

THE ORIGINS AND EVOLUTION OF THE FIRST AMERICAN ENVIRONMENTAL PROTECTION AGENCIES

DEAN LUECK and DOMINIC PARKER*

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ABSTRACT

Government agencies manage and regulate important environmental assets, but there is little economic research on their creation, evolution, and size. We address this void by studying the oldest American environmental protection bureaus - U.S. state wildlife agencies - from their inception to their manifestation as modern administrative agencies. We develop a model in which demand for agency management depends on the private costs of landowner coordination and state capacity to administer and enforce regulations. We test implications by examining the timing of agency emergence across states from 1870 through 1920, changes in the size of agency budgets from 1952-2007, and the proportion of budgets spent on nongame species for which private control is least profitable. Estimates show that high levels of state capacity and higher landowner coordination costs, caused by small landholdings and weak rights against trespass, are associated with earlier and larger agencies with less focus on nongame.

* Lueck: Indiana University, Bloomington IN. lueck@indiana.edu. Parker: University of Wisconsin, Madison WI. dominic.parker@wisc.edu. Research support was provided to Lueck as a Julian Simon Fellow at the Property and Environment Research Center and to Parker from the Graduate School at the University of Wisconsin. We received helpful comments on earlier drafts from Josh Abbott, Lee Alston, Terry Anderson, Amy Ando, Tim Fitzgerald, Don Fullerton, Michael Hannemann, Dan Kaffine, Jon Klick, Kerry Krutilla, Bryan Leonard, Gary Libecap, Kerry Smith, Henry Smith, and Katrina Wyman, and participants in seminars at PERC, the Ostrom Workshop at Indiana U., Northwestern U., Notre Dame U., Arizona State U., U. of Illinois, Purdue U., U. of Utah, and the U. of Torino. Earlier version of the paper were presented at the annual meetings of the American Law and Economics Association and the Society for Institutional and Organizational Economics. Mike Stroup provided excellent research on the history of state trespass laws.

[T]here is no reason why, on occasion, such governmental administrative regulation should not lead to an improvement in economic efficiency. This would seem particularly likely when, as is normally the case with the smoke nuisance, a large number of people is involved and when therefore the costs of handling the problem through the market or the firm may be high.

It is clear that the government has powers which might enable it to get some things done at a lower cost than could a private organization. But the governmental administrative machine is not itself costless. It can, in fact, on occasion be extremely costly.”
(Ronald Coase 1960, p.17-18)

I. INTRODUCTION

Government agencies are an obvious and important form of economic organization. At the federal level they control vast resources and are involved directly in the production of goods and services, or indirectly in the regulation of private sector activities. In the fifty U.S. states, agencies are just as pervasive, where they are involved in many similar endeavors including education, law enforcement, public health and safety, and transportation. For environmental and natural resources, in particular, state agencies have a long history and today nearly all states have agencies involved in agriculture, environmental quality, fish and wildlife, forests, minerals, parks, state lands, and water.

Though agencies are important, there has been little systematic research on the factors determining their creation, evolution, and extent. Public interest theory suggests they will emerge to solve real or perceived market failure problems (e.g., Pigou 1938, Pinotti 2012), but special interest theory suggests they may also emerge to capture and transfer rents to well-organized groups (e.g., Tullock 1967, Stigler 1971, Peltzman 1976, Becker 1983, McChesney 1987). The literature on state capacity suggests that more populated states, and those with an existing governmental apparatus, are more likely to produce regulations and regulatory agencies (e.g., Mulligan and Schleifer 2005, Besley and Persson 2009). To our knowledge, there are no studies that test for the influence of these factors on the timing of agency creation, nor on the size and extent of specific governmental agencies, which is what we do here.

We study the creation, size, and extent of state-level wildlife agencies, perhaps the oldest environmental protection agencies. These agencies were formed during 1878 through 1932, in the wake of

severe depletion of many native wildlife stocks and some well-known cases of extinction.¹ As wildlife stocks rebounded during the 20th century, the size and extent of agencies also evolved. Some remained relatively small bureaus funded only by hunting and fishing licenses while others grew into more expansive agencies engaged in many new tasks, such as a focus on managing and researching non-game species.

The history of wildlife agencies raises several questions we study here. First, why did agencies not emerge earlier to stop the decimation of wild populations and what explains the timing of their creation? In fact, state laws to protect wildlife existed long before agency creation, implying that law passage alone was not a sufficient condition. Second, why has the size and extent, in terms of budget sizes and allocation across tasks, of wildlife agencies varied within and across states over time? As we show, the origins and extent of state agencies are not well explained by state population sizes or demographic composition.

Our framework for studying the emergence and extent of wildlife agencies combines ideas on the evolution of property rights (e.g., Demsetz 1967, Anderson and Hill 1975, Shleifer 1998, Fitzpatrick 2006, Bubb 2013) and resource governance (e.g., North 1981, Smith 2002, Kaffine 2009) with ideas from studies of transaction costs and comparative institutional analysis in the tradition of Coase (1960) and Williamson (1999). The framework also draws from Mulligan and Shleifer (2005), who argue that the supply of regulation is determined by the fixed costs of setting up an administrative bureau and from a literature on state capacity, which asks if the state is capable of effectively providing public goods (e.g., Rauch and Evans 2000, Besley and Persson 2009). The cornerstone of our analysis is that effective management of environmental assets - such as fish and wildlife populations but also air and watersheds and underground assets such as oil-gas reservoirs and groundwater aquifers - require a larger geographic scale of governance than the scale of ownership that typically dominate surface uses for urban and agricultural uses. Governance can be facilitated by granting ownership of landscape asset pieces to private landowners, or by a granting ownership over the entire asset to governments. For example, ownership of subsurface mineral stocks follow private surface boundaries in the United States whereas subsurface mineral stocks are owned

¹ Most famously, the last passenger pigeon died in a Cincinnati zoo in 1913 (Belanger 1988) and the American Bison was driven to near extinction in the late 19th century (Lueck 2002, Taylor 2011).

by governments in most other countries (Rasband et al. 2016). And wildlife stocks traversing private land are regulated, if not legally owned, by governments in the United States and Canada, but in many European and African countries private landowners have strong ownership rights (see Lueck 2018).

Our framework differs from Demsetz (1967), who hypothesized that private ownership will emerge with rising values and increasing scarcity.² In contrast, we argue these factors will merely increase the probability that *some form* of governance will evolve, be it private or state.³ The testable hypothesis is that governance form (private or government) and the extent of government administration will vary with the relative costs of private versus state control. Administration by state agencies circumvents the private contracting problem of establishing control over landscape assets. Private contracting costs increase with the ratio of the environmental asset's spatial coverage relative to parcel sizes and with the costs of enforcing against trespass. Even though agencies can eliminate private contracting costs their administration requires setup and administrative costs to monitor and steer the agency towards managing environmental assets in an efficient way.

This framing of tradeoffs is consistent with Coase (1960), who emphasized transaction cost conditions under which government administration might improve economic efficiency relative to control via market contracts in spite of sometimes “extremely costly” governmental administration as noted in the epigraph. The framing is also consistent with Williamson (1999), who argues that public bureaus arise where output is hard to measure and market provision is limited. It predicts that wildlife agencies would have formed earlier where private contracting costs were relatively high and where state administrative capacity was relatively broad. Once formed, the optimal size and extent of agencies would vary inversely with private contracting costs to capture some resource rents that would otherwise be dissipated by agency management.

² In the context of 17th century North America fur trade, Demsetz showed that informal property rights to hunting grounds were better defined and enforced by Native Americans when the value of furs, especially beaver pelts, rose. More generally, he posited that property rights become better defined and enforced when the marginal benefits of more complete ownership exceed the marginal costs.

³ This follows the logic of North (1981) who held that institutions are created when the social benefits from creating them outweigh the transaction costs.

To evaluate the theoretical implications, we develop a panel data set that comprises wildlife and related natural resource agencies for all states since 1860. The data indicate the timing of agency creation and include measures of budget size and allocation along with economic and demographic measures from the states at various time periods. Consistent with the theoretical framework, we find that agencies tended to emerge first in states where private landholdings were small, where rights against trespass were weak, and where the state administrative capacity was strong. In modern times, as laws protecting rights against trespass have strengthened, we find that wildlife agencies are smaller in states where private landholding sizes have grown suggesting a movement back towards private control as private contracting costs fall. To our knowledge, this study is the first to emphasize the important role that trespass laws and enforcement may have played in wildlife decimation, administration, and recovery. We do so by creating a unique panel data set of state trespass laws over 1860 to 2010.⁴

This study is the first empirical analysis to examine a demand-focused rationale for public bureaucracy using long panel data on U.S. state agencies. It is related to econometric work on how demographic and interest group factors explain variation in the scope of regulatory activity (e.g., Pinotti 2012, Mulligan and Shleifer 2005), and on how high transaction costs can reduce private conservation and lead to public governance of resource use (e.g., Hansen and Libecap 2004, Troesken and Geddes 2003). Our study is also related to in-depth, qualitative research by Olmstead and Rhode (2015), who examine how the administration of U.S. and state regulations during the 19th and early 20th century assisted in the success of U.S. agricultural development by addressing animal disease problems that were not solved by market participants. It is also related to other in-depth historical analyses of environmental protection efforts, such as those for water quality (e.g., Keiser and Shapiro 2019).

We begin in Section II with a history and description of state wildlife agencies. In Section III we develop models of agency size, agency emergence, and budget allocation. In Sections IV and V we evaluate implications by estimating the timing of agency emergence between 1870 and 1920, changes in agency

⁴ This aspect of the study contributes to the literature on the ‘right to exclude’, which has been studied extensively in law and economics (e.g., Klick and Parchomovsky 2017).

budgets over 1952 to 2007, and the allocation of those budgets between game and non-game and endangered species management in modern times.

II. HISTORY: FROM GAME LAWS TO ADMINISTRATIVE AGENCIES

State fish and wildlife agencies are the descendants of game laws passed by colonial governments whose goals were to prevent the over-harvest of valuable game animals. Created after local (and private) law enforcement failed, these agencies evolved from small bureaus comprised of specialized game wardens (who enforced hunting and fishing laws), to the modern bureaucracies we observe today.

A. Abundance, Decimation, and Recovery of Wildlife Populations

When European settlers first arrived in North America they were amazed by the abundance and variety of wildlife (Harrington 1991). Harrington (1991), for example, notes that early settlers in Georgia observed the “woods abound with deer...”; in Virginia, he noted that two hundred deer “in one herd have usually been observed.” Tober (1981, 1) described a Massachusetts observer who noted, “I have seen pigeons... that to my thinking had neither beginning or ending, length of breadth, and so think I could see no sun.” Animals now typically associated with the American West were actually once present near the Atlantic coast from New York to Georgia. Elk herds could be found as far east as Pennsylvania until around 1867. In additions, jaguars, black bears, grizzly bears, mountain lions, bobcats, wolves, martens, fishers, river otters, and lynxes were all in abundance in eastern regions during colonial times (Harrington 1991). Passenger pigeons flocked in the eastern woodlands; one gigantic flock was estimated to have contained up to 2.3 billion birds (Tober 1981).

Accounts of abundance were repeated as white explorers moved west on the frontier. Enormous herds of bison and pronghorn antelope roamed in the prairie states west of the Mississippi. In 1804, explorer Meriwether Lewis wrote in his journal “... immence [sic] herds of Buffalo deer Elk and antelopes which we saw in every direction feeding on the hills and plains” (Ambrose 1997, 168). Animals such as prairie dogs, prairie chickens, and mule deer were also found in vast quantities.

Despite the abundant endowment of native wildlife, by the late 1800s many stocks were severely reduced.⁵ As Figure 1 shows, the once ubiquitous white-tailed deer population had dwindled by more than 98%, from estimates of 34 million at the turn of the 18th Century to less than 500,000 by 1900. The deer population recovered through the 20th century and so did antelope, elk, turkey and waterfowl. But other species, such as the American Bison and the passenger pigeon, did not. Indeed, the passenger pigeon became extinct in 1904 and bison while not becoming extinct recovered to just ten percent of their pre-settlement numbers (Lueck 2003).

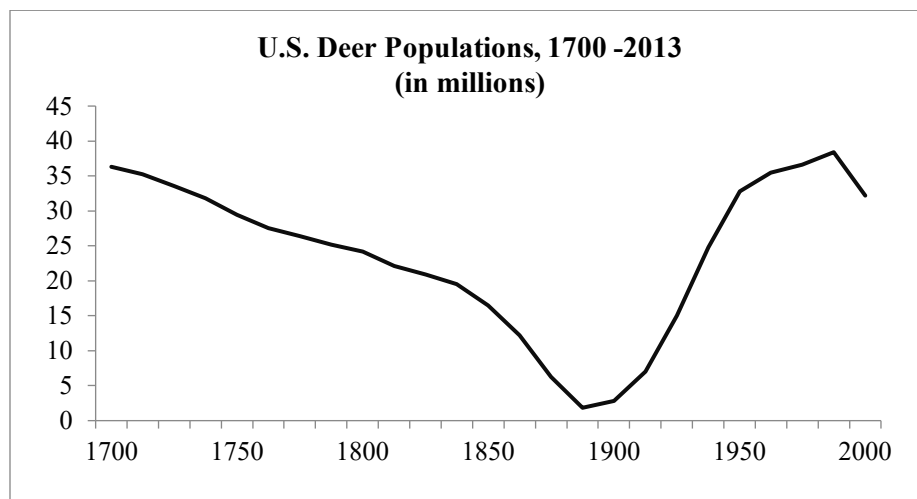


Figure 1: Estimated U.S. Deer Population.

