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Improving Sustainability by Privatizing Wildlife Conservation

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Abstract

The purpose of this study is to improve environmental sustainability by identifying the most sustainable/least fragile of the three major wildlife conservation access models—open, government, and private—under varying environmental and socioeconomic conditions. The private access model is the most sustainable of the three major conservation models because it provides the best information and incentives to balance the needs of humans and wildlife, maintain general wildlife habitat, and adapt quickly to changing environmental and/or socioeconomic conditions. Government-controlled access, however, can be employed as a model of last resort if the private access 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. Government regulators may also be needed to enforce property rights arrangements like catch shares and to monitor resources that remain open access in case socioeconomic or environmental conditions change sufficiently to trigger the tragedy of the commons. Most treatments of wildlife regulation default to various iterations of the government access model and fail even to consider the costs and benefits of private and open access models. The analysis here instead shows the conditions in which each conservation access model is most appropriate: open when a resource is in high supply and low demand, private most of the time, and government when the others fail to slow resource depopulation/depletion.

Keywords

Wildlife Conservation, Open Access Conservation Model, Government Access Conservation Model, Private Access Conservation Model, Extinction, Extirpation, Incentives, Information, Habitat, Sustainability

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 [1] [2]. 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 [3] [4]. Recent calls for conservation model reform also reveal conflicting economic interests [5]. Given those competing interests, no consensus on how best to conserve wildlife in a sustainable fashion has yet to emerge, but the default in many countries remains some sort of government regulation.

The purpose of this article is to survey the three archetypal ways that humans conserve wild animals through access control, explore their relative costs and benefits, and suggest a sustainable conservation access 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, even as environmental (supply) and socioeconomic (demand) conditions change over time and space [6] [7].

No human or animal subjects were directly employed or utilized in this research because the methodology employed is synthetic and narrative. As described in [8], the information and insights provided in the source material cited in the references section provide the basis for the conclusions. Per [9], it can be replicated by reading the source material from the perspective of standard neoclassical microeconomic theory. Those employing different "mental maps" may not find the findings conclusive, but they should not be able to definitively refute the major claims [10].

Section 2 describes the three major models, which represent points on a continuum from open access (no regulation) to complete regulation by the government to complete ownership by private entities [11]. Section 3 examines historical instances of species extinction and local extirpation under different access models and socioeconomic and environmental conditions.

The major finding is that, contra the broad top-down principles suggested by others [5], a predominantly private access approach will improve the sustainability of wildlife conservation. Policymakers truly interested in saving wildlife resources now, and for the foreseeable future, should empower entrepreneurs to pursue wildlife-related enterprises, not shackle them.

2. Wildlife Conservation Access Models

Following [10], this section tries to escape "habitual modes of thought and expression" by describing wildlife conservation from the perspective of access, or in other words, who or what asserts the right to control consumptive access to wildlife. In other words, it differentiates between "recreational" hunting, fishing, trapping, and gathering based on an economic analysis of who controls access to natural resources [12].

Three major conservation access models exist: open access (sometimes called common pool), government access (sometimes referred to as top-down regulatory or command and control), and private access, which includes a wide range of economic entities from commercial organizations (proprietorships, partnerships, corporations) to mutuals to nonprofits to co-operatives [13] [14]. Properly understood, the three access models are distinct, though more than one may operate in specific instances. They resemble, but differ from, schema that stresses "ownership" or rulemaking in the tradition of the Bloomington School of Political Economy.

The focus on control of consumptive access to wildlife allows for clearer characterization of the incentives and ability (informational but also physical capacity) to sustainably regulate wildlife and to ascertain the conditions under which each access model is most likely to conserve wildlife and wildlife habitat as supply and demand (environmental and socioeconomic) conditions change.

2.1. Open Access

An open access 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*) [14] [15] [16]. Appropriators secure property rights in the resource only upon its harvest or capture [17]. Open access was the original, natural conservation access model and remains the default [10].

When an open access common pool species is a resource—*i.e.*, a valuable good instead of a bad, like a disease vector pest [18]—economic entities may possess an incentive to exploit the resource before others do, leading to what [19] called the "tragedy of the commons." Despite the incentive to unsustainably exploit (overexploit) an open access 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 [7].

Wild rats, for example, are considered pests, economic bads that exterminators must be paid to control [20]. Markets for rat fur and especially meat, however, do exist [21], as do markets for live rats for use in scientific experiments. Rats can sustainably remain an open access 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 (private access) than wild rats can be caught [22].

More valuable resources can also remain sustainable under the open access 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 [11]. Rabbits, for example, can remain open access (unregulated and unowned) 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 (*i.e.*, a supply of private access rabbits) provides an alternative source of supply [23].

