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SHORT COMMUNICATION

A case study of surrogate species in aquatic conservation planning

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ABSTRACT

1. The use of surrogate species (i.e. keystones, indicators, umbrellas) has been advocated for the conservation of target taxa and communities.
2. A recent Habitat Conservation Plan, which provided conservation measures intended to protect multiple aquatic species of concern over a large area, established an important precedent for surrogate species in aquatic conservation pursuant to the US Endangered Species Act.
3. The Habitat Conservation Plan's application of federally threatened bull trout was evaluated as an umbrella species for westslope cutthroat trout, which is in decline but not listed under the Act. Approximately 75% of known westslope cutthroat trout strongholds are not captured within bull trout strongholds west of the continental divide. The Habitat Conservation Plan failed to evaluate the suitability of this umbrella species and consequently failed to cover important priority areas for westslope cutthroat trout conservation.
4. This case study highlights the feasibility and importance of formally validating assumptions of surrogate species utility in multi-species conservation planning.

KEY WORDS: surrogate species; umbrella species; bull trout; westslope cutthroat trout

INTRODUCTION

Surrogate species (i.e. keystones, flagships, umbrellas (Simberloff, 1998)) may present either opportunities or obstacles for biological conservation. Ideally, surrogate species optimize conservation planning by increasing the number of species conserved and by decreasing logistical constraints (Simberloff, 1998). However, the assumed functional or distributional relationships between surrogate and target taxa are rarely tested (Andelman and Fagan, 2000). Given the increasing popularity of multi-species conservation plans (Noss *et al.*, 1997), it is increasingly important to articulate and test the assumptions of surrogate species utility. In this paper, a precedent-setting use of umbrella species for aquatic conservation in the USA is evaluated.

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The umbrella species concept is based on the premise that conserving one species can provide an 'umbrella' of protection for others due to shared habitat requirements and distributions (Lambeck, 1997). Unlike the keystone species concept, functional relationships among surrogate and target taxa are not implied in the umbrella species concept (Simberloff, 1998). Instead, the most basic requirement for an umbrella species is sympatry with target taxa (Fleishman *et al*., 2000).

The umbrella species concept has been most commonly applied to terrestrial taxa with large home ranges (Noss *et al*., 1996). Although umbrella species applications are much less common in aquatic than terrestrial ecosystems (Roberge and Angelstam, 2004), umbrella species provide important opportunities for aquatic conservation (Zacharias and Roff, 2001). For instance, aquatic umbrella species may help prioritize conservation areas in marine (Roff and Evans, 2002) and freshwater ecosystems (IUCN, 2003) and are implicit in freshwater integrity assessments in Europe (e.g. European Union Water Framework Directive; see Schmutz *et al*. (2000)) and the USA (e.g. Environmental Monitoring and Assessment Program; see Hughes *et al*. (2000)). As in terrestrial applications, aquatic species with large home ranges have been recognized as good umbrella species candidates (e.g. sea otter, *Enhydra lutris*; Noss *et al*., 1996).

The Endangered Species Act (ESA) provides an important mechanism for biological conservation in the USA. Habitat Conservation Plans (HCPs) implement the ESA on non-federal lands within the USA. In essence, HCPs authorize biological harm through issuance of an Incidental Take Permit to identified taxa in exchange for specified conservation agreements, usually to protect specific areas or habitat elements. Less than a dozen HCPs were implemented before 1992; from 1992 to 2000, the number of HCPs grew to over 330 (Watchman *et al*., 2001). HCPs are the primary tool used by the United States government to conserve threatened and endangered species on private lands (Watchman *et al*., 2001).

The recent development of an HCP for native fish established an important precedent for the use of surrogate species in aquatic conservation planning. This HCP was developed by the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) for 1.6 million acres (647497 ha) of Plum Creek Timber Company (PCTC) land scattered across Montana, Idaho, and Washington (USFWS and NMFS, 2000). Although the HCP authorized Incidental Take Permits for 17 species and stocks of native fish (i.e. Permit Species), the HCP was initially designed for one species, bull trout (*Salvelinus confluentus*).

