

**Independent
Multidisciplinary
Science Team
(IMST)**



State of Oregon

Neil W. Christensen
Michael J. Harte
Robert M. Hughes
Victor W. Kaczynski
Nancy Molina
Carl Schreck
Carlton Yee

c/o
Oregon State University
Department of Forest Science
321 Richardson Hall
Corvallis OR 97331-5752

January 30, 2007

Chris Wheaton
Oregon Department of Fish and Wildlife
Northwest Region
17330 SE Evelyn St.
Clackamas, OR 97015

Dear Chris,

At the request of the Oregon Department of Fish and Wildlife, the Independent Multidisciplinary Science Team (IMST) has reviewed the draft document titled Clackamas River Bull Trout Reintroduction Feasibility Assessment (US Forest Service draft dated November 28, 2006). In your letter dated September 18, 2006 you listed four questions for the IMST to consider in its review these are addressed within the review.

The IMST applauds the serious, scholarly approach evidenced in this document aimed at assessing the feasibility of successfully reintroducing bull trout to the Clackamas River basin. In this review, the IMST stresses areas that the authors could modify to the content to increase the Assessment's level of scientific credibility. However, this review should not be taken to imply that the IMST does, or does not, endorse bull trout reintroduction into this system. The decision of whether or not to reintroduce bull trout concerns not just science but also management, policy, and societal goals.

The IMST appreciated the consideration of possible negative effects of such a reintroduction to other species in the basin and to potential donor stocks. The tiered approach to catchment selection is logical, as are the ecological considerations in that process. Although the Clackamas River Bull Trout Working Group (CRBTWG) believes that the Assessment presents a scientifically credible case for reintroducing bull trout in the Clackamas River, the IMST believes that the evidence supporting that conclusion could be strengthened substantially if several points received either additional justification or clarification. These points are discussed in detail in the attached review.

In general, the IMST believes the Assessment is a serious, well considered review of the feasibility of reintroducing bull trout into the Clackamas River basin that addresses the pros and cons associated with such an activity. If the precautionary principle is followed and no or minimal harm to local species or donor stocks are probable, then a reintroduction may make sense. In any case, it would be wise to view a

January 30, 2007

Page 2

reintroduction as a scientific experiment that would include adequate pre- and post-introduction effectiveness monitoring of both target and non-target species and their immediate and landscape-scale environments. IMST strongly endorses the intention articulated in the Assessment to use an adaptive management approach if a reintroduction is attempted.

The review was adopted by the IMST at its January 18, 2007 public meeting. There were no dissenting opinions amongst the IMST regarding this review. One IMST member was absent from the final deliberations, but indicated approval prior to the discussion. As we mentioned to Dan Shively (USFS) and Brad Goehring (USFWS) at the meeting, the IMST does not normally release reviews to the public or post them to our web site for 30 days after sending the review to the requesting agency. If you would like IMST to post the review at an earlier time please let Kathy Maas-Hebner (541-737-6105) know and she will post it on IMST's web site.

Let us know if you have any questions or would like further clarification on points made within the review.

Sincerely,

Nancy Molina
Nancy Molina *CB*
IMST Co-Chair

Carl B. Schreck
Carl Schreck
IMST Co-Chair

Cc with enclosures:
Ed Bowles, ODFW
Sue Knapp, GNRO
Tom Byler, OWEB
Dan Shively, USFS
Todd Alsbury, ODFW
Brad Goehring, USFWS
IMST

IMST Review
of the US Forest Service's
Draft Clackamas River Bull Trout Reintroduction Feasibility
Assessment (November 28, 2006 draft)

Released on January 30, 2007



Independent Multidisciplinary Science Team

Oregon Plan for Salmon and Watersheds

<http://www.fsl.orst.edu/imst>

Members:

Neil W. Christensen

Robert M. Hughes

Nancy Molina

Carlton Yee

Michael Harte

Vic Kaczynski

Carl Schreck

Citation: Independent Multidisciplinary Science Team. 2006. IMST Review of the US Forest Service's *Draft Clackamas River Bull Trout Reintroduction Feasibility Assessment* (November 28, 2006 draft). Oregon Watershed Enhancement Board, Salem, Oregon.

Review Preparation: Chris Wheaton (ODFW), Dan Shively (USFS), Todd Alsbury (ODFW), and Brad Goehring (USFWS) presented a summary of the goals, analyses, and intended use of the feasibility assessment at the IMST's October 16, 2006 public meeting. The IMST received a draft of the feasibility assessment for review on November 28, 2006 and comments in this review apply only to that draft. This IMST review is based on an initial draft by an IMST subcommittee including Bob Hughes, Vic Kaczynski, Carl Schreck, and Susie Dunham (IMST Faculty Research Assistant). The subcommittee held a public meeting to discuss the feasibility assessment and to prepare a draft review on December 13, 2006. The draft review was discussed and unanimously adopted (one member absent from vote) at the January 18, 2006 IMST public meeting.

TABLE OF CONTENTS

INTRODUCTION.....	1
GENERAL COMMENTS.....	1
CHAPTER 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin.....	2
CHAPTER 2 – Habitat.....	2
BULL TROUT DISPERSAL AND MIGRATION.....	4
SUFFICIENCY OF PRESENT AND FUTURE BULL TROUT HABITAT	4
CLIMATE CHANGE	5
CHAPTER 3 – Conservation Genetic Considerations and Donor Stock Suitability..	6
BULL TROUT DONOR STOCKS	7
CHAPTER 4 – Ecological Interactions and Food Web Considerations.....	8
BROOK TROUT INTERACTIONS	8
BULL TROUT TRANSFERS	8
BULL TROUT PREY	8
GENERAL CONCLUSIONS.....	9
SPECIFIC COMMENTS.....	9
EXECUTIVE SUMMARY	9
CHAPTER 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin.....	10
CHAPTER 2 – Habitat.....	11
CHAPTER 3 – Conservation Genetic Considerations and Donor Stock Suitability. 	13
CHAPTER 4 – Ecological Interactions and Food Web Considerations.....	14
CHAPTER 5 – Summary.....	15
APPENDIX A – A Decline of Bull Trout in the Western United States: Causes for Decline of Bull Trou	15
APPENDIX B – Hypothesis for Local Extirpation.....	15
APPENDIX C – Population Characteristics of Potential Donor Stocks.....	16
APPENDIX D – Overview of Reintroduction Strategies: Artificial Propagation, Captive Rearing, and Transplantation.....	16
EDITORIAL COMMENTS.....	16
REFERENCES.....	17

This page left blank intentionally

INTRODUCTION

The Independent Multidisciplinary Science Team (IMST) reviewed the US Forest Service's document titled *Draft Clackamas River Bull Trout Reintroduction Feasibility Assessment* (hereafter the Assessment) at the request of the Oregon Department of Fish and Wildlife (ODFW, letter from Chris Wheaton dated September 18, 2006). The Assessment was prepared for the Clackamas River Bull Trout Working Group (CRBTWG) by seven authors representing multiple state and federal agencies including the US Forest Service (USFS), US Fish and Wildlife Service (USFWS), and ODFW. In particular, ODFW asked that the IMST evaluate the document with respect to the following questions:

- Is the Assessment credible?
- Are the tools employed appropriate for addressing the questions posed in the Assessment?
- Are there tools more appropriate for addressing the questions posed in the Assessment?
- With respect to the feasibility of a bull trout reintroduction in the Clackamas River, are there other issues that should be addressed in the Assessment?

