Marbled Murrelet as Target Species For Land Management in Coastal British Columbia

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ABSTRACT

Coastal temperate rain forests are complex ecosystems with high economic value. Conservation management of these forests must be based on clear, defendable strategies with quantifiable goals if they are to withstand economic pressure for exploitation. We introduce the target species strategy as an efficient management tool which allows quantification of conservation goals and continuity in planning time frames. A target species is a species used in defining and monitoring conservation goals. The marbled murrelet (*Brachyramphus marmoratus)* is an excellent example of a target species. This seabird is highly dependent on coastal old-growth forests as breeding habitat. It is a threatened species in Canada and is considered for legal designation as threatened or endangered in British Columbia. Therefore, it has become a focal species in coastal temperate rain forest conservation. Based on data collected during 4 years of marbled murrelet inventory by the British Columbia Ministry of Environment, Lands and Parks in Clayoquot Sound, British Columbia, we designed a habitat suitability index for the marbled murrelet for efficient habitat evaluation. This index allows a prioritization of habitats based on information from digital Vegetation Resources Inventory maps recently completed in Clayoquot Sound, as well as fine scale habitat prioritization based on vegetation plots. The habitat suitability index was used with a geographic information system (GIS) to rank and map habitats of importance to marbled murrelets in the Clayoquot Sound. The target species strategy, in combination with the presented habitat evaluation tools, bridges the gap between research and conservation management of the marbled murrelet and its habitat.

Key words: *Brachyramphus marmoratus*, Clayoquot Sound, coastal temperate rain forest, habitat suitability index, marbled murrelet, target species.

The primary coastal temperate rain forest is a unique and rare ecosystem. It originally covered only <0.2% of the world's land surface; today, it is threatened by permanent deforestation and conversion to managed forests. More than 50% of this rain forest worldwide has already been degraded (Bryant et al. 1997). This ecosystem is highly productive and contributes largely to global biodiversity (Scientific Panel for Sustainable Forest Practices in Clayoquot Sound 1995, Bunnell and Chan-McLeod 1997).

One-quarter of the world's remaining old-growth temperate rain forest is in British Columbia (Bryant et al. 1997). Some 53% of British Columbia's and 70% of Vancouver Island's old-growth temperate rain forest has been logged already (Sierra Club of British Columbia 1997), and logging or development has degraded more than two-thirds of it in British Columbia (Bryant et al. 1997). Most of the remaining rain forest, except for protected areas, is slated to be logged in the next 10 years (Bryant et al*.* 1997).

Clayoquot Sound has the largest contiguous stretch of temperate rain forest on Vancouver Island. It encompasses the southern-most multi-watershed complex of pristine rain forest in North America. To improve land management, the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (1995) produced many recommendations on planning processes, forest practices, and monitoring activities. Clayoquot Sound is supposed to become an economic, social, and ecological model of sustainable forestry.

The focus of the monitoring recommendations of the Scientific Panel was habitat and structural characteristics. An important goal was ecosystem integrity. Concepts such as ecosystem integrity or health have become increasingly widespread in recent years. If they are used in a management context (i.e., for land on which human use and conservation coincide), these concepts need to be clearly defined, quantified, and monitored to be meaningful and operable.

Although we agree that monitoring habitat is important for landscape-level planning, monitoring the organisms that live in the habitat is likely the best indicator of its state (Simberloff 1998). Furthermore, species are entities that do

Table 1. Selection criteria for target species (from Bahn 1998).

Required characteristics	Preferred characteristics
indigenous to the region	important to First Nations
has a chance to survive through the next planning periods without artificial support	threatened (mostly by habitat depletion not directly by human-induced mortality)
representative for the needs other species (umbrella effect)	complex and high habitat requirements (specialist, not ubiquitous)
sensitive to habitat alterations	geographically restricted distribution
	indicator, keystone, flagship species
	not migratory
	low dispersal
	ecological and demographic information available
	feasibility of research
	economically significant

not change in planning time frames and that can be counted. Hence, we would like to put forward a species-based strategy to define and quantify conservation efforts. This strategy could use the existing research results on several selected groups of species in the area (e.g., marbled murrelets, Roosevelt elk, black bears, bats, amphibians, aquatic invertebrates, and owls).

This approach is not meant to replace landscape-level planning which clearly must rely on protection of a representative set of ecosystems without any need to count or prove anything. The species-based approach is only meant for management in areas where human use and conservation coincide (which should be all used areas outside of protected areas).

