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ECOLOGICAL IMPACT ASSESSMENTS AND HABITAT CONSERVATION PLANS

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INTRODUCTION

Federal laws gave rise to use of ecological impact assessments (EIAs) and habitat conservation plans (HCPs) in wildlife conservation. The concept of ecological impact assessment originated with the National Environmental Policy Act (NEPA) of 1969 and its requirement for environmental impact analysis of major federal actions. The term "ecological impact assessment" commonly refers to that part of a NEPA document that describes impacts to biota, but it also can mean the process of analyzing such impacts. Development of HCPs evolved from requirements of the Endangered Species Act (ESA) of 1973 (as amended in 1982) to alleviate impacts to animals or plants listed as threatened or endangered and candidates for such listing. Major HCPs may require NEPA analysis.

Ecological impact assessments differ from HCPs in policy focus and number of species commonly addressed. An EIA usually attempts to predict (disclose) impacts of a proposed legislative or development action on numerous species potentially affected. A HCP as originally conceived prescribed habitat management or protection for species listed as federally threatened or endangered. More recently HCPs cover some non-listed species as well and may encompass numerous development actions. We include EIAs and HCPs in a single chapter because they share important overriding qualities—a common ecological basis, the need for agency oversight, and involvement of multiple interest groups (Truett et al. 1994, Henker and Braun 2001).

The need to involve multiple interest groups and follow prescribed protocols complicates the difficulty of preparing effective documents. Different interest groups come with different perspectives and levels of understanding that can frustrate the process (Holling 1978, Henker and Braun 2001). The common inability of policy makers to understand ecology and appreciate the inadequacy of information often results in misguided directives (Reid 1996, Wilhere 2002). To successfully meet these and related problems requires "people" skills as well as a clear understanding of ecological principles, species–habitat relationships, and limits of knowledge.

We treat EIAs and HCPs somewhat differently. Given the relatively long history of the EIA process, we review its effectiveness rather than repeating what numerous others (e.g., Truett et al. 1994, Traweek 1995) have reported

about techniques. Because HCPs are relatively new, we elaborate on the process. Case-history examples of each build on these respective approaches.

HISTORICAL DEVELOPMENT

Implicit in the preparation of EIAs and HCPs is the assumption that presence and abundance of wildlife species are governed by environmental factors that can be measured and managed. From an ecological perspective these endeavors differ little from traditional management of wildlife populations. Biologists who understand the basics of habitat management will have little trouble understanding the ecological underpinnings of impact assessments and conservation plans.

Aldo Leopold (1933) first described the principles of wildlife management in the context of habitat. Successful managers since that time have built upon his insight, often elaborating with new terminology and techniques. Good habitat managers are familiar with the roles of limiting factors, habitat structure, habitat alteration, and population measurement and monitoring.

Ecological impact assessment as a practice separate from wildlife management began in the United States with passage of the National Environmental Policy Act (NEPA). It posed a more complex problem than traditional single-species wildlife management because analysts had to consider many species and managers had little direct control over actions that affected wildlife. Analysts wrestling with these new dimensions progressed through about 4 sequential approaches over the next 3 decades (Truett et al. 1994): (1) an initial preoccupation with species inventories generally intended to be used as baselines against which to measure change, (2) an early shift of focus by some to analyses of ecosystem processes (functions) for helping to predict impacts, (3) an ultimate realization that the complexity introduced by trying to assess impacts to numerous species and complex processes created a measurement dilemma, and (4) a consequent search for responsible integrative measures.

Habitat conservation planning evolved from Endangered Species Act amendments passed in 1982 that were designed to ease the burden of the ESA on private landowners. Simply put, after 1982 landowners could develop, if they chose, a HCP that described how they would alleviate ("mitigate") impacts their actions might have on species listed, or being considered for listing, under the ESA. Impact mitigation could come through such mechanisms as improving habitat for the species or providing them a protected reserve. The process became popular only after 1990, and novel ways of mitigating adverse impacts of land use continue to evolve.

ECOLOGICAL BASIS

Ecological impact assessments and HCPs strive to manage or protect habitat in the context of human actions. The former attempt to ameliorate habitat changes adverse to wildlife by helping decision-makers select among, or mitigate impacts of, human actions (Truett et al. 1994). The latter propose to manage or set aside specific areas to benefit species actually or potentially imperiled (Henker and Braun 2001). Responsible EIAs and HCPs, whether they involve habitat modification or habitat preservation, should (1) focus on a limited number of species, (2) base assessments and plans on population limiting factors for these species, (3) develop and apply integrative measures that consider additional species, (4) conduct follow-up monitoring, and (5) iteratively adjust plans and predictions with feedback from monitoring.

Limiting the Number of Species Addressed

Reliably assessing responses of most species to human actions is not only impractical but also usually impossible given constraints of funding, time, and state of knowledge (Diamond 1987, Franklin 1993, Moir and Block 2001). Preparing defensible EIAs and HCPs requires focusing on a few species from among the many potentially affected. How does one make these selections?

Proposed strategies for reducing the number of species addressed in impact assessment have proliferated since the passage of NEPA. Early on, some practitioners focused on species directly valuable to people, e.g., "featured species" (Gould 1977) or "valued ecosystem components" (Beanlands and Duinker 1983). Others proposed using "ecological-indicator" species (Graul et al. 1976) or "management-indicator" species (Graul and Miller 1984) that, in theory, represented the needs of other species with similar habitat relationships. Some analysts proposed that one or a few species could represent entire "guilds" of species with similar habitat needs (Landres 1983). Others suggested using "indicator" species to assay change in habitat quality (Landres et al. 1988), "keystone" species that disproportionately affected other species (Mills et al. 1993), "focal" and "umbrella" species whose requirements encompassed the needs of others (Lambeck 1997), and "flagship" species that rallied support for protection of associated species (Miller et al. 1999).

Habitat conservation plans, unlike EIAs, initially focused on only a few species—those listed under the ESA. But, the process evolved so that many HCPs now include numerous additional species. Similarly to EIAs addressing multiple species, this can complicate the preparation of reliable documents.

Some recommended approaches for limiting the number of species addressed could usefully simplify impact assessment and conservation planning. Some approaches overlap with others in concept. More problematically, some are based on faulty assumptions. Straightforward approaches hampered little by untested or invalid assumptions include focus on listed species (HCPs), featured species, valued ecosystem components, keystone species, and flagship species. We urge caution in using selected species as indicators of needs of other species or to represent species guilds (see Landres et al. 1988).

Focusing on Limiting Factors

Numerous environmental factors affect any given wildlife population but only a few exert major influences. Leopold (1933) called the important ones "limiting factors" and focus on these remains a cornerstone of habitat evaluation and management (Dasmann 1981:71–73, Anderson and Gutzwiller 2005). Application of this principle is important in preparing EIAs and HCPs—like limiting the number of species addressed, it helps reduce complexity to a manageable level.

Limiting factors may range from food scarcity to weather to predation, but commonly impose themselves through the medium of habitat structure (Willson 1974, Short and Williamson 1986, Risser 1995, Wiens 1995). Biologists preparing EIAs and HCPs can increase their effectiveness by focusing on habitat structure and viewing themselves as habitat "architects." Several advantages come with this approach: (1) alteration of habitat structure usually is the most important way in which development affects wildlife habitat (Kautz 1984, Franklin 1993); (2) wildlife responses to structural change frequently are predictable in a general way given existing or easily gathered information (Willson 1974, Short 1988); (3) vegetation communities and microscale "coverts", which provide much of the structure important to wildlife (MacArthur and MacArthur 1961, Maser et al. 1979, Verner 1986), usually are amenable to manipulation; and (4) structure is readily mapped and displayed. A wide range of participants can accept habitat structure as "currency" for measuring habitat quality.

Using Integrative Measures

Focus on some species may encompass the needs of others but invariably many species and the community as a whole remain unaccounted. Ecologists have struggled to develop integrative measures that reflect the "health" of entire wildlife communities and not just the well-being of selected species. Some have used the early-historic (i.e., pre-industrial) state of ecosystems as the explicit or implicit template for good health, and departures therefrom as degrees of "illness." But the assumption of co-evolution of species on which this concept rests may be invalid.

Paleoecological and historical evidence assembled in recent decades makes it increasingly clear that most plants and animals did not co-evolve as members of the same communities they now occupy. Modern communities assembled largely by chance, each species having evolved in association with an ever-changing milieu of other species (Graham 1988, Hunter et al. 1988, Reid 1996, Lockwood et al. 1997). A few interspecific dependencies, such as the black-footed ferret's (*Mustela nigripes*) need for prairie dogs (*Cynomys* spp.), and some host-parasite relationships, do not invalidate the general pattern.

That communities are continually changing assemblages of species rather than co-evolved units raises questions about how to measure community-level impacts. It hints that the concept of "natural" or "pristine" as a template for healthy ecosystems may have arisen from a short view of history (Dickinson 1995) and a poor appreciation for impacts of pre-industrial humans (Sprugel 1991, Wagner and Kay 1993). It suggests that what is healthy in ecosystems depends largely on human judgment (Reid 1996), which varies in time and space. This underscores the need for review by multiple interest groups during the EIA process.

Measures of biodiversity constitute a commonly used integrative index of community value, with greater diversity commonly indicating greater value. Measures of landscape diversity (Westman 1985), smaller-scale structural diversity (Noss and Harris 1986, Noss 1990), and species diversity (richness and equability) (Westman 1990) have been proposed to measure value of habitats or the wildlife community itself. In practice, indices to species richness (Weller 1978, Scott et al. 1987) appeal to many analysts because they are easy to understand and acquire. None of these methods offers the perfect solution (e.g., Harris 1988, Knopf 1992) and which works best often depends on money available and context of the problem.