The IMST will address the four questions from ODFW within the framework of this review.

The general objective of the Assessment was to determine if reintroducing bull trout into the upper Clackamas River would have a high probability of success. The CRBTWG concluded that "a reintroduction of bull trout into the upper Clackamas River is feasible" (page 110 of the Assessment). The IMST does not offer an opinion of the feasibility of reintroduction, but does believe that the framework of scientific questions (page 3 of the Assessment), used by the authors to make this determination is scientifically credible. How completely these questions are answered and the conclusions drawn about the feasibility of a bull trout reintroduction depends on 1) the quality of the data used to address the questions, 2) the appropriateness, accuracy, precision and validity of assumptions of the models used, and 3) the interpretation of available data analyses and modeling results. The following comments are focused primarily on these issues.

The IMST applauds the scholarly approach evidenced in this document aimed at assessing the feasibility of successfully reintroducing bull trout to the Clackamas basin. In particular, IMST appreciated the consideration of possible negative effects of such a reintroduction to other species in the basin and to potential donor stocks. The tiered approach to catchment selection is logical, as are the ecological considerations in that process. Although the CRBTWG believes that the Assessment presents a scientifically credible case for reintroducing bull trout in the Clackamas River basin, the IMST believes that the evidence supporting that conclusion could be strengthened substantially if several points received either additional justification or clarification. These points are discussed below.

GENERAL COMMENTS

Throughout, IMST advises CRBTWG to examine original documents to reduce the possibility of error (e.g., see the Murtagh et al. 1992 citation on p. 7 of the Assessment). In its own literature reviews, IMST has frequently found that secondary summations and interpretations of original

works are biased and inaccurate. Also see Kaczynski and Alvarado (2006) for examples of how citation errors are transmitted through time. Secondly, information pulled from a reference should be double checked for errors or misinterpretations. For example, on page 46 of the Assessment, the authors have miss cited Tague and Grant (2004) on the relative ages of the High Cascades and Western Cascades.

Given that the USFWS bull trout recovery plan (USFWS 2002) remains a draft after four years, it would be helpful to provide assurance that a reintroduction plan could be approved in fewer than the four years it has taken for approval of the recovery plan. It would also be helpful to indicate how the lack of a final USFWS recovery plan may affect the conclusions reached in the Assessment and in subsequent actions by the CRBTWG.

It may help many readers if the CRBTWG were to briefly explain why effective population size (N_e) recovery goals differ for coho salmon versus bull trout. In other words, explain why aspects of bull trout life history, habitats, and biology support a smaller N_e than that required for coho salmon, a species that has received considerably more scientific evaluation and public discussion than has bull trout and with which those readers may be more familiar.

CHAPTER 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin.

PRIORITIZATION AND RISK ASSESSMENT: The Assessment does not address if, why, or how the Clackamas River basin was prioritized for bull trout reintroduction in Oregon. Given the declining state of other bull trout populations in the Willamette River drainage, potential risks to donor populations, and the limited numbers of adults, juveniles and/or eggs available for reintroduction, it seems necessary to demonstrate that reintroduction to the Clackamas River basin is both feasible and is preferable to reintroduction and/or stock rebuilding in other parts of the Willamette River drainage. For example, why should reintroduction into the Clackamas system be preferred to increased introduction efforts on the Middle Fork Willamette River or efforts to stabilize the declining McKenzie River population?

An explanation of how the Clackamas River system compares to other areas where bull trout have been extirpated or reintroduced and whether it is the only (or one of several) area(s) under consideration for bull trout reintroduction would create a useful context that will help readers understand how this action fits within the larger recovery plan for bull trout in Oregon. Also, what will the reintroduction of bull trout in the upper Clackamas basin contribute to the persistence of bull trout in the larger Willamette basin (other than spreading risks associated with catastrophic events)? If this information exists in the federal bull trout draft recovery plan (USFWS 2002), it would be helpful if it were summarized in Chapter 1 of the Assessment, if it does not, it would be wise to address these questions so that the Assessment can stand alone.

CHAPTER 2 – Habitat.

DEFINITIONS: Although the authors may be clear about what constitutes a patch, a population, a population patch, a sustainable population, a river segment, a catchment/watershed/basin, or a subcatchment/subwatershed/subbasin, the meanings these terms are intended to impart is not sufficiently clear in the Assessment. Also in the habitat chapter, one comes across “critical habitat”, “core habitat”, “core area”, and “patch” or “patch habitat”. Perhaps the Glossary in the

federal draft recovery plan (USFWS 2002) could be augmented and used in the Assessment to quantitatively define and describe these terms to aid the reader, provide consistent usage, and reduce contradictions. For example, what exactly is meant by the phrase ‘self-sustaining local population’ versus a sustainable population? Is this a minimum number of individuals or a minimum area, or both? How many bull trout adults per square kilometer constitute a self-sustaining population? What are minimum and maximum river segment lengths, patch sizes, or population areas for sustainable bull trout populations? How are self-sustaining populations related to the 7th field hydrologic unit code (HUC)? The geographic divisions appear to be based on hydrologic units, not true catchments or drainages. Such artificial units are unlikely to be perceived by bull trout, and may be misleading to aquatic ecologists. What constitutes suitable habitat (or critical habitat, core habitat, core area, patch size, or patch habitat) quality and quantity, and over what catchment area and stream size (volume, length, area) is it evaluated?

DELINEATION OF SUITABLE HABITAT PATCHES: It would be very helpful to explain the rationale for assuming that bull trout perceive patch boundaries along the same variables used to delineate them in the Assessment. Depending on how one defines a patch, there may be only three patches (one small (Rhododendron) and two large (Big Bottom/Pinhead, Upper Clackamas/Cub/Hunter) patches), which are hydrologically linked just as tightly as the proposed six patches. Is there any evidence that the proposed patches would produce 6 distinct populations vs. 1–3 populations (e.g., Whiteley et al. 2006)? In other words, are the patches sufficiently interconnected to facilitate panmixia¹ or indistinct populations, versus distinct populations? If Rieman and McIntyre (1993) are correct and fewer than five local populations are at increased risk of extirpation, it may be important whether one defines the Clackamas recovery unit as having one, three, or six populations.