THE TARGET SPECIES STRATEGY

Most land management and conservation strategies that we know of have a striking similarity: the arguments that their critics use to disqualify the approach. Common criticisms include

- lack of precise definitions of strategy goals (e.g., ecosystem health or integrity);
- lack of scientific evidence to support the underlying ideas (e.g., umbrella or keystone species whose protection is assumed to protect other species and ecological processes);
- too complex to be handled with available resources;
- oversimplifying the complicated nature of ecosystems; and
- subjectivity in its interpretation and dependence on current human values.

The universal applicability of these criticisms makes one wonder whether the problems might be inherent in any attempt to manage ecosystems with the relatively small resources typically available to conservation endeavours, rather than having anything to do with the strategies themselves. We admit that all but the last criticism apply to the strategy we will promote as well. Therefore, we want to focus on the benefits of the target species strategy rather than the known drawbacks.

Several related strategies aim to manage land by managing a selection of species: target species (Hansen et al. 1993, Walter et al. 1998); umbrella species (Launer and Murphy 1994); array of indicator species (Plachter 1991*b*); keystone species (Paine 1966); management indicator species (Woodruff 1989); focal species (Lambeck 1997); flagship species (Yen 1993); and indicator species (Soulé and Kohm 1989). Essentially, all of these strategies aim to prevent habitat degradation and further loss of biodiversity by monitoring selected species and maintaining a minimal population level. The strategies differ in how these species are selected, what they stand for, and at what levels they are protected or monitored. We will use the term target species (Woodruff 1989, Walter et al. 1998) and will use the following definition: *A target species is a species used in defining and monitoring conservation goals.*

Management strategies, such as ecosystem sustainability, health, or integrity, will remain weak and hard to implement without quantification of goals and environmental quality standards (Plachter 1991*b,* Hansen et al. 1993). By setting certain lower limits of tolerance for population size of the target species, environmental quality goals become clearly defined and measurable (Plachter 1996, Heidt et al. 1997, Walter et al. 1998).

The selection process for target species should follow certain rules which would have to be adapted for every specific situation and region. For Clayoquot Sound, we suggest the criteria outlined in Table 1. The list of target species should be as comprehensive as possible and should be amended as new information becomes available. It should comprise species of all sizes and trophic levels, not only the large vertebrates.

Summarized, the strategy of target species has the following advantages for land management (Plachter 1991*b,* Hansen et al. 1993, Altmoos 1997, Walter et al. 1998):

- abstract goals and rationales of conservation, such as ecosystem health or sustainability, become concrete and quantifiable;
- quantified goals can be monitored;
- savings of time and money compared with all-inclusive approaches;
- indirect contribution to the conservation of other species, habitats, and processes (umbrella effect);
- a hierarchical (in both a trophic and body size sense) array of target species allows the management and conservation of species and protected areas which considers all spatial scales;
- species remain the same in the planning time frames whereas ecosystems often change or fluctuate;
- some species rely on larger-scale connections and landscape functions that might be overlooked with other approaches;
- different executors of management plans will come to similar conclusions by using a quantitative, well-defined approach; and
- habitat degradation becomes quantifiable in terms of target species declines.

To manage a target species some basic information is required: the distribution and abundance (at least semiquantitatively); the ecology (feeding and breeding, habitat requirements, dispersal); and the basic life history attributes (survival, longevity, fecundity) of the species. Also important is information on the home range (where applicable) and threats. Note that any form of artificial enhancement must be excluded from the target species strategy. For more detailed discussion of the target species strategy, see Bahn (1998).

THE MARBLED MURRELET AS TARGET SPECIES

The marbled murrelet was one of several species and groups of species identified as important for land management decisions in Clayoquot Sound, British Columbia. Therefore, the British Columbia Ministry of Environment, Lands and Parks initiated an inventory of marbled murrelets there in 1995 (see Chatwin et al. 2000). The habitat suitability index put forward in this paper is based on the data and analyses from the 4 years of inventory (Bahn and Newsom 1999).

Marbled murrelet nesting habits are unique among members of the family Alcidae: these birds nest nearly exclusively in trees of old, coastal forests. The forests in which they breed are usually of high economic value and are often easily accessible from the ocean. Therefore, these forests have been and still are heavily exploited by the logging industry. Removal of nesting habitat (i.e., large trees), among other threats such as gill-netting and oil spills, has reduced the numbers of marbled murrelets in North America and caused this species to be recognized as threatened in both Canada and the United States (Rodway 1990, U.S. Fish and Wildlife Service 1992).

