1001-1021.

Griffith, B., J. M. Scott, R. S. Adamcik, D. M. Ashe, B. Czech, R. Fischman, P. Gonzalez, **J. J. Lawler**, A. D. McGuire, and A. Pidgorna. 2009. Climate Change adaptation options for the U. S. National Wildlife Refuge System. *Environmental Management* 44: 1043-1052.

Pergrams, O. and **J. J. Lawler**. 2009. Recent and widespread rapid morphological change in rodents. *PLoS ONE* 4(7): e6452.

Fox, H. E., P. Kareiva, B. Silliman, J. Hitt, D. Lytle, B. S. Halpern, Christine V. Hawkes, **J. J. Lawler**, M. Neel, J. D. Olden, M. Schlaepfer, K. Smith, H. Tallis. 2009. Why do we fly? Ecologists' sins of emission. *Frontiers in Ecology and the Environment* 7: 294-296.

Lawler, J. J. 2009. Climate change adaptation strategies for resource management and conservation planning. *Annals of the New York Academy of Sciences* 1162: 79-98.

Lawler, J. J., S. L. Shafer, D. White, P. Kareiva, E. P. Maurer, A. R. Blaustein, and P. J. Bartlein. 2009. Projected climate-induced faunal change in the western hemisphere. *Ecology* 90: 588-597.

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Nelson, E., S. Polasky, D. J. Lewis, A. J. Plantinga, E. Lonsdorf, D. White, D. Bael, and **J. J. Lawler**. 2008. Efficiency of incentives to produce ecosystem services. *Proceedings of the National Academy of Sciences, U.S.A.* 105: 9471-9476.

Olden, J. D., **J. J. Lawler**, and N. L. Poff. 2008. Machine-learning without tears: a practical primer for ecologists. *Quarterly Review of Biology* 83: 171-193.

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Lawler, J. J., and T. C. Edwards Jr. 2006. A variance-decomposition approach to investigating multiscale habitat associations. *Condor* 108: 47-58.

Battin, J. and **Lawler, J. J**. 2006. Cross-scale correlations and the design of avian habitat-selection studies. *Condor* 108: 59-70.

Lawler, J. J., J. Rubin, B. J. Cosby, S. J. Norton, J. S. Kahl, and I. J. Fernandez. 2005. Predicting recovery from acid deposition: applying a modified TAF (Tracking Analysis Framework) model to Maine (USA) high elevation lakes. *Water, Air, and Soil Pollution* 165: 383-399.

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Lawler, J. J., R. J. O'Connor, C. T. Hunsaker, K. B. Jones, T. R. Loveland, and D. White. 2004. The effects of habitat resolution on models of avian diversity and distributions: a comparison of two land-cover classifications. *Landscape Ecology* 19: 515-530.

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Lawler, J. J., D. White, J. C. Sifneos, and L. L. Master. 2003. Rare species and the use of indicator groups for conservation planning. *Conservation Biology* 17: 875-882.

Lawler, J. J., S. Campbell, A. D. Guerry, M. B. Kolozsvary, R. J. O'Connor, and L. Seward. 2002. The scope and treatment of threats in endangered species recovery plans. *Ecological Applications* 12: 663-667.

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Lawler, J. J., and T. C. Edwards Jr. 2002. Composition of cavity-nesting bird communities in montane aspen woodland fragments: the roles of landscape context and forest structure. *Condor* 104: 890-896.

Campbell, S. P., A. Clark, L. Crampton, A. D. Guerry, L. Hatch, P. R. Hosseini, **J. J. Lawler**, and R. J. O'Connor. 2002. Monitoring as a component of recovery plan efforts: an analysis of its current role. *Ecological Applications* 12: 674-681.

Edwards, T. C., G. G. Moisen, T. S. Frescino, and **J. J. Lawler**. 2002. Modelling multiple ecological scales to link landscape theory to wildlife conservation. Pages 153-172 in: J. A. Bissonette and I. Storch, Editors. Landscape ecology and resource management: making the linkages, Island Press, Covelo, California.

Wheelwright, N. T., **J. J. Lawler**, and J. H. Wienstein. 1997. Nest-site selection in Savannah sparrows: using gulls as scarecrows? *Animal Behaviour* 53: 197-208.

<u>In review</u>

Case, M. J. and **J. J. Lawler**. Relative vulnerability to climate change of trees in western North America. *Ecological Applications.*

Torrubia, S., B. H. McRae, **J. J. Lawler**, S. A. Hall, M. Halabisky, J. Langdon, and M. Case. Getting the most connectivity per conservation dollar. *Frontiers in Ecology and the Environment.*

Bancroft, B. A., C. B. Wilsey, and **J. J. Lawler**. A multi-scale ensemble model for predicting habitat suitability. *Ecography.*

Peer-Reviewed Reports

Groffman, P. M., P. Kareiva, S. Carter, N. B. Grimm, **J. Lawler**, M. Mack, V. Matzek, H. Tallis. 2013. Chapter 8, Ecosystems, Biodiversity, and Ecosystem Services. National Climate Assessment.

Staudinger, M. D., S. Carter, M. S. Cross, N. S. Dubois, J. E. Duffy, C. Enquist, R. Griffis, J. Hellmann, **J. Lawler**, J. O'Leary, S. A. Morrison, L. Sneddon, B. Stein, L. Thompson, W. Turner, E. Varela-Acevedo, W. Reid. 2012. Impacts of climate change on biodiversity. *In* S. Carter, F. S. Chapin III, N. Grimm, P. Kareiva, M. Ruckelshaus, M. Staudinger, A. Staudt, B. Stein, eds. *Climate Change Impacts on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the National Climate Assessment.* U.S. Geological Survey, Reston, VA.

Stein, B. A., A. Staudt, M. S. Cross, N. Dubois, C. Enquist, R. Griffis, L. Hansen, J. Hellman, J. Lawler, E. Nelson, A. Pairis, D. Beard, R. Bierbaum, E. Girvetz, P. Gonzalez, S. Ruffo, J. Smith. 2012. Adaptation. *In* S. Carter, F. S. Chapin III, N. Grimm, P. Kareiva, M. Ruckelshaus, M. Staudinger, A. Staudt, B. Stein, eds. *Climate Change Impacts on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the National Climate Assessment.* U.S. Geological Survey, Reston, VA.

Shafer, S. L., J. Atkins, B. A. Bancroft, P. J. Bartlein, **J. J. Lawler**, B. Smith, C. B. Wilsey. 2012. Projected climate and vegetation changes and potential biotic effects for Fort Benning, Georgia; Fort Hood, Texas; and Fort Irwin, California: U.S. Geological Survey Scientific Investigations Report 2011-5099.

Lawler, J. J., C. Enquist, and E. Girvetz. 2010. Assessing the components of vulnerability. In. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment.* P. Glick and B. A. Stein (eds.). National Wildlife Federation, Washington, DC, USA, pp. 39-48.

Scott, J. M., B. Griffith, R. S. Adamcik, D. M., Ashe, B. Czech, R. L. Fischman, P. Gonzalez, **J. J. Lawler**, A. D. McGuire, and A. Pidgorna, 2008: National Wildlife Refuges. In: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Julius, S.H., J.M. West (eds.), J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA, pp. 5-1 to 5-100.

Kareiva, P., C. Enquist, A. Johnson, S. H. Julius, **J. Lawler**, B. Petersen, L. Pitelka, R. Shaw, and J. M. West, 2008: Synthesis and Conclusions. In: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Julius, S.H., J.M. West (eds.), J.S. Baron, B. Griffith, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC, USA, pp. 9-1 to 9-66.

Non-per-reviewed publications

Lawler, J. J., and B. Stein. 2009. Safeguarding wildlife from climate change. Quick guide to vulnerability assessment. National Wildlife Federation, Washington, D.C.

Lawler, J. J., M. Mathias, A. Yahnke, and E. Girvetz. 2008. Oregon's biodiversity in a changing climate. Report prepared for the Climate Leadership Initiative, University of Oregon.

Lawler, J. J., and M. Mathias. 2007. Climate Change and the Future of Biodiversity in Washington. Report prepared for the State of Washington Biodiversity Council.

Schlaepfer, M. A., J. E. Aukema, J. Grant, B. Halpern, J. Hoekstra, P. Kareiva, **J. J. Lawler**, J. C. Manolis, C. R. Nelson, J. D. Olden, B. Silliman, S. Stephens, J. A. Wiens, and P. Zaradic. 2005. Re-wilding: a bold plan that needs native megafauna. *Nature* 437: 951.

Lawler, J. J. 2003. Integrated public lands management: a coarse-scale economic perspective. Book Review. *Landscape Ecology* 18: 207-208**.**

Taylor, D., and **J. J. Lawler**. 2003. Interview. How do birds see the landscape? *Environmental Review* 10 (11): 1-6.

SELECTED INVITED TALKS (of 143 invited talks)

Will animals be able to track projected changes in climate?
Indo-American Frontiers in Science Symposium, Agra, India, 2013

Connectivity for the 21st century: planning for climate-driven shifts in biota
Duke University, 2013

Planning for species movements in a changing climate
Society for Conservation Biology, Oakland, 2012

Climate change vulnerability assessment for the Pacific Northwest
Steering Committee of the North Pacific Landscape Conservation Cooperative, Seattle, 2012

Anticipating the impacts of climate change on native plants
Key note: Conserving Plant Biodiversity in a Changing World, Seattle, 2012

Projected climate impacts on the fauna of the Western Hemisphere
Department of Biology, Reed College, Portland, 2012

Climate Change and Wildlife
North Cascadia Adaptation Partnership, Seattle, 2012

Vulnerability assessments for managing wildlife in a changing climate
Wild Links, Vancouver, Canada, 2011

Climate change: forecasting impacts, assessing vulnerability, and adaption planning
Y2Y Climate Adaptation Group Meeting, Seattle, 2011

Climate change vulnerability assessment for the Pacific Northwest
Great Northern LCC, webinar, 2011

Climate change adaptation strategies for conservation planning
Yale Science Panel for Integrating Climate Adaptation and Landscape Conservation Planning, Arlington, Virginia, 2011

Vulnerability assessments for managing wildlife in a changing climate
Climate Change Workshop, National Conservation Training Center, 2011

Climate change and wildlife
North Cascades National Park, 2011

Conservation planning in a changing climate
The Nature Conservancy, Portland, Oregon, 2011

Climate change vulnerability assessment
Forest Vulnerability Workshop, National Wildlife Federation, Tacoma, Washington, 2011

Projected climate impacts for the fauna of the western hemisphere
Raymond J. O'Connor Seminar Series, East Carolina University, 2010

Climate change in the Pacific Northwest
Wild Links, Seattle, 2010

Projected climate impacts for the fauna of the western hemisphere
Conservation Biology Seminar Series, University of Missouri, 2010

A national climate change adaptation strategy for wildlife
Panel discussion, Society for Conservation Biology, Edmonton, 2010

Projecting climate-change impacts on the amphibians of North and South America
State of Washington Department of Ecology, 2009.

Faunal range shifts and conservation planning in the western hemisphere
Canadian Wildlife service and Parks Canada, Ottawa, 2009

Assessing potential climate impacts on the fauna of the western hemisphere
Brown University, Ecology and Evolutionary Biology Department, 2009

Assessing climate-change vulnerability for planning and adaptation
Conservation Leadership Forum, NCTC, Shepherdstown, WV, 2009

Assessing potential climate impacts on the fauna of the western hemisphere
Oregon State University, Ecosystem Informatics IGERT Seminar, Corvallis, 2009

Climate change research
PRBO, Petaluma, CA, 2009

Modeling wildlife range shifts in response to climate change
Climate Adaptation Funders Briefing
The Consultative Group on Biological Diversity, The Moore Foundation, San Francisco, 2008

Wildlife in a changing climate
Wild Idaho North, Idaho Conservation League, Sandpoint, ID, 2008

Managing wildlife in a changing climate
Natural Resources Committee of the Oregon Global Warming Commission, Salem, 2008

Protecting biodiversity in a changing climate
Plenary, Wilderness 2008, Seattle, 2008.

Conservation planning in a changing climate: identifying hotspots of change and climate refugia
Society for Conservation Biology, San Jose, 2006

Climate-induced continental shifts in species distributions: implications for the Pacific Northwest.
Society for Ecological Restoration, Northwest Chapter, Vancouver, Washington, 2006

Uncertainty in projecting climate-change impacts on biota
National Center for Ecological Analysis and Synthesis (NCEAS), Santa Barbara, 2005

COURSES TAUGHT

Advanced Landscape Ecology (2008-2011)
Biometry lab (1997-1998)
Case Studies in Wildlife Management (1999)
Conservation Planning (2010)
Connectivity Planning (2012)
Ecological Effects of Climate Change (2007)
Ecological Land-Use Planning (2011)
Ecosystem Services and Climate Change (2013)
Introduction to Geographic Information Systems (2007-)
Landscape Ecology (2008-)
National Parks Assessment (2008-2009)
Topics in Advanced Landscape Ecology (2008)

GRADUATE STUDENTS

Lesley Jantarasami, MS (2009)
Aaron Ruesch, MS (2011)
Tristan Nuñez, MS (2011)
Jorge Ramos, MS (2011)
Carrie Schloss, MS (2011)
Chad Wilsey, PhD (2011)
Christie Galitsky, MS (2012)
Jesse Langdon, MS (2013)
Peter Singleton, PhD (2013)
Michael Case, PhD (projected 2014)
Aimee Fullerton, PhD (projected 2014)
Scott Rinnan, PhD (projected 2016)
Benjamin Dittbrenner PhD (projected 2017)
Caitlin Littlefield PhD (projected 2017)

POSTDOCS

Evan Girvetz (2007-2009)
Betsy Bancroft (2007-2009)
John Withey (2009-2011)
Julie Hienrichs (2011-)
Theresa Nogeire (2011-)
Chad Wilsey (2012-2013)
Jennifer Duggan (2012-)
Jennifer McGuire (2012-)
Maureen Ryan (2013-)
Se-Yeun Lee (2013-)
Julia Michalak (2013-)

PUBLIC TESTIMONY & GOVERNMENTAL POLICY

IPCC 5th Assessment Report, contributing author, 2012-2013
U.S. National Climate Assessment, lead author, 2012
Washington State Topic Advisory Group 3, Integrated Climate Change Response Strategy, 2010

Climate Change subgroup of the Washington State Connectivity Working Group, 2010
Presentation to Department of Interior Working Group on National Climate Adaptation Strategy, 2009
Testimony for the Natural Resources Committee of the Oregon Global Warming Commission, 2008
Western Governors Association Climate Change Working Group, 2008
Congressional testimony: U.S. House Subcommittee on Fisheries, Wildlife, and Oceans, 2007
WA Governor's Climate Change Forestry Resources Preparation and Adaptation Working Group, 2007

EDITING & REVIEWING

Editorial Board:
Landscape Ecology, 2009-2012
Frontiers in Ecology and the Environment, 2010-
Global Ecology and Biogeography, 2010-
Ecology Letters, 2012-
Guest/ad hoc assigning editor:
Conservation Biology, 2008, 2009, *Journal of Fish and Wildlife Management*, 2012
Guest assistant editor: special edition of *Forest Ecology and Management* 1999-2000
Manuscript editor: *Utah Birds*, 1998-1999
Grant reviewer: NSF, NOAA, NCERC, University of Washington, Smith Fellows Program, AXA
Manuscript reviewer

Auk
Biological Conservation
Biodiversity and Conservation
BioScience
Bird Study
BMC Ecology
Climate Change
Coastal Management
Condor
Conservation Biology
Conservation Letters
Diversity and Distributions
Ecography
Ecological Applications
Ecological Modelling
Ecological Research
Ecology Letters
Ecoscience
Ecosphere
Environmental Conservation
Environmental Management
Environmental Monitoring and Assessment
Frontiers in Ecology and the Environment
Global Change Biology
Global Ecology and Biogeography
Journal of Animal Ecology
Journal of Applied Ecology
Journal of Avian Biology
Journal of Biogeography
Landscape and Urban Planning
Landscape Ecology
Nature
Nature Climate Change
Oikos
Ornitologia Neotropical
Proceedings of the National Academy of Sciences
Proceedings of the Royal Society of London
PLoS Biology
PLoS ONE
Science
Wilson Bulletin

COLLEGE AND UNIVERSITY COMMITTEES

Doris Duke Conservation Scholars Program Steering Committee 2013-
Advisory Board, Program on Climate Change 2012-
College of the Environment, Freshwater Cluster Hire 2012-2013
School of Environmental and Forest Sciences PMT Committee Spring 2012, 2013-
College of the Environment, Science Communication Task Force 2012-
College of the Environment, Partners Scoping Committee (Chair), 2011-2012
College of the Environment, GIS and Remote Sensing Task Force, 2011
College of the Environment, School of Forest Resources Director Search Committee, 2011
School of Forest Resources IT Advisory Committee 2009-

Advisory Board, Program on the Environment, 2009-
College of Forest Resources Centers Review Committee, 2009
Conservation of Living Systems Graduate Initiative executive committee, 2008-
College of Forest Resources Wildlife Faculty Search Committee, 2008
College of Forest Resources New Research Group, 2008-2009
College of Forest Resources Planning Committee, 2008-2012

OTHER SERVICE

Ecological Society of America, Rapid Response Team, 2012-
Expert Panel, Decision-making Principles for Ecosystem Adaptation for California, 2011-2012.
Advisory Board Doris Duke Charitable Foundation Funded TNC project, 2012-
Wildlife Conservation Society, Climate Change Adaptation Grants Program, Advisory Board, 2011-
Yale Science Panel for Integrating Climate Adaptation and Landscape Conservation Planning, 2011-
Western Governors Association, Washington Connectivity Pilot Project, Climate Team, 2010-
Washington Habitat Connectivity Working Group, Climate-Change Team, 2010-
Skagit Wildlife Research Program Wildlife Research Advisory Committee, 2008-2012
Doris Duke Charitable Foundation, Listening Project, Steering Committee, 2008
Symposium organizer: Society for Conservation Biology, annual meeting, 2006
Session chair: Ecological Society of America, annual meeting 1998, 2002, 2004, 2005
Student presentation judge: International Association for Landscape Ecology, 2001-2004, 2006

PROFESSIONAL SOCIETY MEMBERSHIPS

Ecological Society of America
International Association for Landscape Ecology
Society for Conservation Biology (*life member*)

DENNIS D. MURPHY

Office:	Biology Department University of Nevada, Reno Reno, NV 89557 (775) 784-1303
Residence:	3280 Old Coach Court Reno, NV 89511 (775) 851-3280

Education

Bachelors of Science	University of California at Berkeley	1974
Doctor of Philosophy	Stanford University	1981

Professional positions

Post-Doctoral Fellow	Stanford University	1981-1983
Director	Center for Conservation Biology, Stanford	1983-1995
President	Center for Conservation Biology, Stanford	1995-1997
Research Professor	University of Nevada, Reno	1997-Present

Organizational ands society affiliations

Board of Directors	The Xerces Society	1987-1997
Board of Directors	Society for Conservation Biology	1993-2001
President	Society for Conservation Biology	1995-1997

Memberships have included

Ecological Society of America, Society for Conservation Biology, Society of Ecological Restoration and Management, Society for the Study of Evolution, The Lepidopterist's Society, The Xerces Society

Boards of editors service

Journal for Research on the Lepidoptera	1982-1992
Wings (Xerces Society)	1988-1998
Conservation Biology	1991-1998

Awards and commendations

Chevron Conservation Award	1988
Team Award - Wildlife Society	1990
Publication of the Year Award - Wildlife Society	1990
Publication of the Year Award - U.S. Forest Service	1992
Pew Scholars Award in Conservation and the Environment	1992
California's Governor's Leadership Award in Economics and the Environment	1994
Commendation - Intermountain Regional Director, U.S. Forest Service	1996
Commendation – Region 5 Regional Director, U.S. Fish and Wildlife Service	1999

Professional Biographical Statement

Dennis D. Murphy is Research Professor in the Biology Department and formerly director of the graduate program in Ecology, Evolution, and Conservation Biology at the University of Nevada, Reno. He received a Bachelors of Science at the University of California at Berkeley and his doctorate from Stanford University. He previously served as Director, then as President of the Center for Conservation Biology at Stanford. Author of more than 200 published papers and book chapters on the biology of butterflies and on key issues in the conservation of imperiled species, Dr. Murphy has worked in conflict resolution in land-use planning on private property since the first federal Habitat Conservation Plan on San Bruno Mountain. He won the industry's oldest and most respected prize in conservation, the Chevron Conservation Award, has been named a Pew Scholar in Conservation and the Environment, and received the California Governor's Leadership Award in Economics and the Environment.

