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MIGRATION AND CONSERVATION: FRAMEWORKS, GAPS, AND SYNERGIES IN SCIENCE, LAW, AND MANAGEMENT

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Abstract

Migratory animals provide unique spectacles of cultural, ecological, and economic importance. However, the process of migration is a source of risk for migratory species as human actions increasingly destroy and fragment habitat, create obstacles to migration, and increase mortality along the migration corridor. As a result, many migratory species are declining in numbers. In the United States, the Endangered Species Act provides some protection against extinction for such species, but no protection until numbers are severely reduced, and no guarantee of recovery to population levels associated with cultural, ecological, or economic significance. Although groups of species receive some protection from statutes such as the Migratory Bird Treaty Act and Marine Mammal Protection Act, there is no coordinated system for conservation of migratory species. In addition, information needed to protect migratory species is often lacking, limiting options for land and wildlife managers who seek to support these species. In this Article, we outline the existing scientific, legal, and management information and approaches to migratory species. Our objective is to assess present capacity to protect the species and the phenomenon of migration, and we argue that al three disciplines are necessary for effective conservation. We find significant capacity to support conservation in all three disciplines, but no organization around conservation of migration within any discipline or among the three disciplines. Areas of synergy exist among the disciplines but not as a result of any attempt for coordination. As a result, significant gaps in information and capacity exist that must be addressed if effective conservation of migratory species is to be undertaken. We suggest that all three disciplines cooperate to identify the most pressing research needs, so that these can become targets for relevant funding sources. We identify areas of current risk to migratory species that represent gaps in current legal protections: protective legislation that provides no guidelines for desirable population sizes or best management practices for migratory species, taxonomic groups, particularly those including long-distance migrants, for which no agency has oversight, and gaps in policies to address impacts of fragmentation and obstacles such as power lines and wind turbines that curtail migration or cause mortality. Finally, we suggest that state-level programs provide either a foundation to augment with, or a model on which to build, conservation efforts targeting migratory species. Problems will arise due to lack of

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funds, difficulties in securing a landscape that will support abundant migrations, lack of adequate standards and best management practices, and an insufficient culture of collaboration among the three main relevant disciplines. However, we view these problems as entirely soluble and see evidence of support in society at large for conservation of migratory species.

I. Introduction

Migratory species once created some of the biggest natural spectacles on the planet: flocks of migrating birds that darkened the skies,[1] migrations of antelope and bison that covered African and North American grasslands from horizon to horizon,[2] sea turtles in the Caribbean so dense that "it seemed that the ships would run aground on them."[3] Abundance made many of these species attractive targets for hunters and fishers. Some, such as the passenger pigeon (*Ectopistes migratorius*), have been lost;[4] others were rescued from extinction when public outcry led to changes in laws protecting them.[5] In the United States, the Lacey Act[6] and the Migratory Bird Treaty Act (MBTA)[7] helped bring to a close the unregulated market hunting of waterfowl and shorebirds and the more focused—but no more sustainable—hunting of migratory waterbirds and songbirds for the millinery trade in ladies' hats.[8]

If the abundance of many migratory species once made them obvious targets for hunting, the movements of migratory species now place them at risk due to loss of habitat, barriers to movement, and mortality from obstacles, pollution, as well as legal and illegal hunting. However, in the absence of evidence of overwhelming mortality such as preceded the MBTA, little additional protection has been extended to these species that run their respective migratory gauntlets year in and year out. At one time, immensely effective protection was afforded one large taxon[9] (birds) simply by modifying one activity (hunting). To seek, now, to protect the wide variety of migratory taxa at levels that allow them to be ecologically relevant and to continue to provide phenomena of abundance requires modifying many aspects of human undertakings.

There is room for optimism, however. Public interest in migration and migratory species is strong. Students learn geography studying the travels of migratory monarch butterflies (*Danaus plexippus*), and interact with their peers in other nations.[10] Touring companies and town festivals profit from our ongoing fascination with the phenomenon of migration.[11] Yet numbers of many migratory species continue to decline.[12]

Changing the conservation landscape to improve protection of migratory species is a complex undertaking. Effective conservation of migrants requires coordinated work by researchers, lawyers and policy makers, and natural resource managers. In this Article, we begin by describing the frameworks used in these three disciplines to categorize migrations and migratory species. These discussions are intended to be descriptive, rather than critical, as no one discipline of the three can be, or claims to be, a complete solution to the problem of conservation of migratory species. Throughout, we seek to communicate the information of all three fields in terms accessible to researchers studying any aspect of migration—legal scholars, who study patterns and trends in legal practice; legal practitioners, who work on behalf of clients to interpret and make use of aspects of the legal system; land managers,

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who manage wildlife on their properties; and wildlife managers, who are responsible for conservation and management of wildlife species without regard to property boundaries.

We then use these frameworks to identify areas of synergy where disciplines approach the subject of migration in complementary ways and support conservation. In particular, several of the distinctions that arise out of research, such as whether migrants concentrate along a narrow migratory route or disperse across a broad front, are important distinctions for policy and management. Not surprisingly, however, the frameworks of the three disciplines are not entirely overlapping, and we identify gaps where differences in approaches weaken conservation of these species. For example, research does not provide strong population estimates for many migratory species, but even where such information is available, it is rarely incorporated into policy in a way that protects migratory species at population levels that ensure ecological relevance.

Finally, we suggest ways of advancing work in all three disciplines individually and collaboratively to improve conservation of migrations and migratory species. We recommend increased communication and collaboration among the disciplines, generally, but also recommend a focused exercise, such as a regularly scheduled conference or workshop, to identify pressing questions of policy makers and managers that could become funding targets for public and private funding sources. We suggest that state-level programs provide either a foundation to augment, or a model on which to build, conservation efforts targeting migratory species. Federal coordination could help to organize regional and national landscape protections; commitment to management standards and practices would ensure consistency. We view most problems associated with conservation of migration as entirely soluble and see evidence of support for conservation of migratory species in society at large.

Part II, the first of our disciplinary parts, delineates the breadth of natural diversity that comes under the umbrella of migration, describing the kinds of migratory species and varieties of migratory behaviors defined by scientific research. Research on migration is often oriented around taxonomic, ecological, and evolutionary areas of interest. Taxonomic focus may be at levels as narrow as individual populations or as broad as all vertebrates. Ecological studies related to migration examine relationships between organisms and their physical and biological environments during part or all of a migration cycle. Evolutionary inquiries track the evolution of mechanisms that underlie physical, ecological, and social aspects of migration.

Part II.A explores the boundaries of what is meant by migration. Part II.B explains those ecological and environmental factors that motivate species to migrate. The ways in which migration can proceed across the land, through the air, or through the water are described in Part II.C. The question of which characteristics of individuals—gender, physical condition, age—are associated with migration is dealt with in Part II.D. Part II.E explains how the seasonal timing of migration is determined and affected. Part II.F discusses the balance of genetic nature and the environmental impacts of nurture and learning in shaping migratory behavior—including how navigation during migration occurs. Finally, in Part II. G, we describe the likely future directions of migration research, which are strongly affected by

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recent advances in technology. The body of knowledge outlined in this Part reveals variety among migratory species in virtually all aspects of migration, from its evolutionary beginnings, to the demographics of the individual migrants, to the manner and scale of the geographic movements of migration. Understanding the diversity encompassed by migratory species is necessary in order to develop and implement appropriate policies and management approaches for their conservation.

Part III examines existing legal approaches to protection of biodiversity, broadly, to determine where there is support for conservation of migrations and migratory species. In acknowledgement of the number and diversity of laws, cases, and regulations, Part III is exemplary, rather than exhaustive—describing categories of laws, not enumerating individual laws. These categories are not mutually exclusive and serve to organize existing law, not to impose sharp distinctions. Part III.A considers possibilities for supporting conservation through funding and capacity building to many kinds of actors. Individuals and organizations vary considerably in their funding and training; by broadening and leveling the field, statutes and the programs they authorize advance what is possible in conservation of migratory species. Part III.A also discusses coordination and information exchange as means of capacity building. Part III.B focuses more narrowly on federal incentives for conservation at the state level. Most wildlife management is the responsibility of state wildlife agencies; these statutes provide a means of manipulating state agendas in favor of migratory wildlife and building capacity, generally. Part III. C deals with the single tool of habitat acquisition, a necessary but insufficient approach for conserving wildlife, and thus, of conserving migratory species. Part III.D describes legal controls on actions that harm species whether by direct mortality or indirectly through harm to habitat. Part III.E discusses statutes that mandate measurable standards or defined management practices to avoid harm to individuals or populations of wildlife. Such firm standards and guidelines are rare in conservation law.

Part IV, the last disciplinary part, develops three different typologies related to management of migratory species. Part IV.A explains the legal authority that enables and constrains land and wildlife management in federal and state lands and waters. The strictures of organic legislation and related interpretative policies, public trust doctrine, and wildlife law bind both the existing responsibilities to migratory species and the possibilities for enlarging or enhancing those responsibilities. Part IV.B describes the tools that land and wildlife managers use to meet their responsibilities, thus casting additional light on what options are available on the ground (or in the air or water) for conserving migratory species. Finally, Part IV.C explores the categories of migrants and migrations that are of primary interest to land and wildlife managers.

In Part V, we begin to bring together aspects of the three disciplines; in Part V.A we describe complementary aspects of the three frameworks—areas where approaches and categories have commonalities. Often, these commonalities strengthen conservation of migratory species, or at least indicate potential for such strength. In contrast, in Part V.B we enumerate important areas where the disciplines fail to work together, where gaps or cross-purposes weaken efforts to conserve migratory species. We indicate where such incongruities may represent opportunities for focusing applied science or for improving or enlarging on law and management practice. We review aspects of practice within each discipline that prevent

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effective conservation of migratory species, and discuss possible solutions. In these two Parts, we find that although science has much to offer both policy and management, it too seldom consults with those disciplines in seeking targets for research. To some extent, this failure is owing to the focus of much of the present research funding on basic research that advances knowledge generally, rather than on applied research to address particular, possibly less fascinating information needs of policy makers and managers. A portion of the failure is also owing to the lack of capacity in management, in particular, to undertake some of its own research and to build collaborative partnerships with applied scientists in academia.

We recommend increased communication and collaboration among the disciplines, generally, but also a focused exercise, such as a regularly scheduled conference or workshop, to identify pressing questions of policy makers and managers that could become funding targets for public and private funding sources. Policy makers incorporate useful aspects of science and management in building conservation laws, but fail to address specific threats of particular concern in conservation of migratory species, including habitat fragmentation, and obstacles that prevent migration outright, such as fences and dams, obstacles that increase mortality such as roads, channelized river segments, wind turbines, and transmission towers.

The political landscape of jurisdiction over migratory species is a bewildering array of agencies, many of which do not count wildlife conservation among their primary responsibilities. Even with this welter of jurisdictions, most migration routes are only partly protected, leaving gaps where migratory species must find their way in potentially hostile landscapes and waterscapes. In addition, only a scant few statutes set population goals for migratory wildlife and fish species that allow their migrations to retain ecologically meaningful roles or migrate in numbers sufficient to constitute phenomena of abundance. These few statues, however, provide models of what such goals might resemble, and scientists and managers can inform efforts to build on these models.

Finally, in properly leaving details of land and species management to the expertise of agencies to include in interpretive policies, policy makers fail to require the development of standards and management practices to ensure efficient and effective conservation, and they fail to require suitable timeframes for their implementation. Without such requirements, agencies cannot be held accountable for meeting legislative goals. Where research suggests firm standards and best management practices, policy makers should require their implementation in a timely fashion; where such standards and practices are incompletely known, policy makers can direct agencies to identify and implement them in a timely fashion.

In Part V.C we consider the totality of conservation efforts on behalf of migratory species. We present ideas for programmatic approaches to conservation of these species, building on the concept of “keeping common species common” that has been used in at least two major conservation undertakings to date. We suggest that state-level programs provide either a foundation to augment with, or a model on which to build, conservation efforts targeting migratory species. Problems will arise due to lacks of funds, difficulties in securing a landscape that will support abundant migrations, lack of adequate standards and best management practices, and an insufficient culture of collaboration among the three main

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relevant disciplines. However, we view these problems as entirely soluble. Further, we see evidence in society at large of support for conservation of migratory species, even in troubled economic times. Such public support could greatly advance conservation of migratory species through increased funding, public oversight, citizen science, and increased private-lands participation.

II. Existing Ecological Typologies of Migration

Aphids, bats, caribou, dolphins, elephants, fish, giraffes, and hummingbirds—such are just a few examples of the hundreds of animal taxa, together encompassing tens of thousands of individual species that demonstrate some type of migratory behavior.[13] Although migratory organisms share the unique and fundamental "need to move," the variety of migratory animals and the diverse characteristics of their particular migrations require careful consideration if effective generalizations and distinctions are to be made in the context of law, policy, and management strategies. Focusing conservation agendas on protecting or restoring the phenomena of migration will require cross-disciplinary dialogue about fundamental but complicated questions such as, "What is a migration?," "Which types of migrations are currently most imperiled?," or "Are certain categories of migrations ecologically more valuable than others?"

Such communication among scientists, policy makers, legal scholars and practitioners, and wildlife managers will require a basic and shared summary understanding of the biological frameworks used by scientists to discuss the diversity of migratory phenomena. Accordingly, our goal in this Part is to present an overview of concepts, definitions, and questions used to characterize, categorize, and further investigate migrations and their underlying biological and environmental mechanisms. The emphasis will not be on comprehensively enumerating specific scientific terminology or jargon—which is often further specific to the study of particular animal taxa. Instead, we aim to introduce key concepts and vocabulary, and to provide brief examples that illustrate what kinds of ecological divisions among types of migrations have already been made that might help inform future scientific, legal, policy, and management agendas targeting the conservation of migrations.

The degree to which typologies and examples are inequitably representative of various animal groups generally reflects the historical trajectory of scientific interest in migrations. As arguably the most abundant and diverse migrants that are easy to observe, birds garnered early attention from researchers of migration. The study of bird migrations was followed by studies of mammal migrations. More recently, the migrations of fish, insects, and marine mammals have received greater attention. The degree to which terminology can be used interchangeably across different types of animals is not always clear, but basic common sense and thorough exposition should suffice.

A What Is Migration?

> "Migration might be one of the great wonders of the natural world, but as a biological concept it is surprisingly fluid and elusive."[14]

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If law, policy, and management strategies are to be developed to address the conservation of migrations, a working answer to the question “What is migration?” needs to be formulated. On the surface, migrations might be defined simply as organisms moving from place to place on a seasonal or annual basis, but a more detailed consideration of what does—and what does not—constitute a migration quickly reveals that this is not an easy distinction. In fact, certain non-animal organisms (e.g., plants or fungi) make movements such as seasonal dispersal of seeds via water or air that could be considered as “migration” under some definitions.[15] Even among animals, great variation in the timing, distance, and motivation underlying movements makes general definitions of migration challenging. Early efforts to formally define migration were arguably quite effective for their simplicity, and they may be very relevant for conservation policy. For example, “true migrations” according to Landsborough Thomson, an ornithologist, were defined as “changes of habitat, periodically recurring and alternating in direction, which tend to secure optimal environmental conditions at all times.”[16] Such optimal conditions might include milder air, water, or soil temperatures, availability of food or water, lack of predators or diseases, suitable habitats for breeding (e.g., nesting substrates for birds or calmer waters for whale calves), or some combination of the above. Importantly, this definition of migration does not specify or discriminate based on distance traveled or the types of organisms that qualify. Instead, the emphasis in Thomson’s definition is placed on 1) a change in habitat, 2) a seasonal phenology, and 3) a “to-and-fro passage.”[17] Certainly, many important and familiar migrations such as those made by songbirds, waterfowl, shorebirds, and seabirds that winter farther south and return each spring to breed at higher latitudes would be included in such a definition.

However appealing, though, this definition could exclude many stunning and extensive animal movements that serve equally important ecological functions. In particular, less spatially or temporally predictable migrations such as the seminomadic circular roamings that were once exhibited by American bison (*Bison bison*),[18] or those that require multiple generations for the return trip as is the case for many species of moths or butterflies, including the classic monarch butterfly journey,[19] could arguably fail to meet these criteria of migration. Conversely, in the open ocean, billions of organisms ranging from plankton to squid to sharks make daily to-and-fro movements through the water column to the surface and back down again in order to exploit optimal conditions.[20] These could qualify as migrations under Thomson’s definition, yet such movements are clearly of a different variety than those that occur only once per year and span continents, especially in the context of conservation policy and management.

These examples highlight the need for formal conceptualizations that are not restricted to round-trip migrations, but that are also not so broad as to lack all heuristic utility.[21] In an effort to identify more encompassing but nevertheless useful criteria, biologists studying migrations have identified traits that distinguish animal migrations from other movements that happen on more local spatial scales and on a daily or weekly basis. These more frequent and localized “station-keeping” movements (which ultimately maintain a similar spatial position relative to the origin) include foraging (e.g., daily movements in search of food), commuting (e.g., daily movements to and away from roost sites each evening), and territorial defense (e.g., patrolling of territory boundaries).[22] Ranging describes exploratory movements in search of suitable habitat or exploitable resources. Dispersal (e.g., natal

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dispersion in birds and mammals), which typically refers to unidirectional movement that also ceases once suitable habitat is found, may or may not be considered migration, perhaps depending on how well it fits other proposed criteria that distinguish migrations. Nomadic migration or nomadism includes animal movements that are not simply to-and-fro, and may appear as random wanderings, but that likely involve movements between known areas of suitable resources.[23] Examples of nomadic migrants include the above mentioned American bison that circuited North America in search of fresh prairie grasses[24] and Cedar Waxwings (songbirds) (*Bombycilla cedrorum*) that roam in search of ripe berry crops.[25]

Migration, in contrast to localized station-keeping movements, has been more specifically defined as a specialized behavior that not only involves shifts in habitat in search of optimal conditions, but that also meets at least some of the following five criteria: 1) persistent movement that is greater in duration than the local station-keeping or ranging movements of the same species; 2) straightened-out movement that is more direct than station-keeping or ranging behaviors; 3) some temporary inhibition of local station-keeping or ranging movements; 4) distinct activities and behaviors observed in association with arrival and departure; and 5) shifts in energy allocation, storage, or usage to facilitate the journey.[26] Importantly, under these criteria, migrations do not necessarily have to cover long distances or include to-and- fro journeys, and they are not restricted only to annual phenomena, but they must involve periods of movement that are more distinct and demanding than the regular station-keeping or ranging movements of the same species.

To date, we are unaware of any systematic efforts to formally define or qualify what is or what is not “migration” in the context of law, policy, or management, yet these clarifications may be an important part of future efforts to justify, categorize, clarify, or prioritize particular migrations that are most relevant for conservation efforts. However, as Professors Fischman and Hyman discuss in their treatment of “migration as a phenomenon of abundance,” to-and-fro migrations, dispersals, or even ranging may be equally important in the context of conservation,[27] based on the degree to which they encompass the ecological, economic, and cultural value targeted by future efforts. Nevertheless, we propose continued consideration of what distinguishes those animal movements deemed migrations (that are likely to be the intended targets of conservation efforts) from the general occurrences of organisms moving about.

B. Why Migrate?

By definition, migrants move in search of better environmental conditions, but there is great diversity in the specific characteristics of the environment that vary between origin and destination, and hence there are many different reasons animals migrate. These reasons may be simple or complex, but a solid ecological understanding of the resources and habitat characteristics that contribute to make migration an adaptive behavioral strategy must be available in order for effective conservation strategies to be drafted. More hospitable conditions targeted by migrants can include abiotic environmental factors such as temperature, moisture (including humidity and precipitation), salinity, elevation, storms, windy air conditions, or rough water conditions. Biotic factors that may lead to migration as an adaptive strategy could include the availability of specific food resources required by

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adults or offspring, or the avoidance of predators, diseases, or competing species whose distributions vary in space and time. Social competition for resources among members of the same population or species can also lead to the evolution of migratory phenomena. Of course, these types of abiotic and biotic factors are often correlated, and many migrations are likely prompted by more than one environmental variable. Thus, although several terms have been formalized to categorize migrations based on the apparent answer to the question “Why migrate?,” these are not mutually exclusive.

Many fish species, for example, are termed reproductive migrants,[28] a term widely applicable across taxa, because they migrate in order to find suitable reproductive habitat, in many cases moving between separate spawning, feeding, and nursery grounds. Breeding habitats for reproductive migrants are likely to have fewer predators to threaten the offspring or specific food resources required by the young. Classic reproductive migrants include Chinook salmon (*Oncorhynchus tshawytscha)* and related species that hatch in the rivers of the United States Pacific Northwest before heading out to sea as adults.[29] Usually after three to four years in the ocean, they return to their natal sites to lay eggs before dying, swimming upstream in rivers that are now often obstructed by hydroelectric dams.[30] Many species of birds, mammals, and insects could also be considered reproductive migrants, and the term most commonly, but not exclusively, applies to seasonal to-and-fro movements.

Reproductive migrations can be contrasted with refuging migrations,[31] which are undertaken for primarily nonreproductive purposes; these migrants seek habitats that provide a refuge from harsh climates, predators, disease, or intense competition. One such example is the molt migrations that are exhibited by certain birds.[32] Although most bird species molt in sequence and continue to fly throughout the process, some species, especially certain ducks, geese, and swans, can become flightless during molt. For example, the largely resident Common Shelduck (*Tadorna tadorna*) that is found throughout Western Europe and the British Isles, makes seasonal movements in huge flocks (up to 100,000 individuals) to safer molting grounds on the Wadden Sea and North German coast where individuals remain mostly flightless for up to thirty days as they replace their feathers.[33] Another type of refuging migration involves seasonal movements to sites for hibernation (to avoid cold conditions, as in many mammals) or aestivation (to avoid heat and aridity, as in many insects, aquatic invertebrates, reptiles, and amphibians). For example, the endangered Indiana bat (*Myotis sodalis)* lives and breeds throughout the Eastern United States in the summer, but migrates in large numbers to hibernate in caves, although specific patterns of migratory connectivity are unknown.[34] Many insects migrate to sites for aestivation, including the Australian bogong moths (*Agrotis infusa*) that fatten up before migrating by the millions to higher elevation caves to aestivate during the hot and dry summer months.[35]

Removal migration, a term which could be used similarly to “dispersal,” refers specifically to those migrations in which the animals do not come back to the habitat they are leaving, usually due to inhospitable abiotic, biotic, or social conditions. These inhospitable conditions could include environmental changes such as floods, droughts, colonization of invasive species, or situations in which the local population has become too big, and groups leave to find less competitive habitat. Many removal migrations are likely to be too spatially and temporally unpredictable to become targets of conservation, but some likely follow

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predictable cycles that could be relevant for conservation or management efforts targeting migration. For example, the short-horned grasshoppers of the family Acrididae are removal migrants that breed rapidly under suitable conditions, but then become gregarious and migratory as adult "locust" forms that travel great distances in search of habitats with sufficient food.[36]

C. The Geography of Migration

Just as the types of animal forms that migrate are incredibly diverse, so are the geographic patterns and scales attributed to animal migrations with respect to the distances traveled and habitats utilized. Accordingly, biologists have categorized and defined certain types of migrations based on their biogeographic and habitat characteristics.

Among migratory birds for example, ornithologists have categorized several types of migrations with respect to distance traveled and the biogeographic context. Long-distance migrants, which make up approximately 1800 of the world's more than 10,000 bird species,[37] are usually considered to be birds whose annual movements traverse continents, making journeys of many hundreds or thousands of kilometers.[38] Examples include more than 300 species of birds that travel from their breeding grounds in the northern latitudes in North America to spend the winter in the Caribbean, Central or South America, or Africa.[39] This common north-south pattern amongst avian species is also termed latitudinal migration, which is also common in whales and certain insects. Although some migrations are "longitudinal" in their geography, this term is not generally applied because broad-scale ecological and climatic gradients do not follow a predictable longitudinal pattern. Some long-distance migrants traverse the globe itself, as is the case for some populations of the Red Knot (*Calidris canutus*), which flies each year from Baffin Island north of the Arctic Circle, all the way to Tierra del Fuego on the tip of South America.[40] The Red Knots are considered coastal migrants, as they generally follow the shoreline, in contrast to pelagic migrants, such as petrels and albatrosses, whose journeys cross expanses of open ocean. Coastal versus pelagic distinctions are also made among migratory aquatic animals.

In contrast to long-distance migrants, short-distance, short-range, or regional migrations among birds are those annual movements that span some hundreds of kilometers, as exemplified by species including Eastern Bluebirds (*Sialia sialis*) and Red-winged Blackbirds (*Agelaius phoeniceus*) that move shorter regional distances south for the winter.[41] Altitudinal migrants are those animals whose seasonal movements traverse the clines of mountains, plateaus, or similar topographic features, typically moving downslope in winter and returning to higher elevations to breed. Sedentary or resident animals, such as Florida Scrub-Jays (*Aphelocoma coerulescens*), Western Scrub-Jays (*Aphelocoma californica)*, or Northern Cardinals (*Cardinalis cardinalis)*, are non-migratory, remaining on the same territories year round.

Among fish species, the United Nations Convention on the Law of the Sea has formally designated some highly migratory species (HMS).[42] The designation is apparently related to the distances covered by these species, although the convention gives no operational criteria for designation.[43] Tuna and their relatives, pomfret, marlin, sailfish, swordfish, suary, sharks, dolphins, and other whales are on the HMS list because they have wide geographic

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distributions that often traverse the exclusive economic zones (EEZs) of multiple countries.[44] The characteristic movements of these various HMS species, however, are diverse, and include latitudinal, regional, coastal, and pelagic migrations undertaken for various purposes such as finding refuge from predators, spatially or temporally dynamic food resources, or suitable breeding grounds.

Determination of which species should be considered “long-distance” versus “short-range” migrants should be made relative to members of similar animal groups, which vary widely in the absolute distance of their migrations. Whereas the longest bird and whale migrations cover 35,000 kilometers (e.g., Arctic Terns, *Sterna paradisaea*)[45] and 15,000 kilometers (e.g., gray whales, *Eschrichtius robustus*),[46] respectively, the longest land mammal migrations (e.g., caribou, *Rangifer tarandus*, circa 1000 kilometers)[47] and insect migrations (e.g., monarch butterflies, circa 3500 kilometers)[48] are much shorter.

In addition to geographic distance traveled, categorizations could be made regarding the altitudes at which migrants fly or float, or the depths at which they swim or drift. Although, like airplane pilots, birds or insects will vary their flight altitude depending on the best wind conditions, some species typically travel at higher altitudes than others. Shorebirds and seabirds, for example, will commonly travel altitudes of 2000 to 4000 meters, whereas passerine songbirds and raptors typically fly below 800 meters.[49] Great variation exists, however, even among closely related species. While some waterfowl migrate at low altitudes, others have set altitude records, including the Bar-headed Goose (*Anser indicus*), which crosses the Himalayan Mountains at over 9000 meters.[50] Similarly, the aquatic depths at which particular species or taxa of fish or whales migrate could provide useful generalizations in the context of conservation or management.