This planning method created a *de facto* umbrella species application. Watersheds containing areas known to be important for bull trout spawning and rearing were classified as so-called Tier 1 areas, and the remaining areas were classified as Tier 2 (Figure 1; USFWS and NMFS, 2000). In practice, the HCP mapped Tier 1 areas based largely on core areas identified from the state of Montana's Restoration Plan for bull trout (Montana Bull Trout Restoration Team, 2000). Tier 2 areas are managed under relaxed conservation prescriptions. For example, Tier 1 areas will be subjected to less riparian forest logging than Tier 2 areas. Core areas were identified based on the known presence of relatively robust populations of bull trout, with limited incursion of invasive fish compared with neighbouring watersheds (Montana Bull Trout Restoration Team, 2000).

The umbrella species concept was a central feature in this HCP. Although the identification of Tier 1 areas was based on bull trout requirements, the application of Tier 1 conservation efforts was intended to benefit other Permit Species in the project area (USFWS and NMFS, 2000). However, the utility of the umbrella species was not evaluated in the HCP, despite the availability of data and requests for this analysis from reviewers (USFWS and NMFS, 2000: Appendix F).

STUDY TAXA

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) was included on the Incidental Take Permit under the assumption that this subspecies would be conserved within important areas for bull trout (USFWS and

