Peer Review Letters

on the

Draft Mexican Wolf Recovery Plan, First Revision

November 2017

Southwest Region

U.S. Fish and Wildlife Service

Albuquerque, New Mexico

Letter from Paul Beier on the Draft Mexican Wolf Recovery Plan, First Revision (June 2017)

Comments on **Draft Mexican Wolf Recovery Plan, First Revision** (June 2017)

Paul Beier, July 6, 2017

Summary: Having served on the Technical Subteam for the Recovery Plans (RP) for the ocelot and jaguar, and on the Implementation Subteam for the Mexican spotted owl, I appreciate the difficulty of devising reasonable recommendations with limited scientific information. The downlisting and delisting criteria are objective and measurable, and are mostly (exceptions below) supported by scientific information in the revised RP and the Biological Report, but it is not clear that the site-specific actions will achieve the goals.

Criteria not well-supported by scientific information in the Recovery Plan & Biological Report

1. The Biological Report defends the historic range of *baileyi* because it corresponds to the distribution of Madrean pine-oak woodlands and geographic distribution of small bodied wolves. But then the Service defends a MWEPA that extends 200 miles beyond the historic range in light of "the recent success shown by rapid growth of the wild population of Mexican wolves" (Heffelfinger et al. 2017). If potential for population growth can be used to define the MWEPA, then a wider buffer could be used to include north rim of Grand Canyon, San Juan Mountains, Sangre de Christos, and other areas of good habitat that lie within the southwestern Distinct Population Segment. **It is reasonable to prioritize areas closest to historic range for recovery by using I-40 as a soft boundary, but the current documents do not justify a hard boundary at I-40.** What if the current MWEPA is too small for the population to reach 320? In my opinion, a reasonable compromise would be to state that if (for example) the population does not reach 200 by 2025 and 300 by 2035, the MWEPA will automatically be expanded northward. With a trigger like this, partners who want to hold to the current boundaries would be incentivized to make it work, possibly including genetic introgression (See point #1 in the next section) if evidence suggests it would be a more reliable way to reach the population criteria than expanding the MWEPA. It took entirely too long to expand the Blue Range Experimental Area; a reasonable trigger could ensure a similar prolonged mess will not occur again.

2. Explain why 320 wolves are needed in MWEPA but 170 suffice for the Sierra Madre Occidental.

3. I would delete the "alternative" downlisting criteria (lines 240-247). The proposed minimum of 150 animals in each population is only slightly more than exists in MWEPA now, and I don't think the MWEPA population is "almost there". I don't see how the added criterion of "increasing trend" makes up for the vastly lower target for population sizes.

Deficiency of site specific actions in the Recovery Plan

The Disclaimer (page 3) explains that the new Recovery Planning and Implementation Process is intended to be less specific than past processes used to write Recovery Plans, so that the RP can be written faster, can remain relevant for a longer period of time, and allow greater flexibility. Having been annoyed at detailed recovery plans that bury important actions in a mind-numbingly long list of actions, I support these goals. However, I find **Section VI (Actions Needed)** <u>far too short on details</u>. It does not suffice as "a description of such site-specific management actions as

may be necessary to achieve the plan's goal for the conservation and survival of the species" (ESA 4(f)(1)). Perhaps all of these details are being pushed into the Recovery Implementation Strategy. However, my subconsultant agreement specifies that I should comment on the adequacy of proposed actions based solely on my review of the Draft Biological Report and the Draft Revised Recovery Plan (excluding the Recovery Implementation Strategy). Thus this is my only opportunity to comment on recovery actions. Although it is fine to relegate *some* recovery actions to the Recovery Implementation Strategy, the RP should include *the most important actions* and describe each of them in enough detail to convince me that the actions will meet the stated criteria. Specifically:

1. **One action should be an experimental introgression of genes of *northern*[1] wolves into a subset of the captive population.** Consider 3 facts: (1) the 7 founders of the captive population had only a fraction (I'd guess less than half) of *baileyi*'s historic gene diversity, (2) only 83% of the diversity of the 7 founders has been retained, and (3) the MWEPA population retains 76% of the gene diversity of the captive population (with some founders highly under-represented). Together, these 3 facts suggest that the population may suffer high genetic load (reduced mean fitness due to fixation or dominance of detrimental mutations) and that the Plan's proposed genetic management (use planned releases to increase the fraction of captive genes from 76% to 90%, with extremely limited ability to improve balance) may be insufficient. The Plan's genetic management addresses only the 3rd of these 3 facts, and if the proposed genetic management is successful the MWEPA would have only 75% [i.e., 90% of 83%] of the already depauperate founder gene pool. I think a high priority action for the RP should be to experimentally cross some *northern* wolves with captive *baileyi* wolves. Only a small fraction of the *baileyi* population (the most over-represented genotypes) need to be involved in the experiment (thus maintaining options for using genotypes in captive and wild populations). The *northern* x *baileyi* individuals (and F_2 backcrosses to *baileyi*) should be compared to well-matched control individuals with respect to growth, survival, disease susceptibility, behavior, reproduction, and offspring survival. The results of the experiment would help managers decide (a) whether to deliberately introduce *northern* genes into the wild populations in MWEPA and the Sierra Madre Occidental, and (b) how to manage any *northern* migrants that enter MWEPA. The hybrid individuals might also be useful in any future program to introgress *northern* genes into MWEPA, allowing managers to have a lower level of introgression than would occur if pure *northern* animals were released into the wild. Because the experiment will take several years, it should begin now so that the managers will not have to act without the information[2].

2. **Management actions regarding *northern* migrants into MWEPA.** The Biological Report suggests that FWS intends to remove all *northern* individuals that might migrate into

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[1] I use the term "*northern* wolves" to refer to subspecies of *Canis lupus* other than *C. l. baileyi*, and in particular individuals of extant subspecies that are most closely related to *baileyi* or that are most similar in behavior and other traits. Because the subspecific taxonomy is so complicated and controversial, I will not attempt to provide a particular subspecific epithet.

[2] In 1994, managers had to hurriedly release Texas pumas into the Florida panther population when managers belatedly realized that genetic load was too high. Fortunately, that introgression program was a resounding success, but it'd have been better if scientific evidence had been available to inform the decision.

MWEPA, and (perhaps) all *northern* individuals that migrate into north rim of Grand Canyon, San Juan Mountains, Sangre de Christos, and other areas of good habitat that lie within the southwestern Distinct Population Segment. Are these areas intended to remain wolf-free for the indefinite future? In the context of recovering *baileyi*, it is reasonable to prioritize historic *baileyi* range, but it is not reasonable to leave large portions of former wolf range as blank spots on the map of recovery of *Canis lupus*. Moreover, in light of the fact that genetic exchange occurred historically and eventually will occur again, such an action (removal of all *northern* migrants) seems inappropriate. Yes, it'd be nice for hybridization to wait until the *baileyi* population is large (to minimize swamping) but the benefits of outcrossing probably outweigh the risks that introgression would disrupt the natural history or behavior of the population. I think 1 or 2 *northern* wolves joining a population of >100 or >300 *baileyi* wolves would mimic historic genetic exchange, and should be encouraged. At a minimum, any proposed action to limit migrants should be clearly stated and justified. The exclusion of the north rim of Grand Canyon, San Juan Mountains, and Sangre de Christos *might* be acceptable *if* the FWS intended these areas to be occupied by *northern* wolves, but there is no evidence that this is the case.

