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Opinion

Endangered Species and Peripheral Populations: Cause for Reflection

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Introduction

Endangered species lists constitute critical foci of conservation attention. Species on such lists are given special attention in prioritizations for conservation (Peterson et al. 2000), with the Endangered Species Act affording immediate protection to areas known to hold populations of endangered species. Hence, decisions regarding "endangered" status of species have profound effects on conservation action (Tear et al. 1995).

Oddly, though, endangered species lists seem to be assembled with little attention to the biology of species involved. The purpose of this commentary is to point out that many "endangered" species in the United States are actually peripheral populations when the entire range of the species is considered (Godown and Peterson 2000). Such populations are often not viable populations to begin with (Holt and Gaines 1992), constituting population "sinks," and indeed are often species of little conservation concern in the main portion of their geographic distributions. Inclusion of these species in status lists dilutes the effectiveness of endangered species legislation and conservation action, and changes geographic foci of endangered species richness (Godown and Peterson 2000).

Endangered species lists

The U.S. endangered species list includes 44 avian taxa (excluding Hawaii). Of these taxa, 19 are endemic or nearly endemic to the United States, such as the California Condor (*Gymnogyps californianus*), Mississippi Sandhill Crane (*Grus canadensis pulla*), Attwater's Greater Prairie-chicken (*Tympanuchus cupido attwateri*), and Florida Scrub-Jay (*Aphelocoma coerulescens*). These taxa are clearly appropriate for inclusion in the list, given that conservation efforts will either prove successful in the United States, or the taxon will be lost to extinction. Another 19 of the endangered bird species, while not endemic to the United States, have substantial populations in the country that can be an appropriate focus of conservation efforts.

Six avian taxa on the list, however, are represented in the United States only by peripheral populations when the entire range of the species is considered: Masked Bobwhite (*Colinus virginianus ridgwayi*), Audubon's Crested Caracara (*Polyborus plancus audubonii*), Northern Aplomado Falcon (*Falco femoralis septentrionalis*), Thick-billed parrot (*Rhynchopsitta pachyrhyncha*), Cactus Ferruginous Pygmy-Owl (*Glaucidium brasilianum cactorum*), and Wood Stork (*Mycteria americana*). Some of these species are indeed in global peril of extinction (Masked Bobwhite), and perhaps the attention that they might receive in the United States is worth the effort. However, others are species that are quite common south of the U.S.-Mexico border. For example, the Ferruginous Pygmy-Owl is a common resident of tropical forests, the Crested Caracara is a common resident of open and disturbed habitats, and the Wood Stork is a frequent species of open wetlands; all three are found broadly throughout the tropical Americas.

These peripheral populations lie at the limits of species' ranges, where they are often not viable in the long term. Hence, whereas extinction of the U.S. populations of Northern Aplomado Falcon would be regrettable, they *always* have been marginal, and as such likely have a tenuous hold on long-term survival. Worse still, for species such as the Crested Caracara and the Ferruginous Pygmy-Owl, although U.S. populations are limited in distribution, the species is abundant, and far from threatened with extinction, just a few hundred kilometers south in Mexico.

State endangered species lists are similarly of curious composition. Some states have very clear and straightforward lists: Michigan, for example, includes Peregrine Falcon , Bald Eagle (*Haliaeetus leucocephalus*), and Piping Plover (*Charadrius melodus*), all of which are represented by breeding populations in the state, as well as Kirtland's Warbler (*Dendroica kirtlandii*), for all intents and purposes endemic to the state as a breeding species; 18 other states have similarly straightforward endangered species lists. Other states, however, include species from the federal list that are marginal or even accidental in that particular state. For example, the Ohio list includes Bald Eagle, which is indeed a breeding species in the state; Peregrine Falcon, which is marginal in occurrence; and Piping Plover, which is extinct as a breeding species in the state.

Discussion

Considering aspects of the theory of population ecology, investing time and resources in the conservation of peripheral populations is a questionable strategy. Peripheral populations are well known to be marginal, and in many

cases unstable in population dynamics, as can be seen in the following hypothetical example. A population grows or declines as the combination of four factors (Figure 1), birth (B), death (D), immigration (I), and emigration (E). If individuals did not move among areas, I and E would be zero, and whether an area is inhabited or not would depend simply upon the balance of B and D. Hence, in Figure 1, the darkest areas would have $B \geq D$, and would be stable or increasing; other areas (light gray and white) would not be inhabited in the absence of immigration. If individuals do move among populations sufficiently frequently, areas adjacent to increasing populations may receive more immigrants than they send out as emigrants ($I > E$), and a population can be maintained as a sink even over long periods of time. Hence, peripheral populations of species can often prove not to be viable if adjacent source populations are removed.

The logical flaw of counting peripheral populations on endangered species lists can thus be appreciated: their conservation has little probability of success. Peripheral populations are vulnerable to wide fluctuations and instability (Holt and Gains 1992), making their population persistence uncertain. What is more, if adjacent source populations are removed or reduced—often the case in endangered species—birth rates are insufficient to maintain the population, numbers decline, and the species rapidly disappears from the peripheral area in spite of conservation efforts.

The point of this commentary is not to detract from the important advances made in endangered species conservation in recent decades. Rather, my focus is on how future efforts should concentrate on taxa in areas in which probabilities of success are high. Under this view, peripheral populations appear frequently to represent a losing proposition: populations in these regions will fluctuate widely, and are likely to decline as source populations are compromised. The effectiveness of the Endangered Species Act would hence be maximized by focus on species that have substantial portions of their geographic distributions within the area of jurisdiction.

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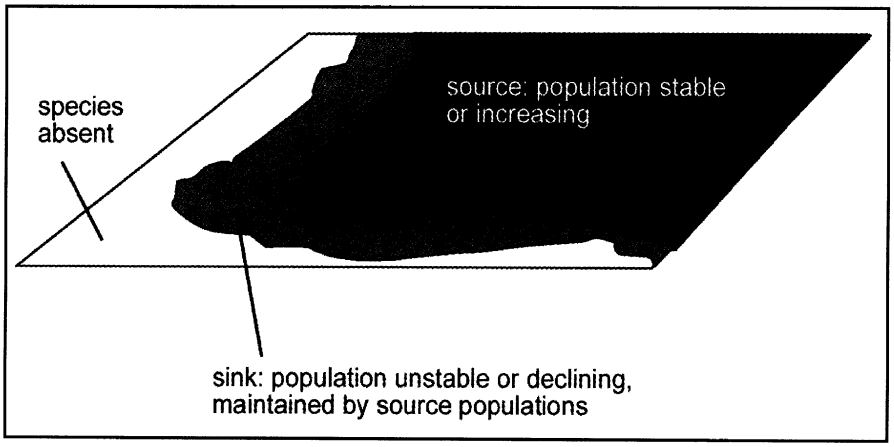

Figure 1. Diagram of hypothetical range limits in a species, showing uninhabited areas ($B + I < D + E$), population sinks ($B + I > D + E$, but $B < D$), and source populations ($B > D$).

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Cover: The endangered American burying beetle (*Nicrophorus americanus*). Photo courtesy of Susan Middleton and David Liittschwager.

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Special Series: Habitat Conservation Planning

Where Property Rights and Biodiversity Converge Part III: Incorporating Adaptive Management and the Precautionary Principle into HCP Design

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Abstract

Concluding a three-part series synthesizing reviewers' recommendations for improving Habitat Conservation Plans (HCPs), this article focuses on the inherent scientific uncertainty in conservation planning and the two primary strategies that performance reviewers have recommended to deal with incomplete data: adaptive management and the precautionary principle. The precautionary principle holds that, in the face of poor information or great uncertainty, managers should adopt risk-adverse practices. Where critical information is scarce or uncertain, application of the precautionary principle counsels that HCPs should adhere to the following recommendations: be shorter in duration, cover a smaller area, avoid irreversible impacts, require that mitigation measures be accomplished before take is allowed, include contingencies, and have adequate monitoring. Under adaptive management, HCPs are acknowledged to be mere working hypotheses of how species will respond to changes in habitat size, location, configuration, and quality. To truly integrate adaptive management into an HCP, a plan must include a monitoring program to evaluate the performance of mitigation measures and a system that automatically triggers alternative conservation actions in the event that performance fails to meet conservation goals. Reviewers, however, have found that few HCPs have well developed and statistically valid monitoring programs. Incorporating adaptive management into HCPs will require a fundamental change in the way that regulatory assurances (for instance, 'no surprises') are structured so that plans remain flexible and contingent rather than immutable, as they are now. Two possible solutions include converting the assurance package from regulatory immunity to regulatory indemnity and calibrating the duration or rigor of the assurance to the quality or expected performance of the HCP's conservation strategy.

Introduction

Habitat Conservation Plans (HCPs) have become the primary vehicle for implementing the Endangered Species Act (ESA) on non-Federal land (*see Part I of this series for a summary of HCPs*). Because of their key role, HCPs have come under the intense scrutiny of both developers and conservationists. Practicing and academic conservation biologists as well as environmental organizations have conducted numerous independent reviews of HCP policy and plans that identify shortcomings in current practices. Recommendations to improve HCPs have been distilled from these studies by the Natural Heritage Institute (NHI). Focusing on the use of the precautionary principle and adaptive management to guide HCP development and implementation in the face of scientific uncertainty, this article is the final in a three-part series that synthesizes these recommendations. It concludes by summarizing the major points outlined in this series.

Because our understanding of the biological world is incomplete, uncertainties are endemic to conservation planning. The biological information available on species and their habitat is always imperfect or ambiguous to some degree. The performance reviews recommend two interrelated tools for dealing with critical uncertainties: adaptive management and the precautionary principle. Adaptive management is a technique that tests the response of biological systems to conservation measures and adjusts conservation strategies as warranted on an ongoing basis. The precautionary principle resolves critical uncertainties in favor of greater protection for the species until and unless better information counsels otherwise.

Applying adaptive management principles to HCP design

Adaptive management is a strategy for coping with the uncertainties inherent in predicting how ecosystems will respond to human interventions, such as timber harvesting or habitat fragmentation. Adaptive management is an essential feature of habitat conservation planning because it responds realistically to ignorance about the ecosystem by monitoring the results of management efforts in order to make adjustments as needed (Noss et al. 1997). Under adaptive management, HCPs are acknowledged to be mere working hypotheses, predicated upon assumptions about how species and their ecological processes and functions respond to changes in habitat size, location, configuration, and quality. These assumptions, uncertainties, and knowledge gaps are made explicit in adaptive management. Moreover, under adaptive management, conservation strategies include concrete plans and funding to test hypotheses against specified, measurable performance goals.

Adaptive management treats every HCP as a "learning laboratory" where conservation strategies continue to evolve as scientific understanding increases. Because HCPs will always be experiments with uncertain outcomes, adaptive management requires resource managers to acknowledge inherent risks in the experiment and modify conservation measures according to experience and new information. Thus, another word for adaptive management is "contingency planning." At its core, an effective adaptive management program must include a method for evaluating HCP performance, and must specify the alternative conservation measures that will be triggered automatically in the event that performance fails to meet conservation goals. Under such a program, it might be necessary for the permit applicant to implement development activity in phases so that permission to begin a later phase is contingent upon verification from the U.S. Fish and Wildlife Service and the National Marine Fisheries Service ("the Services") that the performance standards in the prior phase have been met. This kind of phased development is more easily accomplished in larger landscape-scale plans that are implemented over time (*see to the Part I of this series for a discussion of landscape-level planning for HCPs*).

From the Services' perspective, property rights holders are already successfully incorporating adaptive management into HCPs. In both the existing HCP Handbook and the proposed addendum, however, the practice of adaptive management is limited to circumstances where "significant uncertainty exists," and then only to circumstances where the applicant accedes to its utilization (USFWS and NMFS 1996). Currently, the range of conservation measures that might be required as a result of evolving information is negotiated as a term of the initial HCP. Yet, many conservation biologists agree that "significant uncertainty" may not become apparent until after the HCP has been approved. They advocate the inclusion of adaptive management practices in virtually every plan, making it the rule rather than the exception.

After consulting with conservation biologists, NHI has distilled the following four steps for developing an HCP that utilizes adaptive management practices:

1) Identify explicit and quantifiable biological goals;
2) Characterize the human-induced stressors of the ecosystem that must be overcome or counteracted to achieve these goals, including an explicit acknowledgement of the critical uncertainties regarding the stressor-response relationships;
3) Specify high-probability measures to minimize, mitigate, or offset these stressors or otherwise achieve the biological goals;
4) Monitor biological indices by developing a statistically valid sampling protocol, and develop mechanisms to translate data into needed plan adjustments.

The choice of conservation measures in Step 3 is crucial to an HCP's success. These mitigation measures, such as habitat restoration or the creation of a reserve system, must represent the "best guess" based on the best available data. Once in place, such measures constitute the initial working hypotheses that the adaptive management regimen tests, monitors, and adjusts to as necessary to reach the biological goals.

Measures to reduce the risks of unsuccessful mitigation

The most frequently used mitigation strategies consist of measures to minimize or avoid development impacts on the listed species (Kareiva et al. 1999). These are usually the easiest and least costly procedures to implement, yet their sufficiency can only be tested over time and in relation to the response of target species in the real world. To maximize prospects for successful mitigation, measures should be based on the best science available, and the mitigation strategy must be allowed to change over time as monitoring progresses. To date, researchers have found that the efficacy of the conservation measures initially selected in HCPs varies greatly. In most cases, the mitigation procedures do address the pri-

mary threat to a species' survival, but only about half of the mitigation plans adequately ameliorate this threat (Kareiva et al. 1999).

