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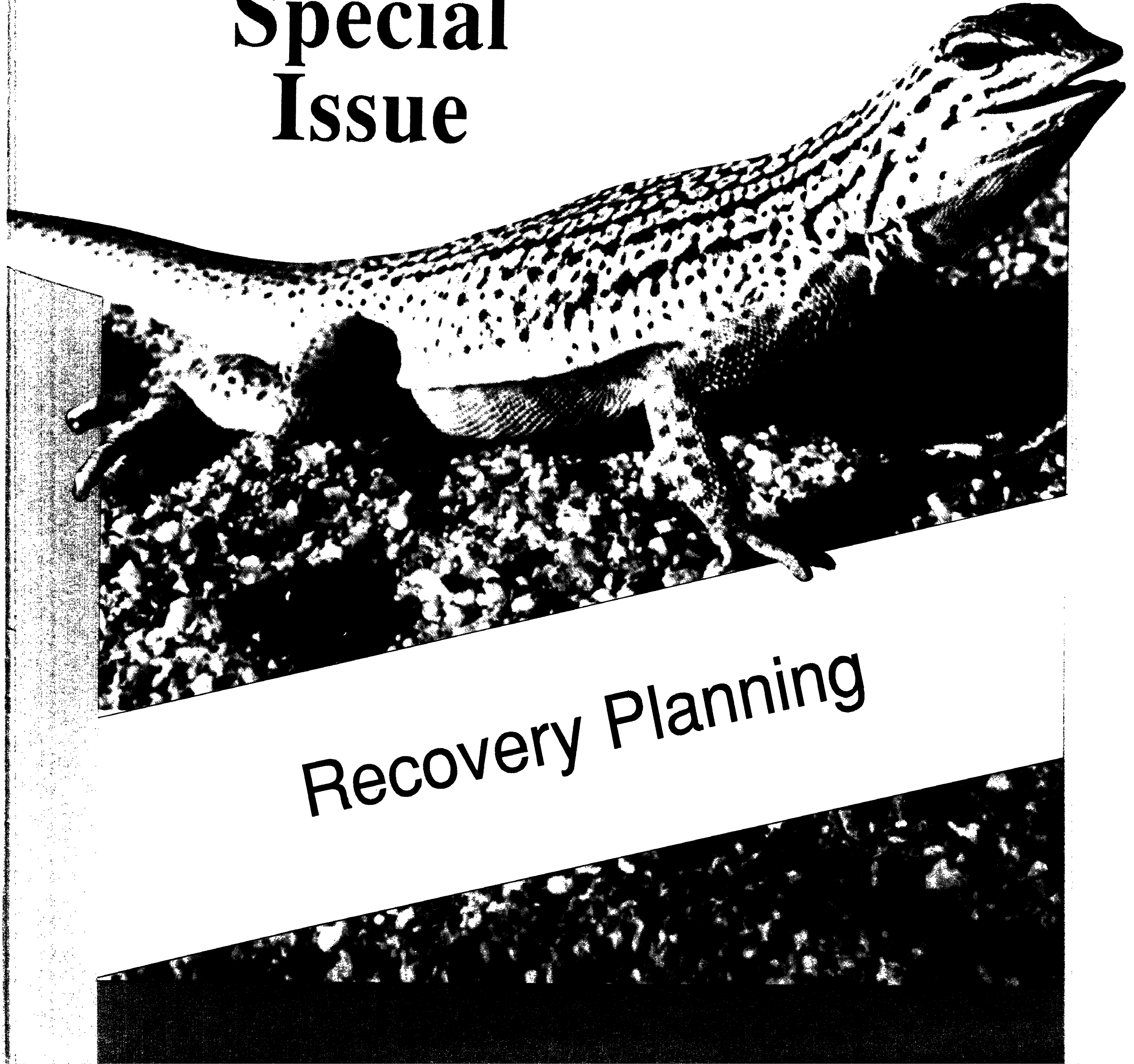


Recovery Planning

Letter From The Editor

In 1973, Congress enacted one of the most powerful pieces of legislation to arise during the environmental movement, the Endangered Species Act (ESA). The purpose of the Act was, and still is, to protect and enhance populations of threatened and endangered species through a variety of conservation steps. These steps include

- the official listing of plants and animals as threatened or endangered;
- restrictions on the killing, collecting, and sale or purchase of listed species;
- acquisition of habitat for the conservation of listed species;
- grants to state governments to assist in carrying out programs for the conservation of listed species;
- restrictions on actions authorized, funded, or carried out by federal agencies that would negatively affect listed species; and
- the development and implementation of specific plans of action for the recovery of listed species.

The last step — that of recovery — is the topic of this special issue of the *Endangered Species UPDATE.*

The planning for, and actual recovery of, endangered species is the ultimate objective of having a species listed under the ESA. Recovery plans are intended to identify the causes of a species' decline and specify actions needed to reverse the decline. The content of a recovery plan depends on the complexities presented by each species but the purpose is to serve as a catalyst for action by all parties involved.

The assessment of the success of recovery planning and the ESA is problematic. The Act provides no time-frame or fixed goals for recovery and, consequently, "success" is difficult to judge. Nevertheless, the absolute numbers paint a rather dismal scene.

During the first 16 years of the Act, only 535 species -- of more than 3,900 candidates -- have been listed as threatened or endangered in the United States while 242 recovery plans have been approved. Only five species have recovered. Two of these species — the brown pelican and the American alligator — have recovered in only parts of their historic ranges and the other three species — the Palau dove, Palau fantail, and Palau owl — owe their "recovery" to the discovery of more birds and not to successful recovery efforts. Ten more species have been "downlisted" from endangered to threatened but five of these were reclassified to allow regulated hunting, fishing, and capture of these species and not because of improvements in their status.

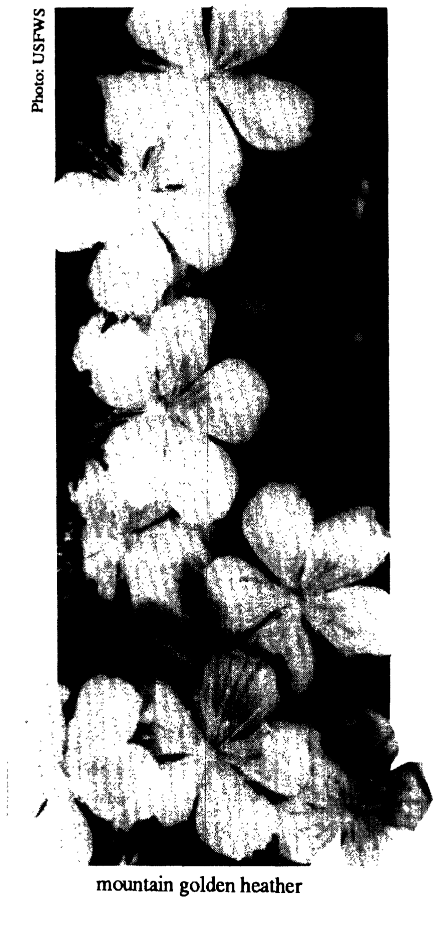
This issue of the *UPDATE* explores planning for and implementing the recovery of endangered and threatened species. The first few articles focus on the biological aspects of recovery planning and offer suggestions on how to improve the process used in developing recovery plans. Here, Michael Gilpin introduces the concept of population viability analysis for assessing the robustness of a population while Michael Soulé offers an example of decision analysis to explicitly assess management options for endangered species.

The latter half of the issue recognizes that recovery planning is not merely in the realm of biologists but that the implementation of recovery plans often enters the realm of politics. Here, Paul Selzer offers a first-hand account of the development of the Habitat Conservation Plan for the Coachella Valley fringe-toed lizard, Ginger Merchant Meese reports on the latest with the red wolf recovery, and Whitney Tilt explores the biopolitics of endangered species.

I hope you enjoy the issue and look forward to your comments.

Rob Blair
UPDATE Editor

Photo: USFWS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Endangered Species UPDATE

A forum for information exchange on endangered species issues

August 1989
Vol. 6 No. 10

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Instructions for Authors:
The Endangered Species UPDATE welcomes articles related to species protection in a wide range of areas including but not limited to research and management activities for endangered species, theoretical approaches to species conservation, and habitat protection and preserve design. Book reviews, editorial comments, and announcements of current events and publications are also welcome.

Readers include a broad range of professionals in both scientific and policy fields. Articles should be written in an easily understandable style for a knowledgeable audience. Manuscripts should be 10-12 double spaced typed pages. For further information please contact Rob Blair at the number listed below.

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Front Cover:
Coachella Valley fringe-toed lizard
(Uma inornata)
Photo courtesy of Paul Selzer

Back Cover:
Passiflora spp.
Photo: William Anderson

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Production and distribution of this special issue was made possible with support from the Chevron Oil Company.

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Recovery Planning and Endangered Species

edited by
Robert Culbert and Robert Blair

Recovery plans are mandated by the Endangered Species Act for endangered and threatened species and are intended to insure the survival of the endangered and threatened species listed under the Act. Of the 1037 species listed under the Act, only 531 of these species live in the United States, and recovery plans exist for only 284 of those species (U.S. Fish and Wildlife Service 1988). About three percent of the listed species are actually recovering, and of the 15 species that have been "delisted" (removed from the endangered species list) or "downlisted", only two were reclassified because of the recovery of the species (U.S. GAO 1988).

About three percent of the listed species are actually recovering, and of the 15 species that have been "delisted" ... only two were reclassified because of the recovery of the species.

These discouraging numbers provided some of the rationale for the amendments passed last year that strengthened the Endangered Species Act (ESA). One of these changes requires the Secretary of the Interior to establish new guidelines for recovery plans that insure that each recovery plan provides "...a more thorough analysis of what the [U.S. Fish and Wildlife] Service believes is required for the recovery of a species," including site-specific management actions (Fitzgerald 1988).

Based on a review of several recovery plans, we discuss some of the major deficiencies in these plans, and present our recommendations for overcoming these problems. We begin by describing the origins of and current processes of recovery planning; then we concentrate our analysis in the following areas: recovery team selection and composition, species ecology, multiple species approaches, population viability analysis, maps, recovery plan objectives, and implementation of the recovery plan.

Origin and Purpose of Plans

Two federal agencies are responsible for the preparation of recovery plans: the U.S. Fish and Wildlife Service (FWS) is responsible for the recovery of 96 percent of the domestic listed species, while the National Marine Fishery Service is responsible for the four percent of listed species that live in the oceans. Because the recovery planning efforts of the latter agency have been limited and less standardized (General Accounting Office 1988), we consider only the recovery plans prepared by the FWS.

Within the FWS, authority for recovery plan preparation, approval, and implementation is delegated to the seven regional offices. For species with ranges that span several regions, one office is designated as the lead office for recovery. At the regional director's discretion, plans may be prepared by an appointed recovery team, FWS staff, other agencies, or knowledgeable individuals.

Recovery plans identify the causes of a species' decline and specify actions needed to reverse the decline. The length and content of recovery plans depends on the complexity of threats to the species, the species' range, and the number of agencies or constituencies concerned with recovery. Although officially approved and sometimes widely distributed, these plans — or "catalysts" for action — are legally non-binding (U.S. Fish and Wildlife Service, n.d.).

Typically, a recovery plan consists of three parts and optional appendices (U.S. Fish and Wildlife Service, n.d.). Part I describes the natural history and current status of the focal species and identifies the causes of its decline, with reference to the relevant literature. Part II contains a step-by-step outline of actions needed to alleviate current threats to the species and to increase the population size and/or number of populations of the species in the future. Recovery objectives for delisting, downlisting from endangered to threatened, or other interim measures are also included in this part of the recovery plan, and must be quantified in terms of population sizes, reproductive activity, and geographic distributions. Part III is an implementation schedule of recovery tasks ranked by priority: highest (priority 1) are those actions necessary to prevent imminent extinction, with lower priorities to prevent a significant negative impact in the species population and/or its habitat (priority 2), and actions necessary to provide for full recovery of the species (priority 3) (U.S. Fish and Wildlife Service, n.d.). This part of the plan also assigns recovery tasks to cooperating agencies or organizations, and includes an estimated budget.

Before the final version of a recovery plan is approved by the regional director of the FWS, it must be reviewed by experts on the species and by cooperating and affected agencies (U.S. Fish and Wildlife Service, n.d.). Once approved, the implementation section of every recovery plan is supposed to be updated at least annually and entire plans should be revised as warranted, but these revisions are rarely accomplished (U.S. General Accounting Office 1988). The 1988 amendments to the Act also require a period for public comment on all new and revised plans (16 U.S.C. 1533 (f)(4)), but the public review procedures have not yet been determined.

As of January 1, 1989, recovery plans had been approved for 284 of 531 listed species occurring in the United States (the term "species" includes listed genera, subspecies, and populations) (U.S. Fish and Wildlife Service 1988). Since neither the preparation of plans nor recovery efforts have kept pace with the rate of species listing, the FWS has published priorities for the order of plan preparation and implementation (U.S. Fish and Wildlife Service 1979). In descending order of importance, listed species are ranked by the degree of threat they face, their recovery potential, taxonomic status (genetic distinctiveness), and conflict with development (Federal Register, 21 September 1983, pp. 43098-43105). Task priorities, identified in each recovery plan, should supersede species priorities. For example, a priority 1 task for a low-ranking species should be completed before priority 2 tasks for high-ranking species are pursued. Despite this ranking system, recovery efforts are often dictated by other constraints, including congressionally targeted budgets and a bias toward high-profile species such as the timber wolf (U.S. General Accounting Office 1988).

In summary, a recovery plan is primarily a document about the population biology of an endangered species in its ecological context and in the context of the present magnitude of human activities. Plans are not intended to address policy issues involving social, economic, or political concerns that conflict with the species' existence. However, recovery plans typically identify human activities (such as suburban development, timber production, livestock grazing, hunting, or collecting) that adversely affect the species and indicate how these impacts should be alleviated.

wolf (*Canis spp.*) Photo: USFWS

Recovery Team Selection and Composition

The selection and composition of the recovery team is of critical importance to the success of a recovery plan. Political factors can weigh heavily in the selection process because team members are chosen by the regional director of the FWS. This could minimize the objectivity and quality of the recovery plan and result in inadequate protection for the species. Thus, it is important to establish a standardized procedure for the selection of the recovery team. The appointment of experts who are not agency employees should be obligatory.

An example of possible conflict of interest is provided by the two recovery plans for the red-cockaded woodpecker. The initial plan was written by a team of scientists, but pressure from the southern timber industry caused this plan to be scrapped. A Forest Service biologist (M. R. Lennartz) was appointed to revise the recovery plan and this revised version was published as the official recovery plan for the woodpecker. The new plan ignored woodpecker habitat on private property and was lenient in its requirements for the preservation of old growth areas in national forests. For example, breeding season territory size was used rather than the larger year-round home range requirements, and the preferred age of trees in woodpecker foraging habitat was underestimated. These and other aspects of the recovery plan favor current timber management practices and may even be detrimental to the recovery of the red-cockaded woodpecker (Ligon *et. al.* 1986).

Many recovery plans are handicapped because they either ignore political realities or because they go too far in accommodating them. Recovery is compromised in both cases. Even though it may require changes in the law and guidelines, we propose a two-stage recovery planning process. During the initial phase, the recovery team comprises biologists, including non-agency experts, who deal solely with the biological issues. The document that they produce becomes the basis for the second stage. During this phase the recovery team is expanded to include a board of advisors, which would include representatives of commercial interests, environmental groups, and others. The final version of the recovery plan would be written with the aid of this advisory board. Thus, the decisions concerning tradeoffs would be made in an explicit manner, and would be open for review and discussion. The point is not to appease those with economic interests, but rather to insure that the plan is realistic and that whatever compromises are made are done so in the open.

Species Ecology

Recovery plans are intended to be strictly biological documents. Nevertheless, political factors often dominate.

For example, recovery plans often emphasize rebuilding populations within remaining habitat, rather than restoring previous habitat. The plan for the American crocodile (*Crocodylus acutus*) states that "No management action that will benefit crocodiles can be taken where habitats are already lost, thus this plan is directed towards protection of remaining crocodile habitat, and control of human activities therein" (U.S. Fish and Wildlife Service 1984, p.10). While we appreciate their honesty in making such a blunt statement, recovery plans are supposed to describe how the species can recover throughout its historic range. It appears to us that habitats outside of the crocodile's very limited current distribution must be restored if the species is to be preserved in southern Florida. The recovery plan should identify areas of formerly suitable habitat, and should suggest how habitat alterations and/or direct human disturbance (the two primary reasons for the crocodile's decline cited in that plan) can be reversed, making the habitat once again suitable for the crocodile.

This same problem occurs in the recovery plan for the Pahranagat roundtail chub (*Gila robusta jordani*). The executive summary of that plan states that when this species recovers, "...chubs will occupy as much as one percent of their historic range" (emphasis added, U.S. Fish and Wildlife Service 1985a). This is certainly not a full recovery.

The recovery plan for Chapman's rhododendron (*Rhododendron chapmanii*, U.S. Fish and Wildlife Service 1983) is an exception to this pattern; one of the recovery tasks in that plan is to establish new populations. It would have been even better, however, if the author had identified some potential sites that have the requisite habitat characteristics.

A different problem occurs when very little is known about the ecology of an endangered species. Todsen's pennyroyal (*Hedeoma todsenii*), for example, was discovered in 1978. There were two populations, only one of which can now be located. It is not known whether each of these populations is one large plant with 500 stems


Photo: Reed Noss

red-cockaded woodpecker (*Picoides borealis*)

or is 500 individual plants. Nor is it known whether it reproduces sexually or by rhizomes. Given the unusually low fertility of its seeds (five percent germination in the laboratory), this plant may even be an infertile hybrid, but that possibility is not even mentioned in the recovery plan (U.S. Fish and Wildlife Service 1985b). Answers to such fundamental questions should be given the highest priority in recovery plans.

Competition and predation are other aspects of ecology that are not discussed sufficiently in most recovery plans. A striking example of this is in the recovery plan for the Pahranagat roundtail chub (U.S. Fish and Wildlife Service 1985a), where competition from exotics is thought to have contributed to the chub's decline. The plan recommends that these exotics be removed from chub habitat, but there is no mention of how this is to be accomplished. At the very least, some of the methods for accomplishing this task should be reviewed. This plan also misrepresents the chub's life history by recommending a captive breeding program, even though an average of 200 juveniles are seen each year and recruitment into the adult population is extremely low (p. 14). Given these facts, a more suitable recovery task would be to increase juvenile survival perhaps by providing artificial refuges where juvenile chubs can escape from their predators rather than by initiating an expensive captive breeding project (see Cerri and Fraser 1983, Werner et al. 1983, Werner and Hall 1988).

Recovery plans also fail to consider the effects of environmental variability on an endangered species. Environmental variability is thought to be the best predictor of extinction probability (Goodman 1987). Perhaps the best documented effects of environmental variability are the effects of droughts in arid climates (Brown 1975, Low and Berlin 1984). Neither the recovery plans for Todsen's pennyroyal (U.S. Fish and Wildlife Service 1985b) or the Pahranagat roundtail chub (U.S. Fish and Wildlife Service 1985a) consider the rare, severe droughts which are known to occur at 50 to 100 year intervals in the American southwest.

The effects of environmental variability must be factored into the recovery objectives. Absurdities occur when this factor is ignored. An example is the plan for the northern rocky mountain wolf (*Canis lupus irremotus*) (U.S. Fish and Wildlife Service 1987). In this plan, downlisting and delisting requirements call for maintaining minimum populations of 10 breeding pairs for three consecutive years. Not only is this target size extremely small with regards to demographic stochasticity (Shaffer 1983), but a three-year time frame is too short by an order of magnitude or more.

Most plans do not provide adequately for movement between populations. Corridors are either not suggested or not explicit in terms of location, geometry (shape, width, length), habitat quality, or management. Corridors are important in maintaining gene flow and for providing enhanced recruitment for a decreasing population. Without corridors, populations are more isolated and more vulnerable to inbreeding depression. For the Pahranagat roundtail chub (U.S. Fish and Wildlife Service 1985a), corridors are not addressed, while for the northern rocky mountain wolf (U.S. Fish and Wildlife Service 1987), corridors are specified, but the extent of protection or management is not. Similarly, for the red cockaded woodpecker corridors are suggested but there are no specific recommendations for acquisition and management.

Multiple Species Approaches

The practice of preparing multiple species recovery plans should be more widespread. The Pahranagat River hosts four endemic species in addition to the chub, two of which are endangered. The chub's recovery plan, however, does not discuss the feasability of combining recovery efforts for all these species. The red-cockaded woodpecker plan could encompass many other species if a habitat recovery plan for the entire old-growth community was prepared. Similarly, a single plan for the entire greater Yellowstone National Park community could benefit wolves, grizzly bears, mountain lions, and other species living in the region. This community approach could benefit more species at less cost, and would also be simpler to implement because there would only be one set of recovery tasks for the region. In addition, conflicts between recovery plans for different species could be resolved.