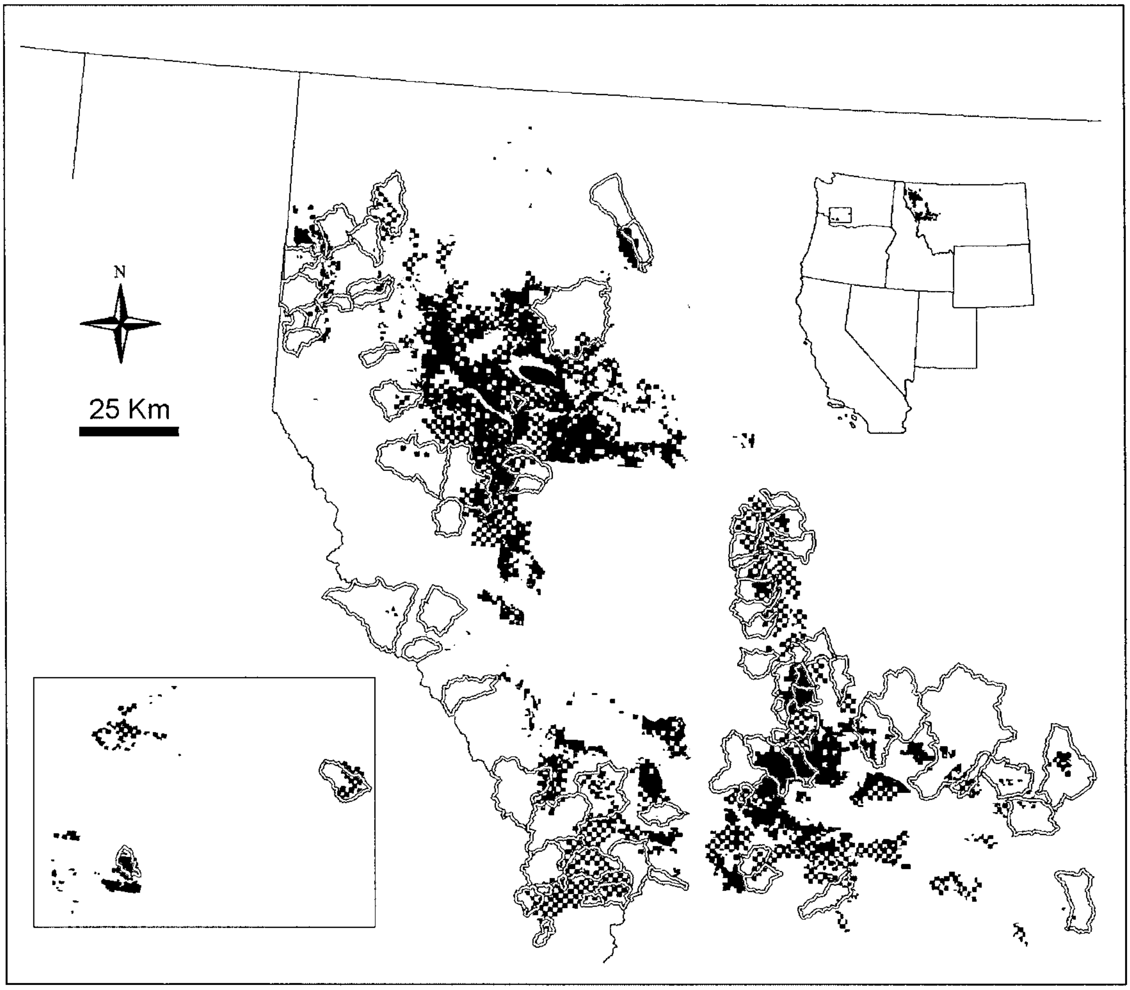

Figure 1. Management classifications for the PCTC Native Fish HCP (USFWS and NMFS, 2000). PCTC-owned lands as of December 2000 are shown as black polygons. Tier 1 areas are shown as double-outlined polygons. All PCTC-owned lands not within Tier 1 areas were classified as Tier 2 areas.

NMFS, 2000). The distribution of westslope cutthroat trout includes lentic and lotic habitats in the Columbia, Saskatchewan, and Missouri River systems in western North America. Disjunct populations also exist in a broad north–south band from Oregon to southern British Columbia (Behnke, 1992).

The distribution of bull trout broadly encompasses westslope cutthroat trout west of the continental divide. The distribution of bull trout extends from the Pacific Coast to western Montana and Alberta. Southern range limits are found in northern California and Nevada; northern limits extend to the headwaters of the Yukon River in Canada (Rieman *et al.*, 1997).

Westslope cutthroat trout and bull trout share several basic ecological characteristics. Both taxa exhibit resident, fluvial, and adfluvial life histories. They share the basic habitat requirements of relatively cold waters rich in structural diversity (e.g. large woody debris) and relatively low levels of sediment, chemical pollution, and non-native fish (Montana Bull Trout Scientific Group, 1998; USFWS, 1999). Both taxa are characterized by a relatively high degree of genetic diversity among populations (Allendorf and Leary, 1988; Spruell *et al*., 1999), permitting local coadaptation of gene complexes.

Both taxa are imperiled as the result of human activities. Bull trout was listed as a threatened species under the ESA in 1998 (Bechtold, 1999). Westslope cutthroat trout is a species of special concern in Montana. Widespread decline of this taxon is acknowledged (Allendorf and Leary, 1988), but it is not listed under the ESA. Both taxa are susceptible to impacts from timber harvesting, mining, grazing, urbanization, and roads (Shepard *et al*., 1997; Montana Bull Trout Scientific Group, 1998) and are strongly associated with roadless areas (Western Native Trout Campaign, 2001).

However, these taxa exhibit important differences in resource utilization. Bull trout are primarily benthic feeders and hold positions close to the stream bed, whereas westslope cutthroat trout are largely drift feeders on terrestrial invertebrates and hold positions higher in the water column (Nakano *et al*., 1992). Furthermore, bull trout have shown greater migration distances than westslope cutthroat trout during autumn and winter (Jakober, 1995) and may require habitat connectivity at a larger spatial scale than westslope cutthroat trout.

These taxa also show important differences in population structure at the landscape scale. Bull trout are positively associated with measures of habitat size and contagion (Rieman and McIntyre, 1995) and tend to inhabit watershed clusters based on their dispersal rates and availability of habitat (Dunham and Rieman, 1999). In contrast, a recent Status Review recognized that westslope cutthroat trout occurrence was not limited to clusters of watershed groups, but was more broadly distributed (USFWS, 1999).

Given these differences in resource utilization and population structure, the suitability of bull trout as an umbrella species for westslope cutthroat trout should be evaluated. A simple analysis of co-occurrence between these taxa is a useful first step when considering an umbrella species application. Moreover, federal direction for HCP development requires an unlisted species to be evaluated with equal rigour as threatened or endangered species recognized by the ESA (USFWS and NMFS, 1996).