Aquatic animal movements also vary systematically in the types of habitat utilized, such as potadromous, denoting those that occur only in fresh water (e.g., Colorado pike minnow, *Ptychocheilus lucius*); oceanodromous, denoting those that occur only in salt water (e.g., beluga whales, *Delphinapterus leucas*); and diadromous, denoting those that travel between both salt and fresh water.[51] Among diadromous animals, further distinctions are made between those that live primarily in marine environments but breed in fresh water (anadromous; e.g., Chinook salmon),[52] those that live primarily in fresh water but breed in the ocean (catadromous; e.g., American eel, *Anguilla rostrata*),[53] and those that move between fresh and salt water during their life cycle, but not in association with reproduction (amphidromous; e.g., bull shark, *Carcharhinus leucas*).[54]

Another important biogeographic distinction applicable across taxa refers to whether a particular migration is broad-fronted or narrow-fronted. Broad-fronted migrations are those in which animals move towards their destinations across relatively wide geographic areas, as opposed to narrow-fronted migrations in which movements are confined to relatively narrow corridors of travel.[55] The pattern of migratory front may be determined by specialized stop-over habitat requirements (or lack thereof), or physical features of the landscape such a mountains, ridges, coastlines, bodies of water, ocean currents, or wind patterns, all of which could serve as physical obstacles, navigational landmarks, or provide physical assistance (e.g., winds, currents). A given migration also could include both narrow-fronted and broad-

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fronted phases; for example, a migration that is facilitated by departing and arriving in wider breeding and wintering ranges, but is forced through more narrow corridors along the way. This is suspected to be the case for many species of migratory birds that breed in northern forests and winter in the tropics but require stopover sites or follow coastlines during their journey.[56] The migration may begin and end as more broad-fronted, but may narrow as flocks navigate along a coastline or follow ever diminishing patches of suitable habitat during their journey.[57]

A final important point with respect to the geography of migrations is that among populations and among individuals within a population, there can be variation in the distances traveled and routes taken. The importance of understanding geographic patterns of migratory connectivity for specific populations, as well as for cohorts of individuals within a population is more fully explored in other articles in this issue, including Marra et al.'s treatment of migratory connectivity,[58] and Atwell et al.'s exploration of within-species variation.[59]

D. Who Migrates?

Identifying important migrations and understanding their ecological underpinnings and geographic patterns is an important first step. However, even within migratory species, great variation exists in the demographic and social patterns of who migrates and who migrates with whom, and this variation likely has important consequences for conservation policy and management agendas. In some species, this variation is relatively well understood; for example in the Dark-eyed Junco songbird (*Junco hyemalis*).[60] However, in most species the demography and sociality of migration are not well understood. We introduce these concepts briefly here.[61]

Complete migration refers to scenarios where virtually all members of a species or population make the journey, leaving behind breeding ranges during the non-breeding season.[62] Complete migrants are typically those animals that inhabit seasonally harsh climates, which reduces the likelihood that some populations or individuals remain sedentary or migrate only partially away from the breeding grounds. Arctic terns are unambiguously complete migrants that spend their entire year in summer, alternating between northern and southern polar regions, making the longest known migration round trip of more than 40,000 kilometers.[63] The term "complete migration" can be used to refer to species in which all identifiable populations move, or the same term can be used in the context of a single population or subspecies.

In contrast, partial migration denotes that not all members of a species or population move, with some individuals or populations remaining sedentary with only local movements.[64] Partial migration is likely the most common variety of migration, exhibited in many taxa from insects to fish to birds,[65] and it is likely much more widespread than has been historically realized.[66] Few species have been examined closely enough to determine whether some populations or individuals are in fact migratory or sedentary. This phenomenon is probably more common in less extreme climates and when species' breeding ranges are larger, such that some populations or individuals benefit by migrating whereas for others it is most beneficial to remain on their territories year-round. For example, in the

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Aldabran giant tortoise (*Geochelone gigantea*) of the Seychelles islands, a portion of the population migrates to the coast at the beginning of the rainy season, where the payoff is a richer food source with the cost of having less shade where overheating can be fatal.[67]

Differential migration, which is not mutually exclusive from partial or complete migration, refers to different patterns of movement made by different cohorts of individuals within a population (i.e., variation in distance or route among those who migrate).[68] Differential migration typically involves different patterns of movement by males versus females or young versus old cohorts.[69] The phenomenon has been observed across taxa, including birds, fish, mammals, and insects.[70] For example, in American eels, females migrate farther upstream than males, dominating the headwater rivers and lakes, leaving the estuarine rivers to be dominated by males.[71]

Among migrating groups of animals there is variation in the size and composition of traveling groups. This could be termed the "sociality of migration." While some animal movements clearly fit the designation of "migration as a phenomena of abundance" described previously,[72] others do not. Some migrate long distances essentially alone, as is the case for juvenile Wandering Albatrosses (*Diamedea exulans*) that make solo journeys across the Southern Ocean.[73] Others form huge unmistakable assemblages that function as large inclusive social groups, such as the tens of thousands of African wildebeests (*Connochaetes gnou*; *C taurinus*) that herd together in search of food and water. Recent research has suggested that large groups of animals moving together, whether birds, fish, or caribou, display emergent social properties (i.e., "swarm intelligence") that may help them respond collectively to obstacles or predators.[74] Some animals migrate in mixed species groups, as is the case for many songbirds, especially the wood warblers and blackbirds, which are known to travel in flocks likely to be made up of adults and young from several related species.[75] And recent evidence from birds shows that interspecific communication about hazards such as predators is possible,[76] so it is likely that the same benefits of travelling as a social group may apply to mixed-species assemblages. Other species of birds such as Common Nighthawks (*Chordeiles minor*) and Common Crows (*Corvus brachyrhynchos*) are known to stick to smaller single-species companies.[77] Whether or not animals are differential migrants with respect to their final destinations, they may travel in groups segregated by age or sex that travel simultaneously or at separate times. In many bird species, adults depart the breeding grounds earlier than juveniles in the fall, and males embark upon spring migration sooner than females in order to arrive on the breeding grounds first.[78] Thus cohorts of young and old or male and female may travel separately, even though they end up in the same places.

E The Timing of Migration

Almost by definition, migrations are associated with some type of temporally variable, spatially distributed environmental conditions. Thus, in order for the movements to be advantageous, precise timing is required. Although many annual migrations are temporally coordinated with the changing seasons, not all migrations follow these simple annual cycles, and it is important to understand the temporal patterns of migration exhibited by different

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species, as well as the environmental cues that individuals use to initiate migration at the correct time.

The environmental cues that animals use to make seasonal timing decisions, such as when to breed and when to migrate, have been relatively well-studied in birds, mammals, insects, and other species. Primary cues, such as changes in day length (photoperiod),[79] provide reliable but imprecise information about the changing season.[80] Other cues, called supplementary cues, such as temperature, rainfall, food availability, or social environment, allow animals to fine tune their decisions about when to initiate or terminate migratory activities.[81] In many animals studied to date, neuro-endocrine and peripheral hormonal control systems have been identified that integrate primary and supplementary environmental cues, leading to physiological and behavioral changes associated with seasonal transitions such as breeding and migration.[82] In the context of conservation, this means that the timing mechanisms for migration could be altered by any environmental pollutants that disrupt these physiological mechanisms, for example by acting as endocrine-disrupting compounds (EDCs). Further, although photoperiod is a relatively stable cue (with the possible exception of artificial light pollution), many supplementary cues such as temperature are affected by human activities, and evidence suggests that contemporary climate change has led to the mis-timing of migration and breeding with optimal food resources in certain birds.[83]

With respect to the frequency of migration, obligate migrations are those that are not optional and hence must be undertaken every year for the given species or population to survive. This term is similar to complete migration but refers more to the timing rather than the extent of the migration. In contrast, facultative migrations are those that typically show annual variation in whether or not their migrations occur at all—that is, migration seems to be optional based on the relative state of the environmental conditions. This appears to be the case for many insects, such as the genus of noctuid moths (*Heliothis* spp.), which migrate variable distances in response to poor local conditions and favorable winds that facilitate the migration to new crops of food.[84] Both obligate and facultative migrants are common across a wide range of taxa.

Similarly to facultative migrations, irruptive migrations are those described as seasonally and geographically unpredictable, usually in response to highly variable food resources. Irruptive migrants are often described as exhibiting nomadism, and examples include boreal finches (forest-dwelling songbirds) that depend on fluctuating tree-fruit crops, as well as certain owls that depend on fluctuating rodent populations.[85] Both of these groups make regional migrations of hundreds or even thousands of kilometers between breeding seasons, and it is often unclear the degree to which they may follow geographically or temporally predictable patterns at scales beyond the scope of research to date.

Although many typical migrations involve individuals traveling twice each year—from breeding to wintering grounds and back again—other migrations involve more complicated individual lifecycles. Itinerant breeders, for example, are species that breed more than once each season in different locations, with some apparently making an additional migration between breeding sites (i.e., three migrations each year instead of two). This phenomenon has been documented in just a few species of birds such as the African Red-billed Quelea

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(*Quelea quelea*)[86] and the Phainopepla (*Phainopepla nitens*), a songbird of the Southwestern United States and Mexico,[87] but these species are relatively nomadic, with unpredictable migratory routes and breeding and wintering locations. More recently, stable isotope data has provided evidence suggesting that at least five species of Neotropical migrant songbirds stop to breed a second time at an intermediate point on their long journey south—therefore making three distinct migrations each year—a term the researchers described as "migratory double brooding."[88]

Although many migratory trips follow annual to-and-fro patterns, other round-trip migrations can take several years, or even multiple generations, to be completed. In some cases a given individual only completes one leg of a multi-stage journey. This is true for the iconic monarch butterfly migration, in which northern populations migrate south where they overwinter and lay eggs the following spring before dying, with the subsequent second, third, and fourth generations journeying increasingly farther north towards the northernmost breeding grounds.[89] In several diadromous fish species such as Chinook salmon, each surviving individual will eventually complete migration back upriver to spawn and die, but several years typically pass between the initial migration from the spawning grounds to the ocean and the return trip back upstream.[90]

In addition to temporal variation among migrants in the frequency and seasonal timing of migration, there is also variation in time of travel during the day, and whether or not stops are made along the way—both important characteristics directly relevant to mitigating the effects of anthropogenic obstacles and habitat destruction on migrating animals. For example, many animals species are known to migrate almost entirely during the night (e.g., bats; most songbirds),[91] whereas others migrate exclusively during the day (e.g., most ungulates; raptors).[92]

Some animals are able to make astounding nonstop efforts during migration. A recent tracking study of Red Knots (shorebirds) documented one individual flying an astounding 5000 miles nonstop over just six days.[93] In contrast, other animals require frequent stops to refuel along the way.[94]

F Genetics, Learning, and Navigation

For many biological characteristics, scientists aim to understand whether variation among individuals, among species, or among years is likely attributable to genetic differences or development under different environmental conditions. Accordingly this question is important for understanding migratory biology: to what degree is variation in migratory behavior or physiology attributable to different genes versus different environmental conditions? These distinctions have important implications for conservation for two reasons. The first is if migratory characteristics have a strong genetic basis, individuals cannot change, but the population as a whole may be able to rapidly evolve in response to changing environmental conditions over the course of a few generations—but only if sufficient genetic variation exists. Importantly, this fact does not always favor the persistence of migration, as a species or population could quickly evolve reduced migratory tendencies.[95] The second is if migrations have a strong environmental basis, then individuals could exhibit behavioral responses to changing environmental conditions, but not necessarily in an adaptive direction.

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That is, not all behavioral changes of individual animals that might result from changing environments will help them cope, as some behavioral responses could actually further imperil the survival of individuals and the persistence of populations or migrations.[96]

In general, where researchers have looked, they have found evidence suggesting a strong genetic basis for the timing and duration of migratory behavior and physiology. For example, population differences in migratory dispositions among migratory and non-migratory populations persist in several species of birds (e.g., Blackcap Warbler, *Sylvia atricapilla*),[97] insects (e.g., cowpea weevils, *Callosobruchus maculatus*),[98] and mammals (e.g., European vole, *Microtus agrestis*),[99] even when individuals were all raised under common environmental conditions in captivity.[100] Further, migratory behavior can evolve rapidly in artificial selection studies[101] and it exhibits high heritability across generations.[102] Nevertheless, there is also evidence that migration is apparently sensitive to environmental changes as evidenced by species exhibiting facultative migrations, as well as captive studies showing that modulating temperature or light availability can induce changes in the migratory behavior of individuals.[103] For migration, like most traits, the answer to the question “Nature or nurture?” is clearly “Both.” But understanding to what degree environmental versus genetic factors appear to influence the migratory habits of particular species may be a very important consideration for conservation research and management agendas.

One of the most inspiring aspects of migration is the stunning abilities of migratory animals to find their destinations—both with respect to knowing where to go in the first place, and navigating to find their way, sometimes across incredible distances and diverse topography. The degree to which migratory routes are learned versus innate, and understanding what environmental cues and internal mechanisms migrants use to navigate are both details that could be important to wildlife managers or policy makers.

There is strong evidence that the correct migratory orientation and distance is largely an innate characteristic for many birds,[104] as is the correct direction of migration for salmon and trout (upstream versus downstream)[105]—meaning that naïve juveniles are able to orient themselves correctly in experiments that remove any possible social learning experiences. However, it is also clear that learning and experience play a critical role, as the migratory journey of first-year birds takes considerably longer than in older birds,[106] and navigation has been shown to be controlled at least in part by early learning in species of several taxa, including birds, reptiles, amphibians, and insects.[107] Operation Migration, a conservation initiative to reintroduce endangered migratory Whooping Cranes (*Grus americana*) back into parts of Eastern North America, utilizes puppets and costumed humans to teach young cranes the correct migratory journey by ultimately training them to follow an ultralight aircraft[108]—demonstrating how the learned component of migratory behavior can have important implications for conservation.

Several environmental cues have been identified that are known to be important sources of information for orientation and navigation of migrating animals. Many of these have been identified through remarkable experiments over more than a century of research on this topic, with the vast majority of this research taking place in birds.[109] The position of the sun

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(solar compass), the position and rotation of the stars (celestial compass), the earth's magnetic field (magnetic compass), variably polarized light, the position of landmarks or topographic features (e.g., mountains, coastlines, rivers), acoustic signals (e.g., ocean waves), and odors in the atmosphere have all been associated with animal navigation.[110] Some animals also navigate by following, or being assisted entirely, by winds or currents.[111] Understanding what cues migrants use for learning and navigation could be useful to conservationists for at least two reasons: 1) human activities have the potential to alter environmental cues that might be important for effective navigation in migratory animals, thus leading them off course; and 2) understanding mechanisms of navigation for a particular species could lead to strategies designed to steer migrants away from obstacles or reintroduce them to restored or alternative habitat refuges.

G Future Directions in Migration Research

In the above Subparts, we enumerate and describe several ways in which biologists have characterized and categorized different types of animal migrations, and these terms and topics should be of use to those pursuing legal, policy, management or research agendas for the conservation of migrations and migratory species. These typologies emerge from centuries of formal and informal research on migration, primarily conducted by zoologists, ethologists, and taxonomists focused on the natural history and behavior of particular species or taxonomic groups. In more recent decades, ecologists and evolutionary biologists have turned their attention to the evolution and ecology of migration biology as a specific focus. Although substantial understanding of migratory species and the nature and function of their movements has been gained through historic and ongoing research as the above discussions and examples show, it is important to emphasize that for most migratory species there is still much that needs to be learned, and many mysteries remain about even the most fundamental details of migratory biology across nearly all knowledge categories described above. Thus, it is imperative that ongoing research initiatives continue to provide information on migrations and migratory species that will be valuable for policy makers and wildlife managers, in addition to addressing the goals of academic science. In the following paragraphs, we consider three important likely future directions for migration research, as predicted in part by technological advances that will enable new approaches and revitalize interest in long-standing questions.

With respect to the geography of migration, for most species, important biogeographic details are unknown. As discussed by Marra et al., for most migratory songbirds the most basic geographic links between breeding and wintering grounds for populations are unknown, as are the routes of the journey and the locations of the critical stopover habitats.[112] This is true for many other taxa, especially smaller animals including birds, fish, and insects, for which relatively heavy satellite tracking devices are too large for them to carry.[113] Even when breeding and wintering grounds are well understood, whether migrants move in broad or narrow fronts, or what particular topographic or habitat zones they traverse, is often unknown.

Emerging remote tracking technologies such as increasingly smaller radio devices, higher resolution stable isotopes or molecular markers, and geolocators make clarifying the

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geography of migration more feasible,[114] and there will likely be a renewed effort to track migrants and establish basic descriptive information on the biogeography of migrations for many species. Although simply establishing geographic detail for a longer list of species may be of limited interest to academic biologists or agencies funding basic science (e.g., the National Science Foundation), obtaining this information will inform unanswered questions about the seasonality, sociality, genetics, learning, physiology, or evolutionary history of migration as a unique behavioral adaptation—topics which are of great interest in science.

Climate change and habitat alteration represent topics that are currently of intense interest to scientists, in addition to conservation practitioners and policy makers, and thus represent key areas for generating interest and funding for migration research projects with both academic and conservation implications. As discussed by Thomas T. Moore,[115] climate change, as well as other types of habitat alteration, presents difficult challenges for migrating animals and those working for their conservation and preservation. Yet with the exception of a few landmark studies,[116] very little is known about how most migratory species are likely to respond to changing environments. Continued research into how global change is altering the migratory biology of animals will be required from scientists interested in both basic biological questions and specific conservation goals. These avenues of research could include, for example, investigating physiological mechanisms of seasonality, characterizing evolutionary or developmental responses to environmental change, or predictive modeling of current versus future habitat needs or demographic trends in the face of changing environments.

In addition to advances in tracking and sensing devices, another advancing set of technologies that will likely shape the future of migration research is the expanding utility and plummeting cost of molecular genetic and genomic tools. In addition to providing increased resolution for studies of population structure and genetic distance (e.g., among subspecies or races that share wintering grounds but return to different breeding grounds), future possibilities include identifying functional genes and gene families associated with migratory behavior and physiology. The possibility of linking these new genetic and genomic lines of research to conservation is most evident when considering how these tools might be applied in a population genetics context. However, identifying the actual genetic sequence variation correlated with behavioral variation among migrants could also prove useful to conservation. For example, scientists could more effectively artificially select migratory lines for reintroduction projects or probe the genetic potential of a population of migrants to respond to environmental change. Thus, similar to tracking/sensing technologies and topics in climate change, genetic tools represent new opportunities that will shape the future of migration research in ways that may also be useful for conservation.

In conclusion, although a large body of historic and ongoing research has led to certain generalities and categorizations of representative types of migratory phenomenon and their underlying mechanisms, for most migratory species, continued research on fundamental topics must remain a primary goal, with emerging technologies allowing advances in knowledge that will be valued by biologists, wildlife managers, and policy makers alike.

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III. Typology of Existing Legal Approaches

This Part presents a classification of legal approaches used in existing conservation laws that are relevant for the protection of migratory animals and their migrations as phenomena of abundance. We discuss exemplars for each of five approaches, and examine the approaches that are likely to be most effective for particular migratory species and migrations.

In general, existing conservation laws are not optimally effective for protecting migratory species and their migrations while still abundant because those laws typically focus our attention on species declines, viable populations, and reactive conservation actions. Maintaining minimal viable populations, however, may not sustain the ecological, psychological, cultural, and economic benefits associated with migrations—these benefits of migration, as well as the persistence of the migratory behavior itself, likely require abundances higher than minimum viable populations.[117] The leading illustration of this limitation is the Endangered Species Act (ESA).[118] The ESA, while offering protections for listed species that migrate, is not fundamentally concerned with protecting the functional benefits derived from the process of migration. Rather, the ESA is generally concerned with protecting the benefits that flow from the existence of the species, and therefore the minimum demographically viable population will suffice for this purpose.[119]

Even laws that were developed with the goal of conserving one or more migratory species, however, such as the Migratory Bird Treaty Act, the Neotropical Migratory Bird Conservation Act,[120] the Marine Mammal Protection Act,[121] and the Migratory Bird Conservation Act,[122] are limited in their ability to protect migrations and associated benefits. Such laws were enacted for a limited purpose, within a particular political context, and for particular taxonomic groups. A law such as the Migratory Bird Treaty Act, enacted with a “take” prohibition to conserve migratory birds,[123] may not serve as an effective model or template for protecting other taxa, such as bats and turtles, which may benefit most from a different set of legal tools. In fact, the Migratory Bird Treaty Act may not be adequate even for protecting the target species.

A starting place for any effort to understand the strengths and limitations of existing conservation laws for the purpose of protecting migratory species and their migrations is to categorize the main legal approaches used by these laws.[124] We delineate five categories of legal approaches used by existing federal conservation laws: 1) providing funding and assistance for conservation projects and fostering coordination and information generation and exchange; 2) providing incentives for state-level conservation planning; 3) acquiring and designating habitat for the benefit of species’ individuals; 4) controlling the “take” of species’ individuals through prohibitions and harvest restrictions; and 5) establishing standards and management practices to avoid harm to species’ individuals and populations. Any particular conservation law may employ multiple approaches, so there is not a one-to-one correspondence between each approach and existing conservation laws.

Our intent is to present a few exemplar laws for each legal approach; our exemplars are limited to federal statutes and regulations authorizing conservation-related actions for species that occupy United States jurisdiction for at least part of the life cycle. Although we

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note associated international agreements where relevant, whether a particular federal law implements an international agreement or alternatively a self-directed national agenda is of secondary importance for our purposes—national legislation is where the rubber hits the road in both cases.[125] For each category of legal approach we present notable features of the approach, highlight one or a few representative exemplars from existing conservation laws, and discuss the likely effectiveness of the approach for particular types of migrations and migratory species.

A. Funding, Assistance, Coordination, and Information Generation and Exchange

A common approach used by existing federal conservation laws is to authorize the transfer of funds from the United States government to domestic state, local, or private projects, or to foreign countries that are important ecologically but less able to fund conservation projects. Such projects may include land acquisition, restoration, education, and research activities. Often associated with authorization of funding and technical assistance for conservation projects are incentives to promote cooperation, coordination, and information generation and sharing among stakeholders.[126] Funding and assistance are often tools of choice for influencing land uses on state, local, and private property because of their voluntary nature,[127] although funding of third-party conservation projects typically requires federal approval based on specified criteria.

This approach is especially useful in three circumstances, which are not mutually exclusive. First, the approach is likely to be most effective for conserving long-distance migrants and migrations, such as the latitudinal migrations in North America that cross United States borders. Funding and assistance are the primary options in circumstances where the federal government lacks regulatory jurisdiction and has limited influence. Second, this approach may be the only politically viable option when privately owned land is a key component of a species' migration habitat, a situation in which the federal government encounters limited influence and much resistance. Third, funding of nongovernmental third-party projects may be the most effective tool when private actors have superior knowledge or capabilities with regard to conserving particular migratory species and migrations. This situation is likely to hold for species that are not the subject of existing conservation laws and for which information is very limited, such as the migratory tree bats discussed by Paul Cryan.[128] Although this approach likely has limited effectiveness for conserving migrations when implemented alone, because of its primarily voluntary and procedural nature, this approach may be the type of federal conservation law that is most likely to be enacted in the current political climate.

As examples of this approach, several United States statutes support international agreements for species protection with mechanisms for funding, coordination, and information exchange across national borders.[129] For example, the Neotropical Migratory Bird Conservation Act of 2000 (NMBCA)[130] authorizes the United States Fish and Wildlife Service (FWS) to dispense funds to applicants who obtain approval for conservation initiatives to conserve neotropical birds throughout the Western Hemisphere.[131] The NMBCA establishes a Neotropical Migratory Bird Conservation Account to receive appropriations and donations.[132] The money is then used to fund conservation projects that

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meet specific criteria and that will enhance the conservation of neotropical migratory bird species in the United States, Canada, Latin America, and the Caribbean.[133] The Secretary of Interior must, among other things, give preference to proposals that address conservation needs not adequately addressed by existing efforts and that are supported by relevant wildlife management authorities.[134] Federal funds requested under the NMBCA must be matched three-to-one by non-federal funds.[135] Funded projects for fiscal year 2008 included a research study of factors influencing the survival of Mountain Plover chicks (*Charadrius montanus*) in Colorado and Montana, invasive species removal in Puerto Rico, and reforestation of critical wintering habitat in Colombia, Ecuador, and Peru. The NMBCA also expressly sets forth other mechanisms of cooperation, including information sharing, interagency collaboration and coordination on projects, public participation, and inter-party agreements.[136]

Other laws focus on funding for domestic, rather than international, conservation projects. For example, the Estuary Restoration Act of 2000 (ERA)[137] establishes an estuary habitat restoration program under which the Secretary of the Army may carry out estuary habitat restoration projects and provide technical assistance through the award of contracts and cooperative agreements.[138] The ERA establishes an Estuary Habitat Restoration Council whose objective is to, among other things, solicit, review, and evaluate estuary restoration project proposals and develop recommendations concerning such proposals and submit to the Secretary of Commerce a list of recommended and prioritized projects.[139] A proposed estuary habitat restoration project must originate from a non-federal interest such as a state or local government, a tribe, or a nongovernmental organization (NGO).[140] The Secretary selects, based on established criteria,[141] estuary habitat restoration projects from a list of project proposals submitted by the Council.[142] Projects nationwide are tied together by an estuary habitat restoration strategy produced by the Council.[143] Projects are funded on a cost sharing arrangement, with the federal share not to exceed sixty-five percent.[144]

Projects approved under the NMBCA and ERA are likely to be developed and implemented mainly by organizations and agencies as part of institutional programs. However, the funding and assistance approach can also facilitate projects not associated with organizational or institutional programs, as some U.S. statutes focus on funding and technical assistance specifically for private landowners. For example, the Partners for Fish and Wildlife Act of 2006 (PFWA)[145] has a stated purpose to provide for the restoration, enhancement, and management of fish and wildlife habitats on private land by working with private landowners to conduct habitat projects for the benefit of fish and wildlife.[146] The PFWA provides technical and financial assistance to private landowners for such projects, as well as technical assistance to other public and private entities for habitat restoration on private land.[147]

B State Conservation Planning in Exchange for Federal Incentives

A second legal approach is to offer incentives to state governments to develop conservation plans that meet specified federal criteria. In this approach the federal government offers financial, technical, or other incentives in exchange for approval authority over the state conservation plans. This incentivized state planning approach is often implemented in

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tandem with the project funding and assistance approach described above. Once a state plan is approved by the federal government, the states are typically eligible for funding and assistance to implement their plans at the project level. Funding of localized state projects without assurance of underlying state planning to coordinate and prioritize those projects may not be optimally effective for conservation. However, we consider the incentivized state planning approach separate from the project funding and assistance approach, because they need not be, and are not invariably, implemented together.[148]

The incentivized state planning approach is likely to be most effective where the migration of concern crosses multiple state boundaries and where the migration habitats include a large amount of state or private lands. This approach can encourage consistency of conservation actions across large areas and multiple jurisdictional boundaries—for example, by fostering consistent standards and practices across states in the design and operation of wind turbines to reduce their impact on migratory birds and bats.[149] But this approach can achieve this objective only if the underlying federal legislation requires such consistency in the approval criteria.

