


# A cost assessment of intensive wild quail management on private lands in the southeastern United States

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## Abstract

Private landowners who operate multifunctional landscapes play a critical role in the conservation of native and imperiled species, and the restoration of native ecosystems. In the southeastern United States, both northern bobwhite (*Colinus virginianus*) and pine savanna ecosystems are imperiled and heavily reliant on conservation efforts by private landowners. Engaging private landowners in the restoration and management of pine savannas and grasslands is essential to the recovery of northern bobwhite, which is also managed as a game species. Since the early 1900s, the cultural tradition of wild bobwhite hunting has motivated landowners to manage their properties to increase bobwhite populations. However, the costs and revenues associated with intensive wild bobwhite management and hunting are imperfectly understood. From May 2021 to February 2022, we conducted semistructured interviews with landowners and land managers of 37 wild bobwhite hunting properties (total of 65,317 ha in bobwhite management) in Alabama, Georgia, Florida, and South Carolina to enumerate the costs and revenues associated with intensive wild bobwhite management. Landowners spent an average of \$154/acre/year (~\$381/ha/year; median of \$142/acre/year or ~\$352/ha/year) to manage for northern bobwhite. These costs included salaries and benefits for labor, depreciated equipment and infrastructure expenditures, and other supplies (e.g., fuel, seed) needed to maintain wild bobwhite populations and their habitat. Few properties offset their bobwhite management costs with revenues generated on the property, including hunting revenues. Non-financial motivations for owning a bobwhite property included a strong land stewardship ethic, the desire to maintain rural lifestyles and family heritage, and securing hunting and recreational opportunities. Through wild quail management, private landowners are helping to secure critical habitat for threatened and endangered species and increasing the landscape's overall resilience to climate change without the use of public funding.

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## KEYWORDS

*Colinus virginianus*, conservation, economics, hunting, land stewardship, northern bobwhite, revenues

## 1 | INTRODUCTION

Private lands are critical to the conservation of biodiversity and ecosystem services (Lute et al., 2018). Private landowners that operate multifunctional landscapes provide an array of public benefits by conserving native wildlife, threatened and endangered species, and native ecosystems and associated ecosystem services (e.g., carbon sequestration, nutrient cycling, hunting; Burger et al., 2019; Hendee & Flint, 2014; Plieninger et al., 2015). Land stewardship that secures biodiversity and ecosystem services requires the investment of both time and resources. Landowners may engage in land stewardship to earn financial returns (e.g., hunting revenues from increased game populations), out of a sense of moral duty, or because their social and cultural norms, sense of place, or the importance they place on intergenerational legacy motivate them to engage in conservation behaviors (Brennan, 2015; Chitwood et al., 2011; Hurst et al., 2017; Kreye et al., 2017; Lute et al., 2018; Rajala & Sorice, 2022). These internal motivations may make landowners willing to forego higher profits from more intensive land uses (Cortés-Capano et al., 2021). However, internal motivations are insufficient unless landowners have the necessary resources, knowledge, and finances to implement stewardship practices (Lute et al., 2018).

Here we focus on the role of private landowners in managing pine savanna ecosystems of the southeastern United States (hereafter, Southeast) with the specific objective of increasing wild northern bobwhite (*Colinus virginianus*) populations (Peterson et al., 2019). Both northern bobwhite and pine savanna ecosystems are imperiled and heavily reliant on conservation efforts by private landowners, notably the application of prescribed fire. Pine savannas once extended across the Atlantic Coastal Plain, Fall-line Sandhills, Southern Coastal Plain, Eastern Coastal Plain, and the Piedmont and Montane Uplands ecoregions of the United States (Peet, 2007). Restoration of pine savanna ecosystems through prescribed burning, the re-establishment of longleaf pine (*Pinus palustris*), and other land stewardship practices benefit northern bobwhite (hereafter bobwhite) while also supporting species diversity and other ecosystem functions. Pine savannas in the Southeast provide critical habitat for 29 threatened and endangered species (e.g., the gopher tortoise *Gopherus polyphemus*, red-cockaded

woodpecker *Leuconotopicus borealis*, the Eastern indigo snake *Drymarchon couperi*; Engstrom & Palmer, 2005; USDA NRCS, 2022) while also securing an array of ecosystem services (e.g., erosion and flood control, nutrient cycling, water filtration, groundwater recharge) and increasing the landscape's overall resilience to climate change (Dixon et al., 2022). As such, private properties managed for wild bobwhite secure an array of public goods.