Population Vulnerability Analysis

A missing component in many recovery plans is a scientific analysis of what constitutes a self-sustaining, or recovered, population. A Minimum Viable Population (MVP), is the minimum population size "... that will insure (at some acceptable level of risk) that a population will persist in a viable state for a given interval of time" (Gilpin and Soulé 1986, p.19). A set of MVPs should be explicitly estimated in every recovery plan. These will provide quantitative biological support for the population sizes listed in the recovery objectives. If enough habitat cannot be set aside to support a MVP, then more human intervention may be necessary to prevent extinction.

Population Vulnerability Analysis (PVA) is a systems approach to the estimation of a minimum viable population. PVA evaluates the probability that various factors—including demographic, environmental, genetic, and catastrophic — will cause a population of a certain size or smaller to become extinct over a predetermined amount of time (Shaffer 1983, Gilpin & Soulé 1986, Shaffer 1987). In addition, conducting a PVA can provide other useful information about the species (Gilpin and Soulé 1986). PVA's can:

1. Summarize knowledge of a species' life history, biology and physical environment.
2. Determine the sensitivity of the estimated MVP to changes in reproductive success, survival or some other trait.
3. Suggest future research priorities to provide better estimates of the MVP.
4. Suggest the minimum area of appropriate habitat (refuge size) based on species density.

Even if there is insufficient data for a full PVA, the attempt will help to define the questions that need answers and guide the setting of research and recovery task priorities.

Demographic modelling is an inevitable aspect of PVA. Software for estimating time to extinction has been written, though the estimation of the required parametric values is not straightforward (Belovsky 1987, based on Goodman 1987; a corrected update is available from Dr. Gary Belovsky, School of Natural Resources, University of Michigan, Ann Arbor MI 48109-1115).

Maps

The absence of adequate maps is a major failing of most recovery plans. Maps are often absent or of poor quality. When maps were included in a recovery plan, they usually were confusing because they were not properly titled and lacked geographic coordinates, a scale, standard compass directions, a legend explaining symbols used, and an inset showing the site's general location.

Maps synthesize geographic information about the endangered species and threats to the species. The construction of maps should be one of the first steps in recovery planning. It is often difficult to clearly illustrate both the species' distribution and land uses on the same map. We suggest that three types of maps may be useful for recovery planning. The first is a habitat map, which should include the species' historic range and distribution. This map could also show pertinent environmental variables, such as topography, soil type, watersheds, precipitation or temperature isoclines.

The second map should represent past, present, and future land use and zoning. The map should reflect the reason(s) for the decline of the species in terms of habitat modification and land use changes. For the vast majority of endangered species, the cause of decline is habitat loss. This map can help to identify the precise reason for habitat loss or alteration. Some examples of land uses that may affect the population status of a species are agriculture, forestry, urban development, human recreation, and transportation systems (including roads and railways). County land survey maps, USGS topographical maps, and aerial photographs are helpful in identifying these land use patterns.

Finally, a recovery plan map should represent the synthesis of the analysis and show the actions necessary for species recovery. This may be accomplished by overlaying the habitat map, including the proposed recovery areas, onto the land use map. The existence of such maps helps to identify recovery tasks including the prevention of further habitat fragmentation. Corridors can also be identified, as can barri-

A missing component in many recovery plans is a scientific analysis of what constitutes a self-sustaining, or recovered, population.

San Marcos lizard (*Eurycea nana*) Photo: Robert Mitchell

ers to dispersal of the species. For example, even narrow dirt roads may be barriers between populations (Swihart and Slade 1984). Yet road easements, railroads and transmission lines may be effective dispersal corridors. The importance of such issues will be dependent on the particular species, but maps are indispensable planning aids.

Recovery Objectives

Recovery plans are intended to assure the continued existence of a species. Recovery objectives should describe when the species can safely be downlisted from endangered to threatened or be removed from the endangered species list entirely. In most cases, however, the objectives of recovery plans provide for nothing more than token existence in a limited part of the species range. Even if such recovery objectives are achieved, the species will always be close to endangered status. Recovery planners can avoid this by seeking to establish and maintain self-sustaining populations larger than the MVP throughout as much as the species' historic range as possible (nobody seriously suggests the reintroduction of the grizzly bear into the Los Angeles basin). In this section we discuss recovery objectives in terms of the numbers of populations to be protected, the distribution of those populations, and the size of those populations.

Many recovery objectives seek three separate populations (U.S. Fish and Wildlife Service 1983, 1985a, 1987) for delisting or downlisting. The rationale for wanting three populations is never explained. Clearly, people understand that the probability of the simultaneous extirpation of three populations is significantly less than that for two. But this may not always be the case, especially if the species has a limited geographic distribution. For example, the recovery objectives for the Pahranagat roundtail chub recommend that the chub be downlisted to threatened status when two out of three populations are secured, and delisted when all three populations have been secured (U.S. Fish and Wildlife Service 1985a). Yet these three populations are located on the same river and may be subject to the same environmental events; whatever causes extinction in one population may affect all of the populations equally, causing them to go extinct simultaneously. Recovery objectives should seek to establish additional populations at sites where the relevant environmental factors are independent. The higher the covariance of factors, the more populations need to be separated.

Another problem is the use and abuse of simple rules of thumb based on a single factor (*e.g.* genetics) for MVP estimation. Genetics is certainly a relevant factor, but other factors can weigh more heavily. More often than not, the genetic criterion is used without due consideration to its complexity and to stated caveats (Franklin 1980, Soulé 1980, Frankel and Soulé 1981, Lande and Barrowclough 1987). For example, an *effective* population size of 500 often translates into a census size of many thousands. Smaller population sizes usually guarantee the eventual depletion of genetic variability. The "50" rule for short-term programs (*e.g.* captive breeding for a few generations) should never be used for long-term recovery *in situ*.

In any case, genetic considerations should be integrated into a more comprehensive viability analysis. When recovery goals employ the number 500 (250 pairs), it is a sure indication of an incomplete and simplistic PVA.

Implementation

The implementation of a recovery plan is perhaps the most challenging part of the recovery process. Well-designed plans are useless unless they can be put into action. Unfortunately, many recovery plans rely on complex and often unworkable processes to accomplish recovery goals. Here we suggest how the recovery plans might be changed to reduce these problems.

Interagency coordination between government and non-government organizations is often required for the recovery effort to be successful. There are two principle reasons why recovery plans do not provide a framework for such cooperation.

The problem of interagency coordination is compounded by vague language in the recovery plan, allowing each agency to provide its own interpretation. Such vague language must be replaced by clearly stated management strategies and objectives that can be measured and evaluated. Procedures for monitoring success of cooperative efforts should be a part of the recovery plan.

Interagency cooperation, especially between agencies that do not have a history of cooperative efforts, is difficult to facilitate. These agencies may have long established loyalties (for example, U.S. Forest Service to timber, Bureau of Land Management to livestock grazing, state wildlife agencies to hunting and fishing interests), and procedures that conflict with the recovery plan. Such conflicts undermine the incentive for that agency to implement or enforce the recovery plan, as may be the case with the red-cockaded woodpecker, where the Forest Service must alter its timber harvest practices in order to maintain suitable woodpecker habitat.

The potential for such conflicts should be explicitly examined in every recovery plan. Interagency task groups have been effective in some cases, *e.g.* the grizzly bear, while the representation of all or most affected agencies has worked well on the California condor recovery team in recent years. Regional protection planning committees (Pulliam 1988) are another option. These committees include mid-level representatives of various agencies with personal interests in the recovery plan and with the power to commit their respective agencies to accomplishing tasks that are within the scope and preference of the agency. This voluntary cooperative effort may prove to be the most effective at accomplishing recovery goals.

Implementation success also relies, in part, on budgetary constraints. Budgets in the recovery plans are often inflated, asking for millions of dollars (realistically, that sort of money is not available for each endangered species). Furthermore, the proposed budgets are not always consistent with the priorities contained in the text of the plans. If the budgets are to be useful they must reflect the priorities of the plan and be responsible estimates of actual monetary needs and availability. Each plan should contain a section on budget justification similar to those in grant proposals to federal agencies.

Perhaps the greatest weakness in the recovery planning process is the general absence of a political feasibility analysis. The success of a recovery plan hinges on its implementation and enforcement capabilities. Endangered species issues are often controversial and politically unpopular among powerful groups. The potential problems of implementing unpopular plans are often ignored. The political climate also affects the enforcement capability. The recovery plan must, to some degree, recognize the prevailing public sentiment and suggest ways to stimulate support for recovery actions.

Public education may be the easiest way to gain support for a recovery plan. Effective education can generate community support, which then encourages otherwise indifferent (or opposing) organizations and landowners to cooperate in the recovery process. Benefits to the cooperating organizations may include property tax incentives for land conservation easements and free publicity for cooperation in the recovery effort. Public education is often given the lowest priority (and may not have been contemplated). An exception is the northern rocky mountain wolf plan (U.S. Fish and Wildlife Service 1987).

The implementation of a recovery plan is perhaps the most challenging part of the recovery process. Well-designed plans are useless unless they can be put into action.

An educated public provides many benefits, even if community support is not widespread. If recovery involves changes in human behavior, the changes will be easier for the public to accept if the reasons for these changes are known. Those people that are supportive of the changes will act as watchdogs, reporting suspected violations to the appropriate authorities. An informed and supportive public is also a potential source of volunteer labor that can be utilized for tasks ranging from office work to manual labor, and to helping monitor the recovery of a species. Finally, the problem of agency compliance and coordination can be reduced through political pressure from an informed and supportive public.

One of the most pertinent aspects of environmental education is that its infrastructure is already in place in most communities. Many nature preserves already have naturalists or educational programs that can coordinate educational programs about the endangered species. If there are no such programs, it should be possible to locate teachers in the local school systems that would be interested in helping establish an educational program. A grant of several thousand dollars for such an educational program could be the most cost-effective way to begin a recovery program, and could also benefit local educational programs, which often are short of money.

Education can be effective even when the species is so sensitive that its locations or breeding sites must be kept secret to prevent vandalism to the species or its habitat. In these cases, there could be articles in the local newspapers describing the species, explaining why it is endangered and why it should be protected. Future articles could inform the public about the progress of the recovery effort. Slide presentations to local civic groups are also effective.

The proposed educational methods rely on the notion that there is something of interest to the public about the life history of any endangered species. Hence, it is important for members of the recovery team, in combination with local teachers and naturalists, to provide accessible, interesting information about the natural history of the endangered species and its habitat.

Conclusion

Each of the recovery plans we reviewed contained flaws in their biology and their implementation. Thus the ineffectiveness of the recovery plans is not surprising; their ineffectiveness is a contributing factor to the low success rate of the Endangered Species Act. Our suggestions for eliminating these flaws from recovery plans are summarized in the box below. The United States Fish and Wildlife Service should incorporate these suggestions into the

Andean condor (*Vultur gryphus*) Photo: Mike Wallace

recovery process, otherwise our endangered species, and our biological diversity, will not be preserved.

• Revise and update all recovery plans.
• Complete recovery plans for all species.
• Initiate a two-stage recovery planning process:
— A team of biologists should prepare a recovery plan dealing solely with biological issues. At least one biologist must be from outside the FWS or affected land management agencies.
— An advisory team should insure that the recovery plan is implemented. Compromises between biology and economic interests must be made in an open, explicit manner.
• Recovery plans should:
— Focus on all endangered species in a community,
— Use population vulnerability analysis to determine minimum viable populations,
— Seek self-sustaining populations larger than the minimum viable population,
— Include detailed maps with appropriate legends,
— Explicitly address how interagency coordination is to be achieved,
— Include a responsible budget, and
— Establish a broad public education program.
• Provide sufficient funding to the FWS to accomplish these tasks.

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Science, Planning, and the Recovery of Endangered Plants

by
Philip M. Dixon and Robert E. Cook

Plants are the most numerous taxonomic category on the U.S. threatened and endangered species list. As of April 1989, 207 species were listed (Endangered Species Technical Bulletin (ESTB), April 1989), while over 2500 species are candidates for listing (Federal Register, Sept 27, 1985). Recovery plans have been written for 84 of the 204 listed species that occur in the United States (ESTB, Apr 1989). Our experience with many of these plans (Cook and Dixon 1987) suggests that the issues involved in writing a plant recovery plan and managing the recovery of plant species are different than those for the "typical" endangered species, a mobile vertebrate. Many of these management differences stem from biological differences between plants and vertebrates. We wish to consider the interface between science and management of rare plants, the life histories of plants and how they differ from animals, and the implementation of plant recovery plans.

Science and Plant Recovery Planning

In most cases, the writer of a recovery plan is faced with a daunting problem. Because the species is rare, basic knowledge about its biology is often unavailable. This is especially true for aspects of its population biology; even an accurate census of numbers may be unavailable. This problem is more acute for plants than for vertebrates. The Fish and Wildlife Service guidelines for recovery plans (U.S. Dept. Interior, undated) emphasize administrative procedures rather than scientific content. Faced with these guidelines and a lack of factual knowledge about the species, writers of recovery plans tended to use already written plans as models (Cook and Dixon 1987). In many cases, plans have the same form and structural outline, and in a few cases, large sections of plans share identical wording. In general, the writing of recovery plans is becoming standardized and formulaic, rather than individually crafted to the biology and ecological setting of the particular species.

The rare plant literature is full of summaries of plant characteristics that might be studied (Whitson and Massey 1981, Brouillet 1985, Huenneke 1986, Pavlik 1987). Faced with little or no knowledge of a species, writers tend to recommend as much research as possible in the most general terms (Cook and Dixon 1987). It is a conservative response; some unknown aspect of a species' biology might provide the critical clue to its recovery, and recommendations for a broad research program are more likely to find it. Often, therefore, no real priorities are made among research activities in a recovery plan. In most recovery plans, nearly all research recommendations are lumped together with a priority of two — "An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction" (U.S. Dept. Interior, undated). Many recovery activities (*e.g.* "study limiting factors", "study pollination biology", "monitor populations", or "study life history") can involve substantial effort that may or may not be relevant to recovery. Our view is that specific recovery activities can be justified by combining information from plant population biology with specific knowledge of the threats faced by a species and some simple field observations.

Plant Population Biology

Recovery of a species is usually defined by numbers of populations and numbers of individuals, so it is no surprise that population biology can contribute to understanding recovery. However, any easy extrapolation of principles from animal ecology to plants may be deceptively misleading, because the differences between plants and vertebrates have fundamental consequences for their population biology. Although plant life histories and vertebrate life histories share many common features, there is more variation in plant life histories (Harper 1977). A generalized plant life history (Fig. 1) demonstrates the many possible paths a seed may take to produce another seed.

The most obvious difference between plants and mobile animals is that plants are fixed in space, rooted in a particular location. Maintaining these locations by some form of habitat protection is a major recovery activity pre-

Photo: Philip Dixon

small whorled pogonia (*Isotria medeoloides*)


Photo: Philip Dixon

northern wild monkshood (*Aconitum noveboracense*)

scribed in plant recovery plans. Often habitat protection is the only priority one action — "must be taken to prevent extinction or to prevent the species from declining irreversibly" (U.S. Dept. Interior, undated)—in a recovery plan. However, saving habitat is maintenance, not recovery. Persistence of a population critically depends on site preservation, although the converse may not be true; site preservation does not ensure population persistence. We assume that catastrophic destruction of the site (*e.g.* by urbanization) has been averted; our focus is the subsequent research necessary to understand how to maintain a population.

The rootedness of plants has several other biological consequences. First, the environmental conditions that most directly affect an individual's performance are those of its immediate surroundings. Broad scale measures of the habitat may have little relevance to a particular plant. Instead, the local neighborhood is all important. Interactions with other plants, including pollination, will be between close neighbors, and most seeds disperse close to the parent plant. Consequently, neighbors may be similar genetically, and plants from different parts of a population may be genetically different. Finally, each plant must be able to tolerate changes in its immediate habitat (through physiological and morphological acclimation); moving to a more favorable site is not an option.

Because plants are immobile, it is relatively straightforward to count the number of stems present in a defined area. Although it is necessary to visit each individual, one need not attract plants to a bait or use mark-recapture techniques to estimate population size. However, the ease of counting hides a fundamental difficulty; what is to be counted? Unlike vertebrates, where the physical individual and the genetic individual are identical, many plant species reproduce asexually, forming large clones of genetically identical stems, some of which may remain physiologically connected by underground rhizomes. Depending on the purpose, one may need to count genets (the genetic individuals) or ramets (the individual stems). The ability to reproduce clonally can influence other life history traits. Successful propagation by seed is infrequent in many species that reproduce clonally (Harper 1977).

Plant demographic methods are not standardized and there are no source books which compile methods (Palmer 1987). Although counting individuals sounds deceptively easy, different methods and different definitions of "individual" influence one's conclusions. We are aware of five different methods used to define individuals of two listed plants, northern monkshood (*Aconitum noveboracense*) and small whorled pogonia (*Isotria medeoloides*). In three studies by different groups in three states, a monkshood individual is defined as: 1) the number of flowering stems divided by an average correction factor for the number of stems per genet, 2) the number of genets, and 3) the number of ramets. In different studies, small whorled pogonia individuals are defined as any shoot within a marked area or as those tagged individuals that could be relocated within an unmarked, unbounded area (Palmer 1987). Comparing population trends across states in northern monkshood is complicated because any regional difference in the number of seedlings, vegetative individuals, or shoots per genet affects the apparent trend. Interpreting trends in small whorled pogonia is complicated because the accidental loss of a tag in the second study may be interpreted as a false death.

Another important difference between the population biology of plants and vertebrates is that many dormant seeds may be buried in the soil (a seed bank), which should be considered part of the population. Unlike vertebrate eggs or embryos, the seeds of many species can remain viable for years after dispersal from a plant and many soils contain large populations of buried seeds waiting for the appropriate environmental cues to stimulate germination.

Because buried viable seeds are part of the population, a simple count of visible shoots may ignore most of the living individuals. The number of shoots at the surface, in turn, is determined by the complex array of stimuli that cause some of the buried population to germinate and reveal their presence. Fluctuations in shoot number may be quite dramatic from year to year, yet the total population may remain fairly stable. Even the "extinction" of a population may not be real if the buried individuals are not counted. For example, the abundance of the endangered annual grass, Solano grass (*Tuctoria mucronata*) fluctuates considerably between years. One population disappeared during two separate dry periods in the 1970s and reappeared in wetter years after absences of one and five years. The recolonization was assumed to be from the soil seed bank rather than by dispersal from some nearby population (Holland 1987).

A variation on the dormant seed bank is the buried individual characteristic of the life history of orchids (Silvertown 1982), including the small whorled pogonia (*Isotria medeoloides*). Orchids produce extremely small seeds that can germinate and remain below ground for some number of years. Orchid seedlings are associated with a fungus and can grow without producing any aboveground leaves or a stem. Larger individuals that have entered the aboveground population may remain dormant some years and not produce a stem or leaves, although few orchids remain dormant more than three years (Mehroff 1989). In a short-term study, a dormant individual could be erroneously recorded as a death.

A final difference between plants and vertebrates is the importance of variation in plant size and its effect on individual performance. Most vertebrates have determinate growth; it slows or stops after they reach some adult size. Plants have indeterminate growth; they may increase in size long after they begin to flower. Consequently, there may be considerable variation in individual size within a population. This size variation influences most aspects of an individual's ecology. With few exceptions, large plants endure more environmental stress, survive better, produce more seeds, tolerate greater herbivore damage, and are better competitors (Harper 1977). The exceptions occur when structural instability becomes a problem, when changes in bark characteristics permit fungal infection (as in the American chestnut, *Castanea dentata*, and Florida Torrey tree, *Torreya taxifolia*), when plants begin to senesce with old age, and when large plants are preferentially collected (*e.g.* most cacti).

The distribution of plant sizes in a population has several important implications. First, it emphasizes just how critical the seedling stage is in the life cycle. Individuals will never be smaller or more vulnerable to adverse environmental conditions. Even if a seedling survives adverse conditions, a slowing of seedling growth may have long-lasting effects; seedling recruitment is often a critical life history stage affecting the number of adults in a population.

Second, all individuals are not equal; some are bigger than others, and large individuals will have disproportionate effects on the population. The distribution of individual sizes will affect the relative reproductive contribution of individuals, as well as the degree of inbreeding within the population. A simple count of the number of plants can give a misleading picture of the real or effective population present. A population with 30 large plants is very different than a population with two large plants and 28 small ones. If mortality is concentrated in small plants and seed production in large plants, the population of 30 large plants is likely to grow, while the population of two large and 28 small plants may decline.

