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MANAGEMENT BRIEF

Assessing the Feasibility of Native Fish Reintroductions: A Framework Applied to Threatened Bull Trout

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Abstract

Translocations to recover native fishes have resulted in mixed success. One reason for the failure of these actions is inadequate assessments of their feasibility prior to implementation. Here, we provide a framework developed to assess the feasibility of one type of translocation—reintroduction. The framework was founded on two simple components of feasibility: the potential for recipient habitats to support a reintroduction and the potential of available donor populations to support a reintroduction. Within each component, we developed a series of key questions. The final assessment was based on a scoring system that incorporated consideration of uncertainty in available information. The result was a simple yet transparent system for assessing reintroduction feasibility that can be rapidly applied in practice. We applied this assessment framework to the potential reintroduction of threatened bull trout *Salvelinus confluentus* into the Clackamas River, Oregon. In this case, the assessment suggested that the degree of feasibility for reintroduction was high based on the potential of recipient habitats and available donor populations. The assessment did not provide a comprehensive treatment of all possible factors that would drive an actual decision to implement a reintroduction, but it did provide a fundamental level of feasibility assessment that is often lacking in practice.

Translocations are a common activity in species conservation (Griffith et al. 1989; Seddon et al. 2007). Among vertebrates, published studies of translocations for conservation are best represented by cases involving mammals and birds, whereas fishes are strongly underrepresented (Fischer and Lindenmayer 2000; Seddon et al. 2005, 2007). In a conservation context, translocations can be an important tool for use with native fishes, but the efficacy of translocations is often in question because they frequently fail to establish new populations (Minckley 1995; Sheller et al. 2006). Here, we focus on translocations in which fish from a wild source are used to establish populations in formerly occupied habitat (i.e., reintroduction).

There are readily available guidelines (Williams et al. 1988; Minckley 1995; IUCN 1998) that identify several steps in fish species reintroductions, including (1) an initial assessment of feasibility, (2) actual implementation if reintroduction is deemed

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feasible, and (3) monitoring and evaluation to determine reintroduction success or reasons for failure. Most of the existing peer-reviewed literature on fishes has retrospectively evaluated the success of reintroductions from genetic (Stockwell et al. 1996) or ecological perspectives (e.g., Harig and Fausch 2002; Sheller et al. 2006). Examples of feasibility assessments for specific reintroductions are still scarce for fish (or any species; Seddon et al. 2007), but they are obviously a critical step. The reported failure of reintroductions for many fishes could be attributed to inadequate feasibility assessments or to a lack of understanding of factors that are likely to contribute to reintroduction success (Minckley 1995).

Here, we consider the case of a reintroduction for threatened bull trout *Salvelinus confluentus* (USFWS 2002). Declines in this species are primarily attributable to habitat loss and fragmentation, but many potentially suitable, unoccupied habitats exist (Dunham and Rieman 1999). Given these unoccupied habitats and their potential role in bull trout recovery, the question of whether they are feasible for use in reintroductions has arisen (Buchanan et al. 1997; Epifanio et al. 2003; J. Ziller, Oregon Department of Fish and Wildlife, personal communication). Our specific objectives were to (1) develop a simple and transparent system for assessing the feasibility of bull trout reintroduction; (2) provide a detailed example of assessment implementation as applied to the Clackamas River, Oregon; and (3) discuss the implications of this effort in the more general context of fish reintroductions as a conservation tool.

METHODS

We began the assessment by consulting existing guidelines (Williams et al. 1988; Minckley 1995; IUCN 1998; Epifanio et al. 2003) to develop a general approach that we could apply to assessing the feasibility of a bull trout reintroduction. To begin, we identified two major components of the feasibility assessment: (1) the potential for a given recipient habitat to support a reintroduction and (2) the potential of available donor populations to support a reintroduction. Within each of these two components, we developed a list of key questions to address. For the first component (recipient habitat), the questions included the following:

1. Was the recipient habitat likely to have been historically occupied by a self-sustaining population of bull trout?
2. Are bull trout unlikely to be present now in the recipient habitat?
3. Is the recipient habitat currently suitable for supporting the spawning and early rearing of a self-sustaining population of bull trout?
4. Have past, present, and potential future threats in the recipient habitat been sufficiently mitigated?
5. Is recolonization of the recipient habitat unlikely to occur in the short-term?

