 doi:10.20944/preprints202209.0376.v1

Research

(Un)Sustainable Wildlife Conservation

Robert E. Wright[1]*

[1] AIER 1; Robert.Wright@aier.org
* Correspondence: Robert.Wright@aier.org

Abstract: Wildlife conservation is an important component of environmental sustainability and can be improved by reviewing the performance of its three major models – common pool, top-down regulatory, and private resource -- under varying environmental and socioeconomic conditions. Generally, the private resource model is the most sustainable because it provides the best incentives to balance the needs of humans and wildlife, to maintain general wildlife habitat, and to adapt quickly to changing environmental and/or socioeconomic conditions. Top-down or "command and control" regulation, however, can be employed as a model of last resort if the private resource model shows signs of failing to protect specific species from local extirpation or extinction, which it is most likely to do for migratory species, species with close commercial substitutes, and species with no direct commercial value. Top-down regulators may also be needed to enforce property rights arrangements like catch shares and to monitor resources that remain in the common pool in the event that socioeconomic or environmental conditions change sufficiently to trigger the tragedy of the commons.

Keywords: wildlife conservation; common pool; top-down regulation; private ownership; extinction

1. Introduction

Compelling reasons to conserve wildlife and the habitats in which wild creatures live include direct and indirect commercial, cultural, dietary, ecological, and moral considerations (Chardonnet et al 2002; Wilson, Hayward, and Wilson 2016). Conservation efforts, however, often conflict with the economic costs created by wildlife, which include crop destruction and livestock predation, traffic collisions, and zoonotic disease transmission (Benson 2001; Gren et al 2018). Recent calls for conservation model reform also reveal conflicting interests (Decker et al 2016). Given those competing interests, no consensus on how best to conserve wildlife in a sustainable fashion has yet to emerge (see the special issue of this journal, "Sustainability in Wildlife Management" edited by Sven Herzog).

The goals of this article are to survey the three archetypal ways that humans conserve wild animals, explore their relative costs and benefits, and to suggest a sustainable conservation paradigm meant to make wildlife less likely to be locally extirpated or driven to extinction, or in positive terms to maintain populations above the minimum needed to ensure sufficient genetic diversity [Lande and Barrowclough 1987]), even as environmental (supply) and socioeconomic (demand) conditions change over time and space.

Section 2 reviews the materials and methods while section 3 describes the three conservation models, which represent points on a continuum from no regulation to complete regulation by government or complete ownership by private entities (Lueck 1995b). Section 4 discusses implications by examining historical instances of species extinction and local extirpation under different conservation models and socioeconomic and environmental conditions. The major conclusion, the need for a polycentric approach to wildlife conservation contra the broad top-down principles suggested by others (Decker et al 2016), is summarized in Section 5.

2. Materials and Methods

 doi:10.20944/preprints202209.0376.v1

As described in Barnett-Page and Thomas (2009), the information and insights provided in the source material cited in the references section provide the basis for the results and conclusions. Per Mahoney and Rueschemeyer (2014), it can be replicated by reading the source material from the perspective of standard neoclassical microeconomic theory. No human or animal subjects were directly employed or utilized in its creation.

3. Results

This section describes the three major conservation models: common pool, top-down regulatory (aka command and control), and private resource (Wilson, Edwards, and Byron 2020). It also surveys the conditions under which each model is most likely to conserve wildlife as supply and demand (environmental and socioeconomic) conditions change and assesses the impact of each on wildlife habitat.

3.1. Common Pool

A common pool species is available to any individual or other economic entity (informal community, commercial business [proprietorship, partnership, corporation], nonprofit organization, or government) without limit or payment because no party can restrict access to it in practical terms, or because no property right in the species has been claimed, granted, or assigned (*res nullius*) (Demsetz 1967; Bulte, van Kooten, and Swanson 2003; Wilson, Edwards, and Byron 2020).

When a common pool species is a resource -- i.e., a valuable good instead of a bad, like a disease vector pest (Ribas et al 2016) -- economic entities possess an incentive to exploit the resource before others do, sometimes leading to what Hardin (1968) called the "tragedy of the commons." Despite the incentive to unsustainably exploit (overexploit) a common pool resource, it may persist indefinitely when the economic cost of extracting, transporting, and utilizing or selling the resource exceeds its market price, or the opportunity cost of its harvest by humans (Wright 2022).

Wild rats, for example, are generally considered pests, economic bads that exterminators must be paid to control (Lee et al 2022). Markets for rat fur and especially meat, however, do exist (Doyle 2014), as do markets for live rats for use in scientific experiments. Rats can sustainably remain a common pool resource, however, because their natural rate of reproduction exceeds human demand, in part due to superior domesticated substitutes. Rats domesticated specifically for experimentation, for instance, are more cheaply farmed than wild rats can be caught (Modlinska and Pisula 2020).

More valuable resources can also remain sustainable under the common pool model so long as the quantity harvested remains below the resource's reproduction rate, or in other words when harvests do not exceed the sustainable yield rate (Lueck 1995b). Rabbits, for example, can remain common pool when environmental conditions allow them to reproduce more quickly than low density human populations care to consume them, the marginal cost of harvesting and transporting them to higher density population centers exceeds their market price, and/or rabbit farming provides an alternative source of supply (Zotte 2015).

Note that humans do not compete with prey like rabbits, which will die of disease, accident, nonhuman predation, or a dearth of water or food if not harvested by humans. Humans, though, may compete with specialized rabbit predators like lynx and the Spanish Imperial Eagle (Norbury and Jones 2015). For the sake of competing predators, wildlife managers might decide to remove prey resources from the common pool and place them somewhere along the spectrum of the other two conservation models (Ferrer and Negro 2004).