The transparency of how habitat patches were delineated would be significantly increased if the criteria used to delineate patch boundaries were explicitly stated and explained. The authors identify six suitable habitat patches distributed within the upper Clackamas River basin. These patches differ dramatically in size and are superimposed on a highly interconnected river network. Are the patches identified in the Assessment evaluated by some comparison with habitat patches in other basins known to support stable bull trout populations? In the absence of explicit criteria used to delineate these patches it is difficult to understand why they vary so dramatically in size. Patch 3 is six times larger than patches 4 and 5. If these smallest patches are capable of supporting a ‘self-sustaining local population’ it would be helpful to explain why so much area is required to support a population in patch 3. Also, patches 1 and 2 and patches 3, 4 and 5 appear to be fully connected by suitable habitat (i.e., not separated by warmer stream reaches). It would aid the reader if the criteria used to determine the boundaries among these patches were explained. This section contains considerable descriptive information on fish habitat in the six delineated patches (pgs. 57–63 of the Assessment). Perhaps this information can be used to better describe how the patches differ and to justify boundary placements.

The justification for the CRBTWG determination that there is sufficient habitat available in the Clackamas River basin to warrant a bull trout reintroduction would be better supported if the authors provided additional discussion addressing: 1) the probability that all six patches can be

¹ All individuals within a geographic area have equal access to one another for the purposes of mating.

recolonized, 2) why an intermediate extinction risk is acceptable, and 3) what constitutes, in a probability range, an intermediate extinction risk.

BULL TROUT DISPERSAL AND MIGRATION: The amount of movement (if any) by bull trout between the upper Clackamas and the lower Clackamas, Willamette, and Columbia that is expected by the CRBTWG is unclear. The IMST recommends that the CRBTWG determine whether ladders designed for upstream passage of adult salmon are effective for upstream passage of smaller, weaker-swimming bull trout. IMST suspects that flow velocities in the ladders may be too high for bull trout. Also adult bull trout tend to move downriver during high fall flows. It would be useful to provide quantitative estimates of the effectiveness of migration of adult steelhead through the ladders and reservoirs as a possible model for bull trout.

SUFFICIENCY OF PRESENT AND FUTURE BULL TROUT HABITAT: IMST questions whether sufficient high quality habitat is available in the upper Clackamas now and will be in the future. It would be very useful for the authors to indicate precisely what constitutes a sufficient amount of high quality habitat for a successful reintroduction. This would include data and information on whether or not winter water temperatures are low enough in all the catchments to allow successful reproduction and juvenile rearing.

Given the importance of an accessible large lentic water body to apparently sustainable bull trout populations in the Metolius and Lewis River systems, it would be helpful to estimate the likelihood of similar success in the upper Clackamas, which lacks such access. Inadequate lake or large river access and egress may be a limiting factor to a sustainable Clackamas bull trout population. The two identified donor stocks are associated with large reservoirs containing kokanee and rainbow trout that may serve as bull trout prey. The North Fork reservoir within the Clackamas River basin is smaller, lacks kokanee, and probably differs significantly in water residence time, stratification, nutrient regime, and primary and secondary productivity. It seems important to explain how these prey and limnological differences might affect potential reintroduction success. Given the requirement of bull trout for lakes or very large complex pools (e.g., Rieman and McIntyre 1993) and the frequent translocation failure of cutthroat trout due to insufficient habitat space (Harig and Fausch 2002), this issue would benefit from further explanation in the Assessment.

Given that upper Clackamas road densities exceed those associated with bull trout decline and extirpation elsewhere, the scientific credibility of the Assessment would increase if the authors provided scientific support for the likelihood of successful reintroduction in the upper Clackamas in the context of current road density. A brief discussion of stream crossings by roads is needed, especially the potential for barriers to upstream and downstream migrations by adult and juvenile bull trout. For example, Heller and Sanchez (2005) found that 90% of culverts in Oregon and Washington national forests impaired fish passage. It would aid this Assessment if scientific documentation were provided for why this is not a limiting factor in the upper Clackamas or the Mt. Hood National Forest.

The Assessment would profit from a discussion on the degree to which current habitat and catchment conditions differ from those occurring when bull trout were extirpated from the Clackamas, and how they compare with those in other basins where bull trout populations are

healthy and increasing. It would be especially useful to document and compare habitat, landscape, and riverscape conditions in basins with increasing populations against those in the Clackamas.

It would be valuable to provide more information about why bull trout populations in other basins are decreasing and to indicate the degree to which these problems have been addressed in the Clackamas. The authors' argument that negative effects stemming from forest management have been ameliorated is not convincing. The Assessment would benefit from an evaluation of possible forest wildfire and forest disease risks that may alter water quality in the upper Clackamas. New and more conservative riparian protection regulations will improve forest conditions *in the future* but do not address landscape alterations that still exist and may hinder the near-term success of a bull trout reintroduction. Riparian and upland forests in the upper Clackamas have been significantly altered by past forest practices. The current condition of the basin and the percentage managed as 'matrix' and subject to future road construction and timber harvest are well documented in Tables 2.3 and 2.4 of the Assessment. Quigley and Arbeldibe (1997) reported that bull trout are less likely to spawn and rear in streams where road densities exceed 1.1 km/ km². Yet the lowest densities in the upper Clackamas are in this range. This conflicts with the Assessment statement that there is sufficient high quality habitat in the upper Clackamas. Road densities in the basin are higher than, and range up to double, those observed to limit the distribution of bull trout elsewhere. This contradiction could be clarified if the Assessment provided scientific evidence that, in the absence of fisheries management practices that facilitated bull trout eradication, continued timber harvest and road construction would not have produced the same result. In addition, inclusion of scientific evidence supporting the contention that future timber harvest, road building, and stream crossing activities on 'matrix' land in the basin will not inhibit successful bull trout reintroduction would strengthen the Assessment.

The federal draft recovery plan states that "to protect and recover bull trout, lands with the most influence on streams must be managed primarily for bull trout and the riparian-dependent resources that bull trout depend upon." (page 111, USFWS 2002) It would be useful if the Assessment presented evidence that this is feasible in the upper Clackamas.

CLIMATE CHANGE: IMST sees a need for the Assessment to explicitly address how predicted changes in temperature and precipitation regimes during the period 2010 to 2040 (e.g., increased rain-on-snow events, lower snow packs in the Cascades, changes in high and low stream flows) might influence the likelihood of a successful bull trout reintroduction. A comprehensive analysis would also address how these factors might influence the status of potential donor populations. Specifically, it would be wise to evaluate the effect of a potential 1–2° C (33.8–35.6° F) increase in temperature due to global warming on the long-term success of a bull trout reintroduction. Preston (2006), modeling the loss of cold water fish habitat, predicted median impacts associated with different temperature distributions suggested habitat loss in years 2025, 2050, and 2100 of approximately 10, 20, and 30%, respectively, for the US and 20, 35, and 50%, respectively, in the Rocky Mountains. Because bull trout require very cold water for spawning and rearing and much of the Clackamas River system has water temperatures that approach or exceed summer temperature tolerances, climate change could be a major factor in the success or failure of bull trout reintroduction.

