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INTEGRATING LONG-TERM AVIAN STUDIES WITH PLANNING AND ADAPTIVE MANAGEMENT: DEPARTMENT OF ENERGY LANDS AS A CASE STUDY

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Abstract. Ornithologists in many regions have initiated long-term studies to examine trends in populations, reproductive success, and chemical contamination that are aimed at understanding the status of avian populations, and in predicting the health and stability of future populations. Yet, the design of such biomonitoring studies often does not include a management component, and may not be based on basic ecological knowledge. Thus the data from such studies are often ignored by planners and managers, either because they are unaware of the studies or because the studies do not meet their needs. I suggest that avian researchers would profit from understanding the data needs of planners and managers, and that cooperation in the early phases of study design would increase the usefulness of long-term avian studies to both managers and basic researchers. The integration of basic biological data into management decisions requires both the researcher and the manager, working in concert. Certain types of data gathered routinely for long-term studies will be extremely useful for all phases of remediation (including restoration) and management of degraded lands, while others will be less useful. While data from endangered birds are useful for a single management approach, long-term data sets that include population or community aspects will be most useful to managers in determining whether to preserve, and what size to preserve. Such data will also be useful in determining variation in assemblage structure, which is important in detecting impacts. Contaminants data will be most useful for decisions concerning whether to remediate, restore, or allow the land to remain a preserve, as well as determining the causes of biological impacts. For all types of data, the appropriate assessment of reference sites is critical to understanding human impacts. The Department of Energy sites serve as an important case study because many of these sites are associated with ecological laboratories that have long-term data sets on resident and migratory birds, as well as contaminant loads.

Key words: avian studies, biomonitoring, Department of Energy, environmental planning, long-term studies, public policy, restoration, stewardship.

For many years different academic disciplines have developed in relative isolation. Integration, when it occurred, often involved either closely related disciplines, or different levels of organization. There has been a split between what is perceived as applied and basic research, rather than the realization that there is a continuum in research objectives. Yet solving many of our most pressing environmental problems on a national scale will involve not only scientists that have either applied or basic expertise, but scientists with both aspects (Meffe and Viederman 1995) or who are willing to work with scientists or managers with a different perspective. Conservation biology and related disciplines are maturing to encompass economic, legal, and political issues as well (Meffe and Viederman 1995).

Stewardship of natural resources is an important national priority, necessary to sustainability goals for the U.S. (Buzzelli and Lash 1996). Ecosystem integrity is an integral part of sustainable agriculture, fisheries, forestry and conservation. Likewise, environmental quality is intimately bound with conservation of natural resources (Buzzelli and Lash 1996). In national polls, concern for the environment ranks very high (Dunlap 1991), along with other environmental and health-related problems. Ornithologists can contribute to such stewardship of environmental resources by providing the necessary data to make knowledgeable management decisions.

In this paper I examine the need for integration between long-term avian studies, public planning, and adaptive management. I discuss avian studies and ecological risk, Department of Energy (DOE) sites as case studies for integration of long-term avian studies and management, the usefulness of different types of long-term avian research for planning and management activities, and suggestions for optimizing the usefulness of long-term avian studies for decision-making about remediation or management.

Although this chapter uses the Savannah River Site (SRS) in South Carolina as a case study, the generality of the observations and suggestions apply to other DOE sites, as well as to Department of Defense sites, Superfund sites, and a variety of other contaminated sites that are being considered for public use. The amount of public land that is being considered for alternate land uses or is being decommissioned as a result of the ending of the Cold War is very large, and ecological data from avian studies can be used in both cleanup and future land use decisions. Cleanup is referred to by DOE personnel as remediation (DOE 1991), although the resultant ecosystem may not mimic natural conditions.

AVIAN STUDIES AND ECOLOGICAL RISK

Risk assessments examine the potential risk to target organisms (or populations, communities or ecosystems) from chemical, physical, or biological hazards. The National Research Council (NRC) (1983) formalized the human health risk assessment paradigm to include four parts: hazard identification, dose-response assessment, exposure assessment, and risk characterization. This basic paradigm has remained the same, and has been extremely useful in providing consistency in methods for identifying the risks to human health (NRC 1993).