Intellectual humility, however, suggests that human tinkering should be minimized because ecological systems are too complex to be fully understood. Increasing striped bass populations in Chesapeake Bay, for example, unintentionally depleted blue crab populations already stressed by pollution encouraged by treating the massive estuary as a com-

 doi:10.20944/preprints202209.0376.v1

mon pool environmental sink (Tobias 2009). Although popular notions of a pristine wildness untouched by humans are fanciful and related notions of the existence of natural "balance" elide natural extinctions and mass fluctuations in wildlife populations and range (Egerton 1973; Friskics 2008), deliberate human attempts to "fix" the ecological systems that they have impacted generally create unsustainable outcomes.

The incentive to preserve or improve habitat for a common pool resource is scant because others could easily free ride on any investments by harvesting the resources before the habitat improver does. People may even destroy habitat in the process of harvest. A wild bee colony may be extirpated when raided for its honey, for example, because the harvester knows that another human or nonhuman predator might do so anyway if any honey or wax remains (Tsing 2003).

American Indian groups that burned woods or prairie to hunt deer or bison *improved* habitat by initiating forest or grasslands renewal and reducing the odds of larger and more destructive natural conflagrations (Mellar 1976; Smith 1981; Patterson and Sassaman 1988). They generally did so, however, under top-down regulatory or private resource regimes, not under common pool conditions (Lueck 1995b). In fact, many resources once thought to be common pool were wholly or partially regulated privately or by informal top-down regulations.

Ostrom (2002), for example, shows that communities, especially smaller, more homogeneous ones, imposed informal harvest or use rules that rendered sustainable resources formerly wrongly considered to be common pool. While American Indians sometimes accessed common pool resources in areas not claimed by any tribe, tribal territories were subject to various top-down regulations (Ross and Pickering 2002; Ramos 2021), including taboos against porcupine consumption except in emergencies (Wall 2007, pp. 31-32, 36, 54-55, 78-80). Or, they were divided into territories subject to private individual, family, or clan management, if not always ownership in the modern western sense (Feit 1991; Bobroff 2001).

3.2. Top-Down Regulatory

In top-down regulatory conservation models, like the North American Wildlife Conservation Model (NAWCM), some communal, governmental, or supra-governmental body asserts a weak form of ownership, often described as stewardship, over wildlife resources and then regulates access to them to achieve conservation goals (Wright 2022). Such regulations may include banning resource exploitation entirely, prescribing the methods, times of day, and seasons during which the resource may be harvested, and limiting the size, number, weight, and/or sex of the harvested resource (Lueck 1995b). In the NAWCM, licenses and tags are typically priced below market, with excess demand rationed via lottery (Lane 2018).

Top-down harvest regulations range from extremely loose to extremely tight. In New Jersey, for example, an individual may harvest for personal consumption every day of the year, night and/or day, up to a bushel of blue crabs using hand lines or collapsible traps so long as no crabs smaller than 4.5 inches breadth or females of any size with eggs attached are retained (https://nj.gov/dep/fgw/pdf/non-comm_crabpot_regs.pdf). The regulations can be loose because commercial crabbing and pollution regulations, not regulation of personal consumption, remain key to conserving the species (Tobias 2009). In contrast, a top-down regulator might completely ban the commercial harvest of wild sheep and proclaim that only male mountain sheep with full curl horns may be taken, and only by licensed tagholders, with a vertical bow, in daylight, during a week-long season.

Ideally, wildlife managers implement restrictions to carefully balance human demand for the resource with its biological characteristics and its place in the local ecology. In unpolluted habitat, blue crabs abound so long as juveniles and reproducing females are protected from harvest. Mountain sheep, by contrast, are more biologically sensitive to human harvest rates. Killing old rams, the reason for the full curl stipulation, culls the

 doi:10.20944/preprints202209.0376.v1

biologically least important member of the herd, leaving juveniles, reproductive-age females, and maturing males more food and cover. Happily, the horns that signal advanced age induce hunters to pay thousands USD for the right to try to harvest one (Demarchi 1978). Moreover, most tagholders fail to harvest a ram, which *increases* the allure of the hunt by rendering each full curl ram a highly esteemed "trophy" (Festa-Bianchet et al 2014).

Top-down regulations can be highly effective, but their efficacy may degrade as environmental and socioeconomic conditions change, becoming either too loose, thus endangering wildlife quantity, or too restrictive, thus endangering wildlife quality. Regulations that become too restrictive reduce resource utilization below sustainable yield while threatening, in the absence of natural predators, overpopulation and its attendant costs on humans (more collisions, livestock predation, crop depredation, etc.), other wildlife (forage or prey species), and the resource itself (smaller, less resistant to disease, less resilient in the face of weather and other shocks, etc.). Regulations that become too loose threaten resource depletion. Sometimes top-down regulators respond quickly to changes in a resource's population or in human harvest demand, but other times weak incentives means that their response lags or is insufficient (Wright 2022).

The incentives of top-down regulators to provide habitat also vary widely depending on their incentives. In North America, wildlife managers want people to enjoy camping, fishing, hunting, trapping, and wildlife watching because excise taxes on their equipment, along with use and license fees, pay the salaries of wildlife managers. Managers therefore want wildlife to be abundant and accessible and that may mean providing more quality habitat through prescribed burns, dredging, paying farmers to maintain wetlands, constructing wood duck nesting poles, and so forth (Lueck 1995a; Benson 2001).

In other places, though, wildlife managers receive salaries regardless of habitat quality, or the quantity or quality of wildlife, so more wildlife and more wildlife users simply make more work for them, encouraging wildlife managers to allow, or even abet, habitat destruction (Gren et al 2018).