There are several techniques that can reduce species' risks associated with unsuccessful mitigation strategies. In general, the Services recommend that habitat used for mitigation should be as geographically close and ecologically similar to the impacted habitat as possible. The Handbook recommends that habitats be "banked" through the use of conservation easements or other means before development occurs (USFWS and NMFS 1996). The "mitigation credit" system is an example of this scheme. Under this system, credit is given to newly created habitat (usually on a per acre basis) that can then be used or sold to other parties requiring mitigation lands. This practice allows landowners to pay mitigation fees into habitat acquisition funds in lieu of conserving habitat on their own lands. Other landowners may create habitat for purchase as mitigation. For instance, International Paper Company is restoring and selling red-cockaded woodpecker (*Picoides borealis*) habitat in the southeastern U.S. The Bakersfield Metropolitan HCP is conserving habitat for multiple species in California's Central Valley based entirely on marketable development rights.

Mitigation banking can achieve habitat goals in an economically efficient manner and can reconfigure habitat in ways that traditional HCPs cannot. Because spatial considerations are critical in conservation, mitigation banking has the potential to result in "no net loss" of habitat and to enhance population stability by exchanging fragmented habitats for non-fragmented habitats. Assuring that mitigation banks do not result in a net reduction in the extent or quality of habitat is absolutely essential for already endangered or threatened species.

The success of mitigation measures depends on their timely implementation. To increase the probability that unsuccessful mitigation procedures can be detected and corrected, implementation should occur before the listed species are impacted by the permitted development activities (Kareiva et al. 1999). If most of the take occurs before mitigation measures are implemented, the chance of adapting the conservation strategy to correct unsuccessful conservation measures is substantially reduced. This statement also applies to plans covering multiple species, both listed and unlisted (Monroe 1997). Also, if take is permitted before the permit applicant implements mitigation measures, the incentive for effective mitigation is reduced. The Services recommend that mitigation habitat should be available before the applicant's activities commence. In some cases, however, the Services will allow the HCP applicant to conduct activities prior to the provision of replacement habitat. The Services find this practice acceptable as long as the HCP offers legal or financial assurances that the permit applicant will fulfill their obligations under the HCP. Such an assurance can be provided through letters of credit controlled by the government until the permit applicant establishes the mitigation lands (USFWS and NMFS 1996).

Because mitigation can be one of the most expensive steps in the development and execution of an HCP, the Services and applicants must determine the cost of the proposed measures, the source of funding, and the time period over which these funds will be available early in the HCP development stage. HCPs generally satisfy these criteria (Kareiva et al. 1999).

The importance of monitoring

The choice of mitigation measures is crucial for an effective program of adaptive management, yet biological monitoring comprises the heart of adaptive management practices. HCPs that do not include a monitoring program cannot be scientifically evaluated. As previously stated, adaptive management treats all HCPs as "learning laboratories" in which the underlying conservation hypotheses are tested against actual responses in the species population. Monitoring of these responses in order to adjust conservation strategies is indispensable (Barrows 1996). In addition, a precise trigger for mitigation adjustments, and procedures for accomplishing the indicated adjustment, need to be spelled out in the HCP agreement. The mere existence of monitoring is not a solution to data shortage unless it includes a quantitative decision-making process that links monitoring data to adjustments in management.

An adequate monitoring program requires the use of quantifiable indicators placed in a hypothesis-testing framework with a valid experimental design. Noss et al. (1997) recommend employing the following checklist when assessing the sufficiency of an HCP monitoring program:

1) *Is the monitoring program scientifically and statistically valid?* Monitoring need not be complex and expensive, just comprehensive.
2) *Does the program effectively test the success of the conservation measures?* The purpose of monitoring is to test hypotheses and inform management. Does the HCP allow for testing of hypotheses regarding effects of management practices on populations and other conservation elements of concern? Does it

allow for testing of alternative management treatments?

3) *Will the program provide timely analysis?* Does the plan include a mechanism for regular and timely analysis and review of monitoring data? HCPs should include specific timetables for analyzing and interpreting monitoring data in order to inform management decisions. Such a requirement assures that monitoring will not stop with the collection of information, but will include efforts to analyze and interpret it. Monitoring must also be time-sensitive to the life cycle of the monitored species.
4) *Is the HCP designed to be responsive to information derived from monitoring?* Can the plan be modified to take into account new information? An HCP that is "set in stone" and designed to avoid future surprises is inflexible and potentially places species and ecosystems at great risk. Since nature is dynamic and unpredictable, surprises will occur; it is a matter of whether we notice them. The sooner we notice them and take corrective action, the lower the risk to biodiversity. Therefore, plans should be evaluated as to how flexible they are to modification based on new information.

The principal criteria for determining the adequacy of a monitoring program should be its ability to evaluate the success of mitigation measures, and the consequent effect on protected species. Monitoring data should be incorporated into centralized databases to facilitate access to information on overall species status, and to facilitate assessment of cumulative impacts for specific plans (Kareiva et al. 1999).

Reviewers found that few HCPs have well developed and statistically valid monitoring programs (Noss et al. 1997; Kareiva et al. 1999). Typically, the Services offer little help to an applicant in constructing a scientifically defensible monitoring program. When monitoring is deficient, the essential goal of learning from experience is much harder to accomplish. Fortunately, the addendum in the Services' HCP draft handbook does propose to improve current compliance monitoring by requiring permit applicants to document completion of mitigation measures and their effectiveness in achieving conservation goals.

The Services require the applicant to demonstrate sufficient funds to conduct the activities listed in an HCP, including conservation measures, plan administration, and biological monitoring (USFWS and NMFS 1996). However, reviewers have found that sufficient funds for monitoring programs have not been designated for many HCPs. Without funding for the thorough biological monitoring essential to adaptive management, HCPs cannot be implemented in a scientifically credible manner. The conservation organization Defenders of Wildlife recommends that applicants be required to post a performance bond or other financial security before they are granted an incidental take permit, ensuring that funds will be available if a permit is revoked or if additional mitigation measures become necessary. Such measures would also protect the public if landowners become insolvent or otherwise terminate the agreement before mitigation steps are completed (Defenders of Wildlife 1998). Other commentators recommend establishing a federal trust to provide supplemental support in the event that landowners comply with the plan, but additional measures are needed to meet biological goals.

Applying the precautionary principle to HCP design

Inadequate information regarding a species' status, its habitat, and the type and magnitude of take that will occur during development activities appears to be endemic in HCP preparation. In their study of over 40 HCPs, Kareiva et al. (1999) reported that, for 25 percent of the species in the plans they reviewed, they could not determine whether there was currently enough habitat to maintain viable populations. (Kareiva et al. 1999). For only one-third of the species analyzed in this study were there enough data to evaluate what proportion of the population would be impacted by the proposed development. Clearly, data limitations make it difficult to determine the impacts of future habitat losses or alterations on the listed species.When baseline data are sparse, as is often the case for species covered in HCPs, it is difficult to design an effective and efficient conservation strategy with confidence. Thus, conservation biologists recommend that HCP conservation strategies should be guided by the traditional scientific method of experimentally proving or disproving testable hypotheses (Williams 1997).

The precautionary principle is another method for coping with incomplete or inadequate information pertinent to habitat conservation planning and is used in many environmental management fields. This principle is also employed in fields as diverse as engineering and economics, where decisions must be made despite uncertainty. The principle holds that, in the face of poor information or great uncertainty, managers should adopt risk-adverse practices (Williams 1997).

In the HCP arena, applying the precautionary principle means dealing with data deficiencies in a way

that guards target species from irreversible habitat loss, yet does not preclude development. The first step of the precautionary principle is to assess the sufficiency of available data. An inventory of this data and acknowledgement of gaps should be a routine requirement in the development of every HCP. Where necessary data are not available and cannot be practicably obtained, the planning process should proceed with caution commensurate with the anticipated risks and uncertainties. In extreme cases, an HCP should not be initiated or approved, for it would be wrong to call the HCP process scientific, or even rational, if it were not an option to halt the process in the absence of crucial information. Regarding the precautionary principle, Kareiva et al. (1999) counsel that:

- The greater the *impact* of a plan, the fewer gaps in critical data should be tolerated. For example, the data adequacy standard should be higher for irreversible activities such as, urban development. A lower data adequacy standard might be tolerated for activities with reversible impacts, for example, water diversions that are made conditional upon protection of aquatic habitat.

  A data scarcity on *impacts of take* should be handled by assuming a worst-case scenario when determining whether or not approval criteria have been satisfied.
- *Take* should be quantitatively assessed for large HCPs covering vast expanses of land.
- *Mitigation measures* should be implemented and assessed before take occurs where information is lacking to validate the effectiveness of mitigation.
- *Monitoring* needs to be very well designed in cases where the success of mitigation is unproven.
- *Adaptive management* needs to be a part of every HCP predicated on substantial data shortages; it is not just to deal with "unforeseen circumstances."

In sum, where critical information is scarce or uncertain, application of the precautionary principle counsels that resulting plans should adhere to the following recommendations: be shorter in duration, cover a smaller area, avoid irreversible impacts, require that mitigation measures be accomplished before take is allowed, include contingencies, and have adequate monitoring. All of these aforementioned principles should be enshrined in the HCP approval criteria in Section 10 of a reauthorized ESA. HCP Review and analysis to date has found that these corollaries of the precautionary principle have not been adequately applied in habitat conservation planning. In particular, HCPs based on a weak information base have tended to be of similar duration and extent as those based on more adequate information. Further, researchers have found that HCPs based on poor information tend to be *more* likely to include activities with irreversible impacts (Kareiva et al. 1999). These results suggest that HCPs are not generally structured to be more cautious in cases where applicants are working with large data gaps.

Alignment of regulatory assurance with adaptive management and HCP conservation performance

Regulatory Assurances: Controversial but Necessary

The Services are convinced that legal assurances are necessary to induce private rights holders to develop HCPs and to implement the conservation measures obligated therein (Thornton 1991). The increase in HCP activity in response to such assurances seems to confirm this assumption. Implicit in this belief is the fear that development will surreptitiously destroy or degrade endangered species habitats on non-federal lands and waters unless owners of these properties are induced to make conservation commitments. Although the ESA prohibits such development, its occurrence can readily overwhelm the Services' detection and enforcement capabilities. Essentially, regulatory assurances provide the necessary inducement for habitat conservation planning by exempting development activities from new or additional mitigation requirements beyond those committed in the HCP (Dept. of the Interior and Dept. of Commerce 1998). The major concern of the HCP performance reviewers is that such regulatory assurances can introduce rigidity in the conservation strategy that inhibits or precludes adaptive management. Through regulatory assurances, the property rights holder typically seeks release from further responsibility for species conservation, irrespective of the future population trends for the covered species.

Assurances are also controversial because they tend to shift to the species the risks associated with our imperfect knowledge about how complex biological systems respond to human interventions. The practice of conferring assurances without regard to the quality or duration of the conservation plan exacerbates these risks (Defenders of Wildlife 1998).

Currently, the Services provide the "no surprises" guarantee, a form of regulatory assurance. This policy can be traced back to a House of Representatives Committee Report on the

1982 Amendments to the ESA (H.R. Rep. No. 97-835). In the event an unlisted species is listed after permit issuance, the report stated: "no further mitigation requirements should be imposed if the [HCP] addressed the conservation of the species and its habitat as if the species were listed pursuant to the Act." The report also stated that "circumstances and information may change over time," and that the original plan might need to be revised. To address this situation, the Committee "expect[ed] that any plan approved for a long-term permit [would] contain a procedure by which the parties will deal with unforeseen circumstances."

Today, the "unforeseen circumstances" clause is interpreted such that landowners are not responsible for listed species' decline if it is attributable to events that the landowner could not have foreseen when the plan was approved (USFWS and NMFS 1996). The Services formally adopted the policy as an agency rule on February 23, 1998.

The "no surprises" policy has had a dramatic affect on the public's perception of ESA. It has muted political concern that the ESA is unworkable and too stringent (Baur 1997). Yet, the policy has no shortage of critics, the harshest of whom are conservation biologists. Some of the outstanding issues that biologists find problematic include the following:

- *Unforeseen circumstances.* The rule distinguishes between "unforeseen circumstances," or events that could not reasonably have been anticipated, and "reasonably foreseeable changes in circumstances," including natural catastrophes that normally occur in the area. HCPs need address only the latter; unforeseen circumstances do not impose any conservation burdens on the applicant (USFWS and NMFS 1996). Thus the rule requires contingency planning only for stochastic events instead of the more likely failure of mitigation measures to work as "foreseen" or anticipated, such as the common circumstance in which the HCP is implemented as agreed, but species decline nonetheless. The risk of such unforeseen events dramatically increases for HCPs that last several decades, cover large areas, and cover many species. Examples of such HCPs include housing developments or timber harvesting.

  Yet, the plans for long-term construction or operation activities contain the same assurances as short-term, single species plans. In the event the Services make a finding of unforeseen circumstances, they can take additional actions at their own expense to protect the species, provided that they have the financial means appropriated by Congress to do so, and provided that the affected landowners agree to cooperate. Curiously, in an era where the Services are only able to meet a fraction of their statutory responsibilities (EDF 1996), they maintain that they have "significant resources" to provide additional protection for listed species subject to an HCP (DOI Doc). The Services also have expressed confidence that many landowners would willingly consider additional conservation on a voluntary basis. Given the wealth of evidence to the contrary, however, further explanation of this assumption is warranted.