Risk assessment is not strictly an academic discipline, but relates to managing risk in the public interest (Nathwani and Narveson 1995). Agencies such as the Environmental Protection Agency are focusing on setting priorities for what they can solve (Morgenstern and Sessions 1988), and dealing with the complicated issue of their own evaluation of risk compared to that of the public. The public clearly places hazardous waste sites as a very serious environmental problem (Morgenstern and Sessions 1988, Kunreuther 1991), and they hold the preservation of the ecosystems on those sites equally high (Burger 1998). One important aspect of hazardous waste is to understand the risk they pose to ecosystems and their component parts.

Several disciplines have studied or evaluated risks to non-human populations and the environment, including ecology, wildlife and land management, ecotoxicology, and more recently, restoration ecology and ecological engineering (Odum 1957, Paine 1966, NRC 1986, Hoffman et al. 1990; Cairns 1991, 1993; Mitsch 1993). Ecological risk assessment has developed from the convergence of human health risk assessment, ecology, and ecotoxicology to provide data for environmental management and decision-making (NRC 1993). Ecological systems are much more complex than the single-species/single lifetime approach used in human health risk assessment, requiring modifications of the risk assessment paradigm for particular uses (Norton et al. 1992, Burger and Gochfeld 1996).

Ecological risk assessment has emerged as an important discipline because it fulfills three needs: it can be used to assess the general health and well-being of animal and plant populations, communities and ecosystems; it can be used to evaluate competing risks (past, present or future); and it can inform decisions about future use of contaminated land. Long-term avian studies can contribute necessary data for all of these objectives, and the existence of such data sets for DOE sites such as the SRS make them particularly useful for assessing current damage, for designing remediation plans, and for evaluating remediation and management actions. Understanding these risks involves developing a holistic biomonitoring plan that uses long-term data as a firm basis (Burger 1999).

For example, long-term data sets on the population levels and reproductive success of endangered species, such as Red-cockaded Woodpeckers (*Picoides borealis*) on SRS, can help determine which forests should be preserved, and the logging regime within that forest (Franzreb and Lloyd *this volume*). Information on reproductive success and contaminants of Wood Ducks (*Aix sponsa*) and other species can be used as indicators of environmental health and well-being (Kennamer et al 1993, Kennamer and Hepp *this volume,* Brisbin and Kennamer *this volume*). These studies can then be used as baselines for comparison both to other areas within SRS or to other DOE sites. These types of studies can be used to evaluate the health of DOE ecosystems, to measure changes in contaminants that pose human and ecological risks, and to inform managers about preservation of habitats.

Ecologists may need to develop expedited risk assessments that will allow more cost-effective answers that are less science-intensive (Cranor 1995). But in some cases, such as at SRS, the presence of long-term data sets for birds will provide some of the necessary data for expedited assessments. The presence of long-term data sets from many of the DOE sites provides a unique opportunity to integrate avian studies in management. For example, having long-term data on the habitat needs of Wood Storks (*Mycteria americana*) provides necessary data for any risk assessment involving cleanup of habitats these species use (Bryan et al. *this volume*). Having long-term data on contaminants of American Coots (*Fulica americana*) from Par Pond on SRS allows managers to quickly examine risks associated with any changes in water levels that expose sediments (Brisbin and Kennamer *this volume*).

Long-term studies on birds can contribute markedly to risk assessments by providing data on population sizes and levels of reproductive success necessary to maintain healthy viable populations in existing habitats. Although the data from long-term studies were not specifically collected for risk assessments, they can contribute because they allow analysis of the types of stressors with associated effects (hazard identification). Another advantage of using birds is that they integrate over fairly large geographical regions, depending upon the choice of bird; recently Cairns (1995) and Suter (1990) noted the importance of using larger scales in ecosystem evaluations. For example, studies with Bachman's Sparrow (*Aimophila aestivalis*) have included large segments of SRS, leading to the opportunity for management on a landscape scale, necessary for a species that has such specific requirement for forest stands of a particular successional stage (Pulliam et al. 1992, Dunning 1993, Dunning et al. *this volume*).

DOE SITES AS CASE STUDIES

Many environmental problems involve contaminated sites such as landfills, Comprehensive Environmental Response Compensation and Liability Act (CERCLA, or "Superfund") sites, nuclear facilities, the siting of waste storage facilities and nuclear power plants, and finally, dealing with the toxic legacy of the Cold War (Kunreuther et al. 1990; Slovic et al. 1991a,b; Barke and Jenkins-Smith 1993, Kivimaki and Kalimo 1993; Flynn et al. 1994a,b). For many years federal regulators and managers focused on point-source pollution and on Superfund sites (Russell 1991, Mones 1991), but recently the realization of the magnitude of contamination on DOE and Department of Defense sites has shifted the focus to federal lands. In the United States, many of the DOE sites that were formerly involved in nuclear weapons production require clean-up before these lands can be used for recreational, industrial, or residential purposes, or placed in long-term stewardship.