When evaluated according to the selection criteria for a target species (Table 1), the marbled murrelet is a promising candidate. It is highly threatened under current forest practices but is unlikely to become extinct if forestry practices improve, as promised by politicians and industry. It is indigenous to British Columbia and is highly dependent on old-growth forests as breeding habitat. Any alteration of breeding habitat is likely to decrease fecundity and long-term abundance of this bird. With its high requirements for breeding habitat, protecting the marbled murrelet would likely protect many other species dependent on old growth. The marbled murrelet is not known to have large-scale migrations although certain seasonal movements are known. In addition, the main cause of its "endangered" status is breeding habitat loss and not threats in other seasonal habitats. Furthermore, the marbled murrelet is thought to exhibit a certain breeding area fidelity, which means that it probably does not disperse quickly, although it is known to fly long distances in search of breeding habitat. Last, conservation efforts for murrelets have made this species well known and popular along the West Coast.

A drawback to selecting the marbled murrelet as a target species is that, despite the relatively large amounts of effort and money that have been put into marbled murrelet research, little is known about its basic life history. Furthermore, all demographic research is overshadowed by high unexplained variability in marbled murrelet inland and at-sea activity and much spatial movement on all time scales. Therefore, much more research into its life history and demography is needed.

Different species can serve to define and monitor different goals (Lambeck 1997). With its high spatial and structural demands on old-growth forests as breeding habitat, the marbled murrelet can be used as an indicator of both the quantity and quality of forestry practices. Preservation of sufficient old-growth and retention of a sufficient number of trees in logged areas (variable-retention system) will keep marbled murrelet numbers stable and facilitate recovery of breeding habitat (Scientific Panel for Sustainable Forest Practices in Clayoquot Sound 1995). In other words, the murrelet can be used to protect both habitat and other species dependent on old growth, as well as define minimum standards for forest practices. It is not useful in a strategy for the conservation of processes or connectivity in the landscape.

For the evaluation and adaptation of land management, continuous monitoring is indispensable (Plachter 1991*a*, Brown and Rowell 1997, Grumbine 1997). Murrelet population sizes can be measured by at-sea counts (e.g., Agler et al. 1998) or, on a watershed level, population levels can be indirectly monitored by radar counts of birds flying to their nesting sites (Burger 1997). For finer scale analyses of planning areas, audiovisual ground surveys (Ralph et al. 1994) and random tree climbing for nests can be used in forests.

The first step is to monitor population levels before habitat disturbances. The second step is to establish limits of tolerance in population changes for individual watersheds (Bahn 1998). These limits cannot be scientifically derived but must be agreed upon by experts. Third, a detailed planning process involves the habitat suitability mappings described in the next section. Last, population levels after forestry impacts must be monitored and plans adapted according to the results.

HABITAT EVALUATION MODEL FOR THE MARBLED MURRELET BASED ON MAPPED INFORMATION

To consider the needs of marbled murrelets in management decisions, methods must be developed to evaluate potential marbled murrelet habitat in a standardized way. The habitat evaluation procedure (HEP) developed by the U.S. Fish and Wildlife Service (1980) is a standardized model for habitat evaluation which has been widely applied in North America (Gray et al. 1996). It is based on a habitat suitability index (HSI) (U.S. Fish and Wildlife Service 1981), which is calculated using habitat variables known or perceived to be important to a species.

The main objective for building this model for the marbled murrelet was to provide a management tool for the evaluation of coastal temperate rain forest as breeding habitat based on digital map information available. The model does not consider any other habitat requirements of the marbled murrelet (e.g., foraging habitat). Vegetation Resources Inventory (VRI) maps contain forest cover variables (e.g., tree height and age) that are linked to mapped polygons representing relatively homogenous areas (about 10 ha in size).

