

## MIGRATORY CONNECTIVITY AND THE CONSERVATION OF MIGRATORY ANIMALS

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*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.*

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## I. INTRODUCTION

Migration is the repeated seasonal movement to and from a breeding area.<sup>1</sup> The linking of individuals or populations within a species range is known as migratory connectivity. This includes not only the geographic linking of breeding, migratory, and wintering areas of given populations, but also an understanding of how demographic components, such as sex and age, relate to the annual distribution of these populations in geographically linked areas. Currently, we know the overall year-round ranges for most species, but we have a poor understanding of their migratory connectivity.<sup>2</sup> Not known is where individuals or populations, including different age and sex classes, go subsequent to breeding or whether these populations mix or remain independent of one another.<sup>3</sup> What is known is that events during one period of the annual cycle, such as reproductive success and survival, can be driven by events in previous periods—often thousands of miles away and often across international boundaries—where legal protection can be different, if not absent.

In this Article, we review and discuss why understanding migratory connectivity is essential for the conservation of migratory animals and consider legal and other approaches in response to this understanding. Both the individuals and the habitats upon which they depend for their various life history stages (e.g., reproduction, molt, growth, and migration) throughout the year need protection. We argue that existing conservation efforts, including domestic laws and international treaties, can be made more effective by considering information on migratory connectivity. Advances in our understanding of the migratory connectivity of different species populations between regions and countries could also help to build

<sup>1</sup> Michael S. Webster et al., *Links Between Worlds: Unraveling Migratory Connectivity*, 17 *TRENDS IN ECOLOGY & EVOLUTION* 76, 76 (2002).

<sup>2</sup> *See id.*

<sup>3</sup> *Id.*

“social connectivity”—the cultural, educational, economic, and institutional linkages between these same regions and countries. Increased social connectivity between distant locations that share biological resources will build a more reliable foundation for effective and sustainable conservation efforts to protect migratory species.

## II. THE IMPORTANCE OF MIGRATORY CONNECTIVITY

Migration varies across species and can include seasonal migrations across latitudes, altitudinal migrations up and down mountains, and migrations that can span multiple generations over space and time.<sup>4</sup> It is found in all major groups of animals, both invertebrates and vertebrates, including insects (e.g., dragonflies and butterflies),<sup>5</sup> fish (e.g., eels and salmon),<sup>6</sup> amphibians (e.g., salamanders and toads),<sup>7</sup> reptiles (e.g., snakes and sea turtles),<sup>8</sup> birds (e.g., terns and warblers),<sup>9</sup> and mammals (e.g., wildebeest and whales).<sup>10</sup>

The Gray Catbird (*Dumatella carolinensis*) is an example of a long-distance migratory songbird that migrates across latitudes and is also a common backyard breeder in the eastern United States.<sup>11</sup> Post-breeding in the autumn, catbirds leave on a long-distance migration for their wintering grounds where they spend the majority of their annual cycle and then return north the following spring to breed.<sup>12</sup> The birds often return to the same exact location (within meters) where they bred the previous year.<sup>13</sup> Although the general nature of this remarkable boomerang journey has been known for years and continues to inspire and befuddle us, only recently—due to technological advances in our ability to track birds—did we come to learn where specific breeding individuals and populations spent the winter. During the 2009 breeding season, scientists from the Smithsonian’s Migratory Bird Center attached miniature daylight level data loggers to the backs of 20 breeding catbirds in the Washington, D.C. suburb of Takoma

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<sup>4</sup> See HUGH DINGLE, *MIGRATION: THE BIOLOGY OF LIFE ON THE MOVE* 293, 320–21 (1996).

<sup>5</sup> T. R. E. Southwood, *Migration of Terrestrial Arthropods in Relation to Habitat*, 37 *BIOLOGICAL REV.* 171, 175–97 (1962) (discussing the migratory habits of different families of insects).

<sup>6</sup> R. J. F. SMITH, *THE CONTROL OF FISH MIGRATION I* (1985) (providing an overview of fish migration).

<sup>7</sup> See Anthony P. Russell et al., *Migration in Amphibians and Reptiles: An Overview of Patterns and Orientation Mechanisms in Relation to Life History Strategies*, in *MIGRATION OF ORGANISMS: CLIMATE, GEOGRAPHY, ECOLOGY* 151, 151 (Ashraf M.T. Elewa ed., 2005).

<sup>8</sup> See *id.*

<sup>9</sup> See PETER BERTHOLD, *BIRD MIGRATION: A GENERAL SURVEY I* (2d ed. 2001).

<sup>10</sup> C.H. Lockyer & S.G. Brown, *The Migration of Whales*, in *ANIMAL MIGRATION* 151 (D.J. Aidley ed., 1981).

<sup>11</sup> See The Cornell Lab of Ornithology, Gray Catbird, Sounds, All About Birds, [http://www.allaboutbirds.org/guide/Gray\\_catbird/sounds](http://www.allaboutbirds.org/guide/Gray_catbird/sounds) (last visited Feb. 18, 2011).

<sup>12</sup> See Seattle Audubon Soc’y, Gray Catbird – Northwest Shade Coffee Campaign, <http://shadecoffee.org/shadecoffee/Profile.aspx?birdid=356> (last visited Feb. 18, 2011).

<sup>13</sup> See J. A. Darley et al., *Effects of Age, Sex, and Breeding Success on Site Fidelity of Gray Catbirds*, 48 *BIRD-BANDING* 145, 147, 149 (1977).

Park, Maryland.<sup>14</sup> During the subsequent breeding season, six of these catbirds were recaptured, the data loggers recovered and the mysteries of their migratory journey revealed.<sup>15</sup> Scientists learned the exact day of departure from Takoma Park and the exact day of arrival at the wintering grounds.<sup>16</sup> Four of the catbirds spent the winter on the island of Cuba and two in the Everglades of Florida.<sup>17</sup> The scientists also discovered which states the individuals stopped in during migration to build fat stores for their migratory journey.<sup>18</sup> Such advances in understanding “migratory connectivity” are still in their infancy, but the implications for wildlife conservation in the future could be profound.

Species, such as the gray catbird, which move north and south between breeding areas in North America and non-breeding areas in the Caribbean, Central America, and South America, are considered Nearctic-Neotropical migratory birds.<sup>19</sup> Such species spend approximately three months of the year at breeding areas at temperate latitudes. Individuals then replace feathers, a process known as molting, accumulate fat stores for energy consumption during migration, and migrate south in August and September to a distant, ecologically dissimilar, and politically distinct location, often within the tropical latitudes.<sup>20</sup> The fall post-breeding migration can take one to three months and involve several stopovers for refueling on the way south.<sup>21</sup> The individuals will spend the majority of the annual cycle, approximately six to eight months, at their stationary non-breeding area.<sup>22</sup> Depending on the species, these animals will either remain in their territories, roam locally, or at most, roam regionally.<sup>23</sup> From March to May—depending on the species and wintering location—individuals once again begin to accumulate fat stores, depart wintering areas, and commence on a northward spring migration to return to breeding areas.<sup>24</sup> Areas to which

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<sup>14</sup> Thomas B. Ryder et al., *Estimating Migratory Connectivity for Gray Catbirds* (*Dumetella carolinensis*) *Using Geolocator and Mark-Recapture Data*, AUK (forthcoming 2011) (manuscript at 18) (on file with authors).

<sup>15</sup> *Id.* at 5.

<sup>16</sup> *Id.* at 5, 12 tbl.1.

<sup>17</sup> *Id.* at 5.

<sup>18</sup> *Id.* at 5, 15–17.

<sup>19</sup> See David W. Steadman, *The Paleoecology and Fossil History of Migratory Landbirds*, in *BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION* 5, 11 (Russell Greenberg & Peter P. Marra eds., 2005) (providing information on migratory bird ecology).

<sup>20</sup> See Sievert Rohwer et al., *Ecology and Demography of East-West Differences in Molt Scheduling of Neotropical Migrant Passerines*, in *BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION*, *supra* note 19, at 87, 91–99.

<sup>21</sup> See, e.g., Ryder et al., *supra* note 14, at 12 tbl.1.

<sup>22</sup> Michael S. Webster, *Overview to Behavioral Ecology*, in *BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION*, *supra* note 19, at 305, 305.

<sup>23</sup> Russell Greenberg & Volker Salewski, *Ecological Correlates of Wintering Social Systems in New World and Old World Migratory Passerines*, in *BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION*, *supra* note 19, at 336, 345–46.

<sup>24</sup> Theunis Piersma et al., *Fuel Storage Rates Before Northward Flights in Red Knots Worldwide: Facing the Severest Ecological Constraint in Tropical Intertidal Environments?*,

individuals or populations of most species departing breeding or wintering areas go still remain a biological mystery, largely because of technological limitations. The animals themselves are small, and the areas they traverse are vast, making their annual cycle movements nearly impossible to track.

In addition to challenges relating to tracking their movements, protecting these diverse species is remarkably complex, in part due to the disparate geographic areas they occupy at different times of the year. As we argue below, effective conservation requires taking into account the geographic linkages of breeding, migration, and wintering populations. This will mean protecting the habitats upon which they depend for their various life history stages (e.g., reproduction, molt, growth, and migration) throughout the year. For a sea turtle, this means protection of important nesting beaches as well as the oceans that are essential for foraging, mating, and survival during the rest of the year. For a Nearctic-Neotropical migratory bird, this means protecting important temperate breeding habitats, temperate and tropical stopover sites during fall and spring migration, and the tropical wintering habitats where they spend the majority of the annual cycle. Protecting such sites for linked populations of a species across such broad geographic expanses will be difficult and will likely necessitate novel approaches and information from the biological, social, and legal disciplines.

The geographic linking of individuals or populations between different stages of the annual cycle, including between breeding, migration, and winter stages, is known as “migratory connectivity.”<sup>25</sup> Currently, we know the overall year round ranges that most, but not all, animal species occupy throughout the year.<sup>26</sup> For some restricted-range species (i.e., those that have small breeding, migratory, or wintering areas), species conservation will depend on the protection of one or all of those restricted geographic areas.

Two examples of range-restricted species include the monarch butterfly (*Danaus plexippus*) and the Kirtland’s Warbler (*Dendroica kirtlandii*) (Figures 1 and 2). The Monarch butterfly’s life cycle starts with an egg laid on the leaf of a milkweed (*Asclepias* spp.) plant.<sup>27</sup> After four days, a caterpillar (larvae) emerges, feeds on the milkweed for about two weeks, and then forms into a pupa (chrysalis).<sup>28</sup> Approximately ten days later an adult butterfly emerges and the cycle is repeated.<sup>29</sup> The spectacular migratory story of the Monarch begins as individuals migrate south to a restricted wintering region in the mountains of Michoacan, Mexico, where

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in BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION, *supra* note 19, at 262, 265–71.

<sup>25</sup> Webster et al., *supra* note 1, at 76.

<sup>26</sup> *Id.*

<sup>27</sup> Karen S. Oberhauser, *Overview of Monarch Breeding Biology*, in THE MONARCH BUTTERFLY: BIOLOGY AND CONSERVATION 3, 3 (Karen S. Oberhauser & Michelle J. Solansky eds., 2004).

<sup>28</sup> *Id.* at 3–5.

<sup>29</sup> *Id.* at 5.

they spend several months in one of about ten local populations.<sup>30</sup> Here, millions of Monarchs drape cedar trees at high elevations and then in early spring begin migrating north, stopping along the way to breed, lay eggs and die.<sup>31</sup> The cycle is repeated through four generations as the animals move north. The fourth generation adults are the individuals that migrate south again to Mexico.<sup>32</sup> Aside from small wintering populations in Florida and southern California, all Monarchs breeding in the United States and Canada winter in this small area of Mexico.<sup>33</sup> The long-term stability of this population is largely dependent on the protection of individuals and habitat on the wintering grounds since it has a broad breeding range but a restricted wintering area.

The Kirtland's Warbler—North America's most endangered songbird with less than 2000 singing males—has both a restricted breeding and wintering range, and little is known about the routes it takes to journey back and forth.<sup>34</sup> Over 95% of this population breeds in the Jack Pine forests of Michigan and winters on a few islands of the Bahamas.<sup>35</sup> Interestingly, it has been only within the last ten years that a sizable wintering population was discovered on the Bahamian island of Eleuthera.<sup>36</sup> Prior to this, the entire wintering area was known from only a few specimen records. We still know little about the routes individuals take during migration. Clearly, in this case, conservation must occur with individuals and habitats on breeding and non-breeding (including migration) grounds for the species to be adequately protected.

The breeding population of a migratory species can be comprised of many subpopulations that can often have drastically different abundance trajectories.<sup>37</sup> For example, consider a hypothetical migratory species whose

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<sup>30</sup> Eligio García-Serrano et al., *Locations and Area Occupied by Monarch Butterflies Overwintering in Mexico from 1993 to 2002*, in THE MONARCH BUTTERFLY, *supra* note 27, at 129, 129.

<sup>31</sup> Andrew K. Davis & Mark S. Garland, *Stopover Ecology of Monarchs in Coastal Virginia: Using Ornithological Techniques to Study Monarch Migration*, in THE MONARCH BUTTERFLY: BIOLOGY AND CONSERVATION, *supra* note 27, at 89, 89.