Dr. Murphy has served a number of scientific societies and environmental organizations, and is Past President of the Society for Conservation Biology. He serves currently on the Water, Science, and Technology Board at the National Research Council (of the National Academy of Sciences). Previously, he served on the Board on Environmental Studies and Toxicology at the National Research Council. His professional activities outside of academia include service on the Missouri River Independent Science Advisory Panel, on the Interagency Spotted Owl Scientific Advisory Committee, impaneled by Congress to develop a solution to that planning crisis in the Pacific Northwest, as chair of the National Park Service's Scientific Advisory Committee on Bighorn Sheep, as co-chair of the State Department's American-Russian Young Investigators Program in Biodiversity and Ecology, as co-director of the statewide Nevada Biodiversity Initiative based at the University of Nevada at Reno, and as chair of the Scientific Review Panel to the first Natural Community Conservation Planning Program in southern California's coastal sage scrub ecosystem. He served the National Academy of Sciences on its Committee on Scientific Issues in the Endangered Species Act, on the Committee on Threatened and Endangered Species on the Platte River, and on the Committee on Hydrology, Ecology, and the Fishes of the Klamath River Basin.

Dr. Murphy currently serves as co-chair of the Independent Science Advisory Panel to the Missouri River Restoration Implementation Committee. Other ongoing and recent activities in the area of conservation planning and adaptive management include service on the Science Board to the CalFed Ecosystem Restoration Planning Program for the Sacramento and San Joaquin river systems, development of a conservation strategy for the imperiled Tahoe yellow cress for the U.S. Fish and Wildlife Service, development of a watershed-based ecosystem management framework for the Truckee, Carson, and Walker hydrological units in the Humboldt-Toiyabe National Forest, and science design for the nation's largest Habitat Conservation Plan under the Endangered Species Act, in Clark County, Nevada, and several other major HCP efforts in southern California and southern Nevada. Dr. Murphy also has served as team leader for the committee of scientists carrying out the Lake Tahoe Watershed Assessment, a Presidential deliverable to the Tahoe Federal Interagency Partnership via the U.S. Forest Service, and now sits with the science committee of the Tahoe Science Consortium. He also has chaired a number commissions and committees for NGOs, currently including the Commission on Performance Measures for State Wildlife Conservation Strategies at the Heinz Center in Washington, D.C. Dr. Murphy has testified more than a dozen times before Senate and House committees and subcommittees on issues mostly pertaining to implementation of the federal Endangered Species Act.

Publications -- 1980

1. Extinction, reduction, stability and increase: The response of checkerspot butterfly (*Euphydryas*) populations to the California drought. Oecologia 46:101-105. (with P.R. Ehrlich, M.C. Singer, R.R. White, I.L, Brown, and C. Sherwood).

2. Two California checkerspot butterfly subspecies: One new, one on the verge of extinction. Journal of the Lepidopterist's Society 34:316-320. (with P.R. Ehrlich).

1981

3. The population biology of checkerspot butterflies (*Euphydryas*). Biologia Zentroblatt 100:613-629. (with P.R. Ehrlich).

4. Butterfly nomenclature: A critique. Journal of Research on the Lepidoptera 20:1-11. (with P.R. Ehrlich).

5. The roles of adult resources in the population biology of checkerspot butterflies of the genus (*Euphydryas*). Ph.D. Thesis. Stanford University.

6. On the status of *Euphydryas editha baroni* with a range extension of *E. editha luestherae.* Journal of Research on the Lepidoptera 20:194-198.

7. Nomenclature, taxonomy and evolution. Journal of Research on the Lepidoptera 20:199-204. (P.R. Ehrlich).

1983

8. Butterflies and moths. Funk and Wagnall's New Encyclopedia vol. 5:78-81. (with P.R. Ehrlich).

9. The role of adult feeding in egg production and population dynamics of the checkerspot butterfly *Euphydryas editha.* Oecologia 56:257-263. (with A.E. Launer and P.R. Ehrlich).

10. Emergence patterns in male butterflies: A hypothesis and a test. Theoretical Population Biology 23:363-379. (with Y. Iwasa, F.J. Odendaal, P.R. Ehrlich, and A.E. Launer).

11. Nectar sources as constraints on the distribution of egg masses by the checkerspot butterfly *Euphydryas chalcedona* (Lepidoptera: Nymphalidae). Environmental Entomology 12:463-466.

12. Butterflies and biospecies. Journal of Research on the Lepidoptera 21:219-225. (with P.R. Ehrlich).

13. Butterfly nomenclature, stability, and the rule of obligatory categories. Systematic Zoology 352:451-453. (with P.R. Ehrlich).

14. Crows, bobs, tits, elfs, and pixies: The phoney "common name" phenomenon. Journal of Research on the Lepidoptera 22:154-158. (with P.R. Ehrlich).

15. A note on the biosystematics of the *Euphydryas* of central Utah. Utahensis 3:53-54. (with P.R. Ehrlich).

16. Biosystematics of the *Euphydryas* of the central Great Basin with the description of a new subspecies. Journal of Research on the Lepidoptera 22:254-261. (P.R. Ehrlich).

17. Book review. Arnold, R.A. Ecological Studies of Six Endangered Butterflies: Island Biogeography, Patch Dynamics, and the Design of Habitat Preserves. Univ. Cal. Pubs. Entomol. Vol. 99. Journal of Research on the Lepidoptera 22:267-269.

1984

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179. Murphy, D.D. and B.R. Noon. 2007. The role of scientists in conservation planning on private property. Conservation Biology 21:25-28.

180. Neill, R.S., P.F. Brussard, and D.D. Murphy. 2007. Butterfly community composition and oak woodland vegetation response to rural residential development. Journal of Landscape and Urban Planning 81:235-245.

181. Talley, T.S., E. Fleishman, M. Holyoak, D.D. Murphy, and A. Ballard. 2007. Rethinking a rare species conservation strategy in an urbanizing landscape. Biological Conservation 135:21-32.

182. Pellet, J,. E. Fleishman, D. Dobkin, A. Gander, and D.D. Murphy. 2007. An empirical evaluation of the area and isolation paradigm of metapopulation dynamics. Biological Conservation 136:483-495.

183. Richardson, T.W., L.H. Crampton, and D.D. Murphy. 2007. Influence of springs on breeding bird communities in the Spring Mountains of southern Nevada. Great Basin Birds 9:21-34.

2008

185. Kondolf, G.M., et al. 2008. Prioritizing river restoration: projecting cumulative benefits of multiple projects. Environmental Management 6:933-945.

186. Austin, G.T., B. Boyd, and D.D. Murphy. 2008. The ecology and systematic placement of a new and temporally disjunct species related to *Euphilotes ancilla*. Journal of Research on the Lepidoptera 63:148-160.

2009

187. Sanford, M.P., P.N. Manley, and D.D. Murphy. 2009. Effects of urban development on ant communities: implications for ecosystem services and management. Conservation Biology 23:131-141.

188. Murphy, D.D. and P.N. Manley. 2009. A report from Lake Tahoe: observations from an ideal platform for adaptive management. Water Resources IMPACT 11:15-17.

189. Fleishman, E. and D.D.Murphy. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. Conservation Biology 23:1109-1116.

190. Manley, P.N., K.K. McIntyre, M.D. Schlesinger, L.A. Campbell, S. Meredith, and D.D. Murphy. 2009. Use of forest inventory and analysis grid-based animal population data to develop an index of ecological diversity. Pp. 121-136, in Proceedings of the Eight Annual Forest Inventory and Analysis Symposium.

191. Mawdsley, J.R. and D.D. Murphy 2009. Measuring the results of wildlife conservation activities. The Heinz Center, Washington, D.C. 122 pp.

192. Murphy, D.D., and B.R. Noon. 2009. Adaptive management and the development of wildlife monitoring programs. Pages 93-101 in J. R. Mawdsley and D.D. Murphy eds, Measuring the results of wildlife conservation activities. The Heinz Center, Washington, D.C.

193. Murphy, D.D., L. Neel, and J.R. Mawdsley. 2009. Developing a monitoring program for the Nevada Wildlife Action Plan. Pages 103-114 in J. R. Mawdsley and D.D. Murphy, eds. Measuring the results of wildlife conservation activities. The Heinz Center, Washington, D.C.

2010

194. Manley, P.N., D.D. Murphy, and Z. Hymanson. 2010. Conceptual framework for an integrated science program. Chapter 2, in Hymanson, Z. and M. Collopy. A science plan for the Lake Tahoe basin: conceptual framework and research needs. Pacific Southwest Research Station, USFS GTR-226.

195. Manley, P.N., D.D. Murphy, S. Bigelow, S. Chandra, and L. Crampton. 2010. Ecology and biodiversity. Chapter 6 in Hymanson, Z. and M. Collopy eds. A science plan for the Lake Tahoe basin: conceptual framework and research needs. Pacific Southwest Research Station, USFS GTR-226.

2011

196. Crampton, L.H., W.S. Longland, D.D. Murphy, and J.S. Sedinger. 2011. Food abundance determines distribution and density of a frugivorous bird across seasons. Oikos 120:65-76.

197. Murphy, D.D. & P.S. Weiland. 2011. The route to best science in implementation of the Endangered Species Act's consultation mandate: The benefits of structured effects analysis. Environmental Management 47:161-172.

198. Murphy, D.C., P.S. Weiland, and K.W. Cummins. 2011. A Critical Assessment of the Use of Surrogate Species in Conservation Planning in the Sacramento-San Joaquin Delta, California (U.S.A.). Conservation Biology 25:873-878.

199. Fleishman, E. and D.D. Murphy. 2011. Minimizing uncertainty in interpreting responses of butterflies to climate change. Pages 55-66 in E.A. Beever and J.L. Belant, Ecological consequences of climate change: Mechanisms, conservation, and management. CRC Press.

200. Sanford, M.P., D.D. Murphy and P.F. Brussard. 2011. Distinguishing habitat types and the relative influences of environmental factors on patch occupancy for a butterfly metapopualtion. Journal of Insect Conservation 15:775-785.

2012

201. Miller, W.J., B.F.J. Manly, D.D. Murphy, D. Fullerton, and R.R. Ramey. 2012. An investigation of the factors affecting the decline of delta smelt (*Hypomesus transpacificus*) in the San Francisco-San Joaquin estuary. Reviews in Fisheries Science 20: 1-19.

2013

202. Wilson, J.S., M. Sneck, D.D. Murphy, C.C. Nice, J.A. Fordyce, and M.L. Forister. 2013. Complex evolutionary history of the pallid dotted-blue butterfly (Lycanidae: *Euphilotes pallescens*) in the Great Basin of western North America. Journal of Biogeography 40:2059-2070.

203. Murphy, D.D. and S.A. Hamilton. 2013. Eastward migration or marshward dispersal: exercising survey data to elicit an understanding of seasonal movement in delta smelt. San Francisco Estuary and Watershed Science 9:1-20.

204. Lucas, A.M., C.F. Scholl, D.D. Murphy, C.R. Tracy, and M.L. Forister. 2013. Geographic distribution, habitat association, and host quality for one of the most geographically restricted butterflies in North America: Thorne's hairsteak (*Mitoura thornei*). Insect Conservation and Diversity. Insect Conservation and Diversity.

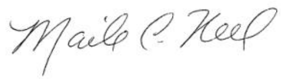
2014

205. Murphy, D.D. and P.S. Weiland. 2014. Science and structured decision-making: fulfilling the promise of adaptive management. Journal of Environmental Studies and Science. [On line.]

206. Murphy, D.D. and S.A. Hamilton. In press. Habitat affinity analysis as a tool to guide environmental restoration for an imperiled estuarine fish: the case of the delta smelt in the Sacramento-San Joaquin Delta.

CURRICULUM VITAE
Maile Catherine Neel

Notarization. I have read the following and certify that this curriculum vitae is a current and accurate statement of my professional record.



Signature____ ____Date____3/18/2014___________________

1. Personal Information

Maile C. Neel

Current Position:
Department of Plant Science and Landscape Architecture (67%; 75% Teaching, 25% Research) & Department of Entomology (33%)
Associate Professor
Appointed to Current Rank 2009

Director, Norton-Brown Herbarium
Appointed May, 2011

Education:

Ph.D. Botany 2000. University of California, Riverside.

M.A. Biology 1994. University of California, Santa Barbara.

B.S. Environmental Biology and Conservation 1985. Humboldt State University.
Magna Cum Laude and Distinguished Presidential Scholar.

Employment Background:

2005 - 2009. Assistant Professor. Department of Plant Science and Landscape Architecture. University of Maryland. College Park, MD.

2003 - 2005. Assistant Professor. Department of Natural Resource Sciences and Landscape Architecture. University of Maryland. College Park, MD.

2001 - 2003. Postdoctoral Research Associate. David H. Smith Conservation Research Fellow (through The Nature Conservancy). University of Massachusetts. Department of Natural Resources Conservation. Amherst, MA. Laboratory of Kevin McGarigal

2000 - 2001. Postgraduate Researcher. University of California, Riverside. Department of Botany and Plant Sciences. Riverside, CA. Laboratory of Norman C. Ellstrand

1998 - 2003. Visiting Investigator. The Marine Biological Laboratory. Woods Hole, MA.

1987 - 1998. Assistant Forest Botanist. San Bernardino National Forest. Fawnskin, CA.

1983 - 1986. Ranger Naturalist. Channel Islands National Park. Ventura, CA.

2. Research, Scholarly, and Creative Activities

a. Chapters in books. Invited Contributions

1. Neel, M. C. 2003. Genetic Diversity in Nature Reserves. Pages 149-151. In: McGraw Hill Yearbook of Science and Technology. McGraw-Hill Companies. New York, NY.

2. Neel, M. C. 2008. Conservation Planning and Genetic Diversity. Chapter 18. Pages 281-296 In: S. P. Carroll and C. W. Fox, Editors. Conservation Biology: Evolution in Action. Oxford University Press.

b. Articles in Refereed Journals. Citation counts as of 4/13/2008 (bold = lead or corresponding author; *=undergraduate student coauthor; **=graduate student coauthor)

1. **Neel, M. C.**, J. Clegg, and N. C. Ellstrand. 1996. Isozyme Variation in *Echinocereus engelmannii* var. *munzii*. *Conservation Biology* 10:622-631.
2. **Neel, M. C.**, and N. C. Ellstrand. 2001. Patterns of Allozyme Diversity in the Threatened Plant *Erigeron parishii* (Asteraceae). *American Journal of Botany* 88:810-818.
3. **Neel M. C.**, J. Ross-Ibarra*, and N. C. Ellstrand. 2001. Implications of Mating Patterns for Conservation of the Endangered Plant *Eriogonum ovalifolium* var. *vineum*. *American Journal of Botany* 88:1214-1222.
4. **Neel, M. C.** 2002. Conservation Implications of Reproductive Ecology in the Federally Endangered Plant *Agalinis acuta* (Scrophulariaceae). *American Journal of Botany* 89:972-980.
5. **Neel, M. C.**, and M. P. Cummings. 2003. Effectiveness of Conservation Targets in Capturing Genetic Diversity. *Conservation Biology* 17:219-229.
6. **Neel, M. C.**, and N. C. Ellstrand. 2003. Conservation of Genetic Diversity in the Endangered Plant *Eriogonum ovalifolium* var. *vineum* (Polygonaceae). *Conservation Genetics* 4:337-352.
7. **Neel, M. C.**, and M. P. Cummings. 2003. Genetic Consequences of Ecological Reserve Design Guidelines: An Empirical Investigation. *Conservation Genetics* 4: 427–439.
8. **Neel, M. C.** and M. P. Cummings. 2004. Section-Level Relationships of North American *Agalinis* (Orobanchaceae) based on DNA Sequence Analysis of Three Chloroplast Gene Regions. *BMC Evolutionary Biology* 4:15.
9. **Neel, M. C.**, K. McGarigal, and S. Cushman. 2004. Behavior of Class-Level Landscape Metrics Across Gradients of Class Aggregation and Area. *Landscape Ecology* 19: 435-455.
10. **Grand**, J.**, J. Buonaccorsi, S. A. Cushman**, C. R. Griffin, and M. C. Neel. 2004. A Multi-Scale Landscape Approach to Predicting Bird and Moth Rarity Hotspots in a Threatened Pitch Pine-Scrub Oak Community. *Conservation Biology* 18:1063-1077.
11. **Grand, J**. M. P. Cummings, A. G. Rebelo, T. H. Ricketts, and M. C. Neel. 2007. Biased Data Reduce Efficiency and Effectiveness of Conservation Reserve Networks. *Ecology Letters* 10: 364-374.
12. **Ferrari**, J. T**., T. R. Lookingbill, and M. C. Neel. 2007. Two Measures of Landscape-Graph Connectivity: Assessment Across Gradients in Area and Configuration. *Landscape Ecology* 22:1315-1323.
13. **Cushman, S. A.**, K. McGarigal, and M. C. Neel. 2008. Parsimony in Landscape Metrics: Strength, Universality, and Consistency. *Ecological Indicators* 8:691-703.
14. **Neel, M. C.** 2008. Patch Connectivity and Genetic Diversity Conservation in the Federally Endangered and Narrowly Endemic Plant Species *Astragalus albens* (Fabaceae). *Biological Conservation* 141:938-955.
15. **Cummings, M. P.**, M. C. Neel, and K. L. Shaw. 2008. A Genealogical Approach to Quantifying Lineage Divergence. *Evolution*. 62:2411-22.

16. Pettengill**, J. B., **M. C. Neel**. 2008. Phylogenetic Patterns and Conservation in the Genus *Agalinis* (Orobanchaceae). *BMC Evolutionary Biology* 8:264.
17. **Burnett, R. K**.*, M. Lloyd**, and M. C. Neel. 2009. Development of Eleven Polymorphic Microsatellite Markers in a Macrophyte of Conservation Concern, *Vallisneria americana* Michaux (Hydrocharitaceae). *Molecular Ecology Resources* 9:1427-1429.
18. **Pettengill, J. B.****, R. K. Burnett, and M. C. Neel. 2009. Characterization of 21 Microsatellites Within *Agalinis acuta* (Orobanchaceae) and Cross-Species Amplification Among Closely Related Taxa. *Molecular Ecology Resources* 9:1375-1379.
19. **Fox, H. E.,** P. Kareiva, B. Silliman, J. Hitt, D. Lytle, B. S. Halpern, C. V. Hawkes, J. Lawler, M. C. Neel, J. D. Olden, M. A. Schlaepfer, K. Smith, H. Tallis. 2009. Why Do We Fly? Ecologists' Sins of Emission. *Frontiers in Ecology and the Environment* 7:294-296.
20. **Laikre, L,** F. W. Allendorf, L. C. Aroner, C. S. Baker, D. P. Gregovich, M. M. Hansen, J. A. Jackson, K. C. Kendall, K. McKelvey, M. C. Neel, I. Olivieri, N. Ryman, M. K. Schwartz, R. Short Bull**, J. B. Stetz, D. A.Tallmon, B. L. Taylor, C. D. Vojta, D. M. Waller, R. S. Waples. 2010. Neglect of Genetic Diversity in Implementation the Convention on Biological Diversity. *Conservation Biology* 24:86-88.
21. **Scott, J. M.**, D. D. Goble, A. Haines, J. A. Wiens, and M. C. Neel. 2010. Conservation-Reliant Species and the Future of Conservation. *Conservation Letters* 3:91-97.
22. **Kennedy, C. M**.**, W. F. Fagan, P. P. Marra, and M. C. Neel. 2010. Landscape Matrix and Species Traits Mediate Responses of Neotropical Resident Birds to Forest Fragmentation in Jamaica. *Ecological Monographs* 80:651-669.
23. **Pettengill, J. B.**** and M. C. Neel. 2010. An Evaluation of Candidate Plant DNA Barcodes and Assignment Methods for Diagnosing Species in the Genus *Agalinis* (Orobanchaceae). *American Journal of Botany* 97:1391-1406.
24. **Leidner, A. K.** and M. C. Neel. 2011. Taxonomic and Geographic Patterns of Decline for Threatened and Endangered Species in the United States. *Conservation Biology*. 25:716-725.
25. **Pettengill, J. B.**** and M. C. Neel. 2011. Comprehensive Genetic and Morphological Analyses do not Support the Taxonomic Rank of Species for the Federally Listed Endangered Plant *Agalinis acuta* (Orobanchaceae**)**. *American Journal of Botany* 98:859-871.
26. **Lloyd, M. W.**** R. K. Burnett Jr., K. A. M. Engelhardt, **M. C. Neel.** 2011. Genetic Diversity and Population Structure of *Vallisneria americana* in the Chesapeake Bay: Implications for Restoration. *Conservation Genetics* 12:1269-1285.
27. **Zeigler, S. L****, M. C. Neel, L. Oliveira, B. E. Raboy, W. F. Fagan. 2011. Conspecific and Heterospecific Attraction in Assessments of Functional Connectivity. *Biodiversity and Conservation*. DOI 10.1007/s10531-011-0107-z (http://www.springerlink.com/content/h12830046582twk7/fulltext.html)
28. **Kennedy, C. M.****, E. H. Campbell Grant, M. C. Neel, W. F. Fagan, and P. P. Marra. 2011. Landscape Matrix Mediates Occupancy Dynamics of Neotropical Avian Insectivores. *Ecological Applications* 21:1837-1850.
29. **Neel, M. C**., A. K. Leidner, A. Haines, D. D. Goble, J. M. Scott. 2012. By the Numbers: How is Recovery Defined by the U.S. Endangered Species Act? *BioScience*. 62:646-657.