The DOE is involved in a massive cleanup, and the Office of Environmental Restoration within the Office of Environmental Management must manage the budget among programs based on considerations of site-specific health risks, ecological risks, regulatory requirements, and costs (Jenni et al. 1995). Grumbly (1996) noted that the DOE has contaminated sites in 34 states, with over 600 billion gallons of contaminated groundwater. The DOE complex houses over 3000 tons of spent nuclear fuel, some of which is in pools that are now corroding, threatening to contaminate groundwater supplies. There are 710 million gallons of radionuclide mixed waste at Hanford (in Washington), SRS, and Oak Ridge (in Tennessee) alone. Clearly the problem of remediation of DOE sties is a national priority. Restoring these sites to a pristine state will be extremely costly, and the degree of cleanup will depend partly on future land use. Stakeholder views are critical to considerations of future land use (NRC 1995, Wernick 1995, DOE 1996b, Commission on Risk Assessment and Risk Management 1996, Nakayachi 1998), and thus to the methods and types of cleanup required (Fig. 1).

Having decided to clean up these sites, several other considerations follow: (1) how much should they be cleaned up; (2) what ecological constraints should apply to cleanup; and (3) what metrics shall be used to determine the success of clean up? An additional question germane to ecologists is whether the cleanup itself will do more damage to the ecosystem, and its component organisms, than leaving the contamination alone (human health considerations aside; Dale and Parr 1998). The DOE must decide both the type of remediation and the degree of remediation (NRC 1994). Data from long-term studies can contribute to all four of these aspects, at least with respect to ecological issues.

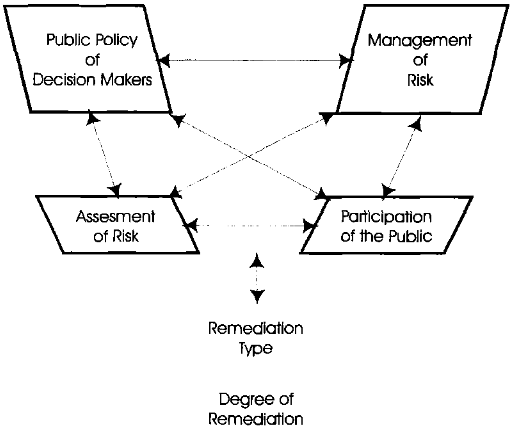

FIGURE 1. Relationship of public policy, management, risk assessment, and the public at the Department of Energy as envisioned by the National Research Council (NRC 1994).

The job of cleanup on DOE sites is estimated to take until the year 2070, and although no similar estimate has been made for the large number of Department of Defense sites, the process will take many years. Thus, this is not a small problem that will disappear in a few years. Further, the creation of new hazardous wastes makes it imperative to develop ecological risk methodologies that managers can use for years to come, and avian data sets can provide useful information for the process.

One important aspect ornithologists should bear in mind when considering the role of long-term avian studies in public planning and management is that the DOE, and perhaps other federal agencies as well, must take into account future land uses when making remediation and restoration decisions. DOE is committed to multiple use of their lands where appropriate, including recreation and industrialization (DOE 1996b). DOE is also committed to natural resource management, with biodiversity as a ma-

TABLE 1. Types of Data Useful for Making Decisions About Preservation of Land, Regardless of Current Contamination or Degradation

Biological Level	Parameter	Decision to preserve	Size to preserve	Landscape issues
Individual	Habitat preferences	X	X	
	Changes in preferences		X	X
	Morphological changes			
Population	Population size and trends	X	X	X
	Age and sex ratio changes			X
	Reproductive success trends	X	X	X
	Contaminant trend	X		
Community/ Ecosystem	Species diversity changes	X	X	X
	Successional changes		X	X
	Endangered species	X	X	X
	Trends in guild populations	X	X	X

Notes: An X indicates the data that will be useful in that decision.

jor goal (DOE 1996b). These aspects should be considered in planning long-term studies.