<sup>32</sup> Michelle J. Solensky, *Overview of Monarch Migration*, in THE MONARCH BUTTERFLY: BIOLOGY AND CONSERVATION, *supra* note 27, at 79, 82.

<sup>33</sup> Michelle J. Solensky, *Overview of Monarch Overwintering Biology*, in THE MONARCH BUTTERFLY: BIOLOGY AND CONSERVATION, *supra* note 27, at 117, 117.

<sup>34</sup> See generally LAWRENCE H. WALKINSHAW, KIRTLAND'S WARBLER: THE NATURAL HISTORY OF AN ENDANGERED SPECIES 17, 22, 180 (1983) (providing general information on the Kirtland's Warbler).

<sup>35</sup> *Id.* at 17, 35.

<sup>36</sup> Dave Currie et al., *Winter Avian Distribution and Relative Abundance in Six Terrestrial Habitats on Southern Eleuthera, The Bahamas*, 41 CARIBBEAN J. SCI. 88, 99 (2005), available at [http://www.caribjsci.org/april05/41\\_88-100.pdf](http://www.caribjsci.org/april05/41_88-100.pdf).

<sup>37</sup> An abundance trajectory is an estimate of a species's population abundance over time based on modeling equations. See Christopher G. Hayes, Investigating Single and Multiple Species Fisheries Management: Stock Status Evaluation of Hammerhead (*Sphyrna* spp.) Sharks in the Western North Atlantic Ocean and Gulf of Mexico 82 (Dec. 14, 2007) (unpublished thesis, Virginia Polytechnic Institute and State University), available at [http://scholar.lib.vt.edu/theses/available/etd-01182008-105214/unrestricted/Hayes\\_Thesis\\_FINAL.pdf](http://scholar.lib.vt.edu/theses/available/etd-01182008-105214/unrestricted/Hayes_Thesis_FINAL.pdf) (using the Fox

breeding populations in the northeastern United States are declining but its southeastern and Midwestern populations are stable or increasing.<sup>38</sup> Despite the fact that the overall winter range for the species is known, where individuals or subpopulations actually spend winter (i.e., migratory connectivity) remains a mystery. Specifically, unknown is whether different breeding populations mix during winter (Figure 1) or remain tightly linked geographically to breeding areas (Figure 2). Understanding this migratory connectivity is important, if, for example, the declining northeastern breeding population winters primarily on the island of Hispaniola (including the country of Haiti) where little native habitat remains, while southern populations winter in Belize and surrounding countries. Refinement of our understanding of how populations distribute themselves throughout their annual cycle will provide for more focused and effective conservation efforts.

Quantifying migratory connectivity is also fundamental to our ability to identify when and where in the annual cycle certain vital rates (i.e., survival and reproduction), which underlie the dynamics of the populations, are being affected. Furthermore, because we now know that events in one period of the annual cycle also affect individuals and populations in subsequent periods, understanding how events throughout the annual cycle interact is essential.

Taking another example from birds, variation in reproductive success at breeding areas can depend largely on events occurring in previous periods often thousands of miles away in the tropics.<sup>39</sup> The American Redstart (*Setophaga ruticilla*), a long-distance migratory bird that breeds in eastern deciduous forests of the United States and Canada and winters in the Greater Antilles, in Mexico, Central America, and South America, provides one such example.<sup>40</sup> Redstarts occupy territories along a wet to dry moisture (and habitat) gradient with drier sites being of lower suitability.<sup>41</sup> In addition, males, because of their dominant behavior, typically exclude females to the lower suitability drier sites.<sup>42</sup> This results in consequences to birds both within and between seasons. Birds in drier habitats, regardless of their sex and age, lose body mass over winter and leave significantly later on spring

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model, Schaefer model, and Pella-Tomlinson model to estimate population abundance of shark species over time and using those estimates to graph abundance trajectories).

<sup>38</sup> Most populations of migratory birds have subpopulations that are distributed in various geographic locations and vary in abundance. See, e.g., Frances C. James et al., *New Approaches to the Analysis of Population Trends in Land Birds*, 77 *ECOLOGY* 13, 16–19 (1996) (examining trends in 26 warbler species).

<sup>39</sup> Peter P. Marra et al., *Linking Winter and Summer Events in a Migratory Bird by Using Stable-Carbon Isotopes*, 282 *SCI.* 1884, 1884 (1998).

<sup>40</sup> The Cornell Lab of Ornithology, American Redstart, Life History, All About Birds, [http://www.allaboutbirds.org/guide/American\\_Redstart/lifehistory](http://www.allaboutbirds.org/guide/American_Redstart/lifehistory) (last visited Feb. 18, 2011).

<sup>41</sup> Peter P. Marra & Richard T. Holmes, *Consequences of Dominance-Mediated Habitat Segregation in American Redstarts During the Nonbreeding Season*, 118 *AUK* 92, 100 (2001).

<sup>42</sup> Peter P. Marra, *The Role of Behavioral Dominance in Structuring Patterns of Habitat Occupancy in a Migrant Bird During the Nonbreeding Season*, 11 *BEHAV. ECOLOGY* 299, 304 (2000).

migration.<sup>43</sup> Using stable carbon isotopes<sup>44</sup> in body tissues of arriving redstarts on breeding areas, a recent study demonstrated that redstarts arriving early on breeding areas wintered in wet habitats and were in better physical condition compared to those arriving later that came from dry habitats and were in poor condition.<sup>45</sup> Another study followed up on this research and demonstrated that winter habitat occupancy also determined the number of young that were fledged during the breeding season.<sup>46</sup> Males and females that wintered in wetter habitats arrived earlier, in better condition, and fledged more young than males and females from dry winter habitat.<sup>47</sup> These studies thus illustrated how “carry-over effects”—“non-fatal” impacts that change timing or condition of birds—resulted in important consequences between seasons thousands of miles apart. Such carry-over effects, which are a type of seasonal interaction, are poorly understood within all animal taxa, largely because of our inability to track animals and quantify their migratory connectivity.

As these examples suggest, understanding migratory connectivity can be important for designing effective conservation efforts. Recent technological advances hold the promise to further expand our understanding of migratory connectivity. In the future, both international and national conservation efforts should be designed and implemented to take better advantage of advances in migratory connectivity science. Conservation efforts will also benefit from enhancing the “social connectivity”—the economic, cultural, educational, and legal connections—between countries and regions that are shown to be ecologically connected through migratory connectivity studies. In the next Part, we provide a brief overview of current technologies available for tracking animals for the purpose of quantifying migratory connectivity.<sup>48</sup> We then discuss how taking full advantage of these new technologies will require designing and implementing national and international legal approaches in new ways to reflect emerging knowledge of migratory connectivity.<sup>49</sup> Finally, we argue that enhanced understanding of migratory connectivity will help us to strengthen the social connectivity—the cultural, educational, legal, and institutional linkages—between distant locales that are ecologically

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<sup>43</sup> Marra & Holmes, *supra* note 41, at 95, 99.

<sup>44</sup> Stable carbon isotopes vary across habitats largely due to differences in the water use efficiency of plants. Water use is determined by stomata or pores on leaf surfaces of plants that regulate the exchanges of gases between the atmosphere and the plant tissue. In dry environments, stomatal opening is reduced, and in wet environments, they are enlarged, thereby creating differences in the amount of carbon that is exchanged with the atmosphere. See generally G. D. Farquhar, J. R. Ehleringer & K. T. Hubick, *Carbon Isotope Discrimination and Photosynthesis*, 40 ANN. REV. PLANT PHYSIOLOGY & PLANT MOLECULAR BIOLOGY 503, 503–37 (1989).

<sup>45</sup> Marra et al., *supra* note 39, at 1884.

<sup>46</sup> Matthew W. Reudink et al., *Non-Breeding Season Events Influence Sexual Selection in a Long-Distance Migratory Bird*, 276 PROC. ROYAL SOC'Y B 1619, 1624 (2009).

<sup>47</sup> *Id.* at 1623.

<sup>48</sup> See *infra* Part III.

<sup>49</sup> See *infra* Part IV.A.



connected through migration, which is ultimately what is required for effective long-term conservation of migratory species.<sup>50</sup>

### III. APPROACHES FOR MEASURING MIGRATORY CONNECTIVITY

#### A. Marked Animal Approaches

Capture-recapture methods—for example, leg bands, neck collars, and satellite transmitters—some of which have been developed only within the last decade, permit direct estimation of movement of individually marked animals across different locations.<sup>51</sup> Millions of birds are marked with aluminum leg bands during one period of the annual cycle with the hope that the bird would be recaptured or found dead in a subsequent period in a different location. Unfortunately, data on return rates of marked individuals to both breeding and wintering grounds have not proven useful for understanding connectivity of migratory bird populations.<sup>52</sup> The geographic area is too large, the birds are too small, and not enough scientists are working to recapture or re-sight banded birds.

In contrast, satellite transmitters offer substantial promise because they do not require recapturing or re-sighting the bird, but they are expensive (\$4,000 – \$6,000 per transmitter) and are limited to animals of large body size (>600 grams; e.g. hawks, ducks, and geese).<sup>53</sup> Despite these drawbacks, satellite transmitters—especially those equipped with global positioning systems (GPS)—allow for the collection of detailed information, often within tens of meters, on the movement patterns of individuals over large spatial areas directly to a computer.

The British Antarctic Survey has recently developed a small and affordable daylight level data recorder (geolocator) for tracking animals over long periods of time.<sup>54</sup> These devices weigh as little as 1.5 grams and can be attached to birds by methods similar to long-standing VHF radio-transmitters used in tracking the daily movements of songbirds. At 1.5 grams, geolocators can be attached to species that weigh as little as 13–14 grams, a category that includes hundreds of smaller bird species ranging from shorebirds to passerine songbirds. Geolocators take consistent readings of daylight timing for approximately one year, but do not transmit signals so the devices must be recovered from returning birds to download

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<sup>50</sup> See *infra* Part V.

<sup>51</sup> W. Douglas Robinson et al., *Integrating Concepts and Technologies to Advance the Study of Bird Migration*, 8 FRONTIERS ECOLOGY & ENV'T 354, 355 tbl.1 (2010).

<sup>52</sup> See Webster et al., *supra* note 1, at 78–79 (noting that the success of leg band mark-recapture studies is hindered by low recapture rates and inadequate statistical methodologies).

<sup>53</sup> *Id.* at 79.

<sup>54</sup> British Antarctic Survey, Geolocator Models, [http://www.birdtracker.co.uk/geolocators\\_2.html](http://www.birdtracker.co.uk/geolocators_2.html) (last visited Jan. 21, 2011) (listing the various archival geolocator models).

the archived data directly.<sup>55</sup> Not only can recapturing the returning animals be difficult, but the annual return rates of the animals themselves can often be far less than 100 percent.<sup>56</sup> If recovered, the data is then interpreted to determine latitude and longitude of the individual bird for every day the logger was attached and exposed to a suitable sunrise and sunset. Geolocators have returned somewhat accurate ( $\pm 200$  kilometers) and detailed location information on ocean birds, and their utility on small migrating songbirds is being used with reliability.<sup>57</sup> The miniaturization of geolocators may represent an unparalleled opportunity to discover how distant breeding and non-breeding areas connect and interact in space and time.

### *B. Molecular Genetic Approaches*

The extrinsic marker methods described above require that the marked individuals be recaptured or relocated at some point in time. A category of newer methods use “intrinsic markers,” that is, markers that come from the animal itself, such as from tissues like blood and muscle. One popular approach has been to use molecular genetic markers found in DNA.<sup>58</sup> The basic idea of most genetic marker approaches is that, if certain genetic markers (e.g., alleles or haplotypes) are found in one breeding population (X) but not another (Y), then finding those markers in a particular wintering population will indicate some degree of connectivity between that wintering population and breeding population X. In some cases, it also should be possible to determine the degree or strength of that connectivity. The molecular genetic approach hinges on some level of genetic differentiation among breeding populations. Typically, markers will not be unique to particular breeding populations, but instead might vary in frequency across populations. In this case, it is possible to calculate the probability that a wintering individual originated from one breeding population or another (or vice versa)—that individual has a high probability of originating from any population where its genetic markers are common, and a low probability of having come from populations where those markers are rare. The strength of the ability to assign individuals and determine connectivity depends on both the degree of genetic differentiation among populations (e.g., in the breeding range), and also on the number of markers used.<sup>59</sup> The primary difficulty with molecular genetic approaches to determine migratory

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<sup>55</sup> See Richard Harris, *Tracking Devices Reveal Songbirds' Travels*, NAT'L PUB. RADIO, Feb. 13, 2009, <http://www.npr.org/templates/story/story.php?storyId=100539101> (last visited May 18, 2011).

<sup>56</sup> See B.J.M. Stutchbury et al., *Bridget Stutchbury on Tracking Long-Distance Songbird Migration*, SCI. WATCH, Sept. 2010, <http://www.sciencewatch.com/dr/fmf/2010/10sepfmf/10sepfmfStuc/> (last visited May 18, 2011).