Source: Kent Webb, who provided the authors with the data underlying his chart (of white-tailed deer populations) at www.deerfriendly.com/decline-of-deer-populations.

The severe decline in wildlife populations resulted, primarily, from exploitation by market hunters (Harrington 1991, Tober 1981, Belanger 1988) operating in an open access regime with limited information about populations and wildlife biology.⁶ Markets for wildlife products (e.g., meat, hides, feathers) were widespread in major cities, especially by the late 19th century (Tober 1973). The abundance of wildlife led many commentators to deem that regulations were unnecessary, even as wildlife populations plummeted in

⁵ Much of the wildlife depletion occurred during the latter half of the 19th century, which is often referred to as the “age of extermination” (Belanger 1988).

⁶ Other causes included the systematic killing of predators, loss of habitat (e.g., through deforestation and homesteading), and the introduction of exotic species (see, e.g., Harrington 1991).

many areas.⁷ Eventually, however, sportsmen (i.e., recreational hunters) groups formed and banded with naturalists (i.e., environmentalists) to lobby for local and state regulatory action (Tober 1981, Warren 1997). Population recoveries occurred during the 20th century, after major governance changes (such as the development of state wildlife agencies) had taken place.

B. From Wildlife Laws to Wildlife Agencies

Laws to limit the harvest of wildlife emerged in the U.S. during the colonial period. The first of these game laws closed parts of the year to killing or ‘taking,’ and applied to public or private land within a state’s jurisdiction. By the end of the colonial period all the colonies but Georgia had closed seasons for deer. West of the Mississippi, there were no game laws in any state or territory, other than restrictions on Native American lands, until 1851. By the 1880s, all 48 continental states (or their respective territories) had game legislation, primarily in the form of statewide closed seasons and limits on trade in game and game products. In addition to season closures, bag limits soon emerged as a standard method of limiting take for fish and game. A bag limit is a daily or seasonal quota on the number of animals that can be taken during a legal hunting season. Iowa, for example, implemented the first bag limits for wild birds in 1878 (25 birds per hunters per day, extremely generous by modern standards).⁸

Local law enforcement authorities, rather than specialized game wardens, were initially charged with enforcing game laws in addition to their other law enforcement duties (Tober 1981, Connery 1935). By the mid-1800s, game laws were becoming increasingly complex but were seldom enforced.⁹ Bavin

⁷ Tober (1981, 17), for example, notes that an Ohio Senate disposed of a passenger pigeon protection bill arguing that the birds “were so wonderfully prolific” that “no ordinary destruction can lessen them.”

⁸ States also imposed restrictions on the legal methods of taking game, most of which are still in effect today. Today restrictions include prohibitions on explosives, automatic and other types of weapons. Restrictions and prohibitions on game trade also became a component of state (and later federal) wildlife management. By 1912 all states but Maryland had banned exports of all or some game products (Palmer 1912). In 1900 the federal Lacey Act outlawed the sale or transportation of game taken in violation of state laws. Today states still generally prohibit the sale of wild game and game products, though there are exceptions, most notably for fur bearing animals (e.g., mink, fox). States also created refuges for wildlife, where hunting was either prohibited or severely curtailed. Wyoming in 1905 and Pennsylvania in 1907 established the first state refuges, and now all states have state controlled – via ownership, easement, or lease – land for wildlife refuges.

⁹ A detailed study of New Hampshire wildlife history, for example, was unable to discover a single instance of the enforcement of a law protecting deer prior the development of the state’s wildlife agency. The 19th Century Naturalist George Bird Grinnell suggested the early laws merely replicated English law and were never taken seriously by subsistence or commercial hunters (see Tober 1981).

(1978) describes why this was likely the case. From the perspective of a local policeman, enforcing wildlife law entailed high expected costs - it required encountering armed hunters and learning complex laws - but low benefits because there was generally not additional compensation nor local political pressure for wildlife enforcement. One important exception was when private conservation clubs paid enforcement agents to patrol against poaching on private lands managed for recreational hunting (Tober 1981).¹⁰ Even then, local juries were often unwilling to enforce wildlife laws viewed as favoring privileged landowners (Tober 1973). Moreover, most land on the frontier was still in the federal domain but with almost no administrative or enforcement presence such that local policemen lacked the capacity and clear jurisdictional authority to enforce game laws in these areas.¹¹

As wildlife populations continued to plummet, there was, according to Tober (1981), a need to clarify and consolidate property rights to wildlife and enforcement authority to a single entity. “That logical mechanism... was a state-level administrative agency that might develop the necessary scientific expertise for wildlife management, enforce existing law by deploying agents in the field, and advocate the cause of wildlife before legislature and the public.” The state-run game department, still intact today, is the governing organization that emerged.¹² The first state game agencies were established in California and New Hampshire in 1878 and the last was established in Mississippi in 1932. As Figure 1 shows wildlife

¹⁰ Tober (1981) argues that these private clubs were most effective. He states: “Through 1885, which may be taken as the initiation of concerned efforts by states to enforce their own game laws, the most effective enforcement agencies were the sportsmen’s clubs whose members brought violation to the attention of officials authorized to persecute them” (p. 215-216).

¹¹ This remains true today where, especially in the Western United States, federal land agencies control large expanses of undeveloped land that is sometimes beyond the jurisdiction of local law enforcement.

¹² Important legal changes took place during the latter part of the 19th century that facilitated the emergence of wildlife agencies. Game laws were repeatedly challenged as illegal and even unconstitutional state action and many cases went to the Supreme Court. During the late 1800s there were many legal challenges to state authority to regulate fish and wildlife. A series of Supreme Court cases upheld this authority, culminating with *Geer v Connecticut* which gave constitutional support for state action in the regulation and management of wildlife. In this case the Supreme Court argued that states owned wildlife within their borders though this ‘ownership’ doctrine was quickly overturned, in part, with federal action in wildlife trade and migratory waterfowl treaties (Lueck 1989).

agencies generally emerged before state forestry, parks, water quality, and air quality agencies but after inland fishery commissions (Figure 1).¹³

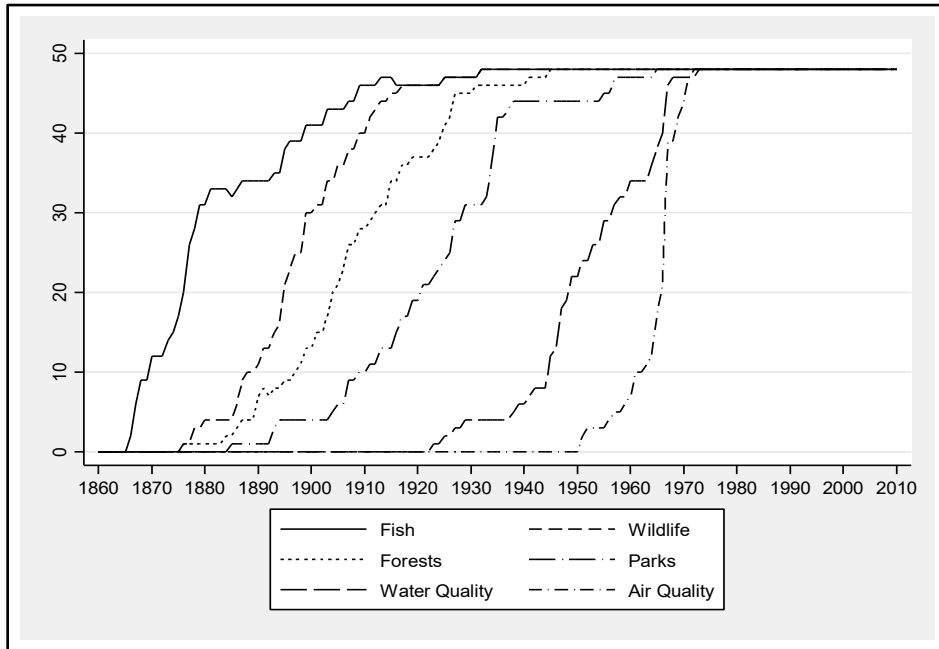


Figure 2: Emergence of Environmental Protection Agencies, 1860-2010.

Notes: Authors' compilation based various sources. See appendix. Only 48 continental states examined.

Law enforcement was the central function of nascent wildlife agencies, which established bureaucratic positions for game wardens (Palmer 1912, Bavin 1978). To fund these positions, hunting license systems emerged in late 19th century but did not generally take hold until the early 20th Century. By 1900, roughly twenty states had some form of licensing system that both limited access to wildlife and generated funds. By 1904, thirty-one states had nonresident fees, and by 1912 forty-six states had such licenses. From their inception, nonresident licenses have been substantially more expensive than resident licenses.¹⁴

¹³ Tober (1981) argues that the fishery agencies were formed to engage in fish stocking efforts for both recreational and commercial fishermen. We are not aware of research on the timing and creation of the other natural resource agencies but discuss their relevance to state capacity in the empirical section.

¹⁴ This discriminatory pricing has been challenged in court many times by nonresidents on the grounds that it violates the privileges and immunities clause of the U. S. Constitution (Art. IV., sec.2.). These challenges have been

Early wildlife agencies were typically autonomous bureaus with narrow jurisdiction over species valued by sportsmen. While many agencies still retain this organization and jurisdiction, others are part of larger “natural resource” or “environmental protection” agencies that also have regulatory jurisdiction over parks, forests, and air and water quality. As of 2015, there were 18 autonomous agencies (38% of the lower 48 states), down from 30 autonomous agencies in 1950.¹⁵ While early agencies typically focused on law enforcement, modern agencies also employ biologists and ecologists and engage in activities such as wildlife stocking, habitat acquisition and management, research, and education. This modern era of wildlife management was inspired by Aldo Leopold (1933), who advocated for scientific research and active habitat management. Modern agencies not only manage traditional game populations (e.g., deer, turkey, elk, waterfowl) but are also responsible for nongame species such as lizards, bats, and songbirds.

Modern wildlife agencies are rather small bureaucracies compared to the other major state agencies. The aggregate budget (expenditures) across the lower 48 states was \$3.53 billion in 2008, ranging from a high of \$425 million (California) to a low of \$5.3 million (Rhode Island). Across all agencies, the expenditures on fish and wildlife in 2008 amounted to 0.24 percent of total state revenues, ranging from a high of 1.36 percent (Montana) to a low of 0.04 percent (New York). For point of comparison, state parks agencies spent \$6.3 billion in 2008 and forestry agencies spent \$2.5 billion. All natural resource agencies combined (fish and wildlife, parks, forests, agriculture) spent \$22.0 billion whereas state public health agencies had collective budgets of \$59.3 billion.

Wildlife agency funding, comes mostly from hunters and anglers, either directly through licenses or indirectly through (federal) taxes on hunting and fishing equipment. A substantial and increasing amount of license revenue comes from non-resident licenses.¹⁶ General appropriations to wildlife agencies account

defeated at all levels, including the Supreme Court. More expensive licenses for nonresidents are found in all states today. The case upholding this practice was *Baldwin v. Fish and Game Commission* 436, U.S. 371 (1978).

¹⁵ Even these distinctions do not include all the possibilities. For example, Pennsylvania still has a Game Department that is separate from its Fisheries Department, and a few states (e.g., Maryland) have separate departments for marine fisheries that are often focused on commercial species.

¹⁶ Nationwide, 30.4 percent of license revenue came from non-residents in 2002, up from 22.1 percent in 1965. At the state level, three states generated more than 70 percent of their license revenue from non-residents in 2002

for the growing difference between user fee revenues and expenditures and comes from sources such as tax check off programs, lotteries, wildlife license plates, dedicated taxes (e.g., cigarette taxes whose revenues are budgeted to a wildlife agency), and miscellaneous fees (e.g., refuge entry revenues). In 2008, general funds accounting for 41.9 percent of total expenditures across all states. The amount of general funding received by each state varies considerably, ranging from close to zero in many states to well over 50 percent in other states, some of which is dedicated for the management of non-game species. This a relatively new function for state wildlife agencies: only four states had nongame programs prior to 1970 and 16 states began their programs during or after 1980. As of 1998 – which is the most recent year of systematic data collection - the average agency spent about 5.4 percent of its budget on nongame management.

C. Private Wildlife Management

Private landowners were engaged in wildlife management before and after the creation of wildlife agencies but the scale of this activity is not systematically documented. Across the US in modern times, approximately 82% of all hunters hunt on private land compared to 40% who hunt on public land. Private landowners routinely lease land to guides or hunting clubs, charging from \$100 a day to hunt pheasants to more than \$10,000 for a bull elk hunt (Aiken 2005).

Tober (1973, 1981) documents how private recreational hunting clubs of the 19th century filled some of the vacuum in wildlife law enforcement, before agencies and specialized game wardens. These sportsmen sought to slow commercial hunters and paid to do so.¹⁷ For example, in 1878 the Rutland County Deer Association of Vermont augmented a depleted deer population with deer acquired from private herds in New York and released them in the state. The Association volunteered to enforce a temporary moratorium on hunting and the population rebounded (Tober 1981). The Bloomington Park Association of Pennsylvania, incorporated in 1871, hired game wardens (deputized by county sheriffs) to patrol enclosed

(Colorado, Montana, and Wyoming) and four states generated less than 10 percent from non-residents (California, Massachusetts, Ohio, and Washington).