30. **Lloyd, M. W.**,** R. K. Burnett Jr., K. A. M. Engelhardt, M. C. Neel. 2012. Does Genetic Diversity of Restored Sites Differ from Natural Sites? A Comparison of *Vallisneria americana* (Hydrocharitaceae) Populations Within the Chesapeake Bay. *Conservation Genetics* 13:753–765.
31. **Che-Castaldo, J. P**., M. C. Neel. 2012. Testing Surrogacy Assumptions: Can Threatened and Endangered Plants be Grouped by Biological Similarity and Abundances? *PloS One* 7:e51659.
32. **Neel, M. C**., J. P. Che-Castaldo. 2103. Do Past Abundances or Biological Traits Predict Recovery Objectives for Threatened and Endangered Plant Species? *Conservation Biology* 27:385-397.
33. **Kennedy, C. M.,** E. Lonsdorf, M. C. Neel, N. M. Williams, T. H. Ricketts, R. Winfree, et al. 2013. A Global Quantitative Synthesis of Local and Landscape Effects on Wild Bee Pollinators in Agroecosystems. *Ecology Letters* 16:584-599.
34. **Neel, M. C.,** K. McKelvey, R. S. Waples, N. Ryman, M. W. Lloyd**, R. Short Bull**, F. W. Allendorf, and M. K. Schwartz. 2013. Estimation of Effective Population Size in Continuously Distributed Populations: There Goes the Neighborhood. *Heredity* 111:189-99. doi:10.1038/hdy.2013.37
35. **Lloyd, M. W.****, L. Campbell, and M. C. Neel. 2013. The Power of Wright's F_{st}, Hedrick's G'_{st}, and Jost's D to Detect Recent Fragmentation Events. *PloS One.* 8: e63981. doi:10.1371/journal.pone.0063981.
36. **Zeigler, S. L.** **, J. P. Che-Castaldo, M. C. Neel. 2013. Actual and Potential Use of Population Viability Analysis in Recovery of Plant Species Listed Under the U.S. Endangered Species Act. *Conservation Biology* 27:1265-1278. DOI: 10.1111/cobi.12130
37. **West**, B. E.,** K. A. M. Engelhardt, M. C. Neel. 2013. Genetic Rescue versus Outbreeding Depression in *Vallisneria americana*: Implications for Mixing Seed Sources for Restoration. *Biological Conservation* 167:203-214. DOI:10.1016/j.biocon.2013.08.012
38. **Engelhardt, K. A. M.,** M. W. Lloyd**, and M. C. Neel. Accepted with Revision. Effects of Genetic Diversity on Individual and Population Performance in a Clonal Plant.
39. **Neel, M. C**., H. Tumas*, B. E. West**, M. W. Lloyd**. Submitted. Representing Resiliency: A Framework for Quantifying Changes in Connectivity.
40. **Neel, M**. C., A. Bazinet, A. Schartner, H. Tumas, J. Sullivan. In preparation. Use of Next Generation Sequencing and Single Nucleotide Polymorphism Genotyping to Identify the Source of American Beech Leaves in a Murder Case in Prince George's County, Maryland.
41. **Che-Castaldo, J. P**., M. C. Neel. In preparation. Species-level persistence probabilities for recovery and conservation status assessment.
42. **Wolf, S. H.,** B. Hartl, C. Carroll, J. Tutchton, N. D. Greenwald, M. C. Neel. In preparation. Beyond PVA: Why recovery under the Endangered Species Act is more than population viability.
43. Evans, D.M, J. P. Che-Castaldo, D. Crouse, F. W. Davis, T. H. Eason, R. Epanchin-Niell, C. H. Flather, K. Frohlich, D. D. Goble, Y. Li, T. D. Male, L. L. Master, M. C. Neel, B. R. Noon, C. Parmesan, M. W. Schwartz, J. M. Scott, B. K. Williams. In preparation. Recovery of Endangered and Threatened Species in the United States. Invited submission: *Issues in Ecology*

c. Monographs, Reports, and Extension Publications.

1. Neel, M. 1988. Lichens and Air Pollution in the San Gabriel Wilderness, Angeles National Forest. Report to the Angeles National Forest, USDA Forest Service Pacific Southwest Region.
2. Neel, M. 1989. Cooperation - The Key to Plant Habitat Conservation on the San Bernardino National Forest. *Crossosoma*. 15:1-4.
3. Neel, M. C. and K. Barrows. 1990. Pebble Plain Habitat Management Guide. Produced in Cooperation Between the San Bernardino National Forest and The California Nature Conservancy. 60 pages.
4. Neel, M. and S. Chaney. 1992. Damage Assessment and Rehabilitation Plan for Vehicle Trespass at North Baldwin Lake. Big Bear Ranger District, San Bernardino National Forest. 37 pages.
5. Tilden, D. and M. Neel. 1993. Reconnaissance of Natural Vegetation Recovery at Mine Sites in the California Desert. Unpublished report submitted to the US Bureau of Mines. 136 pages.
6. Neel, M. C. and J. Greene. 1993. Revegetation Plan for Gordon Quarry. Big Bear Ranger District, San Bernardino National Forest.
7. Neel, M. and P. Somers. 2000. Summary Report on Six Experiments Examining Establishment and Maintenance of *Agalinis acuta* Populations. Prepared for the U. S. Fish & Wildlife Service New England Field Office. Contract 14-48-0005-93-90002 with The Nature Conservancy. 62 pages.
8. Neel, M., S. Neid, and D. Szczebak. 2001. GIS Metadata. Pages 56-67 In: *BioMap Technical Report: A Supplement to BioMap: Guiding Land Conservation for Biodiversity in Massachusetts*. Massachusetts Natural Heritage & Endangered Species Program, Division of Fisheries and Wildlife, Westborough, Massachusetts.
9. Neel, M. C. 2001. Identifying Supporting Natural Landscape. Pages 52-55 In: *BioMap Technical Report: A Supplement to BioMap: Guiding Land Conservation for Biodiversity in Massachusetts*. Massachusetts Natural Heritage & Endangered Species Program, Division of Fisheries and Wildlife, Westborough, Massachusetts.
10. Neel, M. C. and J. B. Pettengill. 2008. Final Report: Evaluation of the Evolutionary Distinctiveness of *Agalinis acuta*. Submitted to the US Fish and Wildlife Service. Cooperative Agreement 50181-6-J002. 139 pages.
11. Engelhardt, K., M. C. Neel, and M. W. Lloyd. 2010. Final Report: SeaGrant.
12. Neel, M. C. 2012. DNA Analysis of American Beech (*Fagus grandifolia*) to Identify the Source of Leaves Recovered from the Body of a Murder Victim in Prince Georges County, Maryland. Submitted to the Office of the State's Attorney for Prince George's County. August 24, 2012. 9 pages.
13. Neel, M.C. 2013. Technical Report: Use of Next Generation Sequencing and Single Nucleotide Polymorphism Genotyping to Identify the Source of American Beech Leaves In Case 09-075-0196. Submitted to the Office of the State's Attorney for Prince George's County and the Prince George's County Police Department. August 27, 2013. 62 pages.

d. Book Reviews, Other Articles, and Notes.

None

e. Collaborative Research Working Groups - Invited

2006 - 2008 Participant. Research Coordination Network. Biodiversity Conservation in Dynamic Landscapes. Case Study: Ecosystem Services in the Little Karoo of South

Africa. Funded by The National Science Foundation. Coordinated by Sandy Andelman.

2008 - 2010 Participant. Genetic Monitoring Working Group. National Center for Ecological Analysis and Synthesis. Organized by Fred Allendorf and Michael Schwartz.

2008 - 2009 Participant. Conservation Biology Collaborative Synthesis. Funded by The Nature Conservancy.

2013 – present Participant. Endangered Species Recovery Synthesis. Special Issue of Issues in Ecology.

f. Talks, Abstracts, and Other Professional Papers Presented.

i. Invited talks, etc.

Academic Seminars

1997 Department of Biology, University of California. Riverside, CA.

1999 Department of Biology, Trinity College. Hartford, CT.

1999 Department of Ecology and Evolutionary Biology, Yale University. New Haven, CT.

1999 Josephine Bay Paul Center in Comparative Molecular Biology and Evolution, Marine Biological Laboratory. Woods Hole, MA.

2000 New England Botanical Club. Cambridge, MAs.

2000 Department of Ecology and Evolutionary Biology, University of Connecticut. Storrs, CTt.

2000 Ecosystems Center, Marine Biological Laboratory. Woods Hole, MA.

2002 Department of Biology, McGill University. Montreal, Canada.

2003 Department of Biology and Institute for Arctic Biology, University of Alaska, Fairbanks.

2003 Department of Biology, University of Denver. Denver, Colorado.

2003 Department of Biology, Wesleyan University. Middletown, Connecticut.

2003 Department of Biology, University of Central Florida. Orlando, Florida.

2003 Department of Wildlife Ecology, University of Maine. Orono, Maine.

2006 College of Natural and Agricultural Sciences. University of California. Riverside, CA.

2007 Department of Biological Sciences, Simon Fraser University, British Columbia, Canada. Gave two seminars during my visit.

2008 University of Maryland Center for Environmental Science Appalachian Laboratory.

2012 University of Maryland College of Agricultural and Natural Resources Convocation. May 3.

Invited Talks/Courses for Conservation Organizations and Agencies (speaker of multi-author talks identified in bold)

1989 National Association for Interpretation National Conference. Big Bear City, CA.

1993 & 1994 Rancho Santa Ana Botanic Garden Public Education Series. Claremont, CA.

1997 USDA Forest Service Pacific Southwest Region Annual Meeting of Botanists and Ecologists. Morro Bay, CA.

2001 Commonwealth Scientific and Industrial Research Organization (CSIRO), Plant Industry Division. Canberra, Australian Capital Territory, Australia.

2002 The Nature Conservancy's All Science Meeting. Albuquerque, NM.

2002 & 2004 US Fish and Wildlife Service Recovery Plan Meeting for the Endangered plant *Agalinis acuta*. Presented results of ongoing population monitoring and systematic studies with recommendations for future research.

2002, 2005, 2006, 2008 & 2009. Faculty in "Applied Conservation Genetics" course. National Conservation Training Center (sponsored by the US Fish and Wildlife Service and Biological Resources Division of the US Geological Survey).

In 2002 and 2005 I guest lectured on plant conservation genetic issues. I was invited to be a full faculty member in this week-long course in 2006, 2008 & 2009. As a faculty member I contribute to the overall course curriculum and develop and present lectures on effective population size, plant conservation genetics, patterns of endangered species threats and recovery, and landscape genetics. I also developed an exercise in which the students apply their knowledge to case studies and have run the exercise for 3 years.

2003 USDA Forest Service National Botanist's and Ecologist's Meeting (1/2 day continuing education course in plant conservation genetics).

2004 Cedar Tree Foundation Board Meeting. Annapolis, MD.

2004 **Jolls, C. L**. and M. C. Neel. The Genetics of Rare Plants: Ecological and Management Considerations. North Carolina Rare Plants Group, NC Zoological Park, Asheboro, NC, 11 March 2004.

2006 Conservation and Land Management Agency (CALM). Perth, Western Australia. June, 2006

2006 **M. C. Neel**, B. Compton, and K. McGarigal. Can We Conserve Biodiversity Without Really Trying? Capturing Non-Target Biodiversity Using Community-Based Representative Reserve Designs. The Nature Conservancy Science Meetings. Tucson, AZ. 11/28-11/30/2006.

2007 **M. C. Neel**, M. Lloyd, J. Greenburg, R. Burnett, and K. Engelhardt. The Role of Genetic Diversity in Restoration Success for *Vallisneria Americana*. Freshwater Submerged Aquatic Vegetation Partnership Science and Technical Advisory Committee, 10/17. National Plant Materials Center, Beltsville, MD.

2009 **M. Lloyd**, M. C. Neel**, R. Burnett, and K. Engelhardt. Updates and Preliminary Results: The Role of Genetic Diversity in Restoration Success for *Vallisneria americana*. Freshwater Submerged Aquatic Vegetation Partnership Science and Technical Advisory Committee, 10/17. Annapolis, MD.

2009 M. Neel. Developing Scientifically Based Recovery Objectives for Federally Listed Species. U.S. Fish and Wildlife Service. Arlington, VA.

2011 **M. Neel and J. Che-Castaldo**. By the Numbers: Recovery Objectives for Endangered Species. U.S. Fish and Wildlife Service. 8/15 & 9/14 Arlington, VA.

2012 **M. C. Neel** and A. Leidner. By the Numbers: Recovery Objectives for Endangered Species. Briefing for the Committee on Natural Resources of the U.S. House of Representatives. 5/16/ Washington, DC.

2012 **M. C. Neel** and A. Leidner. By the Numbers: Recovery Objectives for Endangered Species. Defenders of Wildlife. 9/19. Washington, DC.

2012 **M. C. Neel**, and K. Engelhardt. The Role of Genetic Diversity in Restoration Success for *Vallisneria Americana*. Freshwater Submerged Aquatic Vegetation Partnership Science and Technical Advisory Committee, 11/8. Annapolis, MD.

2013 M. C. Neel and T. Sudol**. Forest Fragmentation in Prince George’s County, MD. Greenbelt Forest Stewardship Program "Walking the Woods" Symposium. Greenbelt, MD 3/9.

2013 M. C. Neel and T. Sudol**. Forest Fragmentation in Prince George’s County, MD. Maryland National Capital Parks Commission. Upper Marlboro, MD 4/2. Note: This talk was modified from the version above.

Invited Lectures in University Courses

1992 “Conservation and Management of Rare Plants and Communities of the Big Bear Region, San Bernardino Mountains”. Ecology. University of Redlands. Redlands, CA.

1993-1995 “Resource Conservation on National Forest Lands”. Environmental Design Studio. University of Redlands. Redlands, CA.

Gave lectures each year and for two years worked with the classes all semester to develop a conservation plan for endangered species on the San Bernardino National Forest.

1996 Panel Member: Career Options for Biology Majors. Biology of Human Problems (undergraduate senior honors course). University of California, Riverside. Riverside, CA.

1997 “Plant Conservation in California”. Spring Wildflowers. University of California, Riverside. Riverside, CA.

2001 “Application of Ecological Methods in Reserve Design and Conservation”. General Ecology. Brown University. Providence, RI

2002 “Development of the BioMap, a Conservation Plan for Rare Species in Massachusetts”. Ecosystem Management, University of Massachusetts Amherst. Amherst, MA

2003 “Genetic Diversity and Conservation of Endangered Plant Species”. Genetic Engineering Honors Course, University of Maryland College Park. College Park, MD

2005 “Genetic Diversity and Extinction Risk in Endangered Plant Species”. Extinction Honors Course HONR 284N, University of Maryland College Park. College Park, MD.

ii. Refereed conference proceedings. (speaker identified in bold, *=undergraduate student coauthor; **=graduate student coauthor)

1995. **Gonella******, M. P.**, and M. C. Neel. Characterization of Rare Plant Habitat for Restoration in the San Bernardino National Forest. Pages 81-93. In: B. A. Roundy, E. D. McArthur, J. S. Haley, D. K. Mann. Compilers. Proceedings: Wildland Shrub and Arid Land Restoration Symposium; October 19-21 1993 Las Vegas, NV. Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

2009. **Eliason, S.** and **M. C. Neel**. A Habitat Management Strategy for Threatened and Endangered Carbonate-Endemic Plants of the San Bernardino Mountains, Southern CA. California Native Plant Society 2009 Conservation Conference: Strategies and Solutions. Sacramento, CA. January 17-19, 2009.

iii. Unrefereed conference proceedings. (speaker identified in bold, *=undergraduate student coauthor; **=graduate student coauthor)

1999 **Neel, M. C.** and N. C. Ellstrand. The Structure of Diversity: Implications for Reserve Design. Society for Conservation Biology Meetings. University of Maryland, College Park, MD.

1999 **Neel**, **M. C.,** J. Ross-Ibarra*, N. C. Ellstrand. Conservation Implications of Mating Patterns in *Eriogonum ovalifolium* var. *vineum*. Meetings of the Society for the Study of Evolution. University of Wisconsin, Madison, WI.

2000 **Neel**, **M. C.,** N. C. Ellstrand, and M. P. Cummings. Are General Reserve Design Guidelines Effective at Conserving Genetic Diversity? Society for Conservation Biology Meetings. University of Montana, Missoula, MT.

2002 **Neel**, **M. C.,** S. Cushman**, and K. McGarigal. Comparison of Landscape Structure Metrics for Evaluating and Quantifying Fragmentation. Society for Conservation Biology Meetings. 7/14-7/19. University of Kent, Canterbury, England.

2003 **Neel, M. C.** Plant Conservation Genetics and The U.S. Endangered Species Act: A Review of the Literature and Assessment of its Impact on Endangered Species Conservation. Society for Conservation Biology Meetings 6/28-7/2. University of Minnesota, Duluth, MN.

2004 **Schlag**, E.**, M. C. Neel, and M. McIntosh. Genetic Diversity of Maryland-Grown American Ginseng (*Panax quinquefolius*). Society for Conservation Biology Meetings 7/30-8/2. Columbia University, New York, NY.

2005 Cummings, M. P., M. C. Neel, **K. L. Shaw**. A Method for Detecting Genealogical Divergence with Applications to the Species Problem. *Evolution 2005*, Meetings of the Society for the Study of Evolution, Society of Systematic Biologists, and the American Society of Naturalists 6/10-6/14. Fairbanks, AK.

2007 **Ferrari**, J.,** M. C. Neel, and T. R. Lookingbill. Graph Analysis of Connectivity Across Gradients in Habitat Proportion in the Mid-Atlantic Region of the United States. US International Association of Landscape Ecologists Regional Meeting 4/9-3/13. Tucson, AZ.

2007 Grand, J., M. P. Cummings, A. G. Rebelo , Taylor H. Ricketts, **M. C. Neel**. Biased Data Reduce Efficiency and Effectiveness of Conservation Reserve Networks. Society for Conservation Biology Meetings 7/1-7/5. Port Elizabeth, South Africa.

2007 **Pettengill**, J. B.** and M. C. Neel. *Agalinis acuta* (Orobanchaceae): A Phylogenetically Unresolved Federally Listed Endangered Plant Species. Student Research Symposium in Plant Biology & Conservation, Botanical Society of America 7/7-7/11. Chicago Botanic Garden, Chicago, IL.

2008 **Neel, M. C.** Patch Connectivity and Genetic Diversity Conservation. Society for Conservation Biology Meetings 7/13-7/18, Chattanooga, TN.

2008 **Lloyd**, M. W**. and M. C. Neel. The Power of Wright's F_{ST} to Detect Sudden Changes in Connectivity Using a Multifactorial Modeling Framework 7/13-7/18. Society for Conservation Biology Meetings. Chattanooga, TN.

2008 **Campbell, L. G.**, M. C. Neel. Genetic Risk and Endangered Species: Strengthening Links Between Science and Recovery. Society for Conservation Biology Meetings 7/13-7/18. Chattanooga, TN.