<sup>57</sup> It was geolocators that gave us the information from our six Gray Catbirds described in the Introduction.

<sup>58</sup> See Sonya M. Clegg et al., *Combining Genetic Markers and Stable Isotopes to Reveal Population Connectivity and Migration Patterns in a Neotropical Migrant, Wilson's Warbler* (*Wilsonia pusilla*), 12 MOLECULAR ECOLOGY 819, 820 (2003).

<sup>59</sup> See *id.*

connectivity is not technological. For many organisms, genetic differentiation among populations is simply too low for assigning individuals to a geographic region using genetic markers alone.<sup>60</sup>

### C. Stable Isotope Approaches

Another intrinsic marker technique using biological tissues to trace the origin and movement of migratory animals involves the use of stable isotopes. Stable isotopes are non-radioactive forms of elements that have similar chemical properties but vary in their atomic mass due to differences in the number of neutrons.<sup>61</sup> Approximately two-thirds of the elements have more than one stable isotope,<sup>62</sup> but isotopes of carbon (<sup>13</sup>C), nitrogen (<sup>15</sup>N), and hydrogen (<sup>1</sup>H or <sup>2</sup>D) are among the most useful for studying migratory connectivity for two reasons. First, their natural abundance varies predictably across broad spatial scales.<sup>63</sup> Second, their high natural abundance allows them to be present at detectable levels in biological tissues.<sup>64</sup> Some of the most informative research on migratory connectivity has involved multiple stable isotopes and we will highlight two of these studies below.

Feathers are a commonly used tissue in stable isotope investigations of migratory connectivity. As mentioned above, most species of migratory birds undergo a complete molt once each year on or near their breeding areas, and the isotopic signatures of foods eaten during this time become incorporated into new feathers. Because isotopic signatures do not change once stored in feather tissue, feather samples collected later on in the year provide information about the geographic origin of birds during molt. Each of the aforementioned isotopes provides different potential clues about a bird's molt location. Stable-hydrogen isotopes in growing season precipitation vary strongly with latitude, and stable-carbon isotopes show a similar pattern due to broad scale differences in plant water use efficiency and photosynthesis strategy.

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<sup>60</sup> The levels of differentiation available for assignment are influenced by two primary factors—the dispersal behavior of the organisms themselves and the time involved for differentiation to occur. High levels of dispersal, and thus gene flow, will prevent or degrade genetic differentiation among populations. Genetic differentiation also requires time to accumulate, and because migratory animals have only recently expanded from a smaller population (e.g., since the last Pleistocene glacial maximum), they are expected to exhibit limited genetic differentiation among populations. See Kevin Winker et al., *Genetic Differentiation Among Populations of a Migratory Songbird: *Limnothlypis swainsonii**, 31 J. AVIAN BIOLOGY 319, 319 (2000).

<sup>61</sup> See THE FACTS ON FILE DICTIONARY OF INORGANIC CHEMISTRY 121 (John Daintith ed., 2004).

<sup>62</sup> See STABLE ISOTOPE GEOCHEMISTRY (J. Hoefs ed., 6th ed. 2009).

<sup>63</sup> See, e.g., D. R. Rubenstein et al., *Linking Breeding and Wintering Ranges of a Migratory Songbird Using Stable Isotopes*, 295 SCI. 1062, 1063 (2002) (describing how isotopic ratios “vary systematically along a latitudinal gradient” throughout the range of the black-throated blue warbler).

<sup>64</sup> See, e.g., *id.* (noting that isotopic ratios of carbon and hydrogen can be measured in birds' feathers).

In one of the earliest studies using multiple stable isotopes, D. R. Rubenstein and his colleagues sampled feathers from black-throated blue warblers at breeding sites from North Carolina to Michigan.<sup>65</sup> As predicted, they found that  $\delta D$  and  $\delta^{13}C$  values varied systematically with the latitude of the sampling location.<sup>66</sup> Feathers collected from wintering populations in the Greater Antilles revealed some mixing of individuals from breeding populations, but also indicated strong regional connectivity between wintering and breeding populations.<sup>67</sup> A greater proportion of individuals wintering in the western islands of the Greater Antilles originated from northern breeding populations, whereas those wintering on islands further east were from more southern breeding populations.<sup>68</sup> Thus, it is more likely that a black-throated blue warbler bred in New Hampshire winters in Cuba or Jamaica, and one from North Carolina winters in Puerto Rico.

An example using multiple stable isotopes with clear implications for conservation involves Monarch butterflies. As described above, the majority of North American Monarch butterflies spend the winter at approximately ten winter sites in a small region in Mexico. Despite over fifty years of intensive study, it remained unknown whether the entire population mixed together at these winter sites or whether there was tighter connectivity between breeding and wintering populations. A 1998 study sampled  $\delta D$  and  $\delta^{13}C$  in butterflies at their natal sites throughout North America and at several winter locations in Mexico.<sup>69</sup> Isotopic signatures indicated that individuals from the Midwestern United States were present at each of the winter sites sampled.<sup>70</sup> However, butterflies from more northern breeding areas were present at only two sites, making these locations strong candidates for protection.<sup>71</sup>

Satellite telemetry, aside from cost, clearly provides the best tool for tracking larger-bodied animals throughout the year. The challenge here will be for the development of smaller transmitters that can be applied to smaller-bodied birds. As far as smaller-bodied birds are concerned, geolocators, isotopes, and perhaps genetics currently remain the best approaches. The challenge is to enhance available funding to support scientists as they attempt to quantify migratory connectivity for the hundreds of species that are still untracked throughout much of the year.

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<sup>65</sup> *Id.* at 1063, 1063 fig.1.

<sup>66</sup> *Id.* at 1063 (13C represents the isotopic ratio for carbon and 13D represents the isotopic ratio for hydrogen).

<sup>67</sup> *Id.* at 1063–64.

<sup>68</sup> *Id.*

<sup>69</sup> Leonard I. Wassenaar & Keith A. Hobson, *Natal Origins of Migratory Monarch Butterflies at Wintering Colonies in Mexico: New Isotopic Evidence*, 95 PROC. NAT'L ACAD. SCI. 15,436, 15,436 (1998).

<sup>70</sup> *Id.* at 15,439.

<sup>71</sup> *Id.*

## IV. LEGAL IMPLICATIONS OF MIGRATORY CONNECTIVITY STUDIES

The emerging science of migratory connectivity, particularly the increased understanding of the detailed migratory pathways and distributions of species' populations by sex and age, holds substantial promise for improving the effectiveness of both national and international legal approaches to the conservation of migratory wildlife. In this section, we examine several examples of how migratory connectivity science may improve future conservation decision making in national legal systems. We then analyze how well existing international conservation treaties are designed to take advantage of emerging migratory connectivity science and what design features would be best for incorporating migratory connectivity in the future. Finally, we explore how migratory connectivity may strengthen the role of customary international law in conserving migratory wildlife, because it allows harm to migratory wildlife to be treated as a more typical transboundary environmental harm.

*A. Improving Conservation Decision Making with Migratory Connectivity*

Better understanding of geographic linkages and distributions of populations by sex and age can support legal measures to address potential impacts to migratory species. These measures can embrace a wide range of approaches, including acquisition of habitat, regulation of habitat-disturbing activities, and control of commercial and recreational harvests of migrating animals or species.<sup>72</sup> Below we highlight how better incorporating of the emerging science of migratory connectivity could lead to more effective application of existing legal measures at the national level. Our goal is not to survey all environmental laws but to highlight a few representative examples of how migratory connectivity can be used to strengthen future conservation efforts.

*1. Acquiring Habitat Through Eminent Domain*

Conservation resources are always scarce and conservationists must decide which habitats or sites are the highest priority for protection. Migratory connectivity studies will allow us to map migration routes of targeted populations in more specific ways that will better identify areas of importance to garner support for their conservation. Presumably, private conservation groups that explicitly set science-based priorities for habitat acquisition and conservation—such as Conservation International, the Nature Conservancy, and the American Bird Conservancy—will use the emerging understanding of migratory connectivity to set their priorities. Unfortunately, the criteria and methods for public agencies to determine which habitats are in need of protection are often defined by national law

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<sup>72</sup> See generally Robert L. Fischman & Jeffrey B. Hyman, *The Legal Challenge of Protecting Animal Migrations as Phenomena of Abundance*, 28 VA. ENVTL. L.J. 173, 211–28 (2010).

and this approach may be slow to reflect the emerging science of migratory connectivity.<sup>73</sup>

Many, if not most, national governments recognize the legal authority of national and subnational entities to expropriate property in the “public interest,” including to establish protected areas.<sup>74</sup> International law similarly supports this right of governments.<sup>75</sup> Measures proposed to secure the public interest, however, must *in fact* be in the public interest; mere assertions that an activity is in the public interest are legally inadequate.<sup>76</sup> Two general criteria exist for evaluating whether a proposed measure is in the “public interest”: 1) the activity must have a legitimate aim, and 2) the interference must strike a fair balance between the public interest and the interests and rights of those impacted, ensuring a “reasonable relationship of proportionality” between the activity and the impacted rights.<sup>77</sup>

The more granular information provided by “migratory connectivity” helps satisfy both of these criteria. The first—that the activity has a legitimate aim—is usually relatively easy to establish. The Canadian Constitution, for example, recognizes that compelling and substantial legislative objectives that justify infringement of property rights (including aboriginal property rights) include protection of the environment or endangered species.<sup>78</sup> Migratory connectivity data will provide the factual

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<sup>73</sup> See Endangered Species Act of 1973, 16 U.S.C. § 1533(b)(2) (2006).

<sup>74</sup> See Rachelle Alterman, *Introduction: Regulatory Takings Viewed Through Cross-National Comparative Lenses*, 5 WASH U. GLOBAL STUD. L. REV. 469, 470, 472 (2006) (discussing takings law in the United States, Canada, Netherlands, Germany, Belgium, and France).

<sup>75</sup> See, e.g., Convention for the Protection of Human Rights and Fundamental Freedoms art. 1, Nov. 4, 1950, 213 U.N.T.S. 221 (“No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law . . .”); American Convention on Human Rights art. 21, *opened for signature* Nov. 22, 1969, 1144 U.N.T.S. 123 (“Everyone has the right to the use and enjoyment of his property. The law may subordinate such use and enjoyment to the interest of society . . .”); African Charter on Human and Peoples’ Rights art. 14, June 27, 1981, 21 I.L.M. 58 (“The right to property shall be guaranteed. It may only be encroached upon in the interest of public need or in the general interest of the community . . .”); Declaration on the Rights of Indigenous Peoples, G.A. Res. 61/295, U.N. Doc. A/RES/61/295 (Sept. 13, 2007) (“State expropriations must be strictly necessary and solely for the purpose of securing due recognition and respect for the rights and freedoms of others and for meeting the just and most compelling requirements of a democratic society.”); see also U.N. CONFERENCE ON TRADE AND DEV. [UNCTAD], TAKING OF PROPERTY 12–16, U.N. Doc. UNCTAD/TTE/IIT/15, U.N. Sales No. E.00.II.D.4 (2000) (highlighting four requirements for taking of property in the context of investment agreements: public interest, just compensation, non-discrimination and due process).

<sup>76</sup> See, e.g., *Kelo v. City of New London*, 545 U.S. 469, 478 (2005) (holding that the government is not permitted to “take property under the mere pretext of a public purpose, when its actual purpose was to bestow a private benefit”).

<sup>77</sup> See, e.g., *Case of Jahn and Others v. Germany*, 2005 Eur. Ct. H.R. 444; see also Ulrike Deutsch, *Expropriation Without Compensation – the European Court of Human Rights Sanctions German Legislation Expropriating the Heirs of “New Farmers,”* 6 GERMAN L.J. 1367, 1375 (2005), available at [http://www.germanlawjournal.com/pdfs/Vol06No10/PDF\\_Vol\\_06\\_No\\_10\\_1367-1380\\_Developments\\_Deutsch.pdf](http://www.germanlawjournal.com/pdfs/Vol06No10/PDF_Vol_06_No_10_1367-1380_Developments_Deutsch.pdf).

<sup>78</sup> See *Delgamuukw v. British Columbia*, [1997] 3 S.C.R. 1010, para. 165 (Can.).

documentation for why the acquisition of a specific site meets important and legitimate conservation purposes.

Migratory connectivity data can also contribute to satisfying the second, more difficult, criteria—ensuring a reasonable relationship of proportionality. In general, the “proportionality” requirement requires states to balance the severity of a prospective interference with a legal right with the importance of the social need for action.<sup>79</sup> “Proportionality” is often determined by consideration of three factors: 1) suitability, 2) necessity, and 3) the absence of disproportionate impact.<sup>80</sup> Migratory connectivity data would help satisfy the first two. “Suitability” requires that a measure affecting a protected interest (e.g., the right to property) be causally linked to the purpose being pursued.<sup>81</sup> A clearer understanding of habitat needs for migratory populations would provide support for showing that the acquisition of a proposed area is causally linked to the stated objectives of biodiversity conservation. “Necessity” requires that the proposed measure be indispensable to achieving the objective pursued.<sup>82</sup> Prior to taking private property, California, for example, requires a “resolution of necessity.”<sup>83</sup> Migratory connectivity data could demonstrate how protecting a particular site is necessary for the sustained conservation of particular species.