Public choice theory also suggests that government wildlife managers may put their own interests ahead of those of wildlife and/or the public in other ways as well (Lueck 1995b; Bulte, van Kooten, and Swanson 2003). Feir, Gillezeau, and Jones (2022), for example, show that official U.S. bison policy almost caused bison extinction while reducing the physical stature and overall health of Plains Indians. Similarly, Yonk et al (2021) show that U.S. wild horse management practices hurt local economies while not effectively managing wild horse populations or the local ecological systems they impact. And according to Wright (2022b), NAWCM regulators continue to forbid markets for wild game meat even though legalization could help to reduce the population of locally overabundant species, as such markets long have in Europe.

3.3. Private Resource

In the private resource model, a commercial, nonprofit, or community-based economic entity asserts ownership over the resource, controlling access to it via legal or customary rights (Demsetz 1967). The entity grants access to the resource to its owners or members and/or to outsiders on mutually agreeable terms, which can be in kind and/or in cash, typically at a market clearing price with price discrimination adjustments for youths, women, handicapped veterans, retirees, and so forth (Ven der Merwe, Saayman, and Krugell 2004; Little and Berrens 2008). Examples include hunting clubs, safari ranches, fee fishponds, hunting and fishing concessions and leases, and aquariums, menageries, zoos, wildlife parks, sanctuaries, and other privately-owned wildlife viewing venues (Smith 1981). In the US alone, revenue for such entities, including day access fees and long-term leases, total several billion dollars per year (Wilson, Edwards, and Byron 2020).

Rational economic entities possess strong incentives to conserve any resources they expect to be able to assert ownership rights over in the future, so that the resources are

 doi:10.20944/preprints202209.0376.v1

available for their own future use, or their sale or lease to another economic entity (Bulte, van Kooten, and Swanson 2003). That may mean restricting the resource's movement to the boundaries of the private owner's property via the use of high fences and/or buying land or leasing hunting, fishing, and/or trapping concessions larger than the natural range of the resource (Lueck 1995b).

Great Britain, for example, vests the ownership of wildlife in real estate owners, who often charge extractive users for access rights. Top-down managers set seasons for different species, but property owners set bag limits and charge fines for careless shooting. If caught, trespassers must pay a fee or surrender harvested game, for which there are legal markets, to the property owner, not to government wildlife managers (Lueck 1995b).

A similar private resource approach transformed southern Africa (Botswana, Mozambique, Namibia, South Africa, and Zimbabwe) starting in the 1970s. Landowners there face few top-down restrictions and have learned ways to maximize revenue from their ranches, leading to thriving, diverse, innovative wildlife management practices and business models that include both extractive (hunting) and non-extractive (photo safari) users. In stark contrast to much of the rest of the continent, the region now has more wildlife than a century ago (Wilson, Hayward, and Wilson 2016).

The private resource model works best for wildlife species that do not need to migrate over long distances unless they can be relied upon to return to specific breeding or feeding areas (Thurman 1981; Lueck 1995b). Before the advent of open ocean commercial fishing, for example, American Indian tribes were able to farm salmon by controlling access to their river migration routes and spawning streams (Johnsen 2009), a type of private resource conservation management still used today, primarily for sport fishing, in parts of Europe (Watz et al 2022). Nesting birds like eiders have been similarly sustainably conserved by the owners of their nesting grounds so they can continue to harvest their down and eggs in perpetuity (Smith 1981).

Moreover, it is possible in some places to exercise ownership rights over large territories. Examples include the enormous private reserve called American Prairie (Huffman 2019), African and Canadian trophy hunting concessions (Cooney et al 2017), and cooperative bison ranching in western South Dakota (O'Brien 2014).

Property owners also possess incentives to provide habitat appropriate for the types of wildlife that they own and/or to improve the aesthetics and/or energy or agricultural efficiency of their properties. Regardless of the precise reason for their creation, shelterbelts and other manmade habitat improvements often provide suitable general habitat for a range of wildlife species (Santiago and Rodewald 2004). Trees planted to provide winter browse and cover for deer, for example, will also succor other animals, from songbirds to squirrels and rabbits to raccoons (http://urbanforestrynetwork.org/benefits/wildlife.htm) and may eventually provide the owner with fruit, fuel, or timber.

The incentive to create suitable wildlife habitat decreases to the extent that property owners cannot control access to wildlife. That may be due to weak property rights, especially in states too weak to discourage trespassers but strong enough to limit private enforcement through violence. Or, it may be due to state stewardship of wildlife, as in North America (Benson 2001).

A quasi-natural experiment in the highlands of southern Ethiopia showed that tropical forest cover shrank fastest in a national park and two unoccupied hunting concessions, which *de facto* turned the forest into a common pool resource. Tropical forest cover, though, increased on an active timber concession and an occupied hunting concession because the leaseholders were able to control access to their concessions (Young et al 2020). Another study in Nepal showed that forests effectively controlled by community groups halted and even reversed regional deforestation trends (Nagendra et al 2008).

Where private parties possess insufficient incentive to maintain wildlife habitat, top-down regulators have provided subsidies with some success, though at the risk of creating a political backlash (Santiago and Rodewald 2004). A more sustainable model would in-

 doi:10.20944/preprints202209.0376.v1

duce nonowner private parties to voluntarily pay for habitat maintenance or improvement via ecotourism or direct donation, especially where property rights are strong enough to minimize misuse of donated funds (Ferraro and Kiss 2002; Ferraro and Simpson 2002).