The Climate Impacts Group at the University of Washington has produced warming and precipitation predictions for the Pacific Northwest based on the latest available climate models. These can be found at <http://ces.washington.edu/cig/fpt/ccscenarios.shtml>. Table 1, below, summarizes these forecasts. Evaluation of how projected annual and seasonal precipitation and temperature changes, increased rain-on-snow events, and lower snow packs in the Cascades may affect critical temperatures and high and low flows for Clackamas bull trout is needed. Another useful analysis would be to forecast what the upper Clackamas landscape and the lower Clackamas riverscape will likely look like in 10, 50 and 100 years, and to assess how those conditions might affect sustainable bull trout populations (e.g. Van Sickle et al. 2004).

Table 1. Likely temperature and precipitation changes: PNW 2020 and 2040 (data from Climate Impacts Group 2007).

	Temperature change			Precipitation change		
	Annual	Oct-Mar	Apr-Sept	Annual	Oct-Mar	Apr-Sept
2020s	°F (°C)			%		
Low	+ 0.7 (0.4)	+ 0.4 (0.2)	+ 0.8 (0.5)	- 4	- 3	- 12
Average	+ 1.9 (1.1)	+ 1.7 (0.9)	+ 2.1 (1.2)	+ 2	+ 4	- 2
High	+ 3.2 (1.8)	+ 2.6 (1.5)	+ 3.8 (2.1)	+ 7	+ 12	+ 5
2040s						
Low	+ 1.4 (0.8)	+ 1.1 (0.6)	+ 1.4 (0.8)	- 4	- 1	- 14
Average	+ 2.9 (1.6)	+ 2.5 (1.4)	+ 3.3 (1.8)	+ 2	+ 5	- 4
High	+ 4.6 (2.6)	+ 4.1 (2.3)	+ 5.4 (3.0)	+ 9	+ 17	+ 6

CHAPTER 3 – Conservation Genetic Considerations and Donor Stock Suitability.

VORTEX MODELING: The value and usefulness of the VORTEX simulation model would be significantly increased by showing and describing the VORTEX model, discussing how it was validated, and listing its assumptions. Also, an explicit description of the direction and magnitude with which these assumptions might bias the results (perhaps in a summary table) would be useful. For example, the strict order of life history events used by VORTEX (p. 80 of the Assessment) represents one such assumption that is identified but not completely addressed in the document. How does the assumption that introduced individuals are advanced to the next age class without any mortality bias the modeled probability of population persistence? Other assumptions inherent but not explicitly stated or discussed in this chapter include (but are not limited to) the absence of mortality associated with removal and translocation of propagules, absence of female mortality with the removal of eggs, the biological relevance of demographic schedules A and B as they apply to real bull trout populations, and the assumption that all propagules have unique genotypes. The substantial loss of heterozygosity and allelic diversity from donor populations when eggs are removed (compared to adults or juveniles; Figure 3.5, p. 86 in the Assessment) is not intuitive but would probably be more transparent if the assumptions underlying these models were more explicitly described.

In addition, further elaboration of the genetic considerations would be helpful given that the genetic variation between bull trout stocks appears to be quite site-specific and not driven by drift and gene flow as commonly assumed (Whiteley et al. 2006). These insights would also relate to determining adequate patch size for sustainable populations, the adequate Ne needed for the reintroduced populations, and probable effects on donor stocks.

The VORTEX modeling exercise is useful in that it allows the exploration of the range of donor population risk and reintroduction success under a restrictive set of assumptions and

demographic schedules applied to the modeled population. However, the IMST believes that extreme caution should be exercised when using the results of these simulations to set absolute thresholds for propagule requirements or donor population size. Population viability analysis is more appropriately used to provide relative outcomes, not to predict absolute results (i.e., a minimum threshold for donor population size).

Using demographic schedule A on page 80 in the Assessment, 2500 eggs results in 1.1 adults in age class 4+. Over 5 years of stocking, this would result in 5.5 adults. Using schedule B, 2500 eggs results in 3.9 adults in age class 4+, and 19.5 adults in 5 years. This implies low probability of introduction success when using 2500 eggs, the need to use more donor eggs, the necessity of using another life stage, or to somehow increase survival rate. In any event it weakens the case for reintroduction and indicates a need to better estimate stocking needs and strategies. Although large numbers of eggs could provide the most alleles, with 99% mortality it will require a very large number, which is one reason few fishery agencies currently stock eggs in streams. It would be wise for the CRBTWG to determine if 5 years of stocking are enough, and whether the introduced bull trout populations can survive on their own without improbable immigrations from another population. Similarly, it is advisable that the CRBTWG determine whether stocking must be continuous, creating a dependent bull trout population. Also, it would be helpful to briefly explain why it was assumed that 2,500 eggs were added (and presumably that all survived to age 1). Would not 25–100 surviving eggs be more likely? Likewise, it might clarify the issue to briefly explain why it was assumed that 25 introduced adults would all survive and reproduce in year one, versus, for example, half that many.

Given the stream lengths, widths, gradients, and habitat complexities of the 6 patches, it would be useful for CRBTWG to estimate the potential carrying capacities for bull trout in each of the 6 patches. This could help evaluate the survival potential of this metapopulation if the transplants are successful. Also, it might improve estimates of the stocking sizes and propagule types needed. Using the Assessment's genetic risk information, are 50 or 100 adults in each of 6 patches a reasonable and sufficient target? If habitat is limiting for some unknown reason, the number of fish stocked to create a desired N_e might create an unrealistic drain on donor populations. On the other hand, if half the propagules die because of unaddressed compensatory or density independent limiting factors, the CRBTWG might wish to stock twice as many. This also could have a serious negative effect on the donor populations without increasing the N_e in the Clackamas, or it could create the need for the reintroduction attempt to be abandoned midway.

BULL TROUT DONOR STOCKS: Like the CRBTWG, the IMST is concerned about donor stocks. The Lewis River stock may be more suitable than the Metolius stocks because no individual Metolius stream appears to have >500 bull trout. Also the Metolius stocks are unlikely to have been exposed to whirling disease or Type 2 strain infectious hematopoietic necrosis (IHN) and will be vulnerable when introduced to the Clackamas where the pathogens for these diseases exist. The Lewis River system has a large bull trout population that has not been bottlenecked and possibly has had exposure to these two pathogens. On the other hand, it would seem wise to evaluate the likelihood of introducing diseases and parasites from the Metolius or Lewis to the Clackamas. In general, it is best that disease and parasite issues such as these be carefully examined before implementing any introductions.