## 2. *Conserving Critical Habitat of Endangered Species*

Many endangered species laws, including the Endangered Species Act (ESA),<sup>84</sup> can help protect critical habitat for migratory species by requiring protection of designated critical habitat and/or preventing habitat disturbance as a “harm” to endangered species, among other measures. The ESA, for example, requires that when a species is listed, the Secretary of the Interior must also develop a recovery plan for the species. In most cases this will require designating the “critical habitat” of the species, which consists of “the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological

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<sup>79</sup> NICOLAS DE SADELEER, ENVIRONMENTAL PRINCIPLES: FROM POLITICAL SLOGANS TO LEGAL RULES 291–92 (2002).

<sup>80</sup> *Id.* at 292–96 (citing Case C-331/88, *Ex parte Fedesa*, 1990 E.C.R. I-4023).

<sup>81</sup> *Id.* at 293.

<sup>82</sup> *Id.* at 293–94.

<sup>83</sup> In California, the government must find and determine the following:

- (1) The public interest and necessity require the proposed project;
- (2) The proposed project is planned or located in the manner that will be most compatible with the greatest public good and the least private injury;
- (3) The property described in the resolution is necessary for the proposed project; and
- (4) That either the offer required by [California law] has been made to the owner or owners of record, or the offer has not been made because the owner cannot be located with reasonable diligence.

CAL. CIV. PROC. CODE § 1245.230(c) (West 2011); *see also* California Eminent Domain Law Group, Eminent Domain Procedures, <http://www.eminentdomainlaw.net/procedures.html#resolution> (last visited Dec. 30, 2010).

<sup>84</sup> Endangered Species Act of 1973, 16 U.S.C. §§ 1531–1544 (2006).

features (I) essential to the conservation of the species and (II) which may require special management considerations or protection.”<sup>85</sup> Critical habitat must be designated on the basis of the best scientific data available and after taking into consideration the economic impact of the designation.<sup>86</sup> An area may be excluded from designation if the benefits of the exclusion outweigh the benefits of the designation, unless the failure to designate will result in the extinction of the species.<sup>87</sup>

Given legal standards like that in the ESA, better data about migratory connectivity will clearly enable better identification and documentation of the critical habitat of endangered species. We currently know much more about the breeding ranges of target species—which are more easily studied—than we know about their migration or wintering grounds.<sup>88</sup> Yet, critical habitat constraining a species’ potential recovery in many instances may be found in places other than their breeding grounds.

The Kirtland’s warbler is one example (Fig. 2). It is well studied and intensely managed on its limited breeding range centered in northern Michigan, but, until recently, less was known about its migratory pathways and limited wintering range.<sup>89</sup> Migratory stop-over locations may be identified in the future as critical habitat for the Kirtland’s Warbler’s recovery and more knowledge about the limited wintering grounds in the Bahamas may lead to expanded international cooperation under the provisions of the ESA.<sup>90</sup>

The ESA also prohibits the “take” of any endangered species,<sup>91</sup> which includes “harm” resulting from “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.”<sup>92</sup> Courts generally require a showing of “reasonably certain” proximate cause before they will enjoin habitat disturbance as a harm under the ESA prohibition.<sup>93</sup> As described by Professor Fischman, this standard highlights the vexing gap between what courts demand and what science provides with respect to data, particularly for efforts to predict and prevent impacts to migratory species.<sup>94</sup> As Fischman notes, “[T]he adverse effects of habitat modification on individual animals may not be immediately visible.

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<sup>85</sup> *Id.* § 1532(5)(A)(i).

<sup>86</sup> *Id.* § 1533(b)(2).

<sup>87</sup> *Id.*

<sup>88</sup> See DINGLE, *supra* note 4, at 64 (“[B]ecause migration often takes place over large scales of space and time relative to the size and life span of the migrating organism, it is one of the most difficult of behaviors to study.”).

<sup>89</sup> See *supra* text accompanying notes 34–36.

<sup>90</sup> See 16 U.S.C. § 1537 (2006).

<sup>91</sup> *Id.* §§ 1532(19), 1538(a)(1)(B).

<sup>92</sup> *Babbitt v. Sweet Home Chapter of Cmty. for a Great Or.*, 515 U.S. 687, 691 (1995) (citing 50 C.F.R. § 17.3 (1994)).

<sup>93</sup> Robert L. Fischman, *The Divides of Environmental Law and the Problem of Harm in the Endangered Species Act*, 83 IND. L.J. 661, 688–92 (2008).

<sup>94</sup> *Id.* at 684.



The link between habitat modification and species decline might not be understood until well after the harm has been done.<sup>95</sup> This is particularly true for migratory species, which individually inhabit different areas during their annual life-cycle. Enhanced understanding of migratory connectivity can close this vexing gap by demonstrating the relative role played by certain habitats in the life cycle of a given migratory species. Also useful will be enhanced understanding of what locations, exactly, certain area-faithful species continue to return to every year and thus are critical for their viability.

### 3. Assessing Impacts to Migratory Species

Migratory connectivity data can support development of more robust environmental impact assessments (EIA).<sup>96</sup> Many countries now require EIAs for proposed projects that can significantly affect the environment.<sup>97</sup> Impacts should include all direct, indirect and cumulative impacts associated with a proposed project, presumably including impacts on migratory species.<sup>98</sup> In practice, however, EIAs have often been criticized for considering only on-site direct impacts or impacts within a narrow spatial and temporal scope.<sup>99</sup> Migratory connectivity data provides support for broadening the spatial and temporal scope of an EIA and consideration of indirect impacts of project activities, particularly when endangered migratory species are likely to be impacted by a project. In the absence of knowledge indicating where and how impacts on a given population in one area (e.g., changes to habitat) impact the population in another area, environmental impact assessments will likely miss the full spatial and temporal scope of impacts to that population.

### 4. Expanding Judicial and Administrative Standing

Standing for judicial review and the ability to participate in administrative proceedings are major obstacles in many jurisdictions to

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<sup>95</sup> *Id.* at 687.

<sup>96</sup> An EIA is described by the International Association for Impact Assessment (IAIA) as “the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made.” INT’L ASS’N FOR IMPACT ASSESSMENT, WHAT IS IMPACT ASSESSMENT? 1 (2009), available at [http://www.iaia.org/publicdocuments/special-publications/What%20is%20IA\\_web.pdf](http://www.iaia.org/publicdocuments/special-publications/What%20is%20IA_web.pdf).

<sup>97</sup> See, e.g., National Environmental Policy Act of 1969, 42 U.S.C. § 4332(C) (2006); United Nations Conference on Environment and Development, Rio de Janeiro, Braz., June 3–14, 1992, *Rio Declaration on Environment and Development*, princ. 17, U.N. Doc. A/CONF.151/26 (Vol. I), Annex I (Aug. 12, 1992); Convention on Biological Diversity (CBD) art. 14.1(a), June 5, 1992, 1760 U.N.T.S. 79.

<sup>98</sup> 40 C.F.R. §§ 1508.25, 1508.27 (2010).

<sup>99</sup> See, e.g., Ben Schiffman, *The Limits of NEPA: Consideration of the Impacts of Terrorism in Environmental Impact Statements for Nuclear Facilities*, 35 COLUM. J. ENVTL. L. 373, 375–76 (2010) (discussing split between Circuits regarding whether possible environmental impacts from terror attacks at nuclear facilities should be included in an EIS).

conservationists seeking to protect species or habitat. In most jurisdictions, animals themselves do not have standing and standing is conferred primarily on those who can show that a direct interest has been harmed.<sup>100</sup> Migratory connectivity has the potential to expand the categories of people who can demonstrate a cognizable interest in a particular proceeding. To the extent that the breeding, migratory, and wintering locations of specific populations are all known, then people living and using these areas would be affected by impacts on the population anywhere along the population's geographic life cycle. People living near the Kirtland warbler's breeding grounds in northern Michigan, for example, would be affected both factually and in a legal sense by decisions taken that affect the species' Bahamas wintering grounds. Being affected in this way can legitimize the participation of otherwise distant communities in the administrative and judicial decisions that affect their migratory species.

Judicial standing in the United States, for example, requires that plaintiffs prove an injury in fact.<sup>101</sup> In environmental cases, establishing an injury in fact has sometimes been difficult. In *Lujan v. Defenders of Wildlife*,<sup>102</sup> the Supreme Court held that the plaintiffs, Defenders of Wildlife and other environmental organizations, failed to establish standing because they did not show how their members would be directly affected by the proposed activities abroad.<sup>103</sup> The Court required that plaintiffs demonstrate a future, specific intent to return to the areas affected by the proposed project.<sup>104</sup> The fact that the plaintiffs had past exposure to the illegal conduct did not create standing.

Migratory connectivity data could help to meet the *Lujan* standard. Rather than needing to demonstrate that plaintiffs have an airplane ticket back to an area threatened by development, plaintiffs could show that they were directly affected by threats to migratory species that would otherwise be returning to their own backyards. If migratory connectivity science can provide information on the specific areas that the birds migrate to, a plaintiff can establish imminent injury in fact without needing to travel to the location of the challenged activities. Threatened damage to the wintering grounds of specific populations known to breed in relatively well-defined areas in the United States, for example, could sufficiently injure the interests of naturalists in those breeding areas to support future findings of standing.

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<sup>100</sup> See, e.g., *Lujan v. Defenders of Wildlife*, 504 U.S. 555, 560–61 (1992). Ecuador is one exception, where a recent Constitutional amendment created standing for “Pacha Mama.” CONSTITUTION OF THE REPUBLIC OF ECUADOR, Oct. 20, 2008, tit. II, ch. 7, art. 71. See generally CHRIS STONE, SHOULD TREES HAVE STANDING?: TOWARD LEGAL RIGHTS FOR NATURAL OBJECTS (3d ed. 1974).

<sup>101</sup> See, e.g., *Lujan*, 504 U.S. at 560.

<sup>102</sup> 504 U.S. 555 (1992).

<sup>103</sup> *Id.* at 563–64.

<sup>104</sup> *Id.* at 564.

*B. Implications for Regime Design in International Wildlife Conservation Treaties*

More detailed population-level data on migratory connectivity offers the potential to significantly improve the design and implementation of international conservation treaties and associated activities. Taking full advantage of the emerging science of migratory connectivity will require dynamic treaty regimes with flexible legal approaches supported by strong institutional arrangements that can nimbly and effectively translate developments in migratory connectivity science into effective conservation measures at the appropriate level. Below we evaluate four categories of existing international conservation regimes: 1) general conservation agreements such as the global Convention on Biological Diversity (CBD)<sup>105</sup> that do not focus specifically on migration; 2) agreements aimed at specific threats to wildlife such as the Convention on International Trade in Endangered Species (CITES);<sup>106</sup> 3) agreements that focus on specific sites or habitats, such as the Convention on Wetlands of International Importance Especially as Waterfowl Habitat;<sup>107</sup> and 4) agreements that aim specifically at protecting migratory species, which includes the Convention on Migratory Species (CMS)<sup>108</sup> and agreements targeting the conservation of a specific family or group of migratory species.

*1. General Conservation Agreements*

Several global or regional conservation agreements prioritize wildlife conservation generally. The CBD provides a general set of principles and establishes an institutional architecture for the conservation of global biodiversity.<sup>109</sup> Regional conservation agreements that set general priorities and principles include the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere<sup>110</sup> and, in Europe, the Berne Convention on the Conservation of European Wildlife and Natural Habitats.<sup>111</sup>

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<sup>105</sup> Convention on Biological Diversity, *supra* note 97, pmbl.

<sup>106</sup> Convention on International Trade in Endangered Species of Wild Fauna and Flora, pmbl., Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243.

<sup>107</sup> Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), pmbl., Feb. 2, 1971, 996 U.N.T.S. 245.

<sup>108</sup> Convention on the Conservation of Migratory Species of Wild Animals (CMS), June 23, 1979, 1651 U.N.T.S. 333. As of April 2011, the Convention had 115 Parties. CONVENTION ON MIGRATORY SPECIES, PARTIES TO THE CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS AND ITS AGREEMENTS (2011), *available at* [http://www.cms.int/about/Partylist\\_eng.pdf](http://www.cms.int/about/Partylist_eng.pdf).

<sup>109</sup> Convention on Biological Diversity, *supra* note 97, pmbl.

<sup>110</sup> Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere, pmbl., Oct. 12, 1940, 56 Stat. 1354, 161 U.N.T.S. 193.

<sup>111</sup> Convention on Conservation of European Wildlife and Natural Habitats art. 3, Sept. 19, 1979, 1284 U.N.T.S. 209; *see* SIMON LYSTER, INTERNATIONAL WILDLIFE LAW: AN ANALYSIS OF INTERNATIONAL TREATIES CONCERNED WITH THE CONSERVATION OF WILDLIFE 129–55 (1985).