Numerous other measures have been proposed as surrogates for community health (Rapport 1989). Many ecologists note the importance of habitat structural measures at landscape (Hansson 1979, Westman 1985, Urban et al. 1987) and other scales (Noss and Harris 1986). Others propose measures of community functional processes such as productivity, nutrient cycling, or energy flow (Truett 1979, Rapport 1989, Vitousek 1990). Yet others plead for retaining species redundancy (2 or more species having similar functions) to hedge against ecosystem instability or collapse if some species disappear (Walker 1995, Naeem 1998). No measures are perfect or even uniformly applicable and some that have been proposed seem ill advised. Beginning analysts would do well to keep current with this rapidly changing field of thought and apply their knowledge of basic ecology and wildlife management to winnow the best ideas from the trivial, the impractical, and (Diamond 1987) the fictitious.

Monitoring

Improving the effectiveness of EIAs and HCPs depends on follow-up monitoring to assess the reliability of impact predictions, habitat plans, and models on which these are based. A major weakness of most EIA protocols is that they do not require monitoring (Duinker 1989). Viewing impact predictions as hypotheses for testing helps focus monitoring in EIAs (Traweek 1995).

A good monitoring program will allow biologists to sort project impacts from effects caused by other human actions or by natural phenomena such as weather. A common design involves comparing post-development wildlife populations at "test" (developed or managed) sites with those at "control" sites similar to test sites in all respects except the development or management action. The best monitoring designs also include pre-development or "baseline" measurements at test and control sites. Unfortunately, conventional baseline studies often lack the measurement focus and inclusion of control areas needed for rigorous post-development monitoring (Truett et al. 1994). Duinker (1989), Walters and Holling (1990), and Murphy and Noon (1991) discuss design of reliable monitoring programs.

What good is monitoring given that meaningful results usually accrue only after development has commenced or a conservation plan prepared? First, results often are applicable to similar future projects. Second, development of EIAs and implementation of HCPs often occur in phases, and results of early monitoring can lead to better decision-making. This iterative process is crucial to improving the utility of EIAs and HCPs.

Adaptive Management

The Achilles heel of EIAs and HCPs is uncertainty. Biologists usually have inadequate knowledge to accurately forecast in detail any of the following: (1) human actions that will occur, (2) responses of wildlife populations to any of the potential actions, and (3) the responses of human social and regulatory institutions to issues surrounding

EIAs and HCPs. Consequently, what actually happens invariably is at odds with the predicted or the expected (Treshow and Allan 1985, Walters and Holling 1990, Moir and Block 2001, Wilhere 2002). One problem with procedural protocols, and especially those associated with NEPA, arises from their failure to acknowledge uncertainty.

An approach commonly used for coping with uncertainty has come to be called adaptive management (Holling 1978, Thomas and Burchfield 2000, Moir and Block 2001). Those applying adaptive management use results of monitoring and experimentation to incrementally improve performance. Information feedback from results of properly designed monitoring programs or experiments (Walters and Holling 1990, Lancia et al. 1996) is key.

Adaptive management can be productively applied to most EIA and HCP situations. Holling (1978) and Walters and Holling (1990) provide a good overview of adaptive management principles and the tools for application in large-scale EIA problems—models, workshops, and experimental design. Murphy and Noon (1991) and Lancia et al. (1996) describe the importance of the hypothetico-deductive process at all scales of effort. Moir and Block (2001) discuss what they consider adaptive management's weakest link—the information feedback system. Walters and Holling (1990) and Lancia et al. (1996) explore "learning by doing" and other shortcuts to conventional experimentation. As the name implies, adaptive management is a creative process for applying science rather than a rigid protocol for action.

ECOLOGICAL IMPACT ASSESSMENT UNDER NEPA: A CRITIQUE

The National Environmental Policy Act requires preparation of environmental impact statements (EISs) that disclose and compare impacts of several alternatives for each major proposed action (Truett et al. 1994). The process of ecological impact assessment (EIA) can take place inside or outside the NEPA context and, indeed, independent research commonly forms the basis for NEPA analyses. But because NEPA documents constitute the formal procedure for disclosing environmental impacts, analysts often think of EIAs in this context.

In the more than 30 years since the passage of NEPA, biologists assessing ecological impacts often have been frustrated by their inability to protect natural resources through the NEPA process. In this section we provide a brief overview of the weaknesses and strengths of this process to inform and empower biologists embarking on a career in impact assessment. We have been inspired by the intent of those who framed NEPA, and hope reviewing its past effectiveness will focus future creativity in using the law to more effectively protect dwindling resources.

Truett et al. (1994) and Trawick (1995) described the formal EIA process in detail. They reviewed legal and procedural requirements, ecological analysis, synthesis of information, impact predictions, and mitigation. They emphasized the purpose of EIA under NEPA—to disclose impacts of development alternatives. Deciding whether a development project should or should not proceed falls upon the shoulders of agency decision-makers and the public.

Box 1. Applying Science to EIAs and HCPs.

Ecological impact assessments (EIAs) and habitat conservation plans (HCPs) make use of 2 kinds of science, analysis of parts and integration of parts (Walters and Holling 1990). The analysis of parts commonly takes the form of hypothetico-deductive experiments (Romesburg 1981) focused on small parts of ecosystems. Researchers using this methodology have assembled over time reliable sets of data that form the basis of ecological knowledge. The integration of parts requires synthesizing from accumulated knowledge the information applicable to a particular question or problem.

Project-specific experiments (analysis of parts) usually will provide the most reliable and defensible data for a particular EIA or HCP. They can be conducted by project biologists, university researchers, or others trained in experimental design and data collection. But on-site experiments alone rarely suffice to adequately assess impacts because the ecosystems involved prove too complex and the money and time available too limited. Those developing EIAs and HCPs usually will find it necessary to depend on synthesis of relevant information from other times, places, and contexts.

Information synthesis is both the savior and nemesis of reliable EIAs and HCPs. It adds reinforcement to the usually sparse sets of data from project-specific investigations. It requires the knowledge and interpretive skills that come only with in-depth training and experience. Edward O. Wilson (1998:71) characterized predictive synthesis as "formidably difficult." Thomas and Burchfield (2000) lamented the currently popular "raids" on agency and university research staff for expertise to meet the increasing demand for cross-disciplinary synthesis.

Those who aspire to develop defensible and useful impact assessments and conservation plans need to be aware of the level of expertise needed, especially for synthesis and interpretation. They should prepare themselves to meet the doctoral-level or "uptraining" standards recommended by Thomas and Burchfield (2000). Only then can they expect to adequately address the complexities and uncertainties involved in these important arenas of wildlife conservation (Duinker 1989, Stanley 1995, Wilhere 2002).

Our intent is to emphasize lessons that have been learned over time and discuss improvements that could be made, but not to repeat descriptions of procedure. We identify provisions in the law that EIA practitioners might use to enhance resource protection. We identify practices inconsistent with the intent of the law and discuss the potential need for a paradigm shift in the way ecological impact assessments have been developed.

We agree with Lindstrom and Smith (2001) that NEPA offers the ethical framework and administrative tools for moving our society toward ecological sustainability. It identifies a broad set of ecological goals and legislates a rational procedure for arriving at federal decisions and actions regarding the environment. It provides a clear and logical way for moving this country and the world into an ecologically conscious twenty-first century.

Policy provisions of NEPA Section 101, supported by Section 102 and its action-forcing procedure, "authorizes and directs that, to the *fullest extent possible*, the policies and regulations and laws of the United States shall be interpreted and administered in accordance with the policies...in this Act." The courts have left interpretation largely to the discretion of agencies and their respective expertise. This provides great opportunity for biologists to apply science in the disclosure and amelioration of adverse ecological impacts.

Historical Problems

Systemic and Political

Ortolano and Shepherd (1995) argued that several problems associated with NEPA documents since the 1970s were systemic and will persist. Most importantly, many project proponents viewed EIAs only as hurdles to be jumped on the way to project implementation. The hurdles posed risks to project proponents because the NEPA process forced public disclosure of impacts.

The framers of NEPA intended it to "fulfill the responsibilities of each generation as a trustee of the environment for succeeding generations" and to "assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings." An EIA that meets only procedural requirements contradicts the act's intent. Investigations of the immediate and cumulative effects of an agency's preferred action and alternatives (Truett et al. 1994) need to reflect NEPA's broad environmental policy vision of sustainability (Lindstrom and Smith 2001).

Some analysts believe ecological impact assessment as practiced under NEPA needs to be restructured. Despite 3 decades of evolution and myriad techniques, the present practice appears unable to prevent environmental disasters such as the Exxon-Valdez oil spill or reduce population declines of many imperiled species. Smith (1993) argued that most environmental problems have occurred not because human activities were unplanned nor their impacts unforeseen but because impact analysts have a flawed view of how impact assessment should function in environmental planning and resource management. Environmental protection has been viewed as a desirable but distinctly secondary objective to development and exploitation of the resource base. Economic gain takes precedence over long-term environmental protection.

Because NEPA is such a broadly worded statute, decision-makers have considerable discretion as to how they address its mandates. As a result, NEPA's apparent intentions, the environmental decisions of federal agencies, and court rulings on implementation often seem at odds with each other (Lindstrom and Smith 2001). Dinah Bear (cited in Lindstrom and Smith 2001) noted the tendency for analysts to focus on process and disregard common sense and substance. Unless presidents, members of congress, administrators, and the courts begin to see NEPA as a tool for environmental protection, it will simply ratify irresponsible actions by agencies unchallenged by the public (Lindstrom and Smith 2001). Over the years some federal managers have learned to comply with the letter of NEPA by preparing EISs that pass the muster of courts and little more (Kennedy 1988).

The history and culture of state and federal agencies influence their preparation of NEPA documents (see Sellars [1997] and Corps of Engineers review below). Because several agencies with different purviews, objectives, and histories collaborate on some EISs, an objective, even-handed assessment becomes difficult. Findings by each agency tend to reflect its own particular ends and priorities.