Two primary types of state plans produced under this approach are Coastal Zone Management Plans and State Wildlife Action Plans. The Coastal Zone Management Act of 1972 (CZMA)[150] encourages states to voluntarily protect natural coastal resources such as wetlands, beaches, and coral reefs, as well as the fish and wildlife using those habitats. It includes areas bordering the Atlantic, Pacific, and Arctic Oceans, Gulf of Mexico, Long Island Sound, and the Great Lakes. The CZMA provides two incentives for coastal states to develop and implement a comprehensive coastal zone management program and plan: 1) matching grants for the administration of the program and coastal resource improvements,[151] and 2) a requirement that "[e]ach Federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone shall be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved state management programs."[152] A state's coastal zone program or plan is submitted to the Secretary of Commerce for review and approval.[153] In order to approve the program, the Secretary must find that the submitted program/plan meets a set of requirements, including a definition of what shall constitute permissible land and water users within the coastal zone, "[a]n inventory and designation of areas of particular concern within the coastal zone," identification of the means by which the state proposes to exert control over the land and water uses, "[b]road guidelines on priorities of uses in particular areas," and that the management program provides for an "inventory and designation of areas that contain one or more coastal resources of national significance," and "specific and enforceable standards to protect such resources."[154] Once approved, a designated state agency manages the state's coastal zone program and serves as liaison between the state and the Commerce Department. Each federal agency carrying out an activity in the state's coastal zone, each applicant for a federal license or permit to conduct an activity in the coastal zone, and each person submitting a plan for exploration or development of leased outer continental shelf lands must provide a showing of consistency with the state's approved program.[155]

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State Wildlife Action Plans (SWAPs) (also known as State Comprehensive Wildlife Conservation Plans) are authorized by the Fish and Wildlife Conservation Act of 1980 (FWCA),[156] and the Fish and Wildlife Programs Improvement and National Wildlife Refuge System Centennial Act of 2000.[157] An approvable SWAP, which is required for a state to receive project funding under the State Wildlife Grants Program,[158] must meet federal criteria, including identification of the problems that may adversely affect the species or their habitats and a determination of actions to be taken to conserve species and habitats identified in the plan as having the greatest conservation need.[159] SWAPs are often touted as tools for conserving nongame wildlife populations proactively before they exhibit signs of decline.

C Acquiring and Designating Habitat for the Benefit of Species ' Individuals and Populations

This legal approach involves delineating a boundary around an identified area and protecting, conserving, and managing the area and the animal and plant populations within. Three applications of this approach are: 1) designation of existing federal land, 2) federal acquisition of full or partial interests in state or private lands, and 3) federal designation of state or private lands as special areas. First, existing public lands may be designated as national parks, wilderness areas, marine sanctuaries, wild and scenic rivers, and national wildlife refuges. In particular, public lands may be designated as migration corridors.[160] Second, property interests in state or private lands can be acquired in full or partially, typically as easements. Lastly, state or private land may be designated as special areas, such as a migration corridor. Designation of state or private land as a special area may be valuable to draw public attention to the area and to motivate further actions such as acquisitions, funding, and restoration.[161]

Acquisitions and designations are likely to be most effective for migratory species that occupy and use a few delineated sites. For example, acquisitions will be most readily identified and likely produce the most bang for the buck when applied to obligate, narrow-fronted migrations moving along relatively narrow corridors or those that gather in mass aggregations at a limited number of stopover, breeding, and overwintering sites.[162]

United States laws that authorize wetland acquisitions are illustrative of the approach. For example, the Migratory Bird Conservation Act of 1929 (MBCA) authorizes the purchase, rental, or gift of full or partial interests in land or water by the federal government for the purpose of protecting migratory birds.[163] The MBCA creates a Commission, chaired by the Secretary of Interior, that is authorized to “consider and pass upon any area of land, water, or land and water that may be recommended by the Secretary of the Interior for purchase or rental under this [Act].”[164] The Secretary may not recommend any area for purchase or rental unless he or she has determined that such area is necessary for the conservation of migratory birds and has consulted with the local government in which such area is located and with the Governor or appropriate agency of the state concerned.[165] Either the governor or the state agency ultimately must approve each proposed acquisition.[166] Acquired areas need not be managed as inviolate sanctuaries; the Secretary is authorized to manage timber,

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range, and agricultural crops, and other species of animals with the objectives of perpetuating, distributing, and utilizing these resources.[167]

Another example of a wetland acquisition statute is the North American Wetlands Conservation Act of 1989 (NAWCA),[168] which is based in part on treaty obligations under the Ramsar Convention[169] and the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere,[170] as well as the 1988 amendments to the Fish and Wildlife Conservation Act of 1980.[171] The Act establishes a North American Wetlands Conservation Council that recommends wetlands conservation projects, including acquisitions, to the Migratory Bird Conservation Commission established by the Migratory Bird Conservation Act.[172] Any wetlands acquisitions under NAWCA within the United States are to be included in the National Wildlife Refuge System.[173] In lieu of including these properties in the Refuge System, the Interior Secretary may, with the concurrence of the Commission, provide the federal funds or convey any real property interest acquired with such funds without cost to a state or to another public agency or other entity, upon a finding by the Secretary that the real property interests should not be included in the Refuge System.[174] In such cases the deed or other instrument of transfer must contain a provision for the reversion of title to the property to the United States if the deed holder fails to manage the property in accordance with the objectives of NAWCA. With regard to wetlands conservation projects in Canada and Mexico, the Interior Secretary is required to provide funding to assist public agencies and other entities in carrying out wetlands conservation projects that have been approved by the Commission, provided that any real property interest acquired, enhanced, managed, or restored with such funds “will be administered for the long-term conservation and management of such wetland ecosystem and the fish and wildlife dependent thereon.”[175]

D. Controls on “Take” of Species ’ Individuals, Including Prohibitions and Harvest Restrictions

Prohibitions and restrictions on “take” of individuals of a species are frequently used legal approaches for conservation. Take prohibitions start from a baseline of no-take, and are often applied to threatened or depleted species or groups. This baseline prohibition is typically tempered by exceptions, so that the prohibition is implemented as a prohibition on taking without the permission of the relevant agency. Where the take prohibition is linked to endangered species or groups, the exemptions from the prohibition are likely to be few and difficult to obtain. In fisheries laws, take prohibitions typically take the form of year-round area closures or species bans. Take restrictions, in contrast, accept take as the baseline condition and attempt to control the amount taken. Take restrictions are typically applied to hunted, fished, or collected species that are not threatened with extinction. In fisheries laws, such restrictions are typically in the form of catch limits, limits on fishing permits, limits on allowed number of fishing days, or seasonal closures of fisheries or areas. Although take prohibitions and take restrictions are often conceptualized separately, both approaches have the common objective of controlling and limiting the intentional as well as incidental killing, harming, capturing, or harassing of individuals.[176]

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Take prohibitions and restrictions are likely to be most effective for migratory species that aggregate at high abundances in sites that may not be fully protected through acquisition. Such aggregations, more common for migratory species that visit a few stopover sites (e.g., Red Knots, *Calidris canutis*),[177] congregate for breeding (e.g., grouper, *Epinephelus* spp.),[178] or congregate for overwintering (e.g., monarch butterflies),[179] may make the included individuals particularly vulnerable to take by humans during those periods.[180] Yet the real strength of a take prohibition or restriction is that it need not be tied to a particular piece of land or water. This approach thus can protect migratory individuals wherever they may be at any moment in time, and can be effective for protecting migrants moving between, or not well served by, protected areas. The approach can also be used to protect the food supply of migrants, such as where migrants prey on populations that are themselves impacted by human development. Take prohibitions and restrictions can be implemented over large geographic extents and may cross many jurisdictions, and that can be good for long-distance migrants. The large geographic extent of implementation that can benefit migratory species may, however, make enforcement difficult compared to a take limitation tied to a specified area.

Two exemplars of federal laws that implement a take prohibition are the ESA[181] and the Migratory Bird Treaty Act (MBTA).[182] Section 9 of the ESA makes it unlawful for any person or entity to "take" any endangered or threatened species.[183] The ESA offers an exception from the prohibition under section 10(a), which authorizes the Secretary of Interior or Commerce to allow a private entity to engage in development or land use activities that may result in a taking of some members of a threatened or endangered species, so long as the taking is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."[184] The Secretary's approval is set forth in an incidental take permit.[185] To qualify for this exception, a private entity must submit a Habitat Conservation Plan (HCP).[186] If the Secretary finds that

> (i) the taking will be incidental, (ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking, (iii) the applicant will ensure that adequate funding for the plan will be provided, (iv) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild, and (v) the measures, if any, required [by the Secretary] will be met.

the Secretary must issue an incidental take permit containing "such terms and conditions as the Secretary deems necessary or appropriate."[187]

"Take" is defined broadly in the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."[188] The implementing regulations define "harm" to include a "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering."[189] To be subject to section 9, the habitat modification or degradation must be significant, must significantly impair essential behavioral patterns, and must foreseeably result in actual injury to a protected wildlife species.[190] ESA actionable harm includes indirect injury due to habitat changes, such as when habitat changes reduce prey availability or reduce the animals' ability to evade predators.[191] Moreover, courts have interpreted the ESA take prohibition to allow a

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permanent injunction for future incidental impacts caused by habitat modification or destruction.[192]

Under the MBTA, it is illegal to "pursue, hunt, take, capture, kill, attempt to take, capture, or kill" any migratory bird or any part, nest, or egg of such bird by "any means or in any manner."[193] The Secretary of Interior is authorized to set forth exceptions to the MBTA take prohibition: "to determine when, to what extent, if at all, and by what means, it is compatible with the terms of the conventions to allow hunting, taking, capture, killing, possession, sale, purchase, shipment, transportation, carriage, or export of any such bird, or any part, nest, or egg thereof, and to adopt suitable regulations permitting and governing the same."[194] Migratory game birds may be taken through hunting in accordance with conditions and restrictions.[195] The Secretary can issue several types of permits under the MBTA for taking of migratory birds, including permits to take migratory birds that are injuring crops and other property interests.[196] Regulations also set forth the conditions under which specified persons and entities are exempt from the permit requirements.[197] However, neither the MBTA nor its implementing regulations provide for permitting of "incidental take" of migratory birds.

While the MBTA take prohibition covers more than hunting or poaching,[198] so far no federal court has concluded that indirect incidental harm to migratory birds caused by habitat modification or degradation alone imposes liability under the MBTA, unlike under the ESA.[199] Importantly, the MBTA definition of take does not include the terms "harass" and "harm" like the ESA definition, and courts have found that difference significant.[200] On the other hand, direct killing of migratory birds caused by habitat changes, such as may occur while harvesting trees during nesting season, may be held to be a MBTA violation by at least some courts.[201] Notwithstanding the substantial variation in existing judicial interpretations of the MBTA take prohibition, FWS may use the threat of enforcement as well as court injunctions (where direct killing is inevitable) to proactively control public and private actions that incidentally and directly kill migratory birds, such as the operation of wind turbines.[202] Courts appear willing to find MBTA violations where the killing of migratory birds is reasonably foreseeable, where the defendant disregards norms of conduct for the relevant industry, and where the defendant fails to implement conservation measures developed by the agency.[203] To serve an effective prevention role, the threat of enforcement and prosecution must be high enough to provide sufficient incentive to would-be takers to subject themselves to agency control before a take occurs.[204] Once a take occurs, proving an MBTA violation may be exceedingly difficult.[205]

Take prohibitions, as in the ESA and MBTA, begin from the baseline of no take and provide exceptions to that prohibition. Take restrictions, on the other hand, begin from the baseline that harvest is allowed and impose limitations on how much can be taken. Fisheries regulations typically implement take restrictions. An example of take restrictions implemented at large spatial scales are from the regulations under the Western and Central Pacific Fisheries Convention Implementation Act of 2007 (WCPFCA),[206] which implements the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean adopted in 2000.[207] These regulations use fishing day limitations[208] and quotas[209] to control take over large expanses of ocean.[210] Similarly,

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regulations for the Atlantic Tunas Convention Act of 1975 (ATCA),[211] which implements the International Convention for the Conservation of Atlantic Tunas adopted in 1966,[212] specify recreational retention limits for several species implemented across large areas of the Atlantic Ocean[213] as well as retention limits for Atlantic bluefin tuna (*Thunnus thynnus*).[214] Take restrictions implemented in relatively small delineated areas are less common than take prohibitions implemented at large spatial scales.

E Standards and Management Practices to Avoid Harm to Individuals and Populations

The take prohibitions and restrictions discussed above clearly are intended to prevent, control, and mitigate take. Their effectiveness for this task, however, ultimately depends on 1) the extent to which the threat of enforcement and successful prosecution deters particular kinds of take and instigates application for permits and exceptions, or 2) the probability that an injunction can be obtained to prevent or stop take. Preventing and controlling incidental take—in particular, take due to habitat modification or degradation—often requires that the lead agency inform sister agencies and private actors how they may avoid taking protected animals. The lead agency may provide such information on a case-by-case basis; for example, as measures in an incidental take permit or incidental take statement under the ESA. Alternatively and more broadly, standards and management practices to avoid and control incidental take may be developed for all activities of a particular type. Such standards and practices may be voluntary or may be set forth and mandated in statute or regulation.

We use the terms standards and management practices in a broad sense. Standards establish goals for the resource or limitations on technologies that may impact the resource, and are typically prescriptive. In water pollution control law, technical standards may specify goals for the clarity and uses of water bodies, set limits on allowable concentrations of discharged pollutants, or directly require the application of a particular pollution control technology.[215] In the context of migration, technical standards could apply at all phases of the migratory cycle, but may find most ready application in the form of habitat standards for corridors or occupied sites (e.g., a specified size or percent of forested area) and design standards for migration barriers (e.g., a specified design for fences encountered by pronghorn or wind turbines encountered by birds and bats). In the broad sense in which we use the term, a standard may apply to relatively unsophisticated technologies such as fences. In circumstances where standards are not or cannot feasibly be established, management practices are specified to control conduct. Best management practices have specific applications in pollution control,[216] federal land management,[217] and state forestry contexts.[218] In our broad use of the term, a management practice, irrespective of whether it is voluntary or mandated by regulation, sets forth rules of conduct that are expected to reduce the impact to the resource. In the migration context, management practices to reduce impacts to migrants and their habitats can be readily applied to all phases of the migratory cycle (e.g., on breeding grounds, wintering grounds, and migration routes). Standards and practices, while common in pollution control laws like the Clean Water Act,[219] less commonly appear in conservation laws.[220]

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Like take prohibitions and restrictions, standards and management practices can be applied at a range of spatial extents and need not be tied to any particular piece of land or water. This makes the approach particularly useful for broad fronted migratory species (e.g., songbirds)[221] and for migratory species limited by multiple or widely dispersed structural barriers or adverse land uses (e.g., roads, fences, communication towers, wind turbines, and dams). Standards and practices may be usefully associated with other approaches; applied, for example, as uniform requirements for federal approval of incentivized state conservation plans, as guidelines or requirements in a land use plan for acquired or designated properties, or as requirements in a take prohibition or reduction plan.[222]

Standards and practices may be voluntary or mandatory depending on legislative authority and the potential impact they are intended to prevent or ameliorate. An example of voluntary conservation standards and practices is FWS guidance to help the wind power industry avoid and minimize the impact of land-based wind turbines on wildlife, particularly migratory birds.[223] So far FWS has no regulations specific to wind power. Enforcement and prosecutorial discretion under the MBTA does provide FWS with some leverage to persuade the wind industry to cooperate in developing and implementing such guidelines. These wind guidelines could, however, be mandated as conditions on incidental take permits under the ESA or on other federal permits or licenses.

Nonvoluntary standards and practices for conservation occur frequently in fisheries laws, and such laws may provide a model for applying this approach to the conservation of migrations. Examples of standards and practices in fisheries laws are fishing gear technical standards, gear restrictions by season or species, and practices for preventing and mitigating bycatch. The regulations for fisheries in the Caribbean, Gulf, and Mid and South Atlantic EEZ specify management measures including the type of fishing gear allowed and prohibited for various species.[224] Similarly, the Atlantic Tunas Convention Act (ATCA)[225] regulations specify gear operation and deployment restrictions, including quantitative standards for the design of pelagic longline hooks.[226] The detailed requirements in the regulations for the ATCA for reducing the incidental capture and mortality of sea turtles caught in longline gear are another good illustration of mandated management practices applied to avoid and mitigate take of animals.[227] The practices specify proper bycatch mitigation gear to be carried on board the fishing vessel including line cutters, dehookers, a standard passenger vehicle tire (to support a boated turtle), turtle control devices, and mouth openers and mouth gags. Methodologies and protocols for removing hooks from sea turtles, either brought into the vessel or still in the water, and for handling and release of incidentally caught sea turtles are also specified.[228]

In theory, such fisheries' standards and practices are no different than standards and practices applied to habitat modification and the design and operation standards and practices of wind turbines, transmission towers, rangeland fences, and highway underpasses, which could help prevent incidental take of migrating animals. Notwithstanding real or perceived political infeasibility or lack of statutory authority, in general, application of uniform standards and management practices is an underutilized conservation approach.

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F Concluding Thoughts

There are many ways to categorize legal approaches in existing conservation laws. The above typology sets out what we consider to be the core approaches that will likely be necessary to protect migratory species and migrations at abundances that maintain associated benefits. The essential question for developing such legal protections is how to achieve the right mixture of approaches and the right timing of implementation for particular species, migrations, and circumstances.

IV. Typologies Related to Wildlife Management

This Part explores the ways in which natural resource managers approach conservation of migratory species. Wildlife management is an applied discipline that seeks to manipulate wildlife habitats and wildlife populations to conserve, control, or exploit species of wildlife, as laws and societal interests dictate.[229] In addition, wildlife managers and land managers whose responsibilities extend to wildlife also interact and collaborate with agencies, NGOs, and the public, and often include public education and outreach among their responsibilities. Wildlife management encompasses the natural science discipline of applied ecology and such social science disciplines as economics and sociology, applying these within the context of the legal structure that both constrains and enables management actions. Ecosystem management and adaptive management,[230] presently regarded as the most effective forms of natural resource management, incorporate scientists, managers, and the stakeholder groups to whom management answers giving strong emphasis to what is termed the “human dimensions”[231] of natural resources management, as well as to the scientific and technical aspects of the discipline.

Part IV. A. 1 describes the legal structure that guides wildlife management on terrestrial properties and Part IV.A.2 similarly delineates aquatic settings under federal, state, and private control. Our focus in these Subparts is narrow—only those aspects of law that enable or constrain state and federal managers and private landowners as they manage wildlife; in contrast, Part III of this Article discusses the broad sweep of other legal instruments that may support conservation of migrations and migratory species. Part IV.A.3 describes species management across the nation, across states, and across the swath of water that is the EEZ. Management across these broad areas of land and water proceeds under different authority and using somewhat different tools than management of specific terrestrial and marine properties discussed in the first two Subparts.

Part IV.B describes the tools available to managers to manipulate habitats and species, including collaborative and educational tools for dealing with other management entities and with the public. Part IV.C presents a typology of migrations and migratory species, similar to the scientific typology presented in Part II of this Article, but from the standpoint of wildlife management.

A. Management Contexts

The context of management dictates, to some extent, the ways in which management can affect migrants. Here, we first differentiate among federal, state, and private management of

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lands and waters. Federal land management is guided by the organic legislation that outlines the responsibilities of the respective landowning agencies and is limited to federal lands, which exist rather like islands in a matrix of state and private land. We limit discussion of state management in Part IV.A. 1 to state properties, although states have broad responsibilities for wildlife management across ownership boundaries. Similarly, in Part IV.A.2 we limit discussion of "land management" in federal water to marine sanctuaries and monuments, which are similar to terrestrial properties in their delineation. In Part IV.A.3, we examine possibilities for affecting migrants through species management, discussing federal programs with responsibility across the nation, state efforts that cross property boundaries within states, and federal authority throughout the broad coastal territory of the EEZ. We close by considering landscape-scale management that ignores political boundaries.

1. Wildlife Management in the Context of Land Management—Land managers are responsible for many aspects of natural resource management, and public land managers may also be responsible for recreation, public safety, law enforcement, and a variety of other activities related to managing the land for the public and managing the public on the land. In this Subpart, we consider conservation of migrations and migratory species as an aspect of management of federal and state public lands and private lands. Federal and state agencies receive their authority through very different aspects of law. Even within federal agencies, we find differences in the specificity of guidance supplied by organic legislation and associated policy guidelines. States vary in the relative weight given to game and nongame species.

a. Federal Lands: Management of federal lands is controlled by the relevant organic legislation—the legislation that outlines the responsibilities of the various systems; more specific statues may address specific units or properties. Although these are laws, we discuss them here, under the management heading, because organic legislation provides a broad, overarching view of agency responsibilities, guiding management through the wording of what is, essentially, a mission statement. Even establishment legislation that creates individual units and describes their purposes and uses is rarely particularly prescriptive. Thus, the fine details of management are generally left to the agencies and may be dictated by agency policy or left to the discretion of managers at various levels.

No federal land system, whether by law or by policy, explicitly seeks to conserve migrants or migrations, with the exception of migratory fish, birds, and marine mammals within the national wildlife refuge system.[232] Protection of migration as a phenomenon is not contemplated by any of these systems. As a result, protection of biodiversity is the main umbrella under which protection of migratory species and of migration can occur on public lands. The major federal land management agencies are, in order of land area managed, the Bureau of Land Management,[233] the Forest Service,[234] the Fish and Wildlife Service,[235] and the National Park Service.[236] (Department of Defense lands, which come fifth, are excluded from this discussion.)

The Bureau of Land Management: The Bureau of Land Management (BLM) is required to use a multipleuse, sustained-yield approach that gives the agency sufficient authority to manage for migration conservation, but does not place any particular requirements on the

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agency to do so. BLM's required management approach is laid out in the Federal Land Policy and Management Act (FLPMA),[237] which defines the multiple-use, sustained-yield principle as

> the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people … including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific and historical values; and harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment with consideration being given to the relative values of the resources and not necessarily to the combination of uses that will give the greatest economic return or the greatest unit output.[238]

The multiple-use mandate gives the agency wide latitude to balance uses as it sees fit; wildlife is granted no primacy. Because some of the indicated land uses are incompatible with simultaneous presence of many wildlife species (notably mineral extraction and, to a lesser extent, grazing and timber harvest), the result of multiple use must be a reduction in the overall area available for most wildlife, including migrating wildlife. The agency may choose to manage portions of its land to benefit migrants, but is barred from doing so throughout its holdings, and is not subject to penalty if it chooses not to manage specifically for migratory species in any of its holdings. Thus, the largest manager of federal lands has no requirement to support migration and migratory species, but the option of doing so on some areas under its control.

The United States Forest Service: Like BLM, the United States Forest Service (Forest Service) has a multiple-use mandate. While federal statutes provide little guidance concerning how the Forest Service should balance the needs of wildlife with other Forest Service objectives, agency policies have provided a high standard for protection of biodiversity,[239] although without any special emphasis on migratory species. Forest Service activities are governed by the National Forest Management Act (NFMA),[240] which requires that Forest Service planning "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives."[241] Presently, agency implementing guidelines direct that, within each national forest, "fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired nonnative vertebrate species in the planning area."[242] These guidelines have been in effect since 1982, with a brief hiatus under the George W. Bush Administration, which sought to set them aside.[243] USDA regulations provide supporting language:

> Habitats for all existing native and desired non-native plants, fish, and wildlife species will be managed to maintain at least viable populations of such species. In achieving this objective, habitat must be provided for the number and distribution of reproductive individuals to ensure the continued existence of a species throughout its geographic range.… Monitoring activities will be conducted to determine results in meeting population and habitat goals.[244]

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By providing for monitoring as well as for conservation throughout a species' geographic range, the regulation clearly indicates that attempts at conservation, alone, are not sufficient —proof of efficacy is also needed. The need to conserve throughout a species' range protects species that migrate within or across forest boundaries, but cannot protect species outside of the individual national forests. The national forests typically choose a subset of "management indicator species" from among a variety of game and nongame taxa specific to each forest; protection of these species is supposed to afford protection to a much broader suite of species.[245]

The United States Fish and Wildlife Service: As the federal agency with primary responsibility for wildlife, the United States Fish and Wildlife Service (FWS) interacts with migrant wildlife in many ways. As a land manager, the agency administers the national wildlife refuges,[246] as well as wetland management districts and coordination areas.[247] We limit our comments here to that role. Unlike the multiple-use land management of BLM and the Forest Service, the national wildlife refuge system has a dominant use—conservation.[248]

For many years, the Forest Service "viable populations" guidance was considered the highest available standard for protecting biodiversity outside of the ESA. However, because the Forest Service guidance is in the implementing regulations, not in the legislation itself, it can be rewritten at any time, so long as the language that replaces it is viewed by the courts as faithfully interpreting the organic legislation. Indeed, as we mention above, the George W. Bush Administration attempted just such a rewrite.[249] The National Wildlife Refuge System Improvement Act (NWRSIA)[250] includes its guidance in the language of the act itself.

The NWRSIA, among other things, protects "biological integrity, diversity, and environmental health" of national wildlife refuges.[251] Both "biological integrity" and "diversity" directives cover migrants, and where migrants and migrations fulfill important ecosystem functions, the "environmental health" language may also extend protection to migrants and migrations.

The NWRSIA also requires that all activities on a refuge be compatible with the primary establishment purposes of the refuge and with the mission of the refuge system as a whole.[252] This requirement highlights the status of the refuge system as a system of lands with a single dominant purpose[253] in contrast to the multiple-use systems of the Forest Service and BLM. The compatibility policy limits activities that reduce or fragment habitat for migratory species, but does not entirely eliminate them; wildlife-focused management that creates, enhances, or restores habitat for one species or set of species may reduce, degrade, or fragment habitat for other species.