In their recent future land use report (DOE 1996b), DOE acknowledged that inputs will be essential from a variety of stakeholder groups, including state and local governments, tribal governments, site-specific advisory boards, and other interest groups. DOE recognized seven land-use categories: agricultural, residential, recreational, industrial/commercial, open space, storage and disposal, and open space/recreational. Thus, open space and recreational (generally low level human use that can maintain the integrity of natural ecosystems) make up three of the seven categories. DOE completed detailed future use plans for the 16 largest or most-contaminated sites, using input from a variety of governmental, scientific, and stakeholder groups (DOE 1996b). They estimated that nearly 86% of the land acreage on these 16 sites should remain open space, 2.4% should be open space/ recreational, and another 0.4% should be recreational. This suggests that a significant proportion of the land at DOE is slated to remain open space, and data from long-term avian studies could be critical to appropriate management of these sites, and to selecting which sites to maintain.

MANAGEMENT NEEDS AND LONG-TERM AVIAN STUDIES

Managers, whether they are dealing with Superfund, DOE, Department of Defense, or other hazardous waste sites, require certain types of data for adaptive management. Adaptive management includes maintaining on-going research to determine the effectiveness of management decisions, and altering management decisions when warranted. Since management goals often include preservation of healthy populations or communities, research involving managed and relatively pristine areas is needed to define "healthy" conditions. Adaptive management provides an opportunity for ornithologists to conduct basic research at reference sites while directly playing a role in adaptive management. Existing long-term data sets provide the basis for adaptive management.

Since it is not possible to have data on all aspects of the life histories of all organisms in an ecosystem, indicators are essential (Hunsaker et al. 1990, Suter 1990). Birds are ideal indicators because they are diverse with respect to trophic level and life history strategies, some are long-lived and at the top of food chains, they are diurnal and highly visible, they are responsive to a variety of stressors, and they are of interest to the public (Burger and Gochfeld 1995).

Currently, long-term studies on birds deal with aspects of individuals, populations, communities, and ecosystems (Table 1). Individual parameters measured include habitat preferences, changes in habitat preferences, and anatomical abnormalities. Population parameters measured in long-term studies include population numbers and trends (the most popular of the long-term studies with birds), trends in reproductive success, changes in age or sex ratios, and trends in contaminant levels. Community or ecosystem parameters recorded in long-term studies include changes in species diversity, changes in numbers and distribution of endangered species, and successional changes in bird communities or guilds, among others (Sheehan 1984, Burger and Peakall 1995, Linthurst et al. 1995). When researchers and managers work together to determine the types of data to be gathered before the initiation of a study, then the necessary data will be available to maximize ecosystem integrity and restoration goals.

One of the important aspects of designing experiments and observations is the opportunity for both managers and researchers to refine and select reference sites for comparison with potentially impacted sites. Recently Reynoldson et al. (1997) defined reference conditions as "the conditions that are representative of a group of minimally disturbed sites organized by selected physical, chemical, and biological conditions." Implicated in this definition is an understanding of natural variation, both temporally and spatially. Natural variation can encompass population size or growth rates, community structure, or ecosystem assemblages. Reference sites can be particularly useful on DOE sites because many of the sites are extremely large, with several square miles, providing minimally disturbed areas as well as those impacted by physical, chemical or biological disturbances.

In most cases, long-term studies are conducted on individual species, and concentrate on individual and population parameters. These include studies on Black-legged Kittiwake (*Rissa tridactyla*; Coulson 1968), Black Skimmer (*Rynchops niger*; Burger and Gochfeld 1990), Common Tern (*Sterna hirundo*; Burger and Gochfeld 1991), Florida Scrub-jay (*Aphelocoma caerulescens*; Woolfenden and Fitzpatrick 1984), Great Tit (*Parus major*; Perrins and McCleery 1985), Red-billed Gull (*Larus novaehollandiae*; Mills 1989), Sparrowhawk (*Accipiter nisus*; Newton 1986), and White Ibis (*Eudocimus albus*; Bildstein 1993; see also Newton 1989).

The decisions that planners and managers have to make relate to current or future land use. The first decision, if land is disturbed or undeveloped, is whether the site (or part of the site) should remain as a preserve. Data from long-term avian studies can be particularly useful in making this initial decision since the presence of viable, healthy populations of endangered species and species or assemblages of concern (i.e., forest interior-nesting neotropical migrants), will contribute to justification of this land use (Table 1). But such data are only useful if they contain information on specific habitat requirements, viable population sizes, and territory requirements such that managers can determine what needs to be preserved. On SRS, data on Red-cockaded Woodpeckers and Bachman's Sparrows has proven particularly useful to managers in determining logging regimes, as well as the matrix of forest types required to preserve the species (see Dunning et al. *this volume*).