Agencies may avoid addressing important impacts by pushing for a narrow EIS scope or by presenting alternatives with only superficial differences. Bureaucratic interpretations of "reasonable" alternatives in EIS preparation often conflict with other groups' wishes for choices that are truly different in terms of impact. Smith (1993) found that most impact assessments evaluated only proximate alternatives and not fundamental choices. According to the Council on Environmental Quality's 1997 Effectiveness Study (cited in Lindstrom and Smith 2001), NEPA's ability to protect resources depends on agencies systematically soliciting comments from those affected and using the information to adjust development actions.

Many environmental impact statements are lengthy, technical, and difficult to read despite Council on Environmental Quality regulations that the language be accessible to the general public. Given that most of the public is not trained in law, ecology, or public administration it behooves agencies to be more innovative in their public outreach. Creating a true partnership with the community involves more than holding public meetings and making documents available.

Formal EISs are being replaced by weaker procedures such as "environmental assessments," "findings of no significant impact," and "categorical exclusions" (Clark and Canter 1997). An environmental assessment is in essence a short version of an EIS. It addresses alternatives and must be made available for public inspection but, unlike an EIS, need not be circulated widely for comment. On the basis of an environmental assessment alone, agencies may issue a finding of no significant impact, and permit a project. Categorical exclusions may exempt from the NEPA process entire categories of actions judged not to have significant adverse effects. These procedures streamline the process but circumvent the original purpose of NEPA; cursory treatment may result in impacts being overlooked and the study of alternatives minimized.

The number of findings of no significant impact has skyrocketed as the number of EISs has decreased, and some believe agencies may be adopting this approach specifically to minimize public involvement (Ortolano and Shepherd 1995). Moreover, an environmental assessment can find significant impacts and proponents still can avoid a full EIS by proposing mitigations and issuing a "mitigated finding of no significant impact". Such proposed mitigation measures often are subsequently ignored.

Scientific

Early inadequacies of impact assessment under NEPA

resulted in attempts to improve the science of the process by making impact statements more analytical and informative. But given the inability of ecologists to accurately measure ecosystems and forecast impacts, results of ecological analyses often took second place to hard data from engineering design and economic feasibility studies (Smith 1993).

By the late 1970s it became apparent EISs had fallen short of their promise. The science to that point had not been good (Boothroyd and Rees 1984). A transition stage ensued in which the scientific efficacy of EISs claimed the focus of attention. The ability of impact assessments to protect the environment was brought into question by a paralyzing amount of NEPA-related litigation that reflected the perceived failure of the science.

This period of change resulted in an expansion of the concept of EISs. In the 1980s, social impact assessment, community impact assessment, risk analysis, technology assessment, and adaptive environmental assessment and management became part of the NEPA process based on the assumption that the procedure had not reached its full potential (Smith 1993). Some believed that attempts to resolve the problem through refinements in technical design elements were misguided. Clark and Herington (1988) noted the excessive interest in methodologies and techniques that, in their view, directed attention from the primary purpose of impact assessment. Caldwell (1989) lamented the overshadowing of purpose by technique.

Although some (e.g., Beanlands and Duinker 1983) proposed that a paucity of science was the problem, others placed the blame on the institutional framework. Smith (1993) argued that improving the science of environmental impact assessment per se did nothing to reform the political process that governed the use of information, and that foundations of the assessment process itself needed to be re-examined.

Storey (1986) proposed that impact assessment had placed too much reliance on professional judgment in lieu of procedure that could be tested, replicated, and refuted. One solution, he believed, was to place more emphasis on the *management* of project outcomes than on their estimation. Like Smith (1993), he proposed that impact assessment should be an adaptive, integrative, and interactive means of decision making in environmental planning.

Successive federal administrations chose to leave interpretation and enforcement of NEPA largely to the courts. This resulted in an emphasis on the judicially enforceable aspects of the act to the neglect of its substantive provisions. The science of ecological impact assessment might have been improved but the basic problem remained political (Smith 1993).

Attempts to Resolve Problems

Systemic and Political Problems

Many agree that ecological impact assessment as currently practiced has good technique but inadequate substance. Smith (1993) proposed that it must become a bridge to integrate the science of environmental analysis with the politics of resource management. Taylor (1984) evaluated the statutory framework for environmental analysis in light of what a science-based approach would require. In his view, a system of formal analysis must: (1) focus on important issues, (2) specify how much detail must be provided, (3) prevent the manipulation of alternatives to obscure real choices, (4) facilitate helpful criticism by outsiders, (5) provide forums for resolving technical disputes, (6) adjust the burden-of-proof rules or distribution of analytical resources to make the system workable if the resources of outsiders and insiders are greatly out of balance, (7) provide incentives for the analysis to be used in decision making, and (8) encourage improvement of analytical methodology. He believed impact assessment as currently practiced under the NEPA framework met few of these requirements. He suggested that environmentally better decisions were likely to result when "inside analysts" were able to explore possible environmental tradeoffs and that all projects could benefit from relatively inexpensive environmental mitigation.

Fromby (1990) contended the purpose of EIA was not simply to assess impacts but to improve the quality of decisions. He maintained the "technocratic view" blinded analysts to political realities, resulting in documents that increasingly had little influence on decisions. He urged practitioners to use results of scientific studies to influence the political process.

The U.S. Army Corps of Engineers (Corps) has demonstrated how NEPA can positively influence a bureaucracy dominated by engineers with a tradition of building (Mazmanian and Clarke 1979, Taylor 1984, Ortolano and Shepherd 1995). In the 1970s following the passage of NEPA, the Corps hired several hundred environmental professionals and incorporated them into their planning process. Some were hired specifically to write EISs and some learned how to influence the engineers responsible for projects. Some were able to stop or modify environmentally risky proposals, changes that were extraordinary given the Corps' Congressional allies who wanted new projects constructed in their home districts. Changes in the Corps' mode of operation demonstrate how NEPA programs, coupled with substantial societal pressures, can positively affect organizational structure and behavior of project proponents (Taylor 1984, Smith 1993).

Scientific Problems

The U.S. Council on Environmental Quality in its 1997 NEPA Effectiveness Study advised the use of "adaptive environmental management" in the NEPA process (Lindstrom and Smith 2001). The council recommended ecological predictions be tested by monitoring to assess the validity of the predictions and the mitigation measures designed to counter adverse effects. The council also proposed adaptive management when the environment was not expected to be permanently damaged, when the project could be modified once started, and when there were opportunities to repair past environmental damage.

The lack of formal requirements by NEPA for monitoring project impacts has been and remains one of the main barriers to the development of a sound predictive base for impact assessment (Eberhardt 1976, Trawick 1995). Post-project monitoring could serve at least 2 purposes: to enhance forecasting ability (Culhane 1993) and to provide a basis for more effective mitigation.

Two emerging procedures for improving the NEPA process are strategic environmental assessment and cumulative effects assessment (Roe et al. 1995). These techniques purport to assess cumulative impacts of multiple

programs, policies, and plans. However, they seldom have been put into practice by the federal government (but see Orions et al. 2003). Some states recently have begun to recommend these approaches, and the World Wildlife Fund published a conceptual framework for cumulative effects assessment (Irwin and Rodes 1992). This framework provides general guidance for identifying multiple stresses, understanding how effects may accumulate, and bounding assessments spatially and temporally.

NEPA requires assessment of impacts on biodiversity where it is "possible to both anticipate and evaluate" such effects. Some agencies increasingly use ecological impact assessment within the NEPA process to try to counter losses of biodiversity (Hirsch 1993, Pritchard 1993).

Conclusions

Goodland and Daly (1995) identified the real test of ecological impact assessment: ensuring that possibly 10 billion people could be decently housed and fed without damaging the environment. Environmental sustainability in the face of burgeoning human numbers constitutes the ultimate goal. This desperate situation underscores the importance of NEPA and similar laws in individual states and other countries. Natural capital is the limiting factor for population sustainability. Actions that could deplete this capital must be anticipated and mitigated.

The National Environmental Policy Act has been the most imitated law in United States history, and its effectiveness could form the basis for global sustainability. Lindstrom and Smith (2001) emphasized the need for the environmental assessment process to build on the value paradigm of NEPA and harmonize human actions with ecological processes. The National Environmental Policy Act provides a philosophical and practical context for effective environmental policy (Lindstrom and Smith 2001); the challenge for wildlife biologists is to bring science to policy decisions and fulfill the promise of NEPA as envisioned by those who fashioned it.

EIA CASE STUDY: ARCTIC ALASKA OIL DEVELOPMENT

One of the largest ecological assessment efforts ever undertaken in terms of expense and duration of study focused on the impacts of oil development in arctic Alaska (Maki 1992). We discuss this program because it illustrates the optimum in assessment opportunity—a lot of money spent to study impacts of a major development in a simple ecosystem occupied by few people. Its approaches, successes, and shortcomings offer insight into the options and limitations that may be expected in other projects. Most of the research took place largely outside the formal NEPA context, but results of the studies have been widely used in EISs, environmental assessments, and other NEPA documents.

In June 1968 Atlantic Richfield Company announced a major oil strike near Prudhoe Bay (Truett 2000_{b7}). The passage of the National Environmental Policy Act shortly thereafter set the stage for escalation of impact-oriented studies, which already had commenced in nearby areas suspected to contain oil (Shaver 1996). The value of the oil accumulation, coupled with the high expectations of NEPA, would during the next few decades attract millions of dollars and many well-qualified scientists to this massive assessment program.

Low temperatures impose major constraints on the region's ecosystems (Truett 2000*a*). Surface soils and water remain frozen for 9–10 months each year, and subsurface soils are permanently frozen. The low temperatures and frozen terrain in winter lead to specialized adaptations or, more commonly, migratory habits in the common vertebrates. Because of the extreme environment, terrestrial, freshwater, and marine ecosystems exhibit lower biodiversity and simpler food-web structure than temperate ecosystems in similar settings.