More specific focus for the national wildlife refuges comes from a broader, current FWS focus on so-called "trust" species. Several more or less consistent definitions appear in a variety of FWS documents and in the Partners for Fish and Wildlife Act of 2006.[254] The Act names "migratory birds, threatened species, endangered species, interjurisdictional fish, marine mammals, and other species of concern."[255] FWS states that efforts to protect trust species provide effective umbrellas for protection of wildlife of all kinds.[256] Thus, although all biodiversity is protected by the NWRSIA, trust species and species specifically targeted

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by individual refuge establishment legislation may be “more equal than others,” to borrow the language of George Orwell.[257]

The national wildlife refuge system has direction from the policy that interprets the NRWSIA to expand its focus beyond the boundaries of its own land in order to assess and protect the resources of the system.[258] Although their legal authority stops at refuge boundaries, managers are encouraged to consider the role of the refuge in the larger landscape and may affect land management outside refuge boundaries through outreach programs in cooperation with other branches of FWS and through collaboration with other agencies, organizations, and with private landowners.

The National Park Service: The National Park Service (NPS) organic legislation has NPS forever balancing the conflicting demands of a mandate to “conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.”[259] In cases of conflict, policy requires that conservation be the dominant use.[260] However, in establishment language for individual parks, Congress can and does use specific language to circumvent the larger system goals, for example, to emphasize recreation or scenery as a dominant value of a particular park.[261]

NPS policy includes a substantial discussion of impairment,[262] as well as extensive direction regarding natural resource management[263] that includes general direction to conserve plants, animals, and natural processes. The policy explicitly addresses migratory species, indicating NPS will work with other agencies and countries as appropriate to identify ranges, assist in developing harvest strategies, and participate in monitoring efforts to assist in conservation of these species.[264] More broadly, NPS policy also directs superintendents to participate in “cooperative conservation beyond park boundaries” designed to help create a “seamless network of parks” and to act to protect parks from impacts in the surrounding landscape.[265]

Although NPS policy addresses many of the same points and uses many of the same mechanisms (e.g., long-range planning) as does National Wildlife Refuge System policy, NPS policy provides no firm timeframe, and fewer specifics.[266] In addition, the NPS mission includes a far wider range of resources—scenic views, soundscapes, historical sites—than the wildlife-focused NWR mission. As a result, although NPS policy creates an affirmative responsibility to wildlife, generally, that responsibility is only one of many, and no means are provided for ensuring progress towards wildlife-related goals. Finally, policy notwithstanding, the organic legislation requirement to “provide for the enjoyment” of parks creates conflicts with conservation. Congress can de-emphasize conservation among the goals for a particular park in the establishment process, and court decisions have made it clear that the parks have wide discretion in choosing which means and levels of “enjoyment” will be permitted, even when these are noticeably harmful to wildlife.[267]

In summary, migratory species that spend all or a considerable part of their time breeding or overwintering on federal lands fall under the policies discussed above, but even on those lands with more specific biodiversity mandates, they are not specific targets of conservation interest unless they happen to be selected as indicator species for a particular national forest

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plan, or unless they are a FWS trust species—a category that excludes migrants that are not birds or fish. Species that pass through federal land on their migratory paths are likely to be best protected on natural wildlife refuges under the umbrella of "biological integrity, diversity and environmental health,"[268] or at present, and if they are vertebrates, on national forests under the umbrella of "viable populations of existing native and desired nonnative vertebrate species."[269]

b. Non-Federal Lands: In the United States, wildlife is owned by the public and states have the power to manage wildlife; states vary in the degree to which they formally claim that power.[270] States generally have authority to manage resident fish and wildlife in federal lands within state borders.[271] Even in cases where Congress has granted federal agencies some latitude over fish and wildlife management on their lands, federal agencies are typically required to coordinate management with state authorities.[272] Here, we confine ourselves to management of land owned by the states; we consider the wider management of wildlife across the breadth of the state in the following Subparts on species management.

State wildlife agencies typically administer a system of state lands, often of several types—state forests, parks, wildlife management areas, nature preserves. Details of management guidelines vary too much among land categories and among states to permit more than general statements. Attention to migratory species on state lands varies according to the purposes of the lands and according to the state. On areas where hunting is permitted, the migratory game species of interest will be explicitly managed and nongame species may be afforded some protection either as an inadvertent result of management for migratory game species or due to additional explicit management for nongame migratory species. Most states also have some conservation-oriented state lands—parks, nature preserves—that explicitly conserve biodiversity broadly.[273] Thus, state lands typically have conservation value for migratory species, but the extent to which management directly addresses migratory species varies by the mission of the particular land system, the mission of the agency, and by importance of the species (e.g., to the public for hunting, fishing, or wildlife watching, or for ecosystem services).

Parks and forests operated by local governments, as well as private lands and lands owned by nongovernmental organizations such as land trusts and conservation societies, also provide habitat for migratory species. The level of planning and range of species of interest are determined by the landowning organization. Migrants and migrations that are not endangered lack any substantial legal protection on private land. A variety of programs seek to involve private landowners in wildlife conservation—these were discussed in the Part on legal protection,[274] and are also covered briefly the later Part on coordination of conservation efforts.[275]

2. Wildlife Management in the Context of Federal and State Waters—Just as we limited our discussion of terrestrial wildlife management to specific publicly and privately owned properties, we limit our discussion of aquatic wildlife and fisheries management to analogous situations. Part IV.A.3 below discusses cases where aquatic wildlife and fish are managed across large scales such as in coastal waters within three miles of shore, controlled

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by coastal states, and from three to two-hundred miles offshore, controlled by the National Oceanic and Atmospheric Administration (NOAA).[276]

a. Waters of the United States: Two general situations create aquatic "properties" under federal management analogous to federally owned public lands: certain short-term or ongoing management activities of inland waters may result in federal ownership of the project area, and a variety of marine protected areas are managed at the federal level.

Bodies of inland water created by impoundment or diversion, and areas that are deepened, while that activity is ongoing, are typically projects of the United States Army Corps of Engineers, the Bureau of Reclamation, or another federal agency that funds, permits, or carries out the project. The United States Army Corps of Engineers manages a number of primarily eastern rivers that are dammed. The Bureau of Reclamation manages project areas including dam sites, primarily on western rivers. The Fish and Wildlife Coordination Act[277] describes responsibility for fish and wildlife on projects that impound, divert, or deepen a body of water. The project agency must consult with the federal and state agencies responsible for the affected fish and wildlife, and mitigate impacts so as to "to obtain maximum overall project benefits."[278] States have authority for managing wildlife on the project lands except in the case of migratory birds (hunting of these is managed by the state).[279] The project agency is also directed to inform Congress if additional land acquisition may be needed to ensure "the wildlife potentials of the particular project area."[280] Specific mention is made of the need to safeguard fish and wildlife resources of the Upper Mississippi River while also maintaining the various river control structures and water depths commensurate with commerce.[281]

Federal "properties" in marine settings are somewhat poorly organized. The only clear system of such areas is the National Marine Sanctuary System created by the National Marine Sanctuaries Act[282] and is managed by the Office of National Marine Sanctuaries within NOAA.[283] The purpose of the act relevant to protection of migrants is "to maintain the natural biological communities in the national marine sanctuaries, and to protect, and, where appropriate, restore and enhance natural habitats, populations, and ecological processes,"[284] by enhancing "public awareness, understanding, appreciation, and wise and sustainable use of the marine environment, and the natural, historical, cultural, and archeological resources of the National Marine Sanctuary System."[285] The remaining property-like areas of federal jurisdiction encompass a variety of marine protected areas including national parks and national monuments, managed as part of the national park system or the national wildlife refuge system and potentially in partnership with NOAA and relevant states. No single system of rules governs these protected areas, but all the relevant federal management agencies have policies supporting conservation or sustainable use.

In summary, as in terrestrial settings, federal managers of aquatic "properties" have the option to extend support to migratory species, but have no mandate requiring them to do so. The island-like nature of these systems means that they rarely protect entire migratory routes of migratory species, but may provide food and shelter along the way, or breeding or resting grounds where they constitute endpoints for some migrants. As a side note, several of the

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agencies involved in managing these aquatic settings—Bureau of Reclamation, the Army Corps of Engineers, NOAA—do not include conservation among their primary missions.

b. State Waters: Public trust doctrine reserves the responsibility for the beds and banks of navigable rivers, and all submerged tidal lands (coasts and estuaries) for states to protect for their citizens.[286] The ability to access and use these areas for the traditional three areas of navigation, commerce, and fishing is protected by most states for all citizens, to at least some extent.[287] Some states go considerably further, broadening the definition of "navigable waters"; by defining a public trust responsibility for aquatic biodiversity, water quality, and, in rare cases, for terrestrial wildlife as well.[288] States have broad discretion in defining the public trust, however this mechanism provides only the *right* to define the public trust; states bear no *responsibility* to expand the public trust beyond maintaining public ownership and access to the aquatic areas to which they were originally granted title.[289] Thus, public trust doctrine has very patchy impact on migratory species that use aquatic habitats; in worst cases, the responsibility for protecting a public trust in fishing may be interpreted to permit introduction of nonnative fish species in the name of providing access to fishing.[290]

Most states undertake fisheries management of resident species as part of the mission of the relevant state agency. In this context, state management of aquatic species and habitats differs little from management of terrestrial species and habitats. We discuss species management in the following Subpart.

3. Wildlife Management in the Context of Species Management—We distinguish species management—in which managers have authority to manage wildlife species at a larger landscape or ecosystem scale, across property boundaries—from land management, in which managers have authority to manage several aspects of natural resources, including wildlife, within their property boundaries.

FWS has broad authority over harvest and other take of migratory birds, under the MBTA,[291] and over endangered species, under the ESA.[292] In addition, FWS provides assistance to states in managing interjurisdictional fishes.[293] State wildlife agencies have authority to set harvest limits and enforce wildlife laws across their states, including harvest plans for migratory birds.[294]

Species management in coastal waters is divided among state and federal agencies. In coastal waters, states manage estuaries and the first three miles of water, including harvest of marine species in those waters.[295] NOAA manages waters between three miles and two hundred miles off shore—the bulk of the EEZ.[296] NOAA oversees fisheries management under the Magnuson-Stevens Fishery Conservation and Management Act,[297] working jointly with states.[298] NOAA also manages marine mammals jointly with FWS under the Marine Mammal Protection Act (MMPA).[299]

Statutes that protect species rarely provide guidance with respect to desirable population sizes. Although the MBTA was created to protect migratory birds, it provides no clear guidelines to FWS concerning desirable population levels of these species. The Magnuson-Stevens Act directs NOAA to manage its fisheries for anadromous and highly-migratory

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fishes for optimum yield, but makes no specific statements about population levels that must be protected in the event that maximum-yield management fails to recover and maintain stocks.[300] The MMPA, alone among the broad taxonomic legal protections, makes provision for desirable populations levels; it directs NOAA and FWS to manage for optimum sustainable populations of marine mammals and provides direction for recovering depleted stocks to optimum sustainable levels.[301]

No specific provisions cover other migratory species including inland migratory fishes, migratory mammals, reptiles, amphibians, and invertebrates; these groups find their only protections through state game and non-game programs, land management, and the ESA. Conservation-oriented NGOs, particularly taxonomically specific NGOs such as Trout Unlimited, Ducks Unlimited, the Wild Turkey Federation, and the Rocky Mountain Bighorn Sheep Society work collaboratively to protect some or all species across the range of lands protected by their private, state, and federal partners.

Thus, species-specific management protects migratory species very unevenly, and results are not what a reading of relevant statues might suggest. Even where specific laws protect migratory species, only fish and marine mammals are protected at levels that might result in ecological relevance, and results on the ground indicate these levels are not necessarily easily achieved. Many species are not the focus of any program, and changes in their status might easily go unnoticed.

B. Management Tools for Conserving Migratory Species

Given the popular focus on technological gadgets and solutions of all kinds, the public could be forgiven for assuming that the routes and habits of migratory species are well known and that managers have finely developed strategies and techniques for supporting migratory species. As we suggest in the closing paragraphs of Part II, technology does offer a range of new tools for learning about migratory species, but the very fact of their novelty means they have been in use only a short time, and many are still prohibitively expensive to use on a large scale.[302] However, many more traditional techniques, and less expensive technologies are in use.[303] As in previous Subparts, we distinguish between managers of specific properties—here, called land managers, but encompassing those whose land is underwater—and those who manage wildlife. Within these categories, tools tend to be used by managers of all kinds (if costs permit)—whether working for private landowners, NGOs, or state or federal agencies.

1. Tools for Land Management—Land management encompasses a wide variety of activities that affect migratory species. Habitat management includes manipulation of hydrology and vegetation on terrestrial sites; of flow velocity, substrate, and cover in stream and lake sites; or of substrate and cover in marine sites.[304] Usually these actions are designed to provide food and cover.[305] Provision or protection of nesting or denning sites and other special needs may also require manipulation of hydrology and vegetation, but could also include provision of nesting structures, restricting public access to breeding or other aggregations areas (e.g., roosting sites for colonial birds, haul-out areas for marine mammals, portions of reefs best suited for nursery habitat). Land management to protect

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migrants may also involve managing disturbance regimes (e.g., fire, flood, grazing, mowing, and tidal influences), and control of invasive plants and animals. Land acquisition by public land agencies can be used to target sites of particular importance to migrants. Within property boundaries, enforcement of hunting, fishing, and other protection laws is also an important form of management. Collaboration among agencies and between agencies and the public can serve to enlarge the effective area available for conservation and improve the landscape properties of the network of managed lands. Several land management agencies have outreach programs that assist private landowners in creating or restoring wildlife habitat are particularly useful in increasing habitat availability for migrants.[306] Public education is also useful in creating public support and for recruiting private landowners to use outreach assistance programs.

2. Tools for Species Management—When linked to specific properties, species management concerns will include the points listed in the previous Part. However, managers responsible for protecting migratory species throughout a jurisdiction—state, region, or nation—must consider the entire landscape of a migration and threats and obstacles that may occur at any point along the route within their area of responsibility. Short-distance migrants, particularly those whose migration is encompassed with the boundaries of a public property (e.g., salamander movement from forest to breeding streams,[307] snake movements to and from hibernacula)[308] can be managed very similarly to non-migratory species with multiple habitat needs. However, longer-distance migrants will pose additional challenges related to their needs during migration.[309]

Species management includes information gathering concerning species' demographics and species' ranges and movements. Research and monitoring programs, including citizen-science programs such as the North American Amphibian Monitoring Program, Christmas Bird Count, and Breeding Bird Survey, are some of the methods of learning about wildlife and fisheries demographics. Mark-recapture techniques are particularly useful for studying migration,[310] as are radio and satellite transmitters that can be attached to fish and wildlife in order to track individuals across the landscape.[311] When fragmentation has affected populations, translocations among existing populations may be used to bolster declining populations and enrich depleted gene pools. Creation of new populations with new migration traditions, such as teaching Whooping Cranes migration routes using ultralight aircraft, has been practiced for several years.[312] In other instances, new populations are specifically positioned so that migration will not be necessary, as a hedge for species in which migration mortality is problematical.[313]

Species management also includes a variety of mechanism to affect demographic processes. For harvested species, species management includes setting of hunting and fishing seasons, gear restrictions, and limits on numbers and kinds of animals to be harvested—typically age, gender, and size classes. Enforcement of hunting and protection laws also affects demographic rates. At a larger scale, FWS has committees that issue voluntary guidelines and assists with programs to reduce mortality to migratory birds from tall buildings, communications towers, wind farms, and other collision risks.[314] Finally, as with land management, outreach and public education are important to build public support and recruit private landowners to become part of the solution.

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3. Interjurisdictional, Landscape-Scale Management—For longer-distance migrants whose routes cross property, state, and international boundaries, conservation should include an assessment of the ability of the landscape along the entire migration route to support the species in question. Creating such landscapes is largely an exercise in collaboration among conservation organizations and recruitment of private landowners. For migrants that are FWS trust species,[315] FWS leads such efforts, drawing on such non-legislatively-created programs such as Partners in Flight,[316] and NGOs such as the Nature Conservancy and the Audubon Society, in addition to relevant state agencies.[317]

Among the federal lands, only the national wildlife refuges, through the NWRSIA, and the National Parks, through their policies, have a specific mandate to assess the conservation role of their managed properties in the larger landscape. The Forest Service and FWS have outreach programs to private landowners that can contribute to habitat management in the larger landscape that may benefit migrants.

At the state level, State Wildlife Action Plans (SWAPs) often provide a mechanism for collaborative conservation efforts.[318] Congress did not require that SWAPs address migrations; however, the collaborative structures that some states are developing serve as good models for the collaborative efforts needed to build landscape solutions to migration conservation.[319] State agencies can collaborate among themselves to manage species across state lines, but they can also draw on a much larger range of potential collaborators both to secure funding for landscape-scale efforts and to put together networks of properties on the ground to support migration. For species that migrate across international boundaries, or through the high seas, international collaborations provide the only method of conservation over the entire migration route. A variety of treaties already assist in such conservation, as discussed in the Part III of this Article. In addition, a variety of agency and collaborative programs exist to assist with conservation of migrants, but without force of law. Some of the former are listed in Part III; examples of the latter include Partners in Flight, mentioned earlier in this Part.

C. Migration Typology for Managers

In this Part, we develop a typology of migratory species similar to that constructed in Part II of this Article. However, whereas Part II uses the categories and distinctions arising from research results, our typology here arises from the concerns of land and wildlife managers.

Managers concerned with migratory species need to know the importance of managed land to the species in question. Species that complete their entire migratory route on a single property, such as many species of reptiles and amphibians,[320] can be considered resident species with potentially complex habitat needs.[321] Outside threats and the nature of the larger landscape will not affect the individuals on the property.

To migratory species that migrate longer distances along a broad front,[322] a small property along the migratory route may be relatively unimportant. In contrast, such a property may be much more important to a species with a narrow migration route, such as migratory pronghorn antelope (*Antilocapra americana*) whose migration route leads them through narrow valleys in Wyoming,[323] or shorebirds that rely on uncommon coastal mudflats.[324]

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Larger properties, by virtue of their size and the increased habitat diversity they typically contain, are likely to be of importance to a larger range of long-distance migrants.

Managers providing stopover or pass-through habitat to long-distance migrants will be concerned with the timing of the migration and the nature of species' needs along the migratory route. Short-term measures such as road closures or careful hunting guidelines may be all that some migrants—particularly those that do not feed during migration—need to pass safely in sufficient numbers.[325] For species that feed during migration, habitat management along the route may include providing food resources necessary for completing their journey.[326] Food resources are less often provided for migratory species that are predatory, such as hawks and owls.[327]

Connectivity needs of migrants will determine whether a series of "stepping stone" safe havens provides adequate protection, or whether some more continuous corridor or network is needed. Managers need information on the nature of obstacles species may encounter on migration. Migrating fish have been entirely eliminated from rivers due to dams that prevent migration to spawning areas.[328] Large mammal migrations have been frustrated by fences.[329] Migrations may pass through natural or anthropogenic physical bottlenecks, or natural bottlenecks rendered more dangerous by human actions such as habitat fragmentation. Such high-risk areas may be rendered safer through acquisition efforts to bring the land into conservation ownership under a government agency or NGO, or efforts to secure conservation easements on land that otherwise remains in private ownership.

Sources of mortality that are specific to migration, or that are more prevalent along migratory routes must be addressed to ensure conservation of migrants and migrations. For hunted species, information about nonhunting mortality can be used to adjust hunting seasons and take limits. Migratory birds and bats often face increased mortality on migration due to obstructions such as fences, power transmission lines, skyscrapers, and wind power turbines. The latter are particularly likely to be concentrated along flight lines, as migrants often take advantage of favorable winds that are also attractive for wind power.[330] Polluted waters and ponded oil are also threats to these species.[331]

Climate change increasingly affects phenology (timing) and demographics of migrants.[332] Research suggests that species with plastic responses to climate change respond most rapidly to climate change.[333] Thus, managers can benefit from information concerning the plasticity of migration to prioritize efforts and to predict where and when migrants may alter their routes or endpoints.

Finally, managers need information about diseases faced and carried by migrants, both to protect migratory species and to protect human populations. Long-distance migrants can serve as effective vectors of novel diseases. Most of these are diseases that do not jump to humans, but may threaten resident wildlife species, as well as those migrant species that carry the disease. The recent emergence of white-nose syndrome in bats clearly demonstrates the devastating mortality that may result in these instances.[334] Affected populations of the common little brown bat (*Myotis lucifugus*) have been reduced by over ninety percent, and, in some instances, eliminated altogether.[335] When diseases can jump to

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humans, wildlife managers and human health workers need to share information quickly to ensure that human populations are protected in a timely fashion. Efforts against avian influenza provide a good model for such work.[336]

V. Discussion

The typologies we have presented here serve different user groups. It would be surprising if they were entirely parallel in their structure and range. However, in order for migrants to be well protected, scientists must address the information needs of policy makers and managers; policy makers must craft laws and policies that incorporate scientific information and management realities, and managers must integrate scientific information into management strategies, guided by the laws and policies that outline their responsibilities. Among scientists, only those scientists employed by or working with land and wildlife management agencies answer to the information needs of the managers and policymakers of the agencies and the publics they serve. All wildlife managers, in contrast, are limited in what they can contemplate by laws and policies that dictate their powers and responsibilities. The boundaries between management and law are thus somewhat fuzzy, and the communication potentially asymmetrical; whereas managers are bound to follow law and policy, policy makers are not required to consult at length with those whose options they affect.

The existence of gaps within and among research, law, and policy disciplines has clear implications for conservation of migratory species. The present plight of eastern migratory bats serves as a harsh reminder of these. This group includes the Indiana bat (*Myotis sodalis*), an endangered species that migrates up to 500 kilometers from summer habitat in deciduous forest to hibernacula in caves and mines.[337] Despite the endangered status of Indiana bats, and despite U.S. responsibilities under the MBTA, mortality of bats and birds caused by wind turbines was addressed by FWS only through advisory guidelines until an Indiana bat was found dead near a wind turbine in 2009.[338] This finding coincided with the beginning of what seems destined to be a nationwide outbreak of a new epizootic—white-nose syndrome (WNS)—which causes approximately forty percent mortality of Indiana bats in areas that it invades,[339] and greater than ninety percent mortality of the once-abundant little brown bat.[340] At least in the Northeast, little brown bats may in the future be listed under the Endangered Species Act, and the wind turbines that have been known for several years to kill thousands of bats[341] will then be regulated under the ESA over the range of both Indiana bats and little brown bats.

The impact of white-nose syndrome on little brown bats was only discovered during counts initiated for Indiana bats.[342] Had monitoring data been collected for migratory bats more widely before white-nose appeared, we might be able to disentangle the presently confounded effects of turbines and disease, and we might have clearer understandings of the population trends of other once-common bats that may also now be declining rapidly.[343] However, bats are one of the groups of migrants for which no federal oversight exists, and as nongame species generally lacking in charisma, overstretched state programs have not generally tracked them. Thus, present knowledge concerning unendangered migratory

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species is a result of a patchwork of limited state efforts, and population trend information is largely lacking.

Stricter takings restrictions and more extensive research under the MBTA to protect migratory birds would have limited the number of wind turbines deployed, as turbines are a significant source of mortality;[344] researchers recently projected that each turbine will kill thousands to tens of thousands of bats by 2020 in some locations.[345] Now, with white-nosed syndrome suddenly causing catastrophic mortality in some bat species and significant mortality in others, and with wind turbines as an additional mortality source, wildlife managers have few legal mechanisms to protect previously common bats before they become endangered, and very little data with which to analyze the relative impacts of the various sources of mortality and determine the urgency of the resulting trends.

To date, the ESA is the only statute compelling acquisition of data on species trends and on white-nose syndrome generally, and the only statute with the potential to force regulation on turbines as a source of wildlife mortality, but the ESA only compels regulation for listed endangered taxa. On the science side, significant gaps in demographic information—trends and sources of mortality—hamper efforts to determine relative risks to nonendangered taxa; on the legal side, bats represent a significant gap in legislation protecting migrants; on the management side, managers lack the resources and initiative to track species that fall within their general but not specific responsibilities.

In this Part, we begin by identifying overlaps and synergies in the approaches of science, law, and management described in Parts II, III, and IV. Such overlaps are often incomplete and not surprisingly have different motivating interests. We then identify gaps within science, law, and management that currently hamper effective conservation of migratory species. We conclude by making recommendations where we find potential means of bridging these gaps and indicate the areas we believe represent long-term challenges.

A Synergies in Migration Research, Policy, and Management

Migratory species and migration hold different interests for scientists, the legal community, and wildlife managers, and the first three Parts of this Article illustrate the variation in the categories of knowledge that arise as a result. Nevertheless, areas of overlap also arise among the three fields. In some cases, as we will see, these are close matches in the mapping of species or behaviors. In other cases, superficial similarities break down upon closer investigation.

Science identifies distinctions among kinds of migrations and migrations without regard to the immediate usefulness of such distinctions for policy makers and managers. However, basic research has always been justified as an important undertaking in its own right,[346] and in a rapidly changing world, it is impossible to predict what research may suddenly become relevant.

The typologies of science include a number of distinctions of importance both to policy and to management. For example, information about the importance of specific sites to migratory species—whether the migration is broad-fronted or narrow-fronted, about

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migratory paths, and about habitat needs during migration—affects policy decisions to protect certain properties and certain habitats, and informs managers of the relative importance of properties and habitats for species of interest. In contrast, evolutionary information is less immediately obvious in its link to policy. Nevertheless, mechanistic information can be useful in some circumstances; information about the importance of sex hormones in regulating migratory behavior, previously of mostly academic interest, now suggest endocrine-disrupting compounds (EDCs), a class of environmental pollutants, may disrupt normal migration timing.[347] Thus, information about EDCs may become relevant to regulations that protect affected species or taxa and to managers designing monitoring programs to track timing and other aspects of migratory behavior.

Taxonomic distinctions may arise in laws protecting migratory species, such as the MBTA, MMPA, and the Magnuson-Stevens Act, but these statutes borrow the structure of scientific taxonomy for the purposes of responding to a strong public interest and may reflect historical patterns of resources use. Scientific information is needed in order to craft effective law for the taxa of interest, but efficient protection of migrants might suggest different taxonomic groupings in some instances. Thus, fish and marine mammals share many of the same difficulties as migratory species, yet they are protected by separate statutes on commercial grounds and present considerable differences in charisma. If whaling were still a common commercial enterprise, fish and whales might not have separate statutes governing their take and conservation. Similarly, migrating bats and birds presently share many of the same needs and threats. However, the MBTA was a response to historic take of birds for the millinery trade and for market hunting that caused no equivalent mortality for bats,[348] and certainly public interest in bats was not in evidence at the time. Despite the present parallels between the taxa, we are aware of no calls for broadening the reach of the MBTA beyond birds.

