Using ecosystem services to identify inequitable outcomes in migratory species conservation

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Abstract

Biodiversity conservation efforts have been criticized for generating inequitable socio-economic outcomes. These equity challenges are largely analyzed as place-based problems affecting local communities directly impacted by conservation programs. The conservation of migratory species extends this problem geographically since people in one place may benefit while those in another bear the costs of conservation. The spatial subsidies approach offers an effective tool for analyzing such relationships between places connected by migratory species. Designed to quantify ecosystem services provided and received in specific locations across a migratory species’ range—and the disparities between them—the spatial subsidies approach highlights three axes of inequity: between indigenous and settler colonial societies, between urban and rural populations, and between the Global North and Global South. Recognizing these relationships is critical to achieving two mutually reinforcing policy goals: avoiding inequitable conservation outcomes in efforts to conserve migratory species, and ensuring effective long-term conservation of migratory species. In demonstrating how the spatial subsidies approach enables the identification and quantification of inequities involving three migratory species (northern pintail ducks, monarch butterflies, and...
Biodiversity conservation efforts can result in inequitable outcomes across sectors and among different actors and stakeholders (Adams & Hutton, 2007; Dowie, 2009; Duffy, 2010). Despite quantified ecological and societal benefits from habitat conservation, protected areas may constrain livelihoods for local people (Anaya & Espírito-Santo, 2018; Boillat et al., 2018; Kohler & Brondizio, 2017). These equity challenges are typically analyzed as place-based problems affecting the local communities directly impacted by conservation programs, for example, the displacement of local people by the creation of a national park (Brockington, 2002). The conservation of migratory species extends this problem geographically since people in one place may benefit from the ecosystem services provided by migratory species (described below), while those in another bear the costs of conservation investments to protect, restore, and enhance habitat. Such geographic distinctions transform equity challenges from localized, place-based problems into spatially distant, telecoupled problems (López-Hoffman et al., 2017).

Populations of numerous migratory species have declined substantially, in some cases precipitously, over the past 150 years (Wilcove & Wikelski, 2008). In the wake of such declines, nations have entered into international agreements and created domestic laws and regulations to protect the phenomenon of migration (Bowman et al., 2010; see also http://earthweb.info/biodiversity/migration-timeline.html). Regardless of their efficacy, designing conservation solutions for migratory species—particularly those crossing international boundaries—raises several questions revolving around issues of equity. These include:

- Who benefits most from conservation investments? Will one country receive comparatively greater advantages?
- Who bears the costs of conservation investments to protect, restore, and enhance habitat?
- Do those who bear the heaviest costs of conservation receive compensation?
- How is the balance of costs and benefits of conservation across a species’ migratory range determined, and who makes such determinations?

We suggest that the spatial subsidies approach offers an effective tool for analyzing relationships between places connected by migratory species (López-Hoffman et al., 2013; Semmens et al., 2011). By identifying and quantifying inequities across and within distinct yet telecoupled systems, this approach supports two mutually reinforcing goals: (1) avoiding inequitable conservation strategies for migratory species and (2) ensuring effective long-term conservation strategies for migratory species.

In the first part of this review, we explain the spatial subsidies approach and discuss concepts of equity, including a review of three “axes of inequity.” We then demonstrate how both the spatial subsidies approach and axes of inequity apply to examples from our research on three migratory species: northern pintail ducks (Anas acuta, hereafter “pintails”), monarch butterflies (Danaus plexippus, hereafter “monarchs”), and Mexican free-tailed bats (Tadarida brasiliensis, hereafter MFTBs). Finally, we propose how this approach could be extended to inform conservation policies for other migratory species across telecoupled systems.

### 2 | SPATIAL SUBSIDIES AND SPATIAL INEQUITIES

Spatial subsidies are a quantitative measure of both the ecosystem service benefits of a migratory species as well as the costs associated with the conservation of that migratory species across its full migratory range. The spatial subsidies approach is based on two key observations: First, across its migratory pathway, a migratory species can provide different types and amounts of ecosystem services in different locations. Migratory salmon offer a highly discernible example of this, inasmuch as their ecosystem services differ dramatically in character and extent.
between their oceanic saltwater habitat and riverine freshwater habitat (Kulmala et al., 2012). Second, a migratory species’ dependence on particular habitats can vary considerably across its migratory pathway. Keeping with the same example, the dependency of migratory salmon on a specific riverine habitat is greater than the more diffuse oceanic environment. Loss of specific stream habitat can cause the extirpation of a salmon run, while oceanic pollution in a particular place, for example, may be more easily avoided by salmon with large oceanic ranges.