It would be helpful for the CRBTWG to evaluate the degree to which Metolius bull trout that are locally adapted to east side conditions will do well on the west side. The Assessment does not resolve whether the Metolius patches are interconnected in such a way as to allow substantial genetic mixing (p. 91). A detailed map showing the Metolius catchments would be helpful, as would discussion of genetic analyses on the putative populations (with citations). It would also be helpful if the number of donors required to establish a viable population were reexamined and clearly supported in a scientifically rigorous manner. Lastly, we caution the CRBTWG to confirm and quantify the bull trout metapopulation dynamics of the Metolius River basin before removing bull trout from these populations.

CHAPTER 4 – Ecological Interactions and Food Web Considerations.

BROOK TROUT INTERACTIONS: The assessment too easily dismisses brook trout predation, competition, hybridization, and potential dispersal to other catchments. Oregon bull trout have been outcompeted by other salmonids in warmer water temperatures (Ratliff 1992; Dambacher et al. 1992). An explanation of why or why not the same might have occurred in the past and its likelihood of reoccurring in the upper Clackamas would be useful. One conservative approach would be to eliminate patch 3 or cut it in half and not stock bull trout where brook trout are apparently self sustaining. Another option might be a brook trout eradication program. IMST suggests that the CRBTWG evaluate brook trout introgression in the potential bull trout donor stocks. Is there any evidence of recent range extension or population increases by brook trout in the upper Clackamas? If such evidence does not exist, has it been evaluated? Providing explicit scientific reasons why brook trout in the upper Clackamas will not threaten bull trout through competition, predation, and hybridization as it has elsewhere would help convince readers that brook trout would not affect success of the plan in the Clackamas system. In comparing successful and failed greenback cutthroat trout reintroductions, Harig et al. (2000) determined that 48% were reinvaded by nonnative salmonids and 43% had unsuitable habitat.

BULL TROUT TRANSFERS: More concern seems warranted about the effect of introducing bull trout on top of existing salmon populations. Specifically, IMST suggests that CRBTWG evaluate the potential maximum loss of anadromous salmonids to predation and competition by bull trout. Similarly, IMST advises the CRBTWG to consider how it will educate stakeholders who might view bull trout as a scapegoat for declining salmon populations. The CRBTWG would be wise to explain how it plans to approach federal Endangered Species Act concerns and permitting issues related to the reintroduction of one threatened species regulated by the USFWS on top of another that may serve as prey and that is regulated by the NMFS.

BULL TROUT PREY: The assumption that the native fish assemblage in the Clackamas River is healthy, diverse and abundant is testable and it would make sense to test that assumption. At the very least it is advisable to monitor it before and after reintroduction should it occur. In addition, the CRBTWG appears to assume that there are ample prey fish, particularly non-salmonids, to support adult bull trout in the upper Clackamas. However there are insufficient data presented to support this assumption. It would be useful for the CRBTWG to provide scientific survey evidence that the Clackamas and upper Clackamas fish assemblages are healthy. That would

include how the CRBTWG defines a healthy versus an unhealthy fish assemblage. An additional valuable piece of information is to determine the size and composition of a fish forage base required for adult and sub-adult bull trout in a healthy bull trout population. An adequate prey base to support bull trout maturation and successful reproduction is best evaluated rather than assumed. If the lower Clackamas and Willamette are expected to provide prey for adult bull trout, an evaluation of their ability to freely pass the mainstem dam complexes is called for. Also, IMST advises an evaluation of the degree to which the high levels of toxic chemicals in the lower Willamette River might reduce the fitness of bull trout that feed there.

GENERAL CONCLUSIONS: In conclusion, the IMST believes the Assessment is a serious, well considered review of the feasibility of reintroducing bull trout into the Clackamas basin that addresses the pros and cons associated with such an activity. In our review, we have stressed areas where we believe it would be wise to increase the Assessment's scientific credibility. However, our review should not be taken to imply that the IMST does, or does not, endorse bull trout reintroduction into this system; IMST does not express an opinion on this point, nor was it asked to. If the precautionary principle is followed and no or minimal harm to local species or donor stocks are probable, then a reintroduction may make sense. In any case, it would be wise to view a reintroduction as a scientific experiment that would include adequate pre- and post-introduction effectiveness monitoring of both target and non-target species and their immediate and landscape-scale environments.

IMST strongly endorses the intention articulated in the Assessment to use an adaptive management approach if a reintroduction is attempted. There are three scenarios that warrant consideration for adaptive management if a reintroduction plan is developed. 1) The reintroduction is successful with no harm to donor or resident fish assemblages. What near-field and far-field factors insured or aided that success and how can they be continued? 2) The reintroduction failed and the donor stock was harmed. What are the possible adaptive management scenarios to avoid its extirpation? 3) The bull trout reintroduction was successful but negatively affected the native fish assemblage. What is the adaptive management recourse? Another consideration for a reintroduction plan is a thorough review of the trout reintroduction literature (e.g. Harig et al. 2000; Harig and Fausch 2002) which documents variables associated with successes and failures.

SPECIFIC COMMENTS

The IMST believes that the overall clarity and scientific credibility of the Assessment could be improved if more details or explanations were provided on the following topics:

EXECUTIVE SUMMARY

Bullet three might read: "Is suitable habitat reasonably expected to be recolonized through natural processes if conditions are improved?"

Question in quotes at bottom of page might be expanded to include "successfully and without harm to current resident fish and donor stocks".

Is fishing pressure included in socio-economic impacts? Explain why or why not changes in fishing regulations must be considered prior to bull trout reintroduction.

p. 1. Specify here how many bull trout adults and how many per square kilometer constitute a self-sustaining population.

p. 2. Multiple reintroduction strategies are worthy, versus “may be” worthy of consideration.

p. 3 & 110. The fact that no data were found indicating that bull trout predation limited anadromous salmonids does not indicate whether it does or not, or even if it was studied. Such statements raise the specter of type-2 error.

CHAPTER 1 – History, Status, and Draft Recovery Plan Guidance for Bull Trout in the Clackamas River Subbasin.

p.1. The CRBTWG states that the Assessment is focused “very specifically” on the feasibility of reintroduction, yet the document is more than that. There are four main questions addressed in the document as listed on p. 3 and two relate to reintroduction.

p. 3. Specify the percents of BLM, USFS, and private lands in the upper basin, and indicate their locations.

p. 9, half way down. If possible, provide a citation for the statement beginning “ This assumption is consistent with....”