Bobwhites are a native upland game species of conservation concern in the Southeast and are listed as near threatened on the IUCN Red List (BirdLife International, 2016). Bobwhite populations have declined in the Southeast due to large-scale habitat degradation (Burger et al., 1999) and decreased use of prescribed fire on the landscape, a management tool that is necessary for maintaining bobwhite habitat (Brennan, 2015; Neel, 1972). Traditionally, marginal lands in the Southeast were multiple use landscapes planted with a variety of crops (e.g., cotton, sugar cane, tobacco) that supported bobwhite (Brennan, 1991). However, the conversion of agricultural lands to monocultures, commercial timber plantations, and silvicultural systems that maximize basal area and reduced the use of prescribed fire on the landscape have significantly reduced bobwhite habitat (Brennan, 1991).

There is a tradition of managing private lands to support wild bobwhite populations to hunt (hereafter, "bobwhite properties") in the Southeast. In common with the hunting estates of Scotland that support wild populations of red deer (*Cervus elaphus*) and red grouse (*Lagopus scotica*; Watts et al., 2017), bobwhite properties manage wild bobwhite primarily for hunting purposes (Engstrom & Palmer, 2005). Throughout much of the Southeast, bobwhite favor pine savanna ecosystems with sparse to moderate shrub cover and a fully developed herbaceous plant community (Stoddard, 1931). Given the amount of rainfall in the Southeast, disturbances are required to prevent the plant community from becoming dominated by woody plants. Land managers of bobwhite properties use prescribed fire, mechanical treatments (e.g., mowing and roller-drum chopping), and invasive plant control via herbicide application to create and maintain these conditions (Palmer & Sisson, 2017). Landowners may also establish and maintain fallow fields to improve bobwhite foraging and brood cover (Carver et al., 2001; Wells, 2010; Yates et al., 1995). Because bobwhite have high mortality rates

(Sisson et al., 2009), landowners finance supplemental feeding and predator management on their properties. Supplemental feeding reduces the home range size for bobwhite as well as the time bobwhite spend foraging and the distance they travel to feed, thereby reducing mortality risks (Miller et al., 2017; Sisson et al., 2009; Wellendorf et al., 2017). Controlling meso-mammal predators (e.g., armadillos, opossums, racoons) has been shown to improve bobwhite recruitment (Jackson et al., 2018; Palmer et al., 2019; Yeiser et al., 2021). These management activities provide suitable conditions (e.g., habitat, food availability, shelter) that increase bobwhite populations while also supporting high densities of bobwhite to hunt (Palmer & Sisson, 2017).

To facilitate wild bobwhite management and hunting, landowners invest in labor, infrastructure, equipment, and supplies (e.g., fuel, supplemental feed for bobwhite; Palmer & Sisson, 2017). Landowners may also invest in hunting animals and their care (e.g., infrastructure, husbandry) to facilitate bobwhite hunts (Sisson et al., 2017). To offset the costs associated with bobwhite management and land stewardship, some landowners generate revenues on their property (Huang, 2009). For example, hunting revenues may be earned through the sale of day hunts or hunting leases for wild bobwhite (Huang, 2009). Landowners may also generate revenues by managing part of their property for crops (e.g., cotton, peanuts, pecans), livestock or timber (Palmer & Sisson, 2017). However, except for Sisson et al. (2017) who estimated the costs associated with translocating wild bobwhite and Huang (2009) who estimated the economic tradeoffs between bobwhite and timber management, no research has been done on the costs of wild bobwhite management in the Southeast or whether these costs are offset by revenues generated on wild bobwhite properties. To fill this research gap, we surveyed land managers and owners of bobwhite properties in the Southeast to: (1) estimate the costs of managing pine savanna landscapes to maintain wild bobwhite and the additional costs incurred to facilitate wild bobwhite hunting; (2) identify potential revenues generated by bobwhite management (including the prices charged by landowners for wild bobwhite hunts); (3) determine whether landowners offset the costs of bobwhite management through hunting revenues; (4) determine whether hunting success was correlated with investment in bobwhite management; and (5) ascertain what motivates landowners to maintain wild bobwhite properties. Improved understanding of the potential costs and revenues associated with intensive wild bobwhite management allows conservation organizations to better inform landowners of the financial commitments associated with wild bobwhite management. Improved understanding of landowner motivations for engaging in wild bobwhite management provides insights

into what messaging is needed to engage more landowners in bobwhite management.

## 2 | STUDY AREA

Our study encompassed the historic privately-owned bobwhite hunting lands in the “plantation belt” regions of northern Florida (commonly referred to as “Red Hills”) and southwestern Georgia (commonly referred to as “Albany”; Brennan, 2015; Sisson et al., 2017). Some of these properties have been continuously managed for bobwhite since the early 1900s while others were established in more recent years (Burger et al., 1998; Sisson et al., 2017; Thackston & Whitney, 2020). Many properties were originally managed as cotton plantations until the Civil War. After the war, the properties were purchased by wealthy northern families as winter homes and were converted to quail hunting (Thackston & Whitney, 2020). In addition to the historic plantation belt, we also surveyed owners and managers of wild bobwhite properties in Alabama, central Florida, and South Carolina to include more properties in the bobwhite's historic range. All bobwhite properties included in this study collaborate with Tall Timbers (<https://talltimbers.org/>), a research station that assists landowners in establishing and maintaining wild bobwhite populations. Accordingly, landowners and land managers generally follow the same bobwhite management procedures as recommended by Tall Timbers (Palmer & Sisson, 2017).