The spatial subsidies approach can thus identify mismatches between (1) locations where people receive the most benefits of the migratory species and (2) the locations of the most important habitat for a species’ survival, which may then be evaluated to determine the costs of conservation. For example, in the case of the monarch butterfly at a continental scale, cultural benefits enjoyed by people in the United States and Canada are subsidized by migration and overwintering habitat in Mexico. At a finer scale, milkweed (Asclepias spp.) habitat in rural landscapes subsidizes the cultural benefits received by urban residents (Semmens et al., 2018). Similar spatial mismatches have been shown for two other North American migratory species: pintail ducks and Mexican free-tailed bats (see Bagstad et al., 2018; López-Hoffman, Chester, Semmens, et al., 2017; Rubio-Cisneros et al., 2014), all three of which are examined below.

The Convention on Biological Diversity and the International Union for the Conservation of Nature incorporate the concept of equity in their mandates and policies (see Franks et al., 2018). In this context, equity is concerned with creating conditions for fairness in political, economic, and environmental outcomes. As such, equity differs from equality, which suggests all people are equal regardless of current or historical barriers. Understanding inequities implies addressing ongoing forms of exclusion rooted in historical policies that have systematically prevented the fair distribution of resources and opportunities. As a goal, equity entails implementing policies to redress historic discrimination, including through the redistribution of usurped resources. Our interpretation of equity includes the concept of self-determination, in recognition of differing definitions of the “good life,” and in contrast to constrained and unidimensional treatments of equity in the field of neoclassical economics (Lovins et al., 2018).

Despite the centrality of equity in conservation and natural resource management, there are few tools for quantifying inequities in the costs and benefits of migratory species conservation across borders. As a first step in developing conservation approaches that are both actionable and equitable, the spatial subsidies approach fills this gap by providing the necessary means for identifying relationships across great distances, thereby providing a starting point for identifying places where inequities may exist and for placing these inequities into context (López-Hoffman et al., 2013). Ultimately, understanding the spatial distribution of habitat dependencies and ecosystem service benefits for these migratory species may offer a promising means of understanding the equity challenges associated with conservation across jurisdictional boundaries and may lay a foundation for addressing these challenges.

3 AXES OF INEQUITY

To highlight the effectiveness of the spatial subsidies approach to address equity challenges across and between spaces, we have identified three primary axes of inequity that may result from conservation efforts. While these axes of inequity may overlap and each simplifies myriad internal complexities, they constitute a first-order categorization for assessing dynamics between broad societal groupings and across a range of spatial scales.

- **Indigenous ↔ settler colonial societies**. “Settler colonialism” describes contemporary societies founded by colonial settlers and maintained by their descendants after the end of formal colonial rule. In a pattern repeated globally, Indigenous-settler colonial conflicts have resulted from settler colonial societies claiming Indigenous territories acquired through land usurpation, postcolonial treaties, or the assertion of national sovereignty (see Carey & Silverstein, 2020). From both pre- and postcolonial eras, there are numerous examples of Indigenous peoples being excluded from conservation planning, and of protected areas constraining Indigenous livelihoods (Brockington et al., 2008). For example, Indigenous people have been labeled “poachers” for carrying out their traditional hunting and gathering practices (Gombay, 2014). Such exclusion occurs even as the larger settler colonial society reaps the benefits of conservation outcomes while also dictating the terms of when and where resource extraction can happen elsewhere.

- **Urban ↔ rural populations**. Urban–rural conflicts can arise when urban people receive ecosystem services that rural people provide by bearing the costs of habitat protection and other conservation measures, often without compensation. Such conflicts have been extensively discussed in regard to water and forests (see, e.g., Caro-Borrero et al., 2015; Silva et al., 2017), but occur with migratory species as well. In the case of monarchs, presented below, rural communities in the United States and Canada bear the increased management burden of maintaining extensive milkweed.
(Asclepias spp.) populations (Semmens et al., 2012), which is both a competitive weedy pest to agricultural crops as well as the sole food source of monarch caterpillars (although see DiTommaso et al., 2016). Yet, people in urban locations benefit from the ecosystem services the butterflies provide (e.g., existence values and viewing opportunities).