Historically low population densities of humans in arctic Alaska resulted in fewer predevelopment impacts than one usually encounters in temperate climates. Still, the subsistence lifestyles of the native peoples had for generations affected populations of fishes, mammals, and birds (Jamison 1978). Europeans exerted increasingly intensive harvest pressures beginning in the late 1800s (Brower 1942). In addition, oil exploration during the 20 years prior to the 1968 strike had conspicuously and extensively scarred the tundra surface (McKendrick 2000).

The low-growing vegetation and nearly flat coastal environments gave striking relief to the oilfield infrastructure that gradually took shape in the decades following

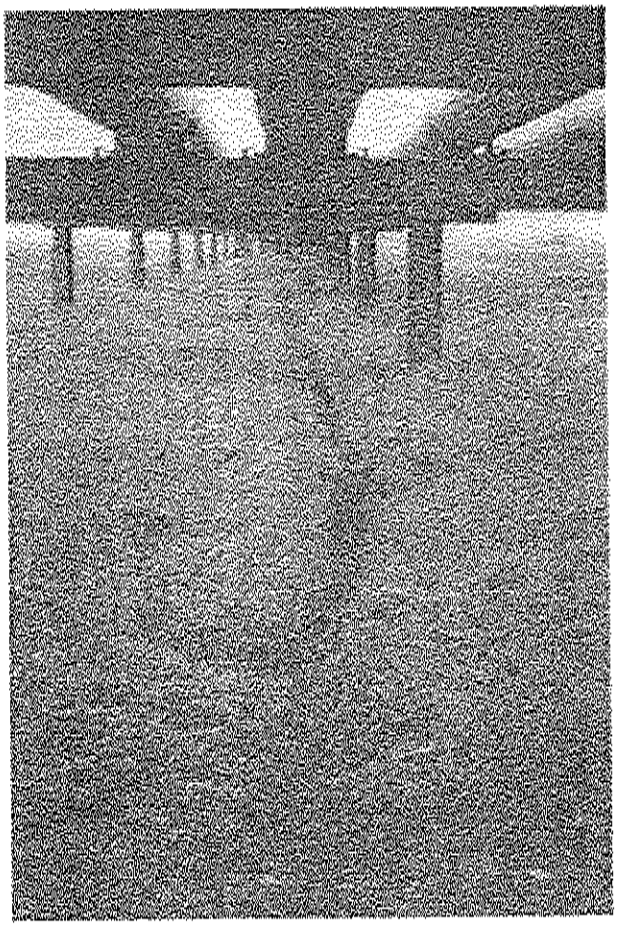

Fig. 1. Pipes carrying oil in arctic Alaska stand ≥1.5 m above the ground to allow caribou (*Rangifer tarandus*) passage. Oestrid flies (*Hypoderma tarandi*, *Cephenemyia trompe*) harass caribou in late summer, sometimes driving them to seek shelter beside or under facilities as illustrated by this trail caribou made after pipe installation (photograph by M. E. Mallery).

1968 (Gilders and Cronin 2000, Truett 2000*a*). Currently, pipelines cross the tundra on stanchions ≥1.5 m above the ground (Fig. 1). Pads of gravel ≤1.5 m thick support drilling operations, production infrastructure, and roads. Gravel fill occupies about 2–4% of the surface of the older oil fields but substantially less of the newer ones. Surface runoff from early summer thaw creates impoundments upslope of gravel roads and pads. Plumes of dust follow trucks on primary roads; the dust settles thickly on the adjacent tundra. In the vicinity of Prudhoe Bay itself, 2 jetties, or causeways, extend from the coastline several km into marine near-shore waters. Artificial islands support wellheads and other facilities in near-shore waters.

Early on, most analysts recognized the impossibility of adequately addressing all or even most species, notwithstanding the large budgets and simple ecosystems involved (Truett 1979). Thereafter, the great majority of impact assessment effort focused on a short list of vertebrates considered most important to people (Truett 1981, Maki 1992, Truett and Johnson 2000). Researchers addressed the habitats, food chains, and processes supporting these "valued ecosystem components" (Duinker 1989). Impacts analysts assessed the potential effects of development on the species and their habitats and food chains.

Most species addressed were abundant and widespread in the oil fields only in summer (Truett 2000*b*). In winter most migrated to other regions, although some assembled in or near the oil fields in restricted areas suitable for their overwinter survival. The fishes that foraged in streams, lakes, and coastal lagoons in summer retreated in winter to the few freshwater and estuarine localities where water was >2 m deep and low in salinity. Nearly all summer-nesting birds migrated south, as did caribou and grizzly bears (*Ursus arctos*). Most arctic foxes (*Alopex lagopus*) moved north onto the sea ice. Polar bears (*Ursus maritimus*) constituted the anomaly—they came into the oil fields in winter but seldom in summer.

The involvement of numerous agencies, public interest groups, scientists, and developers in the EIA studies required special efforts to expedite communication. Periodic workshops, often sponsored by agencies and managed by facilitators, commonly hosted 100 or more attendees and provided the basis for information exchange among the interest groups. Smaller workshops, often conducted by specialists using model-building to structure research (Holling 1978), built rapport among scientific disciplines. Interdisciplinary teams of scientists worked as units on field projects and often lived and ate together in oil-field enclaves; this expedited interdisciplinary communication at the grass-roots level.

Unlike the case with many EIA efforts, the federal government and the petroleum industry provided generous funding for on-site research. The Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the U.S. Department of Commerce was created in 1975 specifically to assess the impacts of the burgeoning Alaska oil industry (Engelmann 1976). This program, and later the U.S. Bureau of Land Management and the U.S. Minerals Management Service, set general research goals and awarded contracts for study. As federal money declined in the 1980s, the oil industry began to pay for larger proportions of the research; their support continues. Universities, federal and Alaska agencies, and private consulting organizations conducted the preponderance of the investigations.

In some research programs (e.g., Truett 1977) adaptive management, introduced by workshop facilitators involved in its development (e.g., Walters 1986), encouraged scientists to adjust their research focus when feedback from initial efforts indicated the need. Interdisciplinary workshops following annual data-collecting forays used models, "looking-outward" matrices, and other adaptive management tools (Holling 1978). Because much research often proceeded independently of NEPA oversight, changes in direction were not constrained by inflexible protocols.

The decades-long succession of research programs and new oil developments offered an ideal setting for adaptive management. Findings of initial studies, often coupled with improvements in engineering design stimulated by the studies, led to new research directions. For example, early studies of caribou responses to above-ground pipelines led to the elevation of pipelines ≥1.5 m and refocusing of subsequent studies to identify which horizontal configurations of elevated pipes least hindered caribou passage (Murphy and Lawhead 2000). Consolidation of oil wellheads on fewer gravel pads with smaller total coverage resulted from early concerns that gravel placement reduced breeding bird populations proportional to the area covered; studies of the fate of birds displaced by the larger pads followed (Troy 2000). Temporal as well as spatial controls proved possible, particularly in some of the later studies.

What happened to wildlife populations in arctic Alaska oil fields in the 3 decades after development commenced? Most oil-field vertebrates intensively studied increased in abundance: several shorebird species (Troy 2000), black brant (*Branta bernicla*) (Sedinger and Stickney 2000), snow goose (*Chen caerulescens*) (Johnson 2000*a*), tundra swan (*Cygnus columbianus*) (Ritchie and King 2000), caribou (Ballard et al. 2000), grizzly bear (Shideler and Hechtel 2000), polar bear (Amstrup 2000), and probably arctic fox (Burgess 2000). Some fishes (Gallaway and Fechhelm 2000) and shorebirds (Troy 2000) have fluctuated annually in abundance with no long-term trend. A few birds, dunlin (*Calidris alpina*) for example (Troy 2000), declined in abundance.

None of these changes except increases in abundances of grizzly bears and arctic foxes can be attributed with any certainty to oil development (Truett 2000*b*). Most changes appear to have resulted from climatic fluctuations or from factors operative in migratory species' ranges outside the oil fields. Causes of many of the population changes remain uncertain.

Some studies disclosed localized impacts within the oil fields (Truett et al. 1994, Truett 2000*b*). Most birds avoided gravel-covered or intensively developed sites (Troy 2000); some mammals appear to have been attracted to them (Ballard et al. 2000, Burgess 2000, Shideler and Hechtel 2000) (Fig. 2). Impoundments displaced some birds and attracted others (Kertell 1996, Troy 2000). Coastal causeways attracted common eiders (*Somateria mollissima*) (Johnson 2000*b*) and altered the distributions and movement patterns of estuarine fishes (Gallaway and Fechhelm 2000). Busy roadways altered caribou distribution when calves were young (Murphy and Lawhead 2000). However, investigators generally could not link

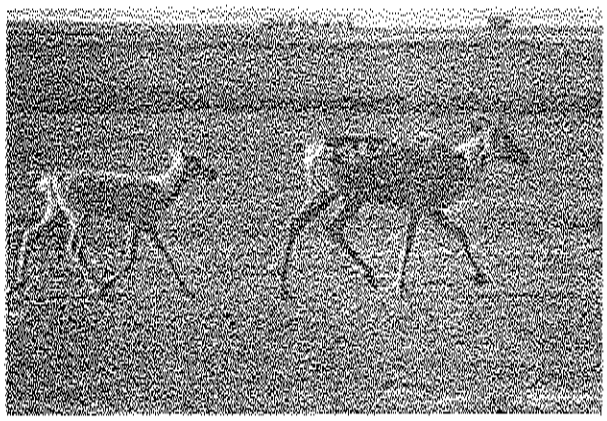

Fig. 2. Caribou cow (in molt) and calf walk along a gravel roadway in an arctic Alaska oil field. Cows with young calves may avoid roads with heavy traffic but, in summer, caribou may assemble on elevated roads and drilling pads to escape intense mosquito harassment (photograph by M. E. Miller).

local changes to increases or decreases in oil-field populations of animals, except that populations of arctic foxes (Burgess 2000) and grizzly bears (Shideler and Hechtel 2000) apparently increased at least seasonally as a consequence of human-related food sources in the oil fields.