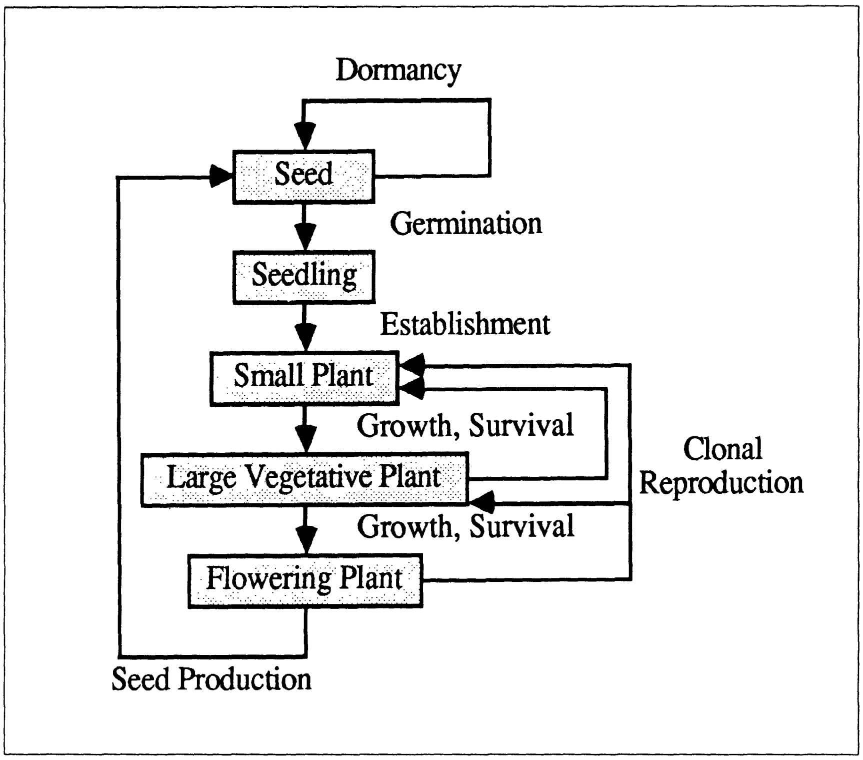

Figure 1. Generalized life cycle of plants. Important demographic processes are shown outside the boxes. Some of these may be unimportant in any given species. Transitions between stages may occur quickly--as in annuals--or require more than one year.

For the the practical field manager, an alternative to the "study everything" approach to recovery planning is to ask some simple questions about a plant's life history. A life history (Fig. 1) can be viewed as a series of filters between life history stages (Harper 1977). At each filter, the number of individuals that pass through is reduced. The filters that should be studied first are those that remove large fractions of individuals. The sequence of questions to be asked might go something like:

1. Are the current adult plants surviving? If not, try to identify what might have changed in the habitat to reduce survival.
2. Are new plants establishing in sufficient numbers to balance adult mortality? If the plant is clonal, what is the balance between clonal and sexual reproduction? What habitat changes are reducing vegetative reproduction?
3. Are seedlings or small plants present? If not:

3a. Are seeds being produced? If so, is dispersal of seeds to unsuitable habitat high, is seed predation high, or seed survival in the soil low? Do seeds germinate? Is survival of small seedlings low?

3b. If no seeds, are pollinators visiting the flowers? If they are, is pollen being transferred, are individuals self-sterile, is fruit abortion high?

3c. If no pollination, why not?

This process isolates stages in the life history that may be responsible for a decline in population numbers (Harvey 1985). Once those stages are identified, more detailed research may be able to find ways to increase survival and hence increase population numbers.

Table 1. Threats to plants and their demographic correlates. Each entry indicates particular features of population biology that can indicate the presence or susceptibility to a threat. Threats are classified into major groups that are ordered from those with rapid and permanent effects on a population (*e.g.* catastrophic loss of habitat) to those with less immediate effects (*e.g.* loss of genetic diversity).

Catastrophic loss of habitat:
- *e.g.* Mining, Urbanization, Flooding, Logging (potentially)
- Little to no contribution from population biology
- Protect by increasing the number of dispersed populations

Catastrophic loss of plants (habitat remains intact):
- *e.g.* Off-road use, Trampling, Herbicide application, Logging (potentially)
- Source and rate of colonization of new individuals:
- Seed production and dispersal, soil seed bank, seedling establishment
- Clonal propagation

Habitat change:
- *e.g.* Succession, Competition (from natives or exotics), Pollution
- Growth and death rates of existing plants
- Source and rate of establishment of new plants

Loss of large plants:
- *e.g.* Collection, Fungal attack, Grazing
- Rate of loss of large plants
- Survival and growth of seedlings and small plants

Lack of seedlings or small plants:
- Adequacy of pollination, seed viability
- Seed predation rates
- Seedling establishment
- Vegetative propagation

Fluctuations in population size, hence higher chance of extinction
- How variable is population size?
- How long-lived are individuals?
- Do new plants establish regularly or infrequently?
  - annual vs slow growing perennial
  - seedling reproduction vs clonal propagation
- Does population have ability to recover from bad years?

Loss of genetic diversity
- Study breeding system, pollination biology, hybridization rates

This life history approach to recovery prioritization requires a little bit of preliminary information. This information could be obtained from monitoring studies that look at all stages in the life history. Unfortunately, very few monitoring studies include a search for seedlings (Palmer 1987). Alternatively, a couple of field inspections may provide clues to the effectiveness of each life history filter. Ideally, one inspection should occur early in the growing season to look for seedlings or small plants and one should occur late to check the production of seeds. Single inspections look at the static population structure and can indicate serious problems, such as the absence of seedlings or small plants. They can not in general be used to infer population dynamics (i.*e.* seedling growth rates or adult survival rates) (Harper 1977).

A second alternative approach to recovery planning is driven by the perceived threats to the population. Part of the listing process for each threatened or endangered species is to consider the threats faced by each species. Some threats have consequences for specific stages in the life cycle (Table 1). For example, succession, competition from exotics, and pollution all involve habitat change. The response of a population depends on the effect of that habitat change on the growth and death rates of individuals. Populations decline if the death rate of established individuals exceeds the establishment rate for new plants. It is not sufficient to monitor survival of the established individuals, as is typical of many monitoring studies (Palmer 1987); it is necessary to study the processes that create new individuals in the population, seedling establishment, and vegetative propagation (if it occurs).

The value of studying all stages in the life cycle is most apparent when different stages respond differently to environmental change. Grazing, the second most frequently named threat to threatened and endangered species (Cook and Dixon 1987), can have different consequences for adults and seedlings. It reduces the size of adults, often reduces seed production (because fruits and flowers are eaten), and may kill adults (Widen 1987). However, it can also reduce the growth of competitors and create small disturbances at the soil surface. Both actions increase the survival of seedlings (Widen 1987).

All the aspects of recovery planning discussed so far concern deterministic factors that influence plants and cause changes in population size. The long-term persistence a of population also depends on the amplitude of random fluctuations. If two populations have the same long-term average size, the one with larger fluctuations in numbers is more likely to go extinct because it is more likely to encounter a series of very bad years in sequence. Annual fluctuations in population size can be measured directly if populations are monitored for a sufficiently long time, but the required monitoring time may be impractically long--in some cases as much as 300 years (Cook and Dixon 1987). Either estimates of persistence time are going to be imprecise because they are computed from uncertain data, or we will have to be content with qualitative indications of persistence time.

Two qualitative indicators of persistence time can be easily observed or measured in a demographic study. A population that responds slowly to a deleterious environmental change but which can quickly recover in favorable circumstances is more likely to persist than a population that is severely affected by a deleterious change or a population that recovers slowly. Perennial plants might tolerate a few years of unfavorable seed establishment, while annuals in that environment might go extinct. Similarly, perennials can tolerate longer periods of increased adult mortality and decreased seed production than can annuals. Because long-lived dormant seeds will increase the resilience of any species, an annual with a seed bank may be as resilient as some perennials.

Table 2. Distribution of plant recovery plan implementation activities in 1983 and 1984. Activities are classified by the status of the recovery plan. A few species had many recovery activities. Only the most active management (highest in this list) was tabulated for each plan.

Status of plan:	Tech. Draft		Agency Rev.		Approved		Total	
	'83	'84	'83	'84	'83	'84	'83	'84
Active Management								
herbivore removal	0	0	1	1	0	1	1	2
weeding	0	0	0	0	2	1	2	1
visitor control	0	0	0	0	1	0	1	0
transplant experiments	0	0	0	0	0	3	0	3
Biological studies								
species biology studies	2	0	3	3	3	7	8	10
monitor populations	0	0	3	0	0	2	3	2
survey for new populations	0	1	2	1	3	6	5	8
Management activities								
land protection	0	0	1	1	1	3	2	4
develop management plan	2	1	1	1	0	0	3	2
consult with other agencies	5	0	0	1	0	1	5	2
No recovery activities	7	3	4	7	1	5	12	15
Total plans covered	16	5	15	15	11	29	42	49

It is harder to observe how quickly a population can increase under favorable conditions, but a qualitative indicator may be sufficient. Populations that flower, mature abundant viable seed, and produce abundant seedlings each year will be able to rapidly increase in favorable conditions. Monocarpic populations (those in which adults flower once, then die), or those with irregular seed set or germination, may recover more slowly because favorable environmental periods may not coincide with periods of seed maturation or seedling establishment.

Classically, populations are treated independently; the success or extinction of one population has no effect on other populations. However, the consequences of some threats depend on the connections between populations. For example, trampling from hikers is a threat listed for many species (Cook and Dixon 1987), including mountain golden heather (*Hudsonia montana*). Whole populations of Furbish lousewort (*Pedicularis furbishiae*) can be eliminated by ice scour (Menges 1988). Reestablishment of the population depends on recolonization from other populations, or germination from a buried soil seed bank. The dynamics of the metapopulation (the rate of establishment of new populations and rate of extirpation of existing ones) (Menges 1988), are especially important in two types of species: those subject to extensive disturbance, and those in linear corridors, such as along a stream bank. Extensive disturbance leads to higher extirpation rates, and being in a linear corridor often leads to higher dispersal rates.

The value of studying population biology is best demonstrated by the extensive work on the Furbish lousewort (*Pedicularis furbishiae*) (Menges 1988, Menges and Gawler 1986). Furbish lousewort grows in scattered colonies along the banks of the St. Johns River in Maine. Under a classical site-specific approach to site preservation, one would attempt to preserve the current lousewort sites and maintain each population. Demographic studies showed that once a population gets established, it is very successful until it gets destroyed by ice-scour or shaded by invading shrubs. Preservation of the lousewort seems to require managing disturbance along the river to create conditions suitable for the establishment of new colonies (Menges 1988).

Implementation of Plans

The production of a recovery plan is not the final action in the process of species preservation. The activities recommended by the plan must be implemented and be successful. Very little data has been systematically collected on the implementation of recovery plans, although such reports will be forthcoming. The 1988 amendments to the Endangered Species Act require a regular report to Congress on recovery plan implementation. However, during 1983 and 1984, each region of the Fish and Wildlife Service was required to submit a semi-annual report of recovery activities for each draft or approved recovery plan. Generally, a plan covers a single species, although a few plant recovery plans consider more than one species at a site. A tabulation of recovery activities (Table 2) from these reports presents some interesting trends.

Currently, recovery plans recommend a "do everything" approach to conserving a species. We feel that more focused recommendations will increase the value of research on endangered plants...

It was not necessary for a recovery plan to be finally approved before recovery activities started. Some recovery activity was reported for over half of the plans in the initial stages (technical draft) or final stages (agency review) of preparation; most of the activity was managerial and research, including initiating studies of species biology.

Even so, little attention was given to plant recovery activities. Active manipulation of populations or habitats was rare. Active management, including transplant experiments, was reported for six plans (12 percent) by 1984, and life history and demographic studies has been started on 10 species (20 percent of plans). However, there was no recovery activity for 12 species (28 percent) in 1983, and 15 species (31 percent) in 1984. Much of the activity that did occur was managerial, including developing management plans, consulting with other agencies, and signing conservation agreements.

Implementation of recovery plans differed considerably between regions of the United States. Most of the species with no recovery activities were western species, especially cacti. Eight plant recovery plans had a strong implementation program: bunched arrowhead (*Sagittaria fasciculata*), Channel Islands species, Furbish lousewort (*Pedicularis furbishiae*), green pitcher plant (*Sarracenia oreophila*), northern monkshood (*Aconitum noveboracense*), Robbins cinquefoil (*Potentilla robbinsiana*), small whorled pogonia (*Isotria medeoloides*), and round-leaved birch (*Betula uber*). All plans except the Channel Islands species plan are for eastern species. There is clearly a concentration of recovery efforts on a few plant species in areas where there are lots of botanists. However, no plant species received the intensive management and monetary support received by some highly visible vertebrate species (*e.g.* California condor, black-footed ferret, or peregrine falcon).

Summary

Currently, recovery plans recommend a "do everything" approach to conserving a species. We feel that more focused recommendations will increase the value of research on endangered plants, increase the chance that recovery activities will be implemented, and ultimately increase the information available to the manager. We have discussed selected aspects of the population biology of plants, especially the ways plants differ from vertebrates, and emphasize biological characteristics that indicate important stages in a plants life history.

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Population Viability Analysis

by
Michael Gilpin

Small firms go bankrupt in the economic arena, just as small populations go extinct in their own ecological arena. Can parallels be drawn from these better-observed economic processes to guide our investigations in the newly formed science of conservation biology? For instance, what does small mean, and how is it quantified?

Minimum Viable Populations

In conservation biology, one branch of which is planning for the avoidance of species extinction, the term Minimum Viable Population (MVP) was in vogue during the early 1980s. It was thought that there was a total population number below which a population was doomed to extinction. In other words, a population became inviably small when it crossed the MVP threshold.

Mark Shaffer (1983), who was concerned with chance birth and death events, saw a population size of approximately 50 adult females as the number of grizzly bears that the Yellowstone Ecosystem could minimally contain with a high probability of persistence. Using a computer model containing age-specific birth and death probabilities, he found that only with an initial population of 50 or more females would the Yellowstone population have a better than 95 percent probability of surviving a century.

Somewhat earlier, Ian Franklin (1980) argued that a species population must maintain a minimum amount of selectable genetic variation, which alone would assure its ability to make evolutionary adjustments to changing environmental conditions. He found 500 individuals to be a fundamental lower limit to the species population size. Of course, this number only becomes important with the onset of environmental change, which, in the sense of evolutionary time, might take a while. Planetary greenhouse warming models, however, place such environmental challenges in the offing for virtually all species.

Two different numbers, two different mechanisms, and two different time scales have been considered while delineating MVP's. Other biological mechanisms involving social behavior—*e.g.* mating, defense, and group hunting—and the occupation of a patchy environment have also been identified as having important critical lower limits for population viability, that is, as giving MVPs. Many different factors may point to many different minimum sizes for a population. What are conservation planners to do? Which value should they use?

In considering a theoretical population (Fig. 1), conservationists would, correctly, argue for the MVP associated with factor C. On the other hand, the existence of other MVPs, could give exploiters and developers an opportunity to argue that factor A should have primacy. Clearly, a single answer is best.

Returning to our analogy, a small firm starts its economic life with some capital, an idea, and a team of employees. Is it viable? Will it fail or succeed? It will go extinct if more employees resign or die than can be replaced—a stochastic birth and death process in which a smaller firm could be devastated by a short run of bad luck. If each employee makes independent decisions based completely on personal considerations, this threat to the firm is not likely to be great above a certain lower minimum number, probably in the range of five to 10 employees. If, however, there is a change in the employment marketplace—the economic environment of the firm—which affects all of the employees in a similar way, a mass exodus could occur to higher-paying jobs or to greater opportunities outside the firm.

The comings and goings of employees are not the only factors that determine the fate of the small firm. A firm needs capital, which among other things is cash in the bank. And, it needs the power to borrow against its probable future earnings. Without these financial strengths, it will not be able to ride out reversals in fortune. The analogous biological capital of a small population may be held in various forms. A matriarchal elephant with a 60-year investment of knowledge of regional geography is one form of investment. A diapausing butterfly larvae awaiting the environmental signal of better living conditions is a second kind. As these or other diverse forms of biological capital are exhausted, the species population is pushed closer to the threshold of ecological insolvency.

In conservation biology ... the term Minimum Viable Population (MVP) was in vogue during the early 1980s. It was thought that there was a total population number below which a population was doomed to extinction.

A firm lives or dies by ideas, its

reserve of adaptive information. No single idea will prevail forever in the marketplace of new ideas. While widgets and WD-40 may win wide acceptance for a time, the economic fashions are fickle and will sooner or later work against the firm to undercut its market share. Without diversification, any small firm is doomed. The source of such adaptive ideas is analogous to the addition of beneficial mutation to a population—typically a rare event. The small number and great value of beneficial ideas probably underlies the distribution of both firm size and species population size. The large and strong are few, while the small and struggling are many.

The small firm becomes the large firm in different ways. It may grow by simply increasing at the site with the addition of employees and construction of a larger central facility (Hershey's single chocolate factory); by replicated spread of the basic unit over the economic landscape (our world covered by McDonald's Restaurants); or by diversification and acquisition of products and markets (a conglomerate such as ITT) through a hierarchical process.

Switching from Large to Small

But how does the large firm become the small firm? This is the analogous economic question to the central issue that is increasingly faced by conservation planners: big, continuously-distributed species populations are turning into smaller, often fragmented species populations. What mistakes can the management of a firm make that causes it to contract? What external factors can produce the same effect?

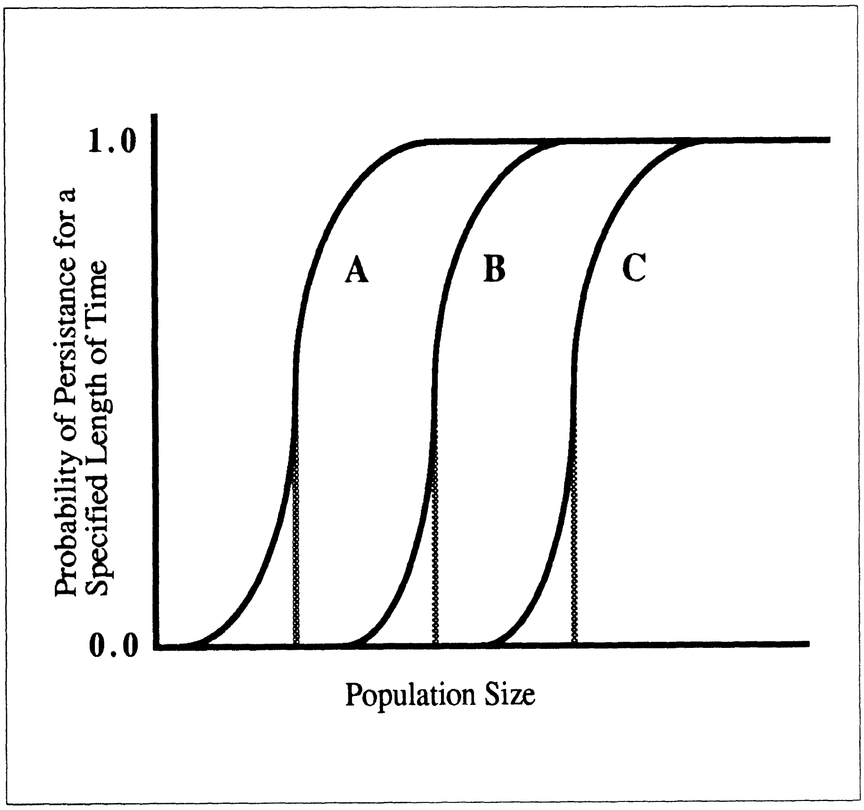

Figure 1. The analysis of population persistence from factors A, B , and C, which gives three different population minima.

For economic firms, several kinds of smallness (analogous for biological populations to rarity) can be reached by following a different series of economic events. A firm that is steadily losing money and employees across all of its operations and at all of its locations is in bad shape, regardless of the specific cause. It is doing something wrong, and unless this is identified and changed, bankruptcy is certain. A second firm might become small simply by losing some of its markets (habitats) to strong specialist competitors. While this might weaken the firm, there is no reason to think that this bodes ill for its operations in unrelated markets. Lastly, a firm could contract spatially. For example, a firm operating in many states of a single country might pull back to a single region or a single state as local tax laws change, remaining fully diversified as it does so.

While these last two cases, analogous to loss of habitat niches and to loss of geographical range, are the better ways to approach rarity, they nonetheless have limits that must be recognized. A firm does not want to be reduced to producing and marketing a single product, for this is a dangerous over-specialization (the widgets case, mentioned above). Nor does it want to become too closely tied to a single locality, which among other things means a single employment market. In both cases, the firm could be ruined by a single environmental shock or catastrophe, something that it might have weathered as a larger, more diversified firm.

A management decision between two different forms of rarity faced by most firms is, "Is it better to have a single central facility or several smaller local offices?" The strategy of the single central facility permits the stock of a greater diversity of parts and materials, it is less affected by employee turnover, and it has advantages in its economies of scale. Yet the countervailing advantage of the strategy using several smaller facilities is that the individual local units may better interface with a diversity of local markets such that not all will fail from any single shift in economic fortunes. Clearly, the degree of correlation between the local economic environments of the branch offices is an important consideration in deciding this issue. An additional consideration is the ability of the firm's local units to shift resources among themselves along established "corridors" of commerce and intrafirm exchange.