The CRBTWG confirmed the historical presence of bull trout in entire river segments if ‘*enough*’ confirmed sightings were documented within close proximity. How many confirmed sightings constitute ‘*enough*’ to determine historical presence throughout a river segment and what length of river constitutes a segment to which this index was applied?

p.10. Indicate the causes of warmer water temperatures since 1850, as well as steps being taken to reverse the trend.

Clarify the apparent contradiction in bull trout distribution described here with that on page 3.

pp.12-17. With one cottid exception, all the fish survey results reported indicate that only cutthroat and rainbow trout and coho and Chinook salmon are likely present in the upper basin. Yet elsewhere it is implied that healthy populations of cyprinids and catostomids are present and potential bull trout prey. Clarify this contradiction.

p.14. It is best to confirm presence above barriers as well as below barriers via surveys.

p. 15. The IMST applauds the CRBTWG for recognizing that surveys conducted before 2004 lacked the statistical rigor required to confirm the absence of bull trout and for conducting additional surveys in 2004. The conclusion reached from the analysis of this survey effort would be better supported if the implications of survey methods and assumptions for bull trout detection were discussed. Specifically, the authors state that streams ‘*too large*’ to snorkel safely at night were not sampled. Briefly indicate what constitutes ‘*too large*’ and estimate the likelihood that these larger stream harbor undetected bull trout that would be detected in the smaller, sampled streams.

p. 17. Estimate or at least discuss the detection efficiencies for bull trout in deep pools and large streams, and for electrofishing versus snorkeling and how these efficiencies influence the habitat analysis.

p. 20. Provide information about the extent of forest disease or unhealthy forests, and the likelihood of catastrophic wildfire in the upper Clackamas.

p. 25. Clarify whether adult bull trout abundance criteria are met with 900 individuals in the entire Willamette River Unit. This could mean very few individuals in each of the basins (upper Willamette, McKenzie, Santiam, Clackamas), which are fundamentally fragmented by mainstem dams.

CHAPTER 2 – Habitat.

p. 25, first sentence. Briefly explain why 3 patches will meet the distribution criteria. Also, justify the 900-1,500 abundance criterion.

p. 28. Given the 5-9 degrees Celsius required for bull trout spawning and juvenile preference, explain why 15 degrees was set as a temperature criterion for suitable habitat. Also indicate the suitability of winter habitat requirements.

p. 27. Add a bullet: ‘What is the likelihood that the habitat will persist and improve?’

p. 29. There are an infinite number of watersheds and patches in a basin. Use quantitative areas versus “watershed scale” and “patches”. The same goes for basin and subbasin.

p. 30, first line. Bull trout are actually distributed over a small proportion of the conterminous USA. Perhaps modify to Pacific Northwest, USA.

There is usually an inverse correlation between slope and roads, and a positive one between roads and temperature. The site-scale stressors (e.g., sediment, temperature, prey, pool volume, wood) should be evaluated as well as the landscape-scale disturbances.

Briefly describe the floodplain and riparian functions and how roads decrease them.

p. 31. In the sentence, “Survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999).” clarify that this statement is comparing springs to hyporheic flows.

A patch is defined here and on p. 42 differently, but neither definition is sufficient.

p. 32. The Assessment focus on spawning and rearing habitat includes insufficient analysis of cover, volume, and prey for several hundred bull trout to mature and achieve sufficient size to produce high numbers of eggs.

Specify that the 15° C criterion is for summer water temperatures. What are fall and winter water temperatures in the proposed catchments? What was the study design for temperature recorders (number, placement)? (also p. 38).

p. 36, figure 2.3. Indicate whether the line presented is the best fit for the data or simple linear regression. Briefly explain why pooling the data across basins is appropriate. Units should be shown on axes for clarity. Provide the R value to indicate the significance of this regression.

Since the X-axis is a log, a slight difference in slope can result in a large change in the predicted Y value. Also, the figure title is missing an f from (summer low-flow width).

Solving the regression equation for a stream width of 10 feet yields a catchment area of 2199 (and a log of 3.34), not 1742 acres. The log of 1742 is 3.24, which multiplied by 29.8 is 96.58, if 89.6 is then subtracted, that yields 6.98 feet for stream width—not 10 feet. Because exclusion of streams and stream segments from consideration as suitable habitat was based on the assumption, of 1742 acres, it is critical to resolve the discrepancy between the text and Fig. 3 with respect to stream width vs. watershed size. IMST recommends that the CRBTWG evaluate exclusions based on a critical watershed size of 2199 acres if streams <10 feet wide are limiting.

p. 38. Are there no cold water refugia? Explain the methods behind temperature data collection and how these might bias delineation of habitat.

p. 42. It seems preferable to list patches as water bodies vs. catchments. Fish occupy water bodies, and patches are defined as stream segments.

p. 43. Although the captions use >1700 acres for an apparently incorrect catchment size of 1742 acres, this process should be corrected based on a critical watershed size of 2199 acres.

p. 45-46. The patches appear arbitrary and based on HUC mapping conventions, versus ecology, biology, or hydrology.

p. 46. Tague and Grant (2004) are miss cited; their paper indicates that the High Cascades are geologically younger not older than the Western Cascades. Also check the other attributes listed for both. Also see p. 127 of the Assessment for accuracy and needs a reference to Tague and Grant (2004). The citation for Tague and Grant (2004) is also incomplete in the reference section.

If possible, the Assessment should elaborate on the legacy effects of the 1996 storm event relative to these differing geological types.

p. 47. Some numbers are incorrect. For example, Upper Clack Austin acreage should probably be 7488, not 748.8. Acreage numbers and square miles are not always consistent; i.e. Olallie Creek. Check all entries and column sums. Right, or decimal, justifications of numbers makes tables easier to read. Some column headings are redundant; i.e., acres/acres, Sq. miles/mi²

p.48. Although it is stated here that Patches 3 and 4 are the most geologically stable, Table 2.2 indicates that patches 3 (92%) and 5 (86%) have the highest % of low landslide potential, rather than patches 3 and 4 (81%).

p. 49. Although parent geology is related to flow regime, this figure depicts geology not flow regime. If it does depict flow regime, it would be preferable for the Assessment to indicate flow regime is in terms of flow, runoff, or base flow to bank full flow ratio.

p. 51. Only one catchment in Table 2.3 has road density <1.1km/km². This indicates widespread disturbance and potentially many migration barriers. Indicate how the lack of migration barriers was determined, in terms of study design and indicators.