¹⁷ The recreational sporting clubs were comprised mainly of higher income Americans from western European descent whereas the market hunters tended to be lower income and were “farmers, frontiersmen, rural youth, and southern European immigrants ... who did not embody the qualities of sportsmen” (Tober 1981, 52).

hunting grounds (Tober 1981). The Hartford Game Club of Connecticut offered rewards for information about game law violations, and the New York Association for the Protection of Game employed detectives to roam market stalls in New York City in search of dealers with illegal wildlife products (Tober 1981).

In addition to private enforcement, there were also private efforts to more thoroughly stock and manage game. For example, an association of sportsmen in Berks County Pennsylvania leased nearly 3,000 acres from 15 farmers and in exchange received exclusive hunting and stocking privileges. In New Jersey, the landowner members of the Farmer's Mutual Protective Union issued hunting permits which were valid to registered hunters on all cooperative lands. The system provided approximately 15,000 acres of exclusive hunting (Tober 1981, 124). Sportsmen clubs in New York reportedly had leased, owned, and fenced between 500,000 and 800,000 acres of land as private game parks in the Adirondack area of the state (Tober 1981, 127).

Early private efforts, however, were not widespread and did not check the depletion of wild stocks. One obstacle was that landowners had weak rights against trespass. Provided they did not violate game laws, hunters generally had open access to private land, especially if it was unenclosed and uncultivated (Freyfogle et al. 2019, Hynes 2013, Sigmon 2004).¹⁸ States could attempt to override the default right to hunt on unenclosed and uncultivated land by legislation. According to our analysis of state statutes, as of 1850, only three states had laws requiring hunters to gain landowner permission. Just two states had laws stating that posting against trespassing could restrain hunter access, and the remainder of states lacked any statute.¹⁹ By 1890, permission was required in six states and posting could restrain access in six states. In 2018, by contrast, approximately half of the states required permission with the other half recognizing

¹⁸ Numerous 19th Century cases from various states confirm this doctrine. For example, in 1818 the South Carolina Supreme Court rules that: "the right to hunt on unenclosed and uncultivated land has never been disputed, and it is well known that it has been universally exercised from the first settlement of the country up to the present time ..."
McConico v Singleton 9 SCL 244 (SC Ct App. 1818)

¹⁹ We ordered four categories of laws, ordered from weakest to strongest. These are 1) Open Access (unenclosed and uncultivated private lands are open access even if posted; 2) Access to All Lands Absent Posting (posting required to keep hunters off any private land); 3) Access to Unenclosed/Uncultivated Land Absent Posting (posting required only to keep hunters off of unenclosed or uncultivated land); and 4) Permission-Based Access (landowner permission required to hunt on any private land). .

posting (see Appendix Table A3). The eventual emergence of stronger trespass laws provided a stronger basis for private contracting but, until later in the 20th century, these laws remained difficult to enforce especially on unenclosed and uncultivated lands where landowners were often absent.²⁰

A second obstacle to private contracting remains important today. As emphasized by Tober (1981) and Lueck (1989, 1991), wildlife populations move across geographic spaces that naturally exceed the size of most private landholdings. When the boundaries of wildlife populations exceed property lines, private contracting becomes a land assembly problem in which a sufficient number of contiguous acres must be dedicated to the private wildlife reserve.²¹ As Coase (1960) emphasized, successful contracting becomes increasingly difficult with increases in the number of contracting parties (e.g., landowners, hunters, and wildlife recreationists). The contracting problem is further exacerbated when trespass is not enforceable.

III. ECONOMIC FRAMEWORK

We develop an economic rationale for the state-run game agency system that evolved in the U.S. The goal is to generate a theory that is capable of explaining differences in the timing of agency creation across the 50 U.S. states, and differences in the size of modern wildlife agencies. Beginning with the problem of contracting for control of a large-scale environmental asset, our models focus on the demand for and cost of state action.

A. Model Basics

We consider the management of a large-scale asset (wildlife), which can be provided by either private parties (e.g., group of landowners) or a state agency. Wildlife management effort (e) is used to produce wildlife output (W) from a unit of land (i.e., habitat). Management effort is a composite variable

²⁰ Strong rights of trespass were opposed by subsistence and commercial hunters during the 19th century. Norms at the time considered wildlife to be common property that should be accessible to all (Freyfogle et al. 2019, Tober 1973). Moreover, unless landowners hunting on their own land could be more effectively be bound to the same wildlife laws applicable to other hunters, strong rights against trespass would have been akin to granting landowners ownership of the wildlife resource itself. Granting *de facto* wildlife ownership to landowners was highly controversial (Tober 1981).

²¹ Fencing is possible, albeit costly and sometimes ineffective, and it diminishes the recreational value wildlife.

that includes law enforcement, population regulation (e.g., damage control, harvest rates), habitat manipulation, and research. The production of wildlife is $W(e)$ and has the standard properties $W_e > 0$ and $W_{ee} < 0$.²² The total cost of wildlife management per acre is C with $C_e > 0$ and $C_{ee} > 0$. We denote the shadow value of the output as ρ and L is the total acres of land (or potential habitat) in a landscape, so that the objective for first-best management is²³

$$(1) \quad \max_e V = [\rho W(e) - C(e)]L.$$

The first-best level of management effort (e^*) satisfies $\rho W_e(e^*) = C_e(e^*)$ and the comparative statics are straightforward.²⁴ Increases in the shadow value (ρ) will increase per acre management effort, but changes in total acres (L) have no effect on per acre effort. The total amount of management in the state is $(e^*)L$ and the total value of the output is $\rho W(e^*)L$. The first-best expenditures on wildlife management is $C(e^*)$.

B. Demand for a State Agency

If the costs of establishing and enforcing private contracts to manage wildlife were zero and private landowners controlled the entire wildlife landscape, they would implement and benefit from e^* ; thus, there would be no demand for a wildlife agency. In our empirical setting, however, private parties and government agencies own parts of the wildlife-habitat landscape and contracting costs are non-zero.²⁵ This creates demand for agency enforcement and management.

To allow for simultaneous private and public management, let (e_A) represent the effort of the agency and (e_P) represent the effort of private managers. Wildlife output (per acre again) is $W_A(e_A)$ for the agency and $W_P(e_P)$ for the private sector. Wildlife management costs (per acre) are $C_A(e_A)$ for the agency and $C_P(e_P)$ for the private sector. The total land in the state is comprised of public land (denoted l_A) and private land

²² We assume static production technology and thus ignore biological parameters such as intrinsic population growth rates and carrying capacity.

²³ It would be possible to add a physical parameter (e.g., $\alpha > 1$) on L to capture economies of management from larger parcels of habitat.

²⁴ We ignore the distribution of rents generated. For private management, the rent accrues to the landowner.

²⁵ As discussed in the empirical sections, there is great variation across the states in the distribution of private and public lands. Western states generally have the largest fraction of public (federal usually) land and often this is well over 50 percent of all land.

(denoted l_P) so that $L=l_A+l_P$ where L is fixed. The allocation of public and private land is taken to be exogenous to the wildlife management decision. The joint maximization problem is

$$(2) \quad \begin{aligned} \max_{e_A, e_P} V &= \rho[W_A(e_A)l_A + W_P(e_P)l_P] - C_A(e_A)l_A - C_P(e_P)l_P \\ \text{subject to } L &= l_A + l_P \end{aligned}$$

Assuming private and public landowners manage wildlife only on land they own, the optimal levels of private and public wildlife management are given by

$$(3A) \quad \rho W_A^A(e_A^*)l_A \equiv C_A^A(e_A^*)l_A$$

$$(3B) \quad \rho W_P^P(e_P^*)l_P \equiv C_P^P(e_P^*)l_P$$

Note that the agency's budget is the cost of production evaluated at the optimal level of management effort is $B^* = C_A(w_A^*)l_A$.²⁶ In the case where private and state costs are the same, this implies that the amount of public and private management will be identical on a per-acre basis and that that relative size of the agency is determined solely by the fraction of public land in the state.²⁷

In this formulation, the (budget) size of public agencies is simply a function of the amount of public land and the costs of agency management. Empirically, public land might include lands in federal and state forests and historically, land that was in the public domain and not yet private claimed. One can also conceptualize "public land" to include private but uncultivated land on which landowners had no right against trespass from public hunting.

Introducing costs of private contracting means that the extent of private management and thus the optimal size of the state agency are also determined by the ability of private landowners to contract for control of the wildlife landscape (habitat and populations). In this framing, and in our empirical setup, private contracting costs depend on the size of private parcels relative to the expanse of the wildlife

²⁶ In Niskanen's (1970) budget maximization model the revenues would be identical to expenditures (and both equal to the agency budget) because all rent is dissipated.

²⁷ If they did differ then the most efficient party would have the largest budget even with identical land holdings. Adding a market for land would then reallocate the land as well.

landscape. We take as exogenous parcel sizes, which have been determined primarily by historical homesteading policies, historical and modern farming technologies, and distances to urban centers.

It is useful to think of ‘effective wildlife habitat, as the amount of land that can be controlled for (profitable) wildlife purposes. Contracting costs determine the amount of effective habitat under the control of private managers and by implication the amount of habitat that becomes under the *de facto* control of the state agency. Let h_P be the effective private habitat and h_A be the effective agency habitat, where $L = h_A + h_P$. Effective private habitat is the amount of private land less the land not controllable because of contracting costs, so that $h_P = l_P - \chi$ where χ is the amount of land not profitable to control privately because of contracting costs. On the public side effective habitat is public land plus the private land not controlled privately, or $h_A = l_A + \chi$. The total amount of land in the state remains unchanged, or $h_A + h_P = l_A + \chi + l_P - \chi = L$. We use a formulation in which the uncontrolled land -- $\chi(n)$ -- depends solely on the number of private landowners and takes the specific form

$$\chi = \begin{cases} \left[\frac{n-1}{K} \right] l_P & \text{if } n \leq K+1 \\ l_P & \text{if } n > K+1 \end{cases}$$

where K is a threshold number of private landowners for which contracting becomes prohibitively costly.²⁸ The amount of uncontrolled private land is zero if there is a single landowner and approaches the entire amount of private land as the number of landowners increases.²⁹

The optimal (per-acre) levels of private and state wildlife management do not change since they are determined by the per-acre returns to wildlife management, but the amount of land controlled by the agency and by private landowners is affected. This, of course, affects the optimal size of the agency, which now becomes

²⁸ Contracting costs might also depend on the number of landowners, the size of private holdings, the variance in the size of private land holdings, and the territorial habitat requirements of the wildlife (Libecap 1989, Lueck 1989).

²⁹ The mean size of landholding is simply l_P/n . One might use alternative specifications for $\chi(n)$ but the main point is that contracting costs are increasing at a decreasing rate in the number of contracting parties. This formulation of χ also assumes that habitat requirements for wildlife exceeds the size of individual private parcels.

$$(4) \quad B = C_A(e_A^*)h_A = C_A(e_A^*)\left[L - l_p + l_p\left(n - \frac{1}{K}\right)\right]$$

The agency's effective habitat is the total state area less private land plus the amount of private land lost because of contracting costs. Thus, the size of the agency is increasing in the number of private landowners (n) and decreasing in the average size of private land holdings (l_p / n), which is an implication testable with the data.³⁰ The size of the agency is also decreasing in the contracting threshold number of parcels (K), and is increasing in the size of the state L .³¹ The implications about optimal agency budgets can be summarized as follows:

- Implication B1. An increase in the size of the state (L) will increase the optimal size of the agency budget (B^*).
- Implication B2. An increase in the amount of public land (l_A) in a state will increase the optimal size of the agency budget (B^*).
- Implication B3. An increase in the amount of private land on which trespass is unenforceable (l_A) will increase the optimal size of the agency budget (B^*).
- Implication B4. An increase in the average size of private land holdings (l_A/n) will decrease the optimal size of the agency budget (B^*).

An additional implication can be derived by distinguishing between game and non-game species. The key distinction is that game species are used 'consumptively' (by recreational hunters and consumers of wildlife products) where as non-game enjoyment of species such as songbirds and bats is 'non-consumptive.' Game for consumptive use is a private good, because use in this capacity is rivalrous and excludable. Nongame species are more like public goods, because nonuse benefits are not rivalrous and typically not excludable, especially for birds and species that migrate long distances. Because private landowners will find it more difficult to capture rents from nongame (i.e., public good) management it means that state agency provision of non-game is less dependent of landowner contracting costs, and that

³⁰ It is possible that the agency can acquire private land or that the gains from private control of habitat might change. For example, the threshold value of parcels might depend on the shadow value of wildlife – $K=K(\rho)$ and $K' < 0$ -- so that an increase in this value would increase the gains to private ownership and thus indirectly reduce the size of the agency.

³¹ The agency size is also increasing in the value of wildlife since it is positively related to the optimal level of wildlife management. The comparative statics for the size of the private budget are the opposite (e.g., increases in landowners decrease private wildlife management).

the proportion of total agency expenditures spent on non-game species increases with decreases in private landowner contracting costs.

Implication B5. An increase in the average size of private land holdings (l_A/n) will increase the optimal proportion of the agency budget spent on non-game management.