In some jurisdictions, policies create perverse incentives for landowners. Some 35 percent of the world's modern mammal extinctions have occurred in Australia, in part due to top-down policies that encourage native habitat destruction. Reforming those policies to allow for wildlife property rights could stop or reverse habitat destruction, allowing native flora and fauna to expand their range and rendering native species more resilient to shocks (Wilson, Edwards, and Byron 2020). If, after implementation of such reforms, conservation goals remain unmet, governments or nonprofits could directly pay private landowners in Australia, New Zealand, or elsewhere to increase the population of threatened or endangered species on their property, encouraging them to create suitable habitat and to discourage poaching (Wilson, Hayward, and Wilson 2016).

Table 1 summarizes Section 3 by highlighting the conditions in which each major conservation model is most likely to succeed or fail at conserving specific wildlife resources and their respective effects on wildlife habitat.

Table 1. Tabular Summary of Results

Conservation Model	Most Likely to Succeed	Most Likely to Fail	Habitat Externalities
Common pool	Resource is in low demand relative to resupply rate.	Resource is in high demand relative to resupply rate.	None to negative.
Top-down or command and control	Strong incentives and capabilities to conserve wildlife and habitat.	Weak incentives and capabilities to conserve wildlife and habitat.	Varies with the incentives of wildlife managers.
Private resource	Resource can thrive on local range only, or, if migratory, reliably returns to the same breeding or feeding grounds.	Resource thrives only by migrating over a large range encompassing numerous nations or international waters.	Generally positive.

Source: Section 3

4. Discussion

Rapid change in ecological, environmental, and/or socioeconomic conditions threatens wildlife because it disrupts beliefs about sustainable harvest levels, perhaps before human conservation efforts may be able adjust (Lueck 1995b). This section describes several episodes where rapid change led to unsustainable outcomes for wildlife ranging from downward population trends to local extirpation to species extinction.

Extinction remains unsustainable because efforts to revivify extinct species have yet to succeed and face significant controversy and cost (Shultz 2017). Population reductions including local extirpation can be serious, but wildlife can reinhabit areas, with or without human intervention, when favorable conservation, ecological, and/or socioeconomic conditions return (Wilson, Edwards, and Byron 2020). For instance, brown bears naturally repopulated Norway, where they were extirpated, from populations in Sweden, Finland,

 doi:10.20944/preprints202209.0376.v1

and Russia (Swenson et al 1995). In 2022, pine marten returned to London after their extirpation there a century ago, perhaps with direct, informal human assistance but perhaps by spreading from northern population pockets (https://www.theguardian.com/environment/2022/sep/08/pine-marten-spotted-in-london-for-first-time-in-more-than-a-century). Wildlife can also be introduced to entirely new habitats, but at the risk of severe ecological disruption (Mooney and Cleland 2001).

The discussion is divided into five subsections that discuss threats to wildlife due to unintended consequences, intended consequences, insufficient privatization incentives, unexpected biological shocks, and a confluence of negative factors.

4.1. Unintended Consequences

One of the many unintended consequences of Covid-19 lockdowns across much of the globe was a documented increase in poaching in many nations, including Malaysia (Amat and Abdullah 2021), India (Behera et al 2022), Nepal (Koju et al 2021) and several African countries (Cherkaoui et al 2020; Ndlovu, Matipano, and Miliyasi 2021). Top-down regulation of wildlife was particularly fragile in Africa because it was relatively new there, largely implemented two decades ago during a "bushmeat crisis" that threatened the livelihoods of growing numbers of poor agriculturalists and led to increased regulatory attempts (Nasi et al 2008).

Increases in domestic dog and cat populations also threaten wildlife, especially when fragile socioeconomic conditions induce humans to allow their pets to forage for themselves (Khadka 2019).

Attempts to limit livestock herds, ostensibly to combat global climate change, may increase market prices enough to induce more people to harvest wild animals to meet their protein needs (Morais et al 2022). Disruptive climate change reforms may also decrease the ability of states to enforce wildlife regulations, as in Sri Lanka during its 2022 economic depression and political revolution (Mongabay 2022). In fact, poaching typically increases when and where perpetrators are less likely to be caught, or prosecuted if caught, which is typically in low-capacity states, like Zimbabwe during its early Third Millennium hyperinflation (Mapedza and Bond 2006).

In places with stronger rule of law and more effective enforcement, various unanticipated shocks may stress common pool resources and wildlife managed by top-down regulators, especially those with incentives to sell more licenses and tags. The wildlife managers may interpret increased interest in hunting, fishing, and trapping as a revenue boon before fully understanding the potential adverse effects of higher demand on resource populations.

4.2. Intended Consequences

Policymakers in some places may have incentives to talk about conservation and create top-down regulatory regimes that appear to protect wildlife but that condone unsustainable rates of exploitation. That way, they win the support of rural inhabitants who know that despite the law they can kill predators or foragers that endanger their livelihoods and the support of urban inhabitants who do not comprehend the *de facto* details of the *de jure* policies (Smith 1981).

Policymakers may also exploit voter indifference. In North America in the second half of the nineteenth century, bison numbers declined rapidly because policymakers kept them a common pool resource even as the cost of harvesting them plummeted due to the advent of railroads and modern rifles. It is now widely understood that the U.S. government sought the extermination of bison to decrease the economic and military capacity of Plains Indian tribes reluctant to move to Reservations and to create biological space for the domesticated cattle of settlers (Cunfer and Waiser 2016). Bison may have gone extinct if remnant herds had not been privatized, albeit extralegally, and bred with domesticated cattle (Freese et al 2007).

4.3. Insufficient Privatization Incentive

 doi:10.20944/preprints202209.0376.v1

Many species are bred in captivity even when they thrive in the wild, serving as a private "ark" in the face of ecological shocks (Rakes, Shute, and Shute 1999), though at the risk of reducing the genetic fitness or even domesticating the captive population (Lynch and O'Hely 2001; Araki, Cooper, and Blouin 2007). Most species are not bred in captivity but when a species declines in population, each surviving member becomes more valuable, increasing the incentive of economic entities, like zoos, ranchers, or wildlife managers, to privatize and breed them (Balmford, Mace, and Leader-Williams 1996).