- **Global North ↔ Global South.** North-south dynamics largely entail people in the Global South bearing the cost of conservation, while the benefits of conservation accrue to people in the Global North (see Solarz, 2012 for a review of north-south terminology). These costs and benefits relate to wide-ranging conservation issues, including habitat protection, climate change mitigation, cultural services, and tourism. Although North-South dynamics are complicated by the presence of “elite” populations within the Global South who may derive higher financial and other benefits from conservation (Mollett & Kepe, 2018), there are many reported instances of Indigenous and rural communities in the Global South not receiving commensurate benefits from conservation outcomes (Adams & Hutton, 2007; Anaya & Espírito-Santo, 2018; Brockington, 2002; Brockington et al., 2008; Dowie, 2009; Duffy, 2010; Franks et al., 2018; Kohler Brondizio, 2017; Mollett & Kepe, 2018; Tran et al., 2020; Watson, 2013).

We use these axes of inequity in combination with spatial subsidies to step beyond a limited economic view of the distribution of costs and benefits of migratory species conservation. Our approach allows for the examination of equity challenges that may arise when designing conservation programs spanning multiple nations, communities, and cultures. We apply the axes of inequity to three case studies in North America.

### 4  |  CASE STUDIES

#### 4.1  |  Pintail ducks: Indigenous ↔ settler colonial societies and urban ↔ rural inequities

Pintails migrate between their winter habitat in California and coastal areas of the Gulf of Mexico (the United States and Mexico) and their two major summer breeding grounds of (1) far northern Canada and Alaska and (2) the prairie potholes region (PPR) of the northern Great Plains of the United States and Canada (Clark et al., 2014). Pintail populations declined ∼50% to ∼3 million individuals in the mid-20th century and, unlike other migratory waterfowl species, have failed to recover (Mattsson et al., 2012; Mattsson et al., 2020b; USFWS, 2018a).

Models of pintail population dynamics show that the interaction between habitat conservation in the PPR and waterfowl hunting in the pintail’s winter range affects population size and the ability to reach the population goals set in the North American Waterfowl Management Plan (NAWMP) (Mattsson et al., 2012, 2020a). Both the PPR and pintail habitat in northern Canada and Alaska, managed in large part by Indigenous nations, provide a net spatial subsidy to winter habitat locations in the United States and Mexico (Bagstad et al., 2018). Indigenous groups in northern Canada and Alaska also rely on pintails and other migratory waterfowl as a traditional source of protein (a provisioning service) and have strong cultural traditions around hunting, which are central to many Indigenous groups’ identities (Goldstein et al., 2014). Overwintering areas in rural Mexico also support hunting in the United States by supporting the survival of overwintering pintails that are later hunted in the United States (Rubio-Cisneros et al., 2014).

While Indigenous-settler colonial inequities are typically treated as localized, place-based problems (see, e.g., Dahl, 2018), for pintails, the combination of large-scale agriculture and hunting practices across the large PPR (viz., in places distant from Indigenous populations) can lead to a decline in pintail populations and may threaten the subsistence and cultural resources of sovereign Indigenous nations. Indigenous groups in the northern breeding regions of northern Canada and Alaska may have little ability to influence agricultural and wildlife management policies in the United States and Canada that result in the persistent failure to reach pintail population goals (Watson, 2013). For example, in the United States, wildlife, including waterfowl, has largely been managed according to the North American Model of Wildlife Conservation. Although this model has been an important doctrine within US and Canadian wildlife management agencies over the last several decades (Organ et al., 2012), a recent critical review by Eichler and Baumeister (2018) has described this set of principles as based on European-American values that prioritize sport hunting, restrict subsistence hunting, institutionalize public ownership of wildlife by settler colonial societies, and place western science above Indigenous knowledge. According to Bagstad et al. (2018), the spatial subsidies provided by the northern breeding regions, many of which are located in Indigenous territories, benefit settler colonial governments and societies by supporting the persistence of migratory pintails. Specifically, Indigenous communities contribute to migratory waterfowl conservation, including pintails, through implementation of traditional management practices (e.g., rotating harvest areas to minimize disruption to the larger population; Gadgil et al., 1993) from which US wildlife management authorities in the winter range of these...
species generate revenue through hunting fees that are retained by state wildlife management agencies to support their operations (Mattsson et al., 2020a; Watson, 2013).