METHODS

Broad-scale data from the Interior Columbia Basin Ecosystem Management Project (ICBEMP) were used to assess the efficacy of bull trout as an umbrella species for westslope cutthroat trout. The ICBEMP Key Salmonid Status Database was employed in this study to map areas of strong bull trout and westslope cutthroat trout populations at the subwatershed level (i.e. sixth field hydrologic unit) within the historic range of westslope cutthroat trout west of the continental divide in the USA (ICBEMP, 2000). Areas delineated as strong subwatersheds are those considered to support: all historically present life histories; stable or increasing numbers (at least half of the historical size or density); at least an estimated 5000 individuals or 500 adults. Data sources consisted of state and federal fisheries databases and the systematically surveyed professional opinions of more than 150 biologists. The ICBEMP database contains the most spatially comprehensive information for the region, and was available to HCP authors.

A geographic information system (Arcinfo version 7.1.1) was used to assess the overlap of ICBEMP-classified strongholds between bull trout and westslope cutthroat trout at two levels: (1) within the historical range of westslope cutthroat trout west of the continental divide in the USA and (2) within the 1.6 million acre Project Area considered by the HCP and owned by PCTC as of December 2000. For the range-wide analysis, a simplified sweep analysis (Kiester *et al*., 1996) was employed by comparing spatial overlap of bull trout and westslope cutthroat trout strongholds. For the HCP analysis, the authors calculated areas of strong westslope cutthroat trout populations within subwatersheds that were under PCTC ownership and classified as Tier 1 or Tier 2 in the HCP.

RESULTS

There were 134 bull trout strongholds recognized (i.e. strong populations within subwatersheds) and 419 westslope cutthroat trout strongholds recognized within the 2646 subwatersheds constituting the historic range of westslope cutthroat trout west of the continental divide. Overlapping strongholds were found in 102 subwatersheds (Figures 2 and 3). Per-unit probabilities of strongholds were 0.120 for westslope cutthroat trout only, 0.012 for bull trout only, and 0.039 for both taxa concurrently.

Over 75% (317) of westslope cutthroat trout strongholds were not captured within strong bull trout subwatersheds. In contrast, 24% (32) of bull trout strongholds did not include westslope cutthroat trout strongholds (Figures 2 and 3). Although the presence of bull trout strongholds was disproportionately associated with the presence of westslope cutthroat trout strongholds ($X^2 = 36.6$, $P < 0.001$), their lack of spatial coverage makes them a poor (i.e. 'leaky') umbrella species for westslope cutthroat trout.