Adaptive feedback from research findings prompted mitigative actions (Truett 2000*b*). Consolidation of facilities in newer developments reduced infrastructure density and habitat coverage by gravel. Breeches built in coastal causeways expedited fish passage and reduced arctic fox access to waterfowl nesting on the causeways. Changes in placement and design of pipelines and roadways reduced their barrier effects on caribou. Removal of human refuse alleviated, to some extent, the increases in arctic fox populations. It also reduced habituation by grizzly bears to humans, which apparently had elevated their vulnerability to hunting outside the oil fields.

The inability of well-funded and long-term research to disclose population-level impacts of such a visually impressive development offers lessons for ecological impact assessment. First, even if development-caused impacts occur, factors unrelated to development have a disturbing way of masking them. Although in theory experimental controls can sort development-related causes from others, firm establishment of cause-and-effect remains rare (Lancia et al. 1996). The liberally funded Alaskan oil-field assessment effort illustrates the main assumption underlying NEPA—that impacts can be reliably forecast—is seriously flawed (Walters and Holling 1990).

Experience in the oil fields underscores the need for adaptive approaches in both the political and ecological dimensions of impact assessment. The framework for impact assessment and for mitigation planning must allow feedback and consequent adjustment in direction (Moir and Block 2001). Unfortunately, adaptive management often proves difficult in agency-managed programs because the system of planning and decision-making can be inflexible (Thomas and Borchfield 2000). This emphasizes the need for well-trained and highly experienced analysts—professional judgment often must make up for deficiencies in funding, procedure, and knowledge.

In March 2003 the National Academy of Science released the report *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope* (Orians et al. 2003). Few among the 19 members of the committee that prepared the report had conducted impact assessment research in the oil fields, but all visited Alaska during report preparation. The committee's report and the National Research Council's summary of the report (National Research Council 2003) implied, with some ambiguity, that development had caused adverse population impacts to several wildlife species, in apparent contradiction to conclusions of some of the researchers referenced above. *The New York Times Magazine* (10 March 2003) referenced the report to present an even more adverse (and less reliable) scenario of impacts to wildlife.

Such is the nature of impact assessment. Science seldom "proves" anything, and people, even scientists, interpret data with their own views and biases (Ludwig et al. 1993). During the past decade many have selectively used findings of research in the Prudhoe Bay area to support their own views for or against development of the nearby Arctic National Wildlife Refuge. Major disagreements about impacts after 30 years illustrate the continuing inadequacy of knowledge and the influence of judgment in the impact assessment process. The challenge for all ecologists is to remain objective despite their own views and pressures from interest groups.

HABITAT CONSERVATION PLANS

Legislative Background

The Endangered Species Act of 1973 affords protections to federally listed endangered and threatened species (hereafter "listed" species). One protection found in Section 9 of the ESA prohibits "taking" of animals, with take defined as "…to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". Endangered plants are protected from removal from federal lands and from certain activities on private lands, but the broad "taking" prohibition that applies to listed animals does not apply to plants. Listed species also receive protection through review of the actions of federal agencies.

Section 7(a)(2) of the ESA requires every agency to ensure that any action it authorizes, funds, or carries out will not jeopardize the continued existence of any listed species or adversely modify or destroy its critical habitat. Federal agencies consult with the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS), depending on the species involved, about each of their actions that may affect any listed animal. A formal consultation results in USFWS or NMFS issuing a "biological opinion" about whether the proposed action satisfies the requirements of Section 7(a)(2). The biological opinion typically includes an "incidental take" statement that provides the federal action agency with protective coverage from violation of the Section 9 "taking" prohibition, provided the agency follows the terms and conditions of the "incidental take" statement.

After passage of the ESA, some landowners objected to the stringent "take" prohibitions of Section 7, believing they interfered with legitimate use of private land. In response, Congress in 1982 amended the ESA to authorize "incidental take" permits based on an acceptable conserva-

Box 2. Environmental Assessment, Sheep Basin Restoration Project.

On 1 August 2001 the Reserve Ranger District of the Gila National Forest in New Mexico released an environmental assessment for its proposed Sheep Basin Restoration Project. This project would "restore" the forest in the 6,000-ha Sheep Basin area to conditions less conducive to high-intensity wildfires and more beneficial to wildlife. The 5 alternatives presented in the assessment differed from each other primarily in whether trees would be cut in groups or singly, to what extent large trees would be cut, how forest thinning and harvesting would be applied, whether and how herbicides would be used, and to what extent forest roads would be decommissioned. Previous public review, resulting from letters to interested parties, a notice in a local newspaper, and guided field trips to the project area, influenced the content of the assessment.

On 24 April 2002 the Gila Forest supervisor issued a "Decision of Notice and Finding of No Significant Impact" that announced her intent to proceed with a modified Alternative 2. The decision notice summarized comments from about a dozen parties. Some of the comments objected to the proposed removal of large, old ponderosa pine trees (*Pinus ponderosa*).

In summer 2002 the Reserve Ranger District marked trees for cutting. Public objection intensified, primarily because many of the marked trees were large and old pines. The Catron County (New Mexico) Citizens Group commissioned an information review of the importance of large, old pines to wildlife. Three environmental groups submitted separate appeals against the decision notice. In response, the U.S. Forest Service Regional Office remanded the original environmental assessment back to the Reserve Ranger District for revision.

On 15 November 2002 the Reserve Ranger District released a revised environmental assessment. A sixth alternative had been added; it resembled the originally preferred Alternative 2 except that no "yellow pines" would be cut. (Bark of ponderosa pine trees turns from dark to yellow as they age; pines in the project area turn yellow usually when they reach 100–120 years old [R. C. Moore, Catron County Citizens Group, personal communication]).

On 29 January 2003 the Gila Forest supervisor issued another "Decision Notice and Finding of No Significant Impact" that identified Alternative 6 of the revised assessment as the preferred action. The decision notice specified: "There will be no size limitation for trees that will be cut but all yellow-barked ponderosa pine will be retained". Two of the 3 environmental groups submitted appeals to this second decision notice. As of this writing, the Forest Service Regional Office has not responded to these appeals.

This project illustrates the importance of public involvement in the NEPA process. Even should environmental assessments (or impact statements) identify adverse impacts of proposed projects to wildlife, the projects still can legally proceed. The purpose of NEPA is to disclose impacts, not stop projects. Public objection often is necessary to alter or prevent projects that threaten wildlife or wildlife habitat. Appeals and environmental litigation in recent years have become popular mechanisms to this end.

Fig. 2. Large trees, the snags and logs resulting from them, and forest openings elevate wildlife diversity and abundance in southwestern ponderosa pine forests conventionally managed as young, even-aged stands (photograph by J. C. True).

tion plan, commonly referred to as a "habitat conservation plan" (HCP). Specifically, through creation of ESA section 10(a)(1)(B), Congress authorized otherwise prohibited "taking" of federally listed threatened and endangered animals "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." Congress used as a model for HCP development an effort to reconcile land development on San Bruno Mountain near San Francisco with conservation of the endangered mission blue butterfly (*Icaricia icarioides missionensis*) and the callippe fritillary butterfly (*Speyeria callippee callippee*) (Bean et al. 1991). Spurred by proposed designation of critical habitat for one of the butterfly species, the county, state and federal wildlife agencies, developers, and a local environmental organization negotiated a conservation agreement. The main participants in the San Bruno process were the primary proponents of the 1982 ESA amendments.

Unlike Section 7 and other legal requirements of the ESA, the Section 10(a)(1)(B) "incidental-take" permitting process is applicant-driven. An applicant seeks a permit to ensure his or her activities are not in violation of the "take" prohibitions of ESA Section 9. This permit provides non-federal landowners relief from the strict "taking" prohibition of the ESA parallel to the relief available for federal actions under Section 7. Congress amended the ESA in 1982 under the assumption that every action that might result in incidental "taking" of listed species could be classified as either a federal agency action that would follow the Section 7 process or a non-federal action that could follow the Section 10 (HCP) process. But sometimes non-federal developers perceive that Section 7 results in a quicker solution for incidental "taking" than Section 10. In such cases they may search for a way to "federalize" their projects to bring them under the umbrella of Section 7 (Bean et al. 1991).

The HCP process has evolved into an ambitious program. Proponents now use it to integrate development activities with listed species conservation, provide a framework for broad-based conservation planning, and foster a climate of cooperation between the public and private sectors. After a slow start—only 3 HCPs were approved between 1983 and 1989—the procedure gained favor. As of 17 April 2002, 379 HCPs had been approved, addressing approximately 12 million ha and protecting more than 200 endangered or threatened species. Nationwide, HCPs are now seen as one of the fundamental approaches to resolving listed species issues on non-federal lands.

"Incidental Take" Permitting

Depending on the species involved, either the USFWS or the NMFS issues "incidental take" permits. The permitting process consists of 3 phases: (1) HCP development phase, (2) formal permitting phase, and (3) HCP and permit implementation phase.

In Phase 1, the applicant (often through a consultant) prepares a HCP with technical assistance from a USFWS or NMFS field office that outlines the requirements. The application package includes the permit application form, application fee (if applicable), the proposed HCP, the Implementing Agreement (if required by the USFWS or NMFS regional director or requested by the applicant), a draft document outlining compliance with NEPA (an environmental action memorandum, environmental assessment, or environmental impact statement), and certification by the USFWS or NMFS field office that it has reviewed these documents and finds them statutorily complete (U.S. Department of Interior 1996). The applicant may choose to combine the HCP and required NEPA analysis in a single document.