  In addition, the threshold for declaring that circumstances are unforeseen, (for example, that the Services can undertake additional conservation measures at their own expense and with the permission of the landowner), is unrealistically high. Under the current rule (DOI Doc), the Services "have the burden of demonstrating that unforeseen circumstances exist, using the best scientific and commercial data available. The findings must be clearly documented and based upon reliable technical information regarding the status and habitat requirements of the affected species." This rule includes many specific factors that the agency must consider in determining whether it has demonstrated that unforeseen circumstances exist.
- *Adaptive management.* Conservation biologists worry that the "no surprises" policy falsely assumes that we can predict all the consequences of implementing a particular HCP. Under current policy the Services cope with gaps in biological data by either denying the application for a take permit or by requiring the applicant to build an adaptive management program into the HCP (DOI DOC). The policy does not, however, address a situation in which newly obtained data indicate that a change in the conservation strategy is required to achieve conservation goals. If the "no surprises" policy precludes plan modification in response to new information, failures to attain conservation goals are inevitable (Noss et al. 1997).
- *Regulatory assurances for conservation measures covering nonlisted species.* While the ESA does not require landowners to protect unlisted, but declining species on their lands, the Services encourage landowners to "address" any unlisted species in an HCP by conferring additional regulatory guarantees that further mitigation will not be required if such species is later listed.

A good example of the risks posed to unlisted species that are included in an HCP can be found in

the Plum Creek timber plan in the Cascade Mountains of Washington State. The Plum Creek plan allows the take of four species currently protected by the ESA: northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), grizzly bear (*Ursos arctos horribilis*) and gray wolf (*Canis lupus*). The HCP also addresses another 281 unlisted vertebrate fish and wildlife species. The planning area of 419,000 acres provides habitat for 77 mammal, 178 bird, 13 reptile, 13 amphibian, and 4 fish species (Plum Creek 1996). Even though Plum Creek's measures to protect these species include wider riparian buffers and greater wetland preservation than would be required under state forest practice rules or water protection laws, these same conservation commitments will hold far into the future regardless of whether one or many of these species need further protection.

San Diego County's large-scale Natural Communities Conservation Program (NCCP) management plan is another example of how local government and developers in compliance with this program are shielded from providing additional commitments of land or money for conservation purposes. Such regulatory assurances apply to some 85 listed and unlisted species and may be applied to additional species in the future if signatories to the NCCP agree that the species are "adequately conserved" by the plan (Mueller 1997).

If adequately addressed in an HCP, unlisted species could be protected from further decline and could avoid listing, thereby guaranteeing that the landowner will not be subject to further mitigation (Defenders of Wildlife 1998). Unfortunately, establishing conservation requirements for unlisted species is difficult since little is known about species' requirements. As a result, an applicant must be willing to invest in further biological studies to ensure that the HCP adequately covers unlisted species. In this case, a critical issue in HCP development is the early identification of those species or biological communities that the plan is to cover, and the Services' determination that enough is known about the species to enable HCP proponents to construct an effective conservation plan (Thornton 1991).

Reforming Assurances

Given the importance of regulatory assurances to create an environment in which non-federal property rights holders will make commitments to conserve habitat, we must explore options that do not shift risks to the vulnerable species. Adaptive management allows a flexible response

Habitat Conservation Planning...

Performance reviews of habitat conservation planning during its first 15 years reveal substantial opportunities to restructure the process, thereby improving it for both imperiled species and nonfederal property rights holders. These benefits can be accomplished without amending the statutory framework, although a modest "tune-up" of the ESA would help enable these reforms. A marked change in the federal administration of this program and a substantial increase in federal investments in habitat conservation planning are essential. Following are the major points that have been addressed in this three-part series.

1) **Shaping individual HCPs to contribute to a landscape-scale, bio-regional conservation strategy. Responsibility for developing bioregional conservation strategies would fall to either the federal Services or units of government at the state or local level. Increased involvement of government would shift much of the burden of gathering adequate scientific data onto the public sector as well as allow for more involvement by independent scientists and the interested public. The creation of landscape-scale HCPs would define conservation objectives and strategies to which smaller, parcel-specific HCPs would be expected to conform. In addition, eco-regional planning would facilitate a more equitable distribution of responsibility for conservation between federal and nonfederal rights holders.**

2) **Aiming bio-regional conservation strategies at species recovery. The only biologically defensible goal for habitat conservation planning is the recovery of the endangered species. The federal government can advance recovery by managing public lands and waters to a higher conservation standard than the legal *minima*. Recovery would also be advanced incrementally by habitat acquisitions or restoration actions that more than offset the habitat losses (for example, mitigation measures that create a net biological benefit). Where species recovery requires a greater conservation effort by the individual rights holders than is imposed by the current legal standard of avoiding jeopardy, federal resources may be necessary to close the gap. For instance, the highest-value habitats may be purchased from willing owners.** ***(continued next page...)***

that improves as results are monitored. Adaptive management, however, requires a fundamental change in the way the regulatory assurances are structured so that HCPs remain flexible and contingent rather than immutable, as they are now. One solution lies in converting the assurance package from regulatory immunity to regulatory indemnity. Under regulatory indemnity, further conservation strategies or restrictions could be implemented by the Services if the monitoring program indicated that the species would continue to decline without intervention. The costs for such intervention would not be borne by either the Services or the property rights holder but, instead would be paid from a compensation fund.

The use of regulatory indemnity in the HCP process is analogous to risk insurance in that it converts the problem of how to allocate the risks associated with the biological uncertainties of HCPs to the problem of how to allocate the costs of funding the indemnity pool and how to determine eligibility for compensation. The compensation pool could be funded from "premiums" contributed by the "beneficiaries," a category that includes both HCP applicants and the public at large. Indeed, most commentators recognize that the general public will have to bear some, if not most, of the costs involved in adaptive management. This trend is already becoming evident in the California Central Valley water system, the Everglades, and other aquatic ecosystems.

Thornton (1991) notes that biological risks to economic development are not different in kind from the myriad of other risk factors for which an industry is covered through insurance to provide the necessary certainty required by capital markets. In the construction industry, for instance, parties do not argue about the need to provide certainty since they know from experience that surprises are to be expected; rather, they figure out how to minimize the risks and provide sufficient security to afford the lender comfort to finance the project. Accordingly, reducing the financial risks associated with land development under the ESA should lead to more favorable interest rates for development loans. Thus, there is potential to fund a portion of the compensation pool through reducing the costs of debt service for insured development projects. Such a notion is based on the premise that an indemnity arrangement will reduce the risks of development under the ESA.

As discussed in the second article of this series, another suggested reform in regulatory assurances would calibrate the duration or rigor of the assurance to the quality or expected performance of the HCP's conserva-

Special Series Summary

3) Reserving the decision on participation in the HCP negotiations for the Services rather than the permit applicants. If the Services act as "gatekeeper" to the HCP negotiations, highly qualified independent scientists and other representatives of the public interest can be included in what is now often a closed process. Scientific experts should be allowed to "intervene" in HCP negotiations on behalf of local communities and conservation interests to help shape a conservation program from its formative stages. Habitat conservation plans developed with the input of independent scientists are more likely to succeed in their conservation goals, thus diminishing the chances that the Services will need to revise development permits. Through innovative tools such as the HCP Resource Center, which NHI is initiating, all stakeholders can enjoy the benefits of expert scientific input in the HCP negotiation process without the proponent absorbing the cost.
4) Incorporating adaptive management routinely in HCPs. This form of management entails including in the chosen conservation strategy a process for structured learning and adjustment that will improve the conservation venture's prospects for success. If coupled with an insurance arrangement, necessary adjustments can be accomplished without financial risk to the permit holder, thereby reducing regulatory risk more effectively than the current "no surprises" assurance, which, in any event, may be legally infirm in the event of imminent extinction of a target species.

Through their continued support for the ESA and other environmental protection laws, the American people have affirmed their unwillingness to tolerate preventable extinctions. Habitat conservation planning must be made to work better in the interest of all stakeholders. Experience to date illuminates some of the pathways for better performance. It is time to harness these lessons and chart a more certain course.

tion strategy. Under this approach, the scope or duration of the regulatory assurance would depend on the magnitude of the HCPs contribution to the target species' recovery. Plans that confer a net survival benefit would receive longer and more comprehensive guarantees than those that simply maintain the current population level, or allow for some decrease. Similarly, plans for which the underlying data and analyses are judged to be superior would be entitled to superior guarantees. Stronger, more comprehensive, or longer-term assurances would be reserved for HCPs that have the following features: recovery goals, an effective monitoring and adaptive management program, and an effective enforcement mechanism in the event that the commitments in the HCP are not honored.

Conclusion

Conservation decisions inevitably must be made with incomplete or imperfect scientific information. Reviewers of HCPs have recommended that, to reduce risks to species stemming from this uncertainty, plans should incorporate adaptive management and the precautionary principle. Adaptive management is not necessarily incompatible with regulatory assurances; however, the current no surprises policy should be modified to give plans greater flexibility and resources to respond effectively to the information provided by monitoring programs.

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FOCUS ON NATURE™ *by Rochelle Mason*

The MASKED BOBWHITE (*Colinus virginianus ridgwayi*) is an 9 to 11-inch medium-sized quail. The cock chooses a nesting site for the hen's approval, helps her build the nest, and also presents her and the precocial chicks with food. Coveys of up to 20 individuals form after the summer breeding season. They sleep in tight circles on the ground with each bird facing outward. If charged, they fly in all directions confusing the predator. Inhabiting grasslands with scattered small trees and shrubs, this endangered subspecies feeds primarily on seeds but also eats insects when available. Adoption of captive-reared chicks by wild Texas bobwhites has helped establish populations in the Buenos Aires National Wildlife Refuge in southwestern Arizona. Your donation of time or money to nature conservation organizations will help adoption programs and save habitat.

Endangered Invertebrates: The Case for Greater Attention to Invertebrate Conservation

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Abstract

Invertebrates eclipse all other forms of life on Earth, not only in sheer numbers, diversity, and biomass, but also in their importance to functioning ecosystems. Invertebrates perform vital services such as pollination, seed dispersal, and nutrient recycling. Although invertebrates are vitally important, they are often overlooked in management decisions, especially in management for endangered species. One indicator of the low emphasis on invertebrates is the lack of invertebrates included in both worldwide and U.S. endangered species programs. A review of current U.S. Endangered Species Act listings and policies show that this endangered species program is biased toward vertebrates. We believe there is compelling evidence that agencies, scientists, conservationists, and land managers should do more to promote the conservation of imperiled invertebrates. We briefly outline the steps that need to be taken to protect invertebrates and detail butterfly farming and a pollinator protection campaign as two possible ways to protect and restore invertebrate diversity and habitat.

Introduction

Although invertebrates are often overlooked and ignored, they eclipse all other forms of life on earth, not only in sheer numbers, diversity (number of species), and biomass (dry weight), but also in their importance to functioning ecosystems. The group includes an amazing array of organisms, including dragonflies, snails, bees, worms, sea urchins, mayflies, spiders, centipedes, scorpions, worms, starfish, clams, and lobsters. A review of the Endangered Species Act (ESA) and international endangered species lists shows government agencies need to do more to promote invertebrate conservation.

Invertebrate diversity and biomass

The animal kingdom has just over a million scientifically described species categorized into 32 phyla. The phylum Arthropoda (insects, spiders, crustaceans, millipedes, and centipedes, among others) has an estimated 1,085,000 identified species, or 82 percent (Table 1, Figure 1) of the total identified animal species, and with all other invertebrates (excluding viruses and bacteria) the number reaches 1,238,000 or 94 percent (UNEP 1995). The phylum Chordata, which includes all fish, birds, and mammals, contains around 45,000 (3%) species of which only 4,000 (0.03%) are mammals (UNEP 1995). It is estimated that 5 to 8 million insect species have not been identified or discovered (Figure 2), while only 5,000 to 10,000 species of Chordates may await discovery and description (UNEP 1995). Certain marine taxa, particularly small benthic organisms, are nearly as poorly known as terrestrial arthropods, suggesting that we have also greatly underestimated oceanic species diversity of invertebrates (Murphy and Duffus 1996).

Invertebrates are also the undisputed heavyweights of the planet (Figure 3). In the oceans, zooplankton and shrimp-like krill develop vast surface blooms of incredible mass. In the U.S. the biomass of earthworms and arthropods is estimated at 1,000 kg/ha, while the comparative biomass of human beings and all other terrestrial vertebrates is just 36 kg/ha (Pimentel 1980). If the weight of all land animals is summed, arthropods comprise over 85 percent of the total (Wilson 1992).

Invertebrates' importance to functioning ecosystems

The sheer number and mass of invertebrates reflect their enormous ecological impact. Admittedly, some have a negative impact on humans, either by harming us directly (as disease agents) or attacking food crops, tree plantations, and livestock. Even so, all adverse effects combined are insignificant compared to invertebrates' beneficial actions. Invertebrates are a part

of nearly every food chain, either directly as food for other insects, fishes, amphibians, reptiles, birds, mammals, and other arthropods (Gilbert 1980), or indirectly as agents in the endless recycling of soil nutrients. Insects, worms, and mites are extremely important in helping microbes break down dung and dead plant and animal matter. Invertebrates are thought to decompose 99 percent of human and animal waste (Pimentel 1980). The perpetuation of food webs is often dependent on critical species performing essential services such as pollination or seed dispersal (Dodson 1975). Invertebrates, particularly native bees, pollinate most human food crops, and most other plant species. In the U.S., approximately 90 agricultural crops are cross-pollinated by insects (Pimentel 1980).