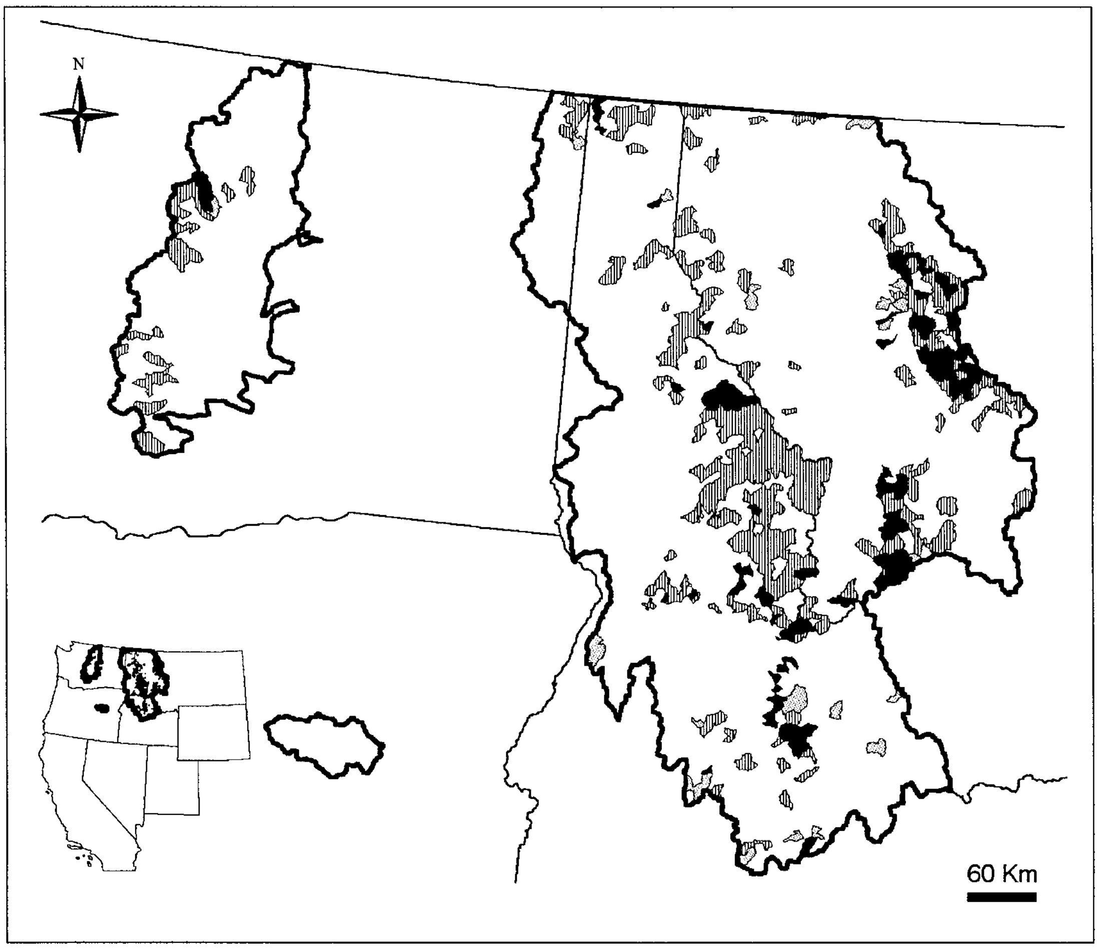

Figure 2. Spatial distribution of watershed strongholds for both westslope cutthroat trout and bull trout (black regions), for westslope cutthroat trout only (vertical lines), and for bull trout only (stippled regions) within the historic distribution of westslope cutthroat trout west of the continental divide in the United States (dark outline). Subwatersheds with strong populations were identified by the ICBEMP (2000).

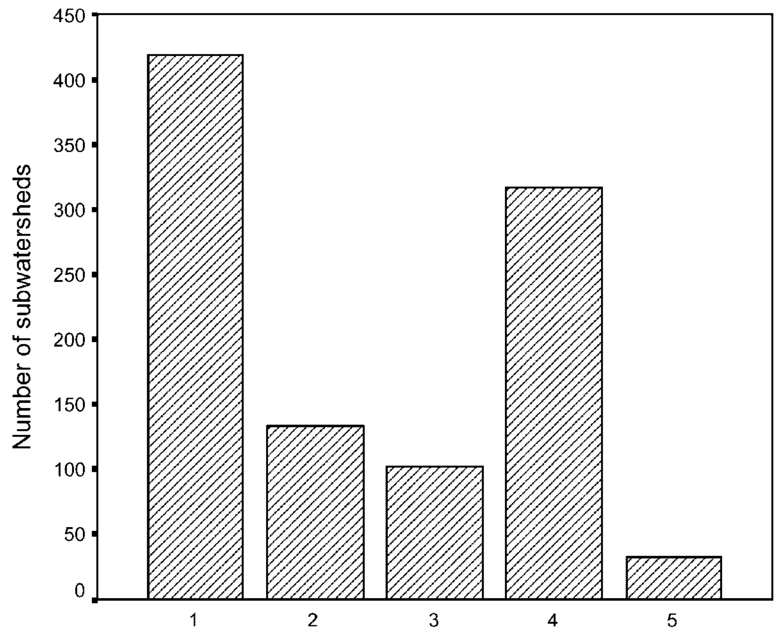

Figure 3. Numbers of subwatershed strongholds for westslope cutthroat trout (1), bull trout (2), both taxa (3), westslope cutthroat trout only (4), and bull trout only (5) in the study area.