Statutes enabling or directing land acquisition for migrants use scientific information about needs of migrants to ensure effective acquisitions. Thus, much of the National Wildlife Refuge system is the result of acquisition of wetlands and riverine habitats to protect migratory birds, particularly waterfowl,[349] using funds from the Duck Stamp Act.[350] Statutes interpreting treaties (and extra legal programs protecting habitat for migrants) such as the Ramsar Convention[351] and the Western Hemisphere Shorebird Reserve Network[352] also work from the science concerning these migrants to determine what parcels best serve needs of target species.

As the examples above concerning broad-fronted migrations and endocrine-disrupting compounds indicate, management, like law, shares some of the typologies of science; however, it by no means shares them all. Information about partial and complete migrations may be less relevant for land managers, who will be more concerned simply to know that a particular species migrates to their properties than to know the specifics of which sexes and age classes will be most common. However, species managers concerned with a particularly vulnerable demographic, or those who set harvest restrictions on the basis of sex and age class will make use of the latter information as well as the former. Specifics such as which species pause on migration will be of use both to policymakers considering mechanisms to protect habitat needed in such locations and to managers who manage species and land.

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Knowledge of species' needs during migration pauses will be of use to managers, but also to designers and directors of incentive programs to increase food and cover for migratory species on private lands.

Until fairly recently, information about timing and cues for migration would have been of limited use to managers. The general timeframes of migration for major species were known, and could be considered relatively stable. However, managers can benefit from understanding how climate change may affect migration phenology, and from studies that reveal disconnects between related changes in phenology, such as migration timing that loses synchrony with important resources at the migration endpoint.[353] In this area, managers might benefit from considerably more data than is presently available or likely to become available in the near future. Presently, such fine-scale examples of climate change impacts to migrants have aroused no interest in the legal arena.

The preceding discussion suggests that most scientific information about migration and migratory species may be of at least some use to managers. Policymakers focus more specifically on information that helps them understand what constitutes risk for migratory species and how that risk is best reduced or mitigated. Conservation law, in contrast to regulatory law, generally leaves fine detail to the agencies to incorporate into policy guidelines; these are more easily modified to encompass new information.[354]

The interrelatedness of policy and management leads to similarities in their typologies because policy defines many aspects of management. Managers manage lands acquired to protect migrants, employ, and direct programs designed to assist migratory species, and design and enforce regulations against take and harm. In addition, managers make distinctions related to the tools and approaches available to them.

Overall, the wide-ranging interests of science often produce information of at least some use to managers. However, science is rarely exhaustive in producing parallel information for all migratory species, despite the fact that managers must protect them all. Management typologies draw more from applied than from basic science; many aspects of management typologies are motivated by the constraints and responsibilities created by legal statutes. These, in turn, are more likely to be responsive to political pressures and public interest than to scientific distinctions, some of which may be at odds with policy interests.[355]

B. Gaps in Migration Conservation

In Part I, we stated that effective conservation of migrants requires coordinated work by researchers, policy makers, and managers. Such coordination can be difficult precisely because the three disciplines view migrants differently, as we have illustrated in the previous Parts. Here, we identify places where efforts to conserve migratory species are incompletely coordinated among the three disciplines.

1. Gaps in Scientific Information to Support Conservation of Migratory Species—

The rich typology of migration that arises from scientific research amply demonstrates the wide range of areas of inquiries available for scientists to pursue. However, much of the information needed by managers in order to effectively conserve migratory

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species breaks little of the new ground of basic science. For example, the details of geographic pathways, migration timing, and behavior are needed for many species, but it is unlikely that simply establishing geographic detail for additional species will be of great interest to academic biologists, despite the fact that this information will be of fundamental importance to wildlife managers and policymakers. Further, from a scientist's perspective, much routine demographic or behavioral monitoring is not viewed as science, but as data collection in search of a question.[356] Instead, standard practice in science is to first develop research hypotheses that break new ground in explaining the natural world, then to collect the data necessary to assess the hypotheses.

Managers, in contrast, may need similar kinds of data for many species or contexts—at most modest new ground for science, but important for conservation of a diversity of species. Similarly, although year-to-year variation in behavior and demography is important to science from time to time in order to answer certain kinds of questions, it is of ongoing interest to managers in order to assess the status of the species they manage.

Harvestable migratory species attract considerable attention from managers and policy makers, but relatively little from basic science in part because their demographics are so strongly affected by human intervention that much of the science related to these species is, almost by definition, applied rather than basic in its direction. As is often the case, when basic science information does become available, as in studies of the evolutionary impact of harvesting systems on harvested species, the results are of interest to managers.[357] Other areas of human impact (e.g., bottlenecks in migration routes created by development and other land uses, obstacles and fragmenting effects) also create information needs for managers that are more often addressed by applied sciences such as wildlife ecology and management and conservation biology.

Managers can and do undertake to monitor wildlife species. However, most are not trained in the research methods and principles of study design needed for efficient monitoring, or in the more complex forms of analysis that may be needed to untangle the many factors affecting population size or behaviors such as migration timing.[358] In addition, most management agencies lack funds necessary to commit to the kind of consistent effort required to document long-term migration patterns through monitoring.[359] Adding to information needs, climate change and habitat alteration constantly rewrite the details of migrations, requiring that even well-described species be revisited and monitored at least from time to time if their migrations are to remain sufficiently well understood for effective conservation. Citizen scientists can accomplish some of this information gathering,[360] but not all of it. Partnerships of managers with academic scientists (most often, but not always, from applied disciplines) and with agency scientists can improve the quality of both monitoring and analysis, but such collaborations may require additional funds, and open-mindedness on all sides.

To close gaps between research science, the law, and management of migratory species, it will be important for conservation practitioners and scientists to identify ways to form collaborative research agendas aimed at establishing the basic geography of migratory routes and targeting unanswered questions in evolution, ecology, and animal behavior, including

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questions about the demography, seasonality, sociality, genetics, learning, and physiology of migrations. In addition to geography, these latter topics also represent important information needs for land managers that could enable more precise management strategies. Thus, it is not difficult to imagine future migration research projects that fuse basic and applied agendas. For example, future research examining the demographic and physiological mechanisms underlying the evolution of differential migration could simultaneously establish fine-scale geographic information for the species in question. Data collection protocols and analytic techniques established for such studies could serve as models for broader monitoring and research on additional species.

One method of motivating collaborative research to support policy and management needs of migratory species is by modifying existing funding mechanisms. Funds that support migration research come from a wide range of uncoordinated sources. Funding for migration that originates with national research funds provided by the National Science Foundation (NSF) or by scientific societies with specific taxonomic or disciplinary focus (e.g., the Animal Behavior Society, the American Ornithologists' Union) typically does not focus specifically on migration, and funding decisions typically receive little input from either policy makers or managers. These funding sources are focused on basic research, although the NSF has recently begun to assess broader impacts of proposals, in addition to the traditional criterion of the intellectual merit of the proposed research.[361] Conservation groups such as Bat Conservation International and Partners in Flight provide limited funding that may specifically focus on applied migration studies.[362]

Some current funding initiatives overlap with needs for migration research, but only narrowly. Presently, climate change research is well supported by basic research funds from both private foundations as well as United States federal government agencies, including, but not limited to, the National Aeronautics and Space Administration, NSF, the Department of Energy, and the Department of Commerce.[363] However it seems that most of this research is focused on atmospheric, physical, and environmental sciences, with less emphasis placed specifically on biological research.[364] Although some methods to predict future habitat and impacts to resources used by migrants are being refined by information generated in climate change research, other aspects of migration are not consistently funded through these sources. Similarly, new Department of Interior research centers focused on climate change (e.g., the National Phenology Network; the National Climate Change and Wildlife Science Center)[365] and the National Institutes of Health in their focus on wildlife disease vectors,[366] will provide useful information for managers but only within the narrow area in which their work intersects with topics in migration.

The Department of the Interior (primarily through the Biological Resources Division of the USGS),[367] the research arm of the Forest Service, the states (e.g., from the SWAPs),[368] and programs designed to support hunting and fishing (Pittman-Robertson and Dingell-Johnson funds[369]) support research that generally seeks to meet wildlife and land management needs of state and federal natural resource agencies. However, migration studies are not broadly identified as a priority for such research.

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Overall, migration research could serve conservation needs more consistently and efficiently with additional coordination among funding sources. As outlined in the conclusion to Part I, present research directions include, but are not at all limited to, areas that would benefit conservation of migrants and migration. A collaborative effort among major stakeholders interested in research outcomes could identify both high-value targets and low-value targets, without interfering with autonomy of the funding sources. High-value targets include the poorly known migratory routes of economically, ecologically, and culturally important marine species (e.g., whales and fish stocks), and low-effort information targets, include the arrival and departure dates of easily observed migratory birds (which could be obtained via low-cost citizen-science efforts). Such an effort, perhaps in the form of a regular workshop or conference session, could be facilitated by FWS, the USGS, or by an NGO with relevant expertise.

2. Gaps in Laws and Policies—Migrations occur over an enormous range of geographic scales, from migrations up and down trees by tropical tree frogs that breed on the ground, to hemisphere-spanning migrations of birds and marine species. Laws and policies have a difficult task in protecting long-distance migrants, because these species tend to cross more political and ownership boundaries. They therefore need more or higher-level (e.g., federal or international) protection than shorter-distance migrants. Shorter-distance migrants, as in the case of some reptiles and amphibians, are more easily protected within a single jurisdiction, or even a single property; however, some obvious vulnerabilities remain. Here, we identify threats to migrants that are correlated with geographic scale, such as difficulties of coordination across political boundaries, as well as other threats that exist across many geographic scales, such as habitat fragmentation. We differentiate between obstacles that physically impede animal movements, such as fences and dams, and thus act to fragment landscapes, and obstacles that are sources of mortality that threaten the integrity of populations of migrants, such as legal and illegal take and collisions with wind turbines. We identify gaps in existing policies and laws, and discuss the relative ease with which these gaps can be addressed.

a. Gaps in Addressing Fragmentation and Obstacles: Habitat fragmentation[370] and obstacles can affect migrants at almost any geographic scale. Fragmentation may be caused by changes in land cover—conversion of land to agriculture, expansion of urban areas, impacts of climate change. Obstacles may contribute to fragmentation by impeding movements across and over landscapes or through waterways; alternatively, they may limit the numbers of individuals that successfully complete such movements not by blocking movement but by increasing mortality.[371] The daily migrations of plankton are, perhaps safe from fragmentation for now, as are the brief migrations of tropical tree frogs from the tops of the trees to the puddles at their bases. However, many short, overland migrations are impeded by roads—particularly those of reptiles and amphibians moving among wetland complexes, or between wetlands and uplands.[372] These species are also vulnerable to loss of wetlands, which may increase the distance they must move in order to breed. This increases exposure to roads and to predators, as well as simply reducing habitat availability. The reduction shrinks populations and increases the risks of inbreeding and chance extinction. Fences can be serious obstacles to migrants, but they are often an unavoidable aspect of

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rangelands. Fences have caused significant mortality by preventing necessary migrations in North America and in Africa.[373] Aquatic migrants face dams that reduce or eliminate their ability to complete migrations.[374]

Roads can be rendered permeable to overland migrants through the use of raised stretches and culverts that permit passage under the roadbed, but raised roads are usually prohibitively expensive, and predators can learn to exploit narrow corridors such as culverts.[375] Fencing can be rendered more permeable[376] or removed entirely, but since fencing often occurs on private lands, such changes may be difficult to achieve over large areas.[377] One fence erected by one landowner can have disastrous consequences for a migrating population.[378] Dams eliminate or curtail normal migratory routes of fish, and the success of mitigations depends on the particular circumstances.[379] In both the terrestrial and aquatic situations, some obstacles can be mitigated, but not all.

Obstacles that do not fragment habitat by impeding movement still imperil migrants and migrations by killing individual migrants, in some cases in large numbers.[380] Aerial migrations of bats and birds are threatened by mortality caused by obstacles such as fences, wind turbines, communications and energy transmission towers, and tall buildings.[381] As these vertical obstacles multiply on the landscape, more and more migration paths are likely to intersect them, particularly because migratory flight paths are often characterized by consistent winds and high ridges that are high-quality sites for wind energy and transmission towers.[382] Sometimes managers know how to reduce the impacts of such obstacles, but the techniques are not systematically applied, particularly when they increase costs, and there is no legal mandate to do so. Sometimes the solution is not apparent.[383] Bird migrations also face considerable legal and illegal harvest mortality, sometimes along the entire migration route, as is the case for migratory waterfowl, and sometimes only at certain bottlenecks or over certain countries where such hunting is acceptable.[384]

Aquatic migrants face obstacles that cause mortality in the form of legal and illegal harvesting by weir, net, and hook. Some aspects of bycatch during legal harvest have been significantly reduced by technology, such as devices that exclude sea turtles from fishing nets or frighten sea birds away from the baited fishing hooks on longlines during deployment,[385] but many migratory species still face substantial legal mortality.[386]

Land-based obstacles such as roads, fences, turbines, and towers are either typically in the legal purview of federal agencies without primary responsibility for wildlife conservation, such as the FCC's regulation of towers,[387] or are otherwise left for state and local governments to regulate. Federal laws that can significantly influence siting decisions for such obstacles are primarily those that explicitly forbid take—the MBTA[388] and ESA—although section 404 of the Clean Water Act[389] and section 4(f) of the Department of Transportation Act of 1966[390] also have some influence on siting decisions. The ESA and MBTA are limited tools for regulating fragmentation and obstacles. The ESA cannot be used to protect the great many migrations that are declining but not yet on the brink of extinction, although such migrants may in some circumstances benefit from ESA habitat conservation plans and recovery plans for already-listed species. The MBTA's reach does not require migratory bird populations to be threatened with extinction before sanctions can be imposed,

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but the MBTA, unlike the ESA, cannot be used to regulate land use directly through permitting of incidental take, although the agency can leverage the MBTA to control siting and design through the exercise of enforcement discretion. Federal laws and policies thus provide few tools, other than perhaps financial incentives, to reduce fragmentation and obstacles to migration and mortality to nonendangered species.

Public lands can be managed, at least in part, in ways that reduce fragmentation, but even national parks can be crossed by power lines when the need is judged to be sufficiently strong.[391] Although individual land managers of agencies can more freely manage migration obstacles on their own properties, they generally cannot affect decisions on private lands that cause obstacles to be constructed, other than through education and other forms of persuasion.[392] Note, however, that the Property Clause of the United States Constitution allows the federal government, to some extent not yet fully delineated, to regulate activities on private and state-owned land if the regulated activities threaten the designated purposes of the public land.[393]

Acquisition of property interests is a powerful tool for reducing fragmentation and preventing the imposition of obstacles on the landscape. Acquisition has limitations as a means to combat fragmentation, however, and we have too few funds and too little public forbearance to acquire our way out of the problems faced by migrants. Considerable participation by the public and particularly by private landowners will be needed to ensure long-term protection at the necessary scale.

The acquisition approach by itself also fails to protect migrants from obstacles such as towers, buildings, or wind turbines—there are simply too many such obstacles to solve the problem by acquisition. States have substantially more authority under their police powers to regulate such obstacles, and local governments generally may regulate siting and construction of obstacles under such powers delegated from the state, provided that the subject area is not already regulated by the state. The problem with state and local regulation of migration obstacles is that this strategy does not answer the need for uniform standards and best management practices on the design and operation of such obstacles.

b. Jurisdictional Gaps: Migrants, particularly those that move over long distances, experience multiple jurisdictions as they cross state or national boundaries, or the boundaries of agency jurisdictions. As an example, species that migrate through water for at least part of their journey can encounter several jurisdictions, even at relatively small geographic scales: when migrants move from water to land they may cross jurisdictions from state-managed waters to privately-managed land. In a move from near-shore coastal waters to outer coastal waters to the high seas they pass from state jurisdiction to federal jurisdiction and then to waters governed only by international treaties.

Inland migratory fishes are largely under state management, but are affected by federal agencies that manage dams. FWS views inland migratory fishes as trust species, but has no current legal authority over them, and instead provides assistance to those agencies that do have authority. Such assistance does not necessarily unify management: the Mississippi River migratory fishes are the subject of at least three voluntary umbrella management

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organizations, all involving FWS: the Upper Mississippi River Conservation Committee, Lower Mississippi River Conservation Committee, and the Mississippi Interstate Cooperative Resource Association.[394]

Fragmented jurisdiction over migratory populations makes migrations more difficult to protect. Other than consultation provisions such as section 7 of the ESA, a handful of federal executive orders and interagency agreements, and a limited number of regional associations among states, the problem of jurisdictional fragmentation remains an obstacle to providing uniform and coordinated protections for migratory populations as they move through their migration cycle.

c. Taxonomic Gaps: To date, in the United States, birds (MBTA) and marine mammals (MMPA) have the clearest legal protection at the federal level, followed by migratory sport and commercial fish species (Magnuson-Stevens Act). However, migrating terrestrial mammals, including several species of big game and bats (several of the latter migrate internationally), are presently protected only by extralegal mechanisms such as the collaboration supported by the Western Governor's Association[395] or by collaborative programs such as the Program for the Conservation of Migratory Bats of Mexico and the United States.[396] Migratory insects also lack any overall coordinated protection. Although monarch butterflies are the focus of a host of national and international programs, they still suffer considerable loss of habitat,[397] and no program and little research deals with migrating dragonflies or other insects.

d Gaps in Spatial Coverage: Just as the legal structures that seek to protect migrants specifically or biodiversity generally leave important taxa unprotected, and protect others at levels that do not fully protect society's values for migrants, protected lands systems leave important gaps in spatial coverage for many migratory species. Of the federal lands systems, only the National Wildlife Refuge system has been shaped with any emphasis on migrants, and even the refuges have a stronger focus on migratory birds, often with a special emphasis on migratory waterfowl.[398] Some states are collaborating to protect migration corridors,[399] but such efforts are relatively new for state wildlife agencies. Marine protected-area systems have also not been designed with migrants in mind, and the jurisdictional boundaries of the oceans are no more conducive to effective conservation than are international boundaries on land.

e. Limitations on Protection at Ecologically Relevant Levels: Even when statutes and programs exist to protect migratory taxa, they do not protect all the aspects of migration that may have value to the public: economic, social, psychological, ecological, etc. Protecting these public values of migrations may require abundances well over minimum viable populations, possibly even approaching historical levels. Present programs have not consistently protected populations near historical levels except in the case of migratory waterfowl. Indeed, only the MMPA and Magnuson-Stevens Act have specific statutory language describing desirable population sizes; agency discretion is the only other source of such standards. The various laws that deal with migrants tangentially, as a part of larger biodiversity targets, do not close the gap.

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f Summary of Law and Policy Gaps: Overall, existing laws and policies protect migratory species unevenly among taxa, among geographic scales of migrations, and across ownership and political boundaries. Jurisdictional fragmentation, landscape fragmentation, and sources of mortality all create substantial roadblocks to efficient conservation, particularly for long-distance migrants.[400] Migratory species and migration as a phenomenon are no more a strong focus of legal research and activity than they are a strong focus for scientific research. Where laws do provide protection, they rarely do so at abundance levels that protect the ecological roles or social values of the species in question. Existing laws are not entirely without merit however, and in some instances, could be strengthened by amendment, or by modification of the policy guidelines that interpret the statute. For example, as we discuss above, the MMPA and Magnuson-Stevens Act provide better-than-average protection to their respective taxa, and can serve as models for improving other protective statues or for drafting new ones. Wherever changes in laws and policies are undertaken to address the gaps we identify above, policy makers must require development of standards and management practices to ensure efficient and effective conservation, and provide suitable timeframes for their implementation. Without such requirements, agencies cannot be held accountable for meeting legislative goals.

3. Gaps in Management Focus and Needs—Management agencies have the option, through the policies that interpret their respective organic acts, to make explicit provision for migratory species, but no mandate exists to force such consideration. Trust species of FWS or management indicator species for individual national forests receive research attention at least, and legal protection for a few, as do species protected by state and federal ESAs. Otherwise, migration as a phenomenon and migrants as a potentially vulnerable class of species receive no specific attention, as we discuss in more detail in the previous Part on laws and policies.

Even if managers were inclined to extend additional protections to migrants, such as through targeted land management actions, information is often lacking to provide important details for such plans. Managers can assist in conservation of migrants by identifying important information gaps they encounter, and by undertaking monitoring or collaborating in monitoring and by communicating the need for monitoring to address information gaps to their agencies and to the public. Monitoring often lacks excitement and does not attract the kind of public support needed to develop long-term databases needed to detect trends in timing, behavior, and population size of migrants.

C. Improving Conservation of Migrants and Migrations

If we take as our goal the protection of migrations as phenomena of abundance, with their attendant social values and ecological roles intact to the greatest extent possible, then policy and management must seek to protect these species at levels far above minimum viable population sizes, and thus above the levels available to all species through the Endangered Species Act. However, policy targets for abundance are virtually nonexistent in the United States, except in the case of game species or as aspirational targets, rather than targets supported by enforceable standards with accompanying best management practices.

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The concept of “keeping common species common” is a useful one as we contemplate conserving migratory species at ecologically meaningful levels and migrations as phenomena of abundance. The phrase was the early motto of the GAP analysis program[401] and more recently is widely used as an explanation of the role of the state wildlife action programs, which seek, as a primary goal, to reduce the need to use the Endangered Species Act, with its attendant impacts on commerce.[402] Apparently, the notion that abundance may need protection is spreading, despite the fact that it would seem to indicate relative invulnerability. However even this apparent sign of progress has weaknesses in the creeping baseline that accompanies our understanding of commonness and abundance. John Terborgh, a noted conservation biologist, writing in *Where Have All the Birds Gone*, begins by discussing the abundance he experienced as a child of suburbia surrounded by frogs and songbirds and describes how that abundance slowly slipped away, arousing almost no comment in its passing, so that the present generation would be astonished at what was commonplace in his youth.[403]

State-level programs such as the State Wildlife Grant program and the Coastal Zone Management Act[404] provide existing models that may serve as useful starting points for improved conservation of migratory species. Unfortunately, as we earlier discussed, state-level programs are not ideally suited to protect long-distance migrants that cross state and international borders. Nevertheless, the state programs provide a good starting point. State management entails both land management and species management, and federal land management generally includes consultation with state agencies where it affects resident wildlife. A federal coordination program designed to link state, federal, and, where appropriate, international efforts could help to bridge the gaps in existing programs without too cumbersome a bureaucracy. Managers currently have difficulty securing migratory species because they manage lands, not migrations, or they manage species but at too small a scale to manage migrations. A federal overlay would provide the national scale, and, as treaties are handled at the national level, also the international scale needed for conservation of long-distance migrants. As FWS and NOAA currently comanage threatened and endangered species, they make good candidates for a similar parallel effort to provide oversight for migratory species. A program adjunct or parallel to the state wildlife grants would provide incentives for states to extend their efforts on behalf of migrants, similar to existing, relevant incentives for multi-state efforts.[405]

One limitation to working from a basis of the present state wildlife action plans or coastal-zone management plans is that statutory criteria for federal approval of the state plans lack the detail that would be required to mandate consistent standards or practices. For example, although state wildlife action plans are required to identify actions to be taken to conserve species and habitats identified as having the greatest conservation need, states need not actually set forth standards or practices in their actions plans. Strategic rather than operational language is typical in action plans, and as a result the federal government has limited ability to ensure consistent standards and practices across states using the mechanism of the state wildlife action plans. FWS could develop incentives for developing and implementing practices applicable to migration conservation—for example, to work towards consistent standards across states in the design and operation of wind turbines to reduce their impact on migratory bats[406]—as part of the State Wildlife Grants that fund the

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action plans. Such incentives might be effective where adopted, but the use of an incentive, alone, does not guarantee adoption by all states. Regulations that establish management bottom lines are often critical to the success of cooperative conservation efforts between federal and state entities.[407]

The benefit of an assisted, state-based approach is that it is likely to help many migratory species, so long as funding and assistance is prioritized at a landscape scale. Moreover, this approach may be the type of conservation law most likely to be enacted in the current political climate. One drawback, however, is that it may be used as a default approach even when other legal approaches may be more effective as well as politically possible. Conservation of migrations or parts of migrations contained within United States borders and that cross multiple states and jurisdictions may require a greater degree of federal motivation and guidance than is typically provided in existing assisted state programs.

Thus, a state-based program, as a new program or as an addition to an existing program, with federal assistance and oversight, enforceable standards, and strong collaboration provides a good starting point for conservation of migratory species within the United States. Collaboration, not only among management entities but also among researchers, managers, policy makers, and the public will be needed both to develop the program and to ensure its long-term success. Such a program would, for example, begin to protect migratory bats, by developing monitoring programs to provide baseline information, encouraging research to disentangle effects of mortality from multiple sources, encouraging and, when possible, enforcing, best management practices. Such practices would reduce harm, as through modification of turbines and towers, and increase benefits, as through the protection, on public and private land, of breeding sites, food sites along migration corridors, and hibernacula.[408]

To reduce duplication of effort and support learning among practitioners, an information clearinghouse would be helpful, to link managers, legal scholars and practitioners, researchers, and citizen scientists interested in migrants. A number of potentially useful models for sharing data and case studies are emerging in the field of climate change ecology.[409] Standard data publication through peer-reviewed literature is widely acknowledged to be too limiting for the less formal, less groundbreaking information exchange needed for such management problems.[410]

The recent Western Governor’s Association efforts to safeguard migratory game animals[411] and the plethora of informal programs supporting high-interest migrants together indicate the severity of the existing gaps in formal conservation of migratory species. Had existing expertise and capacity sufficed to solve the problem, informal efforts would not be needed—their existence indicates the level of support that can be brought to bear on behalf of migratory species. Stories about long-distance migrations pique the public’s interest and admiration, even when the subjects are migratory dragonflies. The emotional response to migrations as a phenomenon of abundance is demonstrated by the number of local festivals and other events organized around local migration phenomena. School children track individual migrants in real time, and interact with peers in other countries to help protect migratory species.[412] New efforts to coordinate and improve conservation of migrants and

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migrations should consider programs that improve social connectivity among people and communities along migration routes of all scales to build on this public support. Such support, in time, might also increase participation in private-lands programs, strengthening the network of lands that support migratory species.

VI. Conclusion

Migratory species are often highly visible and popular, but they also face high risks, and many have already experienced substantial declines. If conservation efforts are to halt declines and recover migratory species and their migrations to numbers that are socially, ecologically, and economically meaningful, scientists, policy makers, and natural resource managers must work together to address current gaps in needed scientific information, legal protections, and management capacity. Information needs are readily identifiable, and present technologies are increasingly adequate to address them, if funding can be made available to support the needed research and monitoring. Many gaps in legal protection from major sources of risk can be remedied by modifications to existing policy guidelines, without need to revisit the relevant statutes. Increased outreach and collaboration by natural resource managers provides opportunities both to address information gaps and to expand the spatial network of protected areas onto private lands. Finally, we suggest that state-level efforts provide a good starting point for a coordinated effort to improve conservation of the full range of migratory species within the United States, acknowledging that international efforts will be needed for the many species that cross international boundaries. Problems will arise due to lacks of funds, difficulties in securing a landscape that will support abundant migrations, lack of adequate standards and best management practices, and an insufficient culture of collaboration among the three main relevant disciplines. However, we view these problems as entirely soluble. Further, we see evidence in society at large of support for conservation of migratory species sufficient to encourage the changes we recommend.