During Phase 2, the appropriate USFWS regional office or the NMFS office in Washington, D.C., reviews the application for compliance with legal standards. The USFWS or NMFS announces in the *Federal Register* the receipt of the permit application and availability of the NEPA analysis for public review and comment. Issuance of an "incidental take" permit and approval of a HCP requires the USFWS or NMFS conduct a formal internal ESA Section 7 consultation and draft a "biological opinion" that assesses the permit's impact on all listed species, candidate species, and critical habitat for those species.

The ESA requires 5 criteria be met to the satisfaction of the USFWS or the NMFS before an "incidental take" permit can be issued.

1. The "taking" will be incidental, that is, unanticipated and not purposeful.
2. The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such "taking."
3. The applicant will ensure that adequate funding for the HCP and procedures to deal with unforeseen circumstances will be provided.
4. The "taking" will not appreciably reduce the likelihood of survival and recovery of the species in the wild.
5. The applicant satisfactorily ensures other requirements will be met and the HCP will be implemented.

During Phase 3, a *Federal Register* notice announces the issuance of the permit, and the permittee and other responsible parties prepare the HCP. The USFWS or the NMFS tracks a permittee's compliance with the HCP, "incidental take" permit, the implementing agreement, and monitors the HCP's progress and success.

Because the HCP is at the core of the permitting process, our focus is on the HCP itself. Comprehensive guides to the "incidental take" permitting process include the *Habitat Conservation Planning Handbook* (U.S. Department of Interior 1996) and federal regulations governing permits for the USFWS (Code of Federal Regulations 50:13) and NMFS (Code of Federal Regulations 50:217, 220, and 222). Thorough explanations of the requirements for an ESA section 10(a)(1)(B) permit are provided by U.S. Department of Interior (1985, 1988), Webster (1987), Arnold (1991), Houck (1993), and U.S. Department of Interior (1996).

HCP Requirements and Scope

Regardless of project size, all HCPs must specify (1) the impact of the "taking," (2) steps to be taken and funding available to "minimize and mitigate" such impacts, (3) alternative actions considered and reasons for their rejection, and (4) other measures deemed necessary or appropriate by the Secretary of Interior. Habitat conservation plans not consistent with species' recovery plan objectives are discouraged (U.S. Department of Interior 1996).

Habitat conservation plans vary enormously in geo-

graphic area covered, number of species addressed, and time frame. Geographic boundaries of HCPs should encompass the applicant's project or land-use area, or the jurisdiction within which "incidental take" could occur. The size of the area must be appropriate to the planning effort. For endemic species with restricted ranges (e.g., some invertebrates or fish), the plan should ideally cover the entire range of the species. More widely distributed species need larger areas, the exact size depending on HCP objectives.

"Covered species" is a term often used to refer to all species specifically addressed in a HCP. Covered species include listed species specified in the HCP's associated "incidental take" permit. They also may include species that are federal candidates for listing, and even "sensitive species" or "species of concern" without current federal or state listing or candidate listing status. Thus, non-listed species may benefit from HCPs designed primarily for listed species.

Until the mid 1990s, most HCPs were for relatively small projects including single-family housing lots, but some HCPs now encompass hundreds of thousand of hectares and even entire states. A Massachusetts Division of Wildlife single-species HCP for the piping plover (*Charadrius melodus*) addresses 325 km of Massachusetts's coastline. A 100-year HCP with a timber company in Washington State affects nearly 70,000 ha and, directly or indirectly, nearly 200 listed and unlisted species.

Quantifying and Mitigating "Incidental Take"

To quantify "incidental take" requires estimating the number of individuals or amount of habitat in the project area and, on this basis, (1) the number of animals to be "killed, harmed, or harassed" or (2) habitat units (e.g., area of land, volume of water) to be affected. The latter is typically expressed as all individuals occupying a given area or volume of habitat (U.S. Department of Interior 1996). Geographic information systems (GIS) can be invaluable for displaying the projected level of "take" by proposed activities.

After expected "take" has been estimated, the USFWS or the NMFS examines whether estimates are consistent with the ESA Section 10 permit issuance criteria. Authorized "take" cannot "appreciably reduce the likelihood of the survival and recovery of the species in the wild", and a mitigation program must minimize and mitigate "incidental take" to the "maximum extent practicable." A population viability assessment may help explore whether these criteria can be met. If the USFWS or the NMFS finds that initially anticipated "take" levels exceed what can be permitted, additional "take avoidance" and other mitigation measures must be developed. Identifying level of "take" and mitigation needed may be easy or difficult depending on species status; type, location, and urgency of the project; and local politics.

The U.S. Department of Interior (1996) noted that mitigation in HCPs usually takes one of the following forms: (1) avoiding the impact to the extent practicable, (2) minimizing the impact, (3) rectifying the impact, (4) reducing or eliminating the impact over time, or (5) compensating for the impact. For example, project effects can be (1) avoided by relocating project facilities within the project area; (2) minimized through timing restrictions and buffer zones; (3) rectified by restoration and revegetation of disturbed project areas; (4) reduced or eliminated over time by proper management, monitoring, and adaptive management; and (5) compensated by habitat restoration or protection at an onsite or offsite reserve. In practice, HCPs often use more than one of these strategies simultaneously or consecutively. Mitigation measures for species conservation and reserve design should follow what has been learned from experience as well as theoretical considerations (MacArthur and Wilson 1967, Diamond 1975, Noss et al. 1997).

Establishing a reserve as the primary mitigation measure presents many challenges. Scott and Sullivan (2000) observed that constraints to reserve configuration (e.g., land costs, fragmentation, pre-existing amounts of edge, lack of connectivity) cause problems requiring long-term, post facto management. It may be productive to set goals for the persistence of species (states) and ecosystems (processes) within reserves, and accept that reserve configuration will be defined by the landscape and politics of the area and that long-term management will be needed.

The views of independent scientists are important. These individuals may help design mitigation measures or prepare listing documents, recovery plans, and conservation agreements used by applicants to develop HCPs. Their reviews and suggestions also can occur during the public comment period.

The best source of information can be the species' recovery plans (http://endangered.fws.gov), especially if the plans were published or recently revised. Recovery plans may identify the utility of HCPs and the management actions needed for a species' conservation. Bean et al. (1991) discussed the desired coordination between recovery plan measures and habitat conservation planning.

An "incidental take" permit, and often the HCP itself, requires monitoring to track "take" levels and ensure the conservation program is being properly implemented. Both the permittee and the USFWS or NMFS are responsible for monitoring the success of the HCP; the USFWS has the added responsibility of ascertaining whether the permittee is complying with its regulatory requirements. Bean et al. (1991) recommended that HCPs include specifically stated, measurable indicators of plan success or failure to increase objectivity in monitoring.

"No Surprises"

"No Surprises" assurances are provided by the USFWS and NMFS to non-federal landowners through the ESA Section 10(a)(1)(B) process and as codified in federal regulations. Private landowners are assured that, if "unforeseen circumstances" arise, the USFWS or the NMFS will not subject them to additional commitments or restrictions on land and resource use (U.S. Department of Interior 1998). The government will honor these assurances as long as a permittee implements in good faith the terms and conditions of the HCP, permit, and other associated documents. The assurances apply only to those species that are "adequately covered" in a HCP.

For a species to be "covered" under a HCP it must be listed on the Section 10(a)(1)(B) permit. "Adequately covered" listed species in the HCP must have satisfied the permit issuance criteria. "Adequately covered" non-listed species are addressed in the HCP as if actually listed.

Adaptive Management

Significant data gaps often appear in a HCP's operating conservation program. In such cases, adaptive management (Walters 1986, Walters and Holling 1990) becomes an integral component of the HCP. Adaptive management encourages consideration of alternative strategies for research or monitoring, and iteratively adjusts actions based on what is learned. Biologists can use adaptive management effectively if they identify uncertainties in the HCP, incorporate alternatives for addressing those uncertainties, monitor success of the alternatives, and adjust management strategies as monitoring indicates the need. In June 2000 the USFWS and the NMFS amended their HCP Handbook (U.S. Department of Interior 2000) to address the "No Surprises" rule and to further enhance the HCP process through improvements in 5 areas: permit duration, public participation, monitoring provisions, establishment of clear biological goals, and adaptive management (Nelson 2000).

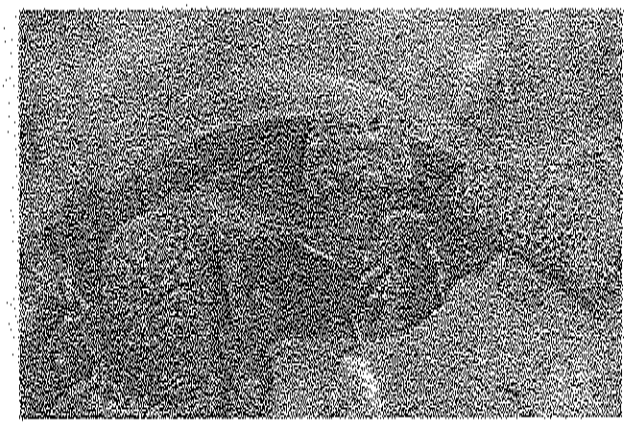

Fig. 4. The desert tortoise is listed under the Endangered Species Act as "threatened." Human development activities have reduced its populations in many areas (photograph by R. A. Fridell).

HCP CASE STUDY: DESERT TORTOISE IN WASHINGTON COUNTY, UTAH

Background

This case involved the establishment of a reserve in Utah as the core mitigation measure for impacts to desert tortoise (*Gopherus agassizii*), a federally listed threatened species (Fig. 4). The species' range in the southwestern United States extends northeast to the vicinity of St. George, Washington County, in extreme southwestern Utah. The Upper Virgin River Recovery Unit (Recovery Unit) in this area is classified as a distinct unit for management and recovery of the tortoise (U.S. Department of Interior 1994). It covers 180–230 km^2 and can support an estimated 7,000–9,000 adult tortoises.