2008 **Pettengill**, J. B**., M. C. Neel. "What is the Taxonomic Status of the Federally Listed Endangered Species *Agalinis Acuta* (Orobanchaceae)?" Society for Conservation Biology Meetings 7/13-7/18. Chattanooga, TN.

2008 **Kennedy**, C. M.,** P. Marra, M. C. Neel, R. DeFries, and W. F. Fagan. Response of Birds to Landscape Matrix in Fragmented Forests in Jamaica: Dispersal or Resource-Limitation? Ecological Society of America 93rd Annual Meeting 8/3-8/8. Milwaukee, WI.

2009 **Kennedy**, C. M,** P. Marra, M. Neel, and W. Fagan. "Landscape Matrix Influences Avian Community Stability in Fragmented Tropical Forests in Jamaica." 94th Ecological Society of America Meeting, 2-7 August 2009, Albuquerque, NM.

2010 **Leidner, A. K**, M. C. Neel. Patterns of Decline for Threatened and Endangered Species in the United States. 24th Annual Society for Conservation Biology Meetings. Edmonton, Alberta, Canada.

2011 **Lloyd**, M.W.,** R. K. Burnett Jr., K. A. M. Engelhardt, M. C. Neel. 2010. Genetic Diversity and Population Structure of *Vallisneria americana* in the Chesapeake Bay: Implications for Restoration. University of Maryland Bioscience Day, College Park, MD.

2012 **Lonsdorf, E**., C. M. Kennedy, M. C. Neel, N. M. Williams, and C. Kremen. Using MCMC Parameterization to Improve Accuracy of an Ecologically-Scaled Landscape Index of Pollinator Abundance. 97th Ecological Society of America Annual Meeting. August 6-10. Portland, OR.

2012 **Neel, M. C.** and J. P. Che-Castaldo. Predicting endangered species recovery objectives using biological traits and patterns of decline. 97th Ecological Society of America Annual Meeting. August 6-10. Portland, OR.

2012 **Kennedy, C. M**., E. Lonsdorf, M.C. Neel, N. M. Williams, and C. Kremen, A global synthesis of local and landscape effects on native bee pollinators across heterogeneous agricultural systems. 97th Ecological Society of America Annual Meeting. August 6-10. Portland, OR.

2013 **Tumas, H**.* M. Neel, B. West Marsden, and K. Engelhardt. Determining the effect of water quality on submerged aquatic vegetation growth and ecosystem benefits. International Congress for Conservation Biology. July 21-25. Baltimore, MD.

2013 **West Marsden, B.******,** M. Neel, and M. Lloyd. Evaluating the potential resiliency of *Vallisneria Americana* in the Potomac River (USA) using individual-based networks of genetic distances. International Congress for Conservation Biology. July 21-25. Baltimore, MD.

2013. **Zdilla, K.****, M. Neel. Social Effects of Forest Stewardship Council Certification in the Tropics and an Assessment of Methodology in Effect Evaluation. International Congress for Conservation Biology. July 21-25. Baltimore, MD.

Symposia Organized

2002 ‘Graduate and Post-Doctoral Research in Ecology: Achieving Conservation Relevance’. Meetings of the Ecological Society of America. Tucson, AZ. Sponsored by the David H. Smith Fellowship Program.

2003 'Conserving the Ecological and Evolutionary Functions of Movement'. Meetings of the Society for Conservation Biology 6/29-7/2. Duluth, MN. Sponsored by the David H. Smith Fellowship Program. Co-Organizer.

2006 'Conservation Planning and Reserve Selection'. Meetings of the Society for Conservation Biology. San Jose, CA 7/25-29. Sponsored by the David H. Smith Fellowship Program.

2006 'Making Conservation Decisions in a Data Limited World'. BioScience Day, University of Maryland College Park. College Park, MD 11/16.

Invited Talks in Symposia (speaker identified in bold)

1992 **Neel, M. C.** American Association for the Advancement of Science Symposium: Rare Plant Communities. Santa Barbara, CA.

1999 **Neel, M. C.** Southern California Botanists Symposium: Perspectives on Biodiversity. California State University Fullerton. Fullerton, CA.

2001 **Neel, M. C.** Symposium on Marine Protected Areas: Design and Implementation for Conservation and Fisheries Restoration. Woods Hole Oceanographic Institution. Woods Hole, MA.

2006 **Ferrari**, J.,** and M.C. Neel. Graph Theoretic Landscape Connectivity Assessment Across Gradients in Habitat Amount. US Regional Association of the International Association of Landscape Ecology Annual Symposium.

2006 **Neel**, **M. C.,** B. Compton, K. McGarigal. 'Can we conserve biodiversity without really trying? Capturing non-target biodiversity using community-based representative reserve designs'. Meetings of the Society for Conservation Biology 6/24-6/28. San Jose, CA. Sponsored by the David H. Smith Fellowship Program.

2008 **Scott, J. M.,** M. C. Neel, A. M. Haines, D. Goble. Recovery Under the Endangered Species Act: The Roles of Science and Policy. Symposium Title: The Road to Recovery: Science to Secure Freshwater Mollusk Biodiversity. Meetings of the Society for Conservation Biology 7/13-7/18. Chattanooga, TN.

2009 **Neel, M. C.**, J. B. Pettengill**, C. M. Kennedy**. The role of phylogenetic data in listing and delisting decisions for plant species under the Endangered Species Act. Symposium Organizer: Sylvia Fallon, Natural Resources Defense Council. Annual Meetings of the American Association for the Advancement of Science. 2/12-2/16/ Chicago, IL.

2009 **Luther, D A.**, Neel, M.C. Management Strategies and Actions for Conservation Reliant Birds. Symposium Organizer: J. Michael Scott and J. Michael Reed. Symposium Title: Conservation Reliant Birds Our New Relationship with Nature. American Ornithologists Union Annual Meeting, 8/12-15. University of Pennsylvania. Philadelphia, PA.

2011 **Neel, M.C.** and L.G. Campbell. Genetic Risk and Endangered Species: Linking Science and Recovery. Symposium Organizer: Dr. Caroline Ridley (Environmental Protection Agency). Symposium Title: Integrating Evolution into Policy: Improved Science-Based Decision-Making for Environmental Stewardship. 96th Ecological Society of America Annual Meeting. August 7-12. Austin, TX.

2013 Neel, M.C. and J. P. Che-Castaldo. New methods for developing recovery criteria and the basic numbers of recovery. Symposium Organizer: Noah Greenwald, Center for Biological Diversity. Symposium Title: The Endangered

Species Act at 40: Measuring Success and the Critical Role of Stakeholders. International Congress for Conservation Biology. July 21-25. Baltimore, MD.

2013 Neel, M.C. and J. P. Che-Castaldo. Improving endangered species recovery planning. Symposium Organizer: Dan Evans. Symposium Title: The Endangered Species Act Turns 40. 98th Ecological Society of America Annual Meeting. August 4-9. Minneapolis, MN.

Workshops Given

2002 Landscape Pattern Analysis Using FRAGSTATS. International Association of Landscape Ecologists, US Chapter Meeting. Lincoln, NE.

2003 Landscape Pattern Analysis Using FRAGSTATS. International Association of Landscape Ecologists, World Congress 7/13-7/17, Darwin, Australia. Co-Instructor.

Posters (primary presenter identified in bold)

2005 **Kennedy**, C.**, P. Marra, M. Neel, R. DeFries, and W. Fagan. 'Response of Birds to Landscape Matrix in Fragmented Forests in Jamaica'. NASA Biodiversity & Ecological Forecasting Team Meeting, Westin Grand Hotel, Washington, DC.

2006 **Kennedy**, C**, P. Marra, M. Neel, R. DeFries, and W. Fagan. 'Birds in Fragmented Landscapes in Jamaica: Differential Mechanisms of Matrix Response'. NASA Joint Workshop on Biodiversity, Terrestrial Ecology & Related Applied Sciences, Adelphi, MD.

2007 **Neel, M. C.**, W. F. Fagan, E. M. Lind**, **E. E. Goldberg**, and **L. G. Campbell**. 'Setting Scientifically Defensible Recovery Goals for Threatened and Endangered Species'. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop. Washington, DC.

2008 **Granberg**, J. E**., K. A. M. Engelhardt, T. M. Beser, M. Lloyd**, R. Burnett* and M. C. Neel. The Response of *Vallisneria americana* to Climate Change: Does Genetic Structure Matter? 5/26-5/30 Society of Wetland Scientists Annual Meeting. Washington, D.C.

2008 **Neel, M. C.**, S. Zeigler**, and D. Luther. Setting Scientifically Defensible Recovery Goals for Threatened and Endangered Species. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop. Washington, DC.

2009 **Neel, M. C.**, S. Zeigler**, and A. Leidner, W. Fagan, and E. Goldberg. Setting Scientifically Defensible Recovery Goals for Threatened and Endangered Species. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop, 12/1-12/3. Washington, DC.

2009 **Zeigler**, S.** and Neel, M. C. Population Viability Analysis and Recovery of Plant Species Listed Under the U.S. Endangered Species Act. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop, 12/1-12/3. Washington, DC.

2009 **Lloyd**, M. W**., M. C. Neel. The power of Wright¹s *F*st and Jost¹s *D* to Detect Sudden Changes in Connectivity Using a Multifactorial Modeling Framework. Bioscience Day, University of Maryland, College Park, MD.

2009 **Pettengill**, J. B.,** M. C. Neel. Comprehensive Genetic and Morphological Analyses do not Support the Taxonomic Rank of Species for the Federally Listed Endangered Plant Agalinis acuta (Orobanchaceae). University of Maryland Bioscience Day, College Park, MD.

2010. Fagan, William F. E Goldberg, E. Larsen, **Y. Pearson[1]**, A. Leidner[3], Paula C., J. Turner, H. Staver, M. Neel. Estimating Reproductive Rates in Mammalian Species. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop, 12/1-12/3. Washington, DC.

2011. **Lloyd, M. W.,** R. K. Burnett, JR., K. A. M. Engelhardt, M. C. Neel. The Structure of Population Genetic Diversity in *Vallisneria american*a in the Chesapeake Bay: Implications for Restoration. GRID, University of Maryland. College Park, MD.

2011. **West, B. E.**,** K. A. M. Engelhardt, M. C. Neel The Effects of Maternal and Paternal Origin on Seed Production and germination in *Vallisneria americana*: Implications or Restoration. GRID, University of Maryland.

2011. **Lloyd, M. W.**,** R. K. Burnett, JR., K. A. M. Engelhardt, M. C. Neel. The Structure of Population Genetic Diversity in *Vallisneria american*a in the Chesapeake Bay: Implications for Restoration. Ecological Society of America Mid-Atlantic Chapter Meeting. April 9-11. Montclair State University, NJ.

2011. **Lloyd, M. W.**,** R. K. Burnett, JR., K. A. M. Engelhardt, M. C. Neel. The Structure of Population Genetic Diversity in *Vallisneria american*a in the Chesapeake Bay: Implications for Restoration. 96th Ecological Society of America Annual Meeting. August 7-12. Austin, TX.

2011. **West, B. E.**,** K. A. M. Engelhardt, M. C. Neel The Effects of Origin in Submersed Aquatic Vegetation Growth and Persistence: Implications or Restoration. EPA STAR Graduate Fellowship Conference. September 19-20. Georgetown University, Washington, DC.

2011. **Neel, M. C**., J. P. Che-Castaldo. Predicting Endangered Species Recovery Objectives Using Biological Traits and Patterns of Decline. Strategic Environmental Research and Development Program. Partners in Environmental Technology Technical Symposium and Workshop, December 3-5. Washington, DC.

2012 **West, B. E.**,** K. A. M. Engelhardt, M. C. Neel. Linking Genotype With Reproductive Success of *Vallisneria Americana* from the Chesapeake Bay to Enhance Restoration Strategies. Ecological Society of America Mid-Atlantic Chapter Meeting. April 9-11. Virginia Tech, Blacksburg, VA.

2012 **West, B. E.**,** L. Peterson*, K. A. M. Engelhardt, M. C. Neel. Linking Genotype With Reproductive Success of *Vallisneria americana* from the Chesapeake Bay to Enhance Restoration Strategies. 97th Ecological Society of America Annual Meeting. August 6-10. Portland, OR.

2012 **Zastrow, S.*** J**.** H. Sullivan, and M. C. Neel. Forest Response to a Tornado on the Campus of the University of Maryland. 97th Ecological Society of America Annual Meeting. August 6-10. Portland, OR.

2013 Che-Castaldo, J and M. C. Neel. A Framework to Quantify Changes in Effective Habitat Availability and Extinction Risk Based on Habitat Area and Configuration. 2013 Smithsonian Botanical Symposium. April 19. U.S. Botanic Garden, Washington, DC.

2013 Che-Castaldo, J. and M. Neel. Predicting Population Extinction Risk Based on Biological Traits and Anthropogenic Threats. International Congress for Conservation Biology. July/21-25. Baltimore, MD.

g. Films, Tapes, Photographs, etc.

Photographs

Krantz, T. 1990. A guide to the rare and unusual wildflowers of the Big Bear Valley Preserve. Friends of the Big Bear Valley Preserve. Pages 17, 19 (3 photos), 27 (2 photos) and 28.

Mohlenbrock, R. H. 1993. This Land: Pebble Plains, California. Natural History 102:14-17.

San Bernardino National Forest. 1994. Forest Recreation Map. *Lupinus* in meadow.

Beacham, W., F. V. Castronova, and S. Sessine, editors. 2001. Beacham's Guide to the Endangered Species of North America. Six Volumes. The Gale Group. Farmington Hills, MI. (Photographs of *Dodecahema leptoceras*, *Eriogonum kennedyi* ssp. *austromontanum*, and *Arenaria ursina*).

Naked Bicycles and Design. 2008. 'Naked Bicycles and Design Wins the Oscars of Bike Building'. Pedal: Canada's Cycling Magazine http://www.pedalmag.com/index.php?module=Section&action=viewdetail&item_id=12684 (2 photographs).

CheckPoint Magazine: The Magazine of Audax Australia. 2008. Photographs of the 'Cascade 1200' 1200k Randonnee. Washington, U.S.A.

CheckPoint Magazine: The Magazine of Audax Australia. 2010. Photographs of the 'Perth Albany Perth' 1200k Randonnee. Western Australia, Australia.

American Randonneurs: Publication of the Randonneurs USA. Photographs of the 'Taste of Carolina 1200k Randonnee. North Carolina, USA.

Photograph of *Dalbergia retusa* used by the Species Survival Network in a document of all proposed additions to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) discussed March 2013 in Bangkok, Thailand.

h. Exhibits, Performances, Demonstrations, and Other Creative Activities

None

i. Original Designs, Plans, Inventions, Software, and/or Patents.

None

j. Contracts and Grants.

Pending

2015-2018 National Science Foundation. Co-Principal Investigator with Katharina Engelhardt (Appalachian Laboratory UMCES). Preliminary Proposal: Alternate states of resilience: Linking interindividual genotypic and phenotypic variation with ecological function and persistence in changing environments. 50% credit.

Awarded: Current

2013- 2014 Maryland Agricultural Experiment Station. Linking Ecological and Genetic Contributions to Resilience of the submersed aquatic Plant Species *Vallisneria americana* in the Chesapeake Bay. $29,861

2014-2015 ADVANCE: Predicting Resilience of *Vallisneria americana* in the Chesapeake Bay. $19,997

Awarded: Past

1989 - 1991 California Department of Fish and Game. Protection of Pebble Plain Habitat on Gold Mountain from Off-highway Vehicle Damage. $4,000

1990 - 1993 The California Nature Conservancy. Research Grant: Morphological and Allozyme Variation in the Cactus *Echinocereus engelmannii* var. *munzii*. $5,000

1991 - 1992 California Department of Fish and Game. Study of Habitat Characteristics of the Federally Endangered Plant *Thelypodium stenopetalum*. $3,000

1992 - 1994 California Department of Fish and Game. Revegetation of Mined Lands on the San Bernardino National Forest. $4,000

1992 - 1995 California Off-Highway Vehicle Green Sticker Fund. Annual funding in operations and maintenance grants for restoration activities associated with damage from off-highway vehicle activity. $5,000-$10,000/year

1993 - 1995 USDA Forest Service Washington Office to the San Bernardino National Forest. Development of a conservation strategy for five federally-listed plant taxa in the San Bernardino Mountains. $300,000

1993 - 1998 County of San Bernardino, CA. Restoration of Illegally Damaged Habitat at the North Baldwin Lake Pebble Plains. $174,000

1994 - 1995 California Off-Highway Vehicle Green Sticker Fund. Development of Native Plant Propagation Facility on the San Bernardino National Forest. $12,000

1997 - 2001 Co-author. U.S. Environmental Protection Agency. “The Structure of Diversity: Implications for Reserve Design”. N. C. Ellstrand Principal Investigator $272,495

2000 - 2001 Massachusetts Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife. Principal Investigator. “Development of reserve design, selection, and evaluation protocols”. $11,500

2000 - 2001 U.S. Fish and Wildlife Service. Principal Investigator. “Investigation of Reproductive Ecology in the Endangered Plant *Agalinis acuta*”. $2,500

2006 International Programs University of Maryland. Travel grant to visit Western Australia to develop collaborative research efforts in ecological sustainability in agricultural landscapes with the Commonwealth Scientific and Industrial Research Organization. $2,100

2006 - 2007 Maryland Agricultural Experiment Station. Principal Investigator. Quantifying Effects of Fragmentation on Reproductive Success and Mating Patterns in the Endangered Plant Species *Agalinis acuta*. $19,984

2005 - 2008 U.S. Fish and Wildlife Service. Principal Investigator. Evaluating the Evolutionary Distinctiveness of the Endangered Plant *Agalinis acuta*. $111,260

2007 - 2010 Maryland Sea Grant. Co-Principal Investigator/Subcontractor. The Role of Genetic Diversity in Restoration Success for *Vallisneria americana* in the Chesapeake Bay. This is a collaborative project with Katharina Engelhardt at the University of Maryland Center for Environmental Science’s Appalachian Laboratory. $172,098, my subcontract = $108,341

2011- 2012 Maryland Agricultural Experiment Station. Effects of Habitat Loss and Fragmentation on Potential for Persistence and Resilience of the Submersed Aquatic Plant Species *Vallisneria americana* in the Chesapeake Bay. $29,834.

2006 - 2013 Department of Defense: Strategic Environmental Research and Development Program. Co-Principal Investigator with William Fagan (Biology). A Bioinformatic Approach to Developing Recovery Goals and Objectives. Total grant = $1,817,782, my portion = $908,891

2009 - 2013 Collaborative Research: Reassembling Pollinator Communities to Promote Pollination Function at the Landscape Scale. National Science Foundation, Division of Environmental Biology: Ecology. Total grant = $800,000, my portion $52,527

2013 High Throughput DNA Sequencing from Highly Degraded Leaf Samples of American Beech. Bureau of Alcohol, Tobacco, Firearms and Explosives. $5,200

2013 High Throughput DNA Sequencing and Genotyping for American Beech Leaves Associated with a Homicide Case. Prince George's County Police Department and State's Attorney General for Prince George's County. $33,600

k. Fellowships, Prizes, and Awards.

Fellowships

1996 Switzer Environmental Graduate Fellowship. Robert K. and Patricia Switzer Foundation. For commitment to and leadership in slowing and reversing environmental degradation.

1998 Science to Achieve Results Graduate Fellowship. U.S. Environmental Protection Agency, National Center for Environmental Research and Quality Assurance. Offered but declined.

2001 - 2003 National Science Foundation Postdoctoral Fellowship in Biological Informatics. "Geographic Information System-Based Comparison of Effectiveness of Reserve Selection Methods for Conserving Biodiversity". Offered but declined.

2001 - 2003 David H. Smith Conservation Postdoctoral Research Fellowship, The Nature Conservancy. "Conservation of Multiple Levels of Biological Diversity Using Community Based Reserve Selection Approaches".

Awards

Scholarship

1990 Best Paper, Proposed Research Category, for "Morphological and Allozyme Variation in the Cactus *Echinocereus engelmannii* var. *munzii*". California Botanical Society Graduate Student Meetings, Rancho Santa Ana Botanic Gardens.

1998 Outstanding Graduate Student Researcher. Department of Botany and Plant Sciences, University of California, Riverside.