President Kennedy, reflecting on the disaster at the Bay of Pigs, said that

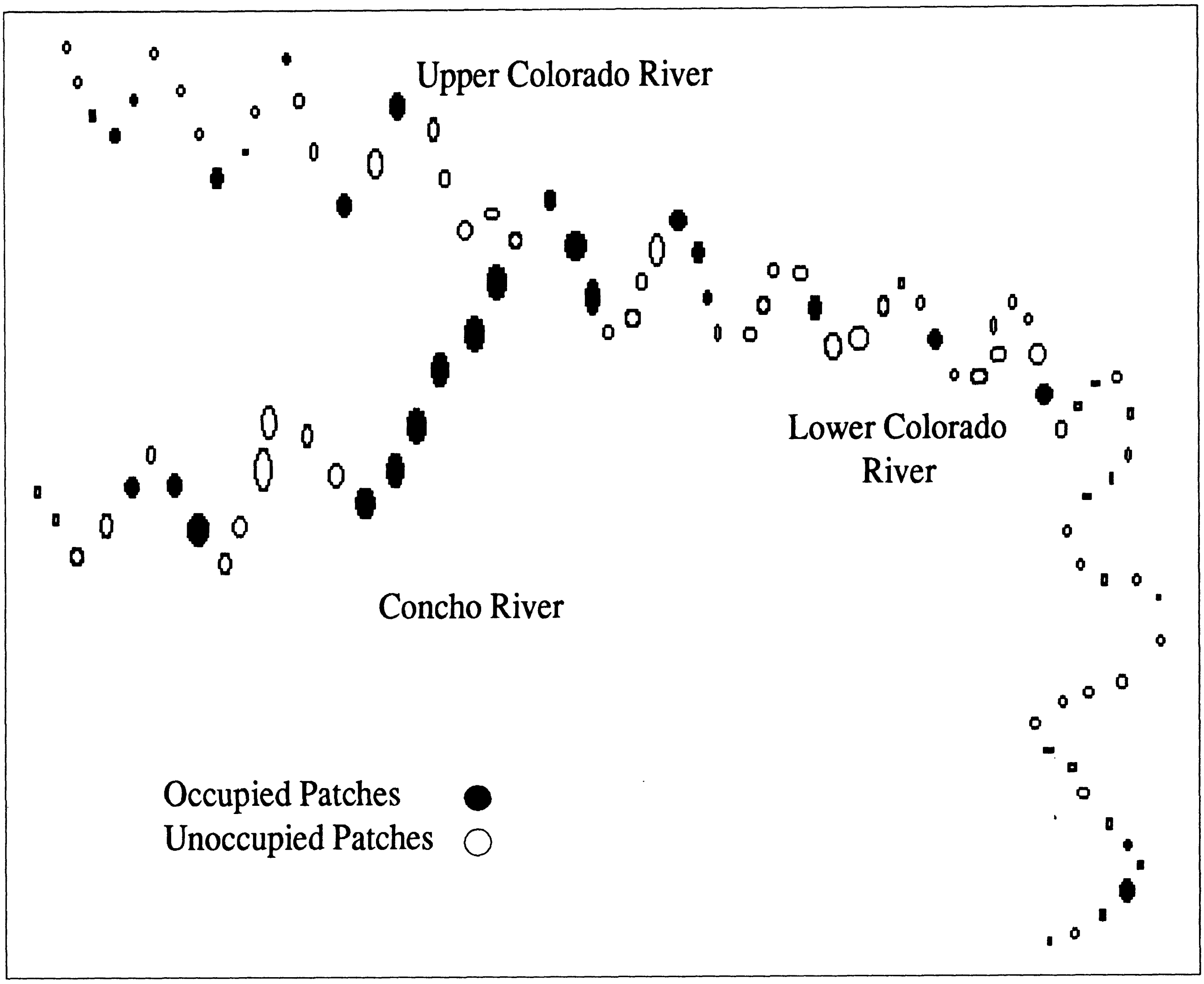

Figure 2. Distribution of patch size and patch occupancy for the Concho water snake. Open circles represent unoccupied patches, while darkened circles are occupied by the snake. Patch size is represented by relative size of the circle.

success has many fathers, while failure is an only child. This may be psychologically true of the way human beings take credit and assign blame but, it is not, despite the analysis we have made above, the situation with economic and ecologic failure. It may be true that each failure, whether of a firm or a species, may be immediately assigned (fathered by) a single, identifiable cause or event, but these events are quite various and they are each set up and primed by a great diversity and network of other forces and events. The managers of a firm may not concentrate on one threat to the exclusion of all others and it is equally true for the managers of small populations. Thus, in conservation biology, the idea of a universal MVP, a single critical limit due to a single extinction factor, is giving way to PVA, Population Viability Analysis (Gilpin and Soulé 1986), which sets out to identify the full spectrum of factors that can lead a species population down the path to extinction. PVA is both multivariate and, more importantly, interactive.

Population Viability Analysis

PVA is not fundamentally new. Biological managers have been assessing the "health" of species populations for decades. Since 1973, with the passage of the Endangered Species Act, they have been managing for the recovery of species. Both of these require much the same kind of knowledge that goes into a PVA. PVA does not provide the quick, simple answers that were expected from a single-factor MVP. For one thing, PVA is data hungry. PVA must also recognize different time scales for data acquisition and analysis, and also for prediction of probabilities of alternative future states. And, after an initial PVA analysis and the rendering of its provisional judgement, PVA needs to incorporate itself with the ongoing management of recovery of the species population.

Where PVA goes beyond the traditional wildlife ecology approach to species "health" is with the inclusion of genetics and the dynamic extinction and colonization interactions over a fragmented habitat. These are, of course, areas of population biology that have only received intense investigation in the last decade or two, so their recent incorporation into conservation biology planning is probably not delayed.

The Concho Water Snake

One of the first analyses of a threatened species population that was self-consciously a full PVA was carried out by Soulé and Gilpin (1986) on the Concho water snake in central Texas. (See Soulé in this issue of the UPDATE.) Water districts in central Texas wanted to build a dam approximately 20 kilometers south of the confluence of the Concho River and the Colorado River.

PVA does not provide the quick, simple answers that were expected from a single-factor MVP. For one thing, PVA is data hungry.

The Army Corps of Engineers was to carry out this $100 million project, but the project was in the middle range of the Concho water snake (*Nerodia harteri paucimaculata*), a species that at least some biologists argued should be listed under the Endangered Species Act. Although it was not a listed species, the Corps of Engineers consulted with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act to see whether their actions would "jeopardize" this species.

Various data were available to permit PVA to reach a decision regarding the jeopardy of the snake by the dam. Genetic surveys using starch gel electrophoresis had been carried out. A master's thesis was completed on the demographics and life history of one local population. And, the U.S. Fish and Wildlife Service had performed a geographical survey of the distribution of the patch habitats and the patch spatial distribution of the species. Figure 2 shows the distribution of habitat patches and their size (proportional to the area of the circles) and the presence or absence (based on 1983 data) of the snake species on them (shown by filled or open circles, respectively).

Briefly, Soulé and Gilpin demonstrated that the demography, the stream ecology, and the low levels of genetic variation, were consistent with a picture of rapid local population extinction and recolonization. Thus, they treated the population viability analysis using an essentially one-dimensional model based on patch-turnover dynamics. The actual data on rates of turnover and recolonization were not sufficient, however, to obtain relative probabilities based on patch area and patch separation. From these relative values Soulé and Gilpin calculated the steady state or equilibrium distribution of patch occupancy, but not how long it would take the species distribution to return to this steady state following a disturbance. This prediction of steady state closely matched the existing distribution before construction of the dam. From this agreement between the model and the field data, Soulé and Gilpin concluded that the present population was viable and would persist, if there was no major disturbance, well beyond any contemplated management horizons.

Based on these conclusions, they predicted, with their model, the steady state distribution of patch occupancy that would ultimately follow the construction of Stacy Dam (but again they were not able to predict how long this would take). The imprecision of the time estimate was not a serious problem, for the early behavior of the system following the disturbance, over the first five to 10 years, would fix these rates and would then allow precise extrapolation to the final steady state of patch occupancy.

The dam would trisect the population. Soulé and Gilpin determined that the species would go extinct on two of the three river stretches that would result following the filling of the reservoir—on the Upper and Lower Colorado River. These two stretches of the river did not contain sufficiently large, connected patches that would protect the population from the vicissitudes of environmental hazards. Further, each would contain very small populations that would suffer high turnover and would, thereby be further jeopardized by the rapid buildup of the deleterious effects of inbreeding. The local populations on the Concho River would persist following the construction of the dam.

Finally, Soulé and Gilpin noted that, although their model predicted the viability of the species population, the range of the species would be greatly contracted. This localization of the population would jeopardize the species to sudden, catastrophic extinction, such as caused by a pollution event down the river.

This PVA did not prevent the construction of the dam, for from it the managers could identify mitigation measures that could reverse the predicted conclusion of the model. The simplest and most obvious of these was to move snakes from the stable, core population on the Concho River above the dam to other stretches, colonizing vacant patches.

This is one example of a full PVA. When conservation biology has produced dozens of these, we shall be able to audit them and glean similarities. That is, like the world of business administration, we shall be able to improve our practice through the review and study of old cases. But this will only be possible when a thorough ecological audit is carried out following the disturbance that led to the initial PVA.

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Risk Analysis for the Concho Water Snake

by
Michael E. Soulé

Editor's note: In this chapter, Michael Soulé uses decision analysis to delineate alternative management schemes and their likely effects on the survival of the Concho water snake. Decision analysis is an analytical tool for clarifying and resolving decision making where the outcome is uncertain and not intuitive. This technique may be particularly useful in recovery planning where many decisions are made without adequate information and where each decision can present a conflict of one sort or another.

Decision analysis is useful in endangered species management because it provides an explicit framework for making management decisions. It can be used to identify species in immediate danger of extinction, define cases that need intervention, evaluate risks and benefits of alternate management schemes, and assess whether management efforts required to prevent a species' extinction can be justified in terms of their costs (Maguire et al. 1987).

In recovery planning, an explicit decision-making framework is necessary because saving endangered species is often a crisis situation where neither time nor money is sufficient. Difficult choices are often made without adequate information and conflicting criteria, such as cost vs. protection, are used to evaluate different options. Decision analysis provides a rational, explicit method for evaluating these alternatives.

This article is not a specific introduction to decision analysis but it provides a detailed example of its use. Here, decision analysis is employed in evaluating management schemes for the Concho water snake and their expected outcomes on its survival. This technique should prove useful in planning for the recovery of many endangered species.

The Concho Water Snake

The Concho water snake (*Nerodia harteri paucimaculata*) occupies a small area of central Texas. Its range includes stretches of the Concho and Colorado rivers and some of their tributaries above and below their confluence. In all, about 400 km of river is apparently occupied (Scott *et al.* 1989). Reliable estimates of population size are lacking, though the population of adults is variously estimated to be between several hundred to several thousand individuals.

The snakes, especially the young, feed in rocky shallows or riffles. Among the other habitat requirements are basking sites (small rocks for juveniles), hibernacula (most mortality apparently occurs during the winter), and pools for adult feeding. Unlike congeners, this piscivorous species rarely feeds on amphibians.

Threats to the population include natural events such as predation, droughts, floods, and anthropogenic events such as habitat destruction, killing by fishermen and hunters, pollution (especially sewage and drain effluents from San Angelo), and reservoir construction, including the downstream effects (Williams 1968). The motivation for this study is the construction of the Stacy dam at the confluence of the Concho and Colorado Rivers, a site considered by most experts to include much of the prime habitat for the subspecies and as much as one-fourth to one-half of the total population. Stacy reservoir will trisect the main body of the subspecies' habitat.

Management Objectives and Time Scale

The assumption is made that the management objective is to maintain or improve the viability of the species in the vicinity of its current geographic range. Any assessment of extinction risk is associated with an explicit or implicit time scale or temporal horizon. In this analysis, the risk of extinction was assessed over the next 25 years. The justification for this time scale is that it becomes difficult to predict anthropogenic events any further into the future. I assume that it is implicit that the viability of an endangered species should not decrease during the planning period. That is, the snake population should be at least as fit demographically and genetically in 2011 as it was in 1986.

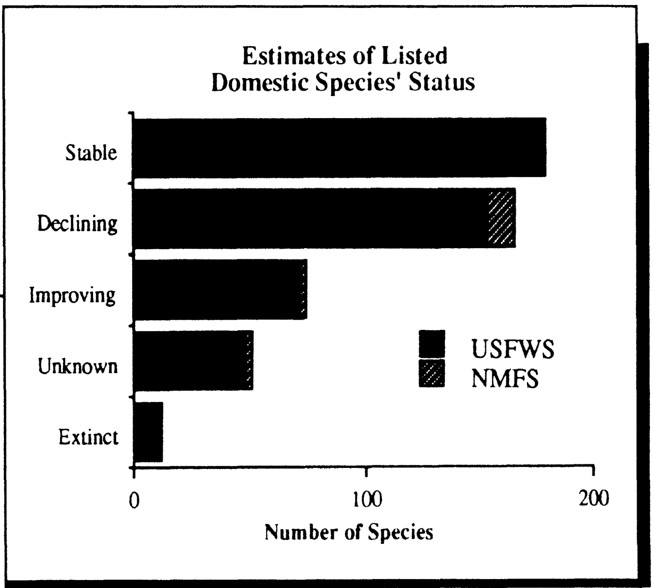
Decision analysis is useful in endangered species management because it provides an explicit framework for making management decisions.

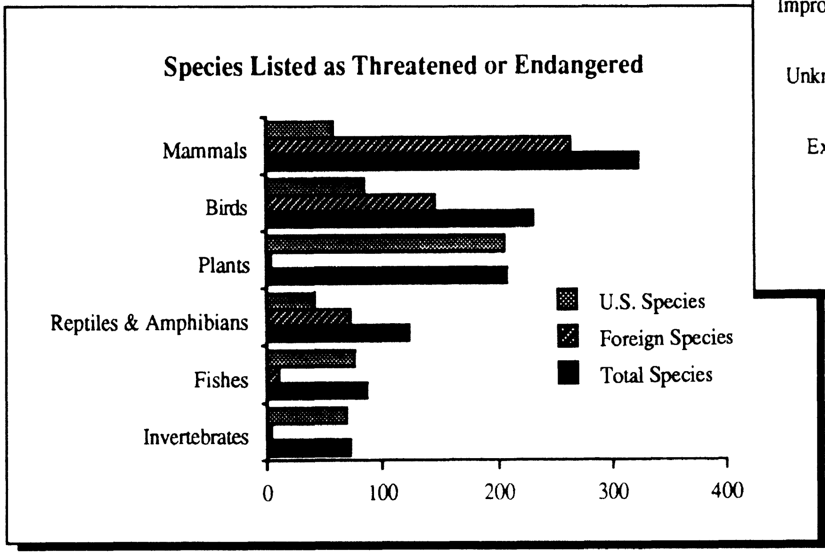
From biological and hydrological viewpoints, however, 25 years is a short period. For example, 25 years is only one generation for humans, and flood vulnerability is often based on a time scale of 100 years. Certain population threats, especially genetic ones, often require more than 25 years to be manifest. For example, in 25 years a population might lose some of its genetic variation to genetic drift and inbreeding, and might be on the verge of extinction from inbreeding depression, including reduced fecundity and juvenile viability (Frankel and Soulé 1981). Such a population might contain many adults and appear healthy to the casual observer. It

(continued on page 22)

Endangered Species Statistics: *(Sources: USFWS and USGAO)*

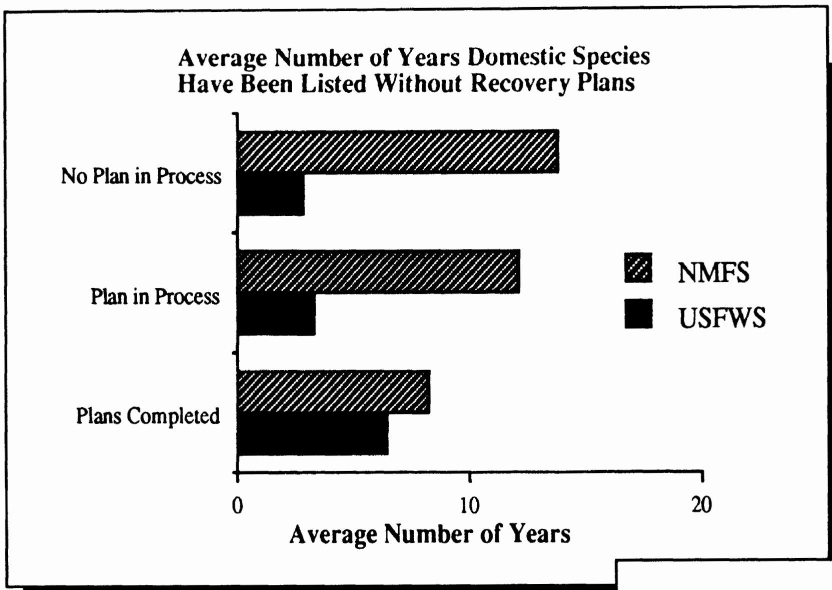
"The Act's goal of protecting and recovering listed species provides a logical standard by which to measure the success of the endangered species program. However, since the act does not provide time frames for achieving recovery, it is difficult to determine whether progress is being made...."



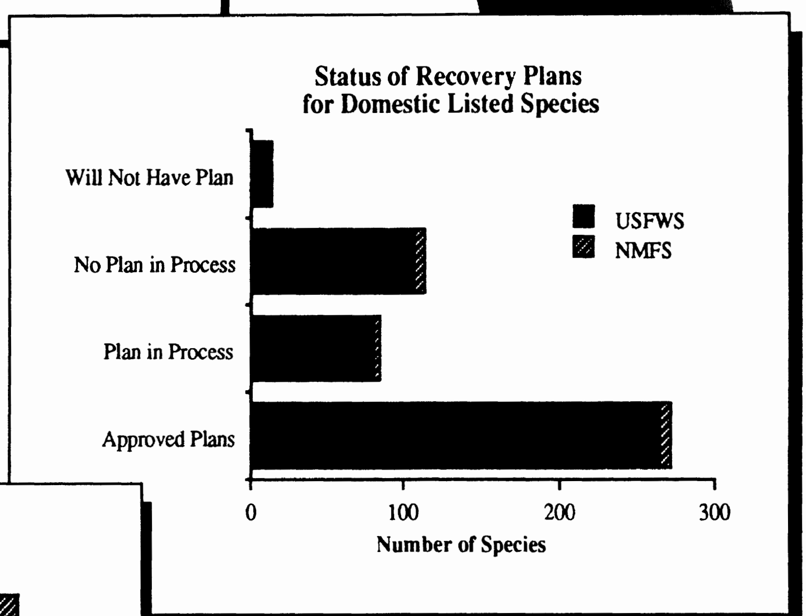


Black-Footed Ferret
(Mustela nigripes)

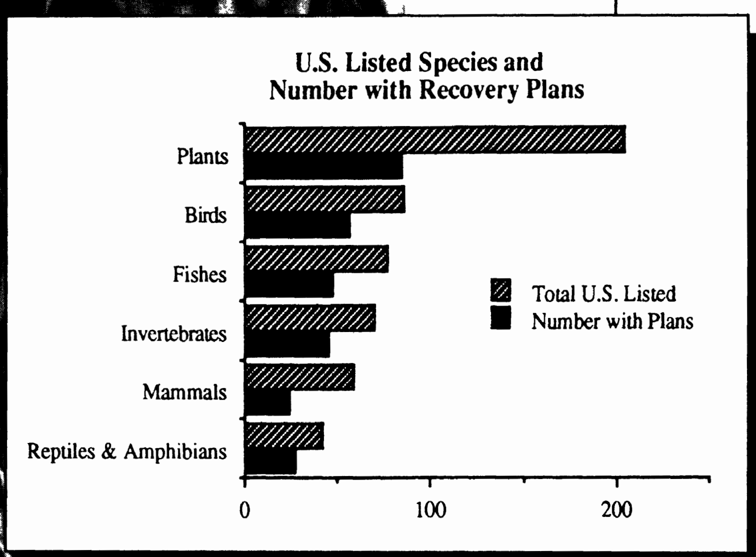
Small White Lady Slipper
(Cypripedium candidum)



Average Number of Years Domestic Species Have Been Listed Without Recovery Plans



Status of Recovery Plans for Domestic Listed Species



U.S. Listed Species and Number with Recovery Plans

"Measured against the logical, absolute standard, the small number of domestic species officially declared recovered would suggest that the program has been of limited success in recovering species."

U.S. GAO, 1988

Figure 1. Risk/Decision Analysis Work Sheet

1. Assuming no Stacy dam, and assuming the maintenance of population viability for 25 years, what is the likelihood of extinction (pE) caused by the following factors in the three (A,B,C) reaches? Note: A=Spence Reservoir to confluence of Concho; B=San Angelo to confluence of Concho; C=from confluence to Pecan Bayou.