3. **Management action to remove any *baileyi* individuals that move to the North Rim of the Grand Canyon, the San Juan Mountains, the Sangre de Christo Mountains, and other areas of good habitat that lie within the southwestern Distinct Population Segment**. The 10(j) rule allows but (I think) it does not require such removals, and Mexican wolves outside the MWEPA would have conservation value. The RP should clearly state how these animals will be treated, and justify the proposed treatment.
4. **Management actions regarding diversionary feeding.** Diversionary feeding has been key to population growth since 2010, but Section VI is silent about this action (presumably it is rolled into row 1 of Table 1). Given the importance of this management action, it deserves more explanation. Does the RP envision that diversionary feeding will likely continue up to and even after downlisting or delisting? Does diversionary feeding have any potential negative consequences, such as increased likelihood of detrimental interactions with humans? Does the RP include any steps to minimize any potential downsides?
5. **Actions (in addition to or instead of diversionary feeding) to avoid management removals.** For example, will there be an action to transfer allotments to wolf-friendly livestock operators, or to retire grazing allotments?
6. **Actions (in addition to or instead of diversionary feeding) to avoid illegal killing.** For example, will there be actions to beef up law enforcement against illegal killing? If the Service fears such actions could backfire if implemented too soon, the RP should specify thresholds (e.g., more than a certain number of illegal killings over a 3-year period) that would trigger more aggressive enforcement. Such triggers could incentivize some opponents of recovery to behave better.
7. **Actions to address the proposed border wall.** Some potential realizations of the Trump Wall could preclude natural connectivity between MWEPA and Sierra Madre Occidental. This problem should be acknowledged. There should be some actions related to this threat to connectivity.

Trivial details

Line 489: 280 mi is not the same as 320 km. One of these numbers is wrong. I expect you meant to write 200 mi.

Fig. 2. The caption should define “recruitment”

Letter from Phil Hedrick on the Draft Mexican Wolf Recovery Plan, First Revision (June 2017)

Draft Mexican Wolf Recovery Plan, First Revision

Comments by Phil Hedrick submitted on 7/21/17

1. Are the downlisting and delisting criteria objective and measurable?

a. For all these criteria, the following criterion should be added.

c) Supplemental and diversionary feeding should be absent for four consecutive years

b. It seems very odd that Mexican wolves could be downlisted given the criteria in Mexico are met and the criteria are not met in the US.

c. It would be much better if "average" was taken out in a number of places so it would read "MWEPA population abundance…" instead of "average MWEPA population abundance…" For example, there could be 400, 400, 400, and 81 individuals over four years with an average greater than 320 but indicating a population that is in real trouble.

d. How is the term of 4 years determined? I assume that this is because it is about one wolf generation. Please state.

e. How is the number of 22 arrived at? Is this from 2017 on? It seems like 22 in the first few years would be quite different than 22 over many years and it would also depend on whether they reproduce or not (and how much). As a result, it would be better to have a genetic goal (expected or observed genomic heterozygosity greater than some value) than this seemingly arbitrary number.

f. It is not clear how important these releases are or the exact number of releases is. There might be a point where the benefit from introductions reducing inbreeding depression and increasing genetic variation is offset by the loss in adaptation in the wild population.

g. Please explain why the Mexican population meets the criteria when the average is 170 while the MWEPA meets the criteria when the average is 320.

h. How important is the 37 number in light of the discussion above about the number 22?

i. If the average MWEPA abundance was only 150 (and that in the Mexican population was 150), it would be downlisted. This is much too small to have the USFWS criteria of "resilience, redundancy, and representation" because the Mexican population will not help the MWEPA on any of these values.

j. This plan does not result in the "resiliency, redundancy, and representation" of USFWS that would be necessary for recovery for the following reasons.

(a) Because the two populations are functionally not connected, it is unlikely that the MWEPA population would have an adequate level of **resiliency** to withstand or bounce

back from environmental or demographic stochastic events without continued diversionary feeding and continued low amount of removals. If either of these management actions were changed, then the population would probably be not resilient. This is particularly true because of the very high rate of human-caused mortality in the MWEPA population.

(b) Because there are only two unconnected populations, the level of **redundancy** advocated is much less than for either the northern Rockies gray wolves or the Great Lakes wolves. The MWEPA population does not have any redundancy because the Mexican population will not increase the ability of the MWEPA population to rebound from catastrophic events. In addition, the very low genetic variation in these unconnected populations very likely decreases the ability of the populations to rebound from catastrophic events.

(c) Because the Mexican wolf already has less variation than any other gray wolf population as measured both by actual genomic data and expected by pedigree analysis, it is not clear that the Mexican wolf population has the genetic variation (called "**representation**" here) to adapt to environmental changes. Perhaps if additional populations were started both on the north rim of the Grand Canyon and in northern NM-southern CO and then there was introgression from northern gray wolves into these three interconnected populations, it would result in enough genetic variation to adapt to environmental changes.

2. Will the site-specific management actions achieve the plan's goal for the conservation and survival of the Mexican wolf?

a. The advocacy of only two unconnected populations, one in AZ – NM and one in Mexico, is not the best science and is not likely to support recovery. Both the northern Rockies and Great Lakes wolf recovery programs advocated three interconnected populations. Earlier Mexican wolf recovery teams also advocated three interconnected populations, the present AZ-NM one and two additional ones on the north rim of the Grand Canyon and in northern NM – southern CO. Exchange between these populations to form a metapopulation could result in both demographic rescue and genetic rescue so that the overall viability of the introduced animals would be increased by the presence of the other populations. The populations in Mexico and the AZ-NM are unlikely to be functionally connected because of the plans of the present administration to build a high, insurmountable-to-wolves wall along the US – Mexico border. In other words, instead of a metapopulation, the two proposed populations, one in the present MWEPA and one in Chihuahua, will not interact and they would not have any demographic and evolutionary connections. As a result, the presence of the Mexican population likely will not increase the viability of the US population or the overall viability of the introduced animals and conservation and survival of the Mexican wolf is unlikely.

b. The surprisingly very high rate of human-caused mortality in the MWEPA, 93 of the documented Mexican wolf mortalities (70% of total mortalities) as given in the Biological Report, along with the high removal rate, appear to explain much of the early slow population growth. Although it is good to have documentation, it is not clear that the causes of this very

high rate of human-caused mortality have been addressed. Is the USFWS going to do something new to address this very high rate of human-caused mortality?

c. It is unlikely that the Mexican population(s) will contribute to recovery of Mexican wolves because of the lack of wild prey, lack of protection, presence of livestock, presence of humans, and presence of roads in the Mexican recovery area. Further, because the Mexican population will not have an effective connection to the US population, it will not contribute to overall recovery and could actually act as a diversion from efforts to recover the Mexican wolf in the US.

d. Mexican wolves have a very low base level of genetic diversity in the captive population compared to other wolf populations because of a low number founders as documented by both pedigree analysis and genomic data. It would be good to cite or acknowledge that the amount of genetic variation from genomic analysis for Mexican wolves is lower than that for other wolves (vonHoldt et al. 2011, *Genome Research* 21:1294-1305). From genomic analysis, vonHoldt et al. (2011) found the observed genomic heterozygosity in Mexican wolves was only 0.12, about 55% that of northern gray wolves which had a heterozygosity of 0.22. This is about the amount of genetic variation expected if a pair of wolves were taken at random from northern gray wolves, this pair reproduced and had two progeny, and those progeny had offspring to produce a population. In other words, the level of genetic variation in Mexican wolves already is that expected from an extreme two-generation bottleneck of two individuals each generation from northern gray wolves.

e. The loss of 17% of the genetic variation predicted is very large but genomic data demonstrate that Mexican wolves already have 45% less variation than northern gray wolves. The concern over the very low genetic diversity (and high inbreeding) in Mexican wolves should result in the logical conclusion that introgression with northern gray wolves could result in an increase in genetic variation both for adaptation and reducing inbreeding depression. This interbreeding is what historically occurred and should be an important goal for the reintroduced population.