Some invertebrates are keystone species, playing particularly important roles in maintaining biotic communities (Kellert 1993). Coral reefs, providing a wide range of niches for a diversity of plants and possibly one-third of all fish species (Goreau 1979), serve as perhaps the most dramatic example of a keystone species. There are dozens more examples of how invertebrates benefit ecosystems and humans as natural biological control, food (such as lobster and shrimp and the many insects consumed by different cultures), and as potential cures for human disease. Without insects most of the terrestrial life forms on this planet would quickly disappear (Wilson 1992).

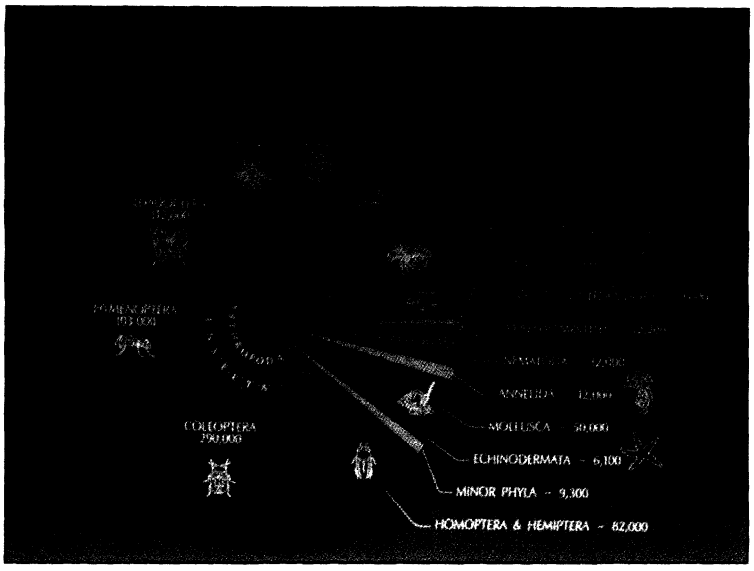

Figure 1. Total number of animal species (© E. O. Wilson 1988, reproduced with permission).

Invertebrate endangerment

Wilson (1992) believes that we are in the sixth great extinction spasm in the history of the world, with a 20 percent extinction of total global diversity a strong possibility by 2022 if the present rate of environmental destruction continues. One unappreciated aspect of this mass extinction is its concentration among invertebrates.

In 1987, West Germany classified 34 percent of its 10,290 insect and other invertebrate species as threatened or endangered; in Austria this figure was 22 percent of 9,694 invertebrate species (Wilson 1992). More recent figures for Great Britain (DETR 2001) show that 10.8 percent (1,578 species) of its 14,634 insects species are rare, vulnerable, or endangered. Many unpublicized scientific observations indicate that marine biodiversity is also severely threatened (Murphy and Duffins 1996). Many, if not most, of the threatened marine species are undoubtedly invertebrates.

Freshwater bivalves, for instance, are among the most endangered groups of organisms in North America (Mulvey 1997). The US freshwater mollusk fauna, especially rich in mussels and gill-breathing snails, is the largest in the world. Also, it is better studied and recorded than most invertebrate taxa. The species of this fauna have been steeply declining in numbers from the damming of rivers,

Table 1. Partial classification of select animal Phylum (modified from UNEP 1995).

ANIMALIA	1,320,000
MESOZOA	
METAZOA	1,320,000
Porifera (sponges)	10,000
Cnidaria (hydras, jellyfish, corals, etc)	10,000
Platyhelminthes (flatworms)	20,000
Nematoda (roundworms)	25,000
Echinodermata (sea uchins, etc.)	6,000
Choradata (fish, birds, mammals, etc.)	45,000
Arthrododa (crabs, spiders, insects, etc)	1,085,000
Mollusca (snails, squids, etc)	12,000
Annelida (segmented worms)	12,000

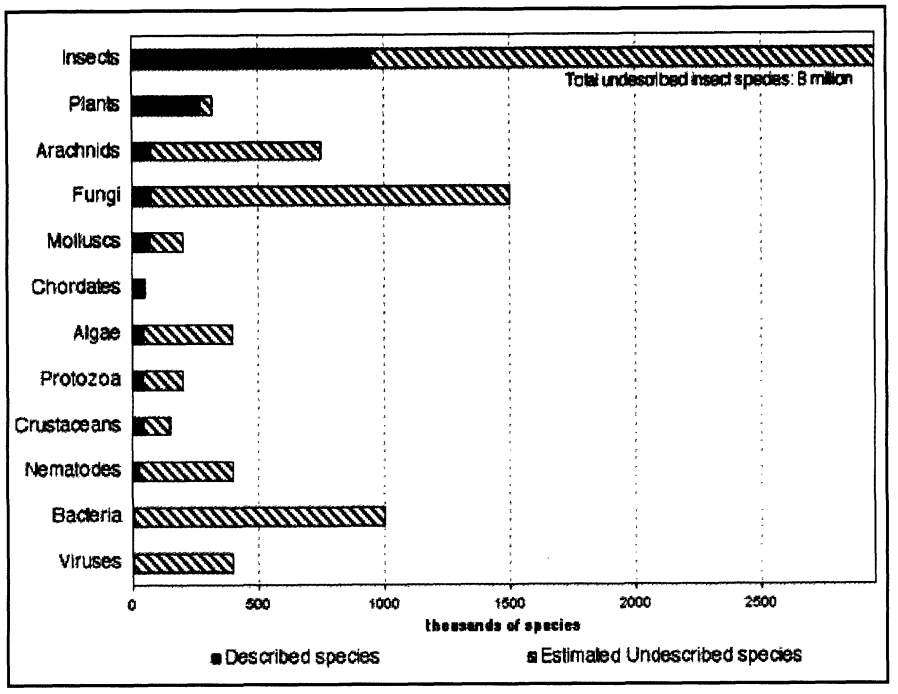

Figure 2. Numbers of described species and conservatively estimated existing species for major groups of organisms expected to contain in excess of 100,000 species. Vertebrates are included for the comparison. Note that the shaded proportion for Chordates does not show up on this graph because the estimated non-discovered species are only 5,000. Note also that the shaded portion of the bar for insects is truncated so as not to imbalance the diagram, and the length of the undescribed species portion is particularly speculative for the various groups of micro-organisms.

pollution, and introduction of alien mollusks and other aquatic animals. At least 21 mussel taxa (7% of the fauna) are presumed extinct throughout their ranges (Williams and Neves 1995). Imperiled species account for 48.5 percent of freshwater mussels, 22.8 percent of freshwater gastropods, and 32.7 percent of crayfishes in North America (Ricciardi and Rasmussen 1999). The combined effects of impoundment and pollution alone extinguished two genera and 30 species of gill-breathing snails in the Tennessee and Cossa Rivers (Wilson 1992).

We may never know how many invertebrate species are at risk. The true impact of extinction on invertebrates is hard to quantify, partly because endangered species documentation is biased in favor of vertebrates. According to the 2000 IUCN (International Union for the Conservation of Nature and Natural Resources) *Red List of Threatened Species*, 375 invertebrates are listed as extinct, and 757 are listed as critically endangered or endangered. In comparison, 318 vertebrate species are listed as extinct and another 1,521 are listed as critically endangered or endangered (IUCN 2000). The IUCN list of critically endangered or endangered species contains only one Arachnid, even though there are 75,000 known species. Only 33 percent of the endangered species on the red list are invertebrates, yet they make up more than 94 percent of global animal diversity.

The disparity is also apparent in a statistics summary of the US Fish and Wildlife Services (USFWS) Threatened and Endangered Species System (TESS). Currently, only 37 percent of U.S. animal species listed as endangered are invertebrates and only one percent of listed foreign endangered species are invertebrates (USFWS 2001).

Invertebrates and the ESA

The ESA has always treated vertebrates more generously than it does invertebrates. Insects are singled out as the only group that cannot be protected if a particular species is determined by the Secretary of Agriculture to be an agricultural pest. This provision has never been used, as any serious pest would not likely be an endangered species. Whereas the ESA authorizes the protection of species, subspecies, and "distinct population segments" of vertebrates, only species and subspecies of invertebrates may be protected. This provision was a compromise between the House of Representatives and the Senate in 1978 after the House voted to eliminate protection for invertebrates altogether (Bean 1993).

Out of 31 species removed from endangered status only two are invertebrates. The first insect officially listed, the Bahama swallowtail butterfly (*Heraclides andraemon bonhotei*), was taken off the list because of an ESA amendment (it was determined to be only an occasional stray in the US and the authority to protect discrete invertebrate populations was ended by the 1978 amendments to the ESA). Sampson's pearlymussel (*Epioblasma sampsoni*) was also taken off the list because it went extinct. Unlike the American alligator and the brown pelican success stories, no insect has been taken off the list because its populations have recovered. Only one species, the Louisiana pearlshell (*Margaritifera hembeli*), has been downlisted from endangered to threatened in the last ten years.

Currently, TESS contains 103 animal species that are considered candidates for endangered or threat-

ened species status, 92 (89%) of which are invertebrates. According to the USFWS, candidate taxa are those for which the Service has on file sufficient information to support issuance of a proposed rule to list under the Act. Designating a species as a candidate taxon does not give it any legal protection under the ESA; protection begins only when a species is formally designated as threatened or endangered. Often these species remain in limbo for years (Suckling pers. comm. 2000) and sometimes go extinct while waiting for formal designation. In 1995 three pomace flies (*Drosophila* sp.) from Hawaii went extinct while on the candidate list (USFWS 1997). The Marianas euploea butterfly (*Euploea eleutho*), an endemic to the Mariana Islands, met the same fate (USFWS 1997). No comprehensive survey has been completed to determine how many species have gone extinct while on the candidate list, and it is likely that many more have disappeared unnoticed.

In the 1990s, many invertebrates (as well as plants and other animals) that might have warranted listing were dropped from consideration. In the 1980s and early 1990s, TESS contained over 1,200 invertebrates and 570 vertebrates on the candidate list. The candidate list consisted of three categories: C1 = sufficient information on hand to list, C2 = appears to need listing, additional information required, and C3 = taxonomic uncertainty. In 1994, the Clinton Administration dropped all C2 and C3 species from the list, including over 1,100 invertebrates.

Although there is no significant difference of the median population size at the time of listing between vertebrates and invertebrates (Wilcove et al. 1993), invertebrate species may be more vulnerable to extinction than listed vertebrates because their smaller body size and shorter individual lifetimes may make them more vulnerable to environmental fluctuations (Murphy et al. 1990). Thomas (1990) suggests that to ensure comparable viability, populations of rare insects should be at least one order of magnitude greater than populations of vertebrates.

Some scientists believe that recovery plans are biased toward vertebrates (Murphy 1991), and other analyses of recovery plans have showed that, with few exceptions, a taxonomic bias has favored vertebrates. It was detected in the recovery process that a higher percentage of vertebrates than invertebrates had approved recovery plans (Tear et al. 1995). There is also a striking contrast between expenditures for invertebrates when compared to vertebrates. In fiscal year 1991, state and federal agencies combined spent an average of $1.1 million for each bird species listed, $684,000 for each listed mammal species, and only $44,000 for each listed invertebrate species (Bean 1993).

Some of the apparent neglect of invertebrates may be because we know a lot less about individual invertebrate species than we do about most vertebrate species. Apart from the relatively few invertebrates that do significant economic damage or that have significant economic value, there has been relatively little research completed on insect ecology.

Regardless of the reason, environmental policy often overlooks invertebrates despite their staggering importance, and despite the catastrophic loss of so much invertebrate life. The general public also seems largely unaware of invertebrates' potential impact on human well-being. Many in the general public view invertebrates with aversion, fear, avoidance, and ignorance (Kellert 1993). Scientists, and to a lesser extent conservationists, have more favorable attitudes toward invertebrates (Kellert 1993), but still favor vertebrate over invertebrate species in research, education, and conservation action.

Causes of endangerment

The causes of invertebrate endangerment is similar to many other animals. According to the IUCN, the leading causes of both vertebrate and invertebrate endangerment include habitat destruction,

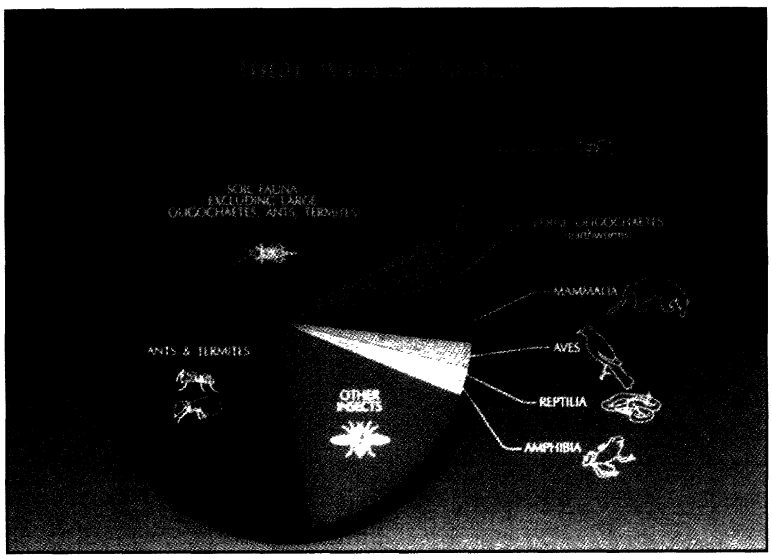

Figure 3. Total animal biomass, as measured in a plot near Manaus, Brazil (© E. O. Wilson 1988, reproduced with permission).

displacement by introduced species, alternation of habitat by chemical pollutants (such as pesticides), hybridization with other species, and over-harvesting (Wilson 1992).