With field data from the inventory we identified the habitat variables most useful in characterizing marbled murrelet breeding habitat (i.e., density of nesting structures and forest structural characteristics). We also used information on marbled murrelet breeding habitat characteristics from the literature and biological reasoning to determine important habitat variables. We correlated these habitat variables with the forest cover variables from the VRI maps to identify useful forest cover variables and to determine their relationship to known marbled murrelet breeding habitat characteristics (Fig. 1). The identified variables were

- height (m) of the leading or the second leading species on the VRI maps (whichever was higher);
- age (yr) of the leading or the second leading species on the VRI maps (whichever was older);
- basal area (m2/ha) of canopy and emergent trees from VRI maps;
- vertical complexity (1–4) of the forest canopy as defined by the VRI manual;
- canopy closure (%) of the tree crowns;

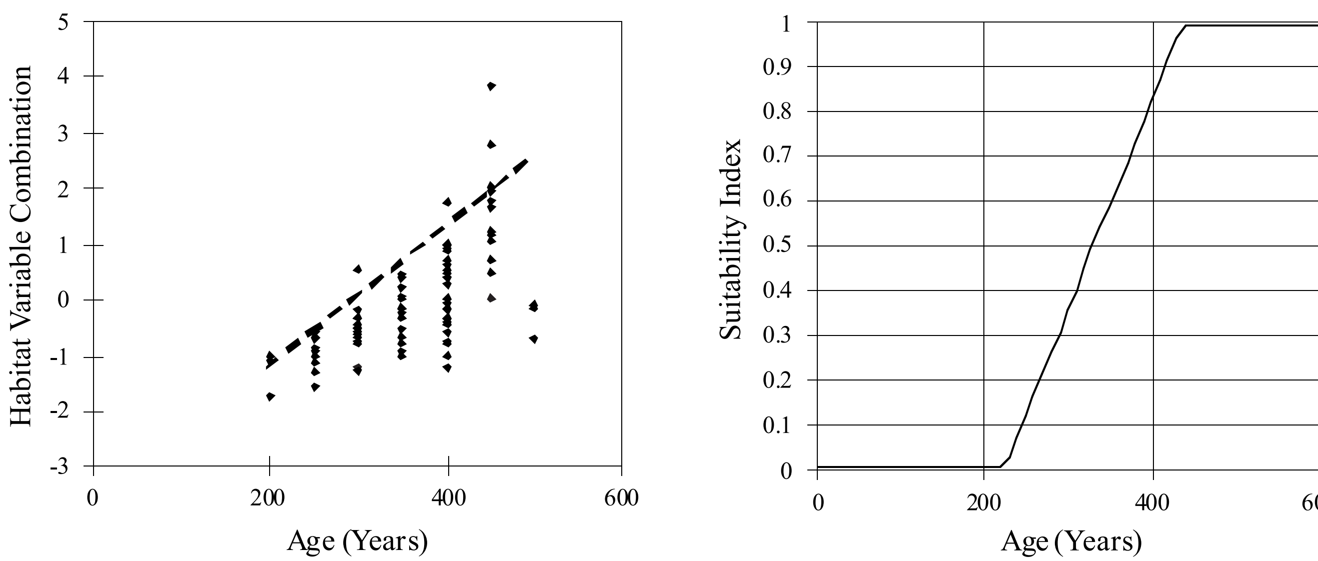

Figure 1. Construction of the marbled murrelet suitability index for the highest average age (yr) of the dominant and the second dominant tree species. This variable stems from a forest cover map (VRI). The graph on the left shows a scatter plot with age as independent and a principal component analysis combination of several habitat variables describing suitable marbled murrelet habitat as dependent variable. The habitat variables were derived from field data and literature. The dashed line is a least absolute deviation 90th quantile regression line. The right graph shows the translation of the left graph into a suitability index ranging between 0 and 1 (from Bahn and Newsom 1999).

- average distance of the polygon from the ocean; and
- average altitude of the polygon.

Another variable that is important for murrelet habitat quality is distance to the next major forest edge. However, we have been unable to make this information available in a digital form.

The next step was to construct evaluation graphs (called suitability indices) for the 7 selected forest cover variables. To determine their relationship to the habitat variables derived from field work, we combined the habitat variables in a principal component analysis (PCA) and made regressions between the PCA combination and the 7 forest cover variables. These regressions were the basis for suitability indices (SIs) which associate different values of the selected variable with an evaluation between 0 and 1. Fig. 1 shows 1 example of the derivation of an SI from a regression between the mapped forest cover variable and the habitat variable measured in the field. For a complete version, see Bahn and Newsom (1999).

The individual SIs for each forest cover variable were combined in a mathematical expression (weighted average) to form a single HSI. The mathematical expression was created according to our judgement of the importance and properties of the variables.