To address the second component (donor population), we identified two key questions:

1. Is there at least one available donor population that is an evolutionary match to the recipient habitat?
2. Within the pool of potential donor populations, is there at least one that could provide a sufficient number of propagules without risking the health of the donor population?

For each question corresponding to a major assessment component, we identified one or more types of evidence that would address the question. Next, we developed a hierarchical series of evaluations to collectively assess the feasibility of reintroduction. Below, we describe the assessment components, detailing the questions associated with each component, the types of evidence associated with each question, and the scoring system used.

Assessment of the Recipient Habitat's Potential to Support a Reintroduction

Was the recipient habitat likely to have been historically occupied by a self-sustaining population of bull trout?—To address this question, we considered three types of evidence: (1) the presence of any bull trout life stage, (2) the presence of specific life stages, and (3) the likelihood of presence as inferred from suitable habitat (Table 1). The presence of any bull trout life stage was evaluated by considering the presence of an archived specimen in a scientific collection, written documentation by a professional biologist, verbal accounts by a professional biologist, and anecdotal accounts. The presence of specific life stages was considered in terms of (1) documented spawning by adults or the presence of small individual bull trout (<150 mm fork length), providing evidence of local reproduction; or (2) the presence of larger fish only (>150 mm), which is a less-reliable indicator of local reproduction. The presence of larger fish is less reliable because bull trout can move extensive distances through river networks (>100 km; Swanberg 1997; Baxter 2002) and can be found in a broad diversity of habitats (Muhlfeld and Marotz 2005; Monnot et al. 2008). To account for cases in which direct historical observations of bull trout were lacking, we also considered indirect evidence that a habitat could have supported bull trout, such as a habitat model to predict occurrence (Peterson and Dunham 2003) or simple comparisons of habitat conditions between the potential recipient habitat and habitats that already support extant bull trout populations.

Are bull trout unlikely to be present now in the recipient habitat?—A reintroduction effort should not proceed unless there is reasonable certainty that the species in question is not present in the recipient habitat. We applied established peer-reviewed protocols (Peterson et al. 2002; Peterson and Dunham 2003) for estimating the probability of presence for small bull trout (<150 mm). Presence was deemed unlikely if the probability of presence was 0.10 or less. Other information for inferring presence included (1) efforts that were intended specifically to detect bull trout based on other protocols (i.e., redd surveys, daytime and nighttime snorkeling surveys, and electrofishing surveys; Dunham et al. 2009), (2) sampling or collection

TABLE 1. The question of historical bull trout occupation of a recipient habitat was addressed based on three types of evidence. Scores were assigned based on the information indicated; the score determined for the Clackamas River is presented (indicated by “X”). The overall score for this question is determined as the greater of (1) the mean score of evidence for the presence of any life stage or the presence of specific life stages or (2) the maximum score for presence inferred from suitable habitat. We did not consider scores less than zero, which can be added in cases where evidence against historical occupation is available.

Question	Type of evidence	Information	Clackamas River	Score
Was the recipient habitat historically occupied?	Presence of any life stage	Confirmed record (archived specimen; professional biologist documented)	X	1
		Biologist verbal accounts		0.75
		Anecdotal record; verbal accounts by public		0.50
		No evidence		0
	Presence of specific life stages	Presence of confirmed spawning or fry		1
		Presence of juveniles (<150 mm)		1
		Presence of larger fish (>150 mm) only	X	0.5
	Presence inferred from suitable habitat	Historical habitat believed to support bull trout	X	0.75
		Limited connectivity OR no information		0

efforts that targeted other salmonids, and (3) other fish sampling efforts that could document the occurrence of bull trout (i.e., operation of rotary screw traps to sample and enumerate outmigrating juvenile salmon, upstream and downstream sampling of fish migrants at hydroelectric dams, etc.; Table 2).Is the recipient habitat currently suitable for supporting the spawning and early rearing of a self-sustaining population of bull trout?—In addressing this question, we considered types of evidence that assess both the quality and quantity of potentially suitable habitat (Table 3). Habitat quality for bull trout spawning and early rearing is primarily a function of water temperature (Dunham et al. 2003). Therefore, we grouped habitats into broad categories representing thermal suitability for spawning and early rearing. Habitats with water temperatures less than or equal to 9°C (instantaneous daily maximum) during the spawning period and less than or equal to 16°C (instantaneous daily maximum) during the summer early rearing period were classified as highly suitable. Habitats with water temperatures greater than 9°C

TABLE 2. The question of contemporary presence of bull trout in a recipient habitat was addressed based on a single type of evidence. Scores were assigned based on the information indicated; the score determined for the Clackamas River is indicated by “X”. If the score for this question is equal to zero, implementation of a formal protocol to determine probability of bull trout presence is recommended.