The CBD was negotiated and signed at the 1992 UN Conference on Environment and Development (the Earth Summit)<sup>112</sup> and was designed to provide a general international legal and institutional framework for the conservation and sustainable use of biological diversity and associated resources.<sup>113</sup> The CBD currently has 193 members; virtually every country except the United States is a party.<sup>114</sup> In part, the CBD enjoys such broad participation because it imposes few, if any, binding obligations on the Parties. Instead, the Convention adopts three broad strategies: 1) promoting and supporting national laws for biodiversity conservation; 2) creating an international institutional structure to support implementation of the Convention and further international cooperation regarding biodiversity conservation; and 3) establishing a set of principles for the international trade in biodiversity resources and the biotechnologies derived from them.<sup>115</sup>

The CBD thus provides a general framework for international cooperation relating to conservation, with specific issues being addressed over time by the Secretariat and Conference of Parties (CoP), primarily through the future development of guidelines, principles, or even binding protocols. This general approach has resulted, for example, in a binding protocol to address the transboundary shipment of genetically modified organisms;<sup>116</sup> non-binding guidelines for controlling invasive species;<sup>117</sup> non-binding guidelines for environmental and social impact assessments;<sup>118</sup> a protocol to address benefit sharing from biodiversity resources;<sup>119</sup> guidelines

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<sup>112</sup> U.N. Dep't of Pub. Info., Earth Summit, <http://www.un.org/geninfo/bp/enviro.html> (last visited Apr. 9, 2011).

<sup>113</sup> The objectives of the CBD "are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources, and by appropriate funding." Convention on Biological Diversity, *supra* note 97, art. 1.

<sup>114</sup> U.N. Env't Programme, List of Parties, <http://www.cbd.int/convention/parties/list/> (last visited Apr. 9, 2011).

<sup>115</sup> Convention on Biological Diversity, *supra* note 97, arts. 5, 6, 15, 16. For a further history and overview of the Biodiversity Convention, see LYLE GLOWKA ET AL., A GUIDE TO THE CONVENTION ON BIOLOGICAL DIVERSITY (1994); *see also, e.g.*, SECRETARIAT TO THE CONVENTION ON BIOLOGICAL DIVERSITY, HANDBOOK OF THE CONVENTION ON BIOLOGICAL DIVERSITY 89-90, 161-62 (2001) (explaining the work of the CoP on articles 6 and 16 of the CBD encouraging parties to implement national legislation and asserting the need for attention to technology transfer matters).

<sup>116</sup> Cartagena Protocol on Biosafety to the Convention on Biological Diversity art. 1, Jan. 29, 2000, 2226 U.N.T.S. 208.

<sup>117</sup> Conference of the Parties to the Convention on Biological Diversity, Sixth Meeting, The Hague, Neth. April 7-19, 2002, *Decision VI/23: Alien Species that Threaten Ecosystems, Habitats or Species*, U.N. Doc. UNEP/CBD/COP/6/20 (2004), *available at* <http://www.cbd.int/doc/decisions/cop-06/full/cop-06-dec-en.pdf>.

<sup>118</sup> SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, AKWÉ: KON GUIDELINES 5, 13 (2004).

<sup>119</sup> Conference of the Parties to the Convention on Biological Diversity, Nagoya, Japan, Oct. 18-29, 2010, *Access and Benefit Sharing*, U.N. Doc. UNEP/CBD/COP/10/5, annex 1, art. 6 (Oct. 16, 2010), *available at* <http://www.cbd.int/doc/meetings/cop/cop-10/official/cop-10-05-en.pdf>.

for implementing an ecosystem approach to conservation,<sup>120</sup> and a new scientific body, the International Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), to guide policymakers in the effective conservation of biodiversity.<sup>121</sup>

The emerging science of migratory connectivity could help to build momentum for addressing migration through the CBD. The CBD includes locations important for migration as among the areas that national governments should protect and among the components of biological diversity that the convention is generally aimed at protecting.<sup>122</sup> The Convention has yet to address in any more detail the need for protecting migration.

Individual Parties would presumably have better information about which locations within their borders are important for different migratory species or their specific subpopulations. The Parties could also decide to address migration through the development of a set of non-binding guidelines perhaps with a longer term goal of creating a binding Protocol meant to protect migration. Because the CBD is too general and global in its approach to address specific challenges to specific migration pathways or migrants, such guidelines or a protocol on migration could focus international attention on the importance of, and generate international support for, conserving the phenomenon of migration. The CBD is probably not an ideal regime for taking full advantage of the emerging science of migratory connectivity. It is not currently structured, for example, to allow subsets of parties to adopt protocols or other instruments specifically tailored to conserve the migratory route of one particular species or population.

One lesson from reviewing the CBD is that a global geographic scope for addressing migration may not be compatible with the specificity of conservation priorities identified by migratory connectivity science. Certainly in the Western hemisphere, migration is primarily a hemispheric phenomena,<sup>123</sup> suggesting that a regime with a regional scale may be better for addressing migratory connectivity. The Western Hemisphere Convention sets forth some general priorities for protecting wildlife, including specific migratory birds.<sup>124</sup> The Convention indicates, among other things, that

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<sup>120</sup> Conference of the Parties to the Convention on Biological Diversity, Fifth Meeting, Nairobi, Kenya, May 15–26, 2000, *Decision V/2: Ecosystem Approach*, U.N. Doc. UNEP/CBD/COP/5/23, Annex III (2003), available at <http://www.cbd.int/doc/decisions/cop-05/full/cop-05-dec-en.pdf>.

<sup>121</sup> Busan Outcome, U.N. Doc. UNEP/IPBES/3/L.2/Rev.1, para. 6 (June 11, 2010), available at <http://www.ipbes.net/meetings/Documents/ipbes3/K1030396-IPBES-3-L.2Rev1.pdf>.

<sup>122</sup> See Convention on Biological Diversity, *supra* note 97, art. 7 (requiring Parties “as far as possible and as appropriate . . . [to] identify components of biological diversity important for its conservation and sustainable use”); *Id.* at Annex I (including in the indicative list of components of biological diversity those “ecosystems and habitats . . . required by migratory species”).

<sup>123</sup> See PETER BERTHOLD, *supra* note 9, at 3 fig.1.1 (indicating tendency for species in the Western Hemisphere to migrate within the Western Hemisphere).

<sup>124</sup> Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere, *supra* note 106, pmb.

governments shall, if feasible, establish areas to protect flora and fauna;<sup>125</sup> seek measures to protect flora and fauna in areas that are not protected;<sup>126</sup> and adopt other “appropriate measures” to protect migratory birds and other species facing extinction.<sup>127</sup>

The Western Hemisphere Convention thus supports protection of migratory species, but its limited institutional architecture constrains its effectiveness. Although the Organization of American States serves essentially as the Secretariat to the Convention, it has no staff dedicated to implementing the Convention and no mandate beyond facilitating communication between the Contracting Parties.<sup>128</sup> Moreover, the Parties to the Convention do not meet regularly to address implementation or modification of the Convention.<sup>129</sup> The Convention thus lacks a functioning mechanism to facilitate consideration and implementation of additional measures to protect migratory species or to otherwise respond to changes in the known status of migratory species. To take advantage of emerging science on migratory connectivity, the Convention needs to be supported by a Secretariat with professional staff and a mandate to monitor the conservation status of wildlife in the hemisphere, requirements for country reporting on implementation of the Convention, and a dynamic process for translating emerging science into conservation initiatives.

## 2. Threat-Specific Conventions

A second category of international conservation treaties include those aimed at addressing the threats to biological diversity. The most well known and global of these is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which is aimed specifically at protecting species that are threatened with extinction from international trade.<sup>130</sup> Another example is the Wellington Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific (Wellington Convention)<sup>131</sup> which prohibits member states’ nationals and vessels documented under their laws from engaging in driftnet fishing activities within the area covered by the Convention.<sup>132</sup>

In general, migratory connectivity will allow regulations of threats to wildlife to be more closely tailored to the lifecycle of the targeted species.

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<sup>125</sup> *Id.* art. II.

<sup>126</sup> *Id.* art. V.

<sup>127</sup> *Id.* art. VII.

<sup>128</sup> See Lyster, *supra* note 111, at 110–11.

<sup>129</sup> *Id.* at 110.

<sup>130</sup> Convention on International Trade in Endangered Species of Wild Fauna and Flora, *supra* note 102, pmb1.

<sup>131</sup> Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific, pmb1., Nov. 24, 1989, 1899 U.N.T.S. 3; see also G.A. Res. 44/225, U.N. Doc. A/RES/44/225 (Dec. 22, 1989).

<sup>132</sup> Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific, *supra* note 131, art. 2.

Thus, if the reason to regulate drift nets is to reduce the impact on migratory birds, sea mammals, and sea turtles, more knowledge about migration routes and timing would allow for the regimes to tailor the regulations both temporally and geographically to ensure that the highest conservation goals are reached while not “over-regulating” the industry.

CITES regulates the global trade in over 30,000 listed plant and animals species.<sup>133</sup> Despite longstanding and public controversies over such charismatic megafauna as elephants or whales, 175 countries are parties to CITES.<sup>134</sup> CITES places species or populations of species on one of three appendices, depending on whether they are threatened or endangered. Endangered species are listed in Appendix I and cannot be traded for commercial purposes.<sup>135</sup> Threatened species are listed in Appendix II and can only be traded with a valid export permit.<sup>136</sup> In rare instances, listings can be quite specific, prohibiting commercial trade for some geographically separate populations while allowing trade of the species elsewhere.<sup>137</sup> Export permits for trading Appendix I and II species can only be issued if a Party finds that further trade will not be detrimental to the species survival (a “no detriment” finding).<sup>138</sup> CITES also has an Appendix III which is for those species subject to conservation regulations by one country who seeks international cooperation in restricting trade of the species from its jurisdiction.<sup>139</sup>

Although CITES does not purport to conserve migration at all, greater understanding of migratory connectivity could improve implementation of CITES in several ways. First, the listing process under CITES is scientifically based and increased knowledge of the conservation status of a species or population throughout its range and life cycle may assist the parties in deciding whether to list a species in one of the Appendices to the Convention. Split listings (where populations in one part of the range are afforded more protection than in other parts of their range) may become more defensible and more common with better migration data, and the use of Appendix III could be expanded considerably as migratory connectivity data may demonstrate how international cooperation is necessary to protect specific populations occurring in only one or a few countries. In addition,

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<sup>133</sup> Convention on Int'l Trade in Endangered Species of Wild Fauna and Flora, The CITES Species, <http://www.cites.org/eng/disc/species.shtml> (last visited Jan. 23, 2011).

<sup>134</sup> Convention on Int'l Trade in Endangered Species of Wild Fauna and Flora, Member Countries, <http://www.cites.org/eng/disc/parties/index.shtml> (last visited Jan. 23, 2011).

<sup>135</sup> Convention on International Trade in Endangered Species of Wild Fauna and Flora, *supra* note 106, art. III(3).

<sup>136</sup> *Id.* art. IV(2)(c).

<sup>137</sup> *See, e.g.*, CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA, APPENDICES I, II AND III, at 5 (2010), *available at* <http://www.cites.org/eng/app/Appendices-E.pdf> (excepting the *Pecari tajacu* populations of the United States and Mexico from the listing of the *tayassuidae* family in Appendix II).

<sup>138</sup> Convention on International Trade in Endangered Species of Wild Fauna and Flora, *supra* note 106, arts. III(2)(a), IV(2)(a).

<sup>139</sup> *Id.* art. V.

increased knowledge about migratory connectivity will help implementing agencies make better no detriment findings in determining whether to issue an export permit for species listed in Appendix I or II. Migratory connectivity data could show how trade in species from certain areas or during certain times might be more detrimental to a population than we might otherwise expect. For example, information that one sex of a species winters in more concentrated areas might suggest that trade from those areas should be restricted more.

CITES has many of the design features that allow it to benefit from migratory connectivity science. It has strong and well established institutions and processes for implementation of the Convention and it enjoys broad participation of almost every country in the world. The CITES process of listing species, particularly if it develops further the practice of split listing,<sup>140</sup> and the goal of sustainable trade in species, can be a mechanism for embracing emerging knowledge of migratory connectivity into the treaty regime. In the end, however, CITES—as well as other threat-specific conventions—have limited mandates, and may not be effective for addressing migration generally or at the species level.

### *3. Site-Specific Conventions*

A third category of conservation treaties are those aimed at conserving specific sites of high conservation value. The two primary global treaties taking this approach are the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (named the “Ramsar Convention” after the city in Iran where it was negotiated)<sup>141</sup> and the UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (the “World Heritage Convention”).<sup>142</sup> These two Conventions are structured similarly and the discussion of how migratory connectivity relates to the Ramsar Convention below can largely apply to the protection of natural heritage under the World Heritage Convention.

The Ramsar Convention is designed to provide international support for the protection of wetlands that support significant populations of migratory waterfowl. It was the first global treaty focused on the conservation of a

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<sup>140</sup> The CITES parties have at times listed populations of a species on more than one Appendix, in order to allow some trade in countries or regions where the species is not yet as endangered. Such split listings are not yet common, but do allow for some greater flexibility in the application of CITES. See Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Res. 9.24, 9th Sess., Nov. 7–18, 1994, at Annex 3 (1994), available at <http://www.cites.org/eng/res/all/09/E09-24R15.pdf>, revised by Document CoP15 Com. I. 1, section 4 (2010).