Continued loss of habitat in the PPR also negatively affects pintail populations, highlighting the potential for additional rural–urban inequities (Mattsson et al., 2012, 2020a). In this region, hundreds of millions of US dollars have been spent to purchase land and conservation easements from rural landowners (Mattsson et al., 2020a), meaning that rural landowners have often been compensated for providing habitat, which in turn has effectively resulted in large spatial subsidies to areas with winter habitat where pintail hunting occurs, benefiting urban residents (Bagstad et al., 2018). However, despite these efforts by the US and Canadian governments to discourage filling and cultivation of ephemeral wetlands in the PPR, habitat loss continues (Johnston & McIntyre, 2019).

At the same time that conservation payments are benefiting settler-colonial agricultural operations for wetland habitat protection and restoration, the management effort by Indigenous groups is not being rewarded with conservation payments. If not curtailed further, the continued loss of prairie pothole habitat may continue to undermine the recovery of pintails and may also make the northern Canadian and Alaskan breeding regions more important as a “source” of pintails (Mattsson et al., 2020b), both for Indigenous communities and for regions in the United States and Mexico receiving spatial subsidies.

4.2 Monarch butterflies: Global north ← global south and urban ← rural inequities

Each spring, millions of monarch butterflies set forth from oyamel fir (Abies religiosa) forests on approximately a dozen small mountaintops in central Mexico (Oberhauser et al., 2015). During their northward migration, they spread across North America from the Rocky Mountains to the Atlantic coast, laying eggs principally on species of milkweed which monarch larvae require for food. These individuals do not return to Mexico; rather, every fall their great-great grandchildren—or even great-great-great-grandchildren—begin the migration back south from Canada and the United States, alighting once again in the fir forests to overwinter.

The eastern North American migratory monarch population has “undergone a precipitous decline over the last two decades” (Semmens et al., 2018), and recent indications of a population resurgence are not reliable (Thogmartin et al., 2020). Wilcox et al. (2019) identified five broad threats to monarchs, with changing climate conditions and the loss of overwintering and breeding habitat likely the greatest (see also Saunders et al., 2018 and Flores-Martinez et al., 2019). Other threats include disease (Altizer et al., 2000) and pesticides (Thogmartin, Wiederholt, et al., 2017). Declines in milkweed abundance are well documented and highly correlated with the expanding use of herbicide-tolerant genetically modified corn and soybeans in the United States and Canada (Plaasants & Oberhauser, 2013), which now constitute 92% and 94% of these crops, respectively (Fernandez-Cornejo et al., 2014).

Monarchs are iconic throughout North America (Gustafsson et al., 2015), and their value “derives from non-market cultural ES, which include their contributions to the non-material benefits (e.g., capabilities and experiences) arising from human-ecosystem relationships” (Diffendorfer et al., 2014). In central Mexico, monarchs carry spiritual significance for Indigenous people as the butterflies’ return in the fall is associated with the important syncretic Mexican celebration of Dia de los Muertos (Agrawal, 2017) and is also related to the harvest season and what Gonzalez-Duarte (2021) calls a ritualized communal forest that connects the lower hill milpa with the upper forest. In the United States, a survey found that 70% of respondents expressed a desire to conserve monarchs; moreover, the sense of wonder many people in the United States experience from the monarchs’ migration, a cultural ecosystem service, has been valued (based on a one-time willingness-to-pay methodology) at US$4.8 to US$6.6 billion (Diffendorfer et al., 2014). While popular appeals for conservation support largely focus on mammalian and avian species, the monarch arguably serves as a bridge to the far more species-rich phylum Arthropoda (see Young-Isebrandt et al., 2015).