	Reaches		
	A	B	C
a. pollution (chemical, sewage)			
•probability of a pollution event			
•pE due to a pollution event			
b. drought			
•prob. of a serious drought			
•pE due to a serious drought			
c. human killing of snakes			
•prob. of signif. human killing			
•pE due to human killing			
d. disease/epizootic			
•prob. of signif. event			
•pE due to disease/epizootic			
e. habitat degradation			
•prob. of signif. habitat degrad			
•pE due to signif. habitat degrad.			
f. other events			
•prob. of other events			
•pE due to other events			

g. What is the overall pE considering the cumulative and interaction effects of all of the above? ________

2. Assuming the construction of Stacy Dam, what is the likelihood of extinction (pE) from the following factors in the three reaches (A,B, and C)?

Same questions (a. through g.) as in #1.

3. Assuming that Stacy Dam is built, what is the likelihood of extinction (pE) if the following intervention/management actions are undertaken?

a. construction of artificial riffles in appropriate reaches
•pE = _____ assuming that they "work"
•probability that the artificial riffles will persist or be replaced for the foreseeable future including following floods_____

b. construction of rocky, low-gradient substrata in reservoirs
•pE = _____assuming that they "work"
•prob. that the lake population will be viable and self-sustaining (N>200)_____
•prob. that they will "work"_____

c. flushing/scouring of reaches, etc. below all reservoirs to maintain high quality snake habitat, including the addition of rock when and where necessary
•prob. that all of the above will "work"_____
•pE if above "works" (in combination with natural and artificial riffles_____

d. establishment of snakes in reaches where it does not occur now; probability that populations will "take" in
•Llano River_____
•San Saba River_____
•above existing reservoirs_____
•pE if most introductions "take"_____

e. establishment of the snake in new, artificially created habitats
•prob. that such a new river at Stacy would "work"_____
•using existing tributary with pumping of water to enhance flow (prob. it would "work"_____)
•within Concho River if water flow is increased by exchange and pumping (prob. it would "work"_____)
•pE if all of above "work"_____

f. Assuming the construction of Stacy Dam, what is the pE assuming that all of the above measures are taken?_____

is important to note that the probabilities given below are sensitive to the time scale that is chosen, although virtually no attempt is made herein to consider longer planning periods.

Objectives of this Analysis

The management of an endangered species is typically a complex matter, involving constituencies with differing priorities and different courses of action. It is the role of governmental agencies and other groups to select among these different management alternatives. Decision theory (Raiffa 1968, Behn and Vaupel 1982) is a formal approach to decisions under uncertainty that is useful in clarifying the decision-making process. This approach to decision making requires that the problem be set in a logical, hierarchical structure, and that the alternatives be clearly stated.

Recently, decision theory has been used by biologists and managers working with endangered species (Maguire 1986), including the Sumatran rhinoceros (Maguire *et al.* 1987) and the black-footed ferret (Maguire *et al.* 1988).

The objectives of this study are to (1) identify the potential threats, both now and for the foreseeable future, to the Concho water snake, (2) identify and clarify the various management interventions that are available for the snake, (3) estimate the probabilities that each of these threats will occur, and that the management interventions will be efficacious, (4) estimate the probability of extinction of the snake, given various combinations of events and interventions, and (5) analyze the sensitivity of the various estimates to changes in their values.

Decision analysis may include the economic costs of the various management interventions. Such data are not available at this time. Even without them, however, the logical framework has heuristic value, and the results in terms of extinction probabilities (in this case) provide the best, available estimates of relative risk of the various management scenarios.

Methodology

I initiated this study with a modified "Delphi" process at a workshop in Midland, Texas, attended by experts on the biology of the snake, its prey species, and its habitat. The objectives of the process were to (1) estimate the probabilities of various possible events that might affect the viability of the snake, and (2) estimate the probabilities that the population would be extinguished (within 25 years) given the occurrence of these events. As a first step, the experts were asked to fill out a questionnaire (Fig. 1). While summarizing the results of the questionnaire, it became clear that some of the questions had been interpreted differently by the different scientists. For this reason and others, a smaller group (the herpetologists) met for about three hours to discuss each of the questions, and to arrive at a consensus, if possible, on each point. Careful notes were taken and, where a consensus was not reached, the range of opinion was recorded and different values were used in the analysis as part of the "sensitivity tests" (see below). The results were used in the construction of a decision tree (Fig. 2) as described in the following section.

Results: Evaluation of the Alternative Scenarios and Interventions

The results of the expert workshop are synthesized in Fig. 2. A square indicates a conscious decision. A circle indicates a random event. The estimated probability of a random event is "p." The probability of extinction, given the associated random event and chosen management alternative is "pE." Finally, "E(pE)" is the expected or average probability of extinction associated with a particular management scenario.

For example, the first decision is "dam" or "no dam." The top of Fig. 2 shows that there are two possible random events given "no dam." The first is serious habitat degradation during the next 25 years. This includes the chance of damage to the rivers and their banks, including a pollution event that might have a major impact on the snake or its prey species. A p of 0.75 is associated with this event. In other words, the experts believed that major habitat degradation would occur in three out of four cases identical to the one under study. The associated pE value is 0.125, meaning that the experts believed that the chance of extinction of the snake given "no dam" and the occurrence of serious habitat degradation is 0.125. It should be noted that the experts were asked to consider other hazards, including the potential for disease/epidemics and human killing (Fig. 1); the consensus was that these factors would not significantly increase the pE of the population during the next 25 years.

The other possibility in this case is "no habitat degradation." For this outcome, p must be 0.25 (*i.e.* 1.0 - 0.75), and the associated pE was estimated to be 0.07. The expected probability of extinction, E(pE), given "no dam" is calculated by multiplying together the probability and the estimated outcome (p and pE) for each event, and then adding together the products:

$$(0.75)(0.125) + (0.25)(0.07) = 0.11.$$

In other words, the consensus was that the probability of extinction of the Concho water snake during the next 25 years, given no dam construction, and (implicitly) no other significant management interventions is about 11 percent.

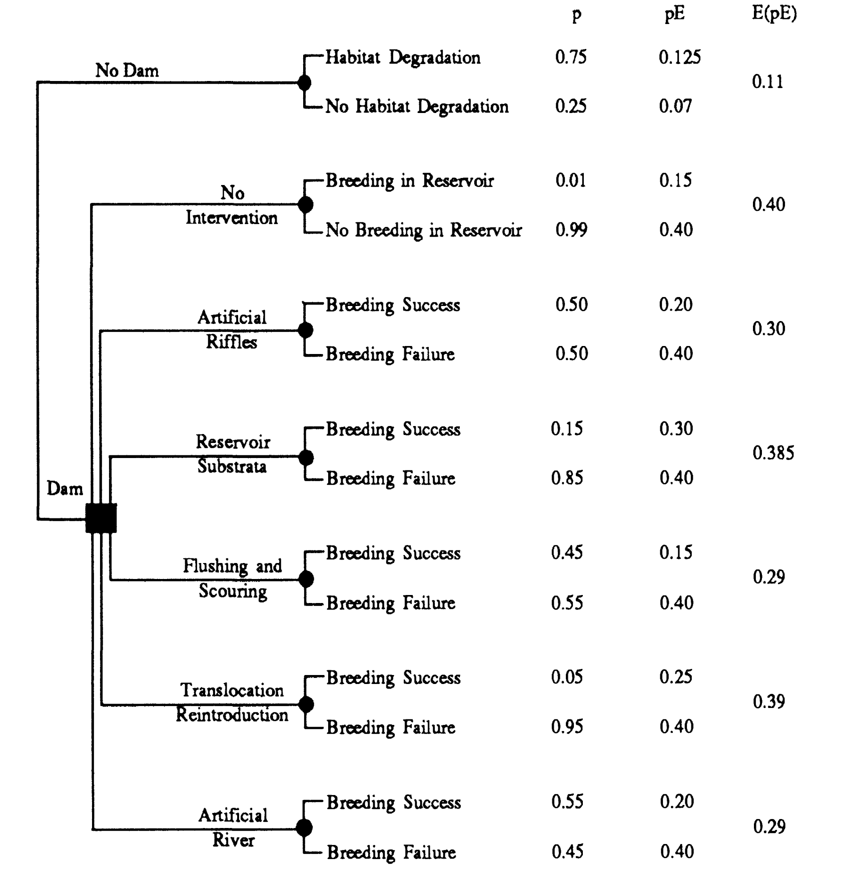
The next branch assumes that the dam/reservoir is developed. The first alternative examined under this scenario is that of no management interventions. For this case, there are two possible events: the snakes breed successfully in the reservoir (p = 0.01), or the snakes do not breed successfully in the reservoir (p = 0.99). (Note: successful reproduction of the Concho water snake requires the presence of foraging habitat for the young, as well as other habitat requirements. Existing data suggest that snakes will not breed successfully in a reservoir unless the necessary substrata for foraging, basking, and other activities occur.) The estimated E(pE) for the "no intervention" alternative is 0.40.

One of the limiting factors in the abundance of the snake is thought to be the amount of riffle habitat. In stretches of the rivers without riffles, there are few snakes. Therefore, the addition of artificial riffle habitat to the rivers is considered to be a reasonable management intervention. The success or failure of such riffles depends on several factors including their acceptability to the snakes and their persistence over time. For this scenario and those that follow, the probabilities are partly based on the outcome in the previous paragraph: an E(pE)=0.40 if the dam is constructed and nothing is done to mitigate its impact except the intervention under examination. The experts guessed that E(pE) would be lowered to 0.30.

The next intervention examined was the construction of artificial, rock substrata for foraging and basking in the reservoir basins. The experts were not sanguine about the success of such an experiment; hence a p=0.15 for success and an overall E(pE) of 0.385. One problem is the virtual impossibility of experimenting with various alternative designs. Another concern is the possibility that the snakes would not be as viable in the reservoir, even if they could use the artificial habitat. Snakes do occur in dams, but they appear thinner. That is, reservoir snakes may suffer nutritional or other handicaps, and these in turn would affect mortality and fecundity rates. These concerns are reflected in the low p value for success.

The construction of the dam is likely to reduce downstream flows. At other dam sites in the region the reduction of downstream flows has resulted in the siltation of the river and the encroachment of vegetation, burying the riffles and destroying the habitat for the snakes. A mitigating intervention that has been discussed is the periodic release of large volumes of water from the reservoirs. These releases are intended to scour the rivers, removing silt and vegetation from the riffles. Combined with this alternative would be periodic replacement of riffle rocks, because the flushing might disturb the riffles and wash rock downstream. This alternative, like the others, was considered to be independent of the construction of

Figure 2. Decison tree for Concho water snake



new riffles. The experts considered this alternative to have a fair likelihood of success (but see the next section on sensitivity analysis).

The next measure to be considered was the introduction of the snake into reaches within the region where it does not occur currently, but where it may have occurred in the past. The sites considered for introductions were the San Saba and the Llano Rivers, and some on the tributaries of the Concho east of San Angelo. A preliminary analysis of the water flows of these rivers suggests that, historically, their flow regimes were quite different from those of the Concho and Colorado. The frequency and kind of riffles may also be different. The experts were not optimistic about the success of such trials, but this measure appears sensitive to changes in these probability estimates as discussed in the next section.

The final intervention is the construction and maintenance of artificial rivers. This would require considerable engineering, the pumping of water, and a permanent commitment to maintenance. Success is considered fairly likely.

Finally, the experts were polled on their opinions regarding the effect on E(pE) given that all of the above interventions were implemented, assuming the existence of the dam. A consensus was not reached, although the range (0.10 to 0.25) was not great considering the degree of uncertainty inherent in the situation.

It is noteworthy, however, that the experts felt that, at best, the dam would not help the snake, even if all of the interventions were implemented. One or two felt that the the overall effect would be neutral, however. Again, it is important to bear in mind the time frame of this exercise. The estimated values for E(pE) would increase significantly if longer time intervals were considered, although the overall ranking of E(pE) values would not change unless the pE values change at different rates for different scenarios.

On the basis of the results discussed so far, it appear that the most effective interventions would be (1) the construction and maintenance of an artificial river, (2) artificial riffles, combined with (3) the maintenance of existing riffles by flushing below dams and the addition of rock when and where necessary (but see Scott *et al.* 1989).

Sensitivity Analysis

A question that naturally arises is the sensitivity of these results to changes in the estimated probability values. Fig. 3 presents sensitivity tests in which some of the values for p and pE were changed, and the corresponding effects on E(pE) were calculated.

Before proceeding, it should be noted that choices of new probability levels are arbitrary, based partly on intuition and partly on the discussions among the experts. The objective of this exercise is to determine which values appear most critical; it is not to achieve more accurate estimates of E(pE).

In Fig. 3, those values underlined or italicized are the ones that were changed. Beginning at the top, the p values for the "no dam" alternative were changed from 0.75 and 0.25 to 0.5. The change in pE is only from 0.11 to 0.098. This suggests that the overall probability of extinction is insensitive to the probability of habitat loss. The small difference between the two pE values tells us that the experts believe that habitat degradation is unlikely to lead to extinction unless it is very widespread. It also implies that the experts felt that other factors are mainly responsible for the relatively high value (11 percent) of the original E(pE).

In the "no intervention" scenario, the results are very sensitive to the pE value chosen for the event of "no breeding" in the reservoirs (because it is multiplied by 0.99). The absolute value of E(pE) (originally 0.40) is important because it is the standard against which the interventions are compared for their relative efficacy. In any case, the E(pE) for the dam with no intervention scenario is much greater than the E(pE) for no dam.

Regarding the construction of new riffles, a change in the p values for success vs. failure does not have a very great effect, although the change is slightly greater than is the effect of decreasing the pE value for success from 0.20 to 0.15. With respect to the construction of snake habitats within the reservoir, the alternative p values do not affect E(pE) significantly. Nor does changing the pE value for success (from 0.30 to 0.15) have much impact when using the original p values.

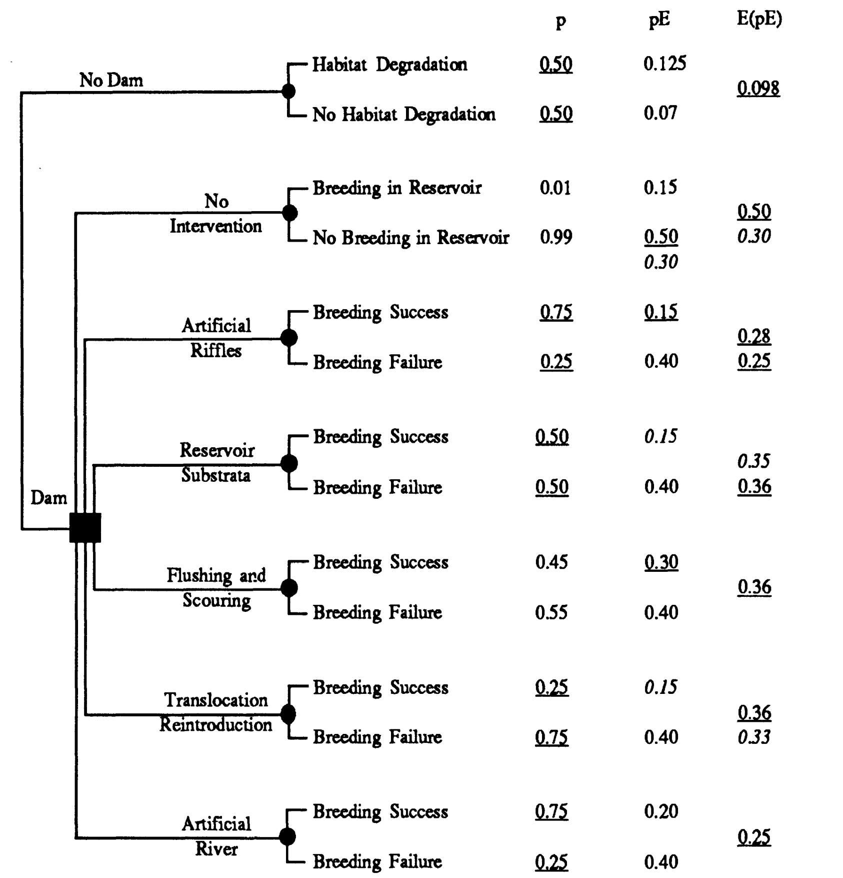
Regarding the utility of the "scouring" alternative, my impression is that the original pE value of 0.15 associated with "success" for this intervention was too low. Doubling it to 0.30 increases the E(pE) from 0.29 to 0.36, which is noteworthy.

Regarding the translocation (introduction) alternative, the effects of large changes in the p values appear insignificant. Combining these changes with a decrease in pE for success produces a reduction of the E(pE) from the original 0.39 to 0.33.

Finally, increasing the p value for success of the artificial river alternative from 0.55 to 0.75 does not cause a very large reduction in the E(pE).

In summary, the results are rather insensitive to modest changes in the estimated values.

Figure 3. Sensitivity tests for the decision tree in Fig. 2. Underlined or italicized values were changed in order to check the sensitivity of the associated E(pE) value on the value of p or pE.



Recommendations and Conclusions

The consensus of the experts appears to be that none of the interventions independently reduces the probability of extinction by more than 10 to 15 percent below the 40 percent "no intervention" figure. The most likely interventions to succeed appear to be the construction of new artificial riffles in the rivers, combined with the flushing of those river stretches below the dams. In addition, the construction of an artificial river looks attractive. Based on the experts' opinions, the construction of artificial habitat in the reservoirs is not only unlikely to succeed, but it will not address one of the most serious issues raised by the existence of Stacy dam, namely the fragmentation of the population. Assuming construction of the dam, some combination of the interventions might reduce the probability of extinction still further, although there is considerable uncertainty as to how much of a reduction of the E(pE) below 0.25 is possible.

It is obvious that actual utility of the various interventions cannot be determined with any certainty without research. In addition, hydrologists should be consulted on the likelihood that artificial riffles would stay in place.

It is conceivable that the interventions examined herein, given that they all succeed, would reduce the extinction vulnerability of the snake to a level below what it is today. The probability of such a decrease in jeopardy cannot be ascertained given all of the uncertainty surrounding the situation at present.

Finally, returning to the issue of time scale and its relationship to jeopardy, it is quite likely that the estimates of pE would be substantially higher if the temporal window were 50 or 100 years instead of just 25. For example, the longer the interval, the more likely are catastrophes such as the 100- or 200-year drought or flood.

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Intensified Efforts for Red Wolves Are Paying Off

by
Ginger Merchant Meese

The photos of appealing red wolf pups in newspapers around the nation signal better times for this endangered mammal. Intensified efforts to breed red wolves produced 13 successful litters this past spring, increasing the population from less than 85 animals to nearly 120. The more than 30 new pups nationwide are excellent public envoys for the wolf and the key to its recovery.

red wolf (*Canis rufus*) Photo: USFWS

The red wolf (*Canis rufus*) is native to the southeastern states where it was nearly extirpated as a feared and unwanted predator. By the early 1970s, the species had been reduced to a remnant population on the Anahuac National Wildlife Refuge and private lands along the Gulf Coasts of Texas and Louisiana. Researchers found the wolves there endangered by continued conflict with humans, parasites, and genetic swamping from hybridization with the coyote. Timely passage of the Endangered Species Act in 1973 enabled the Fish and Wildlife Service (Service) to rescue the red wolf from the brink of extinction by capturing animals to found a captive breeding program. By 1980, the red wolf was considered extinct in the wild.

The rescue was the first step. The more difficult challenge lay in recovering the species. That effort would be stalled until the public, or at least some portion of it, was ready to accept the red wolf in the wild. For more than a decade, the prospects did not look promising and captive breeding was eventually suppressed because of physical and financial constraints. The only site proposed for re-establishing a wild population—the Tennessee Valley Authority's "Land Between the Lakes" on the Tennessee and Kentucky border—fell through in 1984. The State wildlife agencies rejected the Service's reintroduction proposal in the face of opposition from local livestock groups, hunters, and conservation groups. Fortuitously, an important lesson was learned: politics, public education, and negotiation are as important as biology in site selection.

Enlightened by past experience, the Service renewed its efforts to find the red wolf a wild home. The search soon focused on potentially suitable habitat in coastal North Carolina donated for a national wildlife refuge (NWR). While the biological aspects were favorable for the red wolf on the new Alligator River NWR, the politics were potentially volatile. The combined efforts of the Service, local politicians, Congressman Walter Jones' (D-NC) staff, and concerned conservationists, however, resolved such controversial issues as the continuation of traditional deer hunting with hounds and proposed "incidental take" of red wolves. Although the North Carolina wildlife agency elected not to participate, the project was approved at the end of 1986. Captive-bred red wolves were to be returned to the wild on the densely vegetated refuge under the special "experimental population" provisions of the Endangered Species Act.

The experimental reintroduction phase at Alligator River NWR will begin the third of its five-year time frame this fall. The project has already successfully weathered major setbacks. Failure of special radio activated recapture collars, designed to reassure the local public and facilitate recapture of wolves when necessary, occurred at the outset. Consequently, the first four red wolf pairs were not released to the wild until the fall of 1987. Then in December of 1987, the released wolves began to perish for a variety of natural and accidental causes. (See ESTB 14(1&2):3). Only four wolves—a single female with her pup, an orphaned pup, and a lone female wolf—remained in the wild on Alligator River NWR by the winter of 1988. Two pups produced by a pair of red wolves released that same year on Cape Romain's NWR's Bulls Island, South Carolina, were brought to Alligator River and released. All four pups, remarkably, had survived the early loss of one or more parents. The long period in captivity, it appeared, might be handicapping the species' recovery. Wild-reared animals would become a vital part of the strategy for establishing future self-sustaining populations.