<sup>141</sup> Ramsar Convention, *supra* note 107.

<sup>142</sup> Convention Concerning the Protection of the World Cultural and Natural Heritage, Nov. 13, 1973, 27.1 U.S.T. 37, 1037 U.N.T.S. 151.



single type of ecosystem.<sup>143</sup> As of 2010, the Convention had 159 Contracting Parties and covers approximately 1850 wetland sites (totaling over 180 million hectares). Under the Ramsar Convention, Parties designate wetlands for inclusion on the List of Wetlands of International Importance.<sup>144</sup> The Ramsar Secretariat reviews the proposed listing according to several criteria. Although importance for migration is not explicitly among the criteria for listing, the criteria include wetlands that support animals at a “critical stage in their life cycles,” regularly support 20,000 or more waterbirds, or regularly support one percent of the population of one species or subspecies of waterbird. Given these criteria, many of the wetlands on the Ramsar List are critical for migration.

As the Ramsar Convention’s full title suggests, a dominant motivation for the agreement was the desire to protect waterfowl habitat. Indeed, the Convention recognizes that “waterfowl in their seasonal migrations may transcend frontiers and so should be regarded as an international resource.”<sup>145</sup> The Convention also recognizes that each Party has a responsibility to protect migratory waterfowl: “Each Contracting Party shall consider its international responsibilities for the conservation, management and wise use of migratory stocks of waterfowl, both when designating entries for the List and when exercising its right to change entries in the List relating to wetlands within its territory.”<sup>146</sup>

The Ramsar Convention’s focus on migratory waterfowl provides an interesting example of how a global agreement can be used to protect sites critical to migration. Indeed, because waterfowl are generally large and visible, more is known of their migratory connectivity than is known for most other migrants. In fact, it was recognition that the general decline in wetlands was disrupting the migratory life cycles of waterfowl that built the pressure and support for negotiating the Convention in the first place.<sup>147</sup> Emerging science in migratory connectivity thus may not substantially change the knowledge base for effective implementation of the Ramsar Convention, at least as it relates to waterfowl. Information about smaller migratory wetland-dependent birds (shorebirds, herons and egrets, terns, and gulls) on the other hand, could lead to additional wetlands being prepared for the Ramsar List. Such information may also be relevant for identifying declines in protected wetlands.

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<sup>143</sup> VEIT KOESTER, *THE RAMSAR CONVENTION ON THE CONSERVATION OF WETLANDS: A LEGAL ANALYSIS OF THE ADOPTION AND IMPLEMENTATION OF THE CONVENTION IN DENMARK 3* (Malcolm Forester ed., Ramsar Convention Bureau 1989).

<sup>144</sup> The Ramsar Convention on Wetlands, What Is the “Ramsar List”?, [http://www.ramsar.org/cda/en/ramsar-about-faqs-what-is-ramsar-list/main/ramsar/1-36-37%5E7725\\_4000\\_0\\_\\_](http://www.ramsar.org/cda/en/ramsar-about-faqs-what-is-ramsar-list/main/ramsar/1-36-37%5E7725_4000_0__) (last visited Feb. 19, 2011).

<sup>145</sup> Ramsar Convention, *supra* note 107, pmb1.

<sup>146</sup> *Id.* art. 2.6.

<sup>147</sup> The Ramsar Convention on Wetlands, A Brief History of the Ramsar Convention, [http://www.ramsar.org/cda/en/ramsar-about-history/main/ramsar/1-36-62\\_4000\\_0\\_\\_](http://www.ramsar.org/cda/en/ramsar-about-history/main/ramsar/1-36-62_4000_0__) (last visited Feb. 19, 2011).

In general, however, the link between migratory connectivity and the Ramsar Convention may be less about how it will improve implementation of the Convention. More important is to evaluate the Ramsar Convention as a potential model for how migratory connectivity could be used to develop an international treaty aimed at protecting critical migratory sites for smaller birds and animals regardless of the habitat type. The Ramsar Convention is a simple agreement with a small, permanent Secretariat and targeted goals. It aims at providing international attention and support to national efforts at protecting internationally important wetlands. The mechanism for listing specific sites provides the Convention with a dynamic method for targeting priority sites as scientific knowledge evolves. The same treaty design could be applied to protecting areas identified through emergent migratory connectivity studies as critical for other species or populations. As such critical migratory sites are identified, a “convention for conserving migratory hot-spots” could, like the Ramsar Convention, organize international support for domestic protection of these areas.

#### *4. Conventions Aimed at Migratory Species*

Last, but not least, are those conservation agreements aimed directly at conserving a particular family or group of migratory species. In addition to the Convention on Migratory Species (CMS) discussed below, this category also includes treaties aimed, for example, at the conservation of highly migratory fish,<sup>148</sup> sea turtles,<sup>149</sup> tuna,<sup>150</sup> or cetaceans.<sup>151</sup> In general, to the extent that emerging migratory connectivity science improves our knowledge base of the targeted species, the more refined and effective these various agreements could be—if they have mechanisms for adopting to scientific progress over time and prioritize conservation as opposed to merely rationalizing harvests.<sup>152</sup>

The CMS seeks to facilitate international cooperation in conserving a wide range of migratory species. Protected migratory species are divided

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<sup>148</sup> Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, art. 2, U.N. Doc. A/Conf.164/37 (Sept. 8, 1995).

<sup>149</sup> Inter-American Convention for the Protection and Conservation of Sea Turtles, Dec. 1, 1996, S. TREATY DOC. NO. 105-48, 2164 U.N.T.S. 29.

<sup>150</sup> International Convention for the Conservation of Atlantic Tunas (ICCAT), May 14, 1966, 20 U.S.T. 2887, 673 U.N.T.S. 63.

<sup>151</sup> See International Convention for the Regulation of Whaling, Dec. 2, 1946, 10 U.S.T. 952, 161 U.N.T.S. 72. Cetaceans are also addressed by two agreements negotiated under the CMS: the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ABSOBANS), Mar. 17, 1992, 1772 U.N.T.S. 217, and the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area (ACCOBAMS) Nov. 24, 1996, 36 I.L.M. 780.

<sup>152</sup> Many of the regimes targeting migratory species were initially designed to allocate harvest quotas among range states. See International Convention for the Regulation of Whaling, *supra* note 151, *pmbl.*; see also ICCAT, *supra* note 150, *pmbl.*

into two different categories: Appendix I and II. Migratory species listed under Appendix I are “endangered” and parties that contain part of the range of Appendix I species are expected to prohibit the taking of that species, conserve and restore its habitat, and reduce other threats facing the species’ existence.<sup>153</sup> Species listed under Appendix II are those with “an unfavorable conservation status and which require international agreements for their cooperation and management.”<sup>154</sup> One species may be listed in both Appendices I and II. Parties are encouraged to develop agreements according to general guidelines to benefit species listed in Appendix II.<sup>155</sup>

With these designations, the Convention serves as a framework for the negotiation of Agreements and Memorandums of Understanding (MoUs) between relevant “range states.” “Range” is defined in the Convention as “all the areas of land or water that a migratory species inhabits, stays in temporarily, crosses or overflies at any time on its normal migration route,”<sup>156</sup> and “habitat” is defined as “any area in the range of a migratory species which contains suitable living conditions for that species.”<sup>157</sup> Increased understanding of migratory connectivity is essential for better definitions of the range and habitat of migratory species of concern, and for making the initial determination that a particular species requires international cooperation for its conservation. Migratory connectivity data should also improve the specificity and ultimate effectiveness of individual Agreements and MoUs negotiated under the CMS because they can be more targeted to the needs of migratory species throughout their life cycle.

The CMS currently has 114 Parties, but the focus and majority of participation is from Europe and Africa.<sup>158</sup> Many of the key countries for migration in the Western Hemisphere are not parties, including Canada, the United States, Brazil, Mexico, and many of the Caribbean countries. This raises the question about whether an increase in understanding of migratory connectivity in this hemisphere might lead to greater participation and implementation of the CMS in the Americas. To some extent, as we understand migratory connectivity, more pressure will build on key countries to take steps to protect migration. The CMS would seem a likely beneficiary of this increased political will.

The overall design of the CMS is a good fit for taking advantage of the advances being made in migratory connectivity. The CMS’s institutional architecture—a general overarching framework with a centralized Secretariat that works primarily at identifying potential opportunities for

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<sup>153</sup> CMS, *supra* note 108, art. III.

<sup>154</sup> *Id.* art. IV.

<sup>155</sup> *Id.* art. IV(2), (3).

<sup>156</sup> *Id.* art. I(1)(f).

<sup>157</sup> *Id.* art. I(1)(g).

<sup>158</sup> See U.N. ENV’T PROGRAMME, PARTIES TO THE CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS AND ITS AGREEMENTS 1 (2010), available at [http://www.cms.int/about/Partylist\\_eng.pdf](http://www.cms.int/about/Partylist_eng.pdf).

further cooperation among the range states of migratory species<sup>159</sup>—should allow for a multiplicity of agreements tailored to the specific needs of various species or populations. Migratory connectivity studies will identify and refine the understanding of “range states” for given populations of species. The very broad definition of “range states” used to support agreements under the CMS may constrain the ability to reach agreements because countries do not recognize their self-interest in joining. Since the CMS has been in existence, relatively few agreements have been reached, and for only a small number of species.<sup>160</sup> In this respect, migratory connectivity studies can identify migratory pathways, stop-overs and wintering grounds in ways that demonstrate the shared interests of the range states and provide the evidence necessary to target conservation efforts at critical habitats with more specificity. This may provide the basis for greater political will to enter into more MoUs or agreements under the CMS.

Less clear is whether the CMS should be the primary convention for addressing migratory connectivity in the Western Hemisphere. Because most of the migration that takes place in this hemisphere is entirely within the hemisphere, a convention with most of its focus and institutional structure in Europe makes little sense for international cooperation aimed at addressing the multiplicity of conservation challenges that our growing knowledge of migratory connectivity within the hemisphere is going to identify. In this respect, a better option than the CMS may be to develop a similar regime for this hemisphere, perhaps under the auspices of the Organization of American States.

*C. Customary Law: Shifting Migration from Common Concern  
to Shared Resource*

The emerging understanding of migratory connectivity has the potential not only to reinforce our understanding of migration as a widespread and hemispheric phenomenon, but also to enhance our understanding of migration on a species-, population-, or site-specific level. This shift toward a more granular—and biologically relevant—understanding of migration may also allow for a shift in how international law treats migration from that of a common concern of humankind to that of a set of shared sovereign interests that could be subject to transboundary harm. Although both approaches are important for international wildlife conservation, being able to treat impacts

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<sup>159</sup> See U.N. Env't Programme, Organizational Structure of CMS, [http://www.cms.int/about/cms\\_structure.htm](http://www.cms.int/about/cms_structure.htm) (last visited Jan. 25, 2011); see also U.N. ENV'T PROGRAMME, ORGANIZATION CHART FOR THE UNEP/CMS FAMILY OF SECRETARIATS (2010), available at [http://www.cms.int/secretariat/organigram/CMS\\_organigram.pdf](http://www.cms.int/secretariat/organigram/CMS_organigram.pdf).

<sup>160</sup> See CONVENTION ON MIGRATORY SPECIES, AGREEMENT SUMMARY SHEETS (2010), available at [http://www.cms.int/pdf/en/summary\\_sheets/AgmtSumSheet\\_engl.pdf](http://www.cms.int/pdf/en/summary_sheets/AgmtSumSheet_engl.pdf) (listing only seven “agreements” to protect species under the CMS); see also Convention on the Conservation of Migratory Species of Wild Animals, *supra* note 108, apps. I–II (listing the species currently covered under the CMS).

on migration as a transboundary harm could in theory, at least, lead to more specific international remedies.

The CBD states that the conservation of biological diversity is the “common concern” of human kind.<sup>161</sup> Having the status of a common concern is important for conservation because the principle provides the justification for why the conservation of biodiversity (some of which never leaves the territory of a single state) is a legitimate subject of international cooperation. But the principle does not yet imply specific legal obligations beyond a general obligation to cooperate. It thus provides the conceptual framework for international treaty negotiations with respect to what would otherwise be activities or resources considered wholly within the sovereign control of individual states, but it provides little guidance as a rule of decision for resolving specific disputes between sovereign states.

The general phenomenon of migration, as a feature of biological diversity, would also seem to fit into the concept of common concern. Migration is of general and global interest, and countries would be justified in cooperating internationally to conserve the phenomenon of migration. For example, because common concern is the conceptual foundation of the Biodiversity Convention, any action to address migration under that Convention would be premised at least in part on the theory that migration, too, is of common concern to the international community.

By building our understanding of migratory connectivity, states may increasingly view migration—or at least migratory species or populations—as part of their transboundary relationships with other states. Impacts on particular species or populations, for example through impacts on important breeding, stop-over, or wintering sites, would have a direct and increasingly demonstrable impact on other states where the species or population breeds, transits, or winters. In this more granular context, the international law principle of common concern is less relevant than the international law principles surrounding shared resources and transboundary impacts.