The cover types in our study region encompassed open-structured, pine savannas and grassland-shrub that are periodically disturbed by fire, including wiregrass (*Aristida stricta*) communities (Dixon et al., 2022; Engstrom & Palmer, 2005). Pine savannas contain longleaf pine, loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), and hardwood species, such as southern live oak (*Quercus virginiana*), shagbark hickory (*Carya ovata*), and sweetgum (*Liquidambar styraciflua*; Bailey, 1995). Native grass species in genera *Andropogon*, *Aristida*, *Dichanthelium*, *Eragrostis*, *Paspalum*, *Sorghastrum*, *Saccharum*, and *Tridens*, as well as native forbs in genera *Centrosema*, *Chrysopsis*, *Desmodium*, *Helianthus*, *Hieracium*, *Lespedeza*, *Pityopsis*, *Stylosanthes*, and *Tephrosia* are the dominant graminoids and forbs in this study region (Robertson et al., 2021).

## 3 | METHODS

### 3.1 | Data collection

We interviewed landowners and land managers from wild bobwhite properties in Alabama, Florida, Georgia,

and South Carolina. Tall Timbers recruited all research participants. Tall Timbers conducted non-probability sampling based on property size and location and duration of bobwhite management to recruit study participants.

We designed a survey that elicited information on: (1) property characteristics (e.g., property location and size); (2) the type and cost of equipment used in bobwhite management and hunting; (3) the cost of infrastructure that pertains to bobwhite management and hunting; (4) the number of hunting animals owned and husbandry costs; (5) labor costs; (6) how much time staff allocate to different bobwhite management activities and which equipment they use; (7) other recurring costs associated with bobwhite management; (8) revenues generated by the bobwhite property; and (9) measures of bobwhite hunting performance (see Supporting Information). We sent participants the survey prior to interviews to allow them sufficient time to review the questions and collect budget and hunting data. During interviews, we asked follow-up open-ended questions about why landowners chose to invest in wild bobwhite management on their properties.

We designed the questionnaire based on information from Tall Timbers about how wild bobwhite properties are managed. Depending on the size of the operation, these properties are staffed by land managers (who oversee all bobwhite operations), field technicians (who conduct land management activities), mechanics, office staff, and dog trainers who also serve as hunting guides. Landowners may own bird dogs, horses, and mules for hunting, with associated veterinary and feed costs (e.g., dog food) and investments in kennels, stables, tack, mule wagons, and fenced pastures. Pole barns and sheds are required to store equipment used to manage bobwhite habitat (e.g., choppers, harrows, herbicide sprayers, mowers, and tractors). Additionally, landowners must finance equipment maintenance and the purchase of fertilizers, herbicides, and supplemental feed (e.g., sorghum seeds for bobwhite to eat), and pay property taxes. To estimate the cost of each piece of equipment used in bobwhite management, we asked interviewees for the price they paid if the item was bought within the past 5 years. If the equipment was older than 5 years, we asked the interviewees to estimate its replacement cost.

We audio recorded the interviews with the participants' permission. After completion of each interview, we transcribed the recording verbatim and entered financial data into spreadsheets for analysis. Nimlos and Pienaar reviewed the transcripts and spreadsheets independently to ensure data was entered correctly. Follow-up emails were sent to interviewees to collect any missing data or information. The Institutional Review Board at the

University of Georgia reviewed all research materials and protocols and deemed our study non-human subject research.

### 3.2 | Data analysis

All estimated costs were specific to lands managed for bobwhite and did not include other land management activities (e.g., land in crop production or intensive timber management). We used straight-line depreciation to estimate annual depreciation expenses for assets (i.e., equipment and infrastructure):

$$\text{Annual depreciation expense} = \frac{(\text{Cost of asset} - \text{Salvage value of asset})}{\text{Useful life of asset}}$$

where the cost of an asset was either the purchase price or replacement cost for that asset. We estimated salvage values as a percentage of the cost of the asset (0%–40%), based on feedback from surveyed land managers. We also estimated the useful life of assets based on feedback from surveyed land managers (Table S1). Because landowners were able to purchase equipment and infrastructure without third-party financing, we did not include interest in ownership costs for equipment. However, we included insurance, and housing for equipment (i.e., the annual depreciated expense of equipment shops and pole barns) in total annual equipment ownership costs, such that the total annual