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 [24]. For the sake of competing predators, government or private wildlife managers might decide to restrict access to prey resources by placing them somewhere along the spectrum of the other two conservation access models [25].

Intellectual humility, however, suggests that human tinkering should be minimized because ecological systems are too complex, in the sense of [26], 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 common pool environmental sink [27]. 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 [28] [29], deliberate human attempts to "fix" the ecological systems that they have impacted create unsustainable or "fragile" outcomes [30].

Information acquisition regarding open access resources is restricted only by natural limits, *i.e.*, opportunity cost and the nature of the resource and its environment. Anyone who wishes, for example, could try to determine the quantity or quality of open access rabbits or rats. The incentive to do so, however, is weak because anyone at any time could harvest a substantial amount of the open access resource without any legal or moral obligation to give notice.

The incentive to preserve or improve habitat for an open access common pool resource is also scant because others could easily free ride on any investments by harvesting the resource before the habitat improver does [17]. Appropriators may even destroy habitats in the process of harvest. A wild bee colony may be extirpated when raided for its honey, for example, because the appropriator knows that another human or nonhuman predator might harvest any remaining honey or wax [31].

American Indian groups that burned woods or prairie to hunt deer or bison *improved* habitat by initiating forest or grassland renewal and reducing the odds of larger and more destructive natural conflagrations [32] [33] [34]. They did so, however, under government (tribal) or private resource access regimes, not under open access common pool conditions [11]. In fact, as discussed in greater detail in below, many resources once thought to be open access common pool were in fact wholly or partially regulated privately, under various informal ar-

rangements.

Reference [35], for example, shows that communities, especially small, homogeneous ones relative to modern states, imposed informal harvest or use rules that rendered sustainable resources formerly wrongly considered to be open access common pool. While American Indians sometimes harvested open access resources in areas not claimed by any tribe, tribal territories were subject to various top-down regulations [36] [37], including taboos against porcupine consumption except in emergencies [38]. Or, they were subdivided into smaller territories subject to private individual, family, or clan management, if not always "ownership" in the modern western sense [39] [40].

2.2. Government Access

In top-down regulatory conservation models, like the North American Wildlife Conservation Model (NAWCM), some local, national, or supra-governmental body asserts a weak form of ownership, often described as stewardship, over wildlife resources and then regulates access to them, ostensibly to achieve conservation goals [41]. 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 [11]. In the NAWCM, licenses and tags are typically priced below market, with excess demand rationed via lottery [42].

Government 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 in breadth or females of any size with eggs attached are retained. The regulations can be loose because commercial crabbing and pollution regulations, not regulation of personal consumption, remain key to conserving the species [27]. At the other extreme, a government wildlife manager 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, government 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 habitats, 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 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 of USD for the right to try to harvest one [43]. 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" [44].

Government access 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 government wildlife managers respond quickly to changes in a resource's population or in human harvest demand, but other times weak incentives mean that their response lags or is insufficient [41].

Moreover, in places with strong property rights and mostly privately-owned land or water, government wildlife managers cannot easily obtain information about changes in a resource population. In South Dakota, for example, government wildlife managers contract with rural postal carriers to conduct counts of pheasant broods spotted on backcountry dirt roads because they cannot easily conduct a pheasant census on private farmland [45].

The incentive and information problems facing government wildlife managers are important constraints on their ability to set access regulations that are neither too tight nor too loose. Moreover, government access regulations often cover large swathes of territory, rendering any mistakes widespread and potentially quite biologically costly [26].

The incentives of top-down regulators to provide habitat also vary widely. In North America, government 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 [3] [46].

In other places, though, government 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 [4].

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 [7] [11] [16] [47]. Reference [48], for example, shows that official U.S. bison policy almost caused bison extinction while reducing the physical stature and overall health of Plains Indians. Similarly, [49] shows that U.S. wild horse management practices hurt local economies while not effectively managing wild horse populations or the local ecological systems they impact. According to [50], 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.

2.3. Private Access

In the private access model, a commercial, nonprofit, or community-based economic entity asserts ownership over the resource, controlling access to it via legal or customary rights [15]. 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 [51] [52]. 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 [33]. In the US alone, revenue for such entities, including day access fees and long-term leases, total several billion dollars per year [14].

Many informal arrangements are included in the private access model as defined herein, even arrangements some consider examples of a "closed access common pool" conservation model because they are not outwardly commercial in nature. Wildlife resources in those situations are closed (*i.e.*, not open) access because access is controlled through ownership in common. Ownership in common is often conflated with common pool and hence open access, but it is really a form of joint *ownership*, though, unlike in a corporation, without transfer rights. Icelandic sheep ranchers, for example, limited the number of sheep that each could graze on the summer ranges that they owned in common, establishing informal grazing rights that members could exercise but not sell to outsiders [17].