To the extent that migration is increasingly seen through the lens of shared natural resources, a more robust set of obligations and responsibilities under international environmental law come into play. States are generally (or at least arguably) viewed as being under an obligation not to harm the environment of another state.<sup>162</sup> In addition, states are generally obligated to notify<sup>163</sup> and consult in good faith<sup>164</sup> with other states before

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<sup>161</sup> Convention on Biological Diversity, *supra* note 97, pmb1.

<sup>162</sup> *See, e.g.*, Rep. of the Int'l Law Comm'n, 53d sess., Apr. 25–June 1, July 2–Aug. 10, 2001, U.N. Doc. A/56/10, at 371 (“[T]he freedom of States to carry on or permit activities in their territory . . . is not unlimited.”).

<sup>163</sup> *See, e.g., id.* at 373 (“[T]he State of origin shall provide the State likely to be affected with timely notification of the risk and the assessment and shall transmit to it the available technical and all other relevant information on which the assessment is based.”); U.N. ENV'T PROGRAMME, ENVIRONMENTAL LAW GUIDELINES AND PRINCIPLES ON SHARED NATURAL RESOURCES 2 (1978); *see also* Lake Lanoux Arbitration (Fr. v. Spain), 12 R.I.A.A. 281 (Arbitral Tribunal 1957) (concerning the use of waters in the Pyrenees).

conducting any activity that may have significant negative impacts on a shared natural resource. Finally, the need for a full environmental impact assessment may also be part of the obligations visited on states who propose activities that may affect a shared natural resource or otherwise create transboundary environmental impacts.<sup>165</sup>

Thus, by shifting how we think of migration from a solely hemispheric or global phenomenon (of common concern) to one of a shared resource, states may have more specific obligations and responsibilities. The analogy is one of global versus transboundary pollution. We primarily think of climate change as a wholly global problem because greenhouse gases mix in the atmosphere, and one ton of CO<sub>2</sub> released anywhere on the planet contributes equally to the global problem of climate change.<sup>166</sup> We thus address climate change through an international agreement premised on the principle of common concern and seek to address greenhouse gas emissions through a complex global management system.<sup>167</sup> On the other hand, transboundary air pollution—where the toxic plume from one factory pollutes the property in a neighboring state—gives rise to legal obligations between the states.<sup>168</sup>

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<sup>164</sup> See, e.g., Rep. of the Int'l Law Comm'n, *supra* note 162, at 373. ("The States concerned shall enter into consultations, at the request of any of them, with a view to achieving acceptable solutions regarding measures to be adopted in order to prevent significant transboundary harm or at any event to minimize the risk thereof."); U.N. ENV'T PROGRAMME, *supra* note 163, at 2–3.

<sup>165</sup> The International Court of Justice has appeared to recognize that states are under an obligation to conduct an EIA, at least where there are potential impacts on a shared resource. See, e.g., PANOS MERKOURIS, CASE CONCERNING PULP MILLS ON THE RIVER URUGUAY (ARGENTINA V. URUGUAY): OF ENVIRONMENTAL IMPACT ASSESSMENTS AND "PHANTOM EXPERTS" 2 (2010) ("Perhaps the most notable contribution of this judgment to international environmental law and the law on shared watercourses is the fact that the ICJ explicitly recognized Environmental Impact Assessment (EIA) as a practice that has attained customary international law status." *Id.* (citing Case Concerning Pulp Mills on the River Uruguay (Arg. v. Uru.), 2010 I.C.J. No. 135, ¶ 204 (April 20)), available at [http://www.haguejusticeportal.net/Docs/Commentaries%20PDF/Merkouris\\_Pulp%20Mills\\_EN.pdf](http://www.haguejusticeportal.net/Docs/Commentaries%20PDF/Merkouris_Pulp%20Mills_EN.pdf); see also, Rep. of the Int'l Law Comm'n, *supra* note 162, at 373 ("Any decision in respect of the authorization of an activity within the scope of the present articles shall, in particular, be based on an assessment of the possible transboundary harm caused by that activity, including any environmental impact assessment."); Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) art. 2(1), Feb. 25, 1991, 1989 U.N.T.S. 309, available at <http://www.unecce.org/env/eia/documents/legaltexts/conventiontextenglish.pdf> (specifying the parties' obligations related to transboundary environmental impact assessments); U.N. ENV'T PROGRAMME, *supra* note 162, at 2 ("States should make environmental assessments before engaging in any activity with respect to a shared natural resource which may create a risk of significantly affecting the environment of another State or States sharing that resource.").

<sup>166</sup> *Carbon Emissions 'Outsourced' to Developing Countries*, SCI. DAILY, Mar. 15, 2010, <http://www.sciencedaily.com/releases/2010/03/100308151041.htm> (last visited Jan. 26, 2011).

<sup>167</sup> See U.N. Framework Convention on Climate Change pmb., May 9, 1992, 1771 U.N.T.S. 107.

<sup>168</sup> See, e.g., Trail Smelter Arbitration (U.S. v. Can.), 3 R.I.A.A. 1905, 1907 (1939, 1941), available at [http://untreaty.un.org/cod/riaa/cases/vol\\_III/1905-1982.pdf](http://untreaty.un.org/cod/riaa/cases/vol_III/1905-1982.pdf); cf. Case Concerning Pulp Mills on the River Uruguay (Arg. v. Uru.), 2010 I.C.J. No. 135, ¶ 264 (April 20).

To be sure, the international law of transboundary impacts and shared natural resources still comes with significant uncertainties and caveats,<sup>169</sup> but transboundary principles may nonetheless have important implications for international wildlife conservation. As the knowledge of migratory connectivity grows, in some cases the evidence of impact will also grow and the threshold for triggering the rules of transboundary harm may be met. States are typically held responsible only for “significant” transboundary impacts;<sup>170</sup> the science of migratory connectivity may demonstrate “significant” harm to a species where we otherwise might not recognize it. For example, where one sex of a species or one geographic population of a species disproportionately uses a site, then impacts on that site may be more significant than otherwise thought. Thus, in the case of the monarch butterfly noted above, impacts on two of the wintering sites would have more significant impact on parts of the butterfly’s geographic range back in the United States than impacts on the other seven sites.<sup>171</sup>

As our ability to document the “significance” threshold for specific impacts increases, a variety of obligations, rights and responsibilities may be triggered. One state may demand notification and the right to be consulted over proposed development activities having significant impacts on particular migrants. The significance of impacts on a shared resource would also lead over time to more routine inclusion of impacts on migratory species in environmental impact assessments required in the transboundary context. Migratory connectivity will widen the impacts that must be assessed to include impacts on migrant species. Moreover, as the circle of those impacts is widened, so too are the interests affected. Environmental impact assessment procedures often require opportunities for the full participation of and consultation with all stakeholders that are affected by the proposed project or activity.<sup>172</sup> With greater understanding of migratory connectivity, new stakeholders (including distant states as well as non-state actors) would arguably fall within the range of those who would need to be informed and offered an opportunity to participate.

Ultimately, an injured state may even try to bring a case to the International Court of Justice based on evidence of the significance of the

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<sup>169</sup> See, e.g., Gunther Handl, *Balancing of Interests and International Liability for the Pollution of International Watercourses: Principles of Law Revisited*, 13 CANADIAN Y.B. INT’L L. 156, 158–63, 165–70 (1975) (discussing the “ambiguity” of customary environmental law), reprinted in INTERNATIONAL ENVIRONMENTAL LAW ANTHOLOGY 106 (Anthony D’Amato & Kirsten Engel eds., 1996); Gunther Handl, *An International Legal Perspective on the Conduct of Abnormally Dangerous Activities in Frontier Areas: The Case of Nuclear Power Plant Siting*, 7 ECOLOGY L.Q. 1, 3–6, 8–24, 27–39, 47–50 (1978) (same), reprinted in INTERNATIONAL ENVIRONMENTAL LAW ANTHOLOGY, supra, at 108; DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAELEKE, INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 467–77 (4th ed. 2011) (discussing the extent of state responsibility as applied to the obligation not to cause environmental harm).

<sup>170</sup> Espoo Convention, supra note 165, art. 2.

<sup>171</sup> See supra text accompanying notes 27–33.

<sup>172</sup> See, e.g., National Environmental Policy Act of 1969, 42 U.S.C. § 4332(C) (2006) (requiring the release of draft impact statements to the public); 40 C.F.R. § 1503.1(a)(4) (2010) (requiring agencies to request comments from the public on draft environmental impact assessments).

impact. Although in the past, transboundary environmental cases have been brought primarily by neighboring states, as migratory connectivity is clarified distant states may be able to bring disputes as evidence demonstrates that they share the migrating resource and that significant impact may occur on a species or population in that state. In this way, the science of migratory connectivity demonstrates the links that would allow for a particularized international dispute to be brought involving impacts on migratory species.

#### V. STRENGTHENING SOCIAL CONNECTIVITY

Perhaps the most important contribution of the emerging science of migratory connectivity to conservation is not in direct law reform, but in strengthening the scientific and social context for effective law-making. By demonstrating the links between different locations in the life cycle of migratory animals, migratory connectivity can strengthen the “social connectivity” between distant communities—the web of social, cultural, institutional and economic relations that can connect distant locations and allow for the successful pursuit of shared conservation goals.

If, for example, a decline in black-throated blue warblers (*Dendroica caerulescens*) is observed on their breeding grounds in North Carolina, the cause may very well be a thousand miles away on their wintering grounds.<sup>173</sup> Migratory connectivity studies would suggest that we need not address the entire wintering range but concentrate particularly on changes in the eastern Greater Antilles (where a disproportionate number of North Carolina’s Black-Throated Blue Warblers over winter).<sup>174</sup> In such a case, the birding community in North Carolina could be more effectively galvanized to share in the goal of conserving prime wintering habitat because of the clear connection of a specific location to their quality of life back home. This type of strengthened community-to-community connectivity can help to build the scientific, educational, financial and institutional relationships, and the political will, necessary to sustain long-term cooperative conservation efforts.

Organizing around focused, shared conservation goals at the community level can build the political will for national or international conservation efforts, even where national interests might not allow for such cooperation. Often countries or regions have political differences that would disallow formal international cooperation, but citizen diplomacy among like-minded individuals can transcend these differences to achieve specific conservation goals. Thus, for example, broader geo-political issues regarding drug trafficking or fighting rebel forces might dominate the United States-

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<sup>173</sup> Michael C. Runge & Peter P. Marra, *Modeling Seasonal Interactions in the Population Dynamics of Migratory Birds*, in *BIRDS OF TWO WORLDS: THE ECOLOGY AND EVOLUTION OF MIGRATION*, *supra* note 19, at 375, 387.

<sup>174</sup> See Joseph M. Wunderle, Jr., *Population Characteristics of Black-Throated Blue Warblers Wintering in Three Sites on Puerto Rico*, 112 *AUK* 931, 931–32 (1995) (explaining that Black-Throated Blue Warblers mostly overwinter in the Greater Antilles).



Colombian relationships at the national level, but that does not prevent effective international conservation efforts among like-minded organizations and communities.<sup>175</sup> By building the scientific basis for greater cooperation, migratory connectivity will allow more shared conservation goals to be identified and help to organize the advocacy networks necessary to achieve these goals, at political levels below the national stage.

#### *A. Enhancing Conservation Connectivity*

Several federal and state conservation programs have been initiated to increase the awareness of shared species of migratory animals. Many of these efforts could be enhanced by better incorporation of actual migratory connectivity data. A good example is the North American Waterfowl Management Plan (NAWMP).<sup>176</sup> The NAWMP is a joint venture between Canada, the United States, and Mexico to protect all shared species of waterfowl.<sup>177</sup> The Plan by its very nature recognizes that species occupy geographically disparate places throughout their annual cycle and that international cooperation is essential for protecting shared resources. What is unique about the Plan is that it involves governments at all levels, indigenous groups, nongovernmental organizations, corporations, and individuals. This approach to conservation has forged new ground but what is not clear is to what degree this strategy has incorporated migratory connectivity and linked geographical regions. Species-level connections are certainly explicit through joint ventures, but we believe conservation efforts would improve significantly by including information on migratory connectivity for specific populations.

Partners in Flight (PIF), composed of both governmental and non-governmental entities, was launched in the early 1990s in response to declines in many species of songbirds across North America.<sup>178</sup> PIF recognized that to conserve migratory landbirds effectively their conservation efforts must extend beyond political borders. Recognizing the importance of migratory connectivity data to these efforts but lacking suitable data, PIF initiated an effort that relies on species' ranges to summarize migratory connections between individual U.S. states, Canadian provinces and territories, and the regions that support the same birds at the other end of migration.<sup>179</sup> The resulting maps—done only for species of high

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<sup>175</sup> See, e.g., Am. Bird Conservancy, American Bird Conservancy's International Programs, <http://www.abcbirds.org/abcprograms/international/index.html> (last visited Feb. 19, 2011).

<sup>176</sup> N. AM. WATERFOWL MGMT. PLAN COMM., 1994 UPDATE TO THE NORTH AMERICAN WATERFOWL MANAGEMENT PLAN: EXPANDING THE COMMITMENT 1–2 (1994), available at <http://www.fws.gov/birdhabitat/NAWMP/files/NAWMP1994.pdf>.