Question	Type of evidence	Information	Clackamas River	Score
Are bull trout unlikely to be present now?	Probability of presence	Low probability of presence estimated by a formal protocol	X	1
		Failure to detect during recent (last 10 years) sampling efforts using other protocols		0.5
		Failure to detect during recent (last 10 years) sampling for other salmonids		0.25
		No accounts of bull trout from any source of information within the last 10 years		0.1
		No information or effort in the last 10 years		0
		Documented presence (any life stage) within the last 10 years.		–1

TABLE 3. The question of the suitability of a recipient habitat for supporting bull trout was addressed based on two types of evidence. Scores were assigned based on the information indicated; the score determined for the Clackamas River is indicated by "X". The overall score for this question is the mean of the scores for each type of evidence. If a score of zero results, additional information should be collected to assess the evidence.

Question	Type of evidence	Information	Clackamas River	Score
Is the recipient habitat suitable?	Sufficient quality of habitat	Highly suitable for both egg incubation (water temperature ≤9°C) and early rearing (≤16°C)	X	1
		Moderately suitable (egg incubation: >9°C; early rearing: >16°C)		0.75
		No information		0
		Not suitable for egg incubation (≤9°C) or rearing (>16°C)		–1
	Sufficient quantity of habitat	Yes	X	1
		No information		0
		Not enough habitat		–1

during the spawning period and less than 16°C during the summer early rearing period were deemed moderately suitable. Habitats where both temperature criteria were exceeded were considered unsuitable.

The quantity of thermally suitable habitat is also widely recognized as important for persistence of local populations of bull trout (Dunham and Rieman 1999) and other closely related char species (Morita and Yamamoto 2002; Koizumi and Maekawa 2004). We considered habitat size in terms of the watershed area or total stream length with potentially suitable thermal habitat for bull trout (Isaak et al. 2010). If at least one habitat was comparable in size to those sustaining bull trout in nearby river basins (i.e., similar watershed area or length of suitable streams), habitat quantity was scored as sufficient; otherwise, habitat quantity was considered insufficient.

Have past, present, and potential future threats in the recipient habitat been sufficiently mitigated?—The assessment of threats to any species is an uncertain and difficult task. To consider threats to bull trout in the potential recipient habitat, we adapted an existing protocol (Table 4; Master et al. 2003) used by the U.S. Fish and Wildlife Service in a formal review of bull trout status (W. Fredenberg and J. Chan, U.S. Fish and Wildlife Service, personal communication). For the purposes of evaluating threats over a limited area (e.g., within a river basin), we confined our assessment to the severity and immediacy of threats and did not consider the scope of threats (described by Master et al. 2003). The protocol we used includes an assessment of population status, which in the case of a reintroduction is not relevant. Thus, we considered "expected" population status as if a bull trout population was established in the recipient habitat.

TABLE 4. The question of past, present, and future threats to bull trout was addressed based on two types of evidence. Scores were assigned based on the information indicated (see Methods for description of each category); the score determined for the Clackamas River is indicated by "X". The mean of scores from both types of evidence was used to assign an overall score to this question.

Question	Type of evidence	Information	Clackamas River	Score
Have threats in the recipient habitat been mitigated?	Severity of threats	Insignificant	X	1
		Low		0.50
		Unknown		0
		Moderate		–0.50
		High		–1
	Immediacy of threats	Insignificant		1
		Low	X	0.50
		Unknown		0
		Moderate		–0.5
		High		–1

TABLE 5. The question of the short-term colonization potential of a recipient habitat by bull trout was addressed based on four types of evidence. Scores were assigned based on the information indicated; the score determined for the Clackamas River is indicated by "X". Scores for two lines of evidence (barriers, distance) were given twice as much weight in calculating an overall mean score for this question. If distance to the nearest occupied habitat is scored as 1, the overall question receives the same score.