We are aware that, although the individual SIs were based on habitat features known to be important to marbled murrelets, many of the underlying assumptions are untested. For example, although we know that marbled murrelets use platforms for nesting, a definite relationship between density of platforms in a habitat and nesting density has never been established. More accurate relationships between the density of important habitat characteristics and nesting density can only be established by nesting density studies that ideally would include reproductive success. The ideal evaluation output from the model would be linearly related to nesting density and success of marbled murrelets.

Last, we produced maps showing the HSI scores of the individual polygons. For an informative map, we needed to group the polygons according to their HSI scores and to show them in different colours. In addition to the informative value, this grouping exercise is the point at which HSI scores must be translated into a verbal evaluation (i.e., habitat groupings from “excellent” to “unsuitable”).

We suggest that this model could be applicable to within 50 km of the coast in the Coast and Mountains Ecoprovince. This range may be too wide and therefore must be reconsidered when the model is verified. This HSI model is a hypothesis which ought to be tested and refined as new results become available.

CONCLUSION

Talk is cheap. Concepts such as sustainability, ecosystem integrity, or ecosystem health are easily adopted into management vocabulary but remain inoperable until they are expressed quantitatively. The management of species and habitats at risk depends on measurable goals that can withstand economic pressure and can distinguish them from public relations rhetoric.

Although the target species strategy has some deficiencies, we favour it over ecosystem-based approaches to land management in areas where human use and conservation coincide. Shortcomings of the target species strategy are (1) that it has rarely been proven that the needs of 1 species adequately represent the needs of other species and (2) that insufficient information exists on potential target species. Nevertheless, we prefer it because it relies on species as entities that stay the same over time and can be counted. The success of this strategy depends on the selection of the target species and the tools used in their management.

The marbled murrelet is an obvious choice for a target species. Its high dependence on coastal old-growth forests makes its abundance and distribution a valuable indicator of the state of these forests.

The HSI we created for the marbled murrelet based on the research in Clayoquot Sound, British Columbia, could be an efficient tool for the management of this species on a large scale. The HSI bridges the gap between a purely scientific analysis of the habitat requirements of a species and the consideration of these requirements in management and planning. However, the HSI must still be verified. With the help of this tool the marbled murrelet is becoming an integral part of land management in Clayoquot Sound.

LITERATURE CITED

Agler, B. A., S. J. Kendall, and D. B. Irons. 1998. Abundance and distribution of marbled and Kittlitz’s Murrelets in southcentral and southeast Alaska. Condor 100:254–265.

Altmoos, M. 1997. Zoologischer Artenschutz im Biosphärenreservat Rhön. Übersicht zur Konzeptentwicklung und Praxis von Artenschutz in einer Modellregion. Jahrbuch Naturschutz in Hessen, Band2/1997. Naturschutzring Nordhessen e.V. Fuldaer Verlagsanstalt GmbH, Fulda.

Bahn, V. 1998. Habitat requirements and habitat suitability index for the Marbled Murrelet (*Brachyramphus marmoratus*) as a management target species in the Ursus Valley, British Columbia. Diplomarbeit (Thesis), Philips-Universität, Marburg, Germany.

Bahn, V., and D. N. Newsom. 1999. Clayoquot Sound marbled murrelet inland inventory 1998: Habitat evaluation and activity monitoring. Report to B.C. Minist. Environ., Lands and Parks, Vancouver Island Regional Office, Nanaimo, BC.

Brown, A., and T. A. Rowell. 1997. Integrating monitoring with management planning for nature conservation: some principles. Natur und Landschaft 72(11):502–506.

Bryant, D., S. Nielsen, and L. Tangley. 1997. The last frontier forests: Ecosystems and economies on the edge. World Resour. Inst., Seattle, WA.

Bunnell, F. L., and A. C. Chan-Mcleod. 1997. Terrestrial vertebrates. Pp. 25–41 *in* P. Schoonmaker, B. v. Hagen, and E. C. Wolf, eds. The rainforest of home, profile of a North American bioregion. Island Press, Washington, DC.

Burger, A. E. 1997. Behaviour and numbers of Marbled Murrelets measured with radar. J. Field Ornithol. 68:208–223.

Chatwin, T. A., L. E. Jones, A. E. Burger, and D. Newsom. 2000. Using multi-scale inventory and research to conserve marbled murrelets in Clayoquot Sound, British Columbia. Pp. 741–749 *in* L. M. Darling, ed. Proc. Conf. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999. Vol. Two. B.C. Minist. Environ., Lands and Parks, Victoria, BC, and Univ. College of the Cariboo, Kamloops, BC. 520pp.