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81. *Id.* at 139–40.
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97. Dingle, *supra* note 15, at 217, 354–55.
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107. *Id.* at 226–27.
108. *See* Operation Migration, Our Work: Whooping Crane Story, http://www.operationmigration.org/work_wcranes.html (last visited Apr. 10, 2011).
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110. Hoare, *supra* note 13, at 26–29.
111. *Id* at 22.
112. Marra, Hunter & Perrault, *supra* note 19, at 319 (discussing the importance of research to establish "migratory connectivity").
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116. Esterbrook, John. Global Warming Kicks Off a Migration. Jan 2. 2003 Cbs Newshttp://www.cbsnews.com/stories/2003/01/02/tech/main534993.shtml (last visited April 10, 2011)
117. Fischman & Hyman, *supra* note 27, at 196–97, 230–31.
118. Endangered Species Act of 1973, 16 U.S.C. §§ 1531–1544 (2006).
119. Although the ESA also is concerned with conserving the ecosystems upon which listed species depend, the species focus dominates implementation of the ESA. *See id* § 1531(b); Fischman & Hyman, *supra* note 27, at 190, 200, 203.
120. Neotropical Migratory Bird Conservation Act, 16 U.S.C. §§ 6101–6109 (2006).
121. Marine Mammal Protection Act of 1972, 16 U.S.C. §§ 1361–1423 (2006).
122. Migratory Bird Conservation Act, 16 U.S.C. §§ 715 (2006).
123. Migratory Bird Treaty Act, 16 U.S.C. §§ 703–712 (2006).
124. SeeSheldon, Karin P. Wildlife. Campbell-Mohn, Celia, et al., editors. 1993. p. 313Sustainable Environmental Law: Integrating Natural Resource and Pollution Abatement Law From Resources to Recovery 279Ruhl JB. Biodiversity Conservation and the Ever-Expanding Web of Federal Laws Regulating Nonfederal Lands: Time for Something Completely Different?. 1995:565. 66 U. Colo. L. Rev. 558. discussing three models of laws for federal regulation of nonfederal land use decisions: coercion, coordination, and cooperation.
125. Identifying gaps in existing U.S. laws, as presented later in this Article, can indicate deficiencies in international agreements with regard to migratory species that spend only a part of the migratory cycle in the United States. For example, if such a species is unprotected or underprotected by federal law, that may indicate a need for an additional international agreement to cover the species, a need for the United States to sign on to or properly implement an existing international agreement covering the species, or a deficiency in an existing agreement that is fully implemented by U.S. law but that leads to inadequate protection for the species. The next steps after identifying needs for U.S. law would be to identify precisely the reflected deficiencies in international agreements as well as the implementation deficiencies in other countries, but we consider these steps as beyond the scope of our purposes here.
126. Laws that require assessment of environmental impacts fit within the first approach as coordination and information generation and exchange tools. Examples include the National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321–4347 (2006), and the consultation and biological assessment provisions of section 7 of the Endangered Species Act of 1973. 16 U.S.C. § 1536 (2006).
127. SeeEcheverria, John D. Regulating Versus Paying Land Owners to Protect the Environment. 2005:20. 26 J. Land Resources & Envtl. L. 1, 11.
128. Cryan, Paul M. Wind Turbines as Landscape Impediments to the Migratory Connectivity of Bats. 2011:368. 41 Envtl. L. 355.
129. International agreements that call for funding of conservation projects and promote coordination and information exchange include the Inter-American Convention for the Protection and Conservation of Sea Turtles, Dec. 13, 1996, 2164 U.N.T.S. 29, and the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, Apr. 7, 1941, 56 Stat. 1354, 161 U.N.T.S. 193.
130. 16 U.S.C. §§ 6101–6109 (2006).
131. *Id.* §§ 6102(2)–(3), 6103(3), 6104(a); Div. of Bird Habitat Conservation, U.S. Fish & Wildlife Serv., Neotropical Migratory Bird Conservation Act, http://www.fws.gov/birdhabitat/grants/nmbca/ACT.shtm (last visited Feb. 4, 2011) (showing that the Department of the Interior delegated authority to the FWS to manage the grants program).
132. 16 U.S.C. §§ 6104, 6108 (2006).
133. *Id.* § 6104(c); *see also* Div. of Bird Habitat Conservation, U.S. Fish & Wildlife Serv., 2011 Proposal Application Instructions, http://www.fws.gov/birdhabitat/grants/nmbca/InstructionsENG.shtm (last visited Apr. 10, 2011) (listing criteria used in selecting projects).
134. 16 U.S.C. § 6105(3) (2006).
135. *Id.* § 6104(e).
136. *Id.* §§ 6102, 6106.
137. 33 U.S.C. §§ 2901–2909 (2006 & Supp. I 2007).

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138. *Id.* § 2903(a).
139. *Id.* § 2904(b). The Council is constituted of representatives from the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce, the U.S. Fish and Wildlife Service of the Department of the Interior, the Army, the U.S. Department of Agriculture, and the U.S. Environmental Protection Agency. *Id.* §§ 2902(9), 2904(c).
140. *Id.* §§ 2902(8), 2903(b).
141. *See id* § 2903(c)(1)–(2).
142. *Id.* § 2903(c)(1).
143. *Id.* § 2905; *see also* Final Estuary Habitat Restoration Strategy Prepared by the Estuary Habitat Restoration Council, 67 Fed. Reg. 71,942, 71,942–43 (Dec. 3, 2002).
144. 33 U.S.C. § 2903(d)(1) (2006 & Supp. I 2007). However, for the additional incremental cost of demonstrating or testing an "innovative technology," the government's share is eighty-five percent. *Id.* § 2903(d)(2).
145. 16 U.S.C. §§ 3771–3774 (2006).
146. *Id.* § 3771(b).
147. *Id.* § 3773.
148. In some situations, the project funding and assistance approach can be usefully implemented without any requirement of an associated conservation plan, such as where the United States funds projects in other countries or where federal agencies develop an overarching plan into which state or local projects must fit.
149. *See* Cryan, *supra* note 128, at 365; Interim Voluntary Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines, 68 Fed. Reg. 41,174, 41,174–75 (July 10, 2003).
150. 16 U.S.C. §§ 1451–1466 (2006); 15 C.F.R. §§ 923.1, 930.1 (2010).
151. 16 U.S.C. § 1455(a)–(c) (2006).
152. *Id.* § 1456(c)(1)(A).
153. *Id.* § 1453(16) (defining the "Secretary" referenced in section 1454 as the "Secretary of Commerce"); *Id.* § 1454 (noting that the state program and plan are submitted to the Secretary).
154. *Id.* § 1455(d)(2)(B)–(E), (13)(A)–(B).
155. *Id.* § 1456(c)(2) (federal agencies); *Id.* § 1456(c)(3)(A) (applicant for federal license or permit); *Id.* § 1456(c)(3)(B) (any person submitting plan for exploration or development).
156. 16 U.S.C. §§ 2901–2911 (2006); *see also* U.S. Fish & Wildlife Serv., Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service, http://www.fws.gov/laws/lawsdigest/fwcon.html (last visited Apr. 13, 2011) (noting that the FWCA provided for comprehensive state wildlife plans). The regulations implementing the FWCA were recently removed from the Code of Federal Regulations because no funds have been or are projected to be made available under the FWCA. Removing Regulations Implementing the Fish and Wildlife Conservation Act, 75 Fed. Reg. 51,420, 51,420 (Aug. 20, 2010).
157. *See* 16 U.S.C. § 669c(d)(1) (2006). The Fish and Wildlife Programs Improvement and National Wildlife Refuge System Centennial Act amended the 1937 Pittman-Robertson Wildlife Restoration Act and the 1950 Dingell-Johnson Sport Fish Restoration Act. Fish and Wildlife Programs Improvement and National Wildlife Refuge System Centennial Act of 2000 pmbl., Pub. L. No. 106–408, 114 Stat. 1762, 1762 (2000).
158. U.S. Fish & Wildlife Serv., State Wildlife Grant Competitive Program: FY 2008 and FY 2009, at 1 (2009), *available at* http://wsfrprograms.fws.gov/subpages/grantprograms/swg/SWG-NOFA20082009.pdf; *see also* U.S. Fish & Wildlife Serv., State Wildlife Grant Program – Overview, http://wsfrprograms.fws.gov/subpages/grantprograms/swg/swg.htm (last visited Apr. 13, 2011).
159. 16 U.S.C. § 669c(d)(1)(D)(iii) (2006) (identifying the problems that may impact the species and habitats); *See id.* § 669c(d)(1)(D)(iv) (determining actions necessary to preserve those species and habitats, and setting priorities for action); *Id.* § 2903(3)–(6); *see also* 66 Fed. Reg. 7,657, 7,657–58 (Jan. 24, 2001) (listing the requirements discussed); Ass'n of Fish & Wildlife Agencies, State Wildlife Action Plans, http://www.wildlifeactionplans.org (last visited Apr. 13, 2011).

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160. *See* U.S. Forest Serv., Dep't of Agric., Environmental Assessment: Bridger-Teton National Forest Land and Resource Management Plan Amendment: Pronghorn Migration CORRIDOR i (2008) (proposing to designate a Pronghorn Migration Corridor on lands within the Pinedale and Jackson Ranger Districts of the Bridger-Teton National Forests so as to facilitate continued successful migration in that region); U.S. Forest Serv., Decision Notice & Finding of No Significant Impact: Pronghorn Migration Corridor Forest Plan Amendment 1 (2008); *see also* Wildlife Corridors Conservation Act of 2010, H.R. 5101, 111th Cong. (2d Sess. 2010) (proposing an animal movement corridor).
161. *See, eg,*Berger, Joel. The Last Mile: How to Sustain Long-Distance Migration in Mammals. 2004:326. 18 Conservation Biology 320. calling for a formally designated national wildlife migration corridor. Kittatinny-Shawangunk Nat'l Raptor Migration Corridor Project, Home, http://www.raptorcorridor.org (last visited Apr. 10, 2011) (calling for a federally designated Kittatinny-Shawangunk National Raptor Migration Corridor). *See generally*Cherney, David N. Securing the Free Movement of Wildlife: Lessons from the American West's Longest Land Mammal Migration. 2011:615. 41 Envtl. L. 599. noting the combination of public and private land designation in protecting a migration corridor for pronghorn, and the important political attention that has resulted from this process.
162. For example, a few hundred pronghorn antelope annually migrate from the Green River Basin in Wyoming to Grand Teton National Park along a corridor that physically narrows to less than a few hundred meters wide. *See* Berger, *supra* note 161, at 324. American Red Knots spread across a large area of the Canadian Arctic during the breeding season, but for the rest of the year they occur mainly in large flocks at a limited number of key coastal sites. Div. of Fish & Wildlife, Endangered & Nongame Species Program, N.J. Dep't of Envtl. Prot., Status of The Red Knot (*Calidris Canatus Rufa*) in the Western Hemisphere ii–iii (2007), *available at* http://www.state.nj.us/dep/fgw/ensp/pdf/redknot_status07_body.pdf. While migrating, Red Knot populations depend on a limited number of stopover sites, the Delaware Bay area being the largest known spring migration stopover area. *See* COASTAL MGMT. PROGRAM, N.J. DEP'T OF ENVTL. PROT., POTENTIAL EFFECTS OF WIND TURBINES ON BIRDS, BATS, AND MARINE ORGANISMS IN NEW JERSEY'S COASTAL ZONE 1, 5 (2010), *available at* http://www.state.nj.us/dep/cmp/sections-3-potential-effects.pdf. Migratory Sandhill Cranes aggregate along a 75-mile stretch of the Platte River in Nebraska during staging for the spring migration northward. Int'l Crane Found., Sandhill Crane, http://www.savingcranes.org/sandhill-crane.html (last visited Apr. 10, 2011).
163. Acquisition includes fee ownership as well as partial interests in land such as conservation easements. Migratory Bird Conservation Act of 1929, 16 U.S.C. § 715d (2006); U.S. Fish and Wildlife Serv., Dep't of the Interior, Budget Justifications and Performance Information Fiscal Year 2010, at MBC-2 to -3 (2010), *available at* http://www.fws.gov/budget/2010/2010%20Greenbook/FY%202010%20Green%20Book%20final.pdf.
164. 16 U.S.C. § 715a (2006).
165. *Id* § 715c.
166. *Id*. § 715k-5.
167. *Id*. § 715i(b).
168. North American Wetlands Conservation Act of 1989, 16 U.S.C. § 4401(b) (2006).
169. The Ramsar Convention establishes criteria for designating rivers, marshes, coral reefs, and other areas as a "wetland of international importance." Any government, group, community, private organization, or landowner can nominate a site for inclusion on the Ramsar List. Convention on Wetlands of International Importance Especially as Waterfowl Habitat art. 2, Feb. 2, 1971, 996 U.N.T.S. 245. Twenty-seven sites have been designated in the United States (including the Everglades). Ira Seligman, *Ramsar and the Ugly Duckling of Ecosystems*, U.S. Fish & Wildlife Serv. Endangered Species Bulls., Spring 2010, *available at* http://www.fws.gov/endangered/news/bulletin-spring2010/ramsar-and-the-ugly-duckling.html.
170. *See* Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere art. 2, Oct. 12, 1940, 161 U.N.T.S. 193 (stating that the parties agree to "explore at once the possibility of establishing in their territories national parks, national reserves, nature monuments, and strict wilderness reserves," and where such establishment is feasible, "the creation thereof shall be begun as soon as possible after the effective date of the present Convention").

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171. 16 U.S.C. § 4401(a) (2006).
172. *Id.* §§ 4403–4404.
173. *Id.* § 4405(a)(2).
174. *Id.* § 4405(a)(3).
175. *Id.* § 4405(b).
176. Incidental take is take that occurs during the exercise of an otherwise legal activity (i.e., where the individual is not targeted for taking). 16 U.S.C. § 1539(a) (2006).
177. Almost the entire migrating population of American Red Knots congregates at Delaware Bay during their spring migration from wintering grounds in South America to breeding grounds on the Arctic tundra. *See, e.g.*, LAWRENCE J. NILES ET AL., COOPER ORNITHOLOGICAL SOC'Y, Studies in Avian Biology no. 36, Status of the Red Knot (*Calidris Canutus Rufa*) in the Western Hemisphere 19 (2008).
178. Adult grouper live solitary lives, living and feeding in coral reefs, but during the winter months of November to March, just before the full moon, they migrate long distances, sometimes hundreds of miles, to specific locations where they group together in large numbers to breed. Leslie whaylen et al., 57th gulf and caribbean fisheries institute meeting proceedings, aggregation dynamics and lessons learned from five years of monitoring at a nassau grouper (*epinephelus striatus*) spawning aggregation in little cayman, cayman islands, bwi 4–5 (2006).
179. The eastern North American population of 100–500 million monarch butterflies overwinters in dense clusters on the boughs and trunks of trees at about 30 known high-elevation sites in a small area of central Mexico. Lincoln P. Brower et al., *Quantitative Changes in Forest Quality in a Principal Overwintering Area of the Monarch Butterfly in Mexico, 1971–1999*, 16 Conservation Biology 346, 347 (2002).
180. Such aggregations may have been historically adaptive by confusing or deterring natural predators, but they do not deter human predators.
181. Endangered Species Act of 1973, 16 U.S.C. § 1538 (2006). Section 7 of the ESA also contains a requirement for federal agencies, through consultation, to insure that actions are not likely to jeopardize an endangered or threatened species or result in the destruction or adverse modification of critical habitat. *Id.* § 1536(a)(2).
182. *Id.* § 703(a). In 1939, responsibility for enforcing the statute was shifted to the U.S. Department of the Interior from the U.S. Department of Agriculture. *See* Reorganization Act Plan No. II, § 4(f), 53 Stat. 1431, 1433–34 (1939). The MBTA implements the four bilateral migratory bird treaties. The first treaty, the Canadian Convention, was concluded and ratified in 1916 and sought to protect birds migrating between the United States and Canada. *See* Convention Between the United States and Great Britain for the Protection of Migratory Birds, U.S.–Gr. Brit., Aug. 16, 1916, 39 Stat. 1702. Three further conventions followed with Mexico in 1936, Japan in 1972, and the former Soviet Union in 1976. *See* Convention Between the United States of America and Mexico for the Protection of Migratory Birds and Game Animals, U.S.– Mex., Feb. 7, 1936, 50 Stat. 1311; Convention Between the Government of the United States of America and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction, and Their Environment, U.S.–Japan, Mar. 4, 1972, 25 U.S.T. 3329; Convention Between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment, U.S.–Union of Soviet Socialist Republics, Nov. 19, 1976, 29 U.S.T. 4647, 1134 U.N.T.S. 37; *see also* Corcoran & Colbourn, *supra* note 8, at 361 (providing an overview of the conventions). Multinational agreements also seek to prohibit take. These include the Inter-American Convention for the Protection and Conservation of Sea Turtles, art. IV, Jan. 12, 1996, 2164 U.N.T.S. 29, 32, which prohibits the "intentional capture, retention or killing of, and domestic trade in, sea turtles"; the Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere, art. VIII, opened for signature Oct. 12, 1940, 161 U.N.T.S. 193–200, which states that species mentioned in the Annex to the Convention "shall be protected as completely as possible, and their hunting, killing, capturing, or taking, shall be allowed only with the permission of the appropriate government authorities in the country" and that "[s]uch permission shall be granted only under special circumstances, in order to further scientific purposes, or when essential for the administration of the area in which the animal or plant is found"; and the Convention on the Conservation of

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Migratory Species of Wild Animals (Bonn Convention), art. III, June 23, 1979, 1651 U.N.T.S. 333, 360–62, which states that parties agree that they "shall prohibit the taking of animals" belonging to endangered species, with exceptions to this prohibition allowed only if the taking is for scientific purposes or for the purpose of enhancing the propagation or survival of the affected species, is needed to accommodate the needs of traditional subsistence users, or is required by extraordinary circumstances.

183. 16 U.S.C. § 1538 (2006); *see also* Babbitt v. Sweet Home Chapter of Communities for a Great Or., 515 U.S. 687, 690–91 (1995). By itself, Section 9 does not prohibit the take of "threatened" species. Section 4(d) of the ESA, however, allows agencies to apply section 9 prohibitions to "threatened" species. 16 U.S.C. § 1533(d) (2006); *see also* 50 C.F.R. § 17.31(a) (2010).
184. 16 U.S.C. § 1539(a)(1)(B) (2006); 50 C.F.R. § 17.3 (2010).
185. 50 C.F.R. §§ 17.22, 17.32 (2010).
186. 16 U.S.C. § 1539(a)(2) (2006); 50 C.F.R. § 17.3 (2010). The HCP must specify 1) the impact which will likely result from such taking; 2) the steps that the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps; 3) the alternative actions to such taking that the applicant considered and the reasons why such alternatives are not being utilized; and 4) other measures that the Secretary may require as being necessary or appropriate for purposes of the plan. 16 U.S.C. § 1539(a)(2)(A) (2006).
187. 16 U.S.C. § 1539(a)(2)(B) (2006). Section 7 of the ESA provides for a federal agency to incidentally take a listed species. A federal agency may be granted an "incidental take statement" as part of a biological opinion describing the effect of the proposed activity on the species, the amount or extent of anticipated incidental take, and the "reasonable and prudent measures" to avoid or minimize the take of the species or the impact of the taking. *See id.* § 1536(b)(4), (o). Takes are illegal if the "reasonable and prudent measures" are not implemented. *Id.*
188. *Id.* § 1532(19).
189. 50 C.F.R. § 17.3 (2010); *Sweet Home Chapter of Communities for a Great Or*, 515 U.S. 687, 708 (1995) (upholding FWS definition).
190. Endangered and Threatened Wildlife and Plants; Final Redefinition of "Harm," 46 Fed. Reg. 54,748 (Nov. 4, 1981); *Sweet Home Chapter of Communities for a Great Or*, 515 U.S. at 708. One district court opined that in the Ninth Circuit the balance of the authority suggests that a population level effect is necessary for harm resulting from habitat modification to be considered a take. Coal. for a Sustainable Delta v. McCamman, 725 F. Supp. 2d 1162, 1169–70 (E.D. Cal. 2010).
191. *Coal, for a Sustainable Delta* 725 F. Supp. 2d at 1166–68, 1168 n.6.
192. In the Ninth Circuit, plaintiffs must demonstrate "a reasonably certain threat of imminent harm to a protected species" to obtain an injunction under ESA section 9. Defenders of Wildlife v. Bernal, 204 F.3d 920, 925 (9th Cir. 2000); *see also* Marbled Murrelet v. Babbitt, 83 F.3d 1060, 1065–66 (9th Cir. 1996) (noting that harm through habitat modification can be projected into the future only so long as the habitat modification will cause actual killing or injury of members of a protected species).
193. 16 U.S.C. § 703(a) (2006); *see also* 50 C.F.R. § 10.12 (2010) ("Take means to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect."). This prohibition is limited to native species. 16 U.S.C. § 703(b) (2006).
194. 16 U.S.C. § 704(a) (2006).
195. 50 C.F.R. pts. 20, 92 (2009).
196. *Id* § 21.41 (providing for depredation permits); *Id.* § 13.11(d) (listing permits and associated fees).
197. *Id.* § 21.12 (providing general exceptions to permit requirements); *Id.* §§ 21.42–21.51 (providing for depredation orders for migratory birds injuring property interests); *see also* Fund for Animals v. Kempthorne, 538 F.3d 124, 134 (2d Cir. 2008) (holding that a depredation order to take cormorants did not violate MBTA); 50 C.F.R. §§ 21.60–21.61 (2009) (providing for control of certain migratory bird populations deemed overabundant).
198. *See, e.g.*, United States v. Moon Lake Electric Ass'n, Inc., 45 F. Supp. 2d 1070, 1071 (D. Colo. 1999) (interpreting the term "take" to prohibit conduct beyond that of hunters and poachers and

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denying electric association's motion to dismiss where the company was accused of failing to install inexpensive equipment on power poles, causing the death or injury of birds of prey).

199. SeeGiese, Collette L Adkins. Spreading Its Wings: Using the Migratory Bird Treaty Act to Protect Habitat. 2010:1166. 36 Wm. Mitchell L. Rev. 1157. Lilley, Meredith Blaydes, Firestone, Jeremy. Wind Power, Wildlife, and the Migratory Bird Treaty Act: A Way Forward. 2008:1193–94. 38 Envtl. L. 1167. citing City of Sausalito v. O'Neill, 386 F.3d 1186 (9th Cir. 2004); Seattle Audubon Society v. Evans, 952 F.2d 297 (9th Cir. 1991)); *see also* Earth Island Inst. v. Carlton, No. S-09-2020 FCD/EFB, slip op. at 56–58 (E.D. Cal. August 20, 2009) (denying plaintiff a preliminary injunction on timber harvest, holding there was no MBTA violation even though unfledged bird chicks could be killed due to removal of occupied nest trees), *aff' d*, 626 F.3d 462 (9th Cir. 2010). *See generally*Lurman, Julie. Agencies in Limbo: Migratory Birds and Incidental Take by Federal Agencies. 2007 23 J. Land Use & Envtl. L. 39. stating the author's opinion that federal court cases that have found no violation of MBTA during incidental takes were poorly reasoned); Corcoran & Colbourn, *supra* note 8 (noting cases which reasoned that timber activities do not constitute a taking within the meaning of MBTA and that "take" under the MBTA is defined differently than under the ESA)Howe, Shippen. The Intersection of the Migratory Bird Treaty Act and Energy Companies: An Uncertain Crossroad. May.2010 41 Trends. at 1.

200. *See Moon Lake Electric Ass'n, Inc.*, 45 F. Supp. 2d at 1076 (stating that under the ESA "the word 'take' is defined in a broader way to include 'harass,' and 'harm,' in addition to the verbs included in the MBTA definition … the differences in the proscribed conduct under ESA and the MBTA are 'distinct and purposeful").

201. *See* Giese, *supra* note 199, at 1166–67 (citing Sierra Club v. Martin, 933 F. Supp. 1559, 1564–65 (N.D. Ga. 1996)). *But see* Earth Island Inst. v. Carlton, No. S-09-2020 FCD/EFB (E.D. Cal. August 20, 2009) (order denying preliminary injunction and suggesting that the MBTA does not apply); Mahler v. U.S. Forest Serv., 927 F. Supp. 1559, 1573–74 (E.D. Ind. 1996) (holding that the MBTA does not apply even to direct incidental deaths of migratory birds from habitat destruction during the nesting season).

202. *See generally* Lilley & Firestone, *supra* note 199. The authority of FWS under the MBTA was given a boost with regard to federal agency actions by Executive Order No. 13,186, which notes that the migratory bird conventions "impose substantive obligations on the United States for the conservation of migratory birds and their habitats" and requires each federal agency taking an action likely to have a negative effect on migratory bird populations to develop and implement a memorandum of understanding (MOU) with the FWS (the lead agency) to promote the conservation of such populations. Exec. Order No. 13,186, 66 Fed. Reg. 3853, 3854 (Jan. 17, 2001).

203. *See, e.g.*, United States v. Apollo Energies, Inc., 611 F.3d 679, 684–85 (10th Cir. 2010) (upholding strict liability for oil drilling operators charged with violating the MBTA after dead migratory birds were discovered lodged in their oil drilling equipment, but concluding that "proximate causation" requirement was satisfied only for those convictions for which the operators had adequate notice that birds could become trapped in the equipment); United States v. Chevron USA, Inc., No. 09-CR-0132, 2009 WL 3645170, at *3–5 (W.D. La. October 30, 2009) (refusing to accept a plea agreement holding Chevron guilty under the MBTA for the death of brown pelicans in a caisson structure where there was no prohibition cited by the government for leaving a caisson uncovered, use of a caisson to protect the wellhead was legal and widely accepted, and Chevron did not have "fair warning" that the uncovered caisson exposed them to federal criminal prosecution). According to Lilley and Firestone, the FWS is much more likely to prosecute under the MBTA "when entities fail to implement measures to prevent reasonably foreseeable, significant, and easily preventable incidental take of migratory birds." Lilley & Firestone, *supra* note 199, at 1197.