1998 Certificate of Merit. Charles A. and Anne Morrow Lindbergh Foundation. For research focused on balancing advancing technology and preserving the natural and human environment.

Conservation Management and Leadership

1987 & 1988 Certificates of Merit for outstanding work accomplishments. San Bernardino National Forest, USDA Forest Service.

1989 Quality Step Increase for outstanding performance. San Bernardino National Forest, USDA Forest Service.

1990 Certificate of Appreciation for developing creative partnerships for Challenge Cost-Share Projects. Pacific Southwest Region, USDA Forest Service.

1991 Certificate of Appreciation for professional stewardship of botanical resources on the Big Bear Ranger District. Pacific Southwest Region, USDA Forest Service. Awarded in part for completion of the Pebble Plain Habitat Management Guide.

1992 Regional award for outstanding accomplishments and leadership in recovery and conservation of threatened, endangered and sensitive plants. Pacific Southwest Region, USDA Forest Service.

1992 National award for outstanding accomplishments and leadership in recovery and conservation of threatened, endangered and sensitive plants. USDA Forest Service.

1993 Certificate of Merit for completion of an outstanding habitat restoration plan for damaged pebble plain habitat. San Bernardino National Forest.

l. Editorships, Editorial Boards, and Reviewing Activities for Journals and Other Learned Publications.

Editorial Board

2007-2012. Associate Editor Conservation Letters. A Journal of the Society for Conservation Biology.

Manuscript Review for Journals

American Journal of Botany, American Midland Naturalist, American Naturalist, Conservation Biology, Biological Conservation, Biodiversity and Conservation, Canadian Journal of Botany, Crosossoma, Ecography, Heredity, International Journal of Plant Sciences, Journal of Applied Ecology, Journal of Ecology, Journal of the Torrey Botanical Club, Landscape Ecology, Molecular Ecology, Oikos, Plant Systematics and Evolution, Proceedings of the Royal Society B, Regional Environmental Change.

Manuscript Review for Book Chapters

2004: Chapter review: Theobald, D.M. Exploring the functional connectivity of landscapes using landscape networks. In: K. Crooks and M. Sanjayan, editors. Conservation Connectivity.

m. Other.

Grant Proposal Review

2004 Cornell University Agricultural Experiment Station Special Call in Land Use Management. Reviewed four proposals.

3. Teaching, Mentoring, and Advising

a. Courses taught.

i. General.

2003, Fall, PLSC 253 Woody Plant Materials (Lab Section). Enrollment = 15.

2004, Fall PLSC 253/INAG 113 Woody Plants for Mid-Atlantic Landscapes I. Enrollment = 53.

2005, Spring PLSC 254/INAG 220 Woody Plants for Mid-Atlantic Landscapes II. Enrollment = 42.

2005, Fall PLSC 253/INAG 113 Woody Plants for Mid-Atlantic Landscapes I. Enrollment = 35.

2006, Fall PLSC253 Woody Plants for Mid-Atlantic Landscapes I. Enrollment = 40.

2010, Spring PLSC226 Plant Diversity. Enrollment = 8.

2011, Fall PLSC 481 Vegetation Assessment and Analysis. Enrollment = 5

2013, Spring PLSC489E Ecology of Agricultural Systems. Enrollment = 8.

2104, Spring PLSC226/PLSC489O Plant Diversity. Enrollment = 4.

ii. Specialized.

2007, Spring PLSC 689C Science and the Endangered Species Act Research Seminar. Participants = 6.

2007, Fall PLSC 689C Science and the Endangered Species Act Research Seminar. Participants = 7.

2008, Spring PLSC 689C Science and the Endangered Species Act Research Seminar. Participants = 7.

2010, Spring PLSC689C Landscape Pattern Analysis Seminar: Quantifying Fragmentation and Connectivity. Participants = 7.

2011, Spring PLSC689C Applied Seminar in Landscape Pattern and Reserve Design. Participants = 3.

2011, Fall ENTM798Q Genetic Tools for Ecologists n = 8

2012, Fall PLSC689C Applied Seminar in Graph Theoretic Connectivity Analysis and Reserve Design. Participants = 7

iii. University Honors, College Park Scholars, and other special programs.

2010-present, Winter Term PLSC489C/HONR379K Sustainable Tropical Ecosystems Education Abroad course in Costa Rica.

2010 12 students

2011 10 students

2012 9 students

iv. Independent Study, Tutorial, Internship Supervision.

2005 Spring & Fall Semester. **Chris Seabolt**, undergraduate Plant Sciences Major, conducted experiments on seed germination in the federally endangered plant *Agalinis acuta*.

2005 Fall Semester. **Adam Pyle**, undergraduate Plant Science Major, assisted with research on fragmentation and with developing a computer-based synoptic key for woody plants.

2006 Spring Semester. **Robert Burnett**, undergraduate Environmental Science Major, participated in genetic research on *Vallisneria americana* including developing microsatellite markers, collecting plants in the field, extracting DNA, and genotyping individuals.

2007 Spring and Fall Semesters. **Laura Templeton-Brandt**, undergraduate Plant Science Major, conducted research on the magnitude and nature of threats to endangered plant species from invasive species using the recovery database developed in my lab.

b. Course or Curriculum Development.

PLSC 481: Vegetation Assessment and Analysis. In collaboration with Joseph Sullivan developed field exercises to sample forest vegetation and to inventory trees on campus. I designed lab exercises to teach vegetation data analysis using the statistical language R. I developed and presented lectures on quantifying species diversity and distributions.

PLSC 226: Plant Diversity. I developed this new course (first offering in spring 2010) to teach modern plant taxonomy, systematics, and biogeography of seed plants. After completing this course students will understand major identifying features of evolutionary relationships among major seed plant groups and ~100 plant families. They will be able to recognize dominant species of the mid-Atlantic region and will have skills necessary to identify new material through keying. I developed 24 PowerPoint lectures, all lab exercises and manual pages, all lecture and laboratory exams.

PLSC 253/INAG113: Woody Plants for Mid-Atlantic Landscapes I. The content of this course was substantially revised to include modern taxonomy and issues relevant to sustainability of landscape plantings. Twenty-three PowerPoint lectures were developed to cover biogeography, physiological requirements, landscape values, and liabilities of

185 plant species plus ~80 cultivars. Lectures were illustrated with hundreds of photographs, many of which I took. Laboratory exercises were developed to teach identification of 130 species.

PLSC 254/INAG2: Woody Plants for Mid-Atlantic Landscapes II. The content of this course was substantially revised to include modern taxonomy and issues relevant to sustainability of landscape plantings. I developed twenty-one PowerPoint lectures to cover biogeography, physiological requirements, landscape values, and liabilities of 163 plant species plus ~98 cultivars. Lectures were illustrated with hundreds of digital photographs, many of which I took. Laboratory exercises were developed to teach identification of 125 species.

c. **Manuals, Notes, Software, Webpages, and Other Contributions to Teaching.**

Laboratory Manual PLSC 226: Developed lab handouts to comprise a manual for the laboratory section of my Plant Diversity course. Lab handouts included characteristics and photographs of family and species characteristics for required taxa. I also developed exercises for introductory material on vegetative, floral, and fruit terminology.

Laboratory Manual PLSC 253/INAG 113: Substantially revised and expanded the existing laboratory manual for Woody Plants for Mid-Atlantic Landscapes I. The manual is now 146 pages long and is written in Adobe InDesign so it is easily updated. I rewrote much of the text and I replaced all line drawings with digital photographs of identifying characteristics for each of ~130 species.

WebCT Course Site PLSC 253/INAG 113: Developed WebCT-based course materials including 165 Web pages (including both lecture and lab materials), 14 Web-based quizzes, three Web-based lecture exams and three practice exams. In the first semester students accessed course Web pages >40,000 times (from 168 to 1,715 times per student with an average of 767 times). This Website operated for three years but no longer exists due to a campus level decision to change educational management system vendors.

Laboratory Manual PLSC 254/INAG 220: Substantially revised and expanded the existing laboratory manual for the 125 species taught in Woody Plants for Mid-Atlantic Landscapes labs in 2004. The manual is now 128 pages long and is written in Adobe InDesign so it is easily updated. I rewrote much of the text and I replaced all line drawings with digital photographs of identifying characteristics for each of 125 species. I took all digital photographs myself. It has been updated and improved annually since it was first developed.

WebCT Course Site PLSC 254/INAG 220: Developed WebCT-based course materials including 167 Web pages (including both lecture and lab materials), 13 Web-based quizzes, three Web-based lecture exams. This Website operated for two years but no longer exists due to a campus decision to change educational management system vendors

Computer-Based Synoptic Key: I am developing a computer based identification key to ~345 woody plant species native to or commonly planted in the mid-Atlantic. The key structure is developed and data entry is complete for most species. In the last year I have been proofing the database and will be testing the key further. This work was originally funded in part by the instructional improvement grant from the Center for Teaching Excellence.

d. Teaching Awards and Other Special Recognition.

1998 Outstanding Teaching Assistant. Department of Botany and Plant Sciences, University of California, Riverside.

2004 - 2005 Teaching with Technology Instructional Improvement Grant. Center for Teaching Excellence, University of Maryland. $3,000.

e. Advising: Other Than Research Direction.

i. Undergraduate.

2004 Robin Noonan, Natural Resource Sciences and Landscape Architecture. Trained and supervised Robin on entering data into the computer based identification key for PLSC 253.

2004 - 2005 Kristy Sikorski, Natural Resource Sciences and Landscape Architecture. Trained and supervised Kristy on word processing the PLSC 254 lab manual.

2005 Allison Kuzniar, double major in Plant Science and Business. Trained and supervised Allison in collecting and entering data for computerized plant identification keys.

2005 - 2006 Adam Pyle Plant Science major. Trained and supervised Adam in collecting and entering data for computerized database of woody plant landscape characteristics.

ii. Graduate.

Fall 2004 Supervised and mentored three teaching assistants (Joe Ferrari, John Majsztrik, and Kimberly Mead).

Spring 2005, Fall 2005, and Fall 2006 Supervised and mentored two teaching assistants (John Majsztrik, and Kimberly Mead).

iii. Other advising activities.

None

f. Advising: Research Direction.

i. Undergraduate.

2005 Marjorie Linares, an undergraduate in Entomology worked in my laboratory as a research assistant conducting with PCR for DNA sequencing.

2004 - 2006 Ana Marcela Lewis, an undergraduate Honors Student in Biological Sciences worked in my laboratory as a research assistant until she graduated.

2006 - 2008 Robert Burnett, was an undergraduate in Environmental Science worked in my lab until he graduated in January, 2008.

2010 Dierdre Griffen (Environmental Science and Policy) assisted with research on *Vallisneria americana* germination success.

2010 Ryan Blaustein (Biology) assisted with research on *Vallisneria americana* germination success.

2010 - 2011 Arjun Dheer, an undergraduate in Biology worked on effects of fragmentation on bird communities in Jamaica.

2011 - 2012 Paul Widmeyer, an undergraduate in Environmental Science and Policy, assisted with spatial analysis using geographic information system technology.

2011 - 2012 Lessley Peterson, an undergraduate in Environmental Science and Policy, worked on research in *Vallisneria americana* genetic diversity and reproductive biology.

2011 - 2012 Liliana Orellana compiled plant life history traits for use in predicting minimum viable population sizes.

2010 - 2013 Hayley Tumas, an undergraduate Honors Student worked on research in *Vallisneria americana* genetic diversity. She designed and conducted an independent experiment funded by the Howard Hughes Medical Investigator Program. She was awarded best undergraduate presentation at the Mid-Atlantic Ecological Society Meetings for this work.

2011 - present Tara Ruoff is compiling population demographic matrices for plant species.

ii. Master's.

Thesis Advisor

In Progress

None

Graduated

2004 - 2005 Joseph Ferrari (M.S. awarded Fall 2005). Natural Resource Sciences Graduate Program. "Behavior of Graph Theory Metrics Along Gradients of Habitat Area".

Thesis Committee Member

In Progress

None

Graduated

1992 - 1994 Michael Paul Gonella. San Jose State University, San Jose, California.

2003 - 2004 Erin Schlag. Marine, Estuarine and Environmental Science Graduate Program, UM College Park.

2006 - 2007 Jeffrey Sossa. Entomology UM College Park.

2005 - 2008 Kimberly Mead. Natural Resource Sciences Graduate Program, UM College Park.

2008 - 2010 Allen Dawson. Natural Resource Sciences Graduate Program, UM College Park.

2012 - 2013 Laura Kendrick. Landscape Architecture Graduate Program, UM College Park.

Advisor for Professional Paper for Master's Students in the Conservation and Sustainability (CONS) Program

2010 - 2011 Rasolofoson Ranaivo. Title: Effectiveness of Protected Areas in Protecting Silky Sifaka (*Propithecus candidus*) in Northeastern Madagascar.

2010 - 2012 Katie Zdilla. Title: Social Impacts of Forest Stewardship Counsel Certification in the Tropics.

2011 - 2012 Taryn Sudol. Topic: Changes in Connectivity in Forest Patches in Prince Georges County, Maryland.

2013 Mark Hofberg. Topic: Connectivity in the Blue Ridge Corridor for Black Bears: Patch Selection and Prioritization Based on Graph Theory.

iii. Doctoral.

Advisor

In Progress

2009 - present. Brittany West (Ph.D. anticipated 2014). Marine, Estuarine, Environmental Science Graduate Program. Advanced to candidacy fall 2011.

2012 - present. Shanie Gal-Ed (Ph.D. anticipated 2017). Plant Sciences Graduate Program.

2012 - present. Christopher Frye. (Ph.D. anticipated 2017). Plant Sciences Graduate Program.

Graduated

2004 - 2010 James Pettengill. Behavior, Ecology, Evolution and Systematics Graduate Program. Assessing the Evolutionary Distinctiveness of the Endangered Plant Species *Agalinis acuta*.

2004 - 2009 Coadvisor. Christina Kennedy. BEES/Biology. Effects of Patch Area, Isolation and Matrix Characteristics on Jamaican Bird Communities.

2007 - 2012 Michael Lloyd. Plant Sciences Graduate Program. The Role of Genetic Diversity in Restoration Success in *Vallisneria Americana* in the Chesapeake Bay.

Committee Member

In Progress

2009 - present Nathan Jud. BEES/Entomology, UM College Park.

2009 - present Alex Forde. BEES/Entomology, UM College Park.

2011 - present Cesar Herrera. Plant Sciences, UM College Park.

2011 - present Amy Norris. BISI, UM College Park.

2012 - present Demetra Skaltsas. Plant Sciences, UM College Park

2013 - present Jason Berg. BEES/Biology, UM College Park

2014 - present Kelley J. O'Neal. Geography, UM College Park.

Graduated

2002 - 2004 Joanna Grand. Organismal and Evolutionary Biology. University of Massachusetts, Amherst MA.

2003 - 2005 Melissa Songer. Geography, UM College Park. (I stepped down from the committee immediately prior the defense when it was determined I could not be the Dean's representative because I did not yet have tenure).

2005 Justin Calabrese. BEES/Biology, UM College Park.

2003 - 2007 John Hall. Molecular and Cellular Biology, UM College Park.

2004 - 2008 Kuong-Yu Chen. Natural Resource Sciences Graduate Program, UM College Park.

2005 - 2008 Eric Lind. BEES/Entomology, UM College Park.

2008 Thomas Mueller. Biology, UM College Park.

2005 - 2009 Holly Martinson. BEES/Entomology, UM College Park.

2009 Ryan Utz. Marine, Estuarine and Environmental Science Graduate Program, UM Center for Environmental Science Appalachian Laboratory.

2006 - 2010 Sara Ziegler. Geography, UM College Park.

2006 - 2011 Gwen Schlicta. Entomology, UM College Park.

2005 - 2011 Judy Che-Castaldo. Biology, UM College Park.

2004 - 2012 Julie Byrd. BEES/Entomology, UM College Park.

2009 - 2012 Romina Gazis. Plant Sciences, UM College Park.

2012 Caroline Fortunato. Marine, Estuarine and Environmental Science Graduate Program, UM Center for Environmental Science Horn Point Laboratory.

Graduate Student Research Assistants

I have funded Research Assistantships for graduate students who are advised in other departments. I supervise their research efforts that contribute to my SERDP funded project. They are responsible for collecting data and entering it into my Web-based database.

2008 - 2009 Elise Larsen. Biology. Elise was a database programmer.

2008 - 2009 Manasee Mahajan, Computer Science. Manasee worked as a database programmer.

2007 - 2008 Eric Lind. BEES/Entomology. Eric was responsible for collecting data from recovery plans for federally listed animal species.

2007 - 2010 Sara Ziegler. Geography. Sara was responsible for collecting data from recovery plans for federally listed plant species.

2011 Judy Che-Castaldo. Biology. Judy was responsible for collecting data from recovery plans for federally listed plant species.

2012 Amy Norris. Biological Sciences. Amy was responsible for collecting data from recovery plans for federally listed plant species.

iv. Post Doctoral

2004 - 2006 Joanna Grand. NSF Biological Informatics Postdoctoral Fellow; Michael Cummings (UMD) and Taylor Ricketts (World Wildlife Fund) were coadvisors.

2007- 2011 Joanna Grand.

2007 Lesley Campbell. Lesley worked on the Department of Defense SERDP Recovery Database project.

2008 - 2009 David Luther. Department of Defense SERDP Endangered Species Recovery Project.

2009 - 2010 Alison Leidner Department of Defense SERDP Endangered Species Recovery Project.

2009 - 2011 Joe Hereford. NSF Postdoctoral Fellowship.

2011 - 2012 Judy Che-Castaldo. Department of Defense SERDP Endangered Species Recovery Project.

2012 - present Judy Che-Castaldo. Socioenvironmental Synthesis Center.

v. Research Assistants

2008 - 2010 & 2013 Robert Burnett. I supervised Robert’s laboratory research on genetic diversity in *Agalinis acuta* and *Vallisneria americana* and computer based database research on endangered species recovery.

2010 - 2010 Alexander Semenyuk. Database programmer, C++ programmer.

2012 - present Nikolaus Anderson. Nikolaus assisted with development of the woody plant identification key. His duties included entering data into the database, checking data already in the database, and deploying the key on the Web, testing the key, and developing the preliminary Norton-Brown Herbarium Website.

4. Service

a. Professional.

i. Offices and committee memberships held in professional organizations.

ii. Reviewing activities for agencies and organizations.

1997 Grant reviewer. The Netherlands Life Sciences Foundation (Stichting Levenswetenschappen).

1999 Invited reviewer. Rare plant species accounts for the West Mojave Plan. California Desert District, Bureau of Land Management.

2002 Invited reviewer. Revised Pebble Plain Habitat Management Guide for the USDA Forest Service, San Bernardino National Forest, California.

2002 Invited reviewer. Inventory and Monitoring Technical Guide: Development of Protocols to Inventory and Monitor Wildlife, Fish, or Rare Plants. USDA Forest Service. General Technical Report WO-72. Published in 2006, I reviewed in 2002.

2002 Invited reviewer. Rare Plant Outplanting Plan for United States Army's Pohakuloa Training Area, Hawaii.

2000-2003 Invited Reviewer. Rare plant conservation plans. New England Wild Flower Society.

2005 Invited reviewer. Draft Recovery Plan for *Agalinis acuta*, Sandplains Gerardia. US Fish and Wildlife Service.

2006 Invited reviewer. Proposed Rule: Pebble Plains Plants Proposed Critical Habitat. US Fish and Wildlife Service.

2007 Invited peer reviewer. Manuscript: Dole, J. Genetic Variation in Butte County Meadowfoam (*Limnanthes floccose* subsp. *californica*): Patterns of Variation and Populations Genetic Inferences from Microsatellite Data Within and Among Populations. US Fish and Wildlife Service.

2008 Invited reviewer. Revised Recovery Plan for *Astragalus bibullatus*. U.S. Fish and Wildlife Service.

2010 Invited reviewer. US Geological Survey pre-submittal manuscript review: Nancy B. Rybicki, Julie D. Kirshtein, and Mary A. Voytek. DNA fingerprinting of *Hydrilla, Egeria,* and *Elodea* (Hydrocharitaceae) reveals new information on their range and recent history

iii. Other unpaid services to local, state, and federal agencies.

2012 - present. Ex Oficio Member. Invasive Plant Advisory Committee. Maryland Department of Agriculture.

iv. Other non-University committees, commissions, panels, etc.