Washington County, Utah, has been one of the fastest growing counties in the country, with an 83% increase in human population from 1980 (26,125) to 1990 (48,560) (Washington County Habitat Conservation Plan Steering Committee 1995). Growth projections for 2010 range from 80,500 to 139,000. The preferred habitat for desert tortoise—sandstone outcrops and dunes—comprise the most valuable remaining real estate because of its scenic beauty, water availability, and proximity to St. George.

Box 3. Successful Habitat Conservation Planning.

Habitat conservation planning becomes more effective as more plans are written, "incidental take" permits issued, and outcomes of plans monitored. Beatley (1994) suggested multiple guidelines for improving habitat conservation plans.

- Include representatives of all affected stakeholder groups in the process.
- Compile the best possible base of biological and scientific information.
- Integrate the habitat conservation plan into local and regional long-range planning.
- Develop an equitable, long-term funding program that spreads the financial burden of habitat conservation over groups that will benefit (e.g., developers, property owners, and conservation organizations).
- Protect multiple species and broader patterns of diversity rather than focusing only on listed species.
- Seek ways of combining habitat conservation with other community goals such as establishment of public recreation lands and open space and protection of water quality.

Noss et al. (1997) also offered recommendations for judgment and negotiation.

- Set aside preconceived notions of what constitutes scientifically defensible conservation planning—there usually will be far less reliable information than you would like to have available.
- Use science as the foundation for conservation planning, but don't expect planners to follow all of your suggestions.
- Be as honest, objective, and unbiased as possible.
- Do not let your science be corrupted or used improperly by any parties in the negotiations.

A sound plan does not guarantee adequate conservation. The best-designed, most scientifically credible plan is worth little if not implemented as intended (Noss et al. 1997). The habitat conservation planning process is inherently political. Estimating the level of "take" and the mitigation measures needed result from often grueling negotiations under extreme political pressures. Science-based judgments by biologists can make the difference between plans that promote species recovery and those that allow species decline.

The distribution of existing and proposed development in the late 1980s and early 1990s overlapped tortoise distribution, and loss of tortoise habitat to development outpaced protection of habitat at an accelerating rate.

On 1 October 1990 the Washington County Commission established the Washington County Desert Tortoise Habitat Scoping Committee to conduct a feasibility study on habitat conservation planning. This 9-member group identified potential funding, organized the plan development phase, and recommended the county proceed with the HCP process by creating a 15-member Washington County HCP Steering Committee. The Steering Committee held its first official meeting on 29 January 1991 and its last on 24 February 1994.

The project required much effort. Forty-four formal daylong meetings of the Steering Committee went into plan development. These meetings constituted only a small fraction of the effort of the Scoping Committee, 14 subcommittees, individual advocates and negotiators, and contractors who prepared maps, plan components, and other technical products.

HCP Development

Scope

The HCP covers a 20-year permit period and all of Washington County. The proposed "take" areas are all within the Recovery Unit. The permit applied to "incidental take" of desert tortoises only, but the reserve was designed to encompass a large portion of the Recovery Unit and benefit numerous other species. By future amendment, the permit can address the "take" of additional listed and unlisted species.

Duration

The USFWS issued an "incidental take" permit to Washington County in February 1996. Including permit review and processing, the development phase of the Washington County HCP lasted 6 years and 4 months. This protracted length resulted largely from the effort required to form the reserve. This required, in addition to resolving complex reserve location and boundary issues, the Steering Committee confirm that all private landowners within the area were willing sellers or traders. Consensus building among disparate groups proved difficult, reflecting the common pattern for development of region-wide HCPs to take several years. During one period of several months the Steering Committee reached an impasse on reserve design that most thought would terminate development of the HCP. Only when the county named a new Steering Committee chair did discussions resume.

During the HCP development period, an individual HCP was issued by the USFWS for one developer. This individual HCP and other measures were part of a settlement agreement for illegal "take" of desert tortoises resulting from the developer's bulldozing of a road through occupied desert tortoise habitat during the countywide HCP negotiations.

Funding

The State of Utah provided start-up funds for plan development. In addition, local governments, private developers, and ESA Section 7 funds generated as compensation for an earlier pipeline project contributed to the budget. This broad-based funding, totaling $760,622, garnered commitment by the parties to complete the plan.

Leadership

Local government and interest groups provided leadership. A Washington County commissioner chaired the first Steering Committee and a local attorney with experience in arbitrating environmental controversies chaired the second. Involvement of local officials in this process resulted in development of a new county department, now headed by the administrator of the HCP.

Organization

The plan development team included the Steering Committee, specialized subcommittees, and an environmental consulting firm that prepared documents and maps. Voting members of the Steering Committee represented land developers, landowners, Southern Utah Wilderness Alliance, The Nature Conservancy, U.S. Bureau of Land Management (BLM), Utah Division of Wildlife Resources, Utah Division of State Lands and Forestry, Washington County Commission, Washington County Water Conservancy District, Washington County Mayors' Association, and Washington County Cattlemen's Association. Non-voting members included U.S. Representative James V. Hansen, U.S. senators Robert F. Bennett and Orrin G. Hatch, and USFWS representatives. Initially, 3 subcommittees and a majority vote determined action; later decisions were consensus-based. Eleven subcommittees provided specific technical products that were approved or modified at Steering Committee meetings and incorporated into the HCP by the consultant.

Public Relations

Messages for and against the project reached the public through a variety of channels. During the first 18 months, a 20-minute video and an educational pamphlet explaining the natural history of the area and the benefits of habitat conservation planning were produced and made available to local schools and community groups. The project spawned numerous radio talk shows on natural history topics. During the last 2 years of the process, strong anti-conservation stories led the media coverage. A television series, for example, criticized efforts to conserve desert tortoises and desert habitat. The Steering Committee issued few formal news releases itself, although some Steering Committee members provided their individual perspectives to the media. Steering Committee meetings were well attended by the public, especially landowners, and media representatives.

Scientific Support

One of the first subcommittees formed by the Steering Committee was the Technical Advisory Committee. This committee collected and evaluated scientific information, and its members reviewed and analyzed proposed plan elements as they became available. It consisted of federal, state, and private biologists with experience studying desert tortoises and their habitat.

Project participants censused tortoises and mapped habitat. From 1988 through 1990, BLM and the Utah Division of Wildlife Resources conducted 298 1.6-km desert tortoise transects in Utah, and a consultant for the

Steering Committee surveyed 709 transects in the Recovery Unit. The BLM mapped the soils and vegetation of the Recovery Unit and delineated desert tortoise habitat. The Technical Advisory Committee combined transect data and maps to portray desert tortoise distribution and relative abundance across the areas. Mapping became an important tool for designing the HCP and reserve.

The Utah Division of Wildlife Resources periodically surveyed 2 standard 2.6-km^2 study plots for tortoises. Their biologists surveyed the City Creek Plot in the Recovery Unit in 1988 and 1994 and the Woodbury-Hardy Plot in the Northeast Mojave Recovery Unit in 1992. These surveys continue as the basis for estimating tortoise population numbers and trend.

Biological research provided important technical information throughout the process. One member of the Technical Advisory Committee studied radio-marked desert tortoises in the Recovery Unit beginning in 1989 and provided information on habitat use and home range size. These data were incorporated into the reserve design. Contacts with the desert tortoise recovery team and with desert tortoise biologists from other states ensured the HCP process benefited from current information on reserve design theory, disease, genetics, and other relevant topics.

Law Enforcement

During early stages of HCP development, some members of the Steering Committee opposed strong law enforcement, believing it would jeopardize progress of the program. The resulting weak enforcement allowed development to continue in many parts of the county. Consequently, some developers saw no incentive to proceed with the HCP and withdrew from the process.

In response, resource management agencies coordinated an enforcement effort in early April 1992 to provide a higher profile presence, make contacts, and gather information. From 15 April to 15 June 1992, over 40 contacts were made, including 18 with developers and property owners, and 5 of those resulted in major law enforcement investigations. After the initial contacts, USFWS took the lead in 3 cases involving desert tortoise habitat destruction. The Utah Division of Wildlife Resources pursued 2 cases involving "take" of individual desert tortoises, one of which led to a felony conviction.

Minimization and Mitigation of "Take"

The HCP outlined a 7-pronged approach for habitat conservation in Washington County.

1. Place under federal and state ownership and management a reserve including 15,700 ha of desert tortoise habitat and an additional 9,000 ha as buffer and "other species" habitat. Currently, less than two-thirds of this area is under federal management.
2. Remove, by fencing and other means, competing and other consumptive uses within the reserve that may adversely impact the desert tortoise and other Mojave Desert species.
3. Develop controls for minimizing "take" through county-wide ordinances, fees, environmental education, and enforcement, and develop a translocation program to attempt to preserve individuals that otherwise would be killed.
4. Seek Congressional support for establishment of a National Conservation Area.
5. Assist the BLM and the Utah Division of Wildlife Resources in reserve management until a National Conservation Area can be established.
6. Monitor desert tortoise population trends in the reserve.
7. Fund surveys and other actions to gather information, and identify and implement actions to help other listed or candidate species.

These actions serve as the primary mitigation for an estimated level of "incidental take" on 4,965 ha of primarily low-density desert tortoise habitat in the county. Estimated maximum "take" was calculated based on areas likely to be developed within the next 20 years and areas that could be developed without significantly affecting the tortoise.

Numerous conservation measures were instituted to ensure the reserve's effectiveness. The HCP included measures to reduce or eliminate threats (U.S. Department of Interior 1994) and prescribed management for 5 zones within the reserve. A budget covered HCP administrative staff, land management planning, fencing, purchase of grazing permits, tortoise population monitoring, environmental education, law enforcement, tortoise translocation, and conservation of other threatened and endangered species. Strict guidelines governed utility development in the reserve.