Gray, P. A., D. Cameron, and I. Kirkham. 1996. Wildlife habitat evaluation in forested ecosystems: some examples from Canada and the United States. Pp. 407–536 *in* R. M. DeGraaf, and R. I. Miller, eds. Conservation of faunal diversity in forested landscapes. Chapman & Hall, London, U.K.

Grumbine, E. R. 1997. Reflections on “What is ecosystem management?” Conserv. Biol. 11:41–47.

Hansen, A. J., S. L. Garman, B. Marks, and D. L. Urban. 1993. An approach for managing vertebrate diversity across multiple-use landscapes. Ecol. Appl. 3:481–496.

Heidt, E., R. Schulz, and H. Plachter.1997. Konzept und Requisiten der naturschutzfachlichen Zielbestimmung, dargestellt am Beispiel einer Agrarlandschaft Nordostdeutschlands (Uckermark; Brandenburg). Verh. Ges. Ökologie 27, 1997.

Lambeck, R. J. 1997. Focal species: a multi-species umbrella for nature conservation. Conserv. Biol. 11:849–865.

Launer, A. E., and D. D. Murphy. 1994. Umbrella species and the conservation of habitat fragments: a case of a threatened butterfly and a vanishing grassland ecosystem. Biol. Conserv. 69:145–153.

Paine, R. T. 1966. Food web complexity and species diversity. Am. Nat. 100:277–341.

Plachter, H. 1991*a*. Biologische Dauerbeobachtung in Naturschutz und Landschaftspflege. Laufener Seminarbeiträge 7/91:7–29.

_____. 1991*b*. Naturschutz. Fischer, Stuttgart, Germany.

_____. 1996. A central European approach for the protection of biodiversity. Pp. 91–108 *in* D. Ogrin, ed. Proc. Nature conservation outside protected areas conf. Minist. Environ. and Physical Planning, Ljubljana, Slovenia.

Ralph, C. J., S. K. Nelson, M. M. Shaughnessy, S. L. Miller, and T. E. Hamer. 1994. Methods for surveying marbled murrelets in forests. Pac. Seabird Group, marbled murrelet Tech. Comm., Oreg. Coop. Wildl. Res. Unit, Oreg. State Univ., Corvallis, OR. Tech. Pap. No. 1 (revised).

Rodway, M. S. 1990. Status report on the marbled murrelet in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. 1995. Report 5: Sustainable ecosystem management in Clayoquot Sound. Victoria, BC.

Sierra Club of British Columbia. 1997. Half of B.C.’s ancient temperate rainforests gone. Victoria, BC.

Simberloff, D. 1998. Flagships, umbrellas, and keystones: Is single-species management passé in the landscape era? Biol. Conserv. 83:247–257.

Soulé, M. E., and K. A. Kohm. 1989. Research priorities for conservation biology. Island Press, Washington, DC.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedure (HEP): 102 ESM. U.S. Dep. Inter., Fish and Wildl. Serv., Washington, DC. Ecological Services Man. 102.

_____. 1981. Standards for the development of a habitat suitability model. U.S. Dep. Inter., Fish and Wildl. Serv., Washington, DC. Ecological Services Man. 103.

_____. 1992. Endangered and threatened wildlife and plants; determination of threatened status for the Washington, Oregon, and California population of the marbled murrelet. U.S. Dep. Inter., Fish and Wildl. Serv., Fed. Reg. 57:45328–45337.

Walter, R., H. Reck, G. Kaule, M. Lämmle, E. Osinski, and T. Heinl. 1998. Regionalisierte Qualitätsziele, Standards und Indikatoren für die Belange des Arten- und Biotopschutzes in Baden-Württemberg. Das Zielartenkonzept - ein Beitrag zum Landschaftsrahmenprogramm des Landes Baden-Württemberg. Natur und Landschaft 73(1):9–25

Woodruff, D. S. 1989. The problems of conserving genes and species. Pp. 76–88 *in* D. Western, and M. C. Pearl, eds. Conservation for the twenty-first century. Oxford University Press, Oxford, U.K.

Yen, A. L. 1993. The role of museums and zoos in the influencing public attitudes towards invertebrate conservation. Pp. 213–229 *in* K. J. Gaston, T. R. New, and M. J. Samways, eds. Perspectives on insect conservation. Intercept Press, Andover, U.K.