1998 - 2003 Member. Massachusetts Rare Plant Task Force.

2000 Interviewer. Switzer Environmental Fellowship Program. New Hampshire Charitable Trusts.

2002 - present Member. Scientific Advisory Committee for the Native Plant Conservation Campaign.

2002 - 2004 Reviewer of research proposals for the David H. Smith Fellowship Program.

2003 - 2004 Invited Member. Committee working with The Nature Conservancy to write a five year plan for the David H. Smith Conservation Research Fellowship. This plan reviewed the accomplishments from the first five years of the fellowship program, detailed activities for the second five years, and requested $5,000,000 from the David H. Smith Foundation.

2003 - 2004 Member. Selection panel for post doctoral fellowship interviewees. David H. Smith Fellowship Program.

2003 & 2006 Member. Interview panel for post doctoral fellowship candidates. David H. Smith Fellowship Program.

2006 - 2008. Steering Committee Member for NSF funded Research Coordination Network on Biodiversity Conservation in Dynamic Landscapes.

v. International activities not listed above.

2006 Visited the Australian Commonwealth Scientific and Research Organization (CSIRO) Sustainable Ecosystems group in Perth, Western Australia in June to develop collaborative research efforts. In October 2006 I hosted a visit by Dr. Patrick Smith from that office to further discuss collaborations.

b. Campus.

i. Departmental.

2003 - 2010 Member. Natural Resource Sciences Graduate Program Committee. PSLA and NRSL

2003 - 2008 Member. Urban Forestry Program Advisory Board. PSLA and NRSL

2004 - 2005 Member. Search Committee for Faculty Member in Ecological Sustainability. Department of Entomology

2004 - 2006 Member. Awards Committee. NRSL

2004 - 2005 Member. Mentoring and Diversity Committee. NRSL

2006 - 2007 Member. Faculty Search Committee in Landscape Architecture. PSLA

2007 - 2008 Chair. Search Committee for Departmental IT staff. PSLA

2007 & 2009 Member. Merit and Pay Committee. PSLA

2010 Chair. Merit and Pay Committee. PSLA

2010 - 2012 Mentor for Assistant Professor P. Chaverri

2012- present Mentor for Assistant Professor V. Chanse

2012- present Mentor for Assistant Professor B. Kweon

2012-2103 Member. Faculty Search Committee in Landscape Architecture. PSLA

2013-2014 Chair. Faculty Search Committee: Agricultural Ecologist. PSLA

2013-2014 Member. Faculty Search Committee: Urban Ecology/Landscape Management. PSLA

2013-2014 Member. Faculty Search Committee: Sustainable Agricultural Ecology. Entomology

ii. College.

1998 Member. Search Committee for Center for Conservation Biology Director. College of Natural and Agricultural Resources. University of California, Riverside.

2004 - 2005 Member. Steering Committee to develop a new undergraduate course in Agriculture and Natural Resources (AGNR 101). UM College Park.

2004 - 2005 Member. Behavior, Ecology, Evolution and Systematics Graduate Program Admissions Committee (Review ~60-70 applications each year). UM College Park.

2004 Member. Search Committee for Department Chair of Natural Resource Sciences and Landscape Architecture. UM College Park.

2007 - 2008 Coordinator. Behavior, Ecology, Evolution and Systematics Graduate Program Seminar Series for Fall and Spring semesters. UM College Park

2009- 2011. Member. Concentration Area Advisory Committee. Behavior, Ecology, Evolution and Systematics Graduate Program.

iii. **University.** None

iv. **Special administrative assignments.**

2010 - present. Director, Norton Brown Herbarium.

v. **Other.** None

c. Community, State, National.

1988 - 1992 Newsletter Editor/Membership Director. Board of Directors, Friends of Big Bear Valley Preserve. Friends of Big Bear Valley Preserve. Big Bear Lake, California.

1990 - 1992 Director at Large on Board of Directors of the California Native Plant Society.

1996 Judge of talks, 16th California Botanical Society Graduate Student Meetings, Rancho Santa Ana Botanic Garden, Claremont, California.

JAMES H THORNE Ph.D. January 2014 Curriculum Vitae

Office Address
Department of Environmental Science and Policy
University of California
Davis, CA. 95616
Email: jhthorne@ucdavis.edu
Phone:(530) 752-4389
Web: http://ice.ucdavis.edu/people/jhthorne

Academic Background

2005-2012 Adjunct faculty, Geography Graduate Group, University of California, Davis, CA. http://ggg.ucdavis.edu/people/faculty

2006-2012 Research Scientist, Information Center for the Environment, University of California, Davis, CA.

2003-2005 Post-Doctoral Position, Center for Applied Biodiversity Studies, Conservation International. Advisor: Lee Hannah.

2003 Ph.D. Ecology, University California, Davis
Advisors: Drs. James F. Quinn and Michael G. Barbour

1997 M. A. Geography, University of California, Santa Barbara
Advisor: Dr. Frank Davis

1985 B.A. Environmental Studies, University of California, Santa Cruz

Areas of Interest Biogeography, Landscape Ecology, Climate Change, Forestry, Conservation & Regional Planning, Historical Ecology, Species Distribution Modeling, Phenology, Environmental Policy, Urban Growth Modeling

Languages English, French, Spanish

Objective To use my training in ecology, geography, and environmental science for landscape ecological research, to develop effective regional planning and programs in conservation, restoration and training.

Current & Recent Projects

Historical and Projected Landscape Ecology. I am interested in the impacts of climate change to human and biological communities, and use several tools to assess and predict change: historical and contemporary data, and modeled future projections. I led an effort to digitize ~200,000 km^2 of historic California vegetation maps (1930s) and > 10,000 historic vegetation plots. When compared to over 20,000 contemporary vegetation plots and maps, shifts in species ranges and forest structure can be detected and modeled.

I also lead an initiative to bundle biological monitoring around weather stations. This involves development of standard monitoring protocols for plants and vertebrates. If this monitoring is installed near to weather stations, it adds great value to those data over time. I collaborate with multiple groups including the California Energy Commission and the US Forest Service.

San Joaquin Valley Greenprint Development. I am lead PI on a project to develop a regional open space and sustainability design for eight counties in the San Joaquin Valley. The project is being conducted under the auspices of a coalition of 8 county governments and over 60 city governments, originally formed as part of the San Joaquin Blueprint planning process. This project will take special focus on incorporating agricultural interests into views of important open spaces to preserve. Funding comes through the Fresno Council of Governments and originates from the California Department of Conservation.

Resource Management Under Uncertainty, US National Parks. I am a landscape ecologist and GIS modeler for efforts to assess biological and ecosystem vulnerability to climate change in Sequoia and Kings Canyon, Death Valley, and Joshua Tree National Parks. Proactive vulnerability assessments, and development of conservation management strategies is a new area of research for the US National Parks, which is grappling with whether it is possible to increase biological resilience to climate change, and what management strategies might be required.

US Forest Service, International Projects. I developed the curriculum and teach an annual 3 week curriculum for selected 24 international mid-career forest and resource management professionals. Course locations include Washington, DC, UC Davis, and field locations throughout California. Participants are US AID, Embassy adjuncts and mangers in NGOs. I have several international collaborations developed through this program.

Jordan Protected Areas Climate Adaptation Plan Development. I am developing a Climate Change biodiversity adaptation plan for Jordan's Royal Society for the Conservation, the national protected areas management entity in that country.

Climate Change Vulnerability Assessment for California.
I served as a landscape ecologist, modeler and data coordinator for a multi-investigator effort to improve projections of vulnerability to California across multiple sectors including agriculture, water availability, fire, and biodiversity. My group is produced downscaled historic and future climates, urban growth models, and a dynamic vegetation model output.

Korean Initiative. I advise faculty at Seoul National University and the National Inventory and Environmental Research Institute (the Korean equivalent of US EPA) to assess the vulnerability of their biodiversity to climate change; to quantify the impacts of roads on wildlife through landscape scale monitoring and experiment; and to develop studies from national inventory efforts.

Regional Advance Mitigation Planning (RAMP). I study human impacts on natural systems, with the objective of identifying sustainable designs and processes for human-environment interactions. We use an urban growth model to project patterns of new settlements according to various policy scenarios, and to evaluate how the footprint of future growth may impact habitats and wildlife. We also developed biologically relevant measures of landscape fragmentation for California (effective mesh size), and China. I direct a monitoring program assessing wildlife use of unimproved highway underpasses and wildlife road kill along highways on California's central coast. This includes camera installations, track plates and tracking.

Strategic Highway Research Program (SHRP2B). I am lead PI on a project funded through the National Academy of Sciences and the Transportation Research Board to assist in development of a national environmental impact scoping tool for transportation projects. For this project we will assess transportation impacts from all programmed projects on Highway 101 from Santa Barbara to Mendocino counties using protocols we have developed during California RAMP projects. We will then work with the national tool developers (ICF, under SHRP2A) to test the tool and datasets they develop on the same stretch of highway.

Metropolitan Transportation Commission. I am working on a grant from the Moore Foundation to assess the impacts from planned transportation projects in the San Francisco Bay Area. Currently 699 planned projects over the next 30 years will require over 23 Billion in funding. Of these, we are analyzing a subset of 160 that will have impacts to natural resources. Findings will inform MTC and county CMAs of expected mitigation needs.

African Elephants. I advise a GIS analyst at Africa Wildlife Foundation on the development of spatial frameworks to assess movement and habitat preferences from 10 years of daily movement data, collected but not analyzed. From the movement data, regional connectivity models can be extended throughout east Africa.

Institute for Bird Populations. I am conducting a climate exposure analysis for 140 bird species of the Sierra Nevada Mountains, as part of a vulnerability assessment of those species under funding from the US FWS LCC initiative.

Butterfly Phenology 30 Year Study. http://butterfly.ucdavis.edu/. I oversaw development, analysis and online publication of a database of butterfly phenology, records recorded by Dr. Art Shapiro, UC Davis. I was author of a NSF grant ($217,000) obtained under the Informatics and Databases division, to register the 30^{+} year butterfly phenology study into a database and analyze the contents. We have over 85,000 species observation events from 10 sites forming a transect from San Francisco to Nevada.

Oak Restoration & Long-Term Field Experiment. I have run a restoration project that provides native Valley Oak (*Quercus lobata*) seedlings to restoration groups for 10 years. Last year 2 groups used >300 seedlings.

Publications coordinator, Information Center for the Environment (ICE), UC Davis. I coordinate GIS and model development undertaken by my lab for state and national agencies at ICE. In this capacity I identify the publishable elements of ongoing work, and support the development of peer-reviewed publications. This position requires the assembly of manuscript teams, identification of team members' obligations for manuscripts, and preparation for meetings with local and regional government and private business.

Publications

Movies

Thorne JH & S McQuinn. Mapping Change in Sierra Nevada Forests. 2012. http://vimeo.com/41524838

Peer reviewed journal articles and book chapters:

2014

Casner, K.L., M.L. Forister, J. O'Brien, J.H. **Thorne**, D. Waetjan, A.M. Shaprio. 2014. Converging forces associated with the decline of an urban butterfly fauna. *Conservation Biology.* DOI: 10.1111/cobi.12241

McGrann, M.C., J. H. **Thorne**. Elevation ranges of birds along a California Cordilleran Mega-transect. *Western Birds. In Press.*

Santos, MJ, JH **Thorne**, J Christensen, Z Frank. Assessing conservation success through reconstruction of the history of conservation land acquisitions and land-cover dynamics in a metropolitan area. *Landscape and Urban Planning. Accepted*

Zotano, J. G., F. R. Requena, J. H. **Thorne**. Attributes and roadblocks: a conservation assessment and policy review of the Sierra Bermeja, a Mediterranean serpentine landscape. *Natural Areas Journal. Accepted.*

2013

Thorne, JH, C. Seo, A. Basabose, M Gray, T Belfiore, RJ Hijmans. 2013. Spatial management options for mountain gorilla conservation under climate change: the effects of modeling alternative biological assumptions. *Ecosphere.* 4(9):108. http://dx.doi.org.10.1890/ES13-00123.1

Thorne, JH, MJ Santos, J Bjorkman. 2013. Historic and future conservation progress and urban growth impacts in the San Francisco Bay Area, California. PLoS ONE 8(6): e65258. doi:10.1371/journal.pone.0065258

Dolanc, C.R., B. Westfall, H.D. Safford, J.H. **Thorne**, M.W. Schwartz. 213. Growth-climate relationships for six subalpine tree species of the central Sierra Nevada, CA, USA. *Canadian Journal of Forest Research.* 43:1114-1126..

Dolanc, C. R., J.H. **Thorne** and H.D. Safford. 2013. Widespread shifts in the demographic structure of subalpine conifer forests over last 80 years in the central Sierra Nevada. *Global Ecology and Biogeography.* 22:264-276.

Dolanc, C. R., H. D. Safford, S. Z. Dobrowski, J. H. **Thorne**. 2013. Twentieth Century shifts in abundance and composition of vegetation types of the Sierra Nevada, CA, US. *Journal of Applied Vegetation Science.* Doi: 10.1111/avsc.12079.

Flint, L.E., A.L. Flint, J.H. **Thorne**, R.M. Boynton. 2013. Fine-scale hydrological modeling for regional landscape applications: Model development and performance. *Ecological Processes*. 2:25. http://www.ecologicalprocesses.com/content/2/1/25

Seo, C., J. H. **Thorne**, H. Kwon, C. H. Park, T. Choi. 2013. Disentangling roadkill, the influence of landscape, season and road type on cumulative vertebrate mortality. *Landscape Ecology and Engineering.* DOI 10.1007/s11355-013-0239-2.

Swanson, A.; Dobrowski, S.; Finley, A.; **Thorne**, J.; Schwartz, M. 2013. Spatially explicit methods capture prediction uncertainty in species distribution model forecasts through time. *Global Ecology and Biogeography.*22:242-251.

2012

Huber, P.R., F. Shilling, J.H. **Thorne,** S.E. Greco. 2012. Municipal and Regional Habitat Connectivity Planning. *Landscape and Urban Planning.* 105:15-26.

Roth, R. J. H. **Thorne**, R. Johnston, M. McCoy. 2012. Financial costs to agriculture and municipal governments of urban growth in an agricultural valley. *Journal of Agriculture, Food Systems, and Community Development.* ISSN: 2152-0801 online www.AgDevJournal.com

Viers, J.H., A.K. Fermier, R.A. Hutchinson, J.F. Quinn, J.H. **Thorne**, M.G. Vaghti. 2012 Multi-scale Patterns of Riparian Plant Diversity and Implications for Restoration. *Restoration Ecology* 20:160-169 doi: 10.1111/j.1526-100X.2011.00787.x

2011

Dobrowski, S.Z., J.H. **Thorne**, J.A. Greenberg, H.D. Safford, A.R. Mynsberge, S.M. Crimmins, A.K. Swanson. 2011. Modeling plant distributions over 75 years of measured climate change in California, USA: Relating temporal transferability to species traits. *Ecological Monographs* 81:241-257.

Huber, R. P., **J. H. Thorne**, N. E. Roth, M McCoy. 2011. Assessing the ecological condition and vulnerability of a potential conservation network in a working landscape. *Natural Areas Journal* 31:234-245.

O'Brien, J. M., J. H. **Thorne**, and A. M. Shapiro. 2011. Once-Yearly Sampling for the Detection of Trends in Biodiversity: The Case of Willow Slough, California. *Biological Conservation* 144:2012-2019.

2010

Thorne, J.H., P.R. Huber, S. Harrison. 2010. Exploring tradeoffs among conservation goals in serpentine-rich landscapes. *In.* Harrison and Rajakaruna *eds.* Serpentine: A model for evolution and ecology. University of California Press.

Waetjen, D. P. J. H. **Thorne**, A. D. Hollander, A. M. Shapiro, and J. F. Quinn. 2010. The Butterfly Effect: An approach for web-based scientific data distribution and management with linkages to climate data and the semantic web. In: (Eds Anandarajan, M. & Anandarajan, A.) E-Research collaboration: Frameworks, Tools and Techniques. Springer-Verlag. Berlin.

G. F. Midgley, I. D. Davies, C. H. Albert, R. Altwegg, L. Hannah, G. O. Hughes, L. P. Ries, J. H. **Thorne**, C. Seo, W. Thuiller. 2010. BioMove – an integrated platform simulating the dynamic response of species to environmental change. *Ecography*. 33:612-616. doi: 10.1111/j.1600-0587.2009.06000.x

T. Li, F. Shilling, J. H. **Thorne**, F. Li, H. Schott, R. Boynton, A. M. Berry. 2010. Fragmentation of China's Landscape by Roads and Urban Areas. *Landscape Ecology.* 25:839-853. DOI 10.1007/s10980-010-9461-6

Huber, P. R., S. Greco, J. H. **Thorne**. 2010. Spatial scale and its effects on conservation network design: trade-offs and omissions in regional versus local scale planning. *Landscape Ecology*. 25: 683-695. http://www.springerlink.com/content/c3564585tt2uj64l/

Forister, M.L., A.C. McCall, N.J. Sander, J.A. Fordyce, J.H. **Thorne**, J. O'Brien, D.P. Waetjan, A.M. Shapiro. 2010. Compounded effects of climate change and habitat alternation shift patterns of butterfly diversity. *Proceedings of the National Academy of Sciences.* 107:1-5. http://www.pnas.org/content/early/2010/01/14/0909686107.full.pdf+html?sid=059e0402-a5e4-4ba2-bb34-ac4f73785d00

Santos, M.J. and J.H. **Thorne**. 2010. Contrasting culture and ecology: conservation planning of oak woodlands in Mediterranean landscapes of Portugal and California. *Environmental Conservation* 37:155-168. doi:10.1017/S0376892910000238

Huber, P., J. H. **Thorne**, S. Greco. 2010. Boundaries make a difference: the effects of spatial and temporal parameters on conservation planning. *Professional Geographer* 62:1-17.

Schmidt, E., J. H. **Thorne**, P. Huber, N. Roth, E. Thompson, M McCoy. 2010. A new vision for prioritizing farmland preservation in the San Joaquin Valley, California. *California Agriculture* 64:129-134.

2003-2009

Thorne, J.H. 2009. Of refugia and colonization, an innovative use of biogeography for climate studies. *Frontiers of biogeography* 1.2:5-6.

Beardsley, K., J. H. **Thorne**, N. E. Roth, M. McCoy. 2009. Impact of Rapid Human Population Growth on Biological Resources in the San Joaquin Valley of California. *Landscape and Urban Planning* 9:172-183. doi:10.1016/j.landurbplan.2009.07.003

Thorne, J. H., J.H. Viers, J. Price, D. M. Stoms. 2009. Spatial patterns of endemic plants in California. *Natural Areas Journal* 29:137-148.

Thorne, J. H., P. Huber, E. Girvetz, J. F. Quinn, M. McCoy. 2009. Integration of regional mitigation assessment and conservation planning. *Ecology and Society* 14:47 [online] http://www.ecologyandsociety.org/vol14/iss1/art47/.

Williams, C. Seo, J. H. **Thorne**, J. N., J. K. Nelson, S. Erwin, J. M. O'Brien, M. W. Schwartz. 2009. Using species distribution models to predict new occurrences for rare plants. *Diversity and Distributions.* 15: 565-576. DOI: 10.1111/j.1472-4642.2009.00567.x

Thorne, J. H., E. H. Girvetz, and M. McCoy. 2009. Evaluating aggregate terrestrial impacts of road construction projects for advanced regional mitigation. *Environmental Management* 43: 936-948. DOI: 10.1007/s00267-008-9246-8

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Harrison, S., J. H. Viers, J. H. **Thorne**, J. B. Grace. 2008. Favorable Environments and the Persistence of Naturally Rare Species. *Conservation Letters* 1: 65-74. http://www3.interscience.wiley.com/journal/118902559/home

Girvetz, E. H, **J. H. Thorne**, A. M Berry, and J. A.G. Jaeger. 2008. Integration of Landscape fragmentation analysis into regional planning: a state-wide multiscale case study for California. *Landscape and Urban Planning* 86: 205-218. http://www.sciencedirect.com/science/journal/01692046

Girvetz, E. H., J. A. G. Jaeger, J. H. **Thorne**. 2007. Comment on „Roadless Space of the Conterminous United States". *Science- Technical Comment* 1240b.