This spring, only one of three wolf pairs held for breeding in acclimation pens at Alligator River was successful. Female 205 was returned the first of August to her former territory on the refuge with her new mate (257) and four pups. This new family group joined six other wolves in the wild: four yearlings including 205's daughter and an unsuccessful breeding pair released in July. A total of 12 wolves should be sorting out their refuge territories by late August or early September with the release of two additional pairs of young captive wolves.

The National Wildlife Refuge System has been integral to the survival and recovery of the red wolf. In addition to the Alligator River NWR mainland reintroduction site, coastal islands are being utilized to return wolf pairs to natural conditions where they can rear pups. Cape Romain NWR has another and larger litter this spring of five female pups. An impressive litter of seven was produced by the red wolf pair placed last January on Horn Island, Mississippi, administered by the National Park Service. The addition of these pups, many of which will eventually be released at Alligator River or a second yet undetermined mainland site, significantly increases the chances for successfully recovering the red wolf. The wild-reared pups lack imprinted behavior patterns, such as familiarity with automobiles, that may have contributed to the demise of two captive adults formerly released to the wild.

In addition to the biological benefits, the island release projects are yielding significant public relations benefits. Recovery team leader, Warren Parker, reports that the new wolf family on Horn Island is generating much public interest and support for the red wolf in New Orleans and along Mississippi's Gulf Coast.

The pups in captivity in cooperating facilities around the nation are equally important to the recovery effort, which requires the combination of intensified captive and wild breeding strategies. A "Species Survival Plan" guiding the pairing of red wolves in captivity and in acclimation pens in the field is critical to maximizing the genetic diversity of the species and slowing genetic drift. For the first time, such a plan will accompany a traditional species' recovery plan when the red wolf plan is revised this fall. Although controlled initially, the selection of mates and breeding by wolves surviving in the wild will be left for the most part to the forces of natural selection. The Alligator River National Wildlife Refuge project hopefully will achieve wild breeding pairs in 1990.

The State wildlife agencies rejected the Service's reintroduction proposal in the face of opposition from local livestock groups, hunters, and conservation groups. Fortuitously, an important lesson was learned: politics, public education, and negotiation are as important as biology in site selection.

Concerned biologists believe the red wolf can be recovered to portions of its former range if simply given a chance. Increasing public and congressional support, increased funding, and intensified breeding efforts coupled with the addition of new island sites and eight cooperating institutions (see ESTB 14(1&2):3) are all contributing to a solid foundation for red wolf recovery. With the addition of the large number of pups this spring, the red wolf recovery appears likely to succeed.

Ginger Merchant Meese has actively supported red wolf recovery since the early 1980s. Currently, she is vice-president of the National Wildlife Refuge Association. The first red wolf recovery team leader and manager of the Anahuac NWR, Russel W. Clapper, is the NWRA's Board of Directors Representative for the Gulf States.

Habitat Conservation Planning and the Coachella Valley Fringe-Toed Lizard

by
Paul Selzer

The spring of 1982 found the City of Palm Springs, California, and its surrounding communities playing host, as it had for the past 25 years or so, to the Bob Hope Desert Classic Golf Tournament. Former President Gerald Ford, then Speaker of the House Eugene "Tip" O'Neill, as well as countless other well-known entertainers, corporate leaders, and sports personalities had made their annual visit to this famous desert resort community to help raise major contributions for many local charities.

When the tournament began during the 1950s, the population of Palm Springs was approximately 10,000 and the entire 350 square mile Coachella Valley in which the City is located was home to an additional 15,000 full-time residents, most of whom lived snuggled against the foothills of the San Jacinto and Santa Rosa Mountains that marked the southern and western perimeters of the valley. In those early days of the tournament, there were six or so exclusive golf courses stretched out between Palm Springs and Indio, 30 miles to the east.

The Coachella Valley

The remainder of the valley existed as it had for eons, in an easy balance with the rugged mountains that surround it on the north, south, and west sides, protecting it from the coastal clouds and rains and contributing to the unique temperature ranges which make the oasis so attractive to the rich and famous. Temperatures during the fall, winter, and spring of the year seldom stray below 50° F before giving way to blistering summer temperatures that often exceed 110°. These same protective mountain ranges and the westerly passes leading to the ocean also set the character for the ecosystem of the Coachella Valley. As wind and flooding occur in the mountains, the weathering of those rocky faces results in a fall of debris into lower ravines. The debris contains particles ranging in size from very fine silts through sands and gravels to large rocks and boulders. The infrequent, but often violent desert rainfalls cause floods, which carry the rocky debris out of the hills spilling it onto the alluvial plains that fall into the valley floor. There, the westerly winds roaring through the passes pick up the fine silts and sands, carrying them far downwind where they form the loose and shifting sand dunes so often associated with the desert.

During the 25 years the Hope Tournament had been held, economics and a burgeoning southern California population gradually transformed the Coachella Valley. Deep water wells had tapped into the vast underground reservoir that underlies the valley, and the six original golf courses had multiplied to over 10 times that many. The destructive sandstorms that occurred each spring had been ameliorated by windscreens of hearty Tamarisk trees. The population in the area had exploded from less than 50,000 to over 165,000 and it was estimated that by the year 2000 the permanent population would approach 300,000 people. Seasonal visitors during the non-summer months could be expected to have the effect of doubling that number. Land was being consumed at the rate of 1,500 acres per year. Of course, this explosive growth had improved the economy, and demand for housing attracted some of the nation's largest home builders. The mild climate and the resort aesthetic of the area fostered not only a major recreation and second home community, but also a fast-growing sector of full-time residents to service the burgeoning resort and retirement communities.

The Fringe-Toed Lizard

New neighbors were arriving daily. However, on the eve of the 1982 Bob Hope Desert Classic Tournament, the valley suddenly became aware of two very unwelcome neighbors. The first neighbor had actually occupied the valley far longer than any of its human counterparts. The Coachella Valley fringe-toed lizard (*Uma inornata*) had thrived for millennia in the aeolian sand dune network that traversed most of the valley floor. However, because the entire world's population of this species lived in the valley, and because development had, for the past 25 years, been consuming its habitat at ever-increasing rates, it had been listed as an endangered species pursuant to the federal Endangered Species Act (the Act). The other unwelcome neighbor was the U.S. Fish and Wildlife Service (the Service) whose job it was to enforce the Act.

By 1982, almost 60 percent of the original sand dune network that had been home to the fringed-toed lizard (FTL) had been developed. In addition, land development, blow-sand control measures, flood-control works, and other infrastructure improvements had effectively stabilized and protected the valley from floods and winds. Now only 25 percent of the original sand dunes still had access to the sand source and winds that had created them. Finally, the remaining habitat was being consumed at an alarming rate of about three square miles per year. The recovery team appointed by the Service estimated if that rate of development continued, all remaining FTL habitat would be lost by the turn of the century.

The Service began its enforcement procedures by designating a large Critical Habitat that contained not only sand dunes, but also the water courses, wind corridors, and sand sources necessary for the continued existence of the dunes. It also informed all local governmental agencies about the Act and its terms, requesting cooperation as they approved projects on the valley floor.

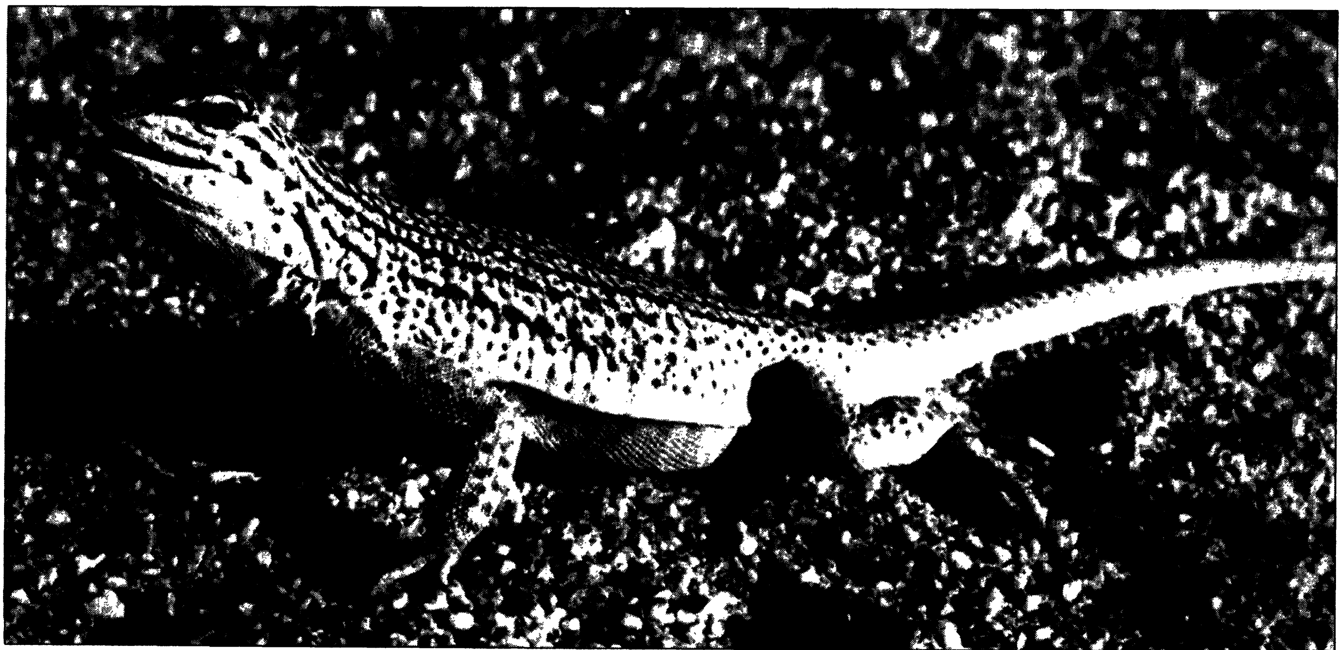
To say that the response of most local politicians was unenthusiastic would be an overstatement. Few, if any of them had ever heard of the FTL, and fewer yet had actually seen one of the creatures whose body shape and fringed toes allow it to "swim" through and live most of its life within the sand dunes. However, notwithstanding a less than sympathetic attitude toward the Service, the local governments did recognize a responsibility to deal with the problem. Development projects, as well as proposed public works, became subject to lengthy public hearings and debates about whether the creature existed on particular project sites. Developers argued, tongue in cheek, that the critters were welcome to inhabit any of the sand traps that would be a part of their new golf courses. Jokes about lizard boots and belts abounded. However, when one project where the lizard was indisputably found to exist was refused permission to proceed, the joking stopped. The development community rose up in anger, and everyone raced for their attorney's office. For a brief time, I'm sure that there were more lawyers in the valley than lizards.

I became involved because I specialize in land use matters and deal regularly with the Board of Supervisors of the County and the city councils of the nine cities in the area. My client proposed to develop approximately 550 acres into a plush, 36-hole golf course and country club community. On the downwind side of the property and covering about 80 acres of the site, we could not deny that there were sand dunes. However, our biologists had informed us that there were few, if any, FTL's populating the dunes, and that already existing upwind projects had effectively cut off a continuing source of sand to replenish the dunes. In the unlikely event that the FTL's actually existed on the 80 acres, they would, in all likelihood, cease to exist within a relatively short period of time. Given these facts, we were reluctantly prepared to leave that area undisturbed for the time being and let nature take its course. We had carefully researched the law, and were convinced that so long as we did not actually kill a lizard as a result of our activities, and so long as we did not disturb the dunes, neither the Service nor the California Department of Fish and Game could legitimately claim violation of the Endangered Species Acts of either jurisdiction. A local environmental group, The Coachella Valley Ecological Reserve Foundation (CVERF) had other ideas, however. They effectively argued that developing the upwind portion of the property would complete the destruction of the dunes, that there was a large and viable community of FTL's in the dunes, and that we should not develop any portion of the property.

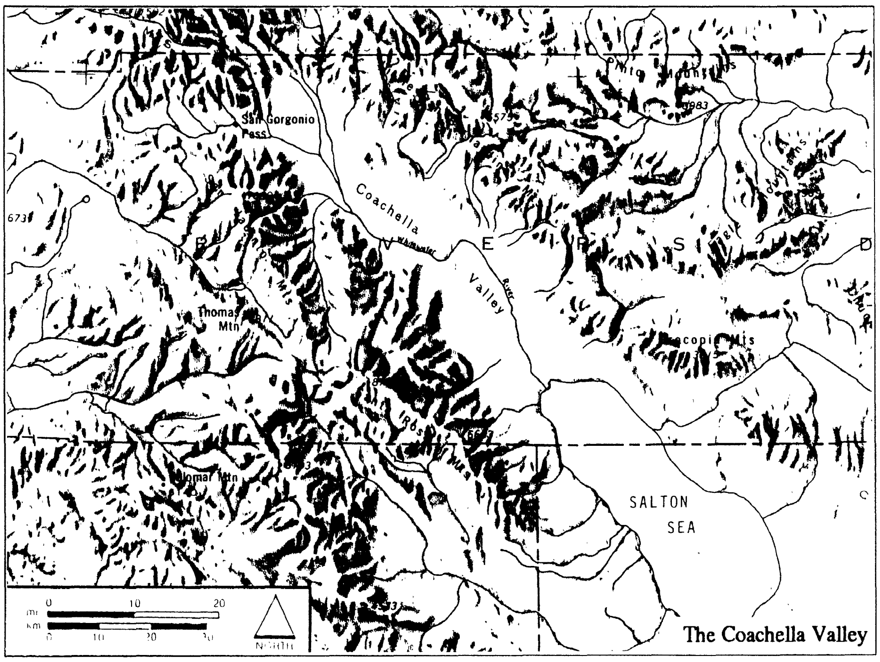
The Conflict

The stage was thus set for a classic confrontation between development and environmental interests. As representatives of the developers, we began to outline both legal and political attacks. Initially, we considered attacking the Endangered Species Act itself, or at least attempting to have the FTL "delisted." We soon discovered that neither of these approaches was politically nor biologically possible. We also outlined less speculative approaches to attack the procedures followed in the listing process, as well as the taxonomic and scientific bases for the listing in the first place. We planned political maneuvers that we hoped would result in having our projects approved through the local political processes and make enforcement financially difficult for the Service and the U.S. Attorney's Office.

On the other side of the fence, members of CVERF prowled the desert floor, constantly on the alert for grading activities that might disturb habitat or anything that looked remotely like habi-



Coachella Valley fringe-toed lizard (*Uma inornata*)



The Coachella Valley

tat. Of course, there were constant battles among the biologists involved. Interestingly, biologists hired by the developers seldom found FTL's; when they did, they were in small, isolated, and scarcely-populated pockets most often located on the outer perimeter of a proposed project. On the other hand, reports prepared by the environmental groups described the same piece of property as ankle-deep in lizards, and a site essential for the continued existence of the species. CVERF had also begun preparations to file suit against the Service, requiring them to enforce the Act, as well as against the developers seeking injunctions prohibiting continuing disturbances of habitat in violation of the Act.

It is important to note that up until this time there had been little or no communication among the warring factions, except in public hearings or by means of threatening letters. Looking back, it seems to me that both sides were so suspect of the motives, agenda, and means of the other, that we viewed possible settlement of our disputes as impossible. In addition, I must admit it was a great deal easier to focus on how misguided and poorly motivated THEY were, than it was to focus on possible solutions to the problem. In truth, neither side was giving much thought to realistic solutions, but was spending most of its time attacking the other or defending its own position.

The process of resolution began when the development community realized that its legal and political maneuvering might not be successful and even then, would solve the problem for only a limited period of time. While we might succeed in our plans to proceed with the immediate project, the most likely scenario we could foresee was a continuing, time-consuming, and expensive dispute over every additional project we planned. My client, the Sunrise Company and its president, Mr. William Bone, instructed me to meet with the president of CVERF, Dr. Allen Muth, to determine if we could work toward a long-term solution that might meet the needs of all concerned.

Our first meeting resulted in what might be expected from a meeting between a lawyer and a biologist. From his perspective, the answer was quite simple and equitable. Since our development activity was the action that directly affected this species, it was only proper that we obtain, replace and protect one acre of land for each we disturbed. It was quite clear to him that this was the most probable long-term solution which stood any chance of the species continuing to exist into the long-term future.

I pointed out that acreage in the designated Critical Habitat was currently selling for about $5,000 per acre, and that our current project encompassed 550 acres. Thus, for a mere $2,750,000 immediately due and payable, we could proceed with our country club development. I informed Dr. Muth for that much money, we could well afford a significant legal and political battle. I also pointed out if this were the solution intended to protect the lizard over the long term, it was doomed to fail. Even if all developers agreed to acquire replacement land at the outrageous rate of one acre of acquisition for one acre developed, there was no assurance that enough contiguous and appropriate land could be acquired quickly enough to save the lizard; furthermore, this process was guaranteed to increase the value of the land within the Critical Habitat as developers bid against each other to attempt to acquire land without the benefit of the power of eminent domain. I left the meeting more than ever convinced that dealing with THEM on any reasonable basis was impossible. I conveniently forgot that I had not made one counter-proposal, but had contented myself with pointing out the many reasons why the plan would not work.

The Habitat Conservation Plan

Within several days of my meeting with Dr. Muth, I was contacted by representative of the Service and asked whether we would be interested in investigating the possibility of putting together a Habitat Conservation Plan (HCP) pursuant to Section 10 of the Endangered Species Act. While I was aware that Section 10 provided for permits to allow endangered species to be taken, I knew of only one instance where the process was being utilized and had been informed that it had been beset by all sorts of problems, not the least of which was a lawsuit challenging the entire process. While recognizing my concerns, the representatives from the Service said they believed a realistic solution was possible. They agreed to work closely with us during the estimated two to three years it would take to develop an acceptable plan. We informed the Service that if that meant we would have to wait until the 10A permit was issued before any development could continue, we would not seriously consider expending the time, effort, or money necessary to put the plan together. We made it clear that we would consider a good faith effort to coordinate a Habitat Conservation Plan, but only if development could continue outside the designated Critical Habitat even though FTL's might be present on this non-critical habitat land.

The Service responded by saying that so long as they did not receive complaints, they could probably keep their enforcement people busy protecting other species. However, if they received any pressure whatsoever, they would have no alternative but to step in. I then met with Dr. Muth's group, receiving assurance they would not complain as long as there was no development in the Critical Habitat and we were making reasonable progress in establishing an HCP. Based upon that representation, we agreed to use our best efforts to develop the plan. In order to give more concrete assurance that we would, in fact, pursue the plan, we agreed with Dr. Muth that Riverside County could require us to use our best efforts to secure a 10A Permit utilizing the HCP process as a condition of our country club project. Otherwise, our County permit to continue construction could be revoked.

Thus, we began. Two and one-half years and $25 million later, we were successful in setting aside four preserves consisting of over 18,000 acres for the preservation of the FTL and other indigenous desert species. This was achieved through the hard work of a coalition of businessmen, environmental groups, and local, state, and federal governmental agencies, all of whose participation was essential to the eventual success of our plan. From my viewpoint, the procedures we used and the positive attitude of the participants were as important as the elements of the plan itself. In other words, how we were able to get all of the participants to cooperate with us was as important as what we were willing to cooperate about in developing the plan. Initially, let me discuss the elements of the plan itself and thereafter show how it was achieved.

The Results

First, we sought and generously received support from The Nature Conservancy (TNC), which agreed to assist us in several important ways.

TNC agreed to be the acquisition agent, procuring the private lands necessary to establish our preserves. They also advanced substantial amounts of seed money for acquiring options to purchase several of the large parcels within the preserves. Their vast experience in land acquisition and their businesslike and economic approach to conservation planning was well-received by the development community.

In addition, TNC agreed to assist us in dealing with the various state and federal agencies whose cooperation and participation were essential. Few of us had any experience dealing with upper echelon personnel of the California Department of Fish and Game, the Service, or the Bureau of Land Management (BLM). None of us had ever investigated the mysterious path to the federal Land and Water Conservation Fund. The prestige and confidence placed in TNC by state and federal agencies, as well as key Congressional members and their staffers, allowed us access to people we might never have known to contact, much less actually meet with. The result was a $10 million appropriation from the Land and Water Conservation Fund and an agreement with the BLM to trade $5 million worth of lands that they owned outside the preserves for lands owned privately inside the preserves.

TNC also provided public relations assistance to help us convince the local populace that the protection of this little-known species and its habitat was also important to us as humans. With the assistance of a grant from the William King Mellon Foundation, they produced a documentary film about our activities which we effectively used to raise funds and convince both politicians and the general public of the worthwhile goal of our endeavors.

In return, we assisted TNC in a local fund-raising effort. The business community enthusiastically supported their efforts and opened the doors to wealthy local residents. In addition, we provided office space, secretarial help, and telephones for the full-time person they had appointed to work with us.