Spatial subsidies calculations show that winter habitat in Mexico benefits monarchs that then provide cultural benefits to people in the United States and Canada, suggesting that potential conservation payments from Canada and the United States could help offset opportunity costs of habitat protection (e.g., foregoing use of forest resources) for local people in the winter range in Mexico (Semmens et al., 2018). Perhaps an even more significant complication for monarch conservation lies in a rural–urban divide. Roughly 85% of the annual benefits from monarchs are supported by rural habitats in southern Canada, the eastern and central United States, and northern and central Mexico (Semmens et al., 2018). In Mexico, all overwintering sites are located in rural, ejido (mestizo), and comunidades (Indigenous) areas that have been declared biosphere reserves. While these reserves do not legally expropriate land from ejidos, they do limit the ways ejido residents can work the land and may both constrain their livelihoods and reshape “local, regional, global, and human-nature relationships in ways that have facilitated the expansion of illicit economies and violence” in the
region (Gonzalez-Duarte, 2021). And because approximately 40% of US milkweed populations located in rural agricultural areas have been lost predominantly due to increased use of herbicides (with a relatively small additional loss due to land conversion; see Pleasants, 2017), stabilizing monarch populations may require habitat restoration in agricultural landscapes the rural United States and Canada (Thogmartin, López-Hoffman, et al., 2017).

4.3 Mexican free-tailed bats: Global north ↔ global south inequities

Summer populations of MFTBs in the United States and northern Mexico have generally migrated northward from winter roosts in central and southern Mexico. Congregating in large, mostly female groups during this season, many of their summer roosts, which consist mostly of natural caves and also bridges, mine shafts, and other human-made structures, are each capable of supporting millions of bats. Throughout the summer, female bats depart their roosts each night in search of high-caloric nocturnal insects to support birth and lactation (Cleveland et al., 2006; López-Hoffman et al., 2013). A key prey species of MFTB is *Helicoverpa zea*, a moth that carries several common names (e.g., cotton bollworm, corn earworm, and tomato fruitworm) and is considered a “major yield-limiting pest” for both cotton and soybeans (Reisig et al., 2019). With arrival of winter, the majority of these bats migrate back to central and southern Mexico, where they broadly disperse across a variety of habitats (McCracken, 2003).

Although MFTB’s range has expanded substantially (McCracken et al., 2018), Wiederholt et al. (2013) argue that MFTBs “have undergone wide-scale population declines since the 1950s; however, definitive evidence is confounded by the likely inaccuracy of historic abundance estimates.” Notably, MFTB is the only chiropteran species listed on Appendix I of the 1979 Convention on the Conservation of Migratory Species of Wild Animals (McCracken, 2003).

The case of MFTB highlights how mismatches between the location where ecosystem service benefits are received and where benefits are generated can result in Global North-South inequities. The MFTB has been widely heralded for its provision of quantifiable ecosystem services, particularly in terms of its value from pest control and ecotourism. For example, Cleveland et al. (2006) estimated a “reference case value” of approximately US$700,000 per year from MFTB pest control services for the cotton crop in the Winter Garden region, an agricultural area of southwest Texas. López-Hoffman, Diffendorfer, et al. (2017) updated these values and found that Texas and New Mexico received an estimated US$12.4 million in pest control services annually between 1994 and 2008. In contrast, the Mexican states of Michoacán, Jalisco, Querétaro, Chiapas, and Hidalgo provided $9.7 million in subsidies, primarily to the United States by providing important overwintering habitat for MFTBs. While the actual value of pest control services provided by MFTBs fluctuates each year with agricultural markets and adoption of genetically modified crops, they provide a potentially high option value to US farmers (López-Hoffman et al., 2014). Ecotourism associated with MFTBs has been valued at US$6 million per year, also primarily in the United States (Bagstad & Wiederholt, 2013). Together, these studies suggest that rural and Indigenous communities in Mexico may provide a consistent subsidy to communities in the United States. Notably, although respondents in both the United States and Mexico expressed a willingness to pay for conservation in either country, contingent valuation studies have found that Mexican households were willing to contribute a greater portion of their income to MFTB conservation than US households (Haefele et al., 2018).