Many insect species are vulnerable because their populations have a severely restricted distribution, often just a single locality. The giant flightless darkling beetle (*Polposipus herculeanus*), for instance, lives only on dead trees on the tiny Frigate Island in the Seychelles. The Socorro sowbug (*Thermosphaeroma thermophilum*), an aquatic crustacean that has lost its natural habitat, survives in an abandoned bathhouse in New Mexico (Wilson 1992). Although freshwater and land mollusks are sometimes widespread species, they are generally vulnerable to extinction because so many are specialized for life in specific habitat conditions and are unable to move quickly from one place to another (Wilson 1992). As a result, isolated populations are highly susceptible to change. For instance, invasive introduced species are a significant problem for many Hawaiian species, including tree snails. In contrast, other species, such as the monarch butterfly, migrate great distances but still face an uncertain future.

Rare insect species often have subtle habitat requirements and have even been lost from reserves as a result of apparently minor habitat changes (Thomas 1995). The large blue butterfly (*Maculina arion*) larvae is an obligate parasite of red ant (*Myrimica sabuleti*) colonies. Accordingly, in 1979 this butterfly went extinct in England because plant communities were not managed for the ants. (The large blue has subsequently been successfully reintroduced to appropriately managed sites in England using a subspecies from Sweden.) Studies of some European grasslands showed that areas not grazed or reforested harbored significantly higher butterfly species richness and heterogeneity, and hosted more Red List species, than grasslands in the early successional stages (Balmer and Erhardt 2000). Old-growth forests in temperate zones also have higher invertebrate diversity than younger stands (Schowalter 1989). Tropical rain forests, however, may hold the majority of terrestrial invertebrate diversity (Wilson 1992). With rainforests and temperate old growth forests around the world being lost at a rapid rate, invertebrates are bound to go with them.

What should be done to protect invertebrates?

Detailing a precise conservation plan for invertebrates would take volumes. The widespread destruction of the earth's biodiversity occurring today must be matched by a conservation response on an order of magnitude greater than that which currently exists. Ultimately, the key to protection of any species is protecting its habitat. Many scientists advocate community–level conservation for non-charismatic taxa. Moreover, community-wide studies appear to offer a practical way to gather information about the diversity and distribution of little known taxa (Hughes 2000). We should move forward with the gathering of information wherever possible. Although protecting whole communities is a valid scientific approach, one of the best methods for protecting species—the ESA—is based on species rather than ecosystem conservation.

Habitat protection

Large swaths of land designated as wilderness, protected for wide ranging species, or set-aside in conservation easements will ultimately benefit invertebrates. Some invertebrates only need small areas to thrive, and indeed backyard gardens can help some pollinators. Working in other countries to protect nature reserves or to protect butterfly and other insect habitat is also a valid approach. In addition, habitat needs to be protected for marine species. We need marine reserves managed for these species, not marine reserves where commercial fishing and other destructive activities are allowed, as is often the case now.

Status reviews and listing petitions

The formal listing of species as threatened or endangered under federal or state endangered species legislation, as sensitive or indicator species under U.S. Forest Service National Forest Management Act regulations, or even under lists from nongovernmental organizations such as IUCN, has been an extremely effective habitat protection tool. Groups and individuals should work to protect invertebrates as well as more charismatic megafauna and ensure that agencies and land managers realize the importance of conserving invertebrates. In some cases, legal action may be needed to ensure that federal agencies follow laws, such as the ESA.

Research

Before we can work to protect some invertebrates we need to at least know if populations are stable or declining, and we need to understand their habitat needs. Many invertebrates have not even been identified. In the long run, more emphasis needs to be placed on invertebrate systematics and taxonomy so that these species can be identified and cataloged. Research needs to go hand in hand with conservation, for there is little use for a catalog of extinct species.

Education

Successful conservation of invertebrates requires a greater understanding by the general public, scientists, land managers, and conservationists of the extraordinary value that these organisms provide. It is unlikely that very many people will develop affection or an affinity for these animals, but it is plausible that a more compelling depiction of invertebrates' extraordinary contributions to human welfare and survival will do much to improve the public attitude toward these organisms (Kellert 1993). An ambitious public education program is needed to enhance the recognition of invertebrates' positive values, and indeed, of all biological diversity.

Case studies in invertebrate conservation

There are many innovative and successful conservation programs implemented by conservation organizations around the world that focus on invertebrates. Below we outline two major programs with which the Xerces Society has been involved.

Butterfly farming

People who live in the cradle of a country's natural resources, given sufficient incentives to conserve, can be (and often already are) allies—not adversaries—in sustainable natural resource management (UNEP 1995). Conservation-based butterfly farming—more accurately, ranching—can be a successful means to protect and conserve critical habitat for threatened species wherever tropical forest butterfly habitats remain intact, and where live butterfly export is legal. The tropical forests of Central and Latin America, the Philippines, Madagascar, Kenya, Malaysian Borneo, Jamaica, and Indonesian Iryan Jaya meet these criteria. Butterfly ranches can offer a sustainable means of economic development that is based on the wise use of forest resources and on the long-term prosperity for the ranchers.

We differentiate between butterfly farming and ranching in this article. According to CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) farming operations are essentially closed systems that are no longer dependent upon regular infusions of wild stock to produce successive generations in captivity. Ranching operations, however, are open-ended operations, depending upon a regular and recurrent infusion of wild stock (such as by harvesting early instar larvae in the wild, and then growing them in controlled environments). Using CITES terminology, butterfly ranching is preferable to farming because the viability of ranching efforts depends upon the continued availability of wild habitat from which to take the needed stock. This assumes, of course, that any harvest from the wild is sufficiently controlled so as not to be excessive.

Butterfly ranching utilizes any buffer zone adjacent to secondary or primary forests, and the forests themselves. It combines village economic development with education about basic biology, ecosystem dynamics, and sustainable management practices. The ranchers quickly understand the importance of their local biological diversity, especially plants and insects, and become protective stewards. Thanks to an intact forest, their butterfly breeding stock is close at hand, derived from wild, genetically vigorous populations. The larval food plants that attract the egg-laying females and feed the caterpillars are also easily accessible, as are the blooming nectar plants that lure the mating adults to the ranches. As ranchers obtain root cuttings from plants locally, they propagate live "fuel" for pupae production. The nearby forest provides the raw materials for their business, and its regenerative powers become highly important.

Butterfly ranching is a sustainable, ecologically responsible cottage industry. The market for live butterfly pupae is a robust one. Exhibits displaying exotic, live, tropical butterflies and plant communities within huge glass exhibit houses are tremendously popular. There are at least 140 butterfly houses located throughout the world in Asia, Australia, New Zealand, Canada, and Europe, and more than 60 in North America. These are lucrative enterprises, with admissions in the U.S. ranging from $6.50 to $18.95. Two million people a year tour the butterfly house at the San Diego Wild Animal Park. The large US exhibits budget as much as $100,000 or more annually for butterfly livestock.

The well-being of people who live on the edges of tropical forests is a prime factor in determining whether those areas are maintained and conserved, according to conclusions reached during the United Nations Rio de Janeiro Conference on Sustainable Development in 1992 (UNEP 1995). Butterfly ranching can be a sustainable economic development tool if there is sufficient in-country support. With skilled scientific direction, it can also directly conserve and regenerate butterfly species on the brink of extinction.

The Xerces Society and Zoological Society of San Diego have been partners for five years in a butterfly ranching pilot project. The goal was to establish an income-producing cottage industry that would be sustainable, ecologically responsible, enhance protection of surrounding habitat, provide education in the natural sciences, and, if possible, involve school-age

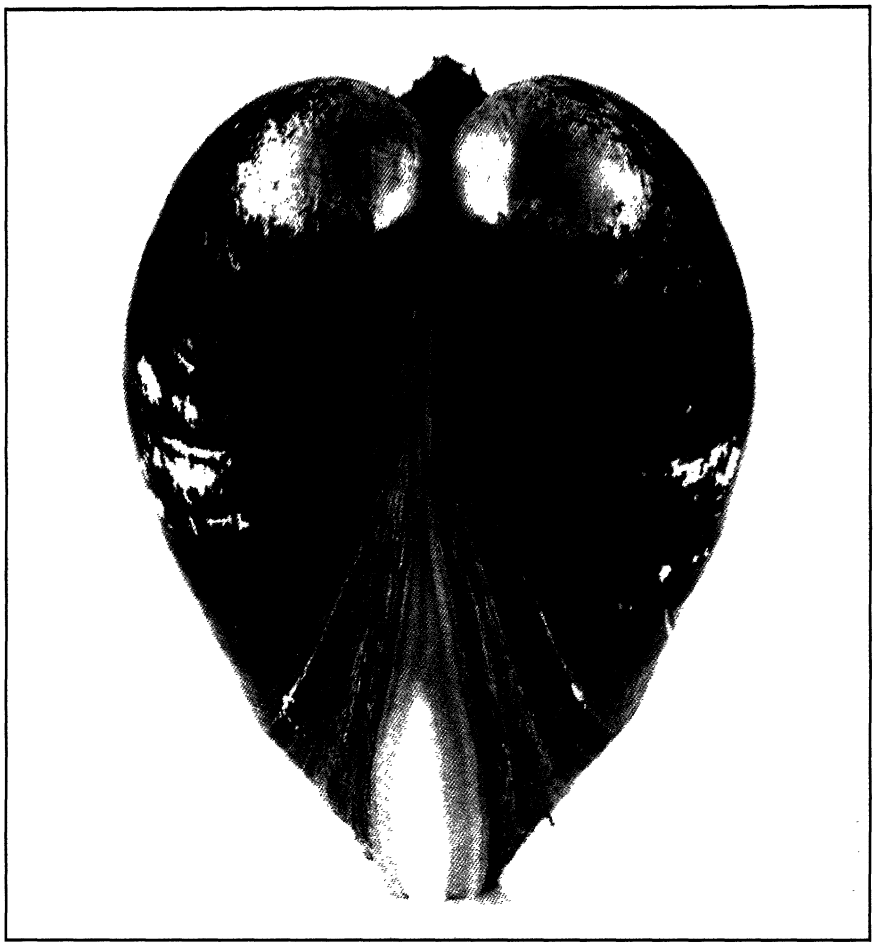

Figure 5. Listed as endangered in June 1976, there are nine known populations of fat pocketbook pearly mussels (Potamilus capax), confined to two river systems in Arkansas and Indiana. Dam building, dredging, and agricultural chemical runoff threaten these populations in their habitat of slow-moving rivers. Photo reproduced with permission of Susan Middleton and David Liittschwager (1994).

children. Barra del Colorado, a village in northeastern Costa Rica near the Nicaraguan border, was chosen because of its spiraling economic problems. This operation, employing women farmers whose children also participated, was highly successful as long as the U.S. organizations were providing on-site management six months of the year. The women lacked the requisite training and skill to deal with the complexities of management; thus, without the presence of on site managers, they lost motivation for the project. The lesson learned is that trained, in-country advisors must be secured at the outset, and be regularly available over time to help with management, exporting, and the personal relationships between the producers.

The Xerces Society has produced a publication to provide guidance: *A Handbook for Butterfly Farmers.* (Please contact one of the authors of this article for more information on this book.)

Pollinators

Pollinators are often considered keystone species as their presence in an ecosystem ensures the continued reproduction and survival of plants, and in turn the other wildlife relying on these plants. Data on at-risk invertebrate pollinator species is lacking; however, there is mounting evidence of the decline in pollinator insects (Allen-Wardell et al. 1998). Also, concern about the potential impact of this decline on both wild lands and food production is on the rise (Buchmann and Nabhan 1996; Kremen and Ricketts 2000).

Bees, the dominant group of pollinators, face a similar series of threats as most other wildlife, especially loss of habitat to development and agriculture. In addition, bees are susceptible to fragmentation of habitat (Westrich 1996), resource competition from non-native species (Buchmann 1996; Thorp 1996; Roubik 2000), and use of pesticides (Sipes and Tepedino 1995). Despite their critical importance, few pollinator insects—including just one bee, Franklin's bumble bee (*Bombus franklini*)—get any official protection in the U.S., and then often only as Species of Concern at the state or federal level.

In 1998, a group of pollinator scientists developed recommendations for conserving pollinators (Allen-Wardell et al 1998). These recommendations were endorsed by numerous conservation organizations and professional societies. The recommendations include the following:

- Increasing attention to invertebrate systematics, monitoring, and reintroduction as part of habitat management and restoration plans;
- Assessing effects of pesticides, herbicides, and habitat fragmentation on wild pollinator populations;
- Including seed monitoring, and fruit set and floral visitation rates in endangered plant management and recovery plans;
- Including habitat needs for vital pollinators in the critical habitat designations for endangered plants;
- Identifying and protecting floral

reserves near roost sites along migration corridors of threatened migratory pollinators.

The work group also recommended increased education and training to ensure that both the general public and resource managers understand the importance of pollinators.