C. Optimal Time to Create an Agency

The potential benefits of an agency are the protection of the periodic rent, R^* net of the costs of establishing and maintaining an agency, that would otherwise be dissipated under a regime of exclusively private wildlife management. Using the notation above, the optimal periodic rent is

$$(5) \quad R^* = [\rho W_A(e_A^*) - C_A(e_A^*)]h_A.$$

We assume the shadow value of wildlife, ρ grows over time at the continuous rate $g < r$, where r is the rate of interest, the rents accrued from agency management grows over time as well. Assume there are one-time costs, F , of establishing an agency that can enforce rights to wildlife. Since establishing an agency is costly and because $g < r$, it may not be optimal to not create an agency. The optimal time to establish the agency is the solution to

$$(6) \quad \max_t V = \int_{t^*}^{\infty} R^*(t) e^{-(r-g)t} dt - F e^{-rt^*},$$

where t^* is the optimal time to establish the wildlife agency, which occurs when the marginal return from waiting to create the agency (the present value of the agency's rental flow at a point in time) equals the marginal cost of waiting to create the agency (the present value of the opportunity cost of agency creation). The optimal time to create an agency is $t^* = (\ln r + \ln F - \ln R)/g$.³² The comparative statics of the optimal time to create and agency time are straightforward and yield the following implications.³³

Implication T1. An increase in the costs of agency establishment (F) will delay the optimal time to establish an agency.

Implication T2. An increase in the amount of public land (l_A) will move forward the optimal time to establish an agency.

³² This satisfies $R^* e^{-(r-g)t^*} = r C e^{-rt^*}$.

³³ These follow from $\partial^*/\partial C = 1/(Cg) > 0$, $\partial^*/\partial R = -1/(Rg) < 0$, and $\partial^*/\partial g = -1/(g^2) < 0$.

- Implication T3. An increase in the average size of private land holdings (l_A/n) will delay the optimal time to establish an agency.
- Implication T4. An increase in the shadow value of wildlife, (ρ), or growth in that shadow value (g), will move forward the optimal time to establish an agency.

As the costs of agency establishment (F) increases, the later will be the optimal time to establish an agency. We assume this a one-time fixed cost in part because the legal and administrative foundation of state regulatory control is costly to establish via state court jurisdictional decisions but need not be replicated once established. The costs of establishing an agency will depend on the administrative capacity of the state government, because a state with an existing administrative law and bureaucracy will have a lower cost of establishing an agency than a state with limited institutions. The costs also depend on the existence of wildlife agency templates from other states to replicate, and perhaps on the amount of legal precedent regarding the legitimacy of state action in other states.³⁴

The other implications simply mean that, as the potential agency rent (R^*) increases (decreases), the earlier (later) will be the optimal time to create an agency. This rent from agency management is higher when more wildlife habitat is open access, either because governments manage it as open access or because private landowners cannot enforce against trespass, and when there are high private contracting costs to capture rents to wildlife.

IV. EMPIRICAL TESTS OF AGENCY EMERGENCE

To evaluate predictions about the timing of U.S. state wildlife agency creation – implications T1, T2, and T3,, we estimate a duration (survival) model with time varying covariates.³⁵ The data sample includes the 48 continental states and begins in 1870.³⁶ Note that some states were still territories at this

³⁴ There are also collective action costs of lobbying for regulatory action, which likely depend on the heterogeneity of political interests (Olson 1965).

³⁵ Duration models are commonly used in economics and political science to assess how the timing of regulatory events correlates with economic and political variables. They have been used to assess wildlife conservation decisions (Ando 1999) and historical state-level regulatory activity (e.g., Geddes and Lueck 2002).

³⁶ Alaska and Hawaii did not become states until 1958 well after all other states had established wildlife agencies.

time. The sample ends in 1920; by that time only one state (Mississippi) had yet to create a wildlife agency. For this reason, censoring is not important.

A. Duration Model Setup

Each state in the sample appears for each year up until, and including, the year of agency creation. States are deleted from the sample after an agency is formed because their covariates provide no additional information about the causes of agency formation. For example, California created an agency in 1878, so it appears in the sample only from 1870 through 1878. As a result of this process, the estimating sample is an unbalanced panel of states from 1870 until the year of formation. There are 1,336 state-year observations in the sample.

The dependent variable is an indicator variable denoting whether or not a state has an agency and equals one for a state-year observation during the year an agency was formed and is otherwise zero. Figure 2, above, shows the cumulative establishment of these agencies. The analysis assumes that the probability of agency creation in a given year depends on time-invariant factors, initial conditions, and conditions the year before creation. The cumulative probability that state agency has been formed by year t can be written as:

$$(7) \quad F(t) = \Pr(T \leq t) = \int_0^t f(t) dt,$$

where T is the year the agency is created, and $f(t)$ is the density function defining the probability that a state agency is created in a given year t . The probability of a state “surviving” to year t without a wildlife agency is

$$(8) \quad S(t) = 1 - F(t) = \Pr(T > t).$$

The hazard rate, or probability that a state establishes a wildlife agency in year t is:

$$(9) \quad h(t) = \frac{f(t)}{S(t)},$$

We estimate a Cox proportional model, which does not assume a baseline hazard rate (see Cox 1972, Wooldridge 2010). In this model, the independent variables are assumed to proportionally shift the hazard rate in each time period. Therefore, we estimate the hazard rate in state s and year t with:

$$(10) \quad h(t_s) = h_0(t) \exp\{\beta X_s + g(t)(\gamma Z_{st})\}.$$

X_s is the vector of time-invariant variables and Z_{st} is the vector of time-varying covariates. The coefficients β and γ are proportional shifters of hazard rates to be estimated.

B. Data, Independent Variables, and Predicted Relationships

Our key independent variables measure private landowners' contracting costs, habitat, state capacity, and demographic characteristics for the period from 1870 to 1920. Key data sources include Agricultural Census reports and historical U.S. Census data (downloaded from Haines et al. 2010). From these sources, we have retrieved time-variant data on the acreage of improved farms, acreage of unimproved farms, the number of large farms (exceeding 1000 and 500 acres), the state's population in total and the proportion of the population in cities exceeding 100,000 and that was born in the United States. Because these census data are decadal, we have interpolated within-decade data by assuming linear changes.

The land area of a state (or territory prior to statehood) is the sum of NON-FARM ACRES, UNIMPROVED FARM ACRES, and IMPROVED FARM ACRES. We interpret UNIMPROVED FARM ACRES to be a measure of open access land because of the structure of trespass laws during this period. Our theoretical framework suggests that unimproved farm acres increases the demand for agency management and should cause earlier agency formation. Our model predicts that more land in the public domain should increase the demand for an agency suggesting NON-FARM ACRES will also be correlated with earlier years of agency formation. However, the NON-FARM ACRES variable includes a mix of lands including land held by Native American tribe as well as land in federal and state forests and parks. Not all of the land in this category was in the public domain and therefore open access for hunting. The variables NUMBER FARMS > 1000 ACRES, NUMBER FARMS > 500 ACRES, and AVERAGE FARM ACRES measure the amount of private land held in large tracts. In our theory, more land held in large tracts decreases landowner costs of contracting for

wildlife control and hence we predict the variables should be associated with delays in wildlife agency creation.

We include two variables to measure the costs of setting up an agency based on political contagion and state capacity. The first variable, NUMBER OF AGENCIES, is the time-variant running count of the number of state agencies governing health, agriculture, inland fish, forests, and parks. This variable, which ranges from 0 to 5, should cause earlier agency formation if the presence of other agencies lowers the fixed costs of adding additional agencies. The second variable, % OF REGION WITH WILDLIFE AGENCY, is a time variant variable that measures the percentage of other states within the region that have developed a wildlife agency at a point in time. This variable ranges from 1878 to 1912 and should be associated positively with the timing of wildlife agency creation, assuming neighboring states with wildlife agencies offer a template that lowers the administrative cost of setting up an agency.

In addition to controlling for total population, the variables PERCENT URBAN POP and PERCENT U.S. BORN POP serve as controls for the collective action costs of privately governing wildlife without a state government agency. These are factors that Tober (1981) stressed as important in generating demand for state regulatory action to conserve wildlife. According to Tober (1981), regulating urban users, who dispersed into the countryside to hunt, was difficult with only private and local government means. Urban dwellers were strangers to rural landowners and this raised collective action and enforcement costs. Moreover, large cities contained markets for wild game, which were a force that prompted state agency creation by increasing the demand for hunting under open access.³⁷ For these reasons, we anticipate PERCENT URBAN POP to correlate with an earlier state agency. By contrast, we expect to PERCENT U.S. BORN POP to correlate with a later state agency because the collective action costs of regulating wildlife privately and locally would be lower in states with populations sharing similar cultural backgrounds. Tober (1981), and especially (Warren 1997), discuss at length how immigrants, particularly from southern and

³⁷ Lueck (2003) and (Taylor 2011) show how the rise of hide markets for bison led to the rapid decimation and near extinction of that once ubiquitous animal.

eastern Europe, were primary actors in market hunting and considered by natives to be the culprits of wildlife decimation.³⁸

In an attempt to measure organized interest group demand for wildlife conservation, we employ information provided by Tober (1981) to create a time invariant variable, SPORTSMAN GROUP. This variable is equal to one if a statewide sportsman association existed in either the late 1870s or in 1891, the two points in time documented by Tober (1981, p. 66). These sportsmen groups formed to lease private land for hunting and to promote the enforcement of laws to preserve fish and game.

Finally, we add further controls in some specifications to assess the robustness of the main coefficients of interest. We add fixed effects for U.S. regions, based on the 1900 census, to non-parametrically control for regional factors potentially correlated with landholding patterns, state capacity, demographics, and the timing of agency creation. We also add two measures to control for a state's inherent wildlife carrying capacity: state annual precipitation (measured over the 20th century) and state mean elevation.³⁹

Table A1 shows summary statistics for the duration analysis sample, which contains 1,336 state-year observations. The graphs in appendix figure A1 plot the minimum, mean, and averages for the farm land and population variables by decade, from 1870 through 1920. There was noteworthy growth in the mean percentage of state land in farms, in the number of large farms, and in urban population over time. The cross-state variation, implied by the differences in minimums and maximums, has also grown over time, indicating this variation might contribute to differences in the timing of state agency creation.

³⁸ William Hornaday, a highly influential 19th century opponent to market hunting, was particularly critical of Italian immigrants who “root out the native American and take his place and income. Toward wildlife the Italian laborer is a human mongoose... The Italians are spreading, spreading, spreading. If you are without them today, tomorrow they will be around you.” (cited in Tober 1981, p. 53).

³⁹ Data are unavailable to systematically measure changes in wildlife populations across states over time. Such data, however, while initially appealing would be of limited value because wildlife populations are endogenous responses to the land ownership, land use, and demographic patterns that are of primary interest.

C. Estimation Results

Table 1 presents the Cox model estimates: columns 1-3 progressively add more control variables, while columns 4-6 include indicators for six regions as defined by the 1900 Census⁴⁰. The reported coefficients are not hazard ratios but coefficients which are interpreted below.

Table 1 indicates that some of the statistically significant correlations in Columns 1-3 become statistically insignificant when we include region fixed effects, in Columns 4-6. This is true of PERCENT US BORN, MEAN PRECIP, and MEAN ELEVATION. Most of the variation in these variables is across, rather than within, regions. This makes it difficult for the model to separately identify the contribution of these covariates to the hazard rate of wildlife agency formation, independent of other factors that varied across regions.

Several coefficients are statistically significant with and without region fixed effects. UNIMPROVED FARM ACRES is associated with an increasing hazard, and hence an earlier year of agency creation. The point estimates imply that a 10 percent increase in unimproved farm acres is associated with an 8% to 22% increase in the rate of agency creation, based on the smallest and largest coefficients (0.77 in Column 1 and 2.18 in Column 6). In the following section, we provide evidence that unimproved farmland accelerated the timing of agency creation because trespass was generally not enforceable on unimproved lands.

NUMBER FARMS > 1000 ACRES is associated with a later year of agency creation as the model predicts. The point estimates imply that a 10 percent increase in the number of farms exceeding 1000 acres is associated with a 5% to 15% decrease in the rate of agency creation, based on the smallest and largest coefficients (Column 1 and 5). These findings are consistent with less demand for agency creation when fewer landowners would need to contract over wildlife control.

⁴⁰ The estimation method is a Cox regression using the 'Breslow Method' for ties.