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Thorne, J.H., S. Gao, A. D. Hollander, J. A. Kennedy, M. McCoy, R. A. Johnston, J. F. Quinn. 2006. Modeling potential species richness and urban buildout to identify mitigation sites along a California highway. *Journal of Transportation Research D* 11(4) 233-314.

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Stubblefield, A., S. Chandra, S. Eagan, T. Dampil, G. Davaadorzh, D. Gilroy, J. Sampson, R. Allen, J. **Thorne**, Z. Hogan. 2005. Impacts of gold mining and land use alterations on the water quality of central Mongolian rivers. *Integrated Environmental Assessment and Management* 1(3) 1-7.

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Vander Zanden, J., J.D. Olden, J.H. **Thorne**, N.E. Mandrake. 2004. Predicting occurrences and impacts of smallmouth bass introductions in north temperate lakes. *Ecological Applications* 14(1) 132-148.

Thorne, J.H. 2003. Development and Interpretation of Ecological Datasets for Conservation Planning and Natural Resources Management. **PhD Dissertation**, UC, Davis.

<u>Manuscripts in Revision:</u>

Thorne, J.H., R.M. Boynton, L.E. Flint, A.L. Flint. Comparing historic and future climate and hydrology for California watersheds using the Basin Characterization Model. *Ecosphere.*

Thorne, J.H., P.R. Huber, E. O'Donoghue, M. J. Santos. Regional Advanced Mitigation Planning (RAMP), a framework to unify infrastructure projects with sustainability goals *Environmental Research Letters*

Perez-Garcia, N., F. Dominguez, X. Font, J.H. **Thorne**. Climate vulnerability assessment of an edaphic endemic plant (*Vella pseudocytisus* subsp. *paui*) by using a spatially explicit demographic dispersal model. *Global Change Biology.*

Siegel, R.B, P. Pyle, J.H. **Thorne**, A. J. Holguin, C. A. Howell, S. Stock, M. W. Tingley. Vulnerability of birds to climate change in the Sierra Nevada Mountains of California. *Avian Conservation and Ecology.*

Santos, MJ, JH Thorne, C Moritz. Synchronicity in elevation range shifts among small mammal and vegetation over the last century is stronger for omnivores. *Ecography.*

Stewart, JA, JD Perrine, LB Nichols, CI Millar, JH **Thorne**, KE Goerhing, CP Massing, DH Wright. Revisiting the past to fortell the future: summer temperature and habitat area predict pika extirpations in California. *Journal of Biogeography.*

<u>Manuscripts Submitted:</u>

Thorne JH, C Dolanc, S Cameron, S Dobrowski H Safford. Contrasting hardwood and conifer tree demographic and range dynamics in a warming mountain range. *Ecology*

<u>Peer Reviewed Technical & Government Reports:</u>

Thorne, J. H. Forest Vegetation Patterns. 2013. *In:* Indicators of Climate Change in California. *Editors*: T. Kadir, L. Mazur, C Milanes, K. Randles, California Environmental Protection Agency, Office of

Environmental Health Hazard Assessment. California Department of Environmental Health Hazard Assessment, Sacramento, CA.

Thorne, J.H. and H. Mussein. *Climate Change Exposure and Adaptation Models for Four Protected Areas of the Jordan Rift Valley.* Technical Report to the Royal Society for Conservation of Nature, Jordan. *In Revision.*

Siegel, R., P. Pyle, A.J. Holguin, J.H. **Thorne**. *Climate Change Vulnerability Assessment for 117 Species of Sierra Nevada Birds*. US Fish and Wildlife Landscape Conservation Cooperative Report. *In Review.*

Thorne, James, Ryan Boynton, Lorraine Flint, Alan Flint, and Thuy-N'goc Le (University of California, Davis and U.S. Geological Survey). 2012. *Development and Application of Downscaled Hydroclimatic Predictor Variables for Use in Climate Vulnerability and Assessment Studies.* California Energy Commission. Publication number: CEC-500-2012-010.

Thorne, James, Bjorkman, Jacquelyn, Roth, Nathaniel. (University of California, Davis). 2012. *Urban Growth in California: Projecting growth in California (2000-2050) under six alternative policy scenarios and assessing impacts to future dispersal corridors, fire threats and climate-sensitive agriculture.* California Energy Commission. Publication number: CEC-500-2012-009.

Cornwell, W. K., S.A. Stuart, A. Ramirez, C.R. Dolanc, J.H. **Thorne**, D.D. Ackerly. 2012. *Climate Change Impacts on California Vegetation: Physiology, Life History, and Ecosystem Change. California Energy Commission. Publication number: CEC-500 -2012-023.*

Hannah, Lee, M. Rebecca Shaw, Makihiko Ikegami, Patrick R. Roehrdanz, Oliver Soong, and James **Thorne**. 2012. *Consequences of Climate Change for Native Plants and Conservation.* California Energy Commission. Publication number: CEC-500-2012-024.

Santos, Maria J., Craig Moritz, and James H. **Thorne**. 2012. *Identifying Vulnerable Species and Adaptation Strategies in the Southern Sierra of California Using Historical Resurveys.* California Energy Commission. Publication number: CEC-500-2012-025.

Hiatt, S., Owen, P., Pallin, A., Davis, J., Slaton, MR, **Thorne**, J. *In Review*. Los Padres National Forest: Firescape Monterey, Landtype Association Ecological Unit Inventory. San Francisco State University, SF, CA.

Schwartz, M.W. J. **Thorne**, A. Holguin. Biodiversity. *In*: Panek, J & J. Battles eds. Natural Resource Condition Assessment for Sequoia and Kings Canyon National Parks. *In Press.*

Thorne, J.H., W.B. Monahan, A. Holguin, and M.W. Schwartz. Landscape Ecology. *In*: Pannek, J & J. Battles eds. Natural Resource Condition Assessment for Sequoia and Kings Canyon National Parks. *In Press.*

Thorne, J.H., C. Seo. 2011. Modeling Species Distribution under Several Climate Change Scenarios for Mountain Gorillas. *In:* The Implications of Global Climate Change for Mountain Gorilla Conservation in the Albertine Rift. Africa Wildlife Foundation. Washington, D.C.

Huber, P.R., F.M. Shilling, J.H. **Thorne**, S.E. Greco, and N.E. Roth. 2010. Safe Passages and the City of Riverbank: Wildlife Connectivity in the San Joaquin Valley, California. *University of California, Davis*.

T. Diamond, C. McFarland, J. Keller, J.H. **Thorne.** 2010. The Central Coast Connectivity Project: Northern Monterey Linkage Report. *Connectivity for Wildlife LLC and Big Sur Land Trust, Monterey, CA. 33pg.*

Thorne, J. H. 2009 Impacts on biological systems: Vegetation- Forest Vegetation Patterns. pp. 136-142. In: *Indicators of Climate Change in California*. Ed: L. Mazur. California Environmental Protection Agency, Sacramento. http://oehha.ca.gov/multimedia/epic/pdf/ClimateChangeIndicatorsApril2009.pdf

Thorne, J. H., E. Girvetz, M.C. McCoy. 2008. Report on California state-wide mitigation needs forecasting database. *Technical Report to the California Department of Transportation*, UC Davis, CA.

Girvetz, E.H., J.H. **Thorne**, J.F. Quinn, M.C. McCoy. 2008. Early Biological Mitigation Needs Assessment: Elkhorn Slough Pilot Project. *Technical Report to the California Department of Transportation*, UC Davis, CA.

Huber, P., E.H. Girvetz, J.H. **Thorne**, A. Hollander, J.F. Quinn, M.C. McCoy. 2008. Early biological mitigation needs assessment: Pleasant Grove pilot project. *Technical Report to the California Department of Transportation*, UC Davis, CA.

L. Hannah, G. Midgley, I Davies, F Davis, L Ries, W Thuiller, J **Thorne**, C Seo, D Stoms, N Snider. 2007. BioMove – Improvement and Parameterization of a Hybrid Model for the Assessment of Climate Change Impacts on the Vegetation of California. *Technical Report for California Energy Commission, Public Interest Energy Research*, Sacramento, CA. 96 p.

Thorne, J., J. Bjorkman, S. Thrasher, R. Kelsey, and B. J. Morgan. 2007. 1930s extent of oak species in the central Sierra Nevada. *US Forest Service General Technical Report*. http://www.fs.fed.us/psw/publications/documents/psw_gtr217/psw_gtr217_569.pdf

Beardsley, K., J.H. **Thorne**, M.C. McCoy. 2007. Policy Implications of Growth Modeling and Environmental Assessment in the San Joaquin Valley. *Technical Report published by John Muir Institute for the Environment*, UC Davis, CA.

Thorne, J. H. 2006. The development of 70-year old Wieslander Vegetation maps and an assessment of landscape change in the central Sierra Nevada. *Technical Report for California Energy Commission, Public Interest Energy Research*, Sacramento, CA. 115 p.

Thorne, J.H., B. J. Morgan, T. R. Kelsey, and J. A. Kennedy. 2006. Wieslander Vegetation Type Maps: A Digitizing Process Manual. *Technical Report prepared for the Pacific Northwest Research Station, US Forest Service*. University of California, Davis.

Thorne, James, M. McCoy, A. Hollander, N. Roth, and J. Quinn. 2005. *Regional Analysis for Transportation Corridor Planning*. **Proceedings of the International Conference on Environment and Transportation**, San Diego, CA.

Thorne, J.H., D. Cameron, V. Jigour. 2002. A Guide to Wildlands Conservation in the Central Coast Region of California. *California Wilderness Coalition,* Davis CA. *http://cain.ice.ucdavis.edu/repository/CC.pdf*

Davis F. W., D. M Stoms, A. D. Hollander, K.A. Thomas, P.A. Stine, D. Odion, M. I. Borchert, J. H. **Thorne**, M. V. Gray, K. Warner, and J. Graae. 1998. The California Gap Analysis Project – Final Report. June 30, 1998. *University of California, Santa Barbara*. http://www.biogeog.ucsb.edu/projects/gap/gap_home.html

Thorne, J.H. 1997. GAP Analysis: the vegetation of northwest California. ***Master's thesis****. University of California*, Santa Barbara.

Manuscripts in Preparation:

Full Working Draft completed:

Burge, D.O., J.H. **Thorne**, S.P. Harrison, L. Hardison, B. O'Brien. Plant diversity and endemism in the California Floristic Province. *Targeted Journal: Madroño.*

In preparation:

Thorne, J. H., J. H. Bjorkman, M. J. Santos, O. Soong, L.Hannah. Assessing the impacts of five urban growth policy scenarios shows infill minimizes impacts to climate-sensitive agriculture, biodiversity corridors, and open space.

Thorne, J. H, T. R. Kelsey, B. J. Morgan. 146 Years of Montane Coniferous Forest Retreat Under Warming Climate.

Thorne, J. H., A. Dawson. Use of multiple historic data to determine baseline ecological conditions for restoration.

Santos, M.J., A.B. Smith, J.H. Thorne & C. Moritz. Modeling species range changes in response to direct and indirect effects of climate change over the last century in Yosemite National Park, California. *Targeted Journal: Journal of Biogeography.*

Santos, M.J., J.H. Thorne, C. Moritz. Synchronicity among small mammal and vegetation distributions varies on an elevation gradient over the last century. *Targeted Journal: Global Change Biology*.

Santos, M.J., A.B. Smith, J.H. Thorne, J.L. Patton, C. Moritz, S. Beissinger. Changes in abundance and its distribution shape do not predict mammal species range shifts.

Santos, M.J., J.H. Thorne, J. Christensen, Z. Frank. Reconstructing the history of conservation land acquisition of the San Francisco Bay Area, California. *Targeted Journal: Conservation Biology.*

<u>Published Conference Proceedings and Presentations</u>

Thorne, JH, J Bjorkman, PR Huber, E O'Donoghue. 2013. Cross-testing transferability of national mitigation planning tools with California's Regional Advance Mitigation Planning (RAMP) framework on a new pilot region (450 miles of US 101). International Conference on Environment and Transportation, Scottsdale, AZ.

Huber, PR, JH **Thorne**, NR Siepel. 2013. Convergence of Green- and Blueprints: Integrating Long Range Transportation Planning and Landscape Connectivity. International Conference on Environment and Transportation, Scottsdale, AZ.

Santos, M.J., J.H. **Thorne**, Z. Frank & J. Christensen. 2012. Reconstructing the conservation history of California over the last 80 years. Ecological Society of America. Portland, OR USA.

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Santos, MJ, JH **Thorne,** C Moritz. 2011. Do changes in habitat predict observed changes in small mammals in Yosemite National Park? Ecological Society of America, Austin, Texas, USA

Santos, M.J., J. H. **Thorne** & C. Moritz. 2011. Do changes in habitat predict observed changes in small mammals in Yosemite National Park? Ecological Society of America, Austin, Texas, USA.

Thorne, J.H. & M.J. Santos. 2011. Historic and contemporary landcover, urban areas and protected areas as a framework for regional conservation planning. Ecological Society of America, Austin, Texas, USA.

Santos, M.J., J. Bjorkman, R. Branciforte, L. Orman, J. Christensen & J.H. **Thorne**. 2011. Conservation history of the Bay Area: when and what was conserved over the last 80 years. Bay Area Conservation Symposium. UC Berkeley

Thorne, JH, MJ Santos, J MacKenzie. 2011. Conservation in metropolitan regions: assessing trends and threats of development and climate change. Ecological Society of America, Austin, TX.

Thorne, JT, E. O'Donoghue, PR Huber, M McCoy. 2011. Moving forward, a review of California's approaches to the challenges and solutions for successful regional advance mitigation planning. International Conference on Ecology and Transportation, Seattle, WA.

Huber, PR, DR Cameron, JH **Thorne**, TM Frink. 2011. Regional advance mitigation planning: a pilot study integrating multi-agency mitigation needs and actions within a comprehensive ecological framework. International Conference on Ecology and Transportation, Seattle, WA.

Santos, M.J., J. Bjorkman, R. Branciforte, L. Orman, J. Christensen & J.H. **Thorne**. 2011. Conservation history of the Bay Area: when and what was conserved over the last 80 years. Bay Area Conservation Symposium. UC Berkeley.

Crimmins, SM, S. Dobrowski, AR Mynsberge, JH **Thorne**. 2010. 20th century shifts in optimum elevations of California plants: the importance of spatial scale. Ecological Society of America Meeting, Pittsburgh, PA.

Thorne, JH, S Dobrowski, HD Safford. 2010. Hardwood expansion along a conifer-oak ecotone. Ecological Society of America Meeting, Pittsburgh, PA.

Dobrowski, S, JH **Thorne**, J Greenberg, HD Safford, AR Mysenbridge, SM Crimmins. 2010. Predicting the present from the past: Modeling plant species distributions over 75 years of measured climate change in California, USA. Ecological Society of America Meeting, Pittsburgh, PA.

Yacoub, R., T Keeler-Wolf, JH Thorne. 2010. Using legacy datasets to analyze changes in vegetation distribution: examples and considerations. Ecological Society of America Meeting, Pittsburgh, PA.

Matthew L. Forister (1), Andrew C. McCall (2), Nathan J. Sanders (3), James A. Fordyce (4), James H. **Thorne** (5), Joshua O'Brien (6), David P. Waetjen (7), and Arthur M. Shapiro (8). 2010. Patterns of richness and decline: 35 years of butterflies along an altitudinal transect in Northern California. 6th International Conference on the Biology of Butterflies, University of Alberta

Huber, P.R., F.M. Shilling, J.H. **Thorne**, S.E. Greco, J.F. Quinn, N.E. Roth, J.D. Hightower, L. Podolsky. 2010. Incorporating landscape connectivity principles into planning at multiple spatial scales in an intensive agricultural region. International Association for Landscape Ecology. Athens, Georgia.

Boynton, R., J.H. **Thorne** et al**.** 2010 Measuring the Fragmentation of China's Landscape Using Effective Mesh Size. ESRI Users conference, Riverside CA. *Accepted.*

Thorne, J.H. 2010. 70 Years of Vegetation Dynamics and climate change in the Sierra Nevada. The Wildlife Society, Visalia, CA. *Plenary talk.*

Beardsley, K. J.H. **Thorne**, J. F. Quinn. 2009. Estimating Greenhouse Gas (GHG) Emissions in 2050 from New Buildings in California. American Geophysical Union Fall Meeting, San Francisco.

T. Diamond, C. McFarland, J. **Thorne**, J. Keller, D. Myers, and J. Devers. 2009. California Central Coast Wildlife Connectivity Project: Identifying and implementing connectivity for wildlife movement throughout the Central Coast of California. The Wildlife Society, Western Chapter, Monterey CA.

Thorne, J. H. 2009. Vegetation Shifts in the Sierra Nevada over the past 100 years. California Energy Commission's Climate Change Conference, Sacramento, CA.

Thorne, J.H. 2009. Stories from California: using vegetation plot data for biodiversity studies, mapping, landcover change and climate studies. Workshop of Biodiversity and Protection Areas – About Habitat Modelling. Graduate School of Environmental Studies, Seoul National University, Seoul North Korea. *Invited Keynote.*

Bjorkman, J., J. H. **Thorne**. 2009. Landscape Change in the Bay Area. ESRI User Conference.

P. R. Huber, D. Cameron, J. H. **Thorne**, T. M. Frink. 2009. Regional Advance Mitigation Planning: a Pilot Study Integrating Multi-agency Mitigation Needs and Actions Within a Comprehensive Ecological Framework. International Conference on Ecology and Transportation. Duluth, MN.

Thorne, J. H., S. E. Cameron. 2008. Three scales of vegetation response to climate change and fire over the past 70 years. Yosemite National Park Hydroclimatology Conference, CA.

Thorne, J. H. 2008. Use of Oaks in Urban and Rural Restoration Settings. Annual Oak Restoration Symposium, Sierra Foothills Research Station, University of California.

Thorne, J. H., J. Bjorkman, R. Boynton, S. Thrasher. 2008. Observed Changes in Vegetation Patterns in California. California Energy Commission's Second Annual Climate Change Conference, Sacramento, CA.

Thorne, J.H., S. Dobrowski, R. Boynton, S. Thrasher, J. Bjorkman, H. Safford. 2008. Ecotones and Vegetation Bands – 70 years of vegetation dynamics in the Sierra Nevada. California Society for Ecological Restoration, Santa Rosa, CA. *Invited talk.*

Thorne, J.H., S. Dobrowski, H. Safford. 2008. Comparing 70 year old vegetation maps in California: lessons from the Sierra Nevada and Bay Area. Ecological Society of America Meetings, Milwaukee, WI. *Invited talk.*

Seo Changwan, J. H. **Thorne**, L. Hannah, W. Thuiller. 2008. "Scale Sensitivity of Species Distribution Models for Conservation Planning", 28th Annual Conference International Association for Impact Assessment, 4-10 May 2008, Perth, Western Australia 2008

Bjorkman, J., J.H. **Thorne**, S. Thrasher, R. Boynton. 2008. Landscape change in the Bay Area: using historic maps to show vegetation change. 10th Annual Bay Area Conservation Biology Symposium, Davis, CA.

Girvetz, E. H., J.A.G. Jaeger, J. H. **Thorne**, A.M. Berry. 2007. Integrating habitat fragmentation analysis into transportation planning using the effective mesh size landscape metric. Paper to the International Conference on Ecology and Transportation.

Thorne, J. H., E. H. Girvetz, and M. McCoy. 2007. A multi-scale and context sensitive state-wide environmental mitigation planning tool for transportation projects in California. Paper to the International Conference on Ecology and Transportation.

Ries, L. P., L. Hannah, C. Seo, J. H. **Thorne**, F. Davis, 2007, A dynamic species modeling approach to assess climate change impacts on California tree species, American Geophysical Union Annual Meeting; Dec 10-14, S. F, CA

Seo, C., J. H. **Thorne**, L. Hannah, W. Thuiller 2007, Climate Change and Biodiversity Conservation Planning : Species Distribution Models Applications, Vietnam-Korea EIA Workshop, December 6-8, 2007, Hanoi, Vietnam.

Hannah, L., C. Seo, G. Midgley, J. H. **Thorne**, D. Stoms, I. Davies, W. Thuiller, N. Snider, F. W. Davis, 2006, Dynamic Modeling of Climate Change Impacts on California Endemic Tree Species, Third Annual Climate Change Research Conference, September 13-15, 2006, Sacramento, California.