The Xerces Society was one of the first organizations to recognize the significance of threats to pollinator insects, and was a founding member of the Forgotten Pollinators Campaign, administered from the Arizona-Sonora Desert Museum (Tucson, AZ). We continue to be an active advocate for insect pollinator conservation in the U.S. Our work focuses on native pollinator insects and includes community-based education activities, habitat enhancement, and petitioning for listing under the ESA.

To promote conservation of native pollinator insects we are working to accomplish the following:

- Increase the awareness of pollinators' important role in ecosystems and of the threats they face among the public;
- Engage people of all backgrounds in pollinator conservation, providing them with the knowledge and confidence to take action to protect pollinator diversity and habitat;
- Protect threatened and endangered pollinator species and their habitat;
- Influence decision-makers and policy through an advocacy and education campaign.

The Society, in collaboration with the USDA Bee Biology and Systematics Laboratory (Logan, UT), has worked with land managers to develop techniques to enhance pollinator habitat. Based on these techniques, pollinator management guidelines have been produced and pollinator conservation has been featured in both print and video magazines as well as on National Public Radio, generating interest and new projects across the country (Shepherd and Tepedino 2000; Shepherd et al 2001; Golf And Environment 2000; Living on Earth 2001).

In the Pacific Northwest, the Society is working to promote pollinator conservation and encourage wider involvement in projects at a grass-roots level. We have been working with educators and students, land managers, and agencies to promote awareness of pollinators, and to engage people in activities to conserve them. We are presenting workshops, establishing demonstration sites, producing a handbook on pollinator management, working with land managers on specific projects to restore pollinator habitat, and petitioning the USFWS to list endangered and threatened pollinator species.

We are also developing a website and database as a pollinator conservation resource for the Northwest region. It will become an integral part of the Society pollinator conservation program in this region, providing a place where people can access information on pollinators and habitat, participate in educational activities, and share experiences and knowledge.

The Society is not the only organization working to protect pollinator insects. In addition to the work of bee scientists at universities and research centers, major programs launched by other organizations include:

- Migratory Pollinators Project, administered by the Arizona-Sonora Desert Museum; this project focuses on protecting "nectar corridors" between Mexico and the United States for four pollinators, including the monarch butterfly (*Danaus plexippus*).
- North American Pollinator Protection Campaign, run by the Co-evolution Institute (San Francisco, CA); this campaign is a collaborative initiative to increase public awareness, create projects to protect pollinators and habitat, and initiate policy change.

Conclusion

The first step to invertebrate protection is to put invertebrates on the same footing as other species in management decisions. Conservation, research, and education are all needed to ensure sustainable populations of invertebrates. The conservation of invertebrates should be of paramount importance to all people as the ecological services they provide are vital to life as we know it on the planet. As Harvard biologist E. O. Wilson stated, "So important are insects and other land dwelling arthropods, that if all were to disappear, humanity probably could not last more than a few months."

Acknowledgments

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The Impact of Communication Towers On Neotropical Songbird Populations

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Abstract

Neotropical migrants are birds of the Western Hemisphere that migrate to the New World Tropics (or "Neotropics") for the winter to take advantage of seasonally abundant food and longer daylight hours. Migration is hazardous and every year, millions of birds collide with human-built structures in North America. Presently, thousands of communication towers are located in migratory flyways. Ornithologists estimate that in the 1970s, 1.2 million migratory birds were killed annually by collisions with communication towers. Today, the U.S. Fish and Wildlife Service (USFWS) estimates the numbers to be four to five million, a violation of the Migratory Bird Treaty Act. Forty-seven comprehensive published studies document the deaths of 230 bird species, encompassing over 25 percent of all avian species found in the U.S. Of the 230 species identified, 52 species are listed either as endangered or threatened. The Telecommunications Act of 1996 brought about the deregulation of communication systems, causing an explosion in the number of communication providers. As a result, the number of communication towers is increasing and its growth rate will be exacerbated by a federal mandate requiring digital television to be available nationwide by 2002. Without the implementation of government regulations, communication companies are not likely to construct bird-friendly towers. Thus, researches are tasked with finding alternative methods to protect birds from collisions with towers.

Introduction

Neotropical migrants are birds of the Western Hemisphere that migrate to the New World Tropics (or "Neotropics") for the winter. The Neotropics are generally defined as the tropical regions of Mexico, Central and South America and the West Indies that lie south of the Tropic of Cancer. There are approximately 360 species of Neotropical migrant birds, many of which are songbirds. Neotropical migrant species include warblers, swallows, swifts, flycatchers, raptors, and herons.

Neotropical migratory birds fly great distances to take advantage of seasonally abundant food and longer daylight hours, which increases their potential for breeding success. Most long distance migratory songbirds travel at night when they are less likely to encounter predators. Additionally, nighttime weather conditions are generally more favorable, with cooler temperatures and calmer winds. Most migratory birds fly at higher elevations when crossing large bodies of water than when flying over land. Seventy-five percent of the Neotropical songbirds migrate at an altitude between 500 to 6,000 feet, with the Blackpoll warblers (*Dendroica striata*), Red knots (*Calidris canutus*) and American golden-plovers (*Pluvialis dominicus*) traveling as high as 12,000 feet. Ninety percent of migrating songbirds fly at airspeeds between 15 and 50 miles per hour (Smithsonian 2000).

Migration is physically demanding, as birds travel across hundreds to thousands of miles, spanning from several weeks to four months. Migratory birds require quality habitats along the migration routes to replenish food reserves and to escape predators. Migration is also hazardous due to inclement weather and collisions. Records of bird mortality at man-made structures have been documented at lighthouses for over a century. Every year, millions of birds collide with structures in North America, including tall buildings, reflective glass, and communication towers—an increasing threat.

Development of communication towers

Ornithologists estimate that in the 1970s, 1.2 million migratory birds were killed annually by collisions with communication towers. (ABC 2000) The actual number of communication towers in the United States today is unknown, but industry experts estimate there are 100,000, which is nearly four times the number that existed in the 1970s (Seeman 2000). Thousands of communication towers are already lo-

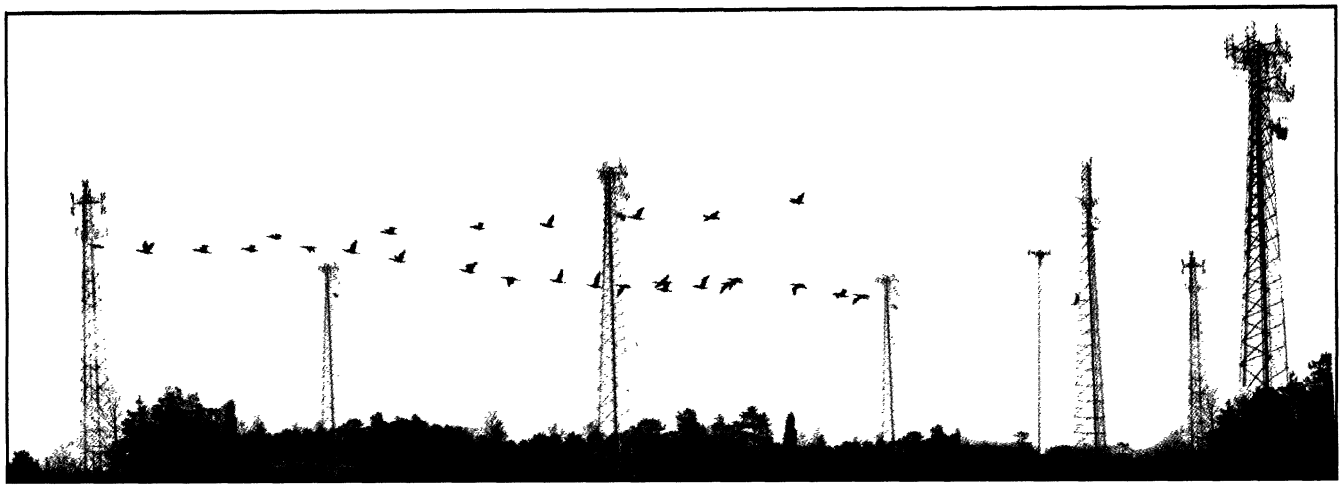

Figure 1. Thousands of communication towers are located in migratory flyways. Over one million birds are killed annually due to tower collisions. Photo courtesy of USFWS Gene Nieminen.

cated in migratory flyways and the Federal Communication Commission (FCC) reports that approximately 5,000 new communication towers are being built each year. This rate is expected to increase with the advancements in digital telephone and television technology.

The FCC regulates communication in the U.S., and as such, is responsible for the regulation of communication towers. The FCC database contains 77,519 registered communication towers, which are used to provide nationwide coverage for cellular telephone, television, radio, paging, messaging, wireless data, and other communication industries. In accordance with FCC regulations, 58,339 of these towers are required to be lit because they are over 199 feet tall, are within a 3.8-mile radius of an airport, or are situated along a major highway. Additionally, it is estimated that there are tens of thousands of towers that do not fall within these criteria, and therefore, do not require registration with the FCC.

The Telecommunication Act of 1996 was established to promote competition and reduce regulations in the communication industry; to secure lower prices and higher quality services for American telecommunication consumers; and to encourage the rapid development of new telecommunication technologies. The Act brought about the deregulation of communication systems and decreases in costs, causing an influx of digital communication providers. The overall result was the construction of a massive telecommunications infrastructure. According to the FCC, the number of customers using mobile phone services increased from 24 million subscribers at the end of 1994 to over 78 million in 1999 (Weisensel 2000).

As the number of mobile phone customers continues to rise, the construction of telecommunication towers is increasing at an alarming rate (Weisensel 2000). In addition to deregulation, a federal mandate requires that all television stations provide broadcasts for digital TV (DTV) by the year 2002. As a result, the construction of 1,000 DTV "megatowers" is anticipated, some approaching a height of 2,000 feet (Green 2000).

Bird kill studies and statistics

The earliest published study of bird kills at communication towers was completed in 1949. Early studies were conducted unsystematically and did not provide sufficient information about the extent of species being affected. For example, some studies included only the total number of birds found on a given day; others were conducted over several days, weeks, or over a single migration season. Some reports included only limited information on the tower without including the height above mean sea level. More comprehensive studies included the total number of birds killed, number of birds by species, tower construction and support structure (i.e. guy wires), total height above ground level (AGL), total height above mean sea level (MSL), lighting systems and other relevant details such as weather conditions.

The American Bird Conservancy (ABC) obtained 149 studies completed in 21 eastern states from 1958 to 1997. ABC revealed that 545,250 avian fatalities occurred as a result of tower collisions during the study period. The number of fatalities varied greatly from one location to another. Of the 149 studies reviewed, 121 provided some detail on the number of birds killed and 88 provided some detail on the number of species killed. None of the studies were conducted west of the Rocky Mountains and only 14 studies were conducted west of the Mississippi River. Only 47 provided sufficient information to be evaluated further. These 47 studies documented a total of 184,250 birds killed, encompassing 230 species, which represented over one quarter of all avian species found in the U.S. Of the 230 species identified, one endangered Red-cockaded woodpecker (*Picoides borealis*)

along with 51 other species were listed either on the U.S. Fish and Wildlife Service (USFWS) Migratory, Nongame Birds of Management Concern List or the Partners in Flight List. Reportedly, the distribution of birds killed averaged less than 85 individuals of any one species at a single tower, even when the number of fatalities numbered in the thousands, with the exception of the Tennessee warbler (*Vermivora peregrina*), Blackpoll warbler (*Dendroica striata*) and Prairie warbler (*Dendroica discolor*). Overall, the warblers, a species in decline, seemed to be the most effected by collisions with communication towers; however, with 230 species documented, bird collisions are not limited to a specific species, or to select communication towers, but distributed widely for all towers over 200 feet (Brown 2000).

One comprehensive study of bird mortality was conducted at a communication tower in Florida. The study began in 1955 and continued for 25 years at the Tall Timbers Research Station near Tallahassee, in Leon County, Florida, where a 1,010-foot tower stood just north of Lake Iamonia. Ornithologists collected birds and cataloged carcasses daily from August to November. During this time period, 42,386 birds representing 190 species were collected, as well as several species of bats. Jim Cox, a biologist with the Florida Fresh Water Fish and Game Commission, observed that occasionally as many as 2,000 birds were found scattered beneath the tower. It was estimated that an additional 2,000 birds had been killed but were carted off by scavengers before they could be counted (Crawford 1981; Brown 2000).

Numerous studies have documented bird deaths into the tens and hundreds of thousands. A 1,368-foot TV tower positioned on a hill (680 foot elevation) located in Nashville, Tennessee was studied for 38 years. Twenty-six guy wires supported the triangular tower. From 1960 to 1997, data was collected daily from September 1 to October 31, during the fall migration. A total of 19,880 birds representing 112 species were collected, with the top five species including Ovenbirds (*Seiurus aurocapillus*), Red-eyed vireo (*Vireo olivaceus*) and three warblers [Tennessee (*Vermivora peregrina*), Magnolia (*Dendroica magnolia*) and Black-and-White (*Mniotilta varia*)] (ABC 2000). During the study period, over 99 percent of the species collected were Neotropical migrants, primarily warblers (Evans 2000).