Some criteria used to select suitable habitat patches may not be as discriminating as the CRBTWG would have readers believe (Table 2.3). For example, Aggregate Recovery Percentage (ARP) seems more procedural than scientifically based. Use of ARP may be required in this Assessment by the Draft FWS Recovery Plan, but it and the Equivalent Clearcut Area

(ECA) methodology produce indices, rather than actual changes in peak flows. The Assessment considers ARP an indicator of “hydrologic impairment”, but there is little explanation provided for why that is the case. Explain how it is related to changes in peak flow quantity or timing, preferably with biplots, and provide correlations between bull trout habitat suitability and these indices, road density, and stand structure.

pp. 52 & 55. The column headings are redundant, as are units in cells if provided in headings.

p. 55. The percentages of catchments classified as matrix suggest widespread disturbance in all but the upper Clackamas. In Lemiti, S.F. Lemiti, Olallie, and Patch 3, the sums are far less than 100%.

p. 57. What design and indicators were used in the habitat surveys? Define the reach scale at which data were collected. Reach is an undefined term that can vary by several orders of magnitude.

Explain how and how many individual reaches were selected for assessment in each catchment. Explain whether the unlabeled bars in figures 2.13 – 2.18 represent only the sampled reaches or all reaches in each catchment. Unless the reaches were randomly selected, they can only represent the limited number of reaches actually surveyed—not entire catchments.

p. 59. Briefly explain (in figure titles) the origin of the multiple bars for each catchment. Briefly explain in the text what each of the metrics measured means to bull trout.

p. 63. Cub and upper Clackamas have more area than Pinhead in the stable flow categories.

p. 64. The Assessment need not give miles in each box if already provided in the table title, nor must it provide redundant values above the diagonal.

p. 65. Briefly explain why each selected patch can support a self-sustaining bull trout population. Indicate whether each patch also includes over wintering habitat for large adults, or whether this must be provided in the lower Clackamas. Support these explanations with data or references.

p. 66. Add a fourth bullet beginning with “What is the appropriate . . .”

CHAPTER 3 – Conservation Genetic Considerations and Donor Stock Suitability.

p. 70. Based on the evidence herein, donor stocks from the lower Columbia River portion of the coastal evolutionary group appear appropriate and scientifically defensible.

p. 72. Briefly explain why bull trout populations are highly isolated within catchments. Define highly isolated and what it means in terms of watershed/basin structure.

Provide scientific reasons why four microsatellite loci are sufficient to determine the substructure of bull trout populations in the Pacific Northwest. That is, indicate what phenotypic characteristics those loci represent and how they relate to bull trout fitness.

p. 75. Briefly explain why 5,000 individuals are sufficient for a species as completely, and potentially permanently, fragmented as bull trout. Does this many individuals suffice for other salmonid species to be viable over evolutionary time frames? Also explain why 50 is a sufficient population size.

p. 75-79. Reducing the length of section 3.3 would increase the clarity of the overall document. This could be achieved by limiting this discussion to issues of immediate relevance to the proposed bull trout reintroduction.

p. 80. Justify the necessity of setting K at 30,000. This seems very high for small catchments.

p. 81. The two point scenarios in Table 3.1 produce straight lines. Is VORTEX a linear model, even though few populations show linear trends? Employ various propagule numbers and types to yield more realistic patterns and options.

p. 82-86. Presentation of the modeling results may be misleading for some readers. Two propagule sizes were modeled for each propagule age class. Plotting the results for the two propagule sizes and drawing a line between them indicates that the shape of the relationship between propagule size and heterozygosity, allelic diversity, or population persistence is understood, but this has not been modeled.

p. 84. Indicate which plots are from demographic schedules A versus B, and add Probability to the y-axis of the second plot.

p. 88-89. Provide the areas and discharges of these potential donor catchments, and their connectivity to over-wintering water bodies for adults. Provide means and ranges of adult abundance so that the reader has some notion of variability. Is there any evidence that the populations are independent or dependent?

It is misleading to specify that Jack Creek has 466 adults without some estimate of variability.

p. 91. Provide a large scale figure sufficiently detailed to indicate stream (population) proximity and the possibility that the populations listed in Table 3.2 are interbreeding and dependent. Provide evidence that the populations are independent or dependent.

p. 92. Indicate the current protective measures provided for persisting bull trout populations, and whether these measures are appropriate or ineffective for reintroduced populations.

CHAPTER 4 – Ecological Interactions and Food Web Considerations.

p. 96, 106 & 110. The survey results on pp. 12–17 provide no support for warmwater fish populations in the upper Clackamas. Provide survey results here indicating the fish species and their abundances and size ranges in the upper Clackamas. Two sucker species does not equate with “several” sucker species. Explain why several sucker species are expected in the upper Clackamas, if they are, i.e., indicate which suckers besides *C. macrocheilus* and *C. platyrhynchus* might exist there. List the sculpin species occupying the upper Clackamas. Explain the importance to the upper Clackamas of a diverse warm water fish assemblage in the lower Clackamas. Such an assemblage seems unlikely in the upper Clackamas at water temperatures <15° C. and mainstem dams may preclude seasonal bull trout migrations.

Use official AFS/ASIH fish names throughout (Nelson et al. 2004). *Catostomus* not *Catastomus*, pikeminnow not pike minnow, *P. oregonensis* not *P. aregonensis*, chiselmouth not chisel mouth, reidside shiner not red-sided shiners, threespine stickleback not three-spine stickleback, *L. tridentata* not *L. tridentate*, pumpkinseed not pumpkinseed sunfish, brown bullhead not brown bull head catfish.

In terms of disease, competition, prey, etc. discuss how hatcheries present in the basin may be expected to have, or not have, negative effects that might compromise the success of the reintroduction effort.

CHAPTER 5 – Summary.

p. 108. Add another bullet: Indicate whether or not there is sufficient habitat to support one or more populations of 500 adult bull trout.

p. 109. Briefly and precisely describe what constitutes a self-sustaining local population of bull trout. Provide number of adults, key habitat complexes, catchment area, and drainage volume.

p. 110. If brook trout are already established in the upper Clackamas, briefly explain why they are assumed to be an insignificant factor for bull trout, given that they are a significant factor elsewhere.

p. 111. Adaptive management and the success of past reintroductions have been discussed, but the negative impacts on donor stocks have not been thoroughly addressed. For example, see tables on bull trout population status and the apparent reduction in Anderson Creek (McKenzie) stocks associated with Middle Fork Willamette introductions (pp. 135 & 136).

The potentially limiting factors are believed to be remedied. Indicate precisely what has been remedied in the upper Clackamas as regards harvest, habitat, brook trout, and dam/road barriers.

Add a ninth factor to the first list of bullets: Quantitatively determine the fish prey base and compare it with the prey base sustaining putatively healthy bull trout populations such as those in the Metolius and Lewis systems.

Alter the third bullet in the second list: Evaluate the possibility of hybridization, competition, and predation with brook trout, as well as the extirpation of brook trout.

p. 112. For emphasis, list the reintroduction plan phases as bullets versus paragraph text. IMST supports expanding and detailing this information should a recovery plan result from this Assessment.