<sup>177</sup> *Id.*

<sup>178</sup> Partners in Flight – U.S., What Is Partners in Flight?, <http://www.partnersinflight.org/description.cfm> (last visited Feb. 19, 2011).

<sup>179</sup> PETER J. BLANCHER ET AL., PARTNERS IN FLIGHT SCI. COMM., PARTNERS IN FLIGHT TECHNICAL SERIES No. 4, MAKING CONNECTIONS FOR BIRD CONSERVATION: LINKING STATES, PROVINCES & TERRITORIES TO IMPORTANT WINTERING AND BREEDING GROUNDS 2–4 (2006); HUMBERTO BERLANGA

conservation concern, and primarily for landbirds—provide a general picture of the breeding and wintering ranges of these species.<sup>180</sup> Once again, detailed migratory connectivity data would provide a new level of specificity that would substantially increase conservation effectiveness by prioritizing and supporting cooperation between those communities most closely linked to a particular species' or population's survival.

Southern Wings is a program started by the Association of Fish and Wildlife Agencies meant to link states with countries in Latin America and the Caribbean that share migratory landbirds.<sup>181</sup> Grants are available for states through matching mechanisms that allow exchanges and visits by state wildlife biologists and natural resource managers.<sup>182</sup> The linkages between states and countries with respect to shared migratory birds or other animals are currently not made with respect to actual data on migratory connectivity.<sup>183</sup> Creating these linkages would build demand for these programs, improve their conservation effectiveness, and demonstrate the vital importance of such international cooperation to long-term conservation goals.

A final example is the Park Flight Program started by the U.S. National Park Service to build cooperative and coordinated programs between the United States and Latin America to protect breeding, migration, and wintering habitats of shared migratory birds.<sup>184</sup> According to the National Park Service, "The Park Flight Migratory Bird Program works to protect shared migratory bird species and their habitats in both United States and Latin American national parks and protected areas through developing bird conservation and education projects and creating opportunities for technical exchange and cooperation."<sup>185</sup> This program contains no actual elements of migratory connectivity between National Parks or protected areas, as we have defined it because the program does not emphasize conservation between linked populations—populations whose breeding and wintering grounds have been documented. Again, the use of migratory connectivity data that demonstrates more specific connections could demonstrate the

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ET AL., PARTNERS IN FLIGHT, SAVING OUR SHARED BIRDS: PARTNERS IN FLIGHT TRI-NATIONAL VISION FOR LANDBIRD CONSERVATION 1, 18 (Ashley A. Dayer & Kenneth V. Rosenberg eds., 2010); see also Cornell Lab of Ornithology, Education Program – What We Do, <http://www.birds.cornell.edu/netcommunity/page.aspx?pid=1673> (last visited Feb. 19, 2011).

<sup>180</sup> BLANCHER ET AL., *supra* note 179, at 7 fig.1; BERLANGA ET AL., *supra* note 179, at 14.

<sup>181</sup> Ass'n of Fish & Wildlife Agencies, The Voice of Fish and Wildlife Agencies: AFWA Press Releases, [http://www.fishwildlife.org/index.php?section=afwa\\_press\\_releases&prid=114](http://www.fishwildlife.org/index.php?section=afwa_press_releases&prid=114) (last visited Feb. 19, 2011).

<sup>182</sup> See BERLANGA ET AL., *supra* note 179, at 35; U.S. Fish & Wildlife Serv., Neotropical Migratory Bird Conservation Act, <http://www.fws.gov/birdhabitat/grants/numbca/index.shtm> (last visited Feb. 19, 2011).

<sup>183</sup> See BLANCHER ET AL., *supra* note 179, at 2 (explaining that the study only generally summarizes migratory connections and is limited in focus to species of high conservation importance).

<sup>184</sup> Nat'l Park Serv. Office of Int'l Affairs, Park Flight Migratory Bird Program, <http://www.nps.gov/oia/topics/flight.htm> (last visited Feb. 19, 2011).

<sup>185</sup> *Id.*

importance of, and build demand for, such park-to-park cooperation as well as improve its effectiveness.

### *B. Educational Connectivity*

Migratory connectivity data can also be used to generate new and better education initiatives in communities along migration routes. Bridging the Americas/Unidos por las Aves, for example, is a cross-cultural environmental education program, coordinated by the Smithsonian Migratory Bird Center in Washington, D.C., that pairs middle school classes in grades 3 through 8 in Maryland, Virginia, the District of Columbia, Vermont, and New Hampshire with classes in Latin America.<sup>186</sup> Partnered classes learn about the migratory birds shared in common and about their partner class' country by exchanging artwork, letters, and other creative materials during the school year.<sup>187</sup> The program provides teachers with tools and support that enable them to use migratory birds as a theme for teaching a variety of subject areas, including science, geography, social studies, visual arts, language arts, and Spanish.<sup>188</sup> Students are offered the opportunity not only to learn about a fascinating part of nature, but also to correspond with students in another part of the world.

The program is designed to instill an appreciation for birds and the need to protect the habitats they depend on throughout the year, as well as to stimulate an interest in learning about other countries and their cultures. Since 1993, over 12,000 students have participated from ten countries: the United States, Mexico, Guatemala, Belize, El Salvador, Nicaragua, Costa Rica, Panama, Ecuador, and Colombia.<sup>189</sup> One hundred classes are participating during the 2010–2011 school year.

Cornell has launched a similar project that pairs middle school students in the United States with students in Costa Rica.<sup>190</sup> Participating middle school classes will conduct schoolyard investigations, participate in citizen science projects, and communicate via the Internet with the other classes.<sup>191</sup> Working with innovative technologies such as the mapping and visualization

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<sup>186</sup> Smithsonian Conservation Biology Institute, Bridging the Americas – Smithsonian Migratory Bird Center, [http://nationalzoo.si.edu/scbi/migratorybirds/education/teacher\\_resources/bridging\\_the\\_americas/default.cfm](http://nationalzoo.si.edu/scbi/migratorybirds/education/teacher_resources/bridging_the_americas/default.cfm) (last visited Feb. 19, 2011).

<sup>187</sup> *Id.*

<sup>188</sup> *Id.*

<sup>189</sup> Mary Deinlien & Susan Bradfield, Bridging the Americas/Unidos por las Aves: Using Birds to Connect Classrooms Across Cultures, Address at the Power of Partnerships: Bird Conservation Conference in the Northeast (Oct. 19–21, 2010) (abstract available in POWER OF PARTNERSHIPS: BIRD CONSERVATION CONFERENCE IN THE NORTHEAST: PROCEEDINGS 42 (2010), available at <http://pcjv.org/docs/Bird%20Conservation%20Conference%20in%20the%20NE%20Proceedings%202010.pdf>).

<sup>190</sup> Cornell Lab of Ornithology, BirdSleuth Debuts in Costa Rica, <http://www.birds.cornell.edu/netcommunity/page.aspx?pid=1693> (last visited Feb. 19, 2011).

<sup>191</sup> *Id.*

power of Google Earth and Google Maps, students will be able to learn collaboratively with their partners in Costa Rica.<sup>192</sup>

Such shared education opportunities will build on and benefit from the emerging science of migratory connectivity. Paired classrooms may in the future be able to track the migration of species in real time as they leave the backyard of one classroom in the United States, for example, and are welcomed days later in the sister school's backyard.

The above examples of existing conservation and education initiatives are just a few illustrations of how migratory connectivity science can help to strengthen the connections between different locations around specific migratory routes. Ultimately, stronger understanding of migratory connectivity could form the foundation of species-specific, community-based initiatives that strengthen conservation significantly. Shared education initiatives, community-to-community support for conservation, and coordinated campaigns to improve conservation measures could all be strengthened along a particular species' migration route.

The potential impact of enhancing social connectivity at the community level can be seen in the following: Every evening in spring and fall in Eugene, Oregon, more than a hundred people gather in the parking lot of a small, old power plant to witness the twilight flight of up to a thousand migrating Vaux's Swifts (*Chaetura vauxi*).<sup>193</sup> Out of nowhere, the swifts suddenly appear and begin to fly in a tightening spiral until like a mini tornado they rush down the power plant's chimney for their evening roost. Spontaneous cheers erupt every night. Within a few weeks, the swifts disappear, continuing north to their breeding locations or south to their wintering grounds. Every year they return to Eugene.

The local Audubon Society provides educational material about the general migration of the swift and general information about the importance of conserving them in their breeding and wintering grounds.<sup>194</sup> Unfortunately, the information lacks sufficient specificity to allow for meaningful conservation efforts by community members. But what if we knew exactly where those Eugene swifts bred, where they wintered, and what other migratory stop-over points were important for that specific population? Armed with that information, the relatively well-educated and wealthy community of Eugene could be enlisted and organized to provide financial support, technical assistance (Eugene is a college town), and political pressure for conservation of "their" swifts. Migratory connectivity science could support countless opportunities for engaging and connecting communities like Eugene for the

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<sup>192</sup> Deinlien & Bradfield, *supra* note 185; Jennifer Fee et al., Connecting Kids Through Migratory Birds, Address at Power of Partnerships: Bird Conservation Conference in the Northeast (Oct. 19–21, 2010) (abstract available in POWER OF PARTNERSHIPS: BIRD CONSERVATION CONFERENCE IN THE NORTHEAST: PROCEEDINGS 9 (2010), available at <http://pcjv.org/docs/Bird%20Conservation%20Conference%20in%20the%20NE%20Proceedings%202010.pdf>).

<sup>193</sup> See Lane Cnty. Audubon Soc'y, <http://www.laneaudubon.org/birdwalk.htm#swift> (describing the organization's annual trip to see the swifts).

<sup>194</sup> See Lane Cnty. Audubon Soc'y, QUAIL, April 2010, at 12, available at [http://www.laneaudubon.org/library-sub/quail\\_pdf/2010-04-apr-quail.pdf](http://www.laneaudubon.org/library-sub/quail_pdf/2010-04-apr-quail.pdf).

conservation of species they feel are important parts of their community's quality of life. The resulting web of connected communities could be a powerful new force for conserving migration.

#### VI. CONCLUSION

Protecting the phenomenon of migration will require looking at it from a continental or hemispheric scale and seeking to conserve the abundance and scale of migration. But conservation also requires setting priorities and succeeding at the species or site level. Enhanced understanding of migration at this more granular level will allow us to identify and protect more individual sites—the building blocks for protecting migration overall. It will also allow us to target conservation efforts at the specific threats causing a decline in specific populations.

To take full advantage of the growing understanding of migratory connectivity, lawyers need to look for innovative ways to integrate migratory connectivity into existing legal mechanisms. At the domestic level, taking into account migratory connectivity can enhance a wide range of conservation efforts, including, as noted here, protecting critical habitat for endangered species, conducting environmental impact assessments, and extending judicial and administrative standing to parties affected along migratory routes. Conservation could also benefit from designing international conservation regimes with the institutional and legal frameworks necessary to respond to the specific opportunities presented by the more granular information found in migratory connectivity studies. Such reforms will be more likely to the extent that we can harness our greater understanding of migratory connectivity to build social connectivity at the community level and, in turn, strengthen the political will to protect our shared heritage of migration.

Figure 1

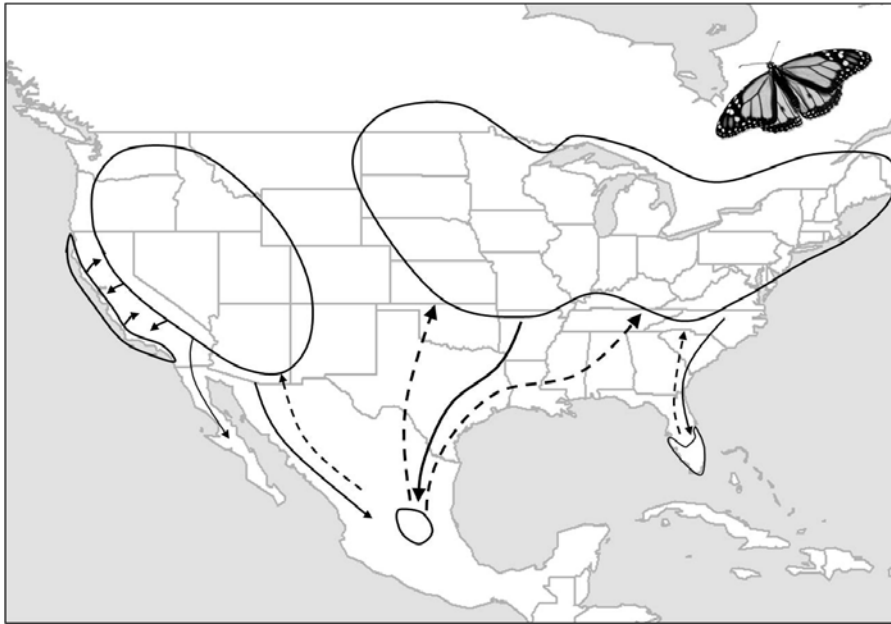


Figure 2