Table 1: Duration Model Estimates of Wildlife Agency Creation, 1870-1920

	(1)	(2)	(3)	(4)	(5)	(6)
Land Variables (logged)						
NON-FARM ACRES	0.026 (0.159)	0.011 (0.192)	0.116 (0.225)	0.128 (0.260)	0.015 (0.438)	0.024 (0.411)
IMPROVED FARM ACRES	-0.046 (0.217)	-0.065 (0.253)	0.050 (0.330)	0.772 (0.516)	0.827 (0.730)	0.945 (0.820)
UNIMPROVED FARM ACRES	0.777* (0.397)	0.943* (0.487)	0.938* (0.491)	1.820*** (0.676)	1.960** (0.778)	2.181** (0.880)
FARMS > 1000 ACRES	-0.508** (0.239)	-0.568** (0.289)	-0.521* (0.304)	-1.326*** (0.380)	-1.540*** (0.374)	-1.380*** (0.371)
Demographics						
LOG OF TOTAL POPULATION	0.134 (0.360)	-0.028 (0.488)	-0.617 (0.589)	-0.494 (0.700)	-0.370 (1.013)	-1.038 (1.458)
PERCENT URBAN POP	0.015 (0.016)	0.009 (0.022)	0.022 (0.024)	0.040* (0.021)	0.045 (0.029)	0.048 (0.034)
PERCENT US BORN	-0.075*** (0.017)	-0.036 (0.023)	-0.064** (0.027)	-0.030 (0.028)	-0.023 (0.044)	-0.054 (0.043)
SPORTSMEN GROUP		-0.338 (0.368)	-0.273 (0.388)		-1.103** (0.477)	-0.633 (0.687)
Setup Costs and State Capacity						
% OF REGION WITH WILDLIFE AGENCY		1.777*** (0.572)	1.752*** (0.636)		2.061*** (0.774)	2.307*** (0.773)
NUMBER OF NON-WILDLIFE AGENCIES		0.521** (0.211)	0.603*** (0.207)		0.699** (0.272)	0.689** (0.278)
Geographic Variables (logged)						
MEAN PRECIP			2.748*** (1.065)			2.367 (2.192)
MEAN ELEVATION			0.796* (0.435)			0.099 (0.523)
REGION FIXED EFFECTS	No	No	No	Yes	Yes	Yes

Notes: The coefficients are shown, not hazard rates. Standard errors adjusted for clusters in the 48 states, p-values in parentheses. * p<0.1, ** p<0.05, *** p<0.01. There were 47 'failures' out of 48 states and all regression include 1336 observations. The regressions employ the 9 regions defined in the 1890 Census. Region 1 is CT, ME, NH, VT, MA, RI. Region 2 is NJ, NY, PA. Region 3 is IL, IN, MI, OH, WI. Region 4 is IA, KS, MN, MO, NE, ND, SD. Region 5 is DE, VA, FL, GA, NC, SC, MD, WV. Region 6 is AL, MS, KY, TN. Region 7 is AR, LA, TX, OK. Region 8 is AZ, CO, ID, MT, NV, NM, UT, WY. Region 9 is CA, OR, WA.

Both state capacity variables are statistically important. The point estimates on % of Region with Wildlife Agency indicate that an increase in the proportion of neighboring states with a wildlife agency of 0.1 is associated with an increase in the hazard rate of agency creation of 17% to 23%. Increases in the Number of non-Wildlife Agencies is also associated with an earlier agency. The point estimates indicate

that an increase in the number of non-wildlife agencies (e.g., forestry, fish, parks, etc) of one is associated with a 52% to 69% increase in the hazard rate of agency creation. These findings indicate that wildlife agencies were more likely to be created when states had the administrative capacity to manage the large-scale asset.

None of the demographic variables are robustly significant in Table 2. In contrast to Mulligan and Shleifer (2005), more populated states are not associated with earlier state agencies, at least not after controlling for the other determinants. Although Tober (1981) and others emphasized the potential importance of demographics to wildlife agency creation (e.g., urban vs. rural populations and US vs. foreign-born populations), we find no statistical evidence of systematic relationships. Instead, the timing of agency creation is explained best by land ownership patterns and state capacity.

D. Robustness and Placebo Tests

One of the key findings is that large private landholdings – those greater than 1000 acres – delayed the timing of wildlife agency creation. The 1,000-acre threshold is somewhat arbitrary, however. As shown in Table A1 of the appendix, the results are robust to other definitions of ‘large farms.’ The coefficients are actually larger (in absolute value), and measured with more precision, if we consider ‘large’ farms to be those greater than 500 acres rather than 1,000 acres. We also find similar relationships when we measure landowner-contracting costs with the average farm size rather than the number of farms over 500 or 1000 acres.⁴¹

As an additional robustness check, we estimate linear probability models (LPM) using cross-sectional data for 1890 and 1900. The dependent variable is an indicator for whether or not a state had a wildlife agency in those years. Appendix Table A3 shows the results. The findings are consistent with the duration model in that increases UNIMPROVED FARM ACRES and % OF REGION WITH WILDLIFE AGENCY are associated with an increased probability of an agency and increases in NUMBER FARMS > 1000 ACRES is associated with a decreased probability of an agency. The LPM estimates also show that these factors

⁴¹ When including multiple measures of farm size (e.g., farms over 1000 acres and farms over 500 acres), the coefficients sometimes become insignificant due to the high collinearity of the measures.

had a smaller effect in 1900 compared to 1890. For example, a 100 percent increase in the number of large farms is associated with a 15 and 19 percentage point decrease in the probability of a wildlife agency in 1890 and 1900, respectively. The mean probability of an agency was 0.23 in 1890 and 0.63 in 1900. The estimates, thus imply that a 100 percent increase in 1890 was associated with a $0.15/0.23 = 65\%$ decrease in the probability of an agency compared to a $0.19/0.63 = 30\%$ decrease in the probability of an agency in 1900.

To assess the extent to the results show spurious correlations, we conducted a series of placebo tests. In these tests, we switch the dependent variable to signify the timing of the creation of agencies for public health, agriculture, inland fisheries, forests, and parks. Table 2 shows the placebo estimates, which can be compared with wildlife agency duration estimates from Column 1 in Table 1.

Table 2: ‘Placebo’ Duration Model Estimates of non-Wildlife Agency Creation, 1870-1920

	Wildlife	Inland Fish	Forests	Agriculture	Health	Parks
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Land Variables (logged)</i>						
NON-FARM ACRES	0.264	-0.526**	0.263	0.113	-0.209	-0.401
IMPROVED FARM ACRES	0.560	0.758**	-0.011	-0.184	-0.891***	-1.183
UNIMPROVED FARM ACRES	1.645**	0.668	0.581	0.228	0.238	-0.445
FARMS > 1000 ACRES	-1.326***	-0.376*	-0.179	0.136	0.067	-0.130
<i>Demographics</i>						
LOG OF TOTAL POPULATION	-0.234	-0.634	-0.265	0.331	1.386**	2.382**
PERCENT URBAN POP	0.034	-0.008	-0.014	-0.015	-0.033	-0.015
PERCENT US BORN POP	-0.027	-0.066**	-0.014	0.006	-0.159***	-0.041
<i>Setup Costs and State Capacity</i>						
% REGION W/ RELEVANT AGENCY	2.392***	4.330***	5.250***	4.104***	4.378***	6.322***
NUMBER OF OTHER AGENCIES	0.504**	0.656**	0.275	0.226	0.712**	0.552
REGION FIXED EFFECTS	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1336	597	1734	728	653	2153
# of States with ‘Failure’/Subjects	47/48	47/48	37/48	46/48	48/48	19/48

Notes: The coefficients are shown, not hazard rates. Standard errors, not shown, are adjusted for clusters in the 48 states. * p<0.1, ** p<0.05, *** p<0.01.

The placebo tests detect no systematic relationships between the land ownership (contracting cost) variables and the timing of non-wildlife agency creation. The one exception is the finding that inland fish

agencies were created later in states with large landholdings. This is not surprising for two reasons. First, some inland fish agencies were created concurrently with wildlife agencies. Second, the open access issues with unimproved farmland, and the contracting cost problems associated with small farms, should also effect the demand for a fishery regulatory institution. The null results on the placebo tests strengthen the case that contracting costs played a causal role in affecting wildlife agency creation rather than being spuriously related to omitted factors at the state-year level that generally led to the creation of state-level administrative agencies. Setup cost and state capacity variables also explain the timing of non-wildlife agency creation. This is as expected because the contribution of these variables to agency timing is not specific to the wildlife resource. Consistent with Mulligan and Shleifer (2005), we also find that certain agencies emerged earlier in higher populated states (state health and state parks).

E. The Role of Trespass Laws

Our theoretical model, and the historical narrative of 19th century American wildlife depletion, suggests that weak trespass laws - and weak enforcement of any strong laws that existed - interacted with land ownership patterns to frustrate private management and motivate wildlife agency creation. A tempting approach for estimating the importance of trespass laws would be to include variables quantifying state trespass laws as independent variables in the Table 1 estimates of agency timing. Trespass laws, however, may be endogenous to land ownership patterns (e.g., IMPROVED FARM ACRES, UNIMPROVED FARM ACRES, and FARMS > 1000 ACRES) especially if landowners with improved and large landholdings lobbied for strong protection against trespass. Our approach is to estimate duration models to test for the endogenous influence of land ownership patterns on trespass laws. The trespass data, summarized in Table A4 of the appendix, list four categories of laws, ordered from weakest to strongest.⁴²

Table 3 shows Cox model estimates of state trespass law changes. The dependent variable in Columns 1-2 is zero until a state passed a statute that requires landowner permission for access. By 1920,

⁴² These are 1) Open Access (unenclosed and uncultivated private lands are open access even if posted; 2) Access to All Lands Absent Posting (posting required to keep hunters off any private land); 3) Access to Unenclosed/Uncultivated Land Absent Posting (posting required only to keep hunters off of unenclosed or

14 states had statutes requiring landowner permission. The dependent variable in Columns 3-4 is zero until a state passed a trespass statute of any kind. By 1920, 41 states had a trespass statute. (The dependent variable in Columns 5-6 is zero until a state passed a statute explicitly expressing open access as the law. As of 1920, 20 states had such laws (which later changed to favor landowners in the years that followed 1920).

Table 3: Duration Model Estimates of Trespass Laws, 1870-1920

	Y = 1 if Statute Requires Permission		Y= 1 if Any Statute Exists		Y= 1 if Statute Permits Open Access	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Land Variables (logged)</i>						
NON-FARM ACRES	-0.774* (0.451)	-0.878 (0.586)	-0.536*** (0.169)	-0.764** (0.336)	-0.123 (0.312)	-0.951* (0.511)
IMPROVED FARM ACRES	2.069*** (0.543)	3.299* (1.687)	0.534** (0.240)	0.129 (0.619)	0.048 (0.469)	0.779 (0.979)
UNIMPROVED FARM ACRES	-2.278*** (0.603)	-4.348*** (1.566)	0.655 (0.436)	0.937 (0.620)	1.455* (0.778)	2.260** (1.110)
FARMS > 1000 ACRES (1890)	0.600 (0.503)	0.475* (0.261)	-0.120 (0.226)	-0.374 (0.308)	-0.115 (0.230)	-0.886** (0.426)
<i>Demographics</i>						
LOG OF TOTAL POPULATION	0.417 (0.640)	2.732** (1.105)	-0.662* (0.360)	0.061 (0.552)	-0.727 (0.586)	-0.251 (0.964)
PERCENT URBAN POP	-0.018 (0.048)	-0.092** (0.046)	0.011 (0.019)	-0.011 (0.026)	-0.019 (0.030)	-0.052 (0.033)
PERCENT US BORN POP	0.059 (0.039)	0.027 (0.061)	0.023 (0.020)	0.000 (0.033)	-0.012 (0.035)	-0.015 (0.051)
SPORTSMEN GROUP	-0.922 (0.851)	-1.770 (1.452)	-0.218 (0.378)	-0.087 (0.605)	0.794 (0.541)	0.409 (0.660)
REGION FIXED EFFECTS	No	Yes	No	Yes	No	Yes
Observations	1921	1921	1090	1090	1702	1702
# of States with 'Failure'/Subjects	14/48	14/48	41/48	41/48	20/48	20/48

Notes: Coefficient estimates, not hazard rates are shown. Standard errors adjusted for clusters in the states, p-values in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

The results suggest that land ownership affected trespass laws. First, more acres of improved farmland is associated with earlier adoption of statutes that explicitly required landowner permission. Second, more acres in unimproved farmland were associated with later (or no) adoption of statutes that explicitly require landowner permission, and with earlier adoption of statutes that explicitly permit open

uncultivated land); and 4) Permission-Based Access (landowner permission required to hunt on any private land). Sigmon (2004) discusses the legal history of wildlife trespass.

access. Third, the number of large farms is weakly associated with earlier adoption of statutes that require landowner permission and later (or no adoption) of statutes that explicitly permit open access. In broad terms, the collection of results suggest trespass laws were created to reinforce private wildlife control where land was improved and farms were large, or to reinforce public control where land was not improved and farms were small.

VI. EMPIRICAL TESTS OF AGENCY SIZE AND EXTENT

To test the theoretical implications about agency budget size (B1 through B5), we employ a panel data set spanning five-year intervals from 1952-2007. To examine agency budget allocation towards non-game, we use data from 1986, 1992, and 1998

A. Data Description

For the period spanning 1952 to 2007, we have collected annual data on the state fish and wildlife budgets and similar annual data for state parks, forests, and public health agencies.⁴³ These data come from U.S. Census surveys of state government finances. Total expenditures over this period range from \$1.4 million to \$489 million, in inflation adjusted 2007 dollars (see appendix Table A4). Appendix Figure A2 shows that an increasing amount of the revenue to finance expenditures is now coming from state general appropriations, rather than hunting and fishing license sales.

To measure land and habitat, we have collected data on total state area, acres owned by federal agencies, and acres in farms. The data on federal landholdings come from Public Lands Statistics and Census reports for 1944, 1970, 1980, 1990, and 2001- 2007 for this variable.⁴⁴ We treat the FEDERAL ACRES variable as time invariant because the reported changes over time have been minor compared to the wide

⁴³ Our model implicitly treats ‘budgets’ and ‘expenditures’ as the same, but the data we have consistently reports expenditures rather than revenues, so our empirical analysis focuses on expenditures.

⁴⁴ The U.S. Dept. of Interior published annual “Public Land Statistics Reports in recent years (see www.blm.gov/about/data/public-land-statistics). State-level data on public land also come from tables in U.S. statistical abstract reports of the U.S. Census Bureau, and, in some cases, from reports of the land holding agencies.

variation in federal acres across states. Federal land comprises less than one percent of total area in five states and more than 50 percent in five western states, with a maximum over 85 percent in Nevada.