If some of the land is to remain wild or relatively undisturbed, the following questions arise: what part of the land should be a preserve, what size should be preserved, and what landscape issues are critical for the target resources? All of these questions require data from long-term avian studies to make reasonable judgements (Table 1). Landscape-scale issues require the most detailed studies from all levels of biological organization. Further, long-term data sets dealing with birds are particularly useful for modeling population changes in a changing landscape (Pulliam et al. 1994), as would surely occur with either remediation or restoration.

Decisions concerning preservation of land are those with which ornithologists are most familiar, and in which they often participate. Further, ornithologists frequently become involved when currently wild land is being considered for development, and the types of data listed in Table 1 from long-term studies are often pivotal in the decision concerning whether to develop land or how much of it to develop. These data are frequently used extensively in environmental impact statements and in public hearings.

However, the nation now faces a large set of future land use decisions that relate to the DOE sites, as well as to Department of Defense lands, that cover far more land than do Superfund sites. Many of the DOE sites are contaminated with nuclear and chemical wastes, and decisions must be made regarding cleanup. Although initially the U.S. Congress and the general public wanted to see these sites cleaned up to pristine conditions, the cost of such cleanup is prohibitive (Grumbly 1996). It is now clear that decisions must be made about what areas to clean up, and how clean they must be. Future land use and ecological considerations will drive such decisions since the degree of human health risk can be managed by controlling access and future land use. If there is no off-site migration of contaminants, then human risk (and in many cases off-site ecological risk) can be reduced or eliminated, if people are kept out of the site.

The decisions that DOE must make regarding their lands include (1) whether to maintain the National Environmental Research Parks in their present state, (2) whether to remediate, (3) how much (amount of land) to remediate and to what contamination level, and (4) what to restore and to what degree. All four of these decisions depend on future land uses, which will be determined by DOE in collaboration with various stakeholders, including scientists (NRC 1995, Wernick 1995, DOE 1996b, Commission on Risk Assessment and Risk Management 1996). Both their immediate and long-term actions will depend on regulatory considerations since DOE must work toward compliance with existing environmental laws. In the 1970s several of the DOE sites that were large with much of their areas in natural ecosystems typical of their respective regions were declared National Environmental Research Parks and were devoted to the study of the effects of energy production on

TABLE 2. TYPES OF LONG-TERM DATA THAT WILL AID IN DECISIONS ABOUT MAINTENANCE OF DOE SITES AS NATIONAL ENVIRONMENTAL RESEARCH PARKS (NERPS) WHETHER TO REMEDIATE, WHETHER TO RESTORE ECOSYSTEMS, AND WHETHER REGULATORY CONSTRAINTS INFLUENCE THEIR MANAGEMENT DECISIONS

Biological Level	Parameter	NERP	Remediation	Restoration	Regulation
Individual	Habitat preferences	X	X	X	
	Changes in preferences	X		X	
	Morphological changes		X		X
Population	Population size and trends	X	X	X	
	Age and sex ratio changes	X		X	
	Reproductive success trends	X		X	
	Contaminant trends	X	X	X	X
Community/ Ecosystem	Species diversity changes	X	X		
	Successional changes	X	X		
	Endangered species	X	X	X	X
	Trends in guild populations	X	X	X	

Notes: An X indicates where the data will be particularly useful in making that decision.

the environment (Dale and Parr 1998). In 1972 the Atomic Energy Commission designated the SRS as America's first National Environmental Research Park (Gibbons 1993).

There are two important aspects to the land use question for researchers: what are the ecological resources that stakeholders wish to preserve, and what are the ecological risks of present disruptions (biological, radiological, and chemical) and cleanup operations? Biologists should enter the discussion about how ecosystems are used, or such decisions will be made without data on use of ecological resources. For example, interviews with both sportsmen and the general public living around SRS indicated that maintenance of SRS as a National Environmental Research Park, Preserve, or for recreation ranked the highest, and residential and industrial uses ranked the lowest (Burger et al. 1997a; Burger 1997, 1998).

It is in the arena of the DOE lands that long-term studies can contribute to all aspects of decision-making (Table 2). Having long-term data on endangered species, sensitive species, or vulnerable groups (such as neotropical migrants) will prove invaluable in making decisions about whether to maintain the NERPs in their current status, or to reduce their size (many of these decisions will be similar to those listed in Table 1).