When government regulators forbid privatization, or when insufficient economic incentives to privatize a species exists, extinction may result. Such is the case with many smaller animals, especially non-vertebrates, and was the case with the passenger pigeon, which was thought to be insufficiently different commercially from other pigeons and doves to bother saving. Top-down regulation came too little, too late for the little birds, which remained a common pool resource for too long, partly due to pressure from farmers who viewed them as agricultural pests. Although many were shot by hunters, most were taken with huge nets in their nesting grounds. Outlawing that method of harvest alone may have been sufficient to save the species if implemented before its final population collapse (Wright 2022).

4.4. Unexpected Biological Shock

Despite commercial incentives to privatize them, the Carolina parakeet also went extinct. A virus combined with the usual rate of harvest may have led to extinction quickly, before top-down regulators or parties potentially interested in their privatization, who sold their feathers to milliners, could react. Historical accounts (Hedeen 2013) and genomic analysis (Gelabert et al 2020) strongly suggest that, for whatever reason, the population collapsed suddenly, in the western part of its range around 1914 and in the eastern part around 1940 (Burgio et al 2021), rather than decreasing steadily over decades before collapse, as was the case with passenger pigeons and bison.

Historically, humans themselves, or their domesticates or commensals, created biological shocks large enough to extirpate species. The first arrival of humans on oceanic islands like Hawaii and New Zealand, for example, precipitated extinction events due to the tragedy of the commons problem and/or the introduction of invasive species (Diamond 1989; Wilson, Hayward, and Wilson 2016).

4.5. Deadly Confluence of Factors

Cetaceans (whales), especially the larger, slower-reproducing species, also suffered from the tragedy of the commons, high demand for their oils, bones, and blubber, improved technologies/lower harvest costs, and, in the twentieth-century, a largely ineffective top-down supranational regulatory regime. International pressure reduced demand and increased harvest costs enough, however, to allow most species to stabilize and even, in some cases, to rebound. The current equilibrium, however, remains fragile (Reeves 2022).

Note that indigenous whalers did not cause the whale crisis as their demand was too small and their harvest mostly composed of smaller, faster reproducing species. Even the New Bedford sailing whalers of the nineteenth century barely dented most cetacean populations. It was the advent of steam ships, cannon harpoons, and, eventually, factory ships, combined with increased worldwide demand for whale products, that brought whale populations to the brink in the twentieth century (Ottaway 2013).

5. Conclusions

The ability of each major conservation model to adapt to change over time varies. The historical examples discussed in Section 4 and neoclassical economic theory suggest that the private resource model is the one most likely to adapt sufficiently quickly to ensure conservation goals, especially prevention of extinction (Wilson, Hayward, and Wil-

son 2016). The private resource model, however, is not a panacea, especially when a resource has a large, especially international, range and/or a close commercial substitute remains abundant.

Top-down conservation therefore should be retained as a model of last resort, but generally policymakers should encourage the efficient movement of wildlife resources from common pool to private resource when environmental and socioeconomic conditions warrant (Lueck 1995b). At a minimum, that means wildlife regulators need to monitor the quantity and quality of common pool resources and encourage their privatization when demand increases and/or the cost of harvest decreases enough to bring harvest rates up to biological reproduction rates. Inexpensive hunting or trapping by drone, for example, could pressure furbearer populations, many of which are currently so difficult to harvest that they remain lightly regulated or common pool (Wright 2022).

Top-down regulators may also play important roles as coordinators between private resource owners and public resource agencies, like public lands and parks managers, to ensure that their respective programs and efforts do not work at cross purposes. Coordination efforts, however, should remain just that, and not mechanisms for top-down control (Wilson, Edwards, and Byron 2020).

Moreover, top-down regulations may also be the first choice when species ownership cannot be conjoined with territorial holdings. Certain migratory species, however, like salmon, could be privately owned and managed through ownership of their breeding grounds if their harvest could be limited or stopped elsewhere over their range.

In addition, top-down regulators may be needed to create and/or to help enforce transferable "catch shares," a property right to harvest a specified number of a specific resource, so that the creatures covered by such arrangements do not devolve into *de facto* common pool resources subject to the tragedy of the commons (Birkenbach, Smith, and Stefanski 2019). Catch shares aid humans as well as wildlife by decreasing risk taking. They do so by substituting a share of harvest quotas for fixed date seasons that encouraged risky and sometimes environmentally damaging harvest races akin to temporarily returning wildlife to the common pool (Pfeiffer and Gratz 2016). It is important, however, not to allow wildlife managers too much discretion, lest they collude with commercial interests to raise total quotas above sustainable levels, as has happened in some fisheries (Biber and Eagle 2015).

Top-down regulators may also encourage habitat creation and maintenance suitable for non-commercial species (Pouydal and Hodges 2009) on private lands and have increasingly done so to varying degrees in the US (Morgan et al 2019). Again, though, their discretion must be constrained to reduce the chance of unintended consequences (Dominick 1998). Generally, reducing human harms, like pollution, poses less risk/is more sustainable than trying to micromanage complex ecological systems (Jackson 1992).

References

Amat, R. and Abdullah, M.T. Response to Challenges in Curbing Selected Wildlife Poaching During COVID-19 Lockdown. *J. of Sust. Sci. & Mgmt.* **2021**, *16*: 1-4.

Araki, H., Cooper, B., and Blouin, M.S. Genetic Effects of Captive Breeding Cause a Rapid, Cumulative Fitness Decline in the Wild. *Sci.* **2007**, *318*: 100-103.