Secondly, working together in an unprecedented fashion, building-industry representatives and environmental groups petitioned for and received the support of the Board of Supervisors of the County and the city councils of the nine cities.

Utilizing emergency zoning procedures authorized by California law, the County rezoned the Critical Habitat. This action prevented development while the HCP was being developed and funds accumulated to acquire the property.

The County and each of the cities imposed a $200 per acre development fee on all lands within the historic range of the FTL, which encompassed virtually all of the Coachella Valley. Developers did not oppose the fee, which was eventually raised to $600 per acre and will remain at that level until all inholdings within the preserves have been acquired. After the inholdings have been acquired, the fee will be reduced to $100 per acre to provide a continuing fund to maintain the preserves.

Third, we were able to convince the BLM to participate in our program by agreeing to trade $5 million worth of lands that they owned outside of preserves for $5 million of privately-owned land within the preserves, and thereafter to manage those lands in a cooperative fashion compatible with the preservation of the FTL. Citing policy and budgetary constraints, the BLM was originally reluctant to participate. That attitude changed when Ed Hastey, State Director of the BLM, saw the plan was supported by both the environmental and business communities, as well as all of the local political entities. The land exchange process was greatly facilitated when TNC agreed to fund a real estate officer position for several years to accelerate the complex legal requirements involved in federal land acquisitions and dispositions.

Fourth, the California Department of Fish and Game appropriated an additional $1 million for acquisition of lands within the Critical Habitat.

Finally, we were able to convince the appropriate House and Senate appropriation subcommittees that this project deserved $10 million from the Land and Water Conservation Fund (the Fund). Those who have attempted to secure money from the Fund realize competition for appropriations is fierce. However, the Service responded favorably when asked to comment about the request. Both the Regional Director, as well as other higher echelon personnel in Washington, apparently believed that our program was worthwhile and might serve as a model for other habitat conservation planning efforts. In addition, the Washington office of TNC helped us contact the right people—people we might otherwise not have known about. We had an opportunity to deliver the message that this was not an effort that we expected the federal government to fund in its entirety. We stressed that support, money, and effort were coming from all segments of the community. When we went to Washington, we went with the blessing and concurrence of the building industry, the environmental groups, the Chambers of Commerce, the labor unions, the State of California, the County, and the nine cities involved. The people with whom we met were impressed that funding for the project was not being sought solely from the Fund. The fact that developers were paying part of the freight and had supported a developer fee imposed by the local governments was important. The fact the project was being led, not by the Service, not by any governmental entity, but by a coalition of private business and environmental groups was unique.

Conflict Resolution

While the foregoing sets forth what we accomplished, how we achieved resolution was equally important. Hopefully, others will find this approach useful in ventures involving conflicts between environmental concerns and development.

I would like to say that we were successful because all of the participants were suddenly enlightened, but the truth of the matter is that the overriding factor that kept this process from failure was fear—fear of what would happen if the process did not work. The developers feared that if we were not successful, development might be stopped entirely, and at the very best, we could look forward to continual delays and expenses dealing with the problem. The environmental community feared that unless something was done immediately, the pace and pattern of development in the area virtually guaranteed the extinction of the species within a relatively short period of time, no matter what actions were later taken. In the words of one of the biologists from the University of California who participated in the process, "this plan represents the last, best hope for this species." While no one in the Service would dare admit it officially, there can be no doubt that they feared they might have to enforce the Act, something they had neither the budget nor the political stomach to handle. Had it been required to enforce the Act and stop development within the entire Coachella Valley, the economic and political repercussions would have made it incredibly uncomfortable for those within the Service involved in the action. Rather than describe this factor as "fear", a more polite expression might be that any plan with any chance of success had to be viewed as the "better alternative" to all of those who had a significant stake in the outcome. Given legal, political, economic, and biological reality, the plan had to be seen by each participant as serving their needs better than the status quo or any other solution that had been presented.

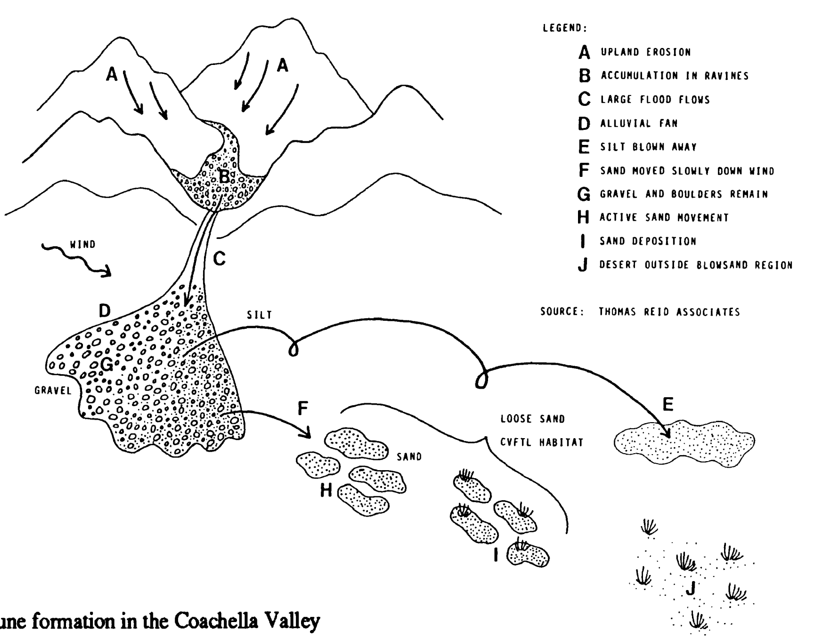
Once each of the parties realized that there was more to lose by continuing the battle rather than trying to find solutions, the next step in the process was an appropriate forum where stakeholders could be heard, contribute to the solution, and buy off on the methods of resolution. The primary participants in our process were representatives of the nine cities that made up the Coachella Valley, the County of Riverside, the California Department of Fish and Game, the local environmental groups, the University of California, the Water and Flood Control Districts active in the area, the Bureau of Indian Affairs, The Nature Conservancy, the BLM, the Service, representatives of the building industry, and local property owners. While the meetings were not officially open to the public, no one was refused admission.

I cannot stress enough the importance of identifying all of the important stakeholders as early as possible and trying to keep them involved and informed about the process. At meetings of what we eventually dubbed Club Lizárd, we recapped what each of the participants was doing in the plan, their problems and concerns, and reasonable alternatives they might suggest. Meetings ended with agreement about the next meeting date and what progress they could expect in the interim. Decisions were made by consensus, and not by vote. Peer and group pressure worked to assure that no one remained unreasonable for very long, although that is not to say that we did not have long and heated debates about many aspects of the plan.

In our case, the meetings were sponsored by the development community, were normally held in pleasant surroundings, and in each case, were scheduled around lunch which was served in a setting where unresolved issues and possible compromises could be discussed by those directly involved. Not only was the luncheon setting ideal for compromise discussion, but it also gave all of us the chance to discover our opponents as real people with legitimate concerns about these issues, not merely names and faces we heard or saw in the heat of our continuing battle. We discovered that the "tree-hugger" we had previously seen only in hearing rooms disparaging our projects was, in general, a rational person with real concerns about biological diversity and our ecosphere as a system, and they found out that we "land-rapers" were meeting a real housing need in our area, that we had enormous investments at risk, and that for every developer who made a profit there were two who did not. Each side discovered the rhetoric we tended to use at public meetings had no place. It was a great deal more difficult to spout unsubstantiated and denigrating generalities about one another when the person was seated across the luncheon table. As a result, the entire focus of our efforts changed. Instead of focusing on the opposition, we all began addressing the problem and what each of us needed to do to find a solution.

Once we had established our forum, it became apparent immediately that unless all of the stakeholders were willing to actively participate, listen and be open to the possibility that the other side might have legitimate concerns, and most importantly be willing to acknowledge biological, economic, political, and legal reality, and to compromise around those realities, we might as well go home. On the other hand, everyone was encouraged to put those items about which they had strong feelings on the table at the earliest possible time, together with the legitimate and reasonable justification for that position.

As an example, when we began to discuss the size and design of the largest preserve that we intended to acquire, the biologists and the environmental community initially proposed that it be twice as large as it eventually became, while the development community wanted it somewhat smaller. The biologists finally convinced the group that a significantly greater acreage than that occupied by the lizard was necessary in order to protect the local ecosystem upon which it relied. Not only the sand dunes, but the surrounding hills, wind corridors and water courses needed to be protected. On the other side, the developers were successful in convincing the group that much of the additional acreage which the biologists wanted had been subdivided, and although not extensively developed, the number of property owners involved in acquiring twice the number of acres added 10 times the number of property owners with whom we would have to deal and increased the cost to a point where the entire plan could be economically and politically impossible. Through the process of debating those issues openly and honestly, we reached the kind of economic, political, legal, and biological compromises that eventually resulted in the plan becoming reality. The willingness of each of the parties to compromise was a direct result of the atmosphere created at our meetings. As soon as it became apparent that all of the constituents were focusing on the problem and good-faith solutions, we slowly but surely generated trust among the group. The trust was earned by inches and over a long period of time.



Dune formation in the Coachella Valley

Compromise and Risk

I have briefly mentioned openness to reality and willingness to compromise as important factors. To those factors, I need to add willingness to risk. Our process could only begin when all of the stakeholders had realistically assessed their positions and were willing to take chances in reaching a solution. It was essential for the developers to acknowledge that the ESA was not going to be repealed, that the FTL was not going to be delisted, that they were in for a continual fight over this issue, and that it was going to cost them money to be a part of the solution. It was essential for the environmental community to acknowledge that unless habitat was permanently acquired and protected, the species was doomed; that most people, and certainly most politicians, could not get excited about protecting the species. Given the fragile and interrelated nature of the ecosystem upon which the FTL relied, even if all of the remaining dunes were left untouched, the development of the rest of the valley virtually assured extinction of the species. It was unrealistic to believe that all development within the Coachella Valley would be stopped by either the courts or the legislatures on behalf of the FTL. It was essential that the Service recognize if it enforced the ESA to the absolute letter of the law, there would be no Habitat Conservation Plan. Without a comprehensive plan, which necessarily required the cooperation of development interests, the species would likely become extinct.

It was also necessary for everyone to recognize a multitude of other political and economic realities. Among them were acknowledging that there was only a finite amount of money available to solve the problem, and that in any long-term political battle between perceived human wants and needs and the fringe-toed lizard, the FTL was bound to lose.

Had any one of the significant participants come to the meetings with preconceived notions from which they were unwilling to move, our efforts would have been fruitless. Everyone was willing to risk abandoning their long-held positions with the hope that some middle ground might be possible. Had the Service insisted that no take occur until a 10A Permit was issued, there would have been no HCP. They took a significant risk that they would be criticized for not assiduously enforcing the Act. Had TNC insisted that a source of repayment for their seed money be assured prior to expenditure, we could not have acquired essential parcels within the preserves. They took a significant risk. Had the building industry demanded assurance that a 10A Permit would eventually be issued before they supported the imposition of the $600 per acre fee, we could not have demonstrated to Congress our willingness to pay our fair share of the burden. In fact, we probably would not have been successful in garnering the support of either the BLM or the Service, much less Congress. This was a significant risk to the building industry. Had CVERF complained to the Service about obvious destruction outside the Critical Habitat, the Service would have stepped in, the building industry would have terminated their efforts, and we would have been back at the starting gate. Nevertheless, they chose to take this risk knowing that if the effort was unsuccessful, a certain amount of habitat would have been irretrievably lost.

Everyone was willing to take risks to move the process along, and risk must accompany this process. Without risk, each side will stand by its traditional position and no movement will occur. I'm not suggesting that any side to the controversy blindly abandon its principles. What I am suggesting is that progress and compromise in these matters appear to build upon themselves, and as good faith and willingness to work together toward resolution become apparent, each side must be willing to risk and move off of its long-held positions. Equally important is the fact that concessions made and the risks taken were done incrementally, and continued cooperation by everyone was a condition for participation by all. We were keenly aware that any one of us could have stopped the process very easily. A telephone call to the Service reporting disruption of habitat, a suggestion to the Board of Supervisors that the fee be repealed, or action by the Service against development outside the Critical Habitat all might have brought our truce to an end. While our process was very much like a house of cards, in many ways it was this fragility that kept everyone in line. While we all had misgivings, no one wanted the result that would occur if the process stopped. The Habitat Conservation Plan always remained the better alternative.

The 10A Permit for the Coachella Valley fringe-toed lizard has been in place for about three years. The three preserves have been operated and maintained pursuant to a cooperative management agreement among the BLM, the Service, TNC, and the California Department of Fish and Game, all of whom own land within the preserves, with the cooperation of the University of California at Riverside, which monitors the progress of the species. To date, the HCP has been implemented exactly as outlined in our proposal to the Service. Development has continued at a significant pace outside of the preserves, and both sides are proud and satisfied with the results of their cooperative venture.

The Future

In October of 1988, Riverside County once again felt the effects of the Endangered Species Act. This time, the Service listed the Stephens' kangaroo rat (*Dipodomys stephensi*) as endangered. Based upon our successful experience with the FTL, the County of Riverside has undertaken the sponsorship of an HCP for this species. In many respects, the situation is vastly different. The historic range of the animal is much larger. The rate of development and the number of builders and developers within the historic range of the animal is much greater. The amount of money that will be necessary to raise in order to assure the continuing existence of the species is significantly higher. The value of the land throughout the historic range of the animal is much greater, and no Critical Habitat has been officially designated by the Service. Nevertheless, we believe that the lessons we learned with the FTL can be utilized again, and we are attempting to replicate the results. To date, we have identified most of the significant stakeholders and invited them to participate in our forum. We have had many meetings with those stakeholders in an attempt to outline parameters within which we might find agreement. The County has imposed a $1,950 per acre fee for all development within the historic range, and we are seeking to obtain the cooperation of the six cities that are located within the boundaries of the historic range. In addition, we have already filed an application for what we are calling a short-term Habitat Conservation Plan that will provide accommodations for both sides as we move forward. Pursuant to our short-term plan, 10 study areas have been designated in western Riverside County. Within those study areas, extensive biological and economic surveys will be taken, which eventually, we hope, will lead to the designation and acquisition of four or five preserves. In return for the significant economic commitment by the County and the developers, we are requesting that take be allowed outside of the study areas. During our interim plan, the amount of take will be limited to 20 percent of the remaining Stephens' kangaroo rat habitat. The estimated cost of the long-range acquisition plan ranges from $100 million to $200 million dollars, and without significant state and federal assistance there is grave concern about its likelihood of success.

In spite of these concerns, we are moving forward step by step with the process, attempting to build the trust among the parties absolutely essential for the HCP. In my opinion, we are again faced with a situation where the species is doomed without a comprehensive plan. Similarly, without the cooperation of all the significant stakeholder, a plan will be impossible. I am optimistic that the stakeholders will be willing to take the necessary risks to make an HCP for this species a reality.

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The Biopolitics of Endangered Species

by
Whitney Tilt

I am sure that many of us remember times in our past when our fathers or mothers turned us out to do something that we may or may not have been ready for — "fish or cut bait" time. This paper argues that we have reached such a time in endangered species management. How well we rise to this challenge will be reflected in the cold glare of 20/20 hindsight when the history books of the late 20th century are written.

Within the pages of the *Endangered Species UPDATE*, readers have been introduced to the complexities of the Endangered Species Act (ESA) — from listing to consultation to recovery plans to delisting. A sampling of endangered species professionals today, however, would reveal a wide range of opinions on how well the Act has functioned, and how effective the program has been in fulfilling its purpose as steward of endangered, threatened and candidate species. It comes as no surprise, or at least it is slowly dawning on us, that endangered species management has as much to do with people management as it has to do with heterozygotes or minimum viable populations. Anyone who has been involved in the recovery efforts of the red and gray wolf, California condor, Coachella Valley fringed-toed lizard, or snail darter can attest to the fact that the science of zoology or ichthyology has a lot less to do with the management of these species than the science of "biopolitics."

A student of the Endangered Species Act could read every line of the ESA and Title 50, Part 17 of the Code of Federal Regulations and never find a single reference to having to "enter into consultation" with a biopolitican. In reflection, however, the status of certain species might be better off today if we had engaged in such consultation. This paper looks at two endangered species, the gray wolf in the northern Rocky Mountains and the snail darter, and examines how non-biological concerns have shaped efforts to recover the species. The paper then summarizes some of the rules of the road governing endangered species management in a biopolitical world.

Lessons from the Wolf

Recovery of the gray wolf in the northern Rocky Mountains is currently a hot topic. Even after two decades of effort, bringing the wolf back to the northern Rocky Mountains is by no means a sure thing. Wolves have a high capacity to reproduce, can sustain a relatively high mortality rate, and pose no threat to human safety. In short, if all that stood between the gray wolf and a recovered population were biological considerations, we could have wolves in Yellowstone National Park next year. However, this is not the case. Numerous hurdles, easily crossed in attempts to recover other species, have proven to be controversial barriers in the case of the gray wolf. Note that it took more than 13 years to simply develop the current recovery plan for the NRM wolf, and the plan is merely a biological blueprint of what "might happen."

Recovery of an endangered species is both legally required and ecologically desirable. In the case of the wolf, however, it is not sufficient merely to state legal and ecological mandates. The need exists to build a popular consensus that having wolves on a limited basis in carefully selected locations is desirable. The people of Idaho, Montana, and Wyoming must be convinced that sharing the land with wolves need not result in socioeconomic loss. Nor is it sufficient merely to speak of "the national interest" or "existence values" — those millions of non-residents who will gain satisfaction from merely knowing that the wolf exists in the wild, even if they never see one. National interest and intrinsic wildlife values are important, but to the rancher, farmer, outfitter, hunter, and trapper in the Intermountain West, these have become empty phrases. History has already demonstrated that humans can eradicate wolves if they choose to. Unless adequate groundwork is laid, history will likely repeat itself.

To date, there has been a certain reluctance on the part of Idaho, Montana and Wyoming to heartily endorse wolf recovery. Speaking privately, many state wildlife officials readily support the return of the wolf. However, their enthusiasm is tempered by political and management realities. By and large, state wildlife officials seek three assurances before supporting wolf recovery in their respective states: management flexibility, sufficient funding, and a commitment to delist the species when appropriate.

The question of management flexibility has largely revolved around the question "under what conditions may a threatened or endangered species be controlled or killed?" The court's decision in the Minnesota wolf case, *Sierra Club v. Clark*, and a threatened law suit against the Montana grizzly bear hunt in 1984, have made state wildlife agencies fearful of being sued if they attempt to control wolves. Therefore it is easier if they avoid getting wolves within their state borders in the first place.

For wolf recovery to proceed, all parties must agree to meet each other halfway. Animal protection groups must recognize that there will be times when wolves must be killed to protect lawfully present livestock and other permitted land uses. State agencies

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must come to trust that opponents will be unable to successfully bring suit against a wolf control program that is backed by good biological information and built on a sound administrative record. The Minnesota wolf dispute addressed in *Sierra Club v. Clark* arose over a proposal for the sport trapping of wolves by the general public -- not the control of specific "problem" animals. Interested parties purporting to have the wolf's best interest at heart need to move forward, not look backwards. Animal protection groups and state wildlife agencies are either going to have to "agree to disagree" and seek a workable arrangement among wildlife advocates or allow a district court to do their thinking for them. *Sierra Club v. Clark* may be perceived as a victory for animal "rights" but it was a set-back for wolf recovery.

The question of adequate funding is vital to endangered species recovery, regardless of the species involved. The majority of state wildlife revenues come from hunting and fishing license sales and the federal excise tax on firearms and ammunition. Traditionally these monies have been used to support "game" animal programs — but this is largely due to the fact that sportsmen's groups continue to be the ones that best put their money where their mouth is. In the era of deficit reductions on federal and state levels, it is not enough to merely request more money — there is a need to build a constituency and work to build public and private partnerships to put money on the ground. The Forest Service's Challenge Cost-Share program is one good example where $1.00 of federal appropriations has been matched by an average of $2.30 from local sponsors like sportsmen groups and others interested in getting involved. Another promising approach is the involvement of Defenders of Wildlife and others in producing the *Oregon Wildlife Viewing Guide* which is helping to build a constituency of wildlife "watchers."

Finally, state officials have expressed concern that once recovery goals are met, the wolf will not be delisted. They feel that anti-hunting groups and other pro-animal advocates will foster a new set of criteria for delisting the wolf once the species has reached the numerical goal established by the recovery plan. Unfortunately, the Endangered Species Act is still too young a program to have established many precedents where species have been successfully listed, recovered, and delisted. There are success stories, like the alligator and brown pelican, but these species did not face the socio-political challenges that the likes of wolves, grizzlies, and condors face. The time has come to move towards delisting of the grizzly bear in northwest Montana and the gray wolf in Minnesota. Many questions remain to be resolved before these actions can be accomplished, including habitat protection and program funding. It is not the intent of the Endangered Species Act, however, that endangered predators and other controversial animals become permanent wards of the endangered species program because we are unwilling to tackle the unknown. If these yet to be formed mechanisms fail to protect a species after delisting, we can always admit defeat and relist the animal.