Question	Type of evidence	Information	Clackamas River	Score
Is recolonization of recipient habitat in the short term unlikely?	Intervening passage barriers	Complete upstream and downstream connectivity		–1
		Partial connectivity	X	–0.50
		Limited connectivity		0
		Complete two-way movement barrier		1
	Distance to nearest occupied habitat	<20 km		–1
		20–100 km		0
		>100 km	X	1
	Bull trout abundance in adjacent occupied habitat	>500 adults	X	–1
		100–500 adults		0
		<100 adults		1
	Bull trout migratory life history in adjacent core area	Strong	X	–1
		Depressed		0
		Absent		1

The severity of threats was classified as "insignificant" if one of the following conditions was satisfied: (1) there was essentially no population reduction, habitat degradation, or degradation of the ecological community due to threats; or (2) populations, habitats, or ecological communities were able to recover quickly (within 10 years) from minor temporary loss. Threat severity was considered "low" if population reduction, habitat degradation or reduction, or ecological community degradation in the affected area was likely to be reversible and if habitat or population recovery was expected within 10–50 years. Severity of threats was considered "moderate" if major population reduction, long-term habitat degradation or reduction, or long-term ecological community degradation in the affected area was likely and if 50–100 years would be required for recovery. Threat severity was considered "high" if total population loss (all individuals), habitat destruction, or ecological community destruction in the affected area was likely and if the effects were essentially irreversible or required long-term recovery exceeding a period of 100 years.

The immediacy of threats was considered "insignificant" if threats were not likely to be operational within 20 years, "low" if threats were likely to be operational within 5–20 years, "unknown" if little information was available to evaluate the immediacy of the threat effect, "moderate" if threats were likely to be operational within 2–5 years, and "high" if threat effects were currently operational or were imminent (likely to become operational within 1 year).

Is recolonization of the recipient habitat unlikely to occur in the short-term?—The ability of bull trout to move extensively raises the possibility of recolonization as an important mechanism in maintaining habitat occupancy (Rieman and McIntyre 1993). If recolonization is likely for a recipient habitat, then a reintroduction effort may not be warranted. To address the question of recolonization, we considered four types of evidence (Table 5): (1) influence of fish movement barriers, (2) distance to habitats currently occupied by bull trout, (3) abundance of bull trout in adjacent habitats, and (4) migratory life history of bull trout in adjacent habitats. Fish movement barriers were classified into four broad categories: (1) complete barriers resulting from blockage of both upstream and downstream movement; (2) limited connectivity resulting from upstream or downstream restrictions on movement (e.g., limited downstream passage via entrainment through dams) or from severely degraded migratory corridors (e.g., limited flows or degraded water quality); (3) partial connectivity as related to two-way fish passage structures, human-assisted transport of fish over barriers, or moderately degraded migratory corridors; and (4) complete upstream and downstream connectivity (no barriers present).

Distance is an important and distinct component of connectivity. We considered distance categories (<20, 20–100, and >100 km) based on past studies of bull trout movement (e.g., Swanberg 1997; Baxter 2002). We did not have information to consider how natal homing may condition the influence of distance. In addition to distance, the supply of individuals should also influence the probability of recolonization. Again, due to a lack of information, we used three subjectively determined levels of bull trout abundance (<100, 100–500, and >500 adults), representing the abundance in adjacent occupied habitats that could serve as potential sources of recolonization to the recipient habitat. The fourth possible recolonization influence we considered was the expression of migratory life history, which was based on the assumption that adjacent populations with a relatively strong representation of migratory life histories would be more likely to supply individuals that could recolonize a recipient habitat. We classified migratory life history into three subjective levels: "strong," "depressed," and "absent" (Rieman et al. 1997). Overall, our consideration of recolonization potential was subjective because of the lack of quantitative information, but we attempted to consider all of the major factors that could influence the potential for recolonization over a relatively short time frame (i.e., 20 years).

Assessment of the Potential of Available Donor Populations to Support a Reintroduction

Assessment of donor populations involved a series of evaluations that were separate from assessing a receiving habitat's suitability for a reintroduction. We focused on two major questions about donor populations (Table 6), as outlined earlier.