More than 120,000 songbird deaths were documented by Dr. Charles Kemper, a retired physician in Eau Claire, Wisconsin. In 1957, Dr. Kemper learned of the problem of birds colliding with communication towers and began checking a nearby 500-foot tower. For several months he turned up nothing, until a second 1,000-foot tower was constructed adjacent to the existing tower. On September 20, 1957, more than 20,000 warblers, thrushes and tanagers carcasses were found within 500 feet of the tower, the largest single night kill ever recorded. Dr. Kemper stated that the tremendous casualties continued into the 1960s and 1970s and then gradually declined (Seeman 2000). Perhaps the decline is due to the presence of fewer birds or due to an increase in predators. A colony of gulls was established near the Eau Claire tower in recent decades and may be scavenging bird carcasses before they can be counted (Weisensel 2000).

The USFWS estimate that four to five million birds are killed annually by collisions with communication towers (Brown 2000). Though most kills are associated with towers greater than 500-feet, on January 22, 1998 approximately 10,000 Lapland longspurs (*Calcarius lapponicus*) were killed as a result of a 420-foot guyed communication tower in Western Kansas. Power lines, a lighted pumping station, other smaller towers, buildings and fences that likely contributed to the mortality surrounded the tower. The flock reportedly took flight during the night due to a heavy snowstorm and dense fog. The flock became disoriented, circled the tower and perished due to collisions with the tower, guy wires and with each other. Longspurs were

Figure 2. Red knot (*Calidris canutus*), Outer Harbor, Princeton, California. July 2000 © Peter LaTourrette.

found dead in an adjacent agricultural field, impaled by wheat stalks, suggesting that the birds were so disoriented that they flew straight into the ground at full speed. Surprisingly, the communication tower in Western Kansas was lit with three flashing white strobe lights, which are reportedly less troublesome than the blinking red incandescent lights typically found at communication towers.

The aftermath of a tower kill rarely is seen. Tall communication towers typically are located in sparsely populated areas. In addition, reported incidents document only the birds that are not removed by scavengers and exclude birds that are fatally wounded, but die later in areas far from the tower. Based upon this information, it is likely that the actual mortality rate is higher than the estimated four to five million birds killed annually.

The Breeding Bird Survey (BBS) has conducted continent-wide bird counts on an annual basis using volunteers since 1966. During the first ten to fifteen years, BBS surveys revealed little evidence of declines in most songbird populations; however, recent analyses have revealed trends in the 1970s and 1980s that suggest sharp declines in many populations. The abundance of Neotropical migrants, such as the Red-eyed vireos (*Vireo olivaceus*), Hooded warblers (*Wilsonia citrina*) and Ovenbirds (*Seiurus aurocapillus*) has dropped by 50 percent or more in the span of several decades (Sauer 2000). These declines, coupled with concurrent reports of a diminishing number of migratory flocks seen on weather radar as migrant songbirds cross the Gulf of Mexico, have led to a sense of urgency for the protection of migratory songbirds.

Importance

Birds are critical ecosystem components. Birds pollinate plants, distribute seeds and prey on insects. According to the Ornithological Council, on average, a pair of adult warblers can remove caterpillars from more than one million leaves within two to three weeks in order to feed hatchlings. This type of natural insect control can provide an enormous benefit to forestry and agricultural industries.

Migratory birds are fundamental components of many local economies. Birding is reportedly second only to gardening as the most rapidly growing leisure interest in the U.S., increasing 155 percent from 1982 to 1995 and outpacing golf by 150 percent (Weisensel 2000). According to surveys completed by the USFWS, more than 63 million Americans watch and feed birds. Each year more than 24 million Americans travel to watch birds. In 1991, bird watchers spent $5.2 billion on goods and services related to bird feeding and watching. The expenditures generated nearly $600 million in tax revenue for states and the federal government. Non-consumptive bird use supports almost 20,000 American jobs (Cherepy 2000).

Solutions

In order to slow down the construction of new towers, Albert Manville, a biologist with the USFWS, stated that expanding companies will be asked to co-locate equipment rather than erecting towers in new locations. If not possible, they would be encouraged to build shorter towers with no supporting guy wires, locate the towers outside areas that are prone to low clouds and mark towers with white strobe lights rather than slow pulsing red lights (Seeman 2000).

The construction and location of a tower with respect to regional geography and migration patterns play an important role in determining a tower's kill potential. Red aviation warning lights reflect the water vapor in the air and form an illuminated area around the tower that attracts birds, causing them to circle and switch to their dinural (visual) mode of navigation. Steve Ugoretz, a biologist with the Wisconsin Department of Natural Resources, stated that scientists believe it is the red lights on communication towers that lure the birds to their death when they are flying in fog and other low visibility conditions says. On nights with heavy fog or a low cloud ceiling, migrating birds lose their cues for stellar and geomagnetic navigation. The lights from the communication towers offer visual clues that are thought to dominate the birds' magnetic compass. Subsequently, the birds position themselves with the tower lights as they would navigate in relation to the moon, keeping the light at right angles to their flight to keep going in the same direction (DNR News 1999). Eventually the birds either die from exhaustion or from colliding with the tower or guy wires in the lighted space.

The Migratory Bird Treaty Act (MBTA) of 1918 states that no migratory bird may be killed unless it is specifically exempted under a permit. The MBTA is a strict liability statute, making the "taking" of a migratory bird without a permit illegal, even if it is unintentional, incidental or inadvertent. The Endangered Species Act (ESA) gives further protection to birds present on the Endangered Species List. However, none of the protection factors set forth by the MBTA or the ESA are being regulated or enforced.

Constructing a tower without supportive guy wires would likely reduce avian mortality; however, the construction would require additional concrete and steel, and thus would be more costly to build. American Tower Corporation (ATC) plans to build 1,200 towers this year. ATC estimates that it would cost an additional $70,000 per site to build with-

out the guy wires (Seeman 2000). With the increased costs, communication companies are not likely to voluntarily construct bird-friendly towers without the implementation of government regulations. Therefore, biologists are searching for alternative methods to protect birds from collisions with communication towers. Some scientists feel that if the towers were limited to urban, well lit areas, the overall mortality rate of the migratory birds may be reduced as the birds would be less drawn to the "room" of light caused by towers located in sparsely populated areas.

Many land management plans in North America include provisions to protect migratory songbirds, including virtually every federal and most state plans (Brown 2000). Additionally, on July 20, 2000, President Clinton signed the Neotropical Migratory Bird Conservation Act into law, which authorizes $5 million annually in grants to promote the conservation of Neotropical migratory songbirds. According to Leslie J. Evans of the World Wildlife Fund and the Fatal Light Awareness Program (FLAP), currently the FCC policy states that communication towers should be as far as possible from migratory bird corridors. FLAP, a registered non-profit organization, was formed in April 1993 to raise awareness and attempt to find a solution for bird fatalities resulting from collisions with man-made structures (Weisensel 2000).

Some promising information came about at a communication tower located within the city of Youngstown, Ohio. The 1,100-foot communication tower was lit by tiers of 3,600-watt red globe incandescent bulbs. From 1974 to 1990, approximately 4,000 migratory birds fatalities were documented at the tower. However, the fatalities fell off sharply in the mid-1980s following a change in the city street lighting. When the city shifted the streetlights to a stronger vapor light that emitted an orange hue, the massive kills stopped. Based upon this information, it is clear that additional research into low cost, effective methods to protect migratory birds is necessary. Some inexpensive protection features proposed by researchers include white lights, fluorescent paints, mirrors that shine lights skyward, giant netting, devices that spin in the wind, and horns or devices that broadcast low frequency sounds, similar to sonic booms (Seeman 2000).

Conclusion

Conserving migratory songbirds is a very difficult task, since nearly any human activity can affect each species in a different way. Almost any land that is taken for urban, agricultural, silviculture, or other human use comes at the expense of another species. In addition to collisions with communication towers, factors that contribute to the decline of Neotropical migratory songbird populations include habitat loss, pesticides, and exotic predators.

Since 1997, there has been very little new information regarding collisions with communication towers and few studies are currently being conducted, largely due to lack of funding. Researchers have concluded that in the absence of legislative mandates, alternative forms of protection must be implemented to protect birds from communication towers; however, without sufficient funding, these protection devices cannot be implemented. Researchers propose inexpensive protection devices, such as white lights, fluorescent paints, mirrors, netting, spinning devices, horns or broadcast speakers. Presently, it is unknown if any of these methods would be effective. Nonetheless, as migratory bird populations face the hazards of collisions with the communication towers, it is evident that we must rely on technology to protect the remaining avian populations from our own technological advances.

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Marine Matters

Marine Protected Areas: Examples from the San Juan Islands, Washington

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Abstract

*Marine protected areas and marine reserves increasingly are promoted as tools for the management of marine resources, and strong support for their implementation has emerged among scientists and non-scientists alike. In San Juan County, WA, voluntary marine protected areas for eight species of bottomfish (*Sebastes *spp.,* Scorpaenichthys marmoratus, Hexagrammos decagrammus, Ophiodon elongatus*) and southern resident killer whales (*Orcinus orca*) have been established through citizen action. Although the efficacy of these protective measures has not yet been demonstrated, they may contribute substantially to the conservation of local marine species.*

Introduction to marine protected areas

Marine protected areas (MPAs) are areas set aside for the protection and recovery of living and non-living marine resources, in much the same way that terrestrial reserves are set aside for the protection and recovery of land-based resources. Different from their terrestrial counterparts, however, MPAs have been employed far less frequently to achieve management and conservation goals, and our collective experience in their design, implementation, and management is far weaker. Additionally, many characteristics of marine systems differ substantially from those of terrestrial systems. For example, long-distance dispersal of larvae is common among some marine species, causing local recruitment to be uncoupled from local reproduction. Furthermore, the dynamics of larval and adult stages can be strongly affected by local and regional oceanographic circulation patterns. For these and other reasons, design criteria developed for terrestrial systems are not fully transferable to marine systems.

As presently defined, MPAs constitute spatially-explicit management areas within which some level of resource protection is conferred through regulatory or voluntary action. Many MPAs are managed for multiple human uses and allow extraction of biological resources. This class of MPAs includes shoreline and underwater parks as well as National Marine Sanctuaries. Other, more restrictive MPAs are fully protected from extractive activities; these are often referred to as "marine reserves" or "fully-protected marine reserves." Contrary to traditional fisheries-management techniques, which typically seek to maximize yield of a target stock or population, MPAs offer place-based protection and management of resources without regard to yield.

MPAs increasingly are proposed as a means of addressing population declines and habitat loss in marine environments in the U.S. and elsewhere. For example, in May 2000, President Clinton signed Executive Order 13158 directing federal agencies to work with state and local interests to establish a comprehensive, representative national system of MPAs that will increase protection for marine resources. In response to this order, the National Oceanic and Atmospheric Administration is assembling an advisory committee, establishing an MPA Center, compiling an inventory of candidate MPA sites, and creating a website (www.mpa.gov) for dissemination of information. Independently, in late 2000, the National Research Council of the National Academy of Sciences completed a two-year review of the utility, design, and implementation of MPAs (National Research Council 2000; www.nap.edu). Among their conclusions were that MPAs can be used as effective management tools to conserve habitats, maintain marine communities and their associated ecosystem functions, and promote recovery of overexploited populations. Importantly, the group argued against maintaining conventional strategies as the sole means of managing marine resources. Instead, they suggested that MPAs

offer a promising alternative management strategy that can be used in addition to conventional management strategies to achieve conservation goals. Most recently, at the annual meeting of the American Associate for the Advancement of Science, a group of scientists expressed strong support for MPAs as a means of providing more effective management for protection of biodiversity, exploited populations, and marine ecosystem health (www.seaweb.org). The consensus statement produced by this group was signed by 150 scientists in support of the use of MPAs in marine management. Finally, numerous shorter articles on the science and implementation of MPAs have appeared in both peer-reviewed and popular publications over the last decade, indicating widespread interest among professionals in the development of a coherent, scientifically-based theory of MPA design and management (National Research Council 2000 and references therein).

The growing enthusiasm for MPAs has been matched in recent years by efforts to establish MPAs in the U.S. and elsewhere. Internationally, the number of MPAs increased by an order of magnitude between 1970 and 1994 (Kelleher et al. 1995). Within the U.S., California, Washington, Hawaii, and Florida have all designated MPAs within the last decade. Even so, less than one percent of the U.S. shoreline is currently protected within designated MPAs (National Research Council 2000).

Despite their current popularity as management tools, MPAs do not represent a new management strategy. Spatially-explicit closures historically have been used by some tropical island nations to manage local marine resources (e.g., Johannes 1978), and some of the best evidence for the success of MPAs in achieving species protection comes from these and other tropical reef areas (e.g., Alcala and Russ 1990, Roberts 1995). In the U.S., several MPAs were established in the middle of the last century, well before the current rush to designate protected areas; these include Everglades National Park, Fort Jefferson National Monument in the Dry Tortugas, and the Key Largo Coral Reef Preserve (established in 1934, 1935, 1960, respectively).