While some of the entities exerting similar access controls may have some of the characteristics of government, they are typically intimately governed, like a local government but also like a nonprofit. They should be considered private entities rather than governmental whenever membership is voluntary, and all members are impacted by access management decisions [13]. As [7] (p. 31) put it: "the appropriators themselves… find ways to organize themselves," much like a co-op or employee-owned business. And as [10] claims (p. 52), "private property pertains to actions that people undertake because they choose to, and about which the remainder of society forbears from contesting."

In the governmental access model discussed above, by contrast, participation is compulsory [53] and the decision-making units are often much larger, such that many members/citizens have little or no stake in access decisions, exacerbating the principal-agent costs discussed above and by [7] and others. In the private access model, entities making access decisions face relatively low agency costs, a concept often characterized by non-economists as high levels of "trust," as in [54]. The low agency costs/high trust render the entities more likely to monitor access outcomes relatively frequently and carefully, to update their

access decisions when appropriate, and more generally to behave rationally.

Rational economic entities possess strong incentives to conserve any goods, including wildlife resources, they expect to be able to assert ownership rights in the future, so that the goods are available for their own future use, or their sale or lease to another economic entity [16] [17]. That may mean creating quality information about the resource's quality and quantity. It may also 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 [11].

Great Britain, for example, vests the ownership of wildlife in real estate owners, who often charge extractive users for access rights. Government wildlife 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 [11].

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 consumptive (hunting) and non-extractive (photo safari) users. In stark contrast to much of the rest of the continent, which employs mostly open access or low-quality government access models, the region now has more wildlife than a century ago [2].

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 [11] [55]. 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 [56], a type of private resource conservation management still used today, primarily for sport fishing, in parts of Europe [57]. Similarly, nesting birds like eiders have been sustainably conserved by the owners of their nesting grounds so they can continue to harvest their down and eggs in perpetuity [33].

Moreover, it is possible in some places to exercise ownership rights over large territories. Examples include the enormous private reserve called American Prairie [58], African and Canadian trophy hunting concessions [59], and cooperative bison ranching in western South Dakota [60].

Property owners also possess incentives to provide habitats 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 human-created habitat improvements often provide suitable general habitats for a range of wildlife species [61]. Trees planted to provide winter browse and cover for deer, for example, will also suc-

cor other animals, from songbirds to squirrels and rabbits to raccoons 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 nations 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 [3].

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 an open access 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 [62]. Another study in Nepal showed that forests effectively controlled by private community groups halted and even reversed regional deforestation trends [63].

Where private parties possess insufficient incentive to maintain wildlife habitat, government wildlife managers have provided subsidies with some success, though at the risk of creating a political backlash [61]. A more sustainable model would induce 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 [64] [65].

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 regulations that encourage native habitat destruction. Reforming those policies to allow for property rights in wildlife could stop or reverse habitat destruction, allowing native flora and fauna to expand their range and rendering native species more resilient to shocks [14]. 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 [2].

Table 1 summarizes this section 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.

3. Causes of Wildlife Conservation Unsustainability

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 to adjust [11]. 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. All unsustainable events occurred due to open access or government access models, though instances, where the private access model failed to rescue endangered species, are also noted.

Table 1. Comparison of the strengths and weaknesses of the three major wildlife conservation models.

Conservation Model	Most Likely to Succeed	Most Likely to Fail	Habitat Externalities
Open Access	Resource is in low demand relative to resupply rate.	Resource is in high demand relative to resupply rate.	None to negative.
Government Access	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 Access	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 and when lacking may be subsidized by government or volunteers.

Extinction remains unsustainable because efforts to revivify extinct species have yet to succeed and face significant controversy and cost [66]. 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 [14]. For instance, brown bears naturally repopulated Norway, where they were extirpated, from populations in Sweden, Finland, and Russia [67]. 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 [68]. Wildlife can also be introduced to entirely new habitats, but at the risk of severe ecological disruption [69]. The discussion is divided into six subsections that discuss threats to wildlife due to unintended consequences, intended consequences, insufficient privatization incentives, unexpected biological shocks, and a confluence of negative factors. It concludes with a discussion of the continuing need for government wildlife management under certain conditions.

3.1. 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 [70], India [71], Nepal [72] and several African countries [73] [74]. Top-down regulation of wildlife was particularly fragile in Africa because it was new there, largely implemented around the turn of the new millennium during a "bushmeat crisis" that threatened the livelihoods of growing numbers of poor agriculturalists and led to increased top-down regulatory attempts [75].