While MFTB’s biology and behavior have received significant research attention during its summer residency in the United States (see Wiederholt et al., 2015), much less is known about its habitats and roosting behaviors in Mexico. More investigation is needed to quantify ecosystem services in the form of pest control to important crops in Mexico, such as corn and tomato, particularly in light of how these ecosystem services will apply across the diversity of land tenure arrangements and Indigenous group land claims in Mexico. Yet, in light of the US-based production of a “cash crop”—viz., cotton, which derives significant pest control benefits from MFTBs—with no comparable crop production in Mexico, there exists the potential of an economic imbalance between the ecosystem services received by the United States and those provided by Mexico.

5 DISCUSSION

While conservationists have long focused on the challenge of developing equitable conservation solutions for particular locales or regions, similar inequities also occur across distant spaces. The three migratory species cases we review—pintail ducks, monarch butterflies, and Mexican free-tailed bats—show how equity challenges arise along three axes: between Indigenous peoples and settler colonial societies, between urban and rural populations, and between the Global North and Global South. In these case studies, conservation benefits may accrue primarily to urban and settler colonial societies in the Global North, while Indigenous peoples and rural communities in the Global North and South may find themselves not
only receiving fewer ecosystem service benefits, but also expected to carry the costs of conservation for the benefit of others.

Across the broader international conservation community, one attempt to address such equity challenges has come under the frame of payments for ecosystem services (PES). Although the phrase “ecosystem services” was first coined in 1981 (Ehrlich and Ehrlich), the core concept was hardly new. In 1902, for example, 11 European countries signed the International Convention for the Protection of Birds Useful to Agriculture, which explicitly justified the need for an international agreement on the pest control services provided by migratory birds (Herman, 1907). Then in 1916, Canada and the United States signed the Migratory Bird Treaty, one of the earliest international agreements to identify the importance of management across space for sustaining a migratory species (López-Hoffman, Chester & Merideth, 2017). The treaty explicitly states that “these species are of great value as a source of food or in destroying insects which are injurious to forests and forage plants on the public domain, as well as to agricultural crops, in both the United States and Canada” (see Dorsey, 1998). In a fashion, subsequent efforts by these countries to protect migratory birds—be it by the establishment of protected areas, hunting regulations, or other means—constituted inchoate PES. Thus, although contemporary definitions of PES entail an exchange of direct or indirect monetary value that is paid by and to particular actors, any conservation action (say, the designation of a protected wetland area) accrued costs for which a payment was made with an end goal of protecting ecosystem services.

Regardless of such a broad interpretation, it would take about two decades after the Ehrlichs’ articulation (Ehrlich & Ehrlich, 1981) of ecosystem services before the idea of PES as compensation between specific actors would become widely applied in the biodiversity conservation arena (Ferraro, 2011). Today, the PES landscape is vast; a 2018 survey found 550 PES programs worldwide “with combined annual payments over US$36 billion” (Salzman et al., 2018). Perhaps the most visible of these is the international REDD+ program, which stands for Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests and the enhancement of forest carbon stock. Implemented through various efforts across much of the Global South, the various manifestations of REDD+ constitute “the world’s largest experiment” in PES (Corbera, 2012). Notably, there remains much debate over the effectiveness and equity of PES (Jones et al., 2020; Kaiser et al., 2021).

In each case of the three migratory species we review, our data suggest that not only has a PES not been made, but that a payment (or cost) for conservation has been paid by those who are not receiving the benefit of an associated ecosystem service. In other words, the three above case studies exemplify the potential for inequitable impacts resulting from how conservation is implemented (viz., paid for) across the path of migratory species.

In each of the three North American case studies, an obvious policy remedy would be for those who benefit from the ecosystem services of migratory species to compensate those who bear the costs of conservation. Yet equally obvious are the significant political and economic realities that make any such transfer a challenging societal and political endeavor. Despite such impediments, an example of a conservation funding approach from the first half of the 20th century that remains important to the present day reveals that such compensation systems have long been established in North America. The US Migratory Bird Hunting Stamp Act of 1934, popularly known as the “Duck Stamp Act,” acknowledged the economic value of the ecosystem services provided by migratory birds by creating a mechanism to finance conservation through hunting permit revenues (Trefethen, 1975). Although subject to criticism (see Swope et al., 2000), the Duck Stamp Act has fulfilled a critical role for resourcing the protection of migratory bird habitat throughout North America (Mattsson et al., 2020a), including in Canada and Mexico—a role that, prior to 1934, may have seemed out of reach of US federal lawmakers.