Is there at least one available donor population that is an evolutionary match to the recipient habitat?—To address this question, we considered information on how a formerly occupied recipient habitat may have shared a common evolutionary history or lineage with other extant bull trout populations (Haas and McPhail 1991; Taylor et al. 1999; Spruell et al. 2003). We assumed that any population within a well-defined lineage could serve as a donor unless there was compelling evidence to suggest that local environmental conditions had selected for population characteristics that were not compatible with the receiving environment.

Within the pool of potential donor populations, is there at least one that could provide a sufficient number of propagules without risking the health of the donor population?—To address this question, we evaluated information on adult spawner abundance for potential donor populations. Our primary concern was to avoid adversely affecting the viability of donor populations by removing individuals for reintroduction purposes. To maintain sufficiently large effective sizes of donor populations, we considered only those donor populations that supported more than 1,000 spawning adults/year (Rieman and Allendorf 2001). Potential donor populations with fewer than 1,000 spawning adults/year were considered to be more at risk for adverse genetic or demographic influences resulting from the removal of adults or the demographic equivalent of adults (e.g., eggs or juveniles). Our approach in considering only very large populations of bull trout as potential donor populations was a risk-averse measure, and it is possible that populations with smaller numbers of spawning adults could have been viable candidates.

System for Evaluating the Evidence

To integrate the information described above, we developed a system for evaluating evidence that addressed the questions within each of the primary assessment components and for ultimately assessing the overall feasibility of a reintroduction. To

TABLE 6. The two questions concerning the potential of available donor populations to support a bull trout reintroduction were each addressed based on one type of evidence. Scores were assigned based on the information indicated; the score determined for the Clackamas River is indicated by "X". The mean of the scores for each question was used to assign an overall score for this major component of the assessment.

Questions	Type of evidence	Information	Clackamas River	Score
Is there at least one available donor population?	Presence of bull trout in a core area within the same evolutionary lineage	Yes	X	1
		Unknown		0
		No		–1
Is there at least one donor population that could provide propagules without risking the health of the donor population?	Number of spawning adults in donor population	Donor population > 1,000 spawning adults/year	X	1
		Donor population < 1,000 spawning adults/year		–1

do this, we used a simple scoring system. Within each question, a score was assigned for each type of evidence. Scores ranged between 1 and −1, where a score of 1 represents the affirmative (yes) and a score of −1 represents the negative (no). Thus, positive scores indicated evidence in favor of a reintroduction, whereas negative scores indicated evidence against a reintroduction. A score of zero was used when available information provided no basis for an evaluation—in other words, a zero represented complete uncertainty. In several cases, we determined that a score of zero should be interpreted as indicating the need to obtain more information before proceeding further (Tables 1–6). For example, if information on the suitability of recipient habitats was lacking (score = 0), then we felt that it would not make sense to proceed with a feasibility assessment. This scoring system is identical to and compatible with other programs used to evaluate the condition of aquatic ecosystems within the Pacific Northwest region (Gallo et al. 2005).

For each question, scores assigned to each type of evidence were averaged when more than one type of evidence was considered. Scores for each question were averaged by using a system that was identical to evaluating the lines of evidence within each question. This resulted in an overall score for each major component (i.e., recipient habitat and donor population) that ranged between 1 and −1. To develop an overall score for reintroduction feasibility, scores for the two major components were averaged. An overall score near 1 would indicate strong evidence for the feasibility of a reintroduction, and conversely an overall score near −1 would indicate that a reintroduction is not considered feasible. We also averaged the absolute values of scores for each component to derive a second index of uncertainty. In this case, scores closer to zero would indicate less certainty, whereas scores closer to 1 would indicate greater certainty. We stress that these overall scores should not overshadow the importance of considering the individual components of the feasibility assessment. In some cases, a lack of information on a key component of feasibility may prove to be more important than the overall score, as emphasized above.

Application to the Clackamas River

We used the information reported by Shively et al. (2007) to apply our feasibility assessment to bull trout reintroduction in the Clackamas River. Scores for each of the questions were averaged for each major component of the assessment, and these scores were averaged to determine the overall feasibility (Figure 1).