Balmford, A., Mace, G.M., and Leader-Williams, N. Designing the Ark: Setting Priorities for Captive Breeding. *Cons. Biol.* **1996**, *10*: 719-27.

Barnett-Page, E., and Thomas, J. Methods for the Synthesis of Qualitative Research: A Critical Review. *BMC Med. Res. Methodol.* **2009**, *9*, https://10.1186/1471-2288-9-59

Behera, A.K. et al. The Impacts of COVID-19 Lockdown on Wildlife in Deccan Plateau, India. Sci. of the Total Environ. **2022**, *822*: https://doi.org/10.1016/j.scitotenv.2022.153268

Benson, D.E. Wildlife and Recreation Management on Private Lands in the United States. Wild. Soc. Bull. **2001**, *29*: 359-71.

Biber, E. and Eagle, J. When Does Legal Flexibility Work in Environmental Law? *Ecol. Law Qtly.* **2015**, *42*: 787-840.

Birkenbach, A.M., Smith, M.D., and Stefanski, S. Taking Stock of Catch Shares: Lessons from the Past and Directions for the Future. *Rev. of Environ. Econ. & Pol.* **2019**, *13*: https://www.journals.uchicago.edu/doi/full/10.1093/reep/rey016.

Bobroff, K.H. Retelling Allotment: Indian Property Rights and the Myth of Common Ownership. *Vand. Law Rev.* **2001**, *54*: 1,560-1,623.

Bulte, E.H., Van Kooten, G.C., and Swanson, T. Economic Incentives and Wildlife Conservation. 2003.

Burgio, K.R. The Two Extinctions of the Carolina Parakeet Conuropsis carolinensis. *Bird Cons. Intern.* **2021**, *32*: https://www.cambridge.org/core/journals/bird-conservation-international/article/abs/two-extinctions-of-the-carolina-parakeet-conuropsis-carolinensis/402E120779F8760E4A95B82E0181805B

Chardonnet, P. et al. The Value of Wildlife. *Rev. Sci. Tech. Off. Int. Epiz.* 2002, 21: 15-51.

Cherkaoui, S. et al. Conservation Amid COVID-19 Pandemic: Ecotourism Collapse Threatens Communities and Wildlife in Morocco. *E3S Web Conf.* **2020**, *183*: https://doi.org/10.1051/e3sconf/202018301003.

Cooney, R. et al. The Baby and the Bathwater: Trophy Hunting, Conservation and Rural Livelihoods. *Unasylva: Inter. J. of Forestry and Forest Ind.* **2017**, *68*: 3-16.

Cunfer, G. and Waiser, B., eds. *Bison and People on the North American Great Plains*, 1st ed. College Station, TX, USA: Texas A&M Press, 2016.

Decker, D. et al. Governance Principles for Wildlife Conservation in the 21st Century. Cons. Lttrs.: J. Soc. Cons. Bio. **2016**, *9*: 290-95.

Demarchi, R.A. Evolution of Mountain Sheep Horn Curl Regulations in British Columbia. B.C. Fish and Wildlife Branch, Cranbrook, B.C., Canada, 1978.

Demsetz, H. Toward a Theory of Property Rights. *Amer. Econ. Rev.* **1967**, *57*: 347-59.

Diamond, J.M. The Present, Past and Future of Human-caused Extinctions. *Phil. Trans. Royal Soc. Bio. Sci.* **1989**, *325*: https://doi.org/10.1098/rstb.1989.0100.

Dominick, R. Capitalism, Communism, and Environmental Protection: Lessons from the German Experience. *Environ. Hist.* **1998**, *3*: https://doi.org/10.2307/3985182.

Doyle, K. Cambodian Rat Meat: A Growing Export Market. *BBC News* **2014**, https://www.bbc.com/news/world-asia-28863315

Egerton, F.N. Changing Concepts of the Balance of Nature. *Q. Rev. of Biol.* **1973**, *48*: https://doi.org/10.1086/407594.

Feit, H.A. The Construction of Algonquian Hunting Territories: Private Property as Moral Lesson, Policy Advocacy, and Ethnographic Error. In *Colonial Situations: Essays on the Contextualization of Ethnographic Knowledge*, 1st ed.; Stocking, G.W., Ed.; University of Wisconsin Press, Madison, WI, USA, 1991.

Feir, D.L., Gillezeau, R., and Jones, M.E.C. The Slaughter of the Bison and Reversal of Fortunes on the Great Plains. Bonn, Germany: Institute of Labor Economics, 2022.

Ferraro, P. and Kiss A. Direct Payments to Conserve Biodiversity. *Science* **2002**, *298*:1,718-19. https://doi.org/10.1126/science.1078104

Ferraro, P.J. and Simpson R.D. The Cost-Effectiveness of Conservation Payments. *Land Econ* **2002**, *78*:339-53. **doi: 10.2307/3146894**

Ferrer, M. and Negro, J.J. The Near Extinction of Two Large European Predators: Super Specialists Pay a Price. *Cons. Bio.* **2004**, *18*: 344-49.

Festa-Bianchet, M. Decrease in Horn Size and Increase in Age of Trophy Sheep in Alberta Over 37 Years. *J. Wild Mgmt.* **2014**, *78*: http://dx.doi.org/10.1002/jwmg.644.

Freese, C.H. et al. Second Chance for the Plains Bison. *Biol. Cons.* **2007**, *136*: 175-84.

Friskics, S. The Twofold Myth of Pristine Wilderness. *Environ. Eth.* **2008**, *30*: 381-99.

Gelabert, P. et al. Evolutionary History, Genomic Adaptation to Toxic Diet, and Extinctionof the Carolina Parakeet. *Curr. Bio.* **2020**, *30*: 108-114.