The data on farm acres come from the Agricultural Census reports (downloaded from Haines et al. 2010) and include total acres in farms, the number of ‘large farms’ (e.g., those exceeding 1000 and 500 acres), and average farm size by state. These data were generally collected in five-year intervals over 1950 to 2010 (e.g., 1982, 1987, 1992, 1997, 2002, and 2005). As Figure A3 highlights, there was stark growth in the farm acres and, especially, average farm size over 1950-2010. Farm acreage fell after 1960 while average farm size, doubled – from less than 200 acres to over 400 acres. These time patterns, which differ across states, provide important empirical variation in landowner contracting costs that our econometric analysis exploits. As Sumner (2014) emphasizes, these changes in farm sizes are driven by technological changes in agricultural processes that have differentially affected regions and states. These processes appear to be exogenous to changing demand for wildlife recreation over time and across states.

To measure state capacity, we use annual data on each state’s total revenue.⁴⁵ These data come from U.S. Census surveys of state government finances. We also employ annual data on state populations and per-capita incomes, from the U.S. Bureau of Economic Analysis.

Some wildlife agencies are autonomous, free-standing entities whereas others are embedded within larger and hierarchical natural resource departments. These organizational differences might affect wildlife agency budgets and resource allocation. To account for this possibility, we use an indicator variable – AUTONOMOUS AGENCY – to denote the case in which the agency is autonomous rather than part of a hierarchy. This variable has a mean of 0.46 indicating that nearly half of the agencies were autonomous over 1952-2007. These measures are time variant, because, over time, wildlife agencies have tended to be combined into large hierarchies.

Data on non-game expenditures, available for 1986, 1992, and 1998 come from surveys on *State Wildlife Diversity Program Funding* conducted by the Audubon Society, Defenders of Wildlife, and an

⁴⁵ Pinotti (2012) measures state capacity in a similar way.

International Association of Fish and Wildlife Agencies. The percentage of expenditures spent on nongame species over 1986-1998 ranges from zero in two states (Mississippi and New Hampshire in 1986) to 39 percent (in Hawaii, which is an outlier) and the mean is 4.4 percent. Overall, however, the trend is towards more focus on non-game. For example, the mean percent of expenditures was 5.4 in 1998 compared to 3.0 in 1986. Because only four states had nongame programs before 1970, the mean around that time was presumably close to zero.

The empirical analysis of the wildlife agency budgets and allocation use a slightly different set of explanatory variables than used in the analysis of agency timing. There are two reasons for this difference. The first reason stems from data availability: some measures, such as federal ownership of land and state-level tax revenues were not systematically collected over 1870 to 1920. The second reason is economic relevance. Some variables, such as the number of regional states with a wildlife agency, the number of non-wildlife agencies in a state, and the amount of uncultivated farmland are relevant for the study of agency creation but not for the study of modern agency expenditures. Other variables, such as the organization structure of environmental and resource agencies within a modern state government, are relevant for the study of modern expenditures but not for the study of agency creation.

B. Estimates of Agency Expenditures

Using the 1952-2007 panel data, we estimate equations (11) and (12). In both cases, the dependent variable is the log of the agency's budget.⁴⁶

$$(11) \quad \ln B_{st} = \alpha_s + \theta_t + \pi Landownership_{st} + \delta X_{st} + \varepsilon_{st}$$

$$(12) \quad \ln B_{st} = \theta_t + \pi Landownership_{st} + \delta X_{st} + \gamma Z_s + \varepsilon_{st}$$

The notation s refers to the 48 states (excluding Alaska and Hawaii) and the notation t refers to each year, spanning five-year intervals over 1952 to 2007, so that B_{st} is the wildlife budget for state s in year t . The notation X_{st} refers to time variant controls (e.g., population, per-capita income, and total state revenues) and the notation Z_s refers to time invariant variables such as state total acreage. The notation θ_t

⁴⁶ This means fish and game expenditures either as an autonomous agency or a division within a hierarchy.

refers to the year fixed effects, which we include for each of the 12 years to control for trends in fish and wildlife demand and other time-related factors. In some specifications we also control for region fixed effects and region-specific year effects to capture some trends in wildlife demand and habitat changes that vary across regions.

Equation (11) differs from equation (12) because (11) allows each state to have its own intercept, by including state fixed effects. Hence, the key coefficients π in (11) measure relationships between land ownership and budgets based on within state variation over time in factors such as farm composition and income per capita). By contrast, the coefficients π in (12) measure relationships between wildlife agency budgets based on both cross-state and within-state time variation. Equation (11) is a better design for identifying the causal effects of land ownership because unobservable, time invariant differences across states (e.g., mix of wildlife species endemic to an area) are absorbed by the state fixed effects. We show the pooled regressions of equation (12), however, to demonstrate relationships between time-invariant variables (and relatively time invariant variables) and state budgets such as federal land ownership and state area.

Table 4 shows estimates of (11) and (12). Variables that we treat as time invariant – total acres, federal acres, mean precipitation, and mean elevation – are dropped in Columns 1-3 because of the inclusion of state fixed effects.⁴⁷ All standard errors are clustered by state, to account for possible serial correlation within states over time. Because the independent and dependent variables are logged, the coefficient estimates have elasticity interpretations.

The estimated specifications employ each of the three substitute measures of farm size. Comparing the results across Columns 1-3 versus Columns 4-6, we note the following patterns. First, in both sets of estimates there is evidence that lower landowner contracting costs, as measured by the prevalence large farms, are associated with smaller wildlife budgets as the theory predicts. In Columns 1-2, we find that agency budgets decrease by an amount ranging from 1 to 2.5 percent with a 10 percent increase in the

⁴⁷ To force the federal land and farm variables into years for which we lack data from those variables, we impute missing values by imposing linear growth between data points

number of farms exceeding 1,000 and 500 acres. Column 3, however, shows no correlation between changes in average farm size and changes in wildlife agency budgets. By contrast, wildlife agency budgets in the pooled regression estimates of Columns 4-6 are negatively related to changes in average farm size, but not with the number of farms exceeding 1,000 and 500 acres. In Column 6, a 10 percent increase in average farm size across states is associated with a 2.3 percent decline in agency budgets.

Table 4: Panel Estimates of Agency Expenditures on Wildlife, 1952-2007

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Land Variables (logged)</i>						
TOTAL ACRES				0.348 (0.292)	0.343 (0.289)	0.377 (0.275)
FEDERAL ACRES				0.157** (0.060)	0.155** (0.060)	0.161*** (0.057)
FARM ACRES	0.364*** (0.133)	0.286** (0.138)	0.192 (0.165)	-0.054 (0.156)	-0.097 (0.175)	-0.031 (0.145)
FARMS > 1000 ACRES	-0.097** (0.041)			-0.019 (0.071)		
FARMS > 500 ACRES		-0.107* (0.062)			0.017 (0.103)	
AVERAGE FARM ACRES			0.257 (0.201)			-0.228** (0.094)
<i>State Capacity</i>						
LOG OF STATE REVENUE	0.435*** (0.155)	0.347*** (0.089)	0.345** (0.167)	0.573*** (0.208)	0.569*** (0.206)	0.587*** (0.195)
<i>Controls (all logged)</i>						
AUTONOMOUS	-0.039 (0.068)	-0.035 (0.065)	-0.049 (0.069)	0.065 (0.103)	0.070 (0.108)	0.113 (0.105)
POPULATION	-0.027 (0.135)	0.095 (0.131)	0.249 (0.171)	-0.223 (0.191)	-0.207 (0.189)	-0.294 (0.183)
PER CAPITA INCOME	0.767** (0.311)	0.648*** (0.177)	0.752** (0.302)	0.863** (0.331)	0.843** (0.329)	0.966*** (0.289)
MEAN PRECIPITATION				0.569*** (0.199)	0.540** (0.213)	0.224 (0.260)
MEAN ELEVATION				-0.010 (0.074)	-0.007 (0.067)	-0.056 (0.073)
CONSTANT	-9.253** (4.204)	-6.990** (2.709)	-11.035** (4.713)	-11.486** (4.488)	-9.465** (3.628)	-8.996*** (2.557)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	576	576	576	576	576	576
Adjusted R-squared	0.800	0.781	0.799	0.806	0.806	0.814

Notes: * p<0.1, ** p<0.05, *** p<0.01. All standard errors are clustered at the state level. The balanced panel data cover 5-year intervals from 1952-2007 with t = 12 time periods and s = 48 states. The variables TOTAL ACRES, FEDERAL ACRES, MEAN PRECIPITATION, and MEAN ELEVATION are dropped from Columns 1-3 because we treat the variables as time invariant.

Why do wildlife agency budgets respond to the number of farms exceeding 1,000 and 500 acres in the estimates with state fixed effects and to average farm size in the estimates without state fixed effects? Can both results be consistent with theory? First, we argue that, in pooled analysis, average farm size is probably a better proxy for landowner contracting costs because it is a more continuous when compared to ‘large farm’ measures that rely on 1,000- and 500-acre thresholds. Hence, the Column 6 result, which is consistent with theory, is probably more meaningful than the null findings in Columns 4 and 5. Average farm size is a less precise measure of contracting costs in the analysis with state fixed effects, however, because identification in that analysis is based on wildlife budget responses to changes in farm composition over short, 5-year intervals. Our concern is that 5-year changes in average farm size are driven by subdivision dynamics for suburban development, which would have an effect on wildlife habitat independent of contracting costs. By contrast, 5-year changes in the number of 1,000 or 500 acre farms should mainly reflect the changing structure of agriculture, which should not have an effect on habitat that is independent of contracting costs.

In terms of the other variables, our measure of state capacity is positively associated with wildlife agency spending with or without state fixed effects. A 10 percent increase in total state revenue is associated with a 3.5 to 5.9 percent increase in wildlife agency budgets. A state’s per-capita income is also strongly associated with wildlife agency spending: a 10 percent increase is associated with a 6.5 to 9.8 percent increase in agency budgets.

The Column 4-6 estimates show that more acreage in a state is associated with larger budgets, and this relationship is driven partly by federal acreage. As our basic model of agency size implied, more open access federal land will increase the size of an agency. A 10 percent increase in federal land is associated with an approximate 1 to 1.5 percent increase in wildlife agency expenditures. State populations have no significant association with fish and wildlife expenditures, perhaps because the larger demand induced by larger populations is offset by habitat loss associated with more people.

C. Robustness and Placebo Tests

To examine the robustness of the results, we have replicated the panel model specifications in Columns 1-3 of Table 4 but added region-specific year effects. These estimates are reported in Table A5 of the appendix and they control for some potential time trends in wildlife demand or wildlife habitat that may be similar within regions. We have also replicated the pooled model specifications of Columns 4-6 of Table 4 but added region fixed effects to control for possible omitted variables that vary across regions (e.g., suitability of land for wildlife habitat). Adding these fixed effects controls for some of the time-varying omitted variables across states. In general, the adding the region-specific year effects and the region fixed effects strengthens evidence supporting the theory.

As with our analysis of agency timing, we conducted a series of placebo tests of state agency expenditures on public health and hospitals, agriculture, parks, and forestry. These estimates are shown in Appendix Table A7 and mimic the state-fixed effects specifications in Column 1 of Table 4 and the pooled specifications of Column 6 in Table 4. The results indicate that our main theoretical ideas for landowner contracting costs - and the empirical measures of those costs - are not relevant for explaining agency expenditures on health, agricultural, or parks. For example, an increase in the number of large farms is associated with *larger* agricultural budgets (as opposed to *smaller* wildlife agency budgets as shown in Table 4). However, we do find that state forestry agency expenditures respond negatively to changes in the number of large farms, and to increases in average farm size. Although we do not have specific theory or data set to examine forestry agencies in detail, we note that private management of factors such as wildfire prevention, tree disease, and timber reseedling may require landowner coordination that becomes more costly when private land holdings, including tree farms, tend to be small.

C. Proportion of Budget Spent on Non-Game

Our theoretical discussion implies that landowner contracting costs should affect state agency expenditures on game management relative to expenditures on non-game management because it is difficult for private landowners to profit from non-game (which is like a public good), even with relatively low landowner contracting costs. The implication is that the proportion of agency expenditures on non-game

should increase with contracting costs. To test that prediction, we estimate the total amount of non-game spending and the proportion of the budget spent on non-game using a pooled regression model spanning the years 1986, 1992, and 1998 using data discussed above. For this analysis there are only 142 observations because some states did not report their non-game spending in particular years.