Development eventually will reduce the total amount of tortoise habitat in the Recovery Unit. However, the mitigation specified should more than compensate for this loss. Biologists expect implementation of the HCP will improve the quality of habitat in the reserve and chances for the tortoise's long-term survival.

Reserve Design

The Technical Advisory Committee collaborated with a Boundary Subcommittee established in March 1993 to negotiate reserve boundaries. The Boundary Subcommittee included 2 attorneys, 2 realtors, a developer, and several landowners. The advisory committee used reserve design criteria summarized in the draft Desert Tortoise Recovery Plan to evaluate numerous configuration options. Once a controversial segment was agreed to and mapped, surveyors often marked it with stakes to avoid later confusion.

The Technical Advisory Committee reviewed several reserve design plans in succession. In February 1992 it criticized the county's first proposal for the large amount of habitat included. This resulted in a revised version in December 1992. A third reserve, proposed by a small group of landowners in May 1993, was judged too small and fragmented. The advisory committee criticized the initial proposals primarily because they largely ignored design criteria used by the Desert Tortoise Recovery Team and advocated small, fragmented reserves with unmanageable inholdings.

In April 1994 the Steering Committee incorporated most recommendations of the Technical Advisory Committee and Boundary Subcommittee into a final reserve design. The final plan proved more responsive to

needs of the tortoise population than did initial proposals, partly because it built on the draft recovery plan. This design accompanied the county's HCP and application to the USFWS for an "incidental take" permit.

HCP Implementation

The Habitat Conservation Advisory Committee advises the county on implementation of the HCP. It draws representation from state and federal agencies, an environmental organization, local government, local development, and the public at large. It meets monthly about important issues such as proposals for the installation and maintenance of utility lines, minor reserve boundary changes, administrative budgets, and quarterly reports prepared by the county.

The Technical Advisory Committee, with help from outside experts, evaluates biological impacts of new issues or proposals (e.g., construction of a utility line). On this basis it advises the Habitat Conservation Advisory Committee, which reviews this advice to consult with the USFWS and make decisions. This "adaptive management" strategy helps address new questions or issues. Technical Advisory Committee biologists also monitor flora and fauna within the reserve.

The Dixie (Utah) Field Office of the BLM quickly exchanged and acquired land and, as of June 2002, had incorporated 2,910 ha into the "Red Cliffs Desert [Tortoise] Reserve" to be managed by the BLM or the state of Utah. Most acquisitions came through exchanges, some were bought with funds from the USFWS and the Land and Water Conservation Fund, and some were donated. Land purchases and exchanges are far from complete.

The county and its conservation partners have taken additional actions. Because cattle compete with tortoises for forage, all grazing permits within the reserve's tortoise habitat have been retired by Washington County. A county-funded law enforcement officer's sole responsibility is protection of the reserve. The BLM also has prohibited off-road vehicle use except on a few designated roads and trails. The BLM has withdrawn the entire reserve from new mining claims. Washington County employs a full-time HCP administrator, a biologist, and a technician who coordinates and conducts day-to-day conservation measures. The county annually funds seasonal technicians for the Utah Division of Wildlife Resources to monitor tortoise populations within the reserve. Several entities have built more than 48 km of fencing to exclude tortoises from roads or other hazards, and to control illegal dumping, vandalism, and off-road vehicle use.

Education and research programs support tortoise conservation. Washington County provides information on tortoises and other wildlife to thousands of its residents. It helped fund a multi-species plan for other wildlife in the reserve. A translocation experiment is providing valuable information about which habitats tortoises prefer, how far they travel, and whether successful translocation is possible. Development of a nature education center focusing on sensitive reserve species is forthcoming.

Areas of disagreement remain. Many local residents would like the reserve open to unlimited recreational use. The USFWS, BLM, and the Utah Division of Wildlife Resources, concerned that unrestrained recreation could harm tortoises and their habitat, developed a public use plan to address these issues. Discussions continue about new utility development proposals within the reserve and about costs of acquiring the remaining private property. Reserve properties still to be acquired are currently worth over $100 million (Owens 2000).

Implications

Washington County's Habitat Conservation Plan addressed complex conflicts between conservation needs

Fig. 5. A habitat conservation plan accepted in southern Utah used the threatened desert tortoise as the cornerstone for a reserve which offers protection for all native ecosystem components (Photo by J. F. Disney)

Box 4. Habitat Conservation Plan, Plum Creek Native Fishes.

The Plum Creek Native Fish Habitat Conservation Plan (http://www.plumcreek.com) was developed by Plum Creek Timber Company, Inc., in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. It was designed to conserve 17 native salmonids in the context of practicable long-term forest management. It encompassed about 650,000 ha, primarily in Montana but partly in Idaho and Washington.

The Plum Creek plan proposed an "incidental take" permit period of 30 years for the species covered. Seven conservation categories included 56 commitments intended to meet the biological goals for the 17 species of fish.

The working relationship between the Plum Creek Timber Company and the federal agencies began in June 1997. The draft Plum Creek plan and a Draft Environmental Impact Statement on the plan were released 17 December 1999, followed by a 90-day public comment period. The Final Environmental Impact Statement was issued on 21 September 2000.

After reviewing and developing responses to 83 public letters and other comments, the Plum Creek Timber Company and the 2 agencies identified issues that needed to be resolved prior to release of the final impact statement. These issues provided the framework for revisions to the habitat conservation plan.

Adaptive Management

The greatest number of issues leading to changes in the plan related to adaptive management.

- Expanding the description of the monitoring studies to be conducted.
- Clarifying that adaptive management decisions were based on an equal partnership, i.e., making sure the Plum Creek Timber Company could not unilaterally veto changes.
- Adding a commitment to establish a process for adding selected watersheds to the plan.
- Adding a commitment to monitor landslides.

Riparian Areas

The next greatest number of issues related to riparian management.

- Improving 8 of 9 commitments with more specific language.
- Adding more fish habitat protection for intermittent streams.
- Extending perennial stream measures to intermittent streams that flowed through unstable landscape features.
- Adding measures to mitigate impacts of streamside roads.
- Incorporating a clearcut limitation into "Interface Caution Areas."

Roads

Several changes related to road management.

- Improving 5 of 8 commitments with more specific language.
- Identifying specific watersheds for high priority treatment and for "Road Sediment Delivery Analyses."
- Incorporating a requirement to avoid building new roads on steep slopes.
- Developing a new, site-specific commitment to address landslide risk at Papoose Creek in the Lochsa River Planning Area basin.

Administration and Implementation

A few changes related to administration and implementation of the plan; the greatest concern was whether the 2 agencies would have sufficient resources to continue a creative partnership once the "incidental take" permit was issued.

- Improving 2 of 6 commitments with more specific language to help ensure long-term viability of the plan.
- Developing a specific protocol for third-party audits (financed by Plum Creek Timber Company) that would verify compliance and streamline the agencies' involvement.

and local development demands. It began to shift HCP and land-management efforts beyond a single species to accommodate an entire ecosystem (Fig. 5) that transcended traditional land management boundaries.

This project exemplified the potential of the HCP approach for species conservation. Conservation plan areas may be defined in terms of ecosystems rather than a species' distribution and thereby can produce an efficiency of scale in conservation funding and management. HCP efforts also may fund ecological research, inventories, and habitat monitoring. But despite the potential benefits, application of habitat conservation plans cannot always prevent regional declines in populations of listed species.

SUMMARY

Ecological impact assessments and habitat conservation plans evolved as conservation tools from provisions of the National Environmental Policy Act and the Endangered Species Act, respectively. They use legal protocols and public involvement to protect wildlife and habitats from impacts of human development. Analysts involved in their preparation need in-depth understanding of wildlife-habitat relationships and skills in working with people. The complexity of ecosystems, institutional agendas, and human motivations commonly involved offer challenges far beyond those ordinarily experienced by most wildlife biologists.

Three decades of application of NEPA have revealed shortcomings in the ability of the EIA process to halt or reverse ecosystem decline. A primary assumption of NEPA---that impacts could be reliably predicted---often has proved invalid. Monitoring to ascertain accuracy of predictions and usefulness of mitigation usually has not been required. Agencies have become good at meeting the letter of the law but often disregard its intention to protect natural resources. Potential improvements to the EIA process could come through monitoring and adaptive management, but even when applied these often have been offset by administrative shortcuts to the process that avoid in-depth analyses and public involvement. Some analysts have proposed ways to restructure the EIA process but change has been slow.

A large and long-term EIA program surrounding oil development in arctic Alaska exemplified some of the strengths and weaknesses of the process. Although well funded and often well designed, research to measure impacts on a number of species usually could not clearly identify whether population changes resulted from development or from other factors. Adaptive approaches characterized both research and management, and adjustments in both over time reduced the likelihood that adverse impacts occurred. Application of NEPA concepts coupled with generous research funding greatly increased scientific understanding of the arctic ecosystem. Major disagreements about oil-field impacts persist for at least 2 reasons: inadequate data sets and differing interpretations of existing data.

Habitat conservation plans have been in common usage only since 1990. Their initial focus on one or a few imperiled species simplified the task of predicting impacts, but the concept has broadened to include numerous species. Their emphasis on monitoring and adaptive management allows for flexibility to meet uncertainties. This voluntary way for developers to participate in conservation lends itself to positive collaboration and creative compromise for resource protection. For sedentary species at least, the option of establishing reserves to mitigate impacts may prove to be a better way than the ecological impact assessment process for protecting whole ecosystems against the chronic "nibbling" away of wildlife and habitats by successions of development projects.

Development of a habitat conservation plan to protect the threatened desert tortoise in southwestern Utah brought together proponents and opponents of development and resulted in creation of a tortoise reserve as mitigation. Positive aspects of this program included research on and monitoring of tortoises, productive collaboration among interest groups, distribution of conservation information to the public, and consolidation of land ownership into a reserve for tortoises that protected other species as well. The increasing use of HCPs suggests such a strategy can provide long-term ecosystem protection in many areas.

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