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## SYMPOSIUM: ANIMAL MIGRATION CONSERVATION

### SYMPOSIUM ESSAY

- Migration Conservation: A View From Above ..... 277  
*Robert L. Fischman*

The extinction prevention focus of natural resources policy diverts attention from important issues of ecological integrity and adaptation to climate change. Animal migration conservation serves as a bridge from the imperiled species problem to the more spatially and temporally difficult problems surrounding climate change adaptation. Conserving abundant animal migrations both strengthens the resilience of the ecosystems in which they function and tests the resilience of social institutions responsible for adaptation. This essay synthesizes the findings of a two-year, interdisciplinary study of animal migration conservation. It also introduces the articles that follow in this symposium issue, which is a result of the study.

### SYMPOSIUM ARTICLES

#### SCIENTIFIC RESEARCH AGENDA

- Animal Migration as a Moving Target For Conservation:  
Intra-Species Variation and Responses to Environmental Change,  
as Illustrated in a Sometimes Migratory Songbird ..... 289  
*Jonathan W. Atwell, Dawn M. O'Neal & Ellen D. Ketterson*

Identifying important “migratory species” and the characteristics of their migrations might sound like a simple starting point for efforts to conserve and protect animal migrations. However, migrations are dynamic phenomena that vary over space and time, and migratory behaviors can vary substantially among closely related species, subspecies, races, or populations, and even among individual animals within a single population. The migratory behaviors of populations or individuals can also change rapidly—or be lost entirely—in response to habitat alteration or climate change. These complexities present

both challenges and opportunities for initiatives to conserve animal migrations. In this Article, we discuss the concepts of intra-species variation in migration and the sensitivity of migrations to environmental change, and we consider the implications of these topics for legal, policy, management, and research agendas.

Migratory Connectivity and the Conservation of Migratory Animals.... 317  
*Peter P. Marra, David Hunter & Anne M. Perrault*

Migration is the repeated seasonal movement to and from a breeding area. The linking of individuals or populations of a given species within its range, including its breeding, migration, and wintering areas, is known as migratory connectivity. In this Article, we discuss how new technologies and approaches are enhancing our knowledge of migratory connectivity, which in turn can improve our legal and policy approaches to the conservation of migratory animals. Advances in studying and documenting migratory connectivity require new approaches to the design and implementation of both domestic and international conservation efforts. Understanding migratory connectivity of different populations of species between specific geographic locations can also help build “social connectivity” for conservation—the cultural, educational, economic, and institutional linkages between these same locations that are a necessary foundation for effective and sustainable conservation efforts.

Wind Turbines as Landscape Impediments to the Migratory  
 Connectivity of Bats ..... 355  
*Paul M. Cryan*

Unprecedented numbers of migratory bats are found dead beneath industrial-scale wind turbines during late summer and autumn in both North America and Europe. Prior to the wide-scale deployment of wind turbines, fatal collisions of migratory bats with anthropogenic structures were rarely reported and likely occurred very infrequently. There are no other well-documented threats to populations of migratory tree bats that cause mortality of similar magnitude to that observed at wind turbines. Just three migratory species comprise the vast majority of bat kills at turbines in North America and there are indications that turbines may actually attract migrating individuals toward their blades. Although fatality of certain migratory species is consistent in occurrence across large geographic regions, fatality rates differ across sites for reasons mostly unknown. Cumulative fatality for turbines in North America might already range into the hundreds of thousands of bats per year. Research into the causes of bat fatalities at wind turbines can ascertain the scale of the problem and help identify solutions. None of the migratory bats known to be most affected by wind turbines are protected by conservation laws, nor is there a legal mandate driving research into the problem or implementation of potential solutions.

Migratory Species and Ecological Processes .....	371
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By definition, migratory species are members of multiple ecological communities separated in space and time. We examine this attribute of migratory species in terms of the ecological roles played by migrants in ecosystems. Using the Millennium Ecosystem Assessment's framework for classifying the services provided to humans by ecosystems, we provide an overview of the community- and ecosystem-level effects of migratory species, considering those effects that lead to human well-being (ecosystem services) as well as effects that pose threats to human well-being (e.g., disease transmission). Ecosystem services and disservices are in many cases a function of abundance, raising the argument that rarity as a traditional threshold of species protection fails to preserve key ecological roles. While this argument applies to all species, migratory species provide instructive case studies.

Climate Change and Animal Migration.....	393
<i>Thomas T. Moore</i>	

Animal migrations are important to the healthy function of many ecosystems. When biotic and abiotic cues are altered by climate change, migrations may be disrupted. Climate change has the potential to disrupt these migrations by altering habitat, changing resource availability, increasing habitat disturbance, changing phenology, and stopping migration. The act of migration (i.e., potentially travelling long distances) causes species to confront a wide range of climatic changes that make adaptation especially difficult. Future research goals should strive to obtain long-term data on migrations and better understand how—and whether—migratory species adapt to changes in climate. Future management techniques should strive to maximize the ability of the target species to adapt to climate change by providing species with more options (e.g., protecting alternative migration corridors) to react to changes in their habitat.

## LAW AND POLICY REFORM

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<i>Jeffrey B. Hyman, Andrea Need &amp; W. William Weeks</i>	

Animal migrations capture the human mind and heart, and provide ecological, psychological (e.g., aesthetic), cultural, and economic benefits. Increasingly, though, migrations are being recognized as threatened phenomena. This article presents an idea for a new federal law that reflects the perspective that conserving migratory behaviors and processes as phenomena of value in and of themselves, and not only of value for species persistence, can provide unique and important benefits. The existing fragmented framework of laws and authorities is insufficient to protect most migratory populations against

a diversity of threats across multiple jurisdictions and broad geographic scales. Our proposed federal law would offer a unified framework, require abundance targets, and authorize a comprehensive set of legal tools, including both carrots and sticks, for conserving a limited set of nationally or regionally “significant” migrations.