Table 1. Management classifications for westslope cutthroat trout strongholds within the Native Fish Habitat Conservation Plan (USFWS and NMFS, 2000) for the PCTC. Numbers given are approximate values. Strong populations of westslope cutthroat trout were identified by the ICBEMP (2000)

Basin	Area (ha)	
	Tier 1 strongholds	Tier 2 strongholds
Lochsa River	5391	9276
Blackfoot River	12181	6092
Lower Clark Fork River	283	141
Lower Kootenai River	606	149
Middle Clark Fork River	177	4572
Middle Kootenai River	33	18
Swan River	1812	876
Upper Clark Fork River	932	126
Lower Columbia River	1783	2788

Approximately 47 240 ha of PCTC lands contained subwatersheds with strong populations of westslope cutthroat trout, constituting approximately 8% of the total land held by PCTC. Of these strongholds, 49% (23 200 ha) were located within the HCP's Tier 1 areas and 51% (24 040 ha) were located within Tier 2 areas (Table 1). The spatial distribution of population strongholds was not uniform across PCTC lands. For example, approximately 88% of the westslope cutthroat trout strongholds in the upper Clark Fork basin were captured in Tier 1 areas, whereas approximately 96% of the westslope cutthroat trout strongholds in the middle Clark Fork basin (where bull trout are today relatively depleted) were not captured (Table 1).

DISCUSSION

Surrogate species may present useful strategies for conservation planning, but must be carefully evaluated to ensure their proper use. In this case study, the patchy distribution of the assumed umbrella species excluded many important areas for westslope cutthroat trout. Although the proportion of westslope cutthroat trout captured within Tier 1 areas in the HCP (i.e. bull trout strongholds) was greater than the range-wide capture probability, this coverage could be greatly improved with relatively small changes in the distribution of Tier 1 areas.

As of 2000, approximately 19% of PCTC lands were classified as Tier 1 areas. Inclusion of all ICBEMP-classified westslope cutthroat trout strongholds would increase Tier 1 areas to approximately 23% of PCTC ownership. Given the importance of population-level conservation for westslope cutthroat trout (Allendorf and Leary, 1988), these additions are clearly warranted. For example, expansion of Tier 1 areas in the Lochsa, Blackfoot, and Clark Fork River basins would encompass important areas for native cutthroat trout with relatively small changes in the distribution of management areas (see Table 1).

This case study demonstrates the importance of patchiness in umbrella species distributions. Although large range size is an important criterion for umbrella species (Noss *et al*., 1996), it may not be a sufficient criterion in freshwater environments. Streams and rivers naturally support a higher level of fragmentation than marine or terrestrial ecosystems (Wiens, 2002), thus requiring sympatry between umbrella and target species to be delineated at a finer spatial scale. In this case study, the patchy distribution of the umbrella species hindered its utility, despite its large range size.

The ESA has been recognized as one of the most important pieces of environmental legislation in the world (Czech and Krausman, 2001). As such, implementation of the ESA may establish conservation standards of global significance. The HCP in this case study established an important precedent for an umbrella species application, yet the simple distribution analysis in this paper was not considered in the HCP, despite the availability of data and requests for such an analysis (see USFWS and NMFS (2001: Appendix F).

This case study underscores the observation of Fleishman *et al*. (2000) that, although umbrella species selection should be prospective, the selection of umbrella species is often retrospective, based on which species already have regulatory protection. Future applications should consider the patchiness of candidate umbrella species relative to target taxa in freshwater ecosystems. Simple distribution and status studies provide the raw data necessary to test spatial co-occurrence, and hence effectiveness or completeness of umbrella coverage. Because freshwater conservation is critically dependent on maintaining the ecological integrity of existing relatively intact and functioning habitat areas (Frissell and Bayles, 1996; Frissell, 1997), special emphasis should be placed on overlap of so-called strongholds for sensitive target species, as we have done here. Such evaluations will benefit all conservation plans with multi-species or ecosystem goals, and specifically will help the ESA to achieve its stated purpose: 'to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved'.

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