Table 6: Pooled Regression Estimates of Nongame Expenditures, 1986, 1992 & 1998

	Y= ln(Nongame Spending)		Y = % of Spending on Nongame	
	(1)	(2)	(3)	(4)
<i>Land Variables (logged)</i>				
TOTAL ACRES	-0.303 (0.604)	-0.256 (0.519)	-0.029 (0.026)	-0.041* (0.023)
FEDERAL ACRES	0.008 (0.290)	0.189 (0.283)	-0.001 (0.012)	-0.001 (0.013)
FARM ACRES	0.350*** (0.123)	0.309** (0.146)	0.006 (0.007)	0.012 (0.009)
AVERAGE FARM ACRES	0.530** (0.219)	0.437 (0.265)	0.049*** (0.017)	0.063*** (0.019)
<i>State Capacity</i>				
LOG OF STATE REVENUE	0.820 (0.567)	0.470 (0.609)	0.010 (0.040)	0.004 (0.040)
<i>Controls (all logged)</i>				
AUTONOMOUS	-0.236 (0.199)	-0.179 (0.204)	-0.015 (0.011)	-0.013 (0.011)
POPULATION	-0.037 (0.599)	0.253 (0.673)	0.023 (0.041)	0.037 (0.042)
PER CAPITA INCOME	1.397 (1.145)	0.522 (1.080)	0.014 (0.063)	-0.056 (0.066)
MEAN PRECIPITATION	0.916 (0.641)	1.294* (0.674)	0.044 (0.030)	0.071* (0.042)
MEAN ELEVATION	0.145 (0.195)	-0.038 (0.182)	0.010 (0.008)	0.007 (0.009)
CONSTANT	-19.002 (13.403)	-11.011 (13.505)	-0.671 (0.720)	-0.053 (0.770)
Region fixed effects	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes
Observations	141	141	142	142
Adjusted R-squared	0.614	0.658	0.242	0.303

Notes: * p<0.1, ** p<0.05, *** p<0.01. All standard errors are clustered at the state level. The panel is slightly unbalanced because a few states did not report their nongame spending in each year of the survey. Here t = 3 time periods (1986, 1992, and 1998) and s = 48 or 47 states, depending on the year. As with Table 2, the estimates here employ the 9 regions defined in the 1890 Census. Region 1 is CT, ME, NH, VT, MA, RI. Region 2 is NJ, NY, PA. Region 3 is IL, IN, MI, OH, WI. Region 4 is IA, KS, MN, MO, NE, ND, SD. Region 5 is DE< VA, FL, GA, NC, SC, MD, WV. Region 6 is AL, MS, KY, TN. Region 7 is AR, LA, TX, OK. Region 8 is AZ, CO, ID, MT, NV, NM, UT, WY. Region 9 is CA, OR, WA.

Table 6 shows the coefficient estimates. The dependent variable in Columns 1-2 is the log of non-game spending.⁴⁸ The dependent variable in Columns 3-4 is the proportion of total spending on non-game. Columns 2 and 4 include region fixed effects whereas Columns 1 and 3 do not. We do not include state fixed effects because there is relatively minor within-state variation in the dependent and key explanatory variables over 4-year intervals within this 12-year period. Because this is a pooled analysis, we measure farm ownership composition with average farm acres for reasons discussed above in the context of Table 4.

The key finding in Table 6 is that landowner contracting costs, as measured here by average farm size, is positively associated with the proportion of budgets spent on nongame as implied by the theoretical framing. The point estimates imply that a 10 percent increase in average farm size is associated with a 0.0049 to 0.0063 increase in the proportion of spending on non-game. These are large coefficients relative to the mean of the dependent variable, which is 0.044. They imply a 10 percent increase in average farm size is associated with an 11 – 14 percent increase in the dependent variable, relative to the mean. The finding that proportion nongame spending rises with larger landholdings suggests large landholdings may facilitate private management of game species (e.g., deer) to a greater extent than they facilitate private management of non-game species (e.g., lizards, bats, turtles). This is intuitive because non-game species lack the private value held by hunters for game species. Generally, the findings suggest that public-goods demand for agency management would persist even if the private landowners could profitably manage game animals.

V. CONCLUSION

Government agencies manage and regulate important environmental assets, but there has been little systematic research on the factors determining their creation, evolution, and size. This paper addresses this void by studying the origins, size, and focus of one of America's first environmental protection agencies.

⁴⁸ For the two observations for which non-gaming spending is zero, we have added a one before making the log transformation.

In particular, we study the emergence of U.S. state wildlife agencies from their inception in colonial game laws of the 1700s to their manifestation as modern hierarchical environmental agencies.

Our focus is on the problem of managing a large-scale environmental asset that spans small private landholdings, so the demand for an agency increases with the costs of landowner coordination to control the asset, but also depends on state capacity. Our econometric results supports qualitative evidence from economic history: both suggest that state wildlife agencies emerged in response to the high costs of controlling a landscape scale asset: mobile wildlife.

The decimation of wildlife resulted from open access to land and wildlife. Game laws existed during the 19th century but they were weakly enforced, especially against private landowners hunting on their own land. Private efforts at wildlife conservation occurred, but not at a large scale, presumably because the costs of private provision were very high due to small and uncultivated landholdings, weak trespass laws, and uncertainty over how much management and policing powers were held by landowners. Wildlife agencies emerged to clarify and consolidate enforcement authority and were likely necessary to stop the decimation.

Our analysis suggests the wildlife agency solution was not equally needed in all states at all times during the late 19th and early 20th century. Moreover, the evidence suggest the wildlife agency solution – at least for game management - has become less needed in some states over time, as trespass laws have strengthened and rural landholdings have grown in size. Demand for agency management of nongame species (a kind of public good) remains relatively large in modern times, however. We argue this is because private contracting is fundamentally less effective for these species, which is evidenced by their prevalence to be listed as endangered while game populations, such as deer, have prospered (see, e.g., Ando 1999).

More generally this study has advanced an empirical approach to the study of public bureaucracy by focusing on the particular tasks of state agencies. State agencies offer a rich and varied laboratory for studying public agencies that is not available for federal agencies. Our focus here on wildlife agencies is but one application and our focus on the governance of large-scale environmental assets suggest that

understanding public agencies requires a topic specific understanding of agencies and that the economics of bureaucracy can be enhanced by attention to institutional details.

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VII. APPENDIX

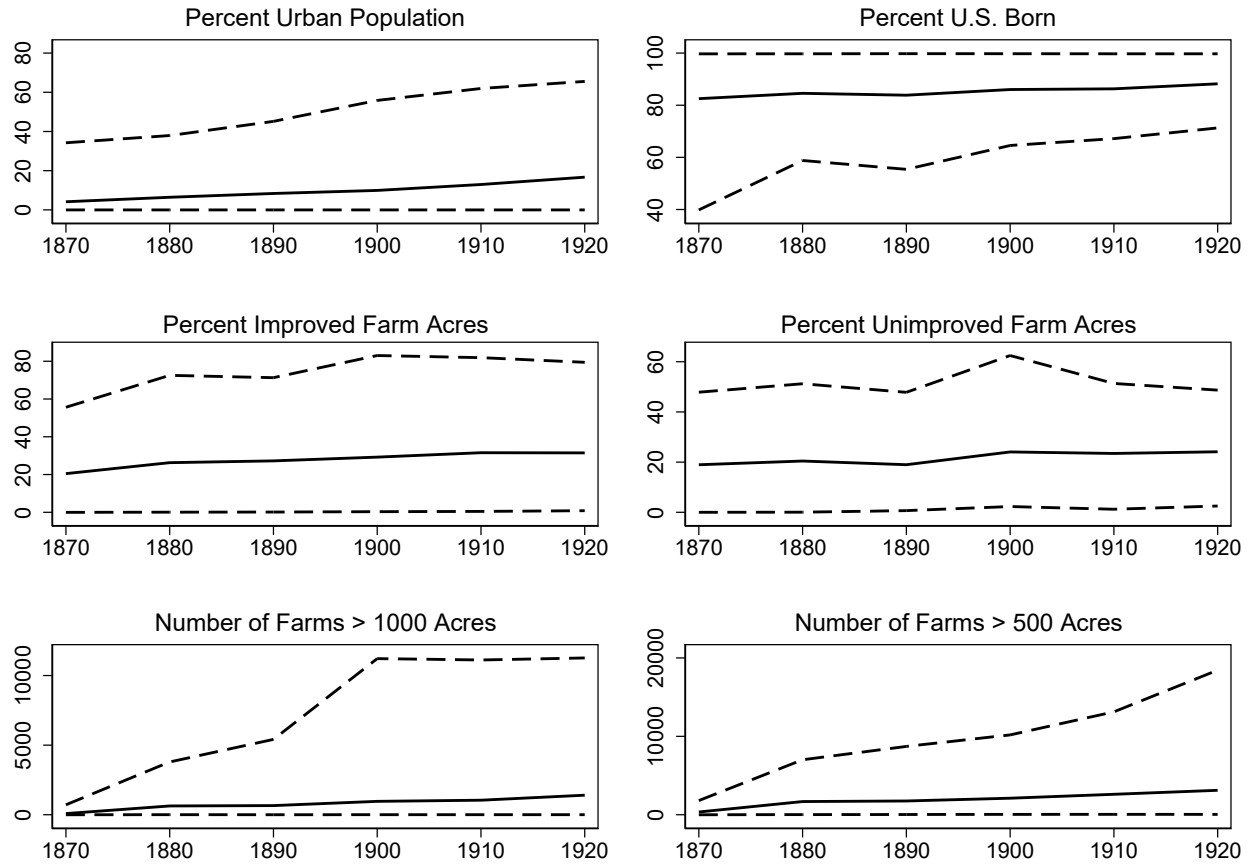


Figure A1: Mean, Minimums, and Maximums for Key Duration Analysis Variables

Notes: The plots show means (solid line) and minimums and maximums (dashed lines) for each state-year combination over 1870-1920.

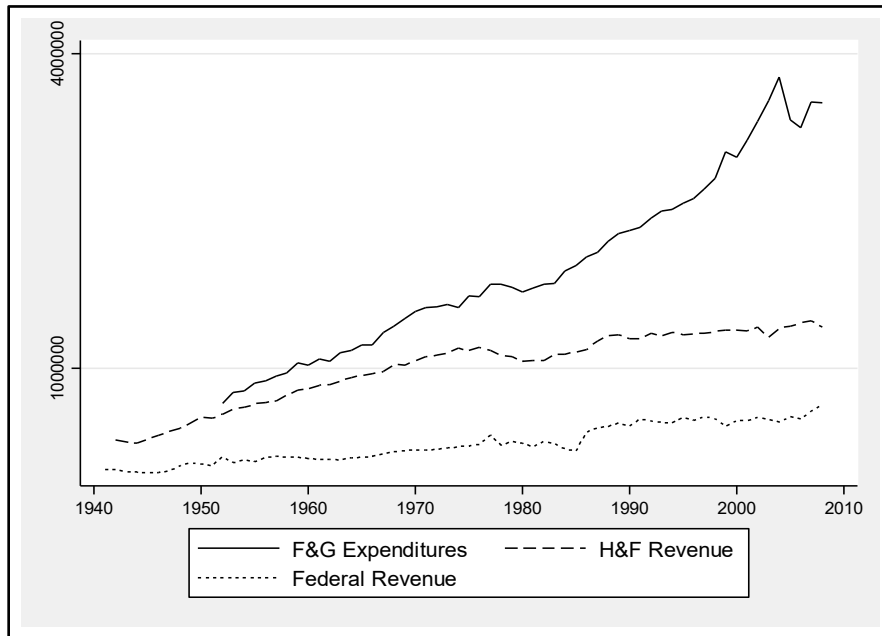


Figure A2: Aggregate Wildlife Agency Expenditures and Revenue Sources, 1940-2010.

Notes: The vertical axis is in thousands of 2008 dollars (e.g., the range is from 1 to 4 billion). F&G denotes expenditures on fish and game and H&F denotes revenue from hunting and fishing sales.

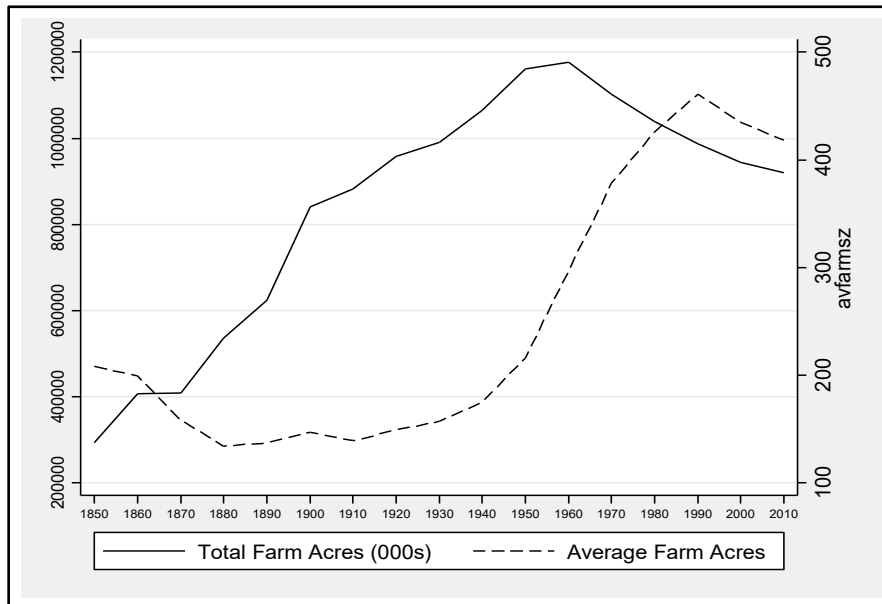


Figure A3: Agricultural Land, 1850-2010.

Source: Statistical abstracts of the U.S. and National Census of Agriculture for various years.