Migration and Conservation: Frameworks, Gaps, and Synergies in Science, Law, and Management .....	447
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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 increasing destroy and fragment habitat, create obstacles to migration, and increase mortality along the migration corridor. This Article outlines scientific, legal, and management information and approaches to migratory species to assess present capacity to protect migrants and the phenomenon of migration and recommends state-centered models for building a unified program to conserve migratory species.

Twenty-Five Years Under the Convention on Migratory Species: Migration Conservation Lessons from Europe.....	535
<i>Elizabeth A. Baldwin</i>	

Animal migrations frequently cross international boundaries, and conservation of migratory species requires the collaborative efforts of multiple nations. The Convention on Migratory Species (CMS) has overseen such conservation efforts for over twenty-five years by encouraging member Parties to conclude daughter agreements focused on protecting individual migratory species or groups of migratory species. In the past twenty-five years, CMS members have concluded twenty-six agreements that protect a wide range of migratory species. Many of these agreements provide targeted actions to offer immediate protection for critically endangered or threatened migratory species, but a handful are much broader in scope, providing protection for large classes of migratory species, regardless of endangerment status. This Article examines the structure of the CMS and its daughter agreements to identify key challenges for international migratory species protection, and draws on international environmental policy literature to identify potential strategies for overcoming these problems in future agreements.

Conservation of Migratory Species in a Changing Climate: Strategic Behavior and Policy Design.....	573
<i>Kathleen A. Miller</i>	

The protection of migratory animals requires cooperation among multiple decision-making entities. These may include individual resource users or property owners, different government agencies within a single national or state jurisdiction, or the governments of different sovereign nations. The fate of the migratory animals, the values accruing to the various human actors, and the costs they bear, will depend on a suite of actions taken by several independent entities

at different points in space and time. No single decision maker has full control over the set of human actions that will determine the overall status of the migratory species—or even the outcomes valued by that single decision maker. Recognizing this interdependence, human decision makers will tend to behave strategically. In other words, their decisions regarding the best way to achieve their individually-valued objectives will depend on the expected actions and reactions of the other relevant actors. This interplay can take a variety of forms—ranging from individual decisions on compliance, or not, with hunting regulations as a function of the likelihood of getting caught and the severity of the resulting punishment, to the strategic positions of individual nations in negotiating treaties on habitat conservation or fishery management. The policy problem thus entails designing an appropriate set of incentives for each of the decision-making entities to channel their actions towards mutually satisfactory and environmentally-responsible outcomes. A changing climate can complicate this task by altering the migratory behavior or reproductive success of the animals that a policy or agreement is attempting to manage. This Article will survey a range of policy situations in which the efficacy of a policy, treaty or other agreement could be undermined by strategic behavior—in particular strategic reactions to the effects of changing environmental conditions.

## COLLABORATION CASE STUDIES

- Securing the Free Movement of Wildlife: Lessons from the American West's Longest Land Mammal Migration ..... 599  
*David N. Cherney*

This paper examines the protection of the lower 48's longest mammal migration as a possible prototype for the conservation of other land mammal migrations. This case suggests that while collaboration among diverse stakeholders is a worthy aspiration, is not necessary for the protection of all migratory species. Key findings include utilizing symbolic politics to build social connectivity and addressing migratory challenges through parallel (or a portfolio) of solutions.

- Habitat Reserve Problem-Solving: Desperately Seeking Sophisticated Intermediaries ..... 619  
*Jamison Colburn*

In 2001, some 137 Pennsylvania communities across a dozen counties joined with the Audubon Society and dozens of other nonprofit organizations in an umbrella “coalition” of citizens alarmed by what they saw as the gradual destruction of one of the most significant wildlife habitat strongholds in the Northeast: the Kittatinny Ridge. Its 500+ square miles traversing Pennsylvania are recognized as a “globally significant” migratory flyway which aids scores of migrant species in spring and fall and supplies interior forest habitat to many more year-round. The Kittatinny Coalition (KC) works from a common plan for the permanent conservation of the ridge as forested space. Their internal plurality and diversity keeps entities like the KC in a

permanent “crisis of identity,” however. This paper sketches some of the ways in which the fragmentative influences of our law lock entities like the KC into the horns of its dilemma as well as some ways in which the law should help entities like the KC scale up their (and our) conservation strategies and actions.

Collaborative Strategies for Managing Animal Migrations: Insights From the History of Ecosystem-Based Management .....	655
<i>Steven L. Yaffee</i>	

Twenty years of experience with collaborative ecosystem-based management (EBM) provides insights that can be applied to the management of animal migrations. Since the principles underlying EBM are the same as those informing migration conservation, and they exhibit many of the same challenges, it is reasonable to presume that factors that have facilitated progress in EBM will be helpful in migration conservation. These include factors related to motivation, organization, resources, adaptability, legitimacy, and energy that create the incentives and capacity to carry out landscape-scale collaborative action to secure migratory corridors. The EBM experience also suggests that these factors are best considered as elements of a dynamic project lifecycle that calls for different strategies at varying points of time. Less demanding social outcomes, such as communication, precede more complex ones, such as trust, and procedural and social improvements often precede ecological change. While collaborative action is almost by definition voluntary, in fact, collaborative EBM exists within an incentive structure that promotes joint decision making and action. Legal mandates such as the Endangered Species Act form part of this incentive structure. Well-managed collaborative processes can be effective at finding creative, win-win type strategies when given a credible goal with the space to invent solutions and the incentives to do so.