Protection of threatened and endangered species

Although MPAs most often are used as management tools to protect biodiversity, restore overexploited populations, and reduce uncertainty inherent in conventional management strategies, in a few cases they have been established for the explicit protection of threatened or endangered species. For example, the Hawaiian Islands Humpback Whale National Marine Sanctuary was established for the protection of endangered humpback whales (*Megaptera novaeangliae*). Among the protections conferred by the Sanctuary is protection from harassment by whale-watching boats. The southern sea otter (*Enhydra lutris*), which is listed as threatened under the U.S. Endangered Species Act, has gained similar protection from harassment by the establishment of a refuge along parts of the central California coast. In Mexico, breeding lagoons used by the eastern North Pacific gray whale (*Eschrichtius robustus*; recently removed from the U.S. List of Endangered and Threatened Wildlife) have been protected from certain types of shoreline development and whale-watching guidelines have been put in place. The establishment of MPAs holds promise for the recovery of other threatened and

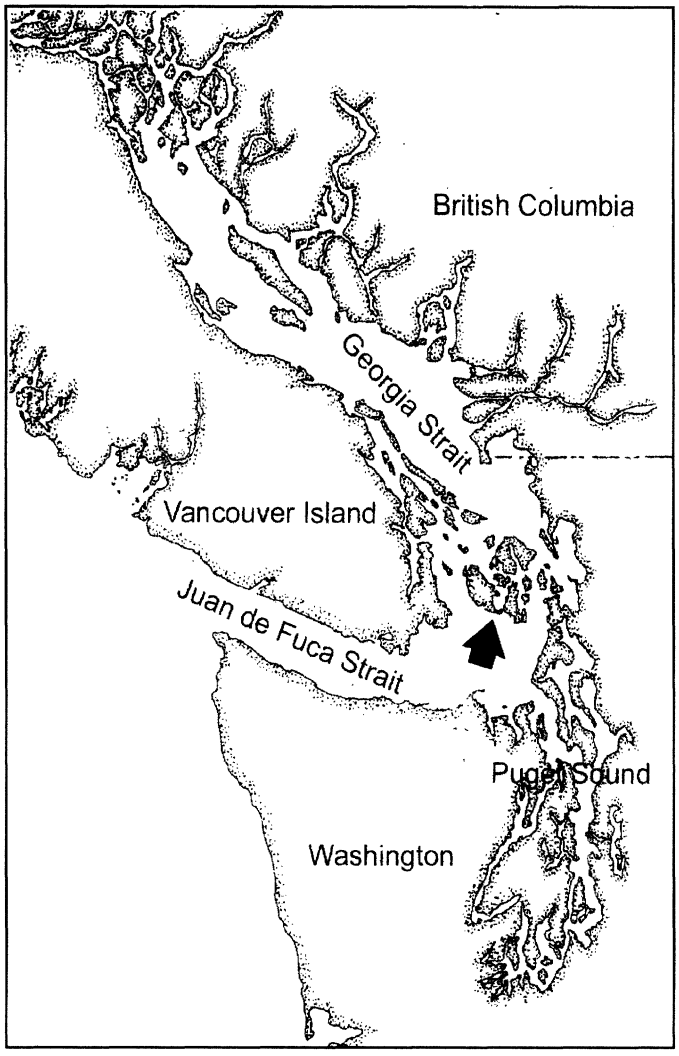

Figure 1. The San Juan Archipelago (arrow) in northwestern Washington state. Map courtesy of the author.

endangered marine species, especially when there is fidelity to specific sites during all or part of the species' life history.

Voluntary versus regulatory protections

MPAs have been established through both voluntary and regulatory means, and each approach has its merits (e.g., Gubbay and Welton 1995). Although only regulatory MPAs can guarantee full protection of resources, the costs of enforcement are high, and the imposition of regulations can erode public support for protection efforts. Voluntary approaches can build public support and enhance stewardship without the considerable costs of enforcement. In addition, voluntary MPAs often can be established more quickly than regulatory MPAs, because no new legislation needed. However, in order for voluntary MPAs to be even moderately successful, they must have the support of the local population and provide protection from poaching. These are conditions that cannot always be met.

Case study in voluntary protection: The San Juan Archipelago

The San Juan Archipelago comprises hundreds of islands and emergent rocky reefs in northwestern Washington State (Figure 1). The larger islands are inhabited by both year-round and seasonal residents, and the entire area is a popular recreational destination for people from western Washington and elsewhere. Earlier in this century, fishing and farming were mainstays of the economy; a more diversified economy in which tourism represents an important element now exists.

The San Juan Islands are rich in marine biological resources. Fish (including salmon; *Onchorhynchus* spp.), marine mammals, and seabirds all are present on a seasonal or year-round basis. However, the marine biological resources of the area are declining (West 1997). The current status of local marine populations is indicated by two recent petitions to list local species under the U.S. Endangered Species Act. The first, a petition to list eighteen species of fish (excluding salmon), was submitted to the National Marine Fisheries Service (NMFS) in 1999. NMFS reviewed the status of stocks for seven of the 18, but declined to list any as threatened or endangered. Even so, there is general recognition that local fish populations have declined steeply over the last two to three decades. Currently, a petition to list the southern resident killer whale population is being prepared, based on small extant population size and documented declines in population size since 1995 (van Ginneken et al. 2000). The petition will be submitted to NMFS later this year.

Independent of federal regulatory actions, the citizens of San Juan County have initiated efforts to address declines both of bottomfish and southern resident killer whale populations. The following recounts the history of local attempts to increase protection for bottomfish and killer whales by implementation of voluntary reserves.

Between 1988 and 1996, the waters surrounding the San Juan Islands were considered for designation as a National Marine Sanctuary under the National Marine Sanctuaries Act. The proposed designation was based on the natural beauty of the area, the perceived value of the local biological resources, and the anticipated threats to their persistence posed by increasing urbanization. However, due to intense local opposition to federal action and oversight, sanctuary designation was never achieved. Following the defeat of the sanctuary designation process in 1996, the San Juan County Board of County Commissioners (BOCC) established the San Juan County Marine Resources Committee (MRC). This committee is composed of local citizens and is charged with advising the BOCC on issues of concern in the marine environment.

One of the first actions taken by the MRC was to recommend the establishment of voluntary no-take reserves for the recovery of eight species of bottomfish. Populations of these species are depressed locally as a consequence of recreational and other fishing pressures. In 1997, after receiving recommendations from the MRC, the BOCC established eight voluntary no-take reserves for the protection and recovery of these eight species of bottomfish. As conceived by the MRC, the bottomfish recovery zones will act as harvest refugia for the depleted stocks. Protected populations within the reserves will serve as spawning stock for the replenishment of fish stocks outside the reserves. The location of the reserves was decided by a public process in which recreational fishers identified sites that formerly had been, but no longer were, productive fishing areas. The number and sizes of the reserves were based on political feasibility. The reserves are relatively small, ranging from about 12 to 60 hectares, and protect less than one percent of the shoreline within the county (San Juan County Marine Resources Committee, unpublished data).

Concurrent with the establishment of the bottomfish reserves, the MRC initiated public outreach efforts to increase citizen support for the reserves and implemented a bottomfish monitoring program to detect trends in fish abundance over time. The life-history characteristics of the species of interest dictate that a decade or so may be required before the benefits of protection are detectable; therefore, the effectiveness of these pro-

tection efforts has not yet been demonstrated. Even so, a reduction in fishing intensity within the voluntary reserves has already been noted, and public awareness of, and support for the program is growing. Similar voluntary reserves now are being proposed in other counties within the region and in neighboring British Columbia.

A second example of citizen-based efforts at voluntary, spatially-explicit protection in San Juan County is provided by the establishment of a 'no-boat' zone for the protection of resident killer whales. Recreational and commercial whale-watching boat traffic surrounding killer whales in San Juan County is often intensive; on some days, more than 100 private and commercial boats can be seen following the local pods. Some argue that such high densities of boats may interfere with feeding and communication by the whales, and may add to stresses imposed on the whales by increasing urbanization and declining availability of salmonid prey. Consequently, a local non-profit organization established a program in 1993 to manage and reduce pressures from boat traffic. Among the elements of this program was the establishment of a voluntary 'no-boat' zone extending for several miles along the western shore of San Juan Island, varying in width from one-quarter to one-half mile offshore. Boaters are asked to allow the whales to pass through this zone without harassment. The program has gained the support of the International Whale Watch Operators Association Northwest as well as many private boat owners and citizens, and compliance with the voluntary guidelines is increasing (Soundwatch Program, Friday Harbor, WA, unpublished data).

Figure 2. Southern resident killer whale (*Orcinus orca*). Photo by Kelley Balcomb-Bartok.

Summary

It is too early to determine whether citizen-based efforts to protect local populations of bottomfish and killer whales will confer long-term benefit to these populations. Certainly, the rate of compliance among users, many of whom are occasional visitors and therefore not highly invested the conservation of local resources, will play a large role in the success or failure of these efforts. Levels of compliance may diminish as fish densities within the MPAs increase relative to populations in unprotected areas. Furthermore, meaningful comparisons between voluntary protection and 'hard' regulatory protection will be difficult to draw, because appropriate regulatory reference sites currently are unavailable. Even so, the extension of voluntary protection to these sites is better than no protection at all.

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News from Zoos

Deeper Look at Dolphins

The Florida Aquarium is launching a dolphin tour with a research twist. Customers on the aquarium's new 64-foot catamaran, the Bay Spirit, will photograph and help build a family album of bottlenose dolphins in Tampa Bay. The pictures will go into a catalog that will identify each dolphin seen between the Port of Tampa and the mouth of the Alafia River. Each sighting will add information about individuals and the population as a whole.

The goal of this project is to answer questions such as how many dolphins live in the area and how many just visit, whether there are locations especially favored by mother-and-calf groups, what an individual animal's range is and which dolphins are related to each other. Researchers at Eckerd College's Dolphin Project have identified about 500 dolphins in Boca Ciega Bay. The Bay Spirit catalog will extend that research to the rest of Tampa Bay. Even though bottlenose dolphins are not endangered, studying them can offer important insights into their endangered relatives. [Adapted from an article by Linda Gibson, *St. Petersburg Times*]

Rabbits on a Come Back

The Oregon Zoo is working with the Washington Department of Fish and Wildlife (WDFW) to save the endangered pygmy rabbit (*Sylvilagus idahoensis*). With less that 100 pygmy rabbits left in the wild sagebrush habitat in the state of Washington, the zoo will help the WDFW design a captive breeding facility. The facility, will supply rabbits for reintroduction to two tracts of protected habitat.

The zoo is home to four pygmy rabbits now under 24 hour monitoring through the use of video recording equipment. Researchers will use the data to catalog mating rituals and reproductive biology. Pygmy rabbits are a protected "sensitive" species in Oregon, but it is thought their populations continue to decline in other regions, including neighboring states of Washington, southern Idaho, northeastern California and parts of Nevada.

Rare Birds Return to Wild

The San Diego Zoo's Keauhou Bird Conservation Center released six endangered Hawaiian puaiohi (*Myadestes palmeri*) on the island of Kauai – the bird's native home. Researchers fitted the captive-bred birds with radio transmitters to track their progress through the island's Alakai Swamp, said to be the rainiest place on earth.

The introduction of non-native animals and diseases has imperiled the island's native puaiohi population, which currently numbers less than 300. To combat this trend, researchers have successfully released two-dozen captive-bred puaiohi into the wild in the past three years.

The Keauhou Bird Conservation Center works cooperatively with the U.S. Fish and Wildlife Service, the State of Hawaii's Division of Forestry and Wildlife and the Biological Resources Division of the U.S. Geological Survey.

Information for News from Zoos *is provided by Joseph Lankard of the American Zoo and Aquarium Association.*

News & Events

World to Share Biodiversity Data
Anyone with access to the Internet will soon be able to access data about biological diversity from the Global Biodiversity Information Facility (GBIF). GBIF will contain information about 1.8 million species ranging from whales to bacteria and will include data on 3 billion specimens located in the world's natural history collections. GBIF is funded by 32 countries and intergovernmental organizations. Further information can be found at http://www.gbif.org.

Arctic National Wildlife Refuge
The Arctic National Wildlife Refuge (ANWR) is the focus of curry debate about oil and gas exploration and development. The U.S. Fish and Wildlife Service (USFWS) maintains the official homepage of ANWR (http://www.r7.fws.gov/nwr/arctic/), which gives information on the refuge, wildlife, habitats, and people. The development issues are summarized in the USFWS document, "Potential Impacts of Proposed Oil and Gas Development on the Arctic Refuge's Coastal Plain: Historical Overview and Issues of Concern."

Waterfowl & Wetland Symposium
Ducks Unlimited will sponsor the eighth international waterfowl and wetlands symposium, "The Waterfowl Legacy: Links to Watershed Health," in Washington D.C. from 20 to 22 July 2001. Experts from around the world will share research and opinions on a range of issues affecting waterfowl, wetlands, and their management. Session topics include watershed health and waterfowl, North American Waterfowl Management Plan, and beyond North America. For more information contact Brenda Carlson, Ducks Unlimited, One Waterfowl Way, Memphis, TN 38120, (901) 758-3707, bcarlson@ducks.org, http://www.ducks.org/conservation/symposium_2001.asp.

InfoNatura: Birds and Mammals of Latin America
A new web site, InfoNatura, provides conservation information on more than 5,500 common, rare, and endangered birds and mammals of Latin America and the Caribbean. InfoNatura, produced by the Association for Biodiversity Information, is an online conservation and educational resource that includes taxonomic, conservation status, and national distribution information for each species, all in a searchable database that is easy to access and understand. You can search InfoNatura to find scientific names for each species, common names in English, Spanish, and Portuguese, conservation status, and color-coded distribution maps that show the countries where each species occurs. For more information: http://www.infonatura.org.

Announcements for the Bulletin Board are welcomed. Some items have been provided by the Smithsonian Institution's Biological Conservation Newsletter *or found on the Society for Conservation Biology Bulletin Board (http://conbio.net/scb/Services/Bboard/).*

Endangered Species UPDATE

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