Much has been made of the wolf. It is seen as everything from a embodiment of deceit to a symbol for wilderness preservation. The endangered species manager, newly steeped in biopolitical wisdom, recognizes that a more realistic view is necessary for wolf recovery in the northern Rocky Mountains to become a reality (Tilt *et al.* 1987).

Remember the Snail Darter

In 1977, a virtually unknown fish threatened to stop construction of Tellico Dam, a Tennessee Valley Authority (TVA) project that was more than 80 percent completed. The snail darter was a tiny fish, unknown prior to 1973, which became a weapon for those who sought to halt a "pork barrel" dam. The vehicle that allowed the lowly snail darter to oppose Tellico Dam was the Endangered Species Act.

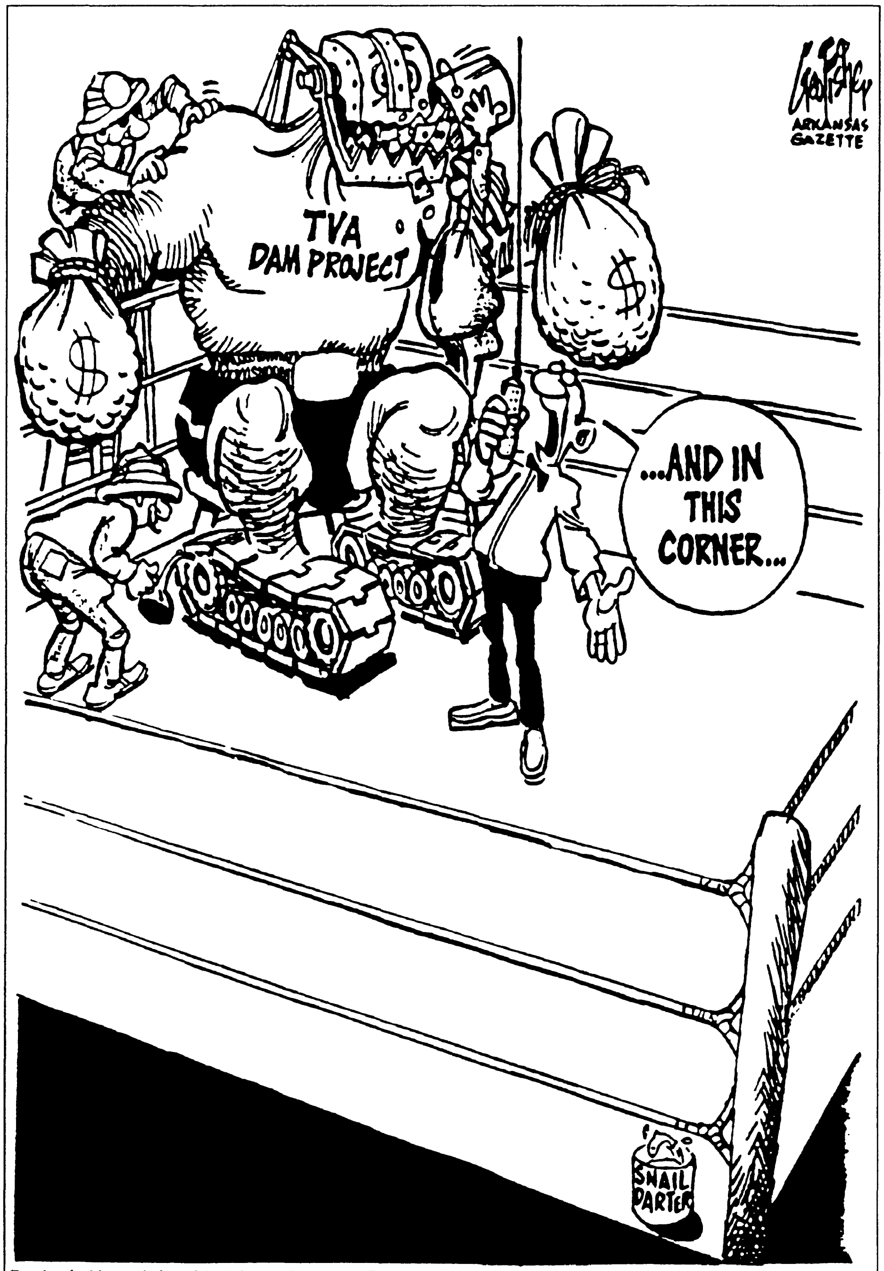
In 1967, TVA began construction of the Tellico Dam on the Little Tennessee River. TVA had built more that 60 dams in the area, and the Tellico Project would dam the last significant freeflowing water in the region. Opposition to the dam was immediate. Lost farmland, inundation of the Cherokee Nation's most sacred religious site, and loss of river recreational opportunities were just three of the concerns of Tellico's opponents. When these concerns had no effect, opponents of the dam sought relief from the courts, claiming that the completion of the dam would violate the ESA by causing the snail darter's extinction. After their case was dismissed by the District Court, the Sixth Circuit Court reversed and ordered the District Court to permanently enjoin completion of the project "until Congress, by appropriate legislation, exempts Tellico from compliance with the Act or the snail darter has been deleted from the list of endangered species or its critical habitat materially redefined"(549 F. 2d 1064 (1977)). The Supreme Court agreed to review the lower court's judgment in 1977.

The Supreme Court, in a 6 to 3 decision, affirmed the lower court's decision, even though Tellico Dam was by then 90 percent completed and TVA had spent over $20 million on the dam and in excess of $80 million on land development. The court found that Congress intended endangered species to be afforded the highest of priorities, and that the ESA's provisions apply to all federal actions without exception and are to be applied whatever the cost (437 U.S. at 184).

As a direct result of the *TVA v. Hill* decision, Congress amended the ESA in 1978. The amendments provided for the granting of exemptions to projects of regional or national significance where project benefits "clearly outweigh the benefits of alternative courses of action" (Pub. L. No. 95-632, 92 Stat. 3757 (codified at 16 U.S.C. Section 1536 (h) (A) (Srpp. IV 1980). This review process was to be carried out by the Endangered Species Committee (ESC), a cabinet-level committee, nicknamed the "God Committee" because of its power over a species' existence. On January 23, 1979, the ESC unanimously denied an exemption for Tellico Dam on economic rather than ecological grounds. Concerning the ESC's decision, Chairman Cecil Andrus stated: "I hate to see the snail darter get the credit for stopping a project that was ill-conceived and uneconomic in the first place." Another ESC member added, "Here is a project that is 95 percent complete, and if one takes just the cost of finishing it against the [total project] benefits, and does it properly, it doesn't pay, which says something about the original design" (Plater, 1982).

Unfortunately for the Little Tennessee River, politics are not bound blindly to the decisions of the Supreme Court or a Congressionally appointed "God Committee." On June 18, 1979, a rider on the annual public works appropriation bill overrode all other decisions, and authorized the completion of Tellico Dam. The rider was neither read nor discussed before the House chamber, "and in forty-two seconds the citizen's work of sixteen years was reversed" (Plater, 1982).

When dam opponents first realized that the diminutive snail darter and the ESA might be used to defeat Tellico dam, they were hesitant to use it, fearing that an "insignificant fish" stopping a dam in midst of construction would brand them as rabid environmentalists. (It is estimated that approximately $12 million had been invested—$4 million on the dam and $8 million on associated land development—at the time that TVA first became aware of the conflict



Reprinted with permission of the Arkansas Gazette and George Fisher with a listed species.) Further they feared that such an action would allow the ESA's opponents to brand the Act as an abuse of regulatory power. The following New York Times editorial perhaps best sums up the controversy:

Environmentalists may come to regret their choice of the snail darter as a weapon against Tellico. They lost the battle and succeeded only in making the fish a cause for snickers. These may escalate to guffaws if it now turns out that the snail darter was able to take care of itself all along. But discovery of the new colony of fish does not mean it was wrong to oppose the project. Tellico Dam remains a costly boondoggle. (NY Times, 1980)

Taking an historical perspective, the first litigants invoking the prohibitive powers of the ESA could have chosen a better champion. Perhaps the continued survival of the Florida panther against a condominium project in Florida would have had the ingredients for a winning hand. Failing the luxury of such hindsight, however, *TVA v. Hill* set a strong pro-endangered species precedent. For example, in 1978 and 1979, Congress sought to tighten, not weaken, interpretation of the ESA through amendments. Unfortunately, the subtleties that framed the original dispute have largely been forgotten — what is remembered are the "guffaws": that a tiny fish nearly stopped the multimillion dollar development of an allegedly necessary dam and reservoir project (this despite official decisions that Tellico's economic costs far outweighed its benefits). It is an image that has recently reemerged in the spotted owl/old growth forest controversy as the timber industry's future is pitted against the "winged snail darter."

Rules of the Game

Snail darters have become symbolic of tilting at windmills while gray wolves are still a long way from roaming Yellowstone National Park. What do these seemingly disparate tales of wolves and darters have to teach us? A brief primer of rules governing the "biopolitics game" would include:

1. Don't bet the "national interest" above the "local interest." Remember House Speaker Tip O'Neill's maxim that "All politics are local." The creation of a strong local constituency in support of a particular critter is step one for a successful recovery. National interest also doesn't mean very much to state wildlife agencies whose budgets are set from within the state, not without.

2. Maintain management purview. If wildlife management is to remain the

Photo: USFWS

Wilderness advocates may not want to hear from researchers that grizzly bears may be able to coexist with a carefully managed timber program, but the purpose of the ESA is to recover listed species, not create wilderness.

purview of the professional wildlife manager, with Congress, the public, and the courts acting in a supporting role, biologists must produce good, sound biology in a timely manner and intelligible form. In addition, we can not view court opinions and special interest lobbying as a replacement for good biology and professional wildlife management. In addition, conservation groups and other interested parties should seek to play an active role in concert with the state and federal wildlife agencies, not merely a manipulative role through Congress and the courts.

3. Ensure adequate funding. Adequate funding must be assured for recovery programs to proceed. It is no longer sufficient to lobby a budget-conscious Congress for more add-ons for pet projects. The development of private-public partnerships demonstrating support for a particular project will not only reduce the level of federal appropriations needed, but will demonstrate broad-based support for the project.

4. Don't hide behind an endangered species. The key to any successful dispute resolution is to bind all parties to the table. Proponents and opponents alike must have something to lose as well as gain by reaching consensus. For example, issues of wilderness protection, hunting or trapping, and the like are important, but is it appropriate to hide behind an endangered species to get them fulfilled? Wilderness advocates may not want to hear from researchers that grizzly bears may be able to coexist with a carefully managed timber program, but the purpose of the ESA is to recover listed species, not create wilderness. If controversy over when and how wolves may be killed (*e.g.* sport trapping) is the pivotal reason for keeping the gray wolf listed in Minnesota, then the wolf should be delisted and the issues of appropriate use of the wolf debated on the state level. As the list of threatened, endangered, and candidate species grows, we do not have the luxury of these hitch-hikers.

5. Perception is reality. The general public's perception of an endangered species issue may not seem important to a wolf lover or darter supporter. But if the general perception runs against an animal or plant's continued survival, all the biological data in the world will be useless against the perception. Opponents of Tellico never changed the general perception that "a little fish might halt a valuable dam project" even though they worked long and hard at trying to do so. While it may be difficult, or seemingly impossible, to achieve a change in public perception, the perception problem must be addressed head-on, and cannot be ignored if recovery of the listed species is to be achieved.

6. Talk to everyone. This applies not only to Congress but the state legislature and local community leaders. Many members of Congress are not people you would find among the national environmental groups' pantheon of heros. However, many are master legislative tacticians who, once you convince them to support your cause, have the clout to carry your banner. The same is true on the state and local level. Do not let the media or a special interest group define the good guys or bad guys. Seek out the players and make your own determination.

7. Avoid an attitude of "all or nothing." Where your final objective cannot be readily obtained, seek to develop partial solutions. In too many cases, while the parties involved battle for total victory, the species in question continues to lose — its habitat, constituency, and chances for survival — while avenues for recovery become fewer and more expensive in terms of socioeconomic costs. Of course, it takes "two to tango," with all parties seeing the dangers of refusing to compromise.

8. Think locally. The scope of endangered species management is changing. While we continue to work to recover the well-known species like the whooping crane, grizzly bear and bald eagle, species coming onto the list are not as well known or widely distributed —two examples are the Minnesota trout lily and the Iowa pleistocene snail. Increasingly, endangered species management will be undertaken on a state and local level. While many advocacy groups continue to concentrate on the high profile species on a national level, the majority of listed species beckon closer to the ground. Today the action is increasingly at the state and local level, not in Washington, DC. Applying the maxim that "all politics are local," success (in terms of acres of land protected or number of endangered species recovered) is more palpable and visible, and therefore more lasting at the local level.

9. If not you, who? Finally, there is the challenge that if the endangered species professional is not willing to take on the leadership responsibilities on behalf of the wildlife profession and the onerous duties entailed in management, administration, budgeting, popular communications and politics, who will? Who is going to do the job of shaping the endangered species agenda: Congress, the courts, the animal protection movement or other special interest groups? Failure to gain proficiency on the multiple disciplines of "biopolitics" will likely lead to continued frustration and a lack of wins (defined as species which are delisted because of recovery, not extinction). What the endangered species effort needs right now are some species in the win column.

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Predicting the Future for Endangered Species

by
David Wilcove

Yogi Berra was right—"it ain't over 'til it's over." And in the case of endangered species, "over" means one of two things: recovery or extinction. Our record thus far is not very impressive. According to Reffalt (1988), 15 species have been "delisted" by the U.S. Fish and Wildlife Service: three species recovered, two recovered over portions of their ranges, and six became extinct.

Both political and scientific barriers stand in the way of recovering endangered species. The political barriers are as formidable as ever. Shrimp nets are still without turtle excluder devices and Yellowstone is still without wolves. The scientific barriers, in contrast, show signs of giving way. The emerging discipline of population viability analysis has provided us with a better sense of the relative importance of various factors that drive small populations to extinction, such as demographic stochasticity, genetic deterioration, and environmental fluctuations. In a growing number of cases, we can quantify survival probabilities of populations of various sizes and spatial configurations.

This growing scientific prowess will inevitably create an interesting moral dilemma. We may be able to set recovery goals the way we build automobiles—with knowledge that the product will last on average for a specified number of years.

All populations, however large or small, are at some risk of extinction. The smaller the population, the more likely extinction is in any given period. Also, the longer the period of time, the more likely extinction is for a population of any given size. Questions of population viability, therefore, reduce to questions of risk: What is the probability that a particular population will persist for a given period of time? For listed species, a decision has already been made that the near-term survival odds are too low. Recovery is necessary. It then becomes a policy issue to choose both the appropriate survival odds and the appropriate time frame.

My principal concern is that endangered species will end up the losers in this decision-making process unless people—especially scientists—become stronger, more vocal advocates for them. The evolutionary forces that create and extinguish species typically operate over a span of thousands and sometimes millions of years. In managing for viable populations, one goal would be to use a similar time scale. Soulé (1987), for example, has defined a viable population as one that "maintains its vigor and its potential for evolutionary adaptation." Yet in a world of quick fixes and short-term solutions, it is difficult to convince policy makers or the public-at-large of the need for a long-term perspective on the issue of viability and recovery. Few if any people want to see an endangered species disappear. But will people be willing to pay the price of protecting them (and their habitats) for not just 50 or 100 years, but 1,000 or 10,000 years?

The northern spotted owl (a candidate for threatened status) is a prime example. In December 1988, the USDA Forest Service—which controls most of the owl's habitat—released a new management plan for the bird. The agency announced that it would protect a network of old-growth patches for the owls in the national forests of Oregon and Washington.

The Forest Service conducted a detailed population viability analysis and predicted that its plan would give the northern spotted owl only a low to moderate probability of survival over the next 100 years. A low probability, according to the Forest Service (USDA Forest Service 1988) meant that "[c]atastrophic, demographic, or genetic factors are likely to cause elimination of the species from parts or all of its geographic range during the period assessed." A moderate probability provided "no latitude for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis." Perhaps because the long-term consequences of the plan were so damaging to the owl, the Forest Service agreed to review it in five years.

Admittedly, few wildlife issues are as contentious and downright painful as this one. Nonetheless, I see a dangerous precedent here. The Forest Service, using the best available information and analyses, was willing to proceed with a plan that provided for only the short-term survival of the owl. The promise to review the plan in five years did not justify its choice in the first place.

Most people are sympathetic to the plight of endangered species. Far fewer understand the need to adopt a long-term perspective with respect to their recovery. Population viability analysis has taken away the mirage of a "magic number" above which a species is safe, below which it is in trouble. It has left us in a starker landscape of probabilities, time horizons, and choices. Those of us who champion the cause of endangered species must fight for the public's support in this strange, new setting.

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Expanding the Range of Species Conservation Information

In 1976, The U.S. Fish and Wildlife Service Office of Endangered Species began publishing the *Endangered Species Technical Bulletin* to keep agencies, private organizations, industry, and concerned individuals abreast of developments in the federal endangered species program, at that time, the *Bulletin* was distributed free of charge to all who requested it. In 1981, however, federal budget cuts forced the Fish and Wildlife Service to limit distribution to federal employees and federally sponsored researchers. This meant that the public could no longer receive up-to-date information on the listing, recovery, and status of endangered species and related federal actions and programs.

In response to the cutbacks, the School of Natural Resources at the University of Michigan initiated a reprint program in 1983. Since then, the *UPDATE* has grown into a unique forum for ideas and information on endangered species protection. Each month, the regular version of the *UPDATE* combines two publications in one: a reprint of the *Endangered Species Technical Bulletin* and a cover section produced by the School of Natural Resources. In this way, the *UPDATE* blends reports on the status of individual species with articles and editorials discussing a broad range of species conservation issues.

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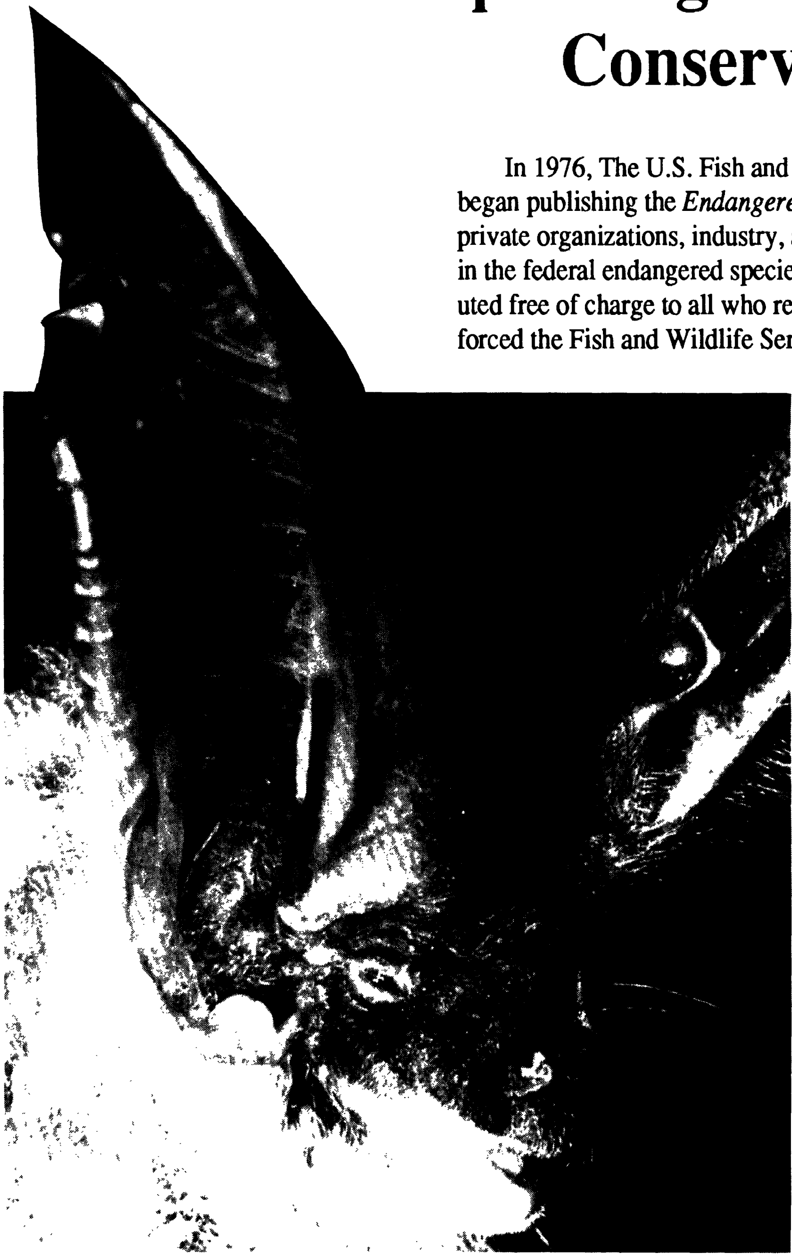

Ozark big-eared bat (*Plecotus townsendii ingens*) Photo: Robert Mitchell

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