In its implicit acknowledgment of the ecosystem services provided by migratory wildlife across space, the Duck Stamp Act highlights both the capacity of practical governance and funding mechanisms to address particular forms of inequality, as well as the failings of existing approaches. However, by generating funding for conservation from hunters, governmental actors were able to protect flows of provisioning and cultural ecosystem services from rural areas through purchasing habitat or conservation easements from rural landowners or by supporting conservation activities implemented by rural landowners (López-Hoffman, Chester, Semmens, et al., 2017). This approach directly compensates rural landowners for the value of the ecosystem services they provide.

Notably, the Act allows for transfer of some conservation funding across international borders (Mattsson et al., 2020a). However, the proportional distribution of these funds indicates persistent Global North-South inequities. For example, although research has shown that there is critically important waterfowl habitat in Mexico contributing to ecosystem services in the United States and Canada (Rubio-Cisneros et al., 2014), in 2017 approximately US$2 million in Duck Stamp revenues went to all waterfowl conservation activities in Mexico—compared to nearly $19 million in Canada and $40 million in the United States (USFWS, 2018b). Implementation of the Duck Stamp Act also highlights persistent Indigenous-settler colonial inequities inasmuch as the Act has not provided financial
support for Indigenous communities to protect habitat or support provisioning of ecosystem services through traditional management practices (such as through Indigenous Protected and Conserved Areas; see Tran et al., 2020). In this context, an important consideration is the fact that conservation through land purchases or conservation easements may violate Indigenous sovereignty or undermine traditional management by limiting access to lands (Adams & Hutton, 2007).

Ultimately, while mechanisms such as the Duck Stamp constitute an initial template for compensation systems around ecosystems services, both inadequacy of funding and imbalances in the distribution of funding can indicate that compensation systems could be refined to address the challenges of developing equitable conservation solutions across space, be it between rural and urban areas, between Indigenous and non-Indigenous territories, or between the Global North and Global South.

Beyond our three case studies from North America, we suggest that this approach might be extended to inform conservation policies for other migratory species across telecoupled systems. For example, under the 1995 African-Eurasian Waterbird Agreement (https://www.unep-aewa.org), where the 82 country membership is split between African countries (38) and Eurasian countries (44), negotiations have focused on tensions over allowable levels of harvest (or how many birds of a particular species can be taken in the different countries along its migratory route) over the course of the convention’s implementation (see Lewis, 2020 and the agreement’s website, http://www.unep-aewa.org). Application of a spatial subsidies approach in this case, where there is a strong distinction between country parties of the Global North and more resource-dependent country parties of the Global South, could help to assign relative ecosystem service values.

Efforts under the 2002 East Asian-Australasian Flyway Partnership (https://www.eaaflyway.net) also could apply an explicit spatial subsidies approach to migratory pathway conservation. While China’s coastal wetlands provide habitat for more than 240 migratory waterbird species (Zhang & Ouyang, 2019), the steady loss of these ecosystems in the country has “caused a dramatic decline in internationally shared biodiversity and associated ecosystem services” that have been estimated on the order of $US200 billion per year (Ma et al., 2014; Dai et al., 2021).

Finally, the spatial subsidies approach could apply in situations where countries share similar economic circumstances, such as the Greater Serengeti-Mara Ecosystem that crosses the Tanzania-Kenya border. Despite relative congruence at the national level, stakeholders include both an economically influential tourism industry as well as resource-dependent local and Indigenous communities (Veldhuis et al., 2019). By informing these actors of the varying ecosystem service values along the migratory routes, applying a spatial subsidies approach could contribute to clarification of who deserves compensation for bearing the cost of conservation in this world-renowned conservation area.

In conclusion, the spatial subsidies approach incorporates understandings of (1) the full migratory range of the species, (2) quantitative measurements of ecosystem services provided in particular areas within the migratory range, and (3) habitat dependency in particular places within the migratory range. Using these three understandings, a spatial subsidies approach can identify the mismatches between the locations where people may receive the most benefits from the presence and use of migratory species and the locations of habitat that provide the most support for a species’ survival, and provide the necessary data to guide more equitable conservation outcomes.

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