204. Private citizens have a limited role in MBTA enforcement. Unlike the ESA, the MBTA does not authorize a private right of action to sue private entities for violating the MBTA, although parties may sue a federal agency for MBTA violations. *See* Turtle Island Restoration Network v. U.S. Dep't of Commerce, 438 F.3d 937, 942 (9th Cir. 2006) (stating that MBTA does not authorize a private right of action, unlike ESA); Jaeger v. Cellco P'ship, No. 3:09CV567, 2010 WL 965730, at *10 (D. Conn. March 16, 2010) (stating that private plaintiffs may, via the Administrative

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Procedure Act, pursue claims against federal agencies for failure to adhere to the MBTA, but cannot bring an MBTA claim against a state entity or private company).

205. *See* U.S. v. WCI Steel, Inc., No. 5:04 MJ 5053, 2006 WL 2334719, at *5 (N.D. Ohio August 10, 2006) (concluding that FWS failed to prove criminal violation beyond a reasonable doubt).
206. Western and Central Pacific Fisheries Convention Implementation Act, 16 U.S.C. §§ 6901–6910 (2006).
207. Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, http://sedac.ciesin.org/entri/texts/fish.west.cent.pac.2000.html (last visited Apr. 10, 2011); *see also* W. and Cent. Pacific Fisheries Comm'n, http://www.wcpfc.int/(last visited Apr. 10, 2011).
208. 50 C.F.R. § 300.223(a) (2009) (establishing purse seine fishing restrictions and specifically the fishing day limits).
209. International Fisheries; Western and Central Pacific Fisheries for Highly Migratory Species; Bigeye Tuna Catch Limits in Longline Fisheries in 2009, 2010, and 2011, 74 Fed. Reg. 63,999, 64,010 (Dec. 7, 2009) (to be codified at 50 C.F.R. § 300.224) (discussing yearly quota for years 2009, 2010, and 2011 of "3,763 metric tons of bigeye tuna that may be captured in the Convention Area by longline gear and retained on board by fishing vessels of the United States during the calendar year").
210. The WCPFCA applies over the "convention area," which means all waters of the Pacific Ocean located roughly between the 4th and 60th parallels south latitude and between the 150th meridian east longitude (the east coast of Australia) and the 130th meridian west longitude (just east of French Polynesia). 16 U.S.C. 6901(a)(4) (2006).
211. Atlantic Tunas Convention Act of 1975, 16 U.S.C. §§ 971–971k (2006).
212. *See id* at § 971(1) (defining "Convention" as the "International Convention for the Conservation of Atlantic Tunas"); *see also* International Convention for the Conservation of Atlantic Tunas, May 14, 1966, 20 U.S.T. 6767, 673 U.N.T.S. 9587.
213. *See, e.g.*, 50 C.F.R. § 635.22(b) (2009) ("*Billfish*. No longbill spearfish from the management unit may be taken, retained, or possessed shoreward of the outer boundary of the EEZ."). Management unit for Atlantic tunas, longbill spearfish, blue marlin and white marlin, means all fish of these species in the Atlantic Ocean. *Id*. § 635.2.
214. *Id*. § 635.23 ("(a) *General category*. (1) No person aboard a vessel that has a General category Atlantic Tunas permit may possess, retain, land, or sell a [bluefin tuna (BFT)] in the school, large school, or small medium size class.… (3) Regardless of the length of a trip, no more than a single day's retention limit of large medium or giant BFT may be possessed or retained aboard a vessel that has a General category Atlantic Tunas permit. On days other than [restricted fishing days], when the General category is open, no person aboard such vessel may continue to fish, and the vessel must immediately proceed to port once the applicable limit for large medium or giant BFT is retained.… (b) *Angling category*. BFT may be retained and landed under the daily limits and quotas applicable to the Angling category by persons aboard vessels issued an [highly migratory species] Angling permit as follows: (1) Large medium and giant BFT. (i) No large medium or giant BFT may be retained, possessed, landed, or sold in the Gulf of Mexico, except one per vessel per year may be landed if caught incidentally to fishing for other species.… (d) *Harpoon category*. Persons aboard a vessel permitted in the Atlantic Tunas Harpoon category may retain, possess, or land an unlimited number of giant BFT per day. An incidental catch of only two large medium BFT per vessel per day may be retained, possessed, or landed.").
215. *See, e.g.*, 33 U.S.C. § 1314 (2006).
216. Best management practices under the Clean Water Act, Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (2006), are developed and implemented to control nonpoint source pollution, and refer to "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States." 40 C.F.R. § 122.2 (2010); *see also* U.S. Envtl. Prot. Agency, the Use of Best Management Practices (bmps) in Urban Watersheds, at 1–4 to 1–5 (2004), *available at* http://www.epa.gov/nrmrl/pubs/600r04184/600r04184.pdf ("[With respect to stormwater management,] BMP refers to operational activities, physical controls or educational measures that are applied to reduce the discharge of pollutants and minimize potential impacts upon receiving waters, and

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accordingly, refers to both structural and nonstructural practices that have direct impacts on the release, transport, or discharge of pollutants."); U.S. Envtl. Prot. Agency, Guidance Manual For Developing Best Management Practices, at 1–3 to −4 (1993) (with respect to industrial facilities specifically, BMP activities focus on activities associated with or ancillary to industrial manufacturing or treatment processes, identified as plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage).

217. The Department of Interior's Bureau of Land Management defines best management practices as "state-of-the-art mitigation measures applied on a site-specific basis to reduce, prevent, or avoid adverse environmental or social impacts … applied to oil and gas drilling and production …" Bureau of Land Mgmt., U.S. Dep't of Interior, BMP Frequently Asked Questions, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/frequently_asked_questions.htm (last visited Apr. 10, 2011). U.S. Forest Service policy (FSM 2532.03) directs that BMPs be the primary tools for controlling nonpoint source pollution for the Forest Service. Pamela Edwards et al., The Usda Forest Service's National Best Management Practice Program 2 (2010), *available at* http://www.acwi.gov/monitoring/conference/2010/manuscripts/E2_2_Edwards.pdf. *See generally* Julianne Thompson & Jenny Fryxell, Best Management Practices (Bmp) Implementation Monitoring Keys to Success and Pitfalls to Avoid (2007), *available at* http://www.stream.fs.fed.us/afsc/pdfs/Thompson.pdf.

218. Ice, George G., Schilling, Erik G., Vowell, Jeff G. Trends for Forestry Best Management Practices Implementation. 2010:268–70. 108 J. Forestry 267. Soc'y of Am. Foresters, Best Management Practices, http://wiki.safnet.org/index.php/Best_Management_Practices (last visited Apr. 10, 2011); *see also* Ga. Forestry Comm'n, Georgia's Best Management Practices For Forestry (2009), *available at* http://www.gfc.state.ga.us/ForestManagement/documents/BMPManualGA0609.pdf; David B. Kittredge, Jr. & Michael Parker, Massachusetts Forestry Best Management Practices Manual (1999), *available at* http://www.mass.gov/dep/water/drinking/forstbmp.pdf; S.C. Forestry Comm'n, South Carolina's Best Management Practices for Forestry (2007–2008), *available at* http://www.state.sc.us/forest/bmp07.pdf

219. Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (2006).

220. Fischman, Robert L. Predictions and Prescriptions for the Endangered Species Act. 2004:475–78. 34 Envtl. L. 451. Fischman, Robert L. The Divides of Environmental Law and the Problem of Harm in the Endangered Species Act. 2008:691–92. 83 Ind. L.J. 661. [hereinafter Fischman, *The Divides of Environmental Law and the Problem of Harm in the Endangered Species Act*].

221. *See supra* text accompanying notes 84–88.

222. *See supra* Part III.B (state conservation plans), Part III.C (land use plans for acquired or designated properties), and Part III.D (take prohibition or reduction plans).

223. *See* Interim Voluntary Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines, 68 Fed. Reg. 41,174, 41,174–75 (July 10, 2003); U.S. Fish & Wildlife Serv., Guidance Regarding Use of the Wind Turbine Guidelines Advisory Committee's Recommendation, http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html (last visited Feb. 11, 2011); *see also* AVIAN POWER LINE INTERACTION COMM. (APLIC), SUGGESTED Practices for Avian Protection on Power Lines: The State of the Art in 2006 (2006), *available at* http://www.aplic.org/SuggestedPractices2006(LR).pdf (suggesting voluntary guidelines developed by the Department of the Interior and a group of electric companies to help the industry protect birds from electrocution on utility poles and power lines); Memorandum from Jamie Rappaport Clark, Dir. of U.S. Fish & Wildlife Serv. to Reg'l Dirs., U.S. Fish & Wildlife Serv. (Sept. 14, 2000), *available at* http://www.fws.gov/policy/m0084.html (regarding service guidance on the siting, construction, operation, and decommissioning of communications towers).

224. 50 C.F.R. § 622.31 (2009) (prohibiting gear and methods); *Id.* § 622.41 (specifying specific limitations).

225. Atlantic Tunas Convention of 1975, 16 U.S.C. §§ 971–971k (2006).

226. 50 C.F.R. § 635.21(c)(2)(v)(A) (2009).

227. *Id.* § 635.21(c)–(d).

228. *Id.* § 635.21.

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229. For our purposes in this Part, “wildlife” encompasses all animal taxa, including all vertebrates, as well as a variety of invertebrates, that undertake annual migrations that transit or have an endpoint in U.S. lands or waters.
230. See generallyPalumbi, Stephen R., et al. Managing for Ocean Biodiversity to Sustain Marine Ecosystem Services. 2009:204–10. 7 Frontiers Ecology & Env’t 204. discussing the meaning and interplay of ecosystem management and adaptive management.
231. See generallyManfredo, Michael J., et al. Human Dimensions of Wildlife Management Basic Concepts. Knight, Richard L., Gutzwiller, Kevin J., editors. 1995. Wildlife and Recreationists: Coexistence Through Management and Research 17providing a good introduction to human dimensions of wildlife management
232. *See* Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1812(a) (2006); Migratory Bird Conservation Act, 16 U.S.C. § 715d; Marine Mammal Protection Act of 1972, 16 U.S.C. § 1389.
233. The total number of acres managed by the Bureau of Land Management is 261.5 million. Carol Hardy Vincent, Cong. Research Serv., Rl 32393, Federal Land Management Agencies: Background on Land and Resources Management 2 (2004), *available at* http://www.nationalaglawcenter.org/assets/crs/RL32393.pdf.
234. The total number of acres managed by the Forest Service is 192.5 million. *Id*
235. The total number of acres managed by the Fish and Wildlife Service is 95.4 million. *Id*.
236. The total number of acres managed by the National Park Service is 79.0 million. *Id*.
237. Federal Land Policy and Management Act of 1976, 43 U.S.C. §§ 1701–1785 (2006).
238. *Id* § 1702(c).
239. *See, e.g.*, U.S. Forest Serv., About Us—Mission, http://www.fs.fed.us/aboutus/mission.shtml (last visited Apr. 10, 2011).
240. National Forest Management Act of 1976, 16 U.S.C. §§ 1600–1687 (2006).
241. *Id*. § 1604(g)(3)(B).
242. 36 C.F.R. § 219.19 (2010).
243. SeeNoon, Barry R., et al. Conservation Science, Biodiversity, and the 2005 US Forest Service Regulations. 2005:1359–61. 19 Conservation Biology 1359. (discussing the biodiversity implications of the 2005 regulations). The 2005 regulations were enjoined in 2007. *See* Citizens for Better Forestry v. U.S. Dep’t of Agric., 481 F. Supp. 2d 1059, 1100 (N.D. Cal. 2007). In 2008, the Bush administration issued another rule and in 2009, it was struck down. *See* Citizens for Better Forestry v. U.S. Dep’t of Agric., 632 F. Supp. 2d. 968, 982 (N.D. Cal. 2009). A proposed planning rule that will replace the 1982 rule is undergoing public comment. *See* National Forest System Land Management Planning, 74 Fed. Reg. 67,165, 67,166 (Dec. 18, 2009)
244. U.S. Dep’t of Agric., USDA Departmental Regulation No. 9500-4, Fish and Wildlife Policy (1983).
245. 36 C.F.R. § 219.19(a)(1) (2010) (outlining the purpose of management indicator species and the criteria to be used in identifying them).
246. U.S. Fish & Wildlife Serv., National Wildlife Refuge System, http://www.fws.gov/refuges/(last visited Apr. 13, 2011).
247. U.S. Fish & Wildlife Serv., How Are Lands Classified Within the National Wildlife Refuge System?, http://www.fws.gov/refuges/about/lands.html (last visited Apr. 13, 2011).
248. SeeFischman, Robert L. The National Wildlife Refuges: Coordinating a Conservation System Through Law 90–93. 2003
249. *See* Noon et al., *supra* note 243, at 1360.
250. National Wildlife Refuge Improvement Act of 1997, 16 U.S.C. § 668dd (2006).
251. 251 *Id* § 668dd(a)(4)(B).
252. Final Compatibility Policy Pursuant to the National Wildlife Refuge System Improvement Act of 1997, 65 Fed. Reg. 62,484, 62,486 (Oct. 18, 2000); *see* 16 U.S.C. § 668dd(a)(3)(A) (2006).
253. *See* FISCHMAN, *supra* note 248, at 91.
254. 16 U.S.C. §§ 3771–3774 (2006).

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255. *Id.* § 3772(1). “Interjurisdictional fishery resource” is defined as

A. a fishery resource for which a fishery occurs in waters under the jurisdiction of one or more States and the exclusive economic zone established by Proclamation Numbered 5030, dated March 10, 1983;

B. a fishery resource for which there exists an interstate fishery management plan; or

C. a fishery resource which migrates between the waters under the jurisdiction of two or more States bordering on the Great Lakes.

Id. § 4102(3)

256. SeeFischman, Robert L., Adamcik, Bob. Beyond Trust Species: The Conservation Potential of the National Wildlife Refuge System in the Wake of Climate Change. Nat. Resources J. (forthcoming), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1561948

257. George Orwell, Animal Farm 118 (Harcourt Brace Jovanovich 1990).

258. U.S. Fish & Wildlife Serv., Fish and Wildlife Service Manual, Refuge Management 3.20 (2001) *available at* http://www.fws.gov/policy/601fw3.pdf.

259. National Park Service Organic Act, 16 U.S.C. § 1 (2006).

260. Nat’l Park Serv., Management Policies 2006 at 11 (2006), *available at* www.nps.gov/policy/mp2006.pdf.

261. Fischman, Robert L. The Problem of Statutory Detail in National Park Establishment Legislation and Its Relationship to Pollution Control Law. 1997:782. 74 Denv. U. L. Rev. 779.

262. NAT’L PARK SERV., *supra* note 260, at 10–12.

263. *Id.* at 36–37.

264. *Id.* at 43.

265. *Id.* at 13–14.

266. The NRWSIA specifies a 15-year rolling planning interval for the Comprehensive Conservation Plans required of each refuge while the NPS management policies provide no time line. 16 U.S.C. § 668dd(e) (2006). The NWRSIA also states that the Secretary of the Interior shall “monitor the status and trends of fish, wildlife, and plants in each refuge.” *Id.* § 668dd(a)(4)(N). NPS management policy indicates that “natural systems in the national park system, and the human influences upon them, will be monitored to detect change.” NAT’L PARK SERV., *supra* note 260, at 37. Further, the NPS states that “[l]ong-term research or monitoring may also be necessary to correctly understand the effects of management actions on natural resources whose function and significance are not clearly understood.” *Id.* No further specifics are provided.

267. Lemons, John. Revisiting the Meaning and Purpose of the “National Park Service Organic Act”. 2010:87. 46 Envtl. Mgmt. 81. In addition, a thorough discussion of the issues arising from the conservation-enjoyment tension is presented by Professor Denise E. Antolini. *See*Antolini, Denise E. National Park Law in the US: Conservation, Conflict, and Centennial Values. 2009:884–911. 33 Wm. & Mary Envtl. H. & Pol’y Rev. 851.

268. *See supra* text accompanying note 251.

269. *See supra* text accompanying notes 242–44.

270. Gordon R. Batcheller et al., Wildlife Soc’y, Technical Review 10-01, Public Trust Doctrine: Implications for Wildlife Management and Conservation in the United States and Canada 9–20, 21 tbl.1 (2010).

271. See generallyFischman, Robert L., King, Angela M. Savings Clauses and Trends in Natural Resources Federalism. 2007:129. 32 Wm. & Mary Envtl. L. & Pol’y Rev. a review of savings clauses—the language that reserves areas of state power in statutory laws that otherwise convey power to the federal government.

272. SeeFischman, Robert L. Cooperative Federalism and Natural Resources Law. 2005:200. 14 N.Y.U. Envtl. L.J. 179. reviewing the requirements in the organic legislation for the BLM, U.S. Forest Services, and FWS). The National Park Service has similar language in its Management Policies. *See* Nat’l Park Serv., *supra* note 260, at 44.

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273. SeeDavis, Steven M. Preservation, Resource Extraction, and Recreation on Public Lands: A View from the States. 2008:316–19. 48 Nat. Resources J. 303.
274. *See supra* Part III.A.
275. *See infra* Part IV.B.3.
276. Noaa Office of the Gen. Council, Maritime Zones and Boundaries, http://www.gc.noaa.gov/gcil_maritime.html (last visited Apr. 10, 2011); *see infra* text accompanying notes 296–97.
277. 16 U.S.C. §§ 661–667e (2006).
278. *Id.* § 662(b).
279. *Id.* § 663(b).
280. *Id.* § 663(c).
281. *Id* § 665a.
282. *Id.* §§ 1431–1445c-1.
283. *See* Exec. Order No. 13,158, 3 C.F.R. 273, 275 (2001), *reprinted in* 16 U.S.C. § 1431 app., at 422–23 (2006).
284. 16 U.S.C. § 1431(b)(3) (2006).
285. *Id.* § 1431(b)(4).
286. Craig, Robin Kundis. A Comparative Guide to the Eastern Public Trust Doctrines: Classification of States, Property Rights, and State Summaries. 2007:4. 16 Penn St. Envtl. L. Rev. 1. The original 13 colonies obtained title when the United States achieved independence; the remaining states acquired the same rights under the Equal Footing Doctrine. *Id.* at 6.
287. IdCraig, Robin Kundis. A Comparative Guide to the Western States' Public Trust Doctrines: Public Values, Private Rights and the Evolution Toward an Ecological Public Trust. 2010:69. 37 Ecology L.Q. 53.
288. Craig, *supra* note 287, at 71, 84.
289. *Id.* at 71.
290. *See* Craig, *supra* note 286, at 82.
291. 16 U.S.C. § 1533(d) (2006).
292. *Id.* § 704.
293. *See supra* note 255 and accompanying text.
294. Lueck, Dean, Yoder, Jonathan. Environmental Federalism. Anderson, Terry Lee, Hill, Peter Jensen, editors. 1997. p. 101("[S]tates have the dominant regulatory authority over wildlife control and use, typically vested in a state "fish and game" or "wildlife" agency."); *see also* 16 U.S.C. § 708 (2006); 50 C.F.R. § 20.20(e) (2009)
295. Submerged Lands Act of 1953, 43 U.S.C. § 1311–1312 (2006); Outer Continental Shelf Lands Act of 1953, 43 U.S.C. § 1333 (2006); Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1856 (2006).
296. Nat'l Oceanographic & Atmospheric Admin., What Is the EEZ?, http://oceanservice.noaa.gov/facts/eez.html (last visited Apr. 10, 2011).
297. 16 U.S.C. §§ 1801–1884 (2006).
298. Wyman, Katrina M. The Property Rights Challenge in Marine Fisheries. 2008:515–16. 50 Ariz. L. Rev. 511. describing the current governance scheme under the Magnuson-Stevens Fishery Conservation and Management Act, including regional fisheries council membership selected by the Secretary of Commerce often composed of "substantial representation" by state interests.
299. Brax, Jeff. Zoning the Oceans: Using the National Marine Sanctuaries Act and the Antiquities Act to Establish Marine Protection Areas and Marine Reserves in America. 2002:80. 29 Ecology L.Q. 71.
300. Rosenberg, Andrew A., et al. Rebuilding US Fisheries: Progress and Problems. 2006:304–05. 4 Frontiers Ecology & Env't 303. (reporting that 72% of stocks under mandated rebuilding plans were still overfished, although 48% were increasing). Clearly, Magnuson-Stevens has not been a panacea for overfishing.
301. Dale D. Goble & Eric T. Freyfogle, Wildlife Law 833–37 (2d ed. 2010).
302. *See* Marra, Hunter & Perrault, *supra* note 19, at 323–24.

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303. *See id.* at 323 (discussing the geolocator, an affordable daylight level data recorder for tracking animals).
304. See generallyAusden, M. Habitat Management for Conservation: A Handbook Of Techniques. Oxford Univ. Press; 2007.
305. SeeYagerman, Katherine Simmons. Protecting Critical Habitat Under the Federal Endangered Species Act. 1990:817. 20 Envtl. L. 811.
306. U.S. Fish & Wildlife Serv., U.S. Fish and Wildlife Service Habitat Restoration Projects, http://recovery.doi.gov/press/bureaus/us-fish-and-wildlife-service/usfws-habitat-restoration-projects-funded-by-the-american-recovery-and-reinvestment-act/(last visited Feb. 9, 2011).
307. See, e.g.Palis, John G., et al. Breeding Biology of a Florida Population of Ambystoma cingulatum (Flatwoods Salamander) During a Drought. 2006:1. 5 Southeastern Naturalist 1. studying how drought affects the migration to breeding pools of one species of salamander.
308. See, egGlaudas X, et al. Migration Patterns in a Population of Cottonmouths (Agkistrodon piscivoras) Inhabiting an Isolated Wetland. 2007:122–23. 271 J. Zoology 119, 119. studying movement patterns of one species of snake from its hibernation dens to its active zones.
309. *See* Atwell, O'Neal & Ketterson, *supra* note 59, at 297–98.
310. Petit, Eric, Valiere, Nathaniel. Estimating Population Size with Noninvasive Capture-Mark-Recapture Data. 2006:1063. 20 Conservation Biology 1062.
311. *See* Marra, Hunter & Perrault, *supra* note 19, at 323–24.
312. *See* Operation Migration, Our Work, http://www.operationmigration.org/work_wcranes.html (last visited Apr. 10, 2011).
313. See, e.g.Cannon, John R. Whooping Crane Recovery: A Case Study in Public and Private Cooperation in the Conservation of Endangered Species. 1996:818. 10 Conservation Biology 813. describing efforts to introduce Whooping Crane populations in locations where migration is unnecessary for species protection.
314. U.S. Fish & Wildlife Serv., Migratory Bird Mortality: Many Human-Caused Threats Afflict our Bird Populations (2002), *available at* http://www.fws.gov/birds/mortality-fact-sheet.pdf.
315. *See supra* Part IV.A.1.a.
316. Partners in Flight, http://www.partnersinflight.org/(last visited Apr. 10, 2011).
317. *See* Partners in Flight, What Is *Partners in Flight* (PIF)?, http://www.partnersinflight.org/description.cfm (last visited Apr. 10, 2011).
318. *See* N.J. Dep't of Envtl. Prot., New Jersey Wildlife Action Plan 2 (2008), *available at* http://www.state.nj.us/dep/fgw/ensp/wap/pdf/wap_draft.pdf; *see also* Ass'n of Fish & Wildlife Servs., State Wildlife Action Plans: Working Together to Prevent Wildlife from Becoming Endangered, http://www.wildlifeactionplans.org/ (last visited Apr. 10, 2011) (cataloging SWAPS from all fifty states, the District of Columbia, Puerto Rico, and the Virgin Islands).
319. *See* Matthew Birnbaum et al., An Evaluation of the State Wildlife Conservation Grant Program, 2004–2008: Building Multi-State Regional Efforts upon State Wildlife Action Plans 4 (2010), *available at* http://www.nfwf.org/AM/Template.cfm?Section=Home&Template=/CM/ContentDisplay.cfm&Contentid=17050.
320. 320 *See supra* text accompanying notes 307–08.
321. See generallySemlitsch, Raymond D., Bodie, J Russell. Biological Criteria for Buffer Zones Around Wetlands and Riparian Habitats for Amphibians and Reptiles. 2003:1220. 17 Conservation Biology 1219. identifying local and migratory habitat needs for amphibians and reptiles.
322. In Part II, we made the distinction between species that migrate along a broad front, such as many songbirds do, and species that migrate along narrow corridors, such as waterfowl do. Because species that migrate along a broad front are spread over a large landscape, no single small property is likely to be of importance to their migration. *See supra* text accompanying notes 55–57.
323. David N. Cherney, *supra* note 161, at 605–609.
324. U.S. Dep't of Agric., Migratory Shore Bird Habitat Management app. 1, *available at* http://www.efotg.sc.egov.usda.gov/references/public/AL/646A.pdf.