Gren, I.M. et al. Economics of Wildlife Management – An Overview. *Eur. J. of Wild. Rsch.* **2018**, *64*: https://link.springer.com/journal/10344

Hardin, G. The Tragedy of the Commons. *Science* **1968**, *162*, 1,243-48.

Hedeen, S.E. The Carolina Parakeet Vanishes: Extinction of the Ohio Valley's Only Parrot. *Ohio Valley History* **2013**, *13*: 3-21.

Huffman, J.L. American Prairie Reserve: Protecting Wildlife Habitat on a Grand Scale. *Nat. Resources J.* **2019**, *59*: 35-58.

Jackson, J.M. Grazing Rights: Time for a New Outlook. *Nat. Resources J.* **1992**, *32*: 623-31.

Johnsen, D.B. Salmon, Science, and Reciprocity on the Northwest Coast. *J. Ecol & Soc.* **2009**, *14*: http://www.ecologyandsociety.org/vol14/iss2/art43/.

Khadka, N.S. Dogs "Becoming Major Threat" to Wildlife. *BBC News* 12 Feb. **2019**: https://www.bbc.com/news/science-environment-47062959.

Koju, N.P. et al. COVID-19 Lockdown Frees Wildlife to Roam But Increases Poaching Threats in Nepal. *Ecol. & Evol.* **2021**, *11*: 9,198-9,205.

Lande, R. and Barrowclough, G.F. Effective Population Size, Genetic Variation, and Their Use in Population Management. In Soule, M.E., ed. *Viable Populations for Conservation*. New York: Cambridge University Press, 1987, 87-124.

Lane, B. Hunters Like Skewness, Not Risk: Evidence of Gambling Behaviors in the Alaska Hunting Permit Lottery. MS Thesis, University of Alaska, Fairbanks, 2018.

Lee, M.J. Reconsidering the "War on Rats": What We Know from Over a Century of Research into Municipal Rat Management. *Front. Ecol. Evol.* 2022: https://doi.org/10.3389/fevo.2022.813600

Little, J.M. and Berrens, R.P. The Southwestern Market for Big-Game Hunting Permits and Services: A Hedonic Pricing Analysis. *Hum. Dim. Wildlife* **2008**, *13*: 143-57.

Lueck, D.L. The Economic Organization of Wildlife Institutions. In *Wildlife in the Marketplace: The Political Economy Forum*, 1st ed.; Anderson, T.L. and Hill, P.J., Eds.; Rowman and Littlefield, New York, USA, 1995a.

Lueck, D.L. Property Rights and the Economic Logic of Wildlife Institutions. Nat. Res. J. **1995b**, *35*: 625-70.

Lynch, M. and O'Hely, Captive Breeding and the Genetic Fitness of Natural Populations. *M. Cons. Gen.* **2001**, *2*: 363-78.

Mahoney, J. and Rueschemeyer, D. eds. *Comparative Historical Analysis in the Social Sciences*, 1st ed. Cambridge University Press: Cambridge, UK, 2014.

Mapedza, E. and Bond, I. Political Deadlock and Devolved Wildlife Management in Zimbabwe: The Case of Nenyunga Ward. *J. Environ. & Dev.* **2006**, *15*: https://doi.org/10.1177%2F1070496506294635

Mellars, P. Fire Ecology, Animal Populations and Man: A Study of Some Ecological Relationships in Prehistory. *Proceedings of the Prehistoric Society* **1976**, *42*: 15-45.

Modlinska, K. and Pisula W. The Natural History of Model Organisms: The Norway Rat, from an Obnoxious Pest to a Laboratory Pet. *eLife* 2020: https://doi.org/10.7554/eLife.50651

Mongabay. Sri Lanka Fuel Shortage Takes Massive Toll on Efforts to Save Wildlife. *EastMojo*, 23 Aug. **2022**: https://www.eastmojo.com/world/2022/08/23/sri-lanka-fuel-shortage-takes-massive-toll-on-efforts-to-save-wildlife/.

Mooney, H.A. and E.E. Cleland. The Evolutionary Impact of Invasive Species. *PNAS* **2001**, *98*: 5,446-51.

Morais, B.H. et al. Use of Wildlife as an Alternative Protein Source: Collared Peccary Meat. *Meat Sci.* **2022**, *192*: https://doi.org/10.1016/j.meatsci.2022.108895

Morgan, J.J. et al. A State Assessment of Private Lands Wildlife Conservation in the United States. *Wild. Soc. Bull.* **2019**, *43*: 328-37.

Nagenda, H. et al. Forest Fragmentation and Regrowth in an Institutional Mosaic of Community, Government and Private Ownership in Nepal. *Land. Ecol.* **2008**, *23*: https://link.springer.com/article/10.1007/s10980-007-9162-y.

Nasi, R. et al. *Conservation and Use of Wildlife-Based Resources: The Bushmeat Crisis*, 1st ed. Convention on Biological Diversity: Montreal, CAN, 2008.

Ndlovu, M., Matipano, G., and Milyasi, R. An Analysis of the Effect of COVID-19 Pandemic on Wildlife Protection in Protected Areas of Zimbabwe in 2020. *Sci. Afr.* **2021**, *14*: https://doi.org/10.1016/j.sciaf.2021.e01031

Norbury, G. and Jones, C. Pests Controlling Pests: Does Predator Control Lead to Greater European Rabbit Abundance in Australasia? *Mammal Review* **2015**, *45*: 79-87.

O'Brien, Dan. *Wild Idea: Buffalo and Family in a Difficult Land*. University of Nebraska Press: Lincoln, NE, USA, 2014.

Ottoway, A. *Commercial Whaling: The Global Guide to Animal Protection*. University of Illinois Press: Urbana, IL, USA, 2013.