Add explicit mechanisms for sharing knowledge learned about proposed bull trout reintroductions in the Clackamas with scientists planning or conducting bull trout reintroductions elsewhere.

APPENDIX A – A Decline of Bull Trout in the Western United States: Causes for Decline of Bull Trout

p. 113. Retitle to: *Causes for Decline of Bull Trout in the Western United States*

p. 114. It is very important to assess upriver and downriver adult passage past dams multiple times.

p. 116. Provide the road density of the Swan River basin.

APPENDIX B – Hypothesis for Local Extirpation

p. 127. Indicate the amount and location of private forest land on the appropriate tables and figures.

APPENDIX C – Population Characteristics of Potential Donor Stocks

p. 135-136. Emphasize that propagule removal was associated with marked declines in the number of redds of the donor population.

APPENDIX D – Overview of Reintroduction Strategies: Artificial Propagation, Captive Rearing, and Transplantation.

p. 153. Emphasize that propagule removal was associated with marked declines in the number of redds of the donor population.

EDITORIAL COMMENTS

Additional editing of the text and figures would improve the readability of the document. The following are some examples rather than a complete listing.

In headings of text, tables, and figures, capitalize first word and proper names only (throughout document).

In some chapters, overly-abundant GIS-generated figures may slow readers down. For example, the information conveyed by Figures 1.1, 1.2, and 1.4 could be presented in a single figure. Also, the text in chapter 1 would be better supported if all streams/creeks and other major land features mentioned during the description of survey efforts were included in this figure (e.g., Farm and Dickey Creeks). Similarly, the usefulness of Figure 1.3 would be improved if the locations of Trail Bridge, and Cougar dams were included.

A general revision of all GIS-generated figures, aimed at reducing redundancy among figures and increasing the representation of land features mentioned in the text (following the examples provided above), would greatly increase overall clarity of the document.

Most of the figures are presented in color, yet readers may print them in black and white. Currently they do not resolve well in black and white and adjusting color choices or using a limited number of grey shades would alleviate this issue.

pp. 5, 10, 13, 20–23, 30, 33, 38, 46, 48, 51, 54, 58, 60–63, 67–68, 70, 73–77, 81, 85, 87, 139. Close blank spaces.

p.13. Italics are inconsistently applied to stream names for 1990 and 1991 surveys.

p. 24. Willamette River “Recover” should be “Recovery”

p. 36, Figure 2.3. Briefly explain the purpose of the line connecting the horizontal and vertical axes in the figure title.

p. 36. the sentence beginning with “Watersheds less than 1,742 acres in size likely to contain streams....” does not make sense because all catchments—regardless of size—are likely to contain streams less than 10 feet wide. Perhaps it should be stated reversely, i.e., catchments <1742 A are unlikely to contain a sufficient number of segments with widths exceeding 10 feet.

p. 43, Figure 2.6. Figures are labeled with >1,700 acres when the cut off described in the text was 1,742 acres.

p. 73, paragraph 3. for the sentence starting with ‘Loss of genetic variation may occur....’ IMST suggests the following revision: Loss of genetic variation may occur in small populations due to genetic drift and inbreeding. Inbreeding depression reduces population fitness.

pp. 82–86. The labels and fonts on Figures 3.3, 3.4 and 3.5 are inconsistently applied.

Throughout, ‘data’ and ‘their’ are plural subjects, so data are, data suggest, their reaches are, their lives, their age classes.

Avoid adjectives like “very” with unique.

Fewer than, not less than, when modifying a count, e.g., fewer than 100 adults.

REFERENCES

- Baxter, J.S., and McPhail, J.D. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bull trout (*Salvelinus confluentus*) from egg to alevin. *Canadian Journal of Zoology*. 77: 1233–1239.
- Climate Impacts Group. 2007. Climate Change Scenarios. Climate Impacts Group, Seattle, WA. <http://cses.washington.edu/cig/fpt/ccscenarios.shtml>, accessed January 26, 2007.
- Dambacher, J.M., Buktenica, M.W., and Larson, G.L. 1992. Distribution, abundance, and habitat utilization of bull trout and brook trout in Sun Creek, Crater Lake National Park, Oregon. Pages 30-36 in P.J. Howell and D.V. Buchanan, editors. *Proceedings of the Gearhart Mountain bull trout workshop*. American Fisheries Society, Oregon Chapter, Corvallis.
- Harig, A.L., and Fausch, K.D. 2002. Minimum habitat requirements for establishing translocated cutthroat trout populations. *Ecological Applications* 12:535-551.
- Harig, A.L., Fausch, K.D., and Young, M.K. 2000. Factors influencing success of greenback trout translocations. *North American Journal of Fisheries Management* 20:994-1004.
- Heller, D., and Sanchez, J. 2005. An assessment of fish passage at road-stream crossings on the national forests of Oregon and Washington. R6-NR-WFW-TP-02-5, U.S. Forest Service, Portland, Oregon.
- Kaczynski, V.W., and Alvarado, F. 2006. Assessment of the southern range limit of North American coho salmon: difficulties in establishing natural range boundaries. *Fisheries* 31:374-391.
- Murtagh, T., Rohrer, M, Gray, E., Olsen, T., and Massey, J. 1992. Clackamas subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland, OR.
- Nelson, J.S., Crossman, E.J., Espinosa-Perez, H., Findley, L.T., Gilbert, C.R., Lea, R.N., and Williams, J.D. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. *American Fisheries Society Special Publication* 29, Bethesda, Maryland.
- Preston, B.L. 2006. Risk-based reanalysis of the effects of climate change on U.S. cold-water

habitat. *Climatic Change* 76: 91-119

- Quigley, T.M. and Arbelbide, S.J. 1997. An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins: volume III. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 vol. Volume III, chapter 4.
- Ratliffe, D.E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. Pages 37-44 in in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. American Fisheries Society, Oregon Chapter, Corvallis.
- Rieman, B.E., and McIntyre, J.D. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT 302. U.S. Forest Service. Ogden, Utah.
- Tague, C. and Grant, G.E. 2004. A geological framework for interpreting the low-flow regimes of Cascade streams, Willamette River Basin, Oregon. *Water Resources Research*. 40: W04303. doi:10.1029/2003WR002629.
- USFWS (U.S. Fish and Wildlife Service). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon.
- Van Sickle, J., Baker, J., Herlihy, A., Bayley, P., Gregory, S., Haggerty, P., Ashkenas, L., and Li, J. 2004. Projecting the biological condition of streams under alternative scenarios of human land use. *Ecological Applications* 14:368-380.
- Whiteley, A.R., Spruell, P., Rieman, B.E., and Allendorff, F.W. 2006. Fine-scale genetic structure of bull trout at the southern limit of their distribution. *Transactions of the American Fisheries Society* 135:1238-1253.