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325. Road closures would be particularly helpful for slow-moving terrestrial species with predictable movements over short periods of time. *See* Richard T. T. Forman & Lauren E. Alexander, *Roads and Their Major Ecological Effects*, 29 Ann. Rev. Ecology & Systematics 207, 222 (1998). Careful consideration of hunting mortality has protected North American migratory waterfowl since the signing of the Migratory Bird Treaty. Waterfowl Hunting Mgmt. in N. Am., Federal Regulations Background, http://www.flyways.us/regulations-and-harvest/federal-regulations-background (last visited Apr. 10, 2011).
326. See generallyMoore, Frank R., et al. Stopover Habitat: Management Implications and Guidelines. 1993 u.s. dep't of agric., status and management of neotropical migratory birds general technical report RM-229, at 58, 65, 66 tbl.1. discussing issues related to conservation and management of stopover habitat.
327. See, e.g.Dewey, Sarah R., Kennedy, Patricia L. Effects of Supplemental Food on Paternal-Care Strategies and Juvenile Survival of Northern Goshawks. 2001:352–53. 118 Auk 352. discussing existing studies of supplemental feeding for birds.
328. Goode, Andrew. The Plight and Outlook for Migratory Fish in the Gulf of Maine. J Contemp Water Res & Educ. Jul.2006 at 23, 24.
329. Danger to migrating pronghorn from fences is well documented. *See* ARTHUR W. ALLEN ET al., u.s. fish & wildlife serv., fws/obs-82/10.65, habitat suitability index models: pronghorn 6 (1984); wildlife mgmt. inst., big game of north america: ecology and management 354 (John L. Schmidt & Douglas L. Gilbert eds., 1978). Problems faced by migrating large mammals in Africa are also well documented. *See* Douglas Williamson & Jane Williamson, *Botswana's Fences and the Depletion of Kalahari Wildlife*, 18 ORYX 218, 218 (2004); Joseph E. Mbaiwa & Onaletshepho I. Mbaiwa, *The Effects of Veterinary Fences on Wildlife Populations in Okavango Delta, Botswana*, Int'l J. Wilderness, Dec. 2006, at 17, 22.
330. Hoover, Stacey L., Morrison, Michael L. Behavior of Red-Tailed Hawks in a Wind Turbine Development. 2005:157–58. 69 J. Wildlife Mgmt. 150.
331. SeeWiese, Francis K., Robertson, Gregory J. Assessing Seabird Mortality from Chronic Oil Discharges at Sea. 2004:627. 68 J. Wildlife Mgmt. 627.
332. Fischman & Hyman, *supra* note 27, at 185–86.
333. SeeCharmantier, Anne, et al. Adaptive Phenotypic Plasticity in Response to Climate Change in a Wild Bird Population. 2008:800. 320 Science 800.
334. U.S. Fish & Wildlife Serv., White-Nose Syndrome in Bats: Frequently Asked QUESTIONS ¶ 10 (2009), *available at* http://www.fws.gov/northeast/pdf/white-nosefaqs.pdf.
335. Id; see alsoFrick, Winifred F., et al. An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. 2010:680. 329 Science 679.
336. For a discussion of the interplay of ecological and sociological issues in analyzing risk from avian influenza, see Graeme S. Cumming, *Risk Mapping for Avian Influenza: A Social–Ecological Problem*, 15 ECOLOGY & SOC'Y, no. 3, at 32, 33 (2010), *available at* http://www.ecologyandsociety.org/vol15/iss3/art32/. The editorial in this special feature summarizes the discussion of the role of migratory birds in spreading avian influenza, and the implications for management of the disease. *See generally id*. Most of the papers associated with the special feature are in previous issues of the same journal. *See* Joseph P. Dudley, *Public Health and Epidemiological Considerations for Avian Influenza Risk Mapping and Risk Assessment*, 13 ECOLOGY & SOC'Y, no. 2, at 21 (2008), *available at* http://www.ecologyandsociety.org/vol13/iss2/art21/ES-2008-2548.pdf; Andy C. Stirling & Ian Scoones, *From Risk Assessment to Knowledge Mapping: Science, Precaution, and Participation in Disease Ecology*, 14 ECOLOGY & SOC'Y, no. 2, at 14 (2009), *available at* http://www.ecologyandsociety.org/vol14/iss2/art14/ES-2009-2980.pdf.
337. SeeKurta, Allen, Murray, Susan W. Philopatry and Migration of Banded Indiana Bats (Myotis Sodalis) and Effects of Radio Transmitters. 2002:597. 83 J. Mammalogy 585.
338. *See* Interim Voluntary Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines, 68 Fed. Reg. 41,174, 41,174–75 (July 10, 2003). Following discovery of the dead bat, FWS has worked with that specific landowner to minimize mortality and, within the Upper Midwest region (FWS Region 3) in the heart of Indiana bat range, has advised other wind farms to assess their potential risk under the ESA. *See* News Release, Georgia Parham, U.S. Fish & Wildlife Serv.,

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U.S. Fish & Wildlife Service and Wind Farm Owners Works Together (Feb. 10, 2010), *available* at http://www.fws.gov/midwest/News/release.cfm?rid=177; Interview with Scott E. Pruitt, Field Supervisor for the FWS Ecological Services office in Bloomington, IN and lead biologist nationally for the Indiana bat (on file with author). For suggestions for improving bird and bat protection from wind turbines, see Lilley & Firestone, *supra* note 199, at 1205–14.

339. The observed decline (−38.2%) from 2007 to 2009 in the Northeast recovery Unit (RU) is likely the result of bat mortality associated with the onset and spread of WNS. E-mail from Andrew King, Fish & Wildlife Biologist, Bloomington Field Office, U.S. Fish & Wildlife Serv. (Dec. 7, 2010) (on file with author). The Northeast RU comprises portions of New York, New Hampshire, Massachusetts, Connecticut, New Jersey, Pennsylvania. *See* U.S. Fish & Wildlife Serv., Indiana Bat (*Myotis Sodalis*) Draft Recovery Plan: First Revision 119 fig. 14 (2007), *available at* http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/IN%20BAT%20DRAFT%20PLAN%20apr07.pdf.
340. Frick et al., *supra* note 335, at 681 figs.3.A–.C.
341. SeeArnett, Edward B., et al. Patterns of Bat Fatalities at Wind Energy Facilities in North America. 2008:61. 72 J. Wildlife Mgmt. 61.
342. Interview with Al Hicks, N.Y. Dep't of Envtl. Conservation (on file with author).
343. *See* Cryan, *supra* note 128, at 366–67.
344. Lilley & Firestone, *supra* note 199, at 1170–75 (discussing high mortality rates caused by wind turbines in some areas combined with mounting stressors on avian populations resulting in mortality rates from turbines that are becoming a "cause of concern" for scientists).
345. Kunz and colleagues provide predictions for mortality in 2020 in Thomas H. Kunz et al., *Ecological Impacts of Wind Energy Development on Bats: Questions, Research Needs, and Hypotheses*, 5 Frontiers Ecology & Env't 315, 319 (2007). Kunz also provides for estimates for migratory and non-migratory bats in the Maryland, Pennsylvania, Virginia and West Virginia. *See id*. Web Tbl.2 (providing estimates for both migratory and non-migratory bats in the MidAtlantic Highlands); *Id*. at 315 (defining the Mid-Atlantic Highlands as Maryland, Pennsylvania, virginia, and West virginia).
346. C.H. Llewellyn Smith, former Director-General of the European Organization for Nuclear Research (CERN), defines "basic science" simply as science "motivated by curiosity," and contrasts it with "applied science" which is "designed to answer specific questions." European Org. for Nuclear Research, Basic Versus Applied Science, http://public.web.cern.ch/public/en/about/BasicScience2-en.html (last visited Apr. 10, 2011). The U.S. National Science Foundation's strategic plan identifies itself as "the premier Federal agency supporting basic research at the frontiers of discovery, across all fields." U.S. Nat'l Sci. Found., Investing in America'S Future: Strategic Plan 1, *available at* http://www.nsf.gov/pubs/2006/nsf0648/NSF-06-48.pdf. The vision articulated in the plan "[a]dvancing discovery, innovation and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering" points to the usefulness of science that seeks new information regardless of its immediate applicability. *Id* at 5. As a generality, academic ecologists and evolutionary biologists often focus primarily or exclusively on basic science, seeking mechanistic and causative explanations of natural phenomena, not necessarily in the context of an applied question. In contrast, agency and academic scientists in a variety of fields such as applied ecology, natural resources management, and conservation biology, as well as natural resource managers with training in research are more likely to undertake studies to address questions of immediate interest to managers or policy-makers. A blunt and somewhat irreverent discussion of the science/management schism in the freshwater arena was presented by a participant in the fray in Australia, Peter Cullen. *See* Peter Cullen, *The Turbulent Boundary Between Water Science and Water Management*, 24 FRESHWATER BIOLOGY 201, 202–03 (1990). Cullen suggested agencies needed to differentiate between scientists hired to undertake research and scientists hired to be information brokers working to ensure science is applied properly in management. *Id*. at 206. Cullen also provided a deliberate caricature of the different mindsets involved in water management to illuminate the differences among the players:

> *Engineers* don't care why it works as long as they think it does.

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Scientists don't care if it works or not as long as they understand why.

Economists don't care either way if the internal rate of return is OK.

Managers don't know unless someone bothers to tell them.

Planners know how it should have turned out.

Id. at 203.

347. Jenssen, Bjørn Munro. Endocrine-Disrupting Chemicals and Climate Change: A Worst-Case Combination for Arctic Marine Mammals and Seabirds?. 2006:78. 114 Envtl. Health Persp. (Supp. 1) 76.
348. SeeFinet, Scott. Habitat Protection and the Migratory Bird Treaty Act. 1996 10 Tul. Envtl. L.J. 6 n.15.
349. FISCHMAN, *supra* note 248, at 36–37.
350. Migratory Bird Hunting and Conservation Stamp Act, 16 U.S.C. §§ 718a–719c (2006).
351. Convention on Wetlands of International Importance Especially as Waterfowl Habitat, *supra* note 169.
352. *See* W. Hemisphere Shorebird Reserve Network, About WHSRN, http://www.whsrn.org/western-hemisphere-shorebird-reserve-network (last visited Apr. 10, 2011).
353. SeeCotton, Peter A. Avian Migration Phenology and Global Climate Change. 2003:219–21. 100 proc. nat'l acad. Sci. 12,219, 12. discussing phonological impacts of climate change on migration.
354. Fischman, *The Divides of Environmental Law and the Problem of Harm in the Endangered Species Act, supra* note 220, at 678.
355. An example of such incongruence between scientific versus legal or policy typologies driven by public and political pressures can be found in the status of Mute Swan under the MBTA. Mute swans, which are native to northern Europe and Asia, were introduced into the United States in the late 19th century for their ornamental value. Mute swans have a scientific classification as an exotic (non-native) species, and research demonstrates their invasiveness and detrimental impacts on bird communities and other animals. *See, e.g*, Charles C. Allin & Thomas P. Husband, *Mute Swan (Cygnus olor) Impact on Submerged Aquatic Vegetation and Macroinvertebrates in a Rhode Island Coastal Pond*, 10 NE. NATURALIST 305, 305 (2003). Mute Swans were included in the MBTA protections by a court order until 2005 due to the public's affinity for the swans. *Compare* Hill v. Norton, 275 F.3d 98, 107 (D.C. Cir. 2001) (invalidating a regulation excluding Mute Swans from coverage under the Migratory Bird Treaty Act), *with* 16 U.S.C. § 703 (2006) (excluding non-native birds from coverage under the Migratory Bird Treaty Act). In 2005, Mute Swans were officially declared a non-native and unprotected species following the Migratory Bird Treaty Reform Act of 2004. *See* Final List of Bird Species to Which the Migratory Bird Treaty Act Does Not Apply, 70 Fed. Reg 12,710, 12,714 (Mar. 15, 2005). The policies of some state governments, however, still protect Mute Swans. *See, e.g.*, N.Y. State Dep't of Envtl. Conservation, Mute Swan, http://www.dec.ny.gov/animals/7076.html (last visited Apr. 10, 2011) (describing mute swan population in New York State and State research activities).
356. See generallyLovett, Gary M., et al. Who Needs Environmental Monitoring?. 2007 5 Frontiers Ecology & Env't 253. discussing the necessity of monitoring not as a science, but as a necessary tool for scientists.
357. For example, a recent study used modeling to examine impacts of plasticity—the ability of organisms to exhibit different behaviors and morphologies without genetic differences—and evolutionary change on the age and size at which harvested individuals mature. Bruno Ernande et al., *Adaptive Change in Harvested Populations: Plasticity and Evolution of Age and Size at Maturation*, 271 PROC. ROYAL SOC'Y B 415, 418 (2003). Evolutionary change tends to reduce biomass of harvested individuals, precisely the opposite impact that managers want. *Id.* at 417–18.
358. Anderson, David R. The Need to Get the Basics Right in Wildlife Field Studies. 2001:1294. 29 Wildlife Soc'y Bull. White, Gary C. Why Take Calculus? Rigor in Wildlife Management. 2001:380. 29 Wildlife Soc'y Bull. The issue has also been raised in conservation biology. *See,*

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*e.g.*Fidler, Fiona, et al. Impact of Criticism of Null-Hypothesis Significance Testing on Statistical Reporting Practices in Conservation Biology. 2006:1539. 20 Conservation Biology. [PubMed: 17002771]

359. A recent study distinguished between focused, or targeted monitoring designed to address specific information needs, and surveillance monitoring, which tracks basic environmental trends as a form of early-warning system and as a means of gathering long-term environmental data that would otherwise not be available. *See* Brendan A. Wintle et al., *Allocating Monitoring Effort in the Face of Unknown Unknowns*, 13 Ecology Letters 1325 (2010).

360. SeeSilvertown, Jonathan. A New Dawn for Citizen Science. 2009:467. 24 Trends Ecology & Evolution. discussing the growth and contributions of citizen science.

361. One of NSF's most important historical and current criteria for making funding decisions is the "Intellectual Merit" of the proposed research activities, which is assessed based on questions like: "How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields?" and "To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?" *See generally* NAT'L SCI. FOUND., GRANT PROPOSAL GUIDE at III-1 (2010), *available at* http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpgprint.pdf. There is also an increasing consideration of the potential "Broader Impacts" of proposed research to more immediately benefit society at large, which includes the relevance for wildlife conservation and is assessed based on questions such as "What may be the benefits of the proposed activity to society?" and "To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?" *See id*.

362. *See* Bat Conservation Int'l, North American Bat Conservation Fund, http://www.batcon.org/index.php/what-we-do/grants/n-american-bat-conservation-fund.html (last visited Apr. 10, 2011); Partners in Flight, What Is Partners in Flight?, http://www.partnersinflight.org/description.cfm (last visited Apr. 10, 2011) (describing partnership between Partners in Flight and various agencies including the U.S. Fish & Wildlife Service). Many of Partners in Flight's partners provide grants to organizations conducting projects focusing on migration. *See, e.g.*, Div. of Bird Habitat Conservation, U.S. Fish & Wildlife Serv., 2010 Neotropical Grants, http://www.fws.gov/birdhabitat/Grants/NMBCA/2010.shtm (last visited Apr. 10, 2011) (describing grants given in 2010 to organizations conducting projects designed to benefit bird habitat).

363. Jeff Kueter, George C. Marshall Inst., Funding Flows for Climate Change Research AND RELATED Activities 2–3, 7 (2005), *available at* http://www.marshall.org/pdf/materials/289.pdf.

364. *Id*. at 6 fig.2 (showing historical percentages of research focused in different scientific fields).

365. U.S.A. Nat'l Phenology Network, About Us, http://www.usanpn.org/about (last visited February 7, 2011); Nat'l Climate Change & Wildlife Sci. Ctr., U.S. Geological Survey, About NCCWSC, http://nccwsc.usgs.gov/about.shtml (last visited Apr. 10, 2011).

366. Nat'l Inst. Of Allergy & Infectious Diseases, U.S. Dept. Of Health & Human Servs., Pub. No. 08-4753, Niaid: Planning for the 21St Century: 2008 Update 19–20 (2008).

367. U.S. Geological Survey: Biological Resources Division, About Us, http://ecosystems.usgs.gov/about.html (last visited Apr. 10, 2011).

368. U.S. Forest Serv., Dept. of Agric., About Forest Service Research & Development, http://www.fs.fed.us/research/(last visited February 8, 2011); Teaming With Wildlife, State Wildlife Action Plans: Defining a Vision for Conservation Success, *available at* http://www.wildlifeactionplans.org/pdfs/wildlife_action_plan_overview.pdf.

369. The Pittman-Robertson Act is also called the Federal Aid in Wildlife Restoration Act, and the Dingell-Johnson Act is also called the Federal Aid in sport Fish Restoration Act. These acts place taxes on hunting and fishing gear in order to provide federal funds to assist states in wildlife and fisheries restoration and management, as well as to provide public access to hunting and fishing, and public education. *See* Pittman-Robertson Wildlife Restoration Act, 16 U.S.C. §§ 669–669k (2006); Dingell-Johnson Sport Fish Restoration Act, 16 U.S.C. §§ 777–777n (2006).

370. For an introduction to fragmentation as a topic of concern for biodiversity conservation, see Alan B. Franklin et al., *What Is Habitat Fragmentation?, in* 25 Studies in Avian Biology, Effects of Habitat Fragmentation on Birds in Western Landscapes: Contrasts With Paradigms from the Eastern United States 20 (T. Luke George & David S. Dobkin eds., 2002).

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371. *Id.* at 26–27.
372. Glista, David J., et al. Vertebrate Road Mortality Predominantly Impacts Amphibians. 2008:81–83. 3 Herpetological Conservation & Biology 77.
373. 373 *See* U.S. Fish & Wildlife Serv., *supra* note 329, at 6 (discussing effects of fences on pronghorn in the U.S. Great Basin); *see also* Mbaiwa & Mbaiwa, *supra* note 329, at 19–20 (discussing effects of fences on wildlife in Okavango Delta, Botswana).
374. Larinier, Michael. Mamulla, Gerd, editor. Environmental Issues, Dams, and Fish Migration. 2001. Fisher Res. Div., U.N. Food & Agric. Org., Dams, Technical Paper No. 419, Fish and Fisheries: Opportunities, Challenges and Conflict Resolution 45available at http://ftp.fao.org/docrep/fao/004/Y2785E/y2785e.pdf
375. Thompson, Jonathan. Highways and Habitat: Managing Habitat Connectivity and Landscape Permeability for Wildlife. Jan.2006 Pac. Nw. Sci. Findings. at 3, 5. *see* Ky. Dep't of Fish & Wildlife, Wildlife Corridors, http://fw.ky.gov/wildcorr.asp (last visited Apr. 10, 2011) (stating that "narrow grassland strips may predispose animals that use them to predation")
376. See, e.g.Dolan, Cori, Mannan, Bill. Fencing For Wildlife. 2009. p. 1available at http://cals.arizona.edu/pubs/natresources/az1481h.pdf (discussing wildlife-friendly fencing)Mapston, Raymond D., et al. A Pass for Antelope in Sheep-Tight Fences. 1970:457–59. 23 J. Range Mgmt. 457. providing information on pronghorn vulnerability to fences.
377. Cherney, *supra* note 161, at 602 (describing a situation in which a conservation group replaced fencing with wildlife-friendly fencing on private land).
378. Rosenthal, Chandra, Gillon, Kara. Don't Fence Me In—Application of the Unlawful Inclosures of Public Lands Act to Benefit Wildlife. 1999:8–10. 5 Animal L. 1. The fence in question killed approximately 700 antelope during one winter snowstorm in 1983. Johnson, Dirk. When Antelope Don't Roam Free. Nov 18.1988 N.Y. Times. at A16.
379. Larinier, *supra* note 374, at 47.
380. Fragmentation and mortality obviously have local impacts on individuals, but their cumulative effects along a migration corridor or migration front affect landscape patterns and have implications at the population and species levels. Where obstacles to movement or levels of mortality are sufficiently severe, species' ranges can be truncated and migrations halted or curtailed. *Id.* at 49–53.
381. U.S. FISH & WILDLIFE SERV., *supra* note 258; Arnett et al., *supra* note 341, at 62.
382. Drewitt, Allan L., Langston, Rowena HW. Assessing the Impact of Wind Farms on Birds. 2006:30. 148 Ibis 29.
383. Appropriate construction can reduce impacts of fences to some species, notably pronghorn. U.S. Fish & Wildlife Serv., *supra* note 329, at 6. However, appropriate construction cannot reduce stationary object-induced mortality of large migrating birds such as cranes. James C. Lewis, *Whooping Crane (Grus americana), in* BIRDS OF N. AM. ONLINE, *supra* note 63, *available at* http://bna.birds.comell.edu/bna/species/153.
384. Kirby, Jeff S., et al. Key Conservation Issues for Migratory Land- and Waterbird Species on the World's Major Flyways. 18 Bird Conservation Int'l S49, S57. The Mediterranean is one such bottleneck. *Id.*
385. *See generally* Eric Gilman et al., U.N. Food & Agric. Org., Fao Fisheries Circular no. 1025, Review of Measures Taken by Intergovernmental Organizations to Address Sea Turtle and Seabird Interactions in Marine Capture Fisheries (2007), *available at* http://ftp.fao.org/docrep/fao/010/a1426e/a1426e00.pdf (describing bycatch reduction strategies).
386. The most recent reauthorization of the Magnuson-Stevens Act contains a requirement for a bycatch reduction program, which includes seabird interactions with fishing operations. 16 U.S.C. § 1865 (2006).
387. *See, e.g.*, Am. Bird Conservancy, Inc. v. Fed. Commc'ns Comm'n, 516 F.3d 1027, 1029 (D.C. Cir. 2008) (remanding order of FCC approving new communications towers in the Gulf Coast region for failure to satisfy requirements of NEpA and ESA). *See generally* Erwin G. Krasnow & Henry A. Solomon, *Communications Towers: Increased Demand Coupled with Increased Regulation*, 18 MEDIA L. & POL'Y 45 (2008) (discussing regulation of communications towers).

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388. Executive Order 13,186, which clarifies the responsibilities of federal agencies under the MBTA, requires each federal agency taking an action likely to have a negative effect on migratory bird populations to develop and implement a memorandum of understanding (MOU) with the FWS (the lead agency) to promote the conservation of such populations. Exec. Order 13,186, 66 Fed. Reg. 3853, 3854 (Jan. 10, 2001).
389. Section 404 of the 1972 Clean Water Act amendments authorize EPA to issue permits for discharge of dredged or fill material into navigable waters of the United States. Federal Water Pollution Control Act, 33 USC § 1344(a) (2006).
390. *See generally* 23 C.F.R. pt. 774 (explaining the role of Department of Transportation).
391. For example, the proposed Energy Policy Act of 2005 provided for new energy corridors that the National Parks Conservation Association warned members could threaten park scenery. Nat'l Parks Conservation Ass'n, Energy Corridors, Power Lines Threaten National Parkland, http://www.npca.org/media_center/fact_sheets/energy_corridors.html (last visited Apr. 10, 2011).
392. See generallyTarlock, A Dan. Land Use Regulation: The Weak Link in Environmental Protection. 2007:651. 82 Wash. L. Rev. history of federal attempts to regulate land use.
393. The property clause provides: "The Congress shall have Power to dispose of and make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States." U.S. CONST. art. IV, § 3, cl. 2. *See generally* Minnesota v. Block, 660 F.2d 1240, 1248–49 (8th Cir. 1981), *cert, denied*, 455 U.S. 1007 (1982) (upholding constitutionality of the Boundary Waters Canoe Area Wilderness Act, which restricted private conduct on state-owned lands and waters within the boundaries of the BWCAW, as a valid exercise of Congress' authority under the Property Clause); Peter A. Appel, *The Power of Congress "Without Limitation": The Property Clause and Federal Regulation of Private Property*, 86 Minn. L. Rev. 1 (2001) (discussing the property clause and private property).
394. *See* Upper Miss. River Conservation Comm., Upper Mississippi River Conservation Committee, http://www.umrcc.org/River%20Issues.html (last visited Apr. 10, 2011); Lower Miss. River Conservation Comm., Who We Are, http://www.lmrcc.org/who_we_are.htm (last visited Apr. 10, 2011); Miss. Interstate Coop. Res. Ass'n, Operation Framework and Procedures, http://www.micrarivers.org/who-we-are/operation-framework.html (last visited Apr. 10, 2011).
395. W. Governor's Ass'n, Initiative on Wildlife Corridors and Crucial Habitat, http://www.westgov.org/index.php?option=com_content&view=article&id=123&Itemid=68 (last visited Apr. 10, 2011) (explaining that the Western Governor's Association is an alliance of governors of the 19 western states that possess territory west of the 100th meridian). The Association's Wildlife Council has an initiative on wildlife corridors and crucial habitat and has committed to coordinating state geographic information systems to address the problem of wildlife corridors by 2013. *Id*
396. On the U.S. side, the program is led by the NGO Bat Conservation International. *See* Steve Walker, *Mexico-U.S. Partnership Makes Gains For Migratory Bats*, 13 Bats Mag. 3, 3–4 (1995), *available at* http://www.batcon.org/index.php/media-and-info/bats-archives.html?task=viewArticle&magArticleID=717.
397. *See* Karen oberhauser et al., Comm'n for Envtl. Cooperation, Monarch Butterfly Monitoring in North America: Overview of Initiatives and Protocols 13 tbl.1 (2009).
398. Fischman & Adamcik, *supra* note 256, at 11.
399. Matthew Birnbaum et al., *supra* note 319, at 2.
400. Species that migrate over shorter distances without crossing jurisdictional boundaries, and that encounter few or no anthropogenic obstacles such as roads along their migratory paths, are most likely to be well protected by existing wildlife management strategies in part because they are not greatly different from resident species in their needs.
401. The Gap Analysis Program, GAP Home, http://www.nbii.gov/portal/server.pt/community/gap_home/1482 (last visited Apr. 10, 2011); *see* J. Michael Scott et al., *Gap Analysis: A Geographic Approach to Protection of Biological Diversity*, WILDLIFE MONOGRAPHS, Jan. 1993, at 3, 7–9 (describing the GAP analysis program).
402. Press Release, Ass'n of Fish & Wildlife Agencies, Teaming with Wildlife Week–September 5–11, 2010 (Sept. 5, 2010), *available at* http://www.fishwildlife.org/index.php?section=afwa_press_releases&prrid=109 (quote from Ron Regan, executive director of the

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Association of Fish and Wildlife Agencies, the umbrella organization for state and federal wildlife agencies: “The program has been an important source of funds to help keep America’s common species common and to conserve wildlife before they become too rare and costly to protect them.”).

403. Terborgh, John. Where Have All the Birds Gone?. 1989:3–6.
404. Coastal Zone Management Act of 1972, 16 U.S.C. §§ 1451–1466 (2006).
405. The oversight we suggest here is analogous to the “cooperation model” espoused by Professor Ruhl: “The essence of the Cooperation model is the expression of strong federal goals and policies in the context of a flexible partnership between federal, state, and local interests in seeing to it that the federal policies are implemented in the form of substantive legal requirements.” Ruhl, *supra* note 124, at 643. “[T]he Cooperation model poses the greatest promise of achieving the goals of a unified federal biodiversity conservation program for nonfederal lands.” *Id* at 661.
406. *See, e.g.*, Cryan, *supra* note 128, at 360–61 (discussing the significant effects of wind turbines on migratory bat populations and the lack of consistent regulatory protections).
407. SeeYaffee, Steven L. Collaborative Strategies for Managing Animal Migrations: Insights from the History of Ecosystem-Based Management. 2011:676–78. 41 Envtl. L. 655. further exploring ways of motivating cooperative conservation between governmental and private entities.
408. SeeHyman, Jeffrey B., Need, Andrea, Weeks, W William. Statutory Reform to Protect Migrations as Phenomena of Abundance. 2011:435–36. 41 Envtl. L. 407. providing an alternative approach to this problem by addressing the question of improving conservation migration from the perspective of law reform.
409. *See, e.g.*, Climate Adaptation Knowledge Exch., CAKE: Climate Adaptation Knowledge Exchange, http://www.cakex.org/(last visited Apr. 10, 2011); Climate Adaptation Case Studies, CASES Database and Adaptation Library, http://cses.washington.edu/cig/cases (last visited Apr. 10, 2011) (providing examples of websites designed to foster information-sharing).
410. U.S. Fish & Wildlife Serv., Science Excellence, http://www.fws.gov/science/publicationsys.html (last visited Apr. 13, 2011) (discussing that in an effort to reduce this problem, FWS recently began publication of the new *Journal of Fish and Wildlife Management*, which deliberately seeks to provide an outlet for papers that would not pass traditional peer review not because they lack rigor, but because “the topics or presentations are not sufficiently broad to appeal to journal audiences”).
411. W. Governor’s Wildlife Council, Initiative on Wildlife Corridors and Crucial Habitat, http://www.westgov.orgindex.php?option=com_content&view=article&id=123&Itemid=68 (last visited Apr. 10, 2011).
412. Oberhauser et al., *supra* note 397, at 35.