Increases in the domestic dog and cat populations also threaten wildlife, espe-

cially when fragile socioeconomic conditions induce humans to allow their pets to forage for themselves [76].

Attempts to limit livestock herds, to combat global climate change, may increase market prices enough to induce more people to harvest wild animals to meet their protein and fat needs [77]. Disruptive climate change reforms may also decrease the ability of states to enforce wildlife regulations and increase incentives to contest government access rules [47], as in Sri Lanka during its 2022 economic depression and political revolution [78]. In fact, poaching typically increases when and where perpetrators are less likely to be caught, or to be prosecuted if caught, which is typically in low-capacity states, like Zimbabwe during its early Third Millennium hyperinflation [79].

In places with stronger rule of law and more effective enforcement, various unanticipated shocks may stress open access resources and wildlife managed by government 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.

3.2. Intended Consequences

Policymakers in some places may have incentives to talk about sustainability and to create government access conservation regimes that appear to protect wildlife but that condone unsustainable rates of exploitation. That way, they win the support of both rural inhabitants who know that despite the law they can kill predators or foragers that endanger their livelihoods and urban inhabitants who do not comprehend the *de facto* details of the *de jure* policies [33].

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 an open access 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 [80]. Bison may have gone extinct if remnant herds had not been privatized, albeit extralegally, and bred with domesticated cattle [81].

3.3. Insufficient Privatization Incentive

Many species are bred in captivity even when they thrive in the wild, serving as a private "ark" in the face of ecological shocks [82], though at the risk of reducing the genetic fitness or even domesticating the captive population [83] [84]. 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 government wildlife managers, to privatize and breed them [85].

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. Government access regulation came too little, too late for the little birds, which remained an open access 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 [41].

3.4. 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 government wildlife managers or parties potentially interested in their privatization, who sold their feathers to milliners, could react. Historical accounts [86] and genomic analysis [87] 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 [88], 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 [14] [89].

3.5. 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, an 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 [90].

Note that indigenous whalers did not cause the whale crisis as their demand was too small and their harvest was 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, which brought whale populations to the brink in the twentieth century [91].

3.6. Role of Government

Although government access has led to more species extirpations and extinctions than private access has, top-down government access conservation regulation might be retained as an access model of last resort. Policymakers, though, need to face limits on their power. They should, for example, encourage the efficient movement of wildlife resources from open to private access when environmental and socioeconomic conditions warrant [11], like during wars, pandemics, or other periods of extreme socioeconomic disruption. At a minimum, that means government wildlife regulators need to monitor the quantity and quality of open access 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 remote furbearer populations, many of which are currently so difficult to harvest that they remain open access or lightly regulated by government wildlife managers [41].

Government 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 government control of access [14].

Moreover, government access may also be the least bad 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 or lifecycle.

In addition, government wildlife managers 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* open access resources subject to the tragedy of the commons [92]. Catch shares aid humans as well as wildlife by decreasing risk taking [17]. They do so by substituting a share of harvest quotas for fixed date seasons that encourage risky and sometimes environmentally damaging harvest races akin to temporarily returning wildlife to the open access common pool [93]. It is important, however, not to allow government wildlife managers too much discretion, lest they collude with commercial interests to raise total quotas above sustainable levels, as has happened in some fisheries [94].

Government wildlife managers may also encourage habitat creation and maintenance suitable for non-commercial species [95] on private lands and have increasingly done so to varying degrees in the US [96]. Again, though, their discretion must be constrained to reduce the chance of unintended consequences [97]. Generally, reducing human-produced harms, like pollution, poses less risk/is more sustainable than trying to micromanage complex ecological systems from the top [26] [98].

4. Conclusions

The ability of each major conservation model to adapt to change over time varies. The historical examples discussed in the previous section and neoclassical economic theory suggest that the private access model is the one most likely to adapt sufficiently quickly to ensure conservation goals, especially prevention of extinction, because private owners have better incentives and information than government wildlife managers and hence are more willing and better able to adapt to changing circumstances. They also hedge conservation efforts by fragmenting access management over many decision makers. If a private resource manager errs, a resource might be extirpated in a small area but continue to thrive under other private managers nearby. Government wildlife management errors, as in the cases of bison and passenger pigeons, can cause much wider destruction.

The private access model is not a panacea, especially when a resource has a large, especially international, range and/or a close commercial substitute remains abundant. One might therefore consider it the least fragile/most sustainable conservation alternative, the default model to be bolstered in specific instances if need be. In general, the world's wildlife will be safer from extinction if access to them is controlled by private parties with incentives to rationally manage their numbers, quality, and habitat. The world's most successful species, the various domesticates, thrive precisely because access to them is privately managed. There is no reason to suspect that wildlife will not also thrive if privately managed.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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