Ostrom, E. Common-pool Resources and Institutions: Toward a Revised Theory. In *Handbook of Agricultural Economics*, 1st ed.; Gardner, B. L. and Rausser, G.C., Eds.; Elsevier: New York, USA, 2002, Vol. 2, Part A, pp. 1,315-39.

Patterson, W.A. and Sassaman, K.E. Indian Fires in the Prehistory of New England. In *Holocene Human Ecology in Northeastern North America*, 1st ed.; Nicholas, G.P., Ed.; Springer, Boston, Mass., USA, pp. 107-35.

Pfeiffer, L., Gratz, T. The Effect of Rights-based Fisheries Management on Risk Taking and Fishing Safety. *PNAS* **2016**, *113*: 2,615-20.

Pouydal, N.C. and Hodges, D.C. Factors Influencing Landowner Interest in Managing Wildlife and Avian Habitat on Private Forestland. *Hum. Dim. Wild.: Intl. J.* **2009**, *14*: 240-50.

Rakes, P.L., Shute, J.R., and Shute, P.W. Reproductive Behavior, Captive Breeding, and Restoration Ecology of Endangered Fishes. *Envir. Biol. Fishes* **1999**, *55*: 31-42.

Ramos, S.C. Understanding Yurok Traditional Ecological Knowledge and Wildlife Management. *J. Wild. Mgmt.* **2022**, *86*: https://doi.org/10.1002/jwmg.22140

Reeves, R.R. Cetacean Conservation and Management Strategies. In *Marine Mammals: The Evolving Human Factor*, 1st ed.; Sciara G.N. and Wursig, B. Eds., New York, USA: Springer, 2022, pp. 1-30.

Ribas, A. et al. Rodents as a Source of *Salmonella* Contamination in Wet Markets in Thailand. *Vector Borne and Zoonotic Diseases* **2016**, *16*: 537-40.

Ross, A. and Pickering, K. The Politics of Reintegrating Australian Aboriginal and American Indian Indigenous Knowledge into Resource Management: The Dynamics of Resource Appropriation and Cultural Revival. *Hum. Ecol.* **2002**, *30*: 187-214.

Santiago, M.J. and Rodewald, A.D. The Benefits of Managing Your Property for Wildlife. Ohio State University Extension: Columbus, OH, USA, 2004.

Shultz, David. Bringing Extinct Species Back from the Deade Could Hurt – Not Help – Conservation Efforts. *Sci.* 27 Feb. **2017**: https://www.science.org/content/article/bringing-extinct-species-back-dead-could-hurt-not-help-conservation-efforts

Smith, R.J. Resolving the Tragedy of the Commons by Creating Private Property Rights in Wildlife. *Cato J.* **1981**, *1*: 439-68.

Swenson, J.E. et al. The Near Extinction and Recovery of Brown Bears in Scandinavia in Relation to the Bear Management Policies of Norway and Sweden. *Wild. Bio. A Journal for Wild. Sci.* **1995**, *1*: 11-25.

Tobias, C.W. The Tragedy of the Commons: The Case of the Blue Crab. *So. Cal. Interdiscip. Law J.* **2009**, *19*: 73-.

Thurman, W.N. "Resolving the Tragedy of the Commons": A Comment. *Cato J.* **1981**, *1*: 469-71.

Tsing, A.L. Cultivating the Wild: Honey-Hunting and Forest Management in Southeast Kalimantan. In *Culture and the Question of Rights: Forests, Coasts, and Seas in Southeast Asia*, 1st ed.; Zerner, C. Ed. Duke University Press: Durham, NC, USA, 2003, 24-55.

Van der Merwe, P., Saayman, M., and Krugell, W. Factors That Determine the Price of Game. *Koedoe* **2004**, *47*: https://koedoe.co.za/index.php/koedoe/article/view/86.

Wall, M. Porcupines … in the First Nations Communities of Black River and Hollow Water: Using Traditional Knowledge of Wildlife in Sustainable Forest Management. University of Manitoba, Master of Environment, **2007**.

Watz, J. et al. Atlantic Salmon in Regulated Rivers: Understanding River Management Through the Ecosystem Services Lens. *Fish and Fish*. **2022**, *23*: 478-91.

Wilson, G., Edwards, M., and Byron, N. Custodianship of Wildlife on Private Land to Support Conservation – An Australian Model. Rangeland J. **2020**, *42*: 309-21.

Wilson, G., Hayward, M.W., and Wilson, C. Market-based Incentives and Private Ownership of Wildlife to Remedy Shortfalls in Government Funding for Conservation. *Con. Ltrs. J. of Soc. For Cons. Bio.* **2017**, *10*: 485-92.

Wright, R.E. *The History and Evolution of the North American Wildlife Conservation Model*, 1st ed. Palgrave MacMillan: Cham, Switzerland, 2022.

Wright, R.E. The Political Economy of Modern Wildlife Management: How Commercialization Could Reduce Game Overabundance. *Ind. Rev. Jour. Pol. Econ.* **2022b**, *26*: 513-32.

Yonk, R. et al. Understanding the Economic Impact of Wild Horse Management on Local Communities. Center for the Study of Public Choice and Private Enterprise, 2021: https://www.ndsu.edu/centers/pcpe/research/publications/understanding_the_economic_impact_of_wild_horse_management_on_local_communities/.

Young, N.E. et al. Twenty-three Years of Forest Cover Change in Protected Areas Under Different Governance Strategies: A Case Study from Ethiopia's Southern Highlands. *Land Use Pol.* **2020**, *91*: https://doi.org/10.1016/j.landusepol.2019.104426

Zotte, A.D. Rabbit Farming for Meat Purposes. *Animal Front.* **2015**, *4*:62-67. doi: 10.2527/af2014-0035