Decisions to remediate will depend first on future land use, to which avian data can surely contribute. For example, the presence of functioning, interesting, unique ecosystems may suggest that some portion of the land should be used either for a preserve or for recreation. Decisions about what land to remediate, and the degree of remediation will depend also on the contaminant levels present. Trade-offs must occur between the presence of the current ecosystem (which may be functioning even though it is slightly contaminated), and the damage that the remediation will do to those systems. This damage, however, cannot be assessed without data on the existing ecosystems, and long-term data will be most useful since they will demonstrate not only current communities but their long-term viability.

Restoration decisions will profit markedly by data from long-term studies since, with knowledge about individual, population, and community structure, it will be possible to define the level of restoration possible for that parcel of land, and the possible trajectory of recovery given the avian assemblages that exist on the site prior to restoration. Restoration may be active or passive, and again, data from avian studies may contribute to the decision about whether to allow natural succession to occur or to speed it up by the process of restoration.

Lastly, there are regulatory constraints that must be addressed in any planning or management decision (Bilyard et al. 1993), and some data from long-term studies are useful for this mandate (Table 2). In most cases, such data relate to contaminant levels and the presence and status of endangered species. In both cases, long-term data sets with birds are particularly useful in establishing the current value of a site, in predicting its future value, in establishing management options, and in stewardship.

Many DOE sites have cleanup and remediation issues that revolve around the cooling ponds from their nuclear reactors that are no longer in operation. Continued maintenance of these ponds costs in the millions of dollars annually, and the question of no longer maintaining them is important. Data from long-term studies with contaminants can contribute to these decisions. For example, from September 1991 to December 1994 the water levels of Par Pond on SRS were lowered by 6 m. Par Pond had received the cooling water effluent that was periodically contaminated with radiocesium and smaller amounts of other contaminants from 1954 to 1964. During the drawdown, Mourning Doves (*Zenaida macroura*) feeding on the exposed sediments were collected for radiocesium and heavy metal analysis (Burger et al. 1997b, Kennamer et al. 1998). Levels of radiocesium in the muscle tissue of doves from Par Pond were sufficiently high as to pose a potential human health risk if hunters had been allowed to hunt there every day during the dove hunting season. These data could be compared to levels in the tissues of other birds from long before the draw-down of Par Pond. These data are useful to managers and regulators in their decisions about future drawdowns, and were important data for them when deciding not to allow L Lake (another cooling pond on SRS) to revert to its previous levels.

DESIGNING LONG-TERM RESEARCH FOR PLANNING AND LAND MANAGEMENT

Many long-term studies with birds at SRS, and elsewhere, were designed many years ago to provide data on behavior, ecology, and reproductive success of individual birds, or groups of birds (Newton 1989). Thus they were not designed with management and pubic planning in mind. This, however, does not mean that the data are not useful for management and planning, nor does it mean that the data that are gathered in the future cannot be even more useful, often with only minor tinkering.

Tables 1 and 2 indicate the types of data that would be useful to managers and planners, with the idea that some types of data can be gathered now, even if they were not part of the original protocol. For example, data from long-term studies can be used to design types of remediation and restoration, and can be used as measures of success of specific remediation or restoration plans. Evaluating the effectiveness of remediation and restoration is an important aspect of management. Without it we will be unable to determine which methods to use in the future (Burger 1994, White 1996).

Finally, risk assessors are defining a role for expert judgement in risk analysis (Otway and Winterfeldt 1992). While expert judgement has always played a role in risk assessment and management (Barke and Jenkins-Smith 1993), this role may increase in the future because good science may not always be able to provide the unambiguous facts necessary for decisions. In the context of avian research, the presence of scientists associated with long term-studies will provide a cadre of experts that are partially legitimized by these studies. An avian directory of long term studies, cross-referenced to species, types of studies, and contaminants or other anthropogenic stressors, could provide an invaluable stable of "experts" for aid in remediation, management, and planning decisions.

In summary, ornithologists have participated in many long-term studies designed to gather information on trends in populations, reproductive success, and chemical contamination. I suggest that avian researchers would profit from understanding the data needs of planners and managers, and that cooperation in the early phases of study design will increase the usefulness of long-term avian studies. Further, long term data sets can be used to evaluate the relative importance and uniqueness of habitat, contributing markedly to the initial decision of whether to remediate contaminated lands.

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