Table A1: Summary Statistics for Duration Analysis

	Mean	St. Deviation	Minimum	Maximum
Land Variables				
NON-FARM ACRES (000s)	26175	28453	162.3	151603
IMPROVED FARM ACRES (000s)	6930.4	6696.6	0.338	28556
UNIMPROVED FARM ACRES (000s)	7006.5	10255	4.003	106230
FARMS > 1000 ACRES ⁺	704.48	1282.8	0	11220
FARMS > 500 ACRES ⁺	1789.7	2068.1	0	12038
AVERAGE FARM ACRES	183.65	173.40	24.80	1301
Demographics				
TOTAL POPULATION (000s)	1194.5	1089.5	9.118	5814.8
PERCENT URBAN POP	5.855	10.55	0	43.71
PERCENT U.S. BORN POP	86.74	11.92	39.85	99.77
SPORTSMEN GROUP	0.485	0.499	0	1
Setup Costs and State Capacity				
% OF REGION WITH WILDLIFE AGENCY	12.62	23.91	0	100
NUMBER OF NON-WILDLIFE AGENCIES	1.797	1.153	0	5
Geographic Variables				
MEAN PRECIP (INCHES)	38.68	14.85	9.5	60.1
MEAN ELEVATION (FEET)	1684.1	1891.2	60	6800

Notes. There are 1336 state-year observations for all variables. + For a small number of state-year combinations, there are zero farms greater than 1000 and 500 acres. In these cases we have added a “1” before logging so that the log of the variable is defined. The variables are described and defined in the text. Three states – Oklahoma, North Dakota, and South Dakota - enter the duration analysis data set in 1890 because the agricultural census first reported land data for these states and territories in 1890.

Table A2: Robustness of Survival Model Estimates of Wildlife Agency Creation, 1870-1920

	(1)	(2)	(3)	(4)	(5)	(6)
Land Variables (logged)						
FARMS > 1000 ACRES	-1.540*** (0.374)			-1.227* (0.650)	-1.232*** (0.462)	
FARMS > 500 ACRES		-2.172*** (0.559)		-0.648 (1.077)		1.889*** (0.691)
AVERAGE FARM SIZE			-2.434** (1.059)		-1.346 (1.256)	-2.099* (1.247)

Notes: The coefficients are shown, not hazard rates. All estimates include the same co-variates and region fixed effects as column 5 of Table 1. Column 1 here is the benchmark specification from Column 5 of Table 2.

Table A3: Linear Probability Model Estimates of if State had Wildlife Agency in 1890 or 1900

	Y =1 if state had agency in 1890			Y = 1 if state had agency in 1900		
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Land Variables (logged)</i>						
NON-FARM ACRES	-0.017 (0.067)	0.015 (0.054)	0.057 (0.070)	0.021 (0.055)	0.013 (0.040)	-0.004 (0.064)
IMPROVED FARM ACRES	-0.206*** (0.075)	-0.151 (0.090)	-0.047 (0.127)	0.068 (0.090)	0.085 (0.083)	0.285** (0.137)
UNIMPROVED FARM ACRES	0.351*** (0.116)	0.443*** (0.095)	0.453*** (0.149)	0.146 (0.172)	0.087 (0.149)	0.045 (0.203)
FARMS > 1000 ACRES	-0.150** (0.073)	-0.158*** (0.049)	-0.214*** (0.070)	-0.191* (0.098)	-0.135 (0.090)	-0.196 (0.128)
<i>Demographics</i>						
LOG OF TOTAL POPULATION	0.166 (0.117)	-0.023 (0.107)	-0.041 (0.133)	-0.062 (0.145)	-0.114 (0.142)	-0.064 (0.185)
PERCENT URBAN POP	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
PERCENT US BORN	-0.019*** (0.006)	-0.005 (0.006)	-0.005 (0.007)	-0.025*** (0.006)	-0.006 (0.007)	-0.012 (0.009)
SPORTSMEN GROUP		0.012 (0.099)	-0.060 (0.146)		-0.148 (0.138)	-0.287* (0.153)
<i>Setup Costs and State Capacity</i>						
% REGION WITH WILDLIFE AGENCY		1.037*** (0.276)	0.431 (0.925)		0.610*** (0.176)	0.968*** (0.322)
NUMBER OF NON-WILDLIFE AGENCIES		0.010 (0.044)	-0.003 (0.061)		0.070 (0.084)	0.054 (0.079)
REGION FIXED EFFECTS	No	No	Yes	No	No	Yes
OBSERVATIONS (STATES)	48	48	48	48	48	48
ADJUSTED R ²	0.313	0.613	0.638	0.475	0.588	0.672
MEAN OF DEPENDENT VARIABLE	0.23	0.23	0.23	0.63	0.63	0.63

Notes: The coefficients are estimated with a linear probability model. P-values in parentheses, based on robust standard errors. * p<0.1, ** p<0.05, *** p<0.01. The regressions employ the 9 regions defined in the 1890 Census. Region 1 is CT, ME, NH, VT, MA, RI. Region 2 is NJ, NY, PA. Region 3 is IL, IN, MI, OH, WI. Region 4 is IA, KS, MN, MO, NE, ND, SD. Region 5 is DE, VA, FL, GA, NC, SC, MD, WV. Region 6 is AL, MS, KY, TN. Region 7 is AR, LA, TX, OK. Region 8 is AZ, CO, ID, MT, NV, NM, UT, WY. Region 9 is CA, OR, WA.

Table A4: Summary Data on State Trespass Laws

	Trespass Regime 1	Trespass Regime 2	Trespass Regime 3	Trespass Regime 4
Year	Requires landowner permission to hunt	Requires posting to keep hunters off unenclosed and uncultivated land	Requires posting to keep hunters off of any private land	Unenclosed and uncultivated lands accessible for hunting
1850	3	0	1	2
1860	6	0	2	4
1870	7	2	2	11
1880	5	2	3	13
1890	6	2	4	17
1900	9	4	7	19
1910	11	4	10	19
1920	11	5	10	18
1930	11	6	12	17
1940	12	7	12	16
1950	12	7	13	16
1960	13	7	13	15
1970	15	9	14	10
1980	19	10	16	3
1990	20	10	17	1
2000	20	10	17	1

Source: The authors' compilation and interpretation of state trespass statute. In the early years of the data, many states lack any trespass statute. In these instances, trespass law was determined by common law precedence, which favored open access for hunting (cite federal court ruling).

Table A5: Summary Statistics for Analysis of Agency Expenditures, 1952-2007

	Mean	St. Deviation	Minimum	Maximum
<i>Dependent Variables</i>				
AGENCY EXPENDITURES (000s)	40556	43454	1388	488976
<i>Land Variables</i>				
TOTAL ACRES (000s)	39619	29730	677	168217
FEDERAL ACRES (000s)	8699	14670	2	61378
FARM ACRES (000s)	21181	22717	49.6	145600
# FARMS > 1000 ACRES	3383	4573	2.0	25340
# FARMS > 500 ACRES	7380	8736	7	48602
AVERAGE FARM SIZE	664	1081	56	6362
<i>State Capacity</i>				
STATE REVENUE (000,000s)	17024	26840	282.7	311425
<i>Controls</i>				
AUTONOMOUS AGENCY	0.458	0.498	0	1
TOTAL POPULATION (000s)	4700.8	5073	181	36226
INCOME PER CAPITA	25294	9103	7316	58770
MEAN PRECIPITATION (INCHES)	36.82	14.13	9.5	60.1
MEAN ELEVATION (FEET)	1751.2	1836	60	6800

Notes. There are 576 state-year observations for all variables spanning 5-year intervals over 1952-2007. In general, the annual measures match the years of the USDA Census of Agriculture. In years where the USDA census does not match, we have interpolated the data assuming linear growth to cover missing years. All money values are in 2007 dollars, adjusted by the federal CPI.

Table A6: Panel Estimates of Agency Expenditures on Wildlife with Region Effects, 1952-2007

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Land Variables (logged)</i>						
TOTAL ACRES				0.396 (0.290)	0.349 (0.245)	0.397* (0.211)
FEDERAL ACRES				0.127* (0.069)	0.124* (0.065)	0.117** (0.057)
FARM ACRES	0.265 (0.239)	0.297 (0.239)	0.209 (0.255)	-0.039 (0.190)	-0.042 (0.179)	0.185 (0.131)
FARMS > 1000 ACRES	-0.131** (0.050)			0.009 (0.082)		
FARMS > 500 ACRES		-0.235*** (0.083)			0.037 (0.109)	
AVERAGE FARM ACRES			0.152 (0.236)			-0.419*** (0.093)
<i>State Capacity</i>						
LOG OF STATE REVENUE	0.424** (0.193)	0.467** (0.201)	0.325* (0.190)	0.563** (0.242)	0.466** (0.220)	0.404** (0.184)
<i>Controls (all logged)</i>						
AUTONOMOUS	-0.026 (0.072)	-0.024 (0.073)	-0.031 (0.075)	0.051 (0.109)	0.045 (0.094)	0.058 (0.086)
POPULATION	-0.086 (0.208)	-0.107 (0.209)	0.082 (0.209)	-0.243 (0.232)	-0.125 (0.205)	-0.231 (0.173)
PER CAPITA INCOME	0.651* (0.335)	0.609* (0.322)	0.852** (0.337)	0.718 (0.444)	0.601* (0.355)	0.912*** (0.273)
MEAN PRECIPITATION				0.710*** (0.237)	0.638*** (0.226)	0.112 (0.246)
MEAN ELEVATION				-0.051 (0.065)	-0.061 (0.059)	-0.193*** (0.066)
CONSTANT	-5.315 (5.832)	-4.786 (5.621)	-9.159 (5.705)	-11.486** (4.488)	-9.465** (3.628)	-8.996*** (2.557)
State fixed effects	Yes	Yes	Yes	No	No	No
Region fixed effects	No	No	No	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Region-specific year effects	Yes	Yes	Yes	No	No	No
Observations	576	576	576	576	576	576
Adjusted R-squared	0.835	0.837	0.833	0.835	0.817	0.835

Notes: * p<0.1, ** p<0.05, *** p<0.01. All standard errors are clustered at the state level. The balanced panel data cover 5-year intervals from 1952-2007 with t = 12 time periods and s = 48 states. The variables TOTAL ACRES, FEDERAL ACRES, MEAN PRECIPITATION, and MEAN ELEVATION are dropped from Columns 1-3 because we treat the variables as time invariant. As with Table 1, the estimates here employ the 9 regions defined in the 1900 Census. Region 1 is CT, ME, NH, VT, MA, RI. Region 2 is NJ, NY, PA. Region 3 is IL, IN, MI, OH, WI. Region 4 is IA, KS, MN, MO, NE, ND, SD. Region 5 is DE, VA, FL, GA, NC, SC, MD, WV. Region 6 is AL, MS, KY, TN. Region 7 is AR, LA, TX, OK. Region 8 is AZ, CO, ID, MT, NV, NM, UT, WY. Region 9 is CA, OR, WA.

Table A7: ‘Placebo’ Panel Estimates of Agency Expenditures, Various Years from 1952-2007

	(1) Health	(2) Parks	(3) Forestry	(4) Agriculture	(5) Health	(6) Parks	(7) Forestry	(8) Agriculture
<i>Land Variables (logged)</i>								
TOTAL ACRES					-0.054 (0.087)	-0.607*** (0.192)	0.394* (0.209)	0.180 (0.151)
FEDERAL ACRES					-0.037* (0.021)	0.152** (0.061)	0.282*** (0.074)	0.079 (0.052)
FARM ACRES	0.273* (0.147)	-1.168 (0.800)	1.574*** (0.347)	0.407*** (0.150)	0.014 (0.046)	0.183 (0.113)	-0.165 (0.114)	0.294*** (0.083)
FARMS > 1000 ACRES	-0.056 (0.059)	-0.052 (0.191)	-0.385** (0.149)	0.091* (0.052)				
AVERAGE FARM ACRES					0.045 (0.069)	0.018 (0.186)	-0.503* (0.272)	0.192 (0.174)
<i>State Capacity</i>								
LOG OF STATE REVENUE	0.312** (0.150)	-0.152 (0.370)	0.097 (0.480)	0.079 (0.175)	0.617*** (0.111)	1.113*** (0.332)	0.776* (0.386)	0.208 (0.242)
<i>Controls (all logged)</i>								
AUTONOMOUS	-0.016 (0.068)	0.311*** (0.105)	-0.305 (0.186)	0.021 (0.078)	-0.028 (0.052)	0.189 (0.147)	-0.058 (0.154)	0.040 (0.073)
POPULATION	0.696*** (0.147)	0.246 (0.651)	1.499*** (0.482)	0.378* (0.203)	0.457*** (0.108)	-0.082 (0.305)	-0.262 (0.359)	0.196 (0.202)
PER CAPITA INCOME	0.244 (0.268)	1.539** (0.696)	0.244 (0.575)	0.613** (0.285)	0.200 (0.222)	-0.225 (0.539)	0.472 (0.498)	0.277 (0.264)
MEAN PRECIPITATION						0.148 (0.151)	-0.060 (0.371)	0.968* (0.502)
MEAN ELEVATION						0.004 (0.050)	-0.106 (0.118)	0.036 (0.136)
State fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	576	335	552	528	576	335	552	528
Adjusted R-squared	0.933	0.378	0.505	0.842	0.960	0.742	0.604	0.887

Notes: * p<0.1, ** p<0.05, *** p<0.01. All standard errors are clustered at the state level. The unbalanced panel data cover 5-year intervals from 1952-2007 with t varying from a high of t=12 (columns 1 and 5) to a low of t=7 (columns 2 and 6) with s = 48 states in most but not all cases. The specifications in Columns 1-4 mimic Column 1 of Table 4. The specifications in Columns 5-8 mimic Column 6 of Table 4