Ries, L., Lee Hannah, C. Seo, J. H. **Thorne**, Frank W. Davis, David Stoms, 2007, Dynamic species modeling; Predicting CA vegetation niches under climate change, Fourth Annual California Climate Change Conference, September 10-13, 2007, Sacramento, California.

Thorne, J. H., S. Dobrowski, H. Safford. 2007. A 70 year review of landscape change across the Sierra Nevada. Ecological Society of America, San Jose, CA.

Cameron, S. E., J. H. **Thorne**. 2007. Influence of fire and climate change on vegetation in a mountainous national park. Ecological Society of America, San Jose, CA.

Huber, P., N. E. Roth, K. Beardsley, **J. H. Thorne**, M. McCoy, R. Meade. 2007. Potential impacts of urban growth on an ecological network in the San Joaquin Valley, California. American Association of Geographers, San Francisco, CA.

Seo C., J. H. **Thorne**, D. Stoms, W. Thullier, F. Davis, and L. Hannah. 2007. Model selection for predictive species range mapping. IAEA, Korea.

Thorne, J. H. 2007. Retreat of the trailing edge of ponderosa pine forests in the Sierra Nevada over 140 years. The Wildlife Society Meetings, Monterey. *Invited Talk.*

Thorne, J. H. and T.R. Kelsey. 2006. 140 Dynamics of a Forest Ecotone under climate and environmental change. American Geophysical Union Meeting, San Francisco. *Invited talk.*

Thorne, James. 2006. Forest Change over 140 Years in the Central Sierra Nevada. Ecological Society of America Meeting. Memphis, TN.

Hannah, L., J.H. **Thorne**, C. Seo, D. Stoms, I. Davies, G. Midgley, W. Thullier and F. Davis. 2005. Modeling climate change impacts on biodiversity. California Energy Commission's Second Annual Climate Change Conference, Sacramento, CA.

Thorne, J.H. and B.J. Morgan. 2005. Developing historical vegetation maps to support modeling in California. California Energy Commission's Second Annual Climate Change Conference, Sacramento, CA.

Thorne, James, Joshua Obrien, Mathew Forister, Arthur Shapiro. 2005. Butterfly community phenology across an altitudinal transect. Ecological Society of America Meeting.

O'Brien, Joshua, Forister, Matthew, **Thorne**, J., Shapiro, Arthur. 2005. Detection of long-term changes in an alpine butterfly community using non-parametric bootstrap methods. Ecological Society of America Meeting.

Quinn, James, Hollander, Allan, **Thorne**, James, Viers, Joshua. 2005. SPIRE: Semantic Web applications for biodiversity and invasive species. Ecological Society of America Meeting

Anderson, Kayce, Forister, Matthew, Shapiro, Arthur, O'Brien, J, **Thorne**, J. 2005. Urban boundaries in a biodiversity hotspot: Declining butterfly diversity in California's modified Central Valley. Ecological Society of America Meeting.

Viers, Joshua, **Thorne**, James, Vaghti, Mehrey, Quinn, James. 2005. Patterns of regional and local diversity in the California Bay-Delta ecoregion and its watersheds: Lessons for riparian restoration and monitoring. Ecological Society of America Meeting.

Thorne, James. 2004. A Conservation Design for the Central Coast of California using modeled cores and corridors for mountain lion (*Felis concolor*). Society for Conservation Biology, UC Davis.

Authored or Co-Authored Grants and Contracts

2013 Current & ongoing funds total ~$534,000 new, 855,000 ongoing. I also co-manage or participate in about $2,000,000 in other contracts at the Information Center for the Environment.

US Geological Survey – *Climate Change Center – 2 contracts totaling* ~120,000.

US Fish and Wildlife Service – *Climate Exposure Analysis for Great Basin refuges*. $15,000.

Caltrans – *SHP, regional advance mitigation planning.*. $95,000.

Caltrans – *Examining funding mechanisms for advance mitigation planning, co-PI with Gian Claudia (UC Davis).* $300,000

Arenz Foundation, *To assemble California-based conservation network designers for retreat to write grant for funding of design of a state-wide conservation network.* $4000.

2012

National Academy of Science (NAS) and Federal Highways Administration *SHRP2- For national tool testing of regional advance mitigation protocols.* $200,000.

UC Berkeley– *KECK award, subcontract from large grant at UC Berkeley, for Wieslander data internet provision*. $35,000

US Fish and Wildlife Service – *Climate Exposure Analysis for northeast California refuges*. $25,000.

Royal Society for Conservation of Nature. *Climate adaptation planning for Protected Areas of Jordan.* $8,000.

Caltrans, *Connectivity planning on the Central Coast*. $200,000.

Fresno council of Governments, *Greenprint planning in the San Joaquin Valley.* $230,000.

Arenz Foundation, *To assemble California-based conservation network designers for retreat to write grant for funding of design of a state-wide conservation network.* $4500.

2011 $525,500

US Forest Service, *To digitize the Wieslander VTM quads for the Shasta Trinity National Forests.* $7,500.

National Park Service, *Natural Resource Conservation Assessment for Mojave Desert parks.* $400,000. *Co-PI with Drs. Mark Schwartz and Erica Fleishman (UCD)*

Royal Society for Conservation of Nature. *Climate adaptation planning for Protected Areas of Jordan.* $40,000.

American Land Conservancy, *Conservation planning for the Blue Ridge Berryessa Natural Area.* $40,000.

National Park Service, *Landscape Ecology Analysis for Sequoia Kings Canyon National Park Natural Resource Condition Assessment*. $30,000.

Arenz Foundation, *To assemble California-based conservation network designers for retreat to write grant for funding of design of a state-wide conservation network.* $4000.

2010 $935,200

California Energy Commission, *Vulnerability Assessment of California biodiversity under climate change.* $1,200,000. Co-PIs Rebecca Shaw (The Nature Conservancy), Lee Hannah (Conservation International), Craig Moritz (UC Berkeley), David Ackerly (UC Berkeley). I am PI on $360,000, total program $4 million.

Caltrans, *Regional Advanced Mitigation Planning.* $96,000. Co-PI with Dr. Patrick Huber- *Approved, in final review at Sponsored Programs.*

California Department of Water Resources, *Implementation of the RAMP Approach to the Central Valley of California.* $86,000.

National Park Service, Climate change vulnerability to Sequoia Kings Canyon biodiversity. $45,000. *Co-PI with Mark Schwartz.*

US Forest Service, International Branch, *Development of curriculum for resource management under climate change, and initiation of 3 week field course in California for international forest managers to be identified by USFS. Yearly course.* $75,000. Co-PI with Dr. Karen Beardsley, UC Davis.

Big Sur Land Trust, *California Central California Coast Wildlife Connectivity Project*. $50,000. Co-PI with Tanya Diamond, Connectivity for Wilderness, LLC.

Ecoadapt. *GIS data assembly and modeling of Mountain Gorilla ranges under climate change.* $12,200.

National Park Service *Digitization of Wieslander VTM maps for National Monument.* $7000.

California Department of Transportation, District 5, *Modeling of habitat connectivity along highway 101 north of San Luis Obispo*, $23,000.

California Energy Commission, *Assembly of ecological knowledge for climate change research.* $199,000.

2009 $416,000

California Resources Law Group. *Proposal to send post-doc to ICOET conference.* $3700.

Conservation International, *Processing of vegetation plot records.* $3000

Korean Institute of the Environment, *To present vegetation monitoring techniques and assist in manuscript preparation.* $4000

Arenz Foundation, *to assemble California-based conservation network designers for retreat to write grant for funding of design of a state-wide conservation network*. $4,300.

United States Forest Service, Cleveland National Forest, *Digitize the Cleveland National Forest Wieslander VTM Maps.* $20,000.

The Nature Conservancy, *Processing of vegetation plot records.* $3000.

California Resources Law Group, *Technical support for regional advanced mitigation planning II* $15,000.

California Resources Law Group, *Technical support for regional advanced mitigation planning* $15,000.

2008 $546,330

Mid Peninsula Open Space District, *Monitoring of wildlife along Highway 17*. $5,000.

San Luis Obispo County, *Creating historic oak vegetation maps*. $50,000

National Science Foundation, *The Wieslander Dataset: Using a historic dataset to test uncertainty in species distribution model projections under climate change. Co-PI with Dr. Solomon Dobrowski, University of Montana*. $364,000.

California Dept of Transportation, *Technical support for multi-agency advanced mitigation scoping and planning.* $62,330. *Quinn & McCoy PI*

Wildlife Conservation Society & California Department of Fish and Game, *Development of Ecoregional Wildlife Connectivity analysis and maps for the San Joaquin Valley. Co-PI with large group of collaborators, lead Wildlife Conservation Society*. $65,000.

2007 $205,100

California Department of Forestry, *Weed Mapping Program, to provide geo-referenced locations of California invasive species for climate change modeling purposes* $6,600.
United States Geological Survey, *Fort Collins, CO, to provide geo-referenced locations of California invasive species for climate change modeling purposes*. $10,000.
United States Forest Service, *Klamath National Forest CESU to digitize the Trinity National Forest Wieslander VTM Maps.* $6,000.
California Energy Commission, *Gradient Study for the Sierra Nevada*. $115,000.
Lassen National Park, US NPS *CESU to digitize the Lassen National Park Wieslander Maps*. $9,400.
United States Forest Service, *Klamath National Forest CESU to digitize the Klamath National Forest Wieslander VTM Maps.* $9,600.
United States Forest Service, *El Dorado National Forest CESU to improve the geo-registration of the Wieslander VTM Maps.* $8,000.
United States Forest Service, *Region Research Office CESU to digitize Lake Tahoe Basin Wieslander Maps*. $20,000.
Mid-Peninsula *Open Space District, to digitize the Santa Cruz quadrangle of the Wieslander Maps.* $7,500.
Arenz Foundation, *to assemble California-based conservation network designers for retreat to write grant for funding of design of a state-wide conservation network*. $5,000.
United States Forest Service, *Region 5 Research Office CESU to develop Wieslander Maps*. $8,000.

2006 $171,000
United State Fish and Wildlife Agency, *to map the Vegetation of San Pablo Bay NWR*. $31,000.
United States Forest Service, *Tahoe National Forest CESU support to develop Wieslander Vegetation Maps for the Forest.* $28,000.
United States Forest Service, *Lassen National Forest CESU support to develop Wieslander Vegetation Maps for the forest.* $15,000.
United States Forest Service, *Plumas National Forest CESU support to develop Wieslander Vegetation Maps for the Forest*. $15,000.
National Park Service, *Sequoia Kings Canyon National Park CESU support to develop Wieslander Vegetation Maps for the Park.* $30,000.
Arenz Foundation, *seed money for graduate student to design conservation network of cores and corridors for California's Central Valley*. $6,000.
University Transportation Center, UC Davis, *to implement analysis of effective mesh size in California, a measure of landscape fragmentation*. lead PI Dr. Alison Berry $75,000.
National Biological Information Infrastructure, *development of California Information Node of the US NBII*. $60,000.

2005 $175,000
National Biological Information Infrastructure, *development of California Information Node of the US NBII*. $60,000.
Integrated Hardwood Rangeland Project, *to conduct 5 year study on planting of native oaks on private ranchlands*. $125,000.

2004 Total $135,000
California Energy Commission, *Development of historical vegetation maps in the Sierra Nevada for use in Climate Change Modeling.* $75,000.
National Biological Information Infrastructure, *development of California Information Node of the US NBII*. $60,000.

2003 $277,000

National Science Foundation, Databases and Informatics Division, *to develop a database of 30 years of butterfly observations and put it online*. $217,000.
National Biological Information Infrastructure, *development of California Information Node of the US NBII*. $60,000.

2002 $60,000
National Biological Information Infrastructure, *development of California Information Node of the US NBII*. $60,000.

Review and Editorial Activities

Reviewer for International Scientific Journals
Science (2010)
Global Change Biology (2007)
Ecology (since 2006)
Biogeography (since 2005)
Oikos (since 2006)
Landscape and Urban Planning (2007)

Professional Activities
2011 – organized climate change sessions for California Native Plant Society conference
2010 – reviewer of grant proposals for NASA terrestrial ecology and climate change programs
2005-present Advisor to ecosystem connectivity initiatives in the Santa Cruz Mountains area.
2004-present Advisor to oak conservation program in Yolo County

Awards
Federal Highways Administration, 2009. Exemplary Ecosystem Initiative for Exceptional Environmental Stewardship – as designer for the Elkhorn Slough Early Mitigation Partnership.
California State Legislature & University of California, Davis- Outstanding Staff Award. 2007. For most dedicated Community Service staff member from the University of California, Davis.

Dissertations and Theses Supervised

Ph. D. Dissertations: Committee member (5)
Masters Theses: Committee member (3)
Graduate Students
Hyeyeong Choe – PhD, full fellowship to study Urban Growth modeling with me, South Korean
Nora Perez Garcia – PhD, visiting from U. Barcelona, studying rare plant landscape ecology
David Waetjen-PhD studying bioinformatics of longitudinal ecological studies for web-based analyses
Michael McGrann- PhD studying plants of the Sierra Nevada
Nate Roth - MA studying economic impacts of urban growth.
Karen Willet-PhD 2009. Use of Urban Growth Models to simulate policy and assess impacts of future growth on biotic resources.
Melissa Whitaker- 2009. MA studying butterfly populations
Jeremiah Mann- 2009. MA field experiment on oak recruitment and cattle grazing
Patrick Huber- PhD Geography, UCD 2009. Now a post-doc working with me on conservation assessment and network design.
Ethan Inlander, MA Geography, UCSB. 2004. Now GIS specialist for TNC, Arkansas.

Classes Taught

As Instructor:

1. Climate Change and Natural Resources Management- 3 week field and policy training for international resource managers. Conducted in Washington, DC, and California.
2. Week long training course in Karst cave conservation in Spanish for The Nature Conservancy in the Dominican Republic. 2008
3. Training Courses (5) in English and French for Park Rangers from 15 countries in Africa. Dec. 2003- Dec. 2004. Instruction in how to set up the computational data entry for the MIKE (Monitoring Illegal Killing of Elephants) program. I helped design, then teach two levels of computer orientation, database use and GIS orientation. Courses were taught in Kenya, Cameroon and Niger. Contact Karen Beardsley– University of California, Davis coordinator for education component of the MIKE program. 530-752-5678
4. Conservation and GIS. I taught an upper division course on the uses of GIS in conservation projects at UC Santa Barbara. Contact Ethan Inlander 479-973-9110, co-presenter.
5. Ran an internship program at UCSB for students to help register 25 years of bird observation records stored at the Vertebrate Natural History Museum. Contact John Gallo gallo@geog.ucsb.edu.

Co-taught, or as Teaching Assistant

1. Ecological Field Methods – Dr. Jim Quinn, UC Davis 2002, 2003
2. Vegetation of California- Dr. Michael Barbour, UC Davis 2002
3. Biogeography, upper division, undergraduate- Dr. Frank Davis, UCSB 1996
4. Physical Geography- Dr. Jeff Dozier UCSB 1996
5. Introduction to Environmental Studies- Social Systems- Dr. Robert Hatherill, UCSB 1995, 1996
6. Introduction to Environmental Studies- Physical Systems- UCSB 1995.

Countries & States worked in

Jordan: Developing biodiversity climate adapation plan for their protected areas. 2011.

Rwanda: Project to model mountain gorilla (Gorilla gorilla beringii) range under climate change. Workshop Gisenyi, 2010.

Dominican Republic, training of cave conservation biologists.2009

South Korea: am advising the National Institute of Environmental Research (NIER) on their biological survey protocols, and co-authoring papers on Asiatic black bear reintroductions and road kill monitoring 2008-2011.

Have worked extensively in the national parks in Alaska.

Cameroon, Kenya, Niger: Trained Park Wardens in database use and GPS as part of 'Monitoring Illegal Killing of Elephants 2005-2006.

Mongolia: field studies of impacts of Gold Mining on rivers containing world's largest salmon, *Hucho taimen taimen.*2002.

Chile, Argentina: 3 month field examination of conservation conditions in the southern temperate rainforests. 1998

Ecuador, Costa Rica, Guatemala: Studied what makes conservation projects successful. 1995

Canada: studied old growth coastal forests on mid-coast of British Columbia, involved in campaign to create the Tatshinshini Provincial Park.
Mexico: Extensive expedition experience in the Copper Canyon region & Baja, California; served as translator for Lumi Indians (from Washington State) who were doing a trans-tribal training with the Lacandon Maya in southern Mexico. Translated from English to Spanish. Another translator then translated to Mayan.

California-Based Projects

Have worked in all terrestrial ecoregions of California, including:

1) Survey of potential UC reserve sites in Modoc Plateau;
2) Vegetation mapping and plot surveys in Klamath & Shasta/Trinity National Forests;
3) Field surveys of vegetation for the California GAP Analysis Program- Sierra Nevada,
East Side, North Coast, Central Coast;
4) National Park Service studies of effects of acid rain and forest monitoring – Sequoia National Park;
5) Supervised surveying of over 1100 vegetation plots in the Mojave & Sonoran Desert regions, included coordinating surveys on 3 national parks (Death Valley, Joshua Tree and Mojave National Preserve), 4 military bases (Naval Air Warfare Center Weapons Division China Lake, Edwards Air Force Base, Fort Irwin, and the Marine Corps Air Ground Combat Center), 2 nature reserves (Granite Mountains Preserve & Desert Research Center), and the BLM lands;
6) Field surveys of mountain lion suitable habitat (core and corridors) in the Central Coast of California;
7) Herpetological field work in central and southern coastal California;
8) Teaching (TA) of field ecology and vegetation courses in central and southern California, and the north coast;
9) Oak restoration and long term studies in the Central Valley of California;
10) First state-wide existing vegetation & conservation lands (GAP Analysis Project);
11) Development of CalJep, a geodatabase of the distributions of 7887 California plants;
12) Assembly of over 25,000 vegetation plots surveyed by various researchers & agencies;
13) Co-developed models of over 400 California plant ranges under current and future Climate;
14) Oversight of development of county-by-county urban growth models projecting future urban growth in California under business as usual assumptions
15) Development of the Wieslander Vegetation maps, originally surveyed in the 1930s covering 1/3 of the state
16) Created MCV 1 ha mmu vegetation map of Napa County
17) Development of a state-wide mitigation needs assessment database for Caltrans;
18) Development of 3 pilot projects assessing potential contributions of multi-project road mitigation efforts to regional conservation designs, for Caltrans and Dept. Water Resources.

Selected Invited Lectures
Conservation Biogeography. Conservation Biology Course, UC Davis, 2005-9.

30 years of butterfly phenology. Museum of Vertebrate Zoology, UC Berkeley, 2005.

70 years of vegetation change. Museum of Vertebrate Zoology, UC Berkeley, 2005-9.

Impact of urban growth and agriculture on native vegetation, Napa County. Seminar on Viticulture Impacts, UC Davis, 2005.

Applications of GIS in Ecology.- to introductory graduate ecology class, UC Davis 2004, 2005.

CalJep- a geospatial version of CalFlora and the Jepson manual. – To Dr. Michael Barbour's lab group. UC Davis 2004.

Parcel level GAP Analysis of the vegetation of Napa County. – Society of Conservation Biology, Davis chapter. 2004.

Hucho taimen, the largest salmonid in the world and Gold Mine Operations in Mongolia. – To The Tahoe Baikal Institute. 2004.

California GAP Analysis. Presented in Spanish to Chilean and Argentine scientists, 1998-1999.

Conservation conditions of the southern temperate rainforests of Chile and Argentina. Slide show presented to multiple audiences in the United States 1999.

Conservation Issues on the Tatshinshini River, British Columbia.

Professional Memberships

Ecological Society of America
American Geophysical Union
Society for Conservation Biology, UC Davis Chapter

Selected Extra Curricular

Survey of old-growth forest plots, Mid-Coast, British Columbia, Canada. Summer 2003. I installed over 20 vegetation plots in remote locations accessed through the fjords near Bella Coola, British Columbia. Access was by boat, with targeted areas those slated for future logging.

Head of restoration committee of the UC Davis chapter of the Society for Conservation Biology, 2002-2009.

Participant- TNC workshops to identify conservation priorities on Central Coast of California.

President, UC Davis Chapter of Society of Conservation Biology, 2002-2003.

Co-founded the Conception Coast Project 1994-1996. This is a successful non-profit organization that provides GIS support and analysis for conservation projects in the Santa Barbara region. http://conceptioncoast.org/Conception_Coast_Project.html.