3. Is the overall recovery strategy and specifically the recovery criteria supported by scientific information in the revised recovery plan and/or the Biological Report?

a. Because of the great increase in diversionary feeding since 2009, it is not possible to measure appropriately inbreeding depression for litter size, as would be experienced by a population that is not being fed. Further, other factors that influence fitness, such as viability, mating success, and probability of reproduction, might also be impacted negatively by inbreeding. In other words, it is highly likely in a population with only two founder genome equivalents remaining (as estimated for the current Mexican wolf population) that there would be inbreeding depression. Ignoring the potential consequences of inbreeding depression would further imperil the population.

b. The proposal here to have only one population in the US, which is not connected to the Mexican population, will make the low genetic variation deteriorate even further. Instead of having a lower number of populations and not having them connected to other populations as in

other wolf populations, these concerns should result in more populations and having them interconnected for Mexican wolves.

c. The range suggested in 1998 ignores the recommendation of two subsequent recovery teams who advocated areas north of I-40 for reintroduced populations. Further, the current general recognition of climate change in the scientific community would suggest that the range should be moved further north to encompass the appropriate suitable habitat for Mexican wolf now and in the future.

d. It is unlikely that the Mexican population(s) will contribute to recovery of Mexican wolves because of the lack of wild prey, lack of protection, presence of livestock, presence of humans, and presence of roads. Further, because the Mexican population will not have an effective connection to the US population, it will not contribute to overall recovery and could actually act as a diversion from efforts to recover the Mexican wolf in the US. The Mexican UMAs where prey density was estimated in the Biological Report are the equivalent of game farms, generally with high densities of white-tailed deer for hunting and where predators are killed. In other words, wolves would not be allowed to live in these areas and they are not appropriate areas to estimate prey density in the areas where wolves would be allowed to live. The natural prey biomass in areas where wolves would be allowed to live is likely to be much less and might be at a level that is unsustainable for wolves.

e. It is likely that the MWEPA and the Mexico population are in quite different habitats and as a consequence the genetic variation necessary for adaptation to environmental changes in the two populations could be quite different. How is this being taken into account? It appears that there will be an effort to make the populations genetically similar even though many aspects of their environments are probably very different.

f. The proposed genetic management appears to have some rather scientifically questionable aspects to it. For example, one would assume that the wild population is adapting to its environment and genetically changing as a result. Introducing captive animals that are not adapted, or adapting, to the wild environment and potentially adapting to the captive environment, might actually be detrimental to some degree for the wild population. In other words, there might be some limit to the benefit of introducing genetic variation from the captive population to the wild population and it might be beneficial to examine the potential for introducing genetic variation from wild-adapted northern gray wolves as would occur naturally. Of course, the potential problems of inbreeding depression should be evaluated as well because they might be somewhat ameliorated by further releases. However, because of diversionary feeding changing the environment around 2009, it might be very difficult to determine the level of inbreeding depression on litter size and other traits since 2009.

Comments specific to particular statements in the text

EXECUTIVE SUMMARY. Because this is a summary of the plan, detailed responses to most of the summary was not given here but to the plan below.

line 181. Should be “descended from 7 founder wolves”. There were actually many more than 7 wolves.

l. 184. The advocacy of only two unconnected populations, one in AZ – NM and one in Mexico, is not the best science and is not likely to support recovery. Both the northern Rockies and Great Lakes wolf recovery programs advocated three interconnected populations. Earlier Mexican wolf recovery teams also advocated three interconnected populations, the present AZ-NM one and two additional ones on the north rim of the Grand Canyon and in northern NM – southern CO. Exchange between these populations to form a metapopulation could result in both demographic rescue and genetic rescue so that the overall viability of the introduced animals would be increased by the presence of the other populations. The populations in Mexico and the AZ-NM are unlikely to be functionally connected because of the present administration plans to build a high, insurmountable-to-wolves wall along the US – Mexico border. In other words, instead of a metapopulation, the two proposed populations, one in the present MWEPA and one in Chihuahua, will not interact and they would not have any demographic and evolutionary connections. As a result, the presence of the Mexican population likely will not increase the viability of the US population or the overall viability of the introduced animals.

l. 187. The surprisingly very high rate of human-caused mortality, 93 of the documented Mexican wolf mortalities (70% of total mortalities) as given in the Biological Report, along with the high removal rate, appear to explain much of the early slow population growth. Although it is good to have this documentation, it is not clear that the causes of this very high rate of human-caused mortality have been addressed. Is USFWS going to do something new to address this very high rate of human-caused mortality?

l. 295. This again is an incorrect statement, how about “a captive breeding population descended from seven Mexican wolf founders.”

l. 319. This summary ignores the three plans written by three different recovery teams formed by USFWS around 1997, 2004, and 2011. These plans all included objectives i) and ii) above and would have included all three objectives if USFWS would have allowed the teams to continue their work.

l. 350. It is not clear that these previous plans were not finalized because of “logistical issues” as suggested, but primarily because USFWS disagreed with these plans developed by wolf and conservation scientists.

l. 388. Previously I made extensive comments about the PVA. Here it is important to note that in the addendum to the PVA report the population numbers over time were given in Figure 1 and 2 (because this was sent out just before our reviews were due, I did not realize the significance of these figures). For MWEPA, under all scenarios, very surprisingly the population number begins to decline after about 50 years. This is completely unacceptable and should be a red flag to indicate that even under the “favorable” conditions modelled here, the population is not sustainable.

l. 390. Previously, I also made extensive comments about the habitat suitability report. In summary, it is unlikely that the Mexican population(s) will contribute to recovery of Mexican wolves because of the lack of wild prey, lack of protection, presence of livestock, presence of humans, and presence of roads. Further, because the Mexican population will not have an effective connection to the US population, it will not contribute to overall recovery and could actually act as a diversion from efforts to recover the Mexican wolf in the US.

l. 396. "We will update the Biological Report as needed to maintain a compendium of the best scientific information upon which to base our recovery efforts…" This statement appears incorrect because there were no changes made in the Biological Report based on my extensive, scientifically based review of the Biological Report before it was made public. As a result, it appears likely that the Biological Report (and the Recovery Plan) will not be changed as the result of the input of scientific information from the reviewers.

l. 407. It would be more correct to say "three effective founder wolves" There were more than 3 wolves captured but some did not reproduce and others were related to the founders.

l. 413. This statement is incorrect. It should read "Ghost Ranch lineage, founded by two unrelated wolves, and the Aragon line, founded by two unrelated wolves, …"

l.423. It would be good to cite or acknowledge that the amount of genetic variation from genomic analysis for Mexican wolves is lower than that for other wolves (vonHoldt et al. 2011, *Genome Research* 21:1294-1305). For genomic analysis, vonHoldt et al. (2011) found the observed genomic heterozygosity in Mexican wolves was only 0.12, about 55% that of northern gray wolves which had a heterozygosity of 0.22. This is about the amount of genetic variation expected if a pair of wolves were taken at random from northern gray wolves, this pair reproduced and had two progeny, and those progeny had offspring. In other words, the level of genetic variation in Mexican wolves already is that expected from a two-generation bottleneck of two individuals from northern gray wolves!

l. 428. This loss of 17% of the genetic variation is very large but the genomic data cited above demonstrate that Mexican wolves already have 45% less variation than northern gray wolves. This concern over the very low genetic diversity (and high inbreeding) in Mexican wolves should result in the logical conclusion that introgression with northern gray wolves could result in an increase in genetic variation both for adaptation and reducing inbreeding depression. This interbreeding is what historically occurred and should be an important goal for the reintroduced population.

l. 437. Some management can be done in the wild such as removing pure inbred McBride pairs that are not reproductive or reintroducing wolves with given lineage representation into areas where that representation is low or lacking. Also on l. 486, it states that one wild pair in Mexico has reproduced in three different years. It appears likely that for good management this wild pair should be removed so that a large proportion of the ancestry in the population does not come just from this single pair.

l. 447. This area does not include large areas of suitable habitat north of I-40 that are very similar to where the present reintroduced population is exhibiting “robust growth.” Arbitrarily eliminating these northern areas from reintroduction greatly reduces the probability of success of Mexican wolf recovery. These areas were recommended as suitable habitat by the two recovery teams that worked on a recovery plan around 2004 and 2011.

l. 453. This increase in population size appears attributable to changes in management in 2009 which increased diversionary feeding and decreased removals. Will these two management changes be continued? How much longer will artificial feeding continue?

l. 455. One surviving cross-foster pup out of six? This low success does not bode well for the cross-fostering efforts, which are presumably much more labor-intensive than translocations.

l. 458. The population increase from 2009 to the present appears to be mainly driven by the increased diversionary feeding and fewer removals. Are these management changes going to be continued into the future? If not, it is likely that the population growth will again stall as it was before 2009? The goal should be to reduce this micromanagement of the population and stop, or greatly reduce, both diversionary feeding and removals.