RESULTS AND DISCUSSION

Assessment of the Clackamas River's Potential to Support a Bull Trout Reintroduction

Was the recipient habitat likely to have been historically occupied by a self-sustaining population of bull trout?—Overall, this question was given a score of 0.75, reflecting strong evidence for the historical presence of bull trout (Table 1). Although we did not have evidence for the presence of juvenile fish, which would have indicated the presence of early rearing and spawning habitats, it is likely that historical habitats within the Clackamas River supported these uses for bull trout. This type of evidence was considered to be of primary importance in determining the overall score for this question.

Are bull trout unlikely to be present now in the recipient habitat?—This question was given a score of 1 as evidence was based on information from a formal survey for bull trout that yielded a very low probability of presence (Table 2). Although the Clackamas River had been surveyed for bull trout over many years, uncertainty in the results of that work prompted a formal survey, thus increasing confidence in the likelihood that bull trout are indeed extirpated from the Clackamas River.

Is the recipient habitat currently suitable for supporting the spawning and early rearing of a self-sustaining population of bull trout?—The score for this question was 1, indicating a high degree of certainty in both the quality and quantity of habitat available in the Clackamas River for supporting a self-sustaining population of bull trout (Table 3). The upper Clackamas River contains a large quantity of cold and interconnected habitats that could support all life stages of bull trout.

Have past, present, and potential future threats in the recipient habitat been sufficiently mitigated?—Past and present threats to bull trout in the Clackamas River were addressed by fishery and land managers, but some uncertainty about future threats remained, leading to an overall score of 0.75 (Table 4). This was largely related to potential impacts of climate change on bull trout, although the realized impacts were acknowledged to be highly uncertain.

Is recolonization of the recipient habitat unlikely to occur in the short-term?—Because the Clackamas River is distant (>100 km) from the nearest potential source of bull trout for recolonization, the score for this question was 1, reflecting the lack of recolonization potential (Table 5). In this case, other lines of evidence were deemed unimportant in terms of scoring. In other words, if a habitat is highly isolated in terms of distance from recolonization sources, then the number of intervening fish passage barriers and the abundance or migratory life histories exhibited by bull trout in nearby populations are irrelevant.

Assessment of the Potential of Available Donor Populations to Support a Reintroduction

Each of the two questions associated with this assessment component was evaluated with one line of evidence (Table 6). The question of the availability of at least one donor stock within the same evolutionary lineage (i.e., an evolutionary match to the recipient habitat) was answered in the affirmative (score = 1). The question of a sufficient population size within at least one of these available donor populations was also given a score of 1, as a consistently large donor population was identified.