l. 463. What is the average mean kinship? What is the relatedness?

l. 467. The captive population only has slightly higher genetic variation than the wild population. The closely related captive and wild populations also share many of the same detrimental variants that result in inbreeding depression.

l. 470. Because of the great increase in diversionary feeding since 2009, it is not possible to measure appropriately inbreeding depression for litter size as would be experienced by a population that is not being fed. Further, other factors that influence fitness, such as viability, mating success, and probability of reproduction, might also be impacted by inbreeding. In other words, it is highly likely in a population with only two founder genome equivalents remaining as in the current Mexican wolf population that there would be inbreeding depression and ignoring inbreeding depression might further imperil the population.

l. 486. It looks like too much ancestry from this pair, which could result in inbreeding depression and loss of genetic variation.

l. 490. 280 miles = 451 km! Or is it 320 km = 199 miles. Please correct.

l. 490. It is interesting to see the statement that 280 miles (451 km) is “within the natural dispersal capabilities of the Mexican wolf.” It seems that the USFWS would therefore agree that natural movement from the present reintroduced US population to the potential sites on the north rim of the Grand Canyon or northern NM would be very possible.

l. 494. One of these was the female “Chiricahua” wolf in 2017 but what was the other one that returned to Mexico? Any details on these wolves, such as sex, age, potential reason for movement, etc. might be relevant to include.

l. 570. The proposal here is to have only two populations, instead of three like both the northern gray wolves and the great lakes wolves, and to not have them connected. In other words, the level of redundancy advocated is much less than for either the northern gray wolves or the great lakes wolves. The MWEPA population does not have any "redundancy" because the Mexican population will not increase its ability to rebound from catastrophic events.

l. 575. Does representation actually mean ability to adapt? This does not seem obvious from the ordinary use of the word "representation." It is not clear that the Mexican wolf population has the genetic variation to adapt to environmental changes because it has much less variation already than any other wolf population.

l. 599. The range suggested in 1998 ignores the recommendation of two subsequent recovery teams who advocated areas north of I-40 for reintroduced populations. Further, the current general recognition of climate change in the scientific community would suggest that the range should be moved further north to encompass the appropriate suitable habitat for Mexican wolf now and in the future.

l. 615. It is unlikely that the Mexican population(s) will contribute to recovery of Mexican wolves because of the lack of wild prey, lack of protection, presence of livestock, presence of humans, and presence of roads. Further, because the Mexican population will not have an effective connection to the US population, it will not contribute to overall recovery and could actually act as a diversion from efforts to recover the Mexican wolf in the US. The Mexican UMAs where prey density was estimated in the Biological Report are the equivalent of game farms, generally with high densities of white-tailed deer for hunting and where predators are killed. In other words, wolves would not be allowed to live in these areas and they are not appropriate areas to estimate prey density in the areas where wolves would be allowed to live. The natural prey biomass in areas where wolves would be allowed to live is likely to be much less and might be at a level that is unsustainable for wolves.

l. 637. This map arbitrarily does not examine any of the suitable habitat north of I-40.

l. 670. Why is this entirely based on pedigree analysis when USFWS supported a study to carry out genomic analysis of Mexican wolves (R. Fitak. 2014. Conservation genomics of the endangered Mexican wolf and de novo SNP marker development in pumas using next-generation sequencing. PhD thesis. University of Arizona, Tucson, Arizona, USA.)?

l. 678. What does "genetically advantageous" mean in this context? Maybe this needs to be defined or reworded.

l. 685. It is unlikely that either the states of Arizona or New Mexico would support any releases into their states. What will USFWS do when they refuse?

l. 692. Why not use the number of released wolves that produce progeny? This is also related to previous definitions of packs. Presumably there is a pedigree of the wild population that is being constructed using molecular data to determine parentage as in other wolf populations.

l. 704. It is likely that the MWEPA and the Mexico population are in quite different habitats and as a consequence the genetic variation necessary for adaptation to environmental changes in the two populations could be quite different. How is this being taken into account? It appears that there will be an effort to make the populations genetically similar even though many aspects of their environments are probably very different.

l. 720. This genetic management appears to have some rather scientifically questionable aspects to it. For example, one would assume that the wild population is adapting to its environment and genetically changing as a result. Introducing captive animals that are not adapted, or adapting, to the wild environment and potentially adapting to the captive environment, might actually be detrimental to some degree for the wild population. In other words, there might be some limit to the benefit of introducing genetic variation from the captive population to the wild population and it might be beneficial to examine the potential for introducing genetic variation from wild-adapted northern gray wolves as would occur naturally. Of course, the potential problems of inbreeding depression should be evaluated as well because they might be somewhat ameliorated by further releases. However, because of diversionary feeding changing the environment around 2009, it might be very difficult to determine the level of inbreeding depression on litter size and other traits since 2009.

l. 736 and following. It is good to see the recognition of the problem of human killing and high rates of removals. How is USFWS going to reduce the human killing? They seem to have been very ineffective in the last 19 years in stopping human killing. When is the artificial feeding of animals going to be stopped? The reintroduction is nearing 20 years, much too long for artificial feeding to continue.

l. 777. Because both Arizona and New Mexico have opposed reintroduction of Mexican wolves, it seems unlikely that they would manage Mexican wolves for the betterment of the species.

l. 796. For all these criteria (lines 810, 822, 831, 848, and 860), the following criterion should be added.

c) Supplemental and diversionary feeding should be absent for four consecutive years

l. 797. This seems very odd that Mexican wolves could be downlisted given the criteria in Mexico are met and they are not met in the US.

l. 800. It would be much better if “average” was taken out so it would read “MWEPA population abundance…” For example, there could be 400, 400, 400, and 81 individuals over four years with an average greater than 320 but indicating a population that is in real trouble.

l. 800. 320. Does this refer to adults older than one year? Please be specific.

l. 801. How is the term of 4 years determined? Is this because it is about one wolf generation? Please state.

l. 804. How is this number of 22 arrived at? Is this from 2017 on? It seems like 22 in the first few years would be quite different than 22 over many years and it would also depend on whether

they reproduce or not (and how much). As a result, it would be better to have a genetic goal (expected or observed genomic heterozygosity greater than some value) than this seemingly arbitrary number.

It is not clear how important these releases or this exact number is. As stated above, there might be a point where the benefit from introductions reducing inbreeding depression and increasing genetic variation is countered by the loss in adaptation in the wild population.

l. 812. Delete “average”.

l. 813. Please explain why the Mexican population meets the criteria when the average is 170 while the MWEPA meets the criteria when the average is 320.

l. 817. Again how important is the 37 number because of the discussion above about 22?

l. 827. Delete “average.”

l. 827. This appears to mean that if the average MWEPA abundance was only 150 (and that in the Mexican population was 150) that it would be downlisted. This is much too small to have the USFWS criteria of “resilience, redundancy, and representation” because the Mexican population will not help the MWEPA on any of these values.

l. 828. What is defined as a “positive growth trajectory”?

l. 830-831. Unclear as to what this means.

l. 835. Again please explain why the Mexican population meets the criteria when the average is 170 while the MWEPA meets the criteria when the average is 320. Also on l. 878-882.

l. 868. This plan does not result in the “resiliency, redundancy, and representation” of USFWS that would be necessary for recovery for the following reasons.

(d) Because the two populations are functionally not connected, it is unlikely that the MWEPA population would have an adequate level of **resiliency** to withstand or bounce back from environmental or demographic stochastic events without continued diversionary feeding and continued low amount of removals. If either of these management actions were changed, then the population would probably be not resilient. This is particularly true because of the very high rate of human-caused mortality in the MWEPA population.

(e) Because there are only two unconnected populations, the level of **redundancy** advocated is much less than for either the northern Rockies gray wolves or the Great Lakes wolves. The MWEPA population does not have any redundancy because the Mexican population will not increase the ability of the MWEPA population to rebound from catastrophic events. In addition, the very low genetic variation in these unconnected populations very likely decreases the ability of the populations to rebound from catastrophic events.

(f) Because the Mexican wolf already has less variation than any other wolf population measured by actual genomic data and by expected by pedigree analysis, it is not clear that the Mexican wolf population has the genetic variation (called "**representation**" here) to adapt to environmental changes. Perhaps if populations were started both on the north rim of the Grand Canyon and northern NM-southern CO, then introgression from northern gray wolves into these three interconnected populations would result in enough genetic variation to adapt to environmental changes.

l. 878. Take out "average".

l. 879. How 'about adult mortality below 25%", take out "average"? This seems to be a reasonable bar to reach.

l. 881 and l. 882. Take out "average."

l. 890. The wolf population should be allowed to increase above 380 and to be in other areas such as the north rim and northern NM-southern CO.

l. 892. There appears to be great general support for recovering wolves in AZ and NM.

l. 893. Here is a statement that indicates the impact suggested by game and fish personnel where they are primarily trying to protect ungulate hunting and revenues. Are these considered "socioeconomic concerns"?

l. 896. A population of 200 wolves is Mexico would not be viable.

l. 935. Is it realistic to have pup survival less than 13%? If supplemental and/or diversionary feeding were discontinued (as presumably it will be), what would pup survival be?

l. 952. Why would removals be increased to change the mean mortality rate?

l. 954-957. Does this mean hunting? If so, why not say it directly?

l. 959. Is 25-35 years realistic (6 to 9 generations) for the population to go from 113 to 320? Does this assume continued diversionary feeding for the whole period and a low level of removals for the whole period?

l. 963. Downlisting in 16-20 years, under what criteria?

l. 974. It is unlikely that the genetic threats will ever be ameliorated in a population with only two founder genome equivalents remaining unless there is gene flow from outside from northern gray wolves.

l. 975. The statement that "ensuring gene diversity in the near term will help ensure inbreeding depression is avoided" is not correct. Remember this population has about two founder genome equivalents remaining and that the captive population has the same ancestry. In other words,

even if releases keep the genetic variation from declining very fast, the releases contain many, if not all, of the same detrimentals and lethals that cause inbreeding depression in the wild population. Remember, inbreeding depression is generally defined as lower fitness in progeny from related parents than in progeny from unrelated parents.

l. 977. As discussed above, the genetic variation in Mexican wolves is much lower than in other wolves so the adaptive response "to various and changing environmental conditions" would also be expected to be much less.

l. 1083. Who is "we" here? Is this USFWS? Or is this the recovery group that has met recently? Or some independent evaluation?

l. 1087. The target for 2022 in the MWEPA is 120? This is not very optimistic.

l. 1125. How about crossing with northern gray wolves? This would be a much more effective approach to increase genetic variation and would replicate the natural situation that occurred before wolves were extirpated.

l. 1162. The amounts in this budget are generally incredibly high and the total is unbelievably high (about $9,000,000/year). It is important to divide the amounts provided by different sources, such as USFWS, AZGFD, NMDGF, etc. For example, AZGFD has claimed that they do not spend money on wolf recovery.

Are the amounts for Forest Service and Wildlife Services "new money" or money that is already in their budgets that they are suggesting is relevant to Mexican wolf activities?

There is surprisingly little money for research, considering the large overall amount in this budget. In particular, it is surprising that only $30,000/year is going to Genetic Analyses. In this era, only genomic analyses can determine what is actually happening, particularly given the complicated scenarios proposed here for population numbers and releases.

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Letter from Alberto Lafon on the Draft Mexican Wolf Recovery Plan, First Revision (June 2017)

1 Mexican Wolf Recovery Plan review. Alberto Lafón - Terrazas

2

Line	Comments / suggestiones
182	Was in 2005 not 2011
284	It´s possible to add a Third option??. 3.- A wolves population is found in central NSMO that could increase the resiliency, representation and redundancy of the ongoing population
291	Family packs or packs?
301	How about the free ranging wolves in Chihuahua?
323	SEMARNAT 2000, is not in LITERATURE CITED
346	USFWS 1982;23 is not in LITERATURE CITED
386	wild born: because it doesn´t said anything about searching for new wild populations that still inhabit some areas of Chihuahua
479	2005 like a "first pilot release" in 2011 continue with the program
482	from the first release an estimation of 20 to 30 wolves is possible inhabit the Sierra del Nido, Las Tunas and Sierra de San Andres, unfortunately non-technical following of these animal has been conducted
490	402 kilometers, not 320
514	and predator control programs using 1080 in half of the 19th century
531	The habitat could be fine for wolves but the "habitat use" for cattle purposes is the real threat for the species. I don´t know is an extra line explaining this concept could be adequate or results could be negative for the Recovery Plan
531	However, there is no records of sport hunting in Mexico, and predator control issues are not mentioned
543	Service 2010. is not in literature
549	citation (USFWS 2017a) ??
607	in 2005 was the first "official" reintroduction in Mexico
639	looks like is not a right way to show this figure (double title ??) maybe must be in the text
722	Do you think the border wall will affect the dispersal of wolves between MWEPA and Northern Sierra Madre Occidental? Because historic records have shown the natural dispersal from both areas
893	Then, an extra effort of a communication and environmental education program in the releasing sites region must be conducted
946	Smith et.al. 2010 or 2011??
1135	one suggestion is to develop an educational process in Mexico at least in the states that the wolves has been released in order to let the people know what´s going on with the species, what is the purpose of this reintroduction program and benefits.
1178	Add SEMARNAT Secretaria del Medio Ambiente y Recursos Naturales and CNG Confederación Nacional Ganadera
Table pag 38,	Add SEMARNAT

num 13 second column	
Table pag 38, num 15 second column	Add SEMARNAT and CNG
Page 4o at end	I don´t know if the recovery plan could consider search for other wolves in the wilderness of Chihuahua and Durango states. At least in those sites were tracks, individuals and/or owls has been reported recently. This wolves population is located in Sierra del Nido and other mountains of this corridor. An extra strategy could be support a last effort to find new genetical material from these animals that could increase the vialability of the program
Literature cited	Goodman D. 1987. is not in the document
	Heffelfinger….2017. is not in the document
	Pimm….. 1988. Is not in the document
	Soule…… 1986. is not in the document
	USFWS 1996. is not in the document

Among what you should consider during your review are the following questions:

1. Are the downlisting and delisting criteria objective and measurable?

Yes, both criteria are objective and measurable. Those criteria depends directly on the released wolves reproduction and adaptation then, monitoring cost must be consider in the plan.

The genetic criteria could improve if part of the program support is focus in the study of the wild wolves in Mexico that could increase the gene diversity.

Also, the in the delisting criteria for Mexico new releasing areas must be consider (Namiquipa, Buenaventura counties as well as the El Nido, las Tunas, San Andres sierras)

Another suggestion is include a third strategy in order to establish a well-developed communication and environmental education program for public and land owners in the specific, and develop a stronger depredation compensation funds for Mexico trough different possible donors or programs like for ecological services payments.

2. Will the site-specific management actions achieve the plan's goal for the conservation and survival of the Mexican wolf?

The selected areas are the best according with the historical distribution of Mexican wolf. NWEPA as well as the Sierra Madre Occidental were the last sites of wild wolf's distribution and this could help to maintain the Redundancy and Representation.

Population abundance would be in relation with prey abundance, unfortunately is not enough wild prey for wolves in some sites and land owners could be in conflict for cattle predation that could be the key factor for population growth.

The genetic part I think is the better supported, it´s clear defined and translocations as well as recapture of wild born individuals, could be the best way to check the genetic variability. As I have been suggesting. An extra effort is needed in sierra del Nido, central Chihuahua, just to know if this population have a special genetic value for the program.

For monitoring and adaptive management the recovery plan consider excellent ideas and it's a key to measure how goals are accomplish and the wolves´ population is reestablishing in the areas.

Collaborative efforts are well developed between countries and technicians, land owners should be included in order to guarantee a better understanding of the Plan objective and it´s benefits in mid and long terms if population increase, more area is going to be covered, thus new conflicts with land owners could go against the recovery plan.

3. Is the overall recovery strategy and specifically the recovery criteria supported by scientific information in the revised recovery plan and/or the Biological Report?

Yes, the overall recovery strategy as well as the recovery criteria are well supported by scientific information, including the previous material reviewed (genetics, biological report). However, information and extra communication effort with people with knowledge on Mexican Wolf like Roy McBride and Jose (Pepe) Treviño, could increase the opinion about the Plan

Letter from Gary Roemer on the Draft Mexican Wolf Recovery Plan, First Revision (June 2017)

The following represents my comments on the Draft Mexican Wolf Recovery Plan, First Revision (U.S. Fish and Wildlife Service 2017b). In so doing, I specifically addressed the three questions posed in an email received from Ms. Molly McCarter (dated: 6/29/2017) and have commented on other issues that I feel are germane and that I have specific expertise or experience in. In so doing, I have also made reference to the population viability analysis (PVA) by Miller (2017) and the habitat suitability analysis by Martinez-Meyer et al. (2017) where appropriate, as well as other pertinent literature. My comments on the Recovery Plan are primarily embedded within my answers to the three questions posed by Ms. McCarter.

Finally, my comments are my own and although I am a professor at New Mexico State University, my comments are not a reflection of NMSU's opinions or views on the status and recovery of the Mexican wolf.

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1. Are the downlisting and delisting criteria objective and measurable?

Demographic Targets

The criteria for downlising or delisting the subspecies refer to two reintroduced populations of Mexican wolves, one larger population located in Arizona and New Mexico of the U.S. – the Mexican Wolf Experimental Population Area (MWEPA) and another smaller population located in the northern portion of the Sierra Madre Occidental in northern Mexico (SMOCC-N). In general, the concept of maintaining populations large enough to reduce the probability of extinction over 100 years is an accepted strategy and a population > 250 individuals that is stable over 2 generations (8 years) appears to have a low risk of extinction that is supported by the current Population Viability Analysis (Miller 2017: Figs. 3 and 4), a prior PVA (Carroll et al. 2014: Fig. 1), and by expert opinion (Wayne and Hedrick 2011). However, populations below this value naturally have a higher risk of extirpation and this risk is dependent on population vital rates (e.g., mortality rate and reproduction), levels of connectivity between the existing populations, and other factors such as demographic stochasticity, inbreeding depression, environmental variation, catastrophes, human-caused impacts to the wolf populations and their habitat, and what level of risk we decide is acceptable. Currently, the target population size in the Recovery Plan for the MWEPA is 320 Mexican wolves whereas the target for the SMOCC-N is 170 wolves. Thus, the latter target may be low, but neither target may preclude long-term persistence and persistence will depend on various factors which may or may not be under management control (Harding et al. 2016).

One factor that was specifically modeled in the current PVA by Miller (2017) was introduction of wolves from the captive population or translocation of wolves from the MWEPA to the SMOCC-N and although both scenarios tended to reduce the extinction risk for the SMOCC-N, one key aspect here is that natural movement between these two populations is most likely minimal owing to the relatively large distance separating them. Natural dispersal was also modeled by Miller (2017) and conclusions there and in the Draft Biological Report (USFWS 2017a: L1456-1469) suggest that without some level of connectivity the risk of extinction for the SMOCC-N will necessarily increase. Carroll et al. (2014) also suggested that the risk of extinction for a population below 200 individuals will be more strongly affected by dispersal. In summary, if management actions, such as translocation of wolves from the MWEPA to the SMOCC-N are to be curtailed or stopped after downlisting or delisting, then the extinction risk to a population of wolves averaging 170 individuals within the SMOCC-N may increase and be unacceptable. The Service has also recognized this (USFWS 2017a: L1373-1379):

"In the northern Sierra Madre Occidental, a population of less than 200 wolves is unable to reach the 90% benchmark except at the lowest tested mortality rate (approximately 19%), which is well below the population's current average adult mortality rate and expected to be unlikely to be achieved during the early years of the reintroduction. Larger population sizes at or above 200-250 are needed for persistence of this population at a mortality rate of approximately 25%, while populations of 200-250 are not able to achieve persistence at mortality rates of 28% and 31%."

This summary reflects the analysis in Miller (2017) and suggests that the recovery target for the SMOCC-N may be too low. What may be important here is to develop a sound monitoring

program that will be used to identify when a population may be in trouble, what causal factors are involved, and to articulate potential management interventions that could be enacted to then avert any potential decline (e.g., see Bakker et al. 2009). That said, a new target of 200-250 individuals in the SMOCC-N may be necessary.

Finally, 2 established populations is the minimum that might be considered for recovery and although there are very influential socioeconomic issues to consider, additional reintroduction sites, such as near the Grand Canyon in Arizona or an additional site in northern New Mexico and southern Colorado (Wayne and Hedrick 2011) might be considered, at least within a modeling context, to explore how such a configuration might reduce the risk of extinction for the entire subspecies.

Are these demographic targets objective and measurable? It is not clear why a target of 170 individuals was selected for the SMOCC-N, as this seems to be somewhat low based on various analyses and opinion, but abundance estimates are measurable.

Genetic Targets

The entire subspecies of the Mexican wolf is founded from 7 individuals, and it is recognized that the wild population has a higher level of inbreeding than the captive population which itself, is larger in number than either reintroduced population. Although inbreeding depression may have occurred in some pairings as the recovery effort unfolded (Fredrickson et al. 2007), more recent reproduction in the wild suggests that inbreeding depression has declined (Harding et al. 2016, USFWS 2017a, b). That said, the current genetic targets for downlisting or delisting include specific language about the number of individuals released from the captive population that will survive and be available to breed. For example, for the MWEPA it is written that: "Gene diversity available from the captive population has been incorporated into the MWEPA through scheduled releases of a sufficient number of wolves to result in 22 released Mexican wolves surviving to breeding age in the MWEPA.", and similarly for the SMOCC-N it is written that: "Gene diversity available from the captive population has been incorporated into the northern Sierra Madre Occidental through scheduled releases of a sufficient number of wolves that results in 37 released Mexican wolves surviving to breeding age in the northern Sierra Madre Occidental." One issue here is that the social structure of wolves, which typically involves an extended family pack structure with a dominant pair that breeds, may actually hinder the incorporation of new genes from individuals released into the reintroduced populations from the captive population. Although counting or estimating the number of released individuals that survive to breeding age is measurable, their genetic contribution to the wild populations is harder to gauge and the increase in genetic diversity resulting from the incorporation of captive genes into the reintroduced populations is really the factor of interest. So rather than counting the number of captive individuals that survive to breeding age it would seem more prudent to estimate parameters directly associated with the genetic diversity of the reintroduced populations that would be affected if the released captive individuals actually bred. Namely to estimate and track the levels of observed and expected heterozygosity, and/or estimate either relatedness or inbreeding coefficients for individuals and the population as a whole using pedigree approaches or new approaches that can be applied to genetic and genomic data (Hedrick and Lacy 2015), and/or to estimate effective population size. The latter is often difficult to estimate but is also key

to understanding how genetic variation may erode over time (Harding et al. 2016, Wayne and Hedrick 2011). These parameters could be estimated along with estimates of reproduction and if there is an unacceptable decline in genetic diversity or if inbreeding depression is subsequently detected then management actions including the cross-fostering of captive young, the translocation of wild-born individuals from one population to the other, or the translocation of individuals from another wolf subspecies, as a form of genetic rescue, could be considered and potentially implemented (Adams et al. 2011, Gustafson et al. 2017, Johnson et al. 2010, Vila´ et al. 2003).

In other words, I think it is more important to articulate particular population characteristics or targets that increase the risk of population decline or extirpation and that when these thresholds are reached, they will then elicit a potential management response that will be used to reverse the negative impact observed. This type of an approach was used in the recovery of the island fox and included both "Population Risk-based Recovery Criteria" and "Threat-based Recovery Criteria" which, if they occurred, would trigger specific recovery actions (see USFWS 2015). I think such targets and associated actions should be specifically listed in the Mexican wolf recovery plan.

2. Will the site-specific management actions achieve the plan's goal for the conservation and survival of the Mexican wolf?

Since 2009, a series of management actions including law enforcement, non-lethal methods of livestock protection, cross-fostering of pups, diversionary feeding, and the cessation or reduction in lethal and permanent removal of individuals have resulted in what appears to be a growing population of Mexican wolves in the MWEPA (Fig. 1; Miller 2017). In addition, a second population of Mexican wolves was reintroduced into the Sierra Madre Occidental of Mexico. These actions are all very positive toward conserving this subspecies, but the recovery criteria merely state what the goals are, and mostly in a general sense, rather than articulate how those goals will be achieved. Under Heading III: Recovery Strategy of the recovery plan, there were statements regarding strategy under 5 additional subheadings: Geographic Distribution (L591), Population Abundance (L642), Genetic Management (L665), Monitoring and Adaptive Management (L731) and Collaborative Recovery Implementation (L763). Here's the statement for Population Abundance:

"Our strategy to establish two populations over a large geographical area of the Mexican wolf's range addresses the conservation principles of *redundancy* and (ecological and geographical) *representation*, as discussed in the Rationale for Recovery Criteria."

This is not a strategy but rather an objective, and although it is a worthy one, it does not explain how this goal will be accomplished. There is no strategy or plan as to how any of these goals are going to be accomplished in the future beyond a general sense. Regarding population abundance, how will the populations be monitored? How many releases are planned per year for each site? How many translocations from the MWEPA to the SMOCC-N are planned per year? How will abundance of each population and the survival of wild-born vs. released or translocated animals be estimated and how will these estimates be used to alter the release schedule? Evidently, another document, a Recovery Implementation Strategy (USFWS 2017b: L1146-1156) will be

forthcoming that will explain site-specific recovery actions, but I thought this is what a "recovery plan" was for! Without such information, it is impossible to evaluate the site-specific management actions and their potential to spur recovery.

3. Is the overall recovery strategy and specifically the recovery criteria supported by scientific information in the revised recovery plan and/or the Biological Report?

There has been a wealth of information collected on both the reintroduced and captive populations and clearly there has been an enormous effort, from a variety of standpoints, to preserve this subspecies. This effort should be lauded; however, the analysis of these data, its presentation, and its incorporation into additional modeling exercises have some serious issues that are reminiscent of problems that plagued other recovery programs, namely that for the Florida panther (Beier et al. 2003). The ESA specifically states that a determination regarding a threatened or endangered species will be made "... solely on the basis of the best scientific and commercial data available..." and that a recovery plan will include "a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species." In regards to these statements, I think the current recovery plan falls short, the data analysis is inadequate and site-specific management actions to recover both populations or critical population-based or threat-based criteria that once breached, will elicit specific management actions to reverse a negative impact on population persistence, have not been outlined.

There is a wealth of data that has been collected on this subspecies that has not been analyzed using appropriate methods. The following is a list of some analyses that may want to be considered.

1. Estimates of the size of the reintroduced population in the MWEPA has apparently been collected via aerial survey but these data have been presented as point estimates without associated estimates of precision, yet the probability of detecting individuals in an aerial survey is clearly < 1. Like any abundance estimation procedure, aerial surveys have various assumptions and data-collection issues and appropriate sightability models should be used with these data to estimate abundance and the precision around the estimate (e.g., see Lubow and Ransom 2016). Further, it is not clear if the estimates of population growth rate were simply calculated as N_{t+1}/N_t, and thus based on the point estimates, which have no measures of precision. Alternative methods of analysis, including recently developed integrated population models may want to be explored to estimate abundance and population growth rate, improve estimates of precision for all demographic rates, as well as be used to compare observed growth rates, based on estimates of abundance, to realized growth rates based on estimates of vital rates (Schaub and Abadi 2011).

2. Regarding the vital rates and in particular the probability of survival, it is not clear how survival estimates were derived. Many wolves were radio-collared and in Appendix D of Miller (2017) there are estimates of survival with associated confidence intervals but how these estimates were obtained is not explained. There also appears to be some assumptions as to the fate of different individuals. These data should most likely be analyzed with an appropriate approach, such as a known-fate model, and presented with an associated variance estimate, and estimate of which would vary depending on sample size (White and Garrot 1990). Known-fate

models can be used to compare survival probabilities over time and between different classes (e.g., age or wild-born vs. captive-born).

3. From Appendix D of Miller (2017) it is clear that a wealth of GPS data on movements and locations of wolves has been compiled; between 2009 – 2014 there were over 75,000 radio-days on wolves across three age classes. Yet there is no use of these data in a resource selection framework (Manly et al. 2002). Given the development of the species distribution models (SDMs) to determine suitable habitat for reintroduction (Martinez-Meyer et al. 2017), it would seem prudent to analyze these locational data to actually assess resource use and to compare that derived from the GPS data to that developed from the SDMs.

4. Although two PVAs have been conducted on this subspecies, both used the Vortex platform and the most recent analysis by Miller (2017) does not appear to incorporate model or parameter uncertainty in the analysis nor does it explore potential functional relationships with, for example, estimates of prey abundance. The Scientific Review Team (SRT; Beier et al. 2003) that reviewed the Florida panther recovery program specifically mentioned that:

"Although VORTEX and other canned procedures can reveal sensitivity to some parameter estimates, they are opaque on many other issues, especially those related to functional relationships."

and

"The SRT recommends that any future PVA models should be built from scratch and explicitly consider parameter uncertainty, variation (demographic, environmental) in parameters, and uncertainty in key functional relationships such as density dependence and the effects of inbreeding."

and further,

"In general, there is a serious need to take into account the various sources of uncertainty in these projections, among them uncertainty in the input values and assumptions. Management alternatives could then be evaluated considering all these sources of uncertainty."

This critique of the Florida panther recovery program has many parallels with the current Mexican wolf recovery plan and should most likely be a source to consider when reexamining the data available for the Mexican wolf. Other sources to scrutinize include the demographic and population viability analysis by Bakker et al. (2009) and the subsequent recovery plan devised for the island fox (USFWS 2015).

So, are the recovery criteria supported by scientific information? In my opinion, no, because an inadequate analysis of existing data or a complete lack of analysis of existing data has occurred and this is what the criteria are based on.

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Letter from Jeff Stetz on the Draft Mexican Wolf Recovery Plan, First Revision (June 2017)

Mexican wolf Draft Recovery Plan of 29 June 2017

Review by Jeff Stetz, PhD, CWB. August 2017

General comments on Recovery Plan:

Among what you should consider during your review are the following questions:

1. Are the downlisting and delisting criteria objective and measurable?

Most of the downlisting criteria are objective and measurable, at least if some of my comments below are addressed; however, some of the criteria themselves raise questions.

United States (a): Setting a target for average abundance (320 wolves over four consecutive years) is straightforward enough. My first concern is how abundance is determined? Elsewhere in the Plan, minimum abundances are reported. Will this continue to be the metric used, or will statistical models be used, and if so, what are they and how will they be used (e.g., point estimate versus lower confidence interval)? It is difficult to assess the criteria without such details. Also, there is nothing about positive population growth rates or mortality thresholds mentioned here even though they are mentioned elsewhere (e.g., in the alternative criteria on Line 238).

United States (b): surviving to breeding age is no guarantee that a wolf will actually incorporate its genes to a population, as acknowledged on Line ~691. So although this criterion is measurable, I am not sure it's the best measurement to make even with *estimates* of post-release survival and reproduction. If genetic diversity is the key metric here, why not define a target based directly on it and not an indirect measure that may or may not reflect population status? From an outsider's perspective, it makes more sense to define a population target (e.g., observed heterozygosity), then adjust the releases accordingly instead of relying on assumptions about how well released animals integrate their genes into the population.

Mexico (a): Same comments as United States (a).

Mexico (b): Same comments as United States (b), which are supported by having a different target (ie, 37 instead of 22 released wolves surviving to breeding age). Again, if the target is genetic diversity, why not measure it directly?