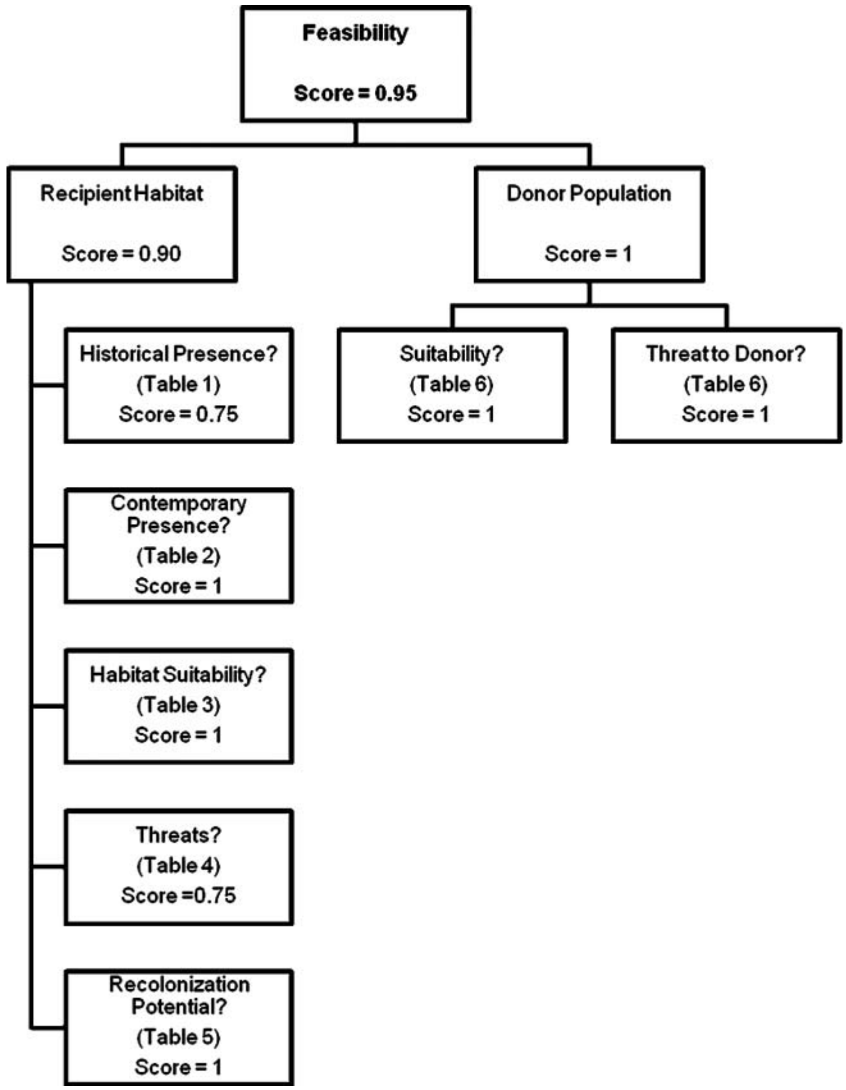

FIGURE 1. Results of the feasibility assessment, including scores for each question within the two primary assessment components (recipient habitat and donor population), scores for each component, and overall score indicating the feasibility of reintroducing bull trout into the Clackamas River, Oregon.

Overall Assessment of Reintroduction Feasibility

Scores to the five questions associated with the recipient habitat component of the feasibility assessment totaled 4.5, yielding an average score of 0.90. Both questions associated with the donor population component scored 1, leading to an average score of 1. Thus, an overall score of 0.95 was calculated for the Clackamas River, indicating a strong potential of this recipient habitat to support a bull trout reintroduction effort (Figure 1). In this case, the degree of certainty was strong (mean of the absolute values of scores = 0.95) and equal to the overall score, since we did not obtain negative scores in this example.

Other Factors Not Explicitly Considered

We have provided a simple feasibility assessment for a reintroduction, incorporating what we viewed as the most essential elements. Other biological factors that could influence a final decision on whether to implement a reintroduction include a risk assessment of the potential for disease transmission by donor populations and potential adverse impacts on other species of concern in the recipient habitat. In addition to biological factors, it is clear that many social and economic factors are important in influencing the final decision to reintroduce a species. These other factors could be explicitly developed as separate components of the assessment framework proposed here.

CONCLUSIONS

The presented framework for assessing the feasibility of native fish reintroductions represents a first step and an example that we hope will motivate more widespread implementation of available guidelines. Even though this approach appears to be superficially simplistic, the actual development and implementation of the Clackamas River assessment effort represented several years of work and coordination among multiple committed parties (Shively et al. 2007). Nonetheless, additional refinements and improvements to our system may be warranted in some cases.

Examples of possible refinements to this assessment framework include (1) methods to account for uncertainty due to a lack of consensus among experts, (2) the addition of other components or questions, and (3) the use of different weighting schemes or systems of scoring. Another level of assessment that was not explicitly incorporated here is a broader-scale evaluation of bull trout reintroduction potential for habitats across larger portions of the species' range; this step would allow for the identification of reintroduction priorities. The particular habitat we selected as an example in this study was identified as part of bull trout recovery planning efforts (USFWS 2002). Clearly, a feasibility assessment such as the one developed here is only a single consideration among the many that may influence the decision to implement a reintroduction.

In the larger view, we feel that the lack of application of available guidelines in practice is an important limitation that in many cases can be overcome with relatively simple approaches. Accordingly, application of approaches like the one we developed may prove useful in many situations. With regard to bull trout and many other fishes, the potential value of reintroductions as a tool in species recovery is not always positive, and it is important to explicitly consider and document both the costs and benefits of a potential effort. The alternative is to proceed on the past course of trial and error, which has produced limited success and even less insight into why reintroductions fail or succeed (Minckley 1995). We suggest that the careful and formal assessment of reintroductions before they are implemented will allow the value of this important species conservation tool to be more fully realized.

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