Alternative criteria (a) ~ Line 238: without documenting functional demographic and genetic connectivity between these two populations, this criterion is not very satisfying. A somewhat extreme example of why would be having 200 wolves in the NSMO population and 100 wolves in MWEPA. Despite being improbable, under this definition, it would still lead to considering a downlisting action. An important distinction here over the population-specific abundance criteria is having a "positive growth trajectory". But as with the abundance criteria, how growth will be estimated and interpreted is not specified. Knowing the expected modeling framework is not necessary, but at least addressing if this is a simple index based on minimum counts versus a rigorous statistical analysis seems reasonable.

My concerns about functional connectivity are acknowledged on Line ~716 (ie, "…we do not expect the level of dispersal predicted between any of the sites (particularly between MWEPA and NSMO) to provide for adequate gene flow between populations to alleviate genetic threats…"). If even genetic connectivity is not expected, demographic connectivity certainly cannot be. As such, I fail to see how the status of the Mexican population can be given such significance, particularly as it would likely weaken

resiliency and *redundancy* overall. And regrettably, connectivity is likely to only worsen as anthropogenic barriers increase, with or without a stupid border wall.

Delisting criteria Line 249:

(1)
United States (a): The longer time frame here (i.e., eight versus four years) makes it less likely that having an average population abundance ≥320 wolves could occur despite potentially serious declines in abundance in later years. Nonetheless, abundance (or average abundance) by itself is not a very strong indicator of population performance without other metrics such as number and distribution of packs.

United States (b): Same comments as the population-specific criteria.

Mexico (a): Same comments as United States (a).

(2) Line 278: The criteria listed here are vague and, therefore, it is difficult to consider them objective or measurable. Other recovery plans that I am familiar with provide explicit mortality limits, usually expressed as age-class/sex-specific percentages of abundance estimates. Defining limits as 'good enough to maintain a viable population' is not sufficient detail. Further, stating that Mexico (or the U.S. for that matter) has a proven track record of protecting wolves may be relatively true in the recent past, but clearly it is not a given. Finally, having such regulations in place does not address other important anthropogenic mortality risks such as vehicle collisions, and does not appear to be adaptive in terms of responding to natural mortality sources including disease.

2. Will the site-specific management actions achieve the plan's goal for the conservation and survival of the Mexican wolf?

Without access to the Recovery Implementation Strategy it is difficult to assess the site-specific management actions that will be taken to achieve down/delisting criteria. The only criteria that have specific actions tied to them are the number of released animals surviving to breeding age, which as I suggest above, may not be the most appropriate criteria. I agree that it is not necessary or prudent to identify future release sites; however, this example is overly specific, and there are other actions that could be better defined. These include empirical genetic diversity measures, disease monitoring and response plans, how population parameters are derived and interpreted, and how supplemental/diversionary feeding is determined and adapted.

3. Is the overall recovery strategy and specifically the recovery criteria supported by scientific information in the revised recovery plan and/or the Biological Report?

Abundance: Among my biggest concerns about the criteria themselves is the lack of any intrapopulation spatial components or number of packs in the population(s). These could be indexed by occupied territories, distribution of packs on the landscape (i.e., proportion of area occupied), and/or trends in each. Such criteria would likely go a long way to providing additional measures of intra-and interpopulation *resiliency*, *redundancy*, and *representation*. They would also be relatively easy to define and objectively measure, and would (I assume) be consistent with monitoring efforts needed to identify future release sites (per Line 1140), among other benefits. Relying strictly on abundance without other considerations, particularly for a social species, is missing an important part of their ecology. Further, given the ongoing legal battles with wolves in the Great Lakes (see Judge Millett's recent ruling), I would expect such criteria to be an easy target, although I recognize that may be beyond the scope of this review. Based on

the PVA, however, the abundance targets should provide reasonable *resiliency* in the near- to mid-terms if they can be met.

Genetics: As I touch on in other places, defining genetic criteria based only on proportion of the captive populations' diversity is missing the point. Clearly there are hard limits to what can be achieved given such a small founding population and the inability to control breeding in the wild. Nonetheless, the issue is with the actual genetic status of the wild population(s), as this has been shown to influence reproduction and is likely to become a bigger concern over time unless additional genetic material is brought into the population (i.e., from other subspecies). I suggest that the current criteria would be more appropriate as a "how" (to achieve a target) than a "what" (the target actually is). Similarly, is there a point at which releases of members from other subspecies would be considered? And if so, what would such triggers look like? Although controversial, such a thing has been done before to considerable success.

Although I do not discount the potential significance of genetic diversity in the wild populations and its interactions with demographic processes, there may be too much emphasis placed on it relative to other threats, particularly for such small populations. One obvious example is disease, which receives essentially no attention throughout the Plan (although I realize it was incorporated into the PVAs, which I'll address later). Relying on data from Yellowstone or other wild populations is a reasonable start, but is not necessarily sufficient for these populations. For one, there are larger human population centers, including Albuquerque and Tucson, than in the GYE, which could support large populations of feral dogs as well as large coyote populations and numerous other potential disease reservoirs (e.g., felids, mustelids, procyonids) throughout the region. Are there disease monitoring efforts and/or protocols for how to respond when a disease is detected?

Somehow I missed this while reviewing the Draft Biological Report, but why is there a 5% *reduction* in adult *mortality* during a CDV outbreak (Line 333 in the revised report). Should this read a reduction in *survival* (as with pups)?

Another concern is the possibility of downlisting or delisting the entire sub-species when a population outside the United States demonstrates even relatively weak evidence of recovery. Although it may be implausible to think the MWEPA population will not continue to be the stronger performing population, using averages or totals across MWEPA and NSMO could place unrealistic long-term pressure on population(s) in Mexico, and weakens the concept of *redundancy*, as noted on Line 1059. Clearly the U.S. has no authority over how wolves are managed in Mexico, regardless of MOUs or a recent history of dedicated recovery efforts. As such, the alternative criteria for downlisting do not seem strong enough, particularly the average abundance criterion, GIVEN the limited (at best) connectivity between MWEPA and NSMO populations. Requiring positive population growth strengthens this criterion; however, how this is determined is not specified. Any model-based approach to estimate growth rates would be expected to be too imprecise to not overlap zero (and likely negative) growth. To really assess how objective and measurable the criteria are, the methods and rules (e.g., growth rate estimate will use model-averaged point estimate versus upper or lower 95% confidence interval) should be specified.

Specific comments:

Line 215: MWEPA not defined in text yet (recognizing it is defined on Line 1171).

Line 499/Fig.2: Again, is this a minimum *count*, or abundance *estimate*? Line 459 says minimum count, but the figure says minimum population estimate.

Line 879: This appears to be the first mention of average adult mortality (<25%) thresholds on top of average abundance of ≥320. I would think this should be listed explicitly with the abundance criteria at each instance assuming that it is applicable to each.

Line 977: “ensure” is a strong expectation here, as even relatively large, well-connected populations may not be able to respond and adapt to changing environmental conditions. Optimizing genetic diversity, to the extent possible, will AID in a species’ ability to adapt, but does not ensure it.

Line 985: Again, a target of 90% of the captive population’s genetic diversity says little about the actual status of the wild population. I would prefer to see specific target values for the wild population such as expected and observed heterozygosity, allelic richness, and average inbreeding coefficients instead. This will not appear as “rosy” as the current 90% target, but are more relevant.

Line 1082 (5- and 10-year status reviews): how were the interim criteria determined? Also, are the abundance targets strictly the status of the population(s) at year 5/10 instead of multi-year averages as with the recovery/downlisting criteria? If so, I would suggest establishing criteria that account for trends in the population(s), either showing positive population growth or at least average abundance over the period of the review. Also, would it make more sense to align the review periods with other criteria (i.e., 4- and 8-year intervals used to calculate average abundance)? I assume this interval is at the discretion of the Team and not a legal mandate under the ESA (pre-delisting, that is). Finally (and again), is this criteria a minimum count or estimate? Either way, the target for the 5-year review seems quite low given the population’s status as of 2016 and, therefore, may not be strong enough to really assess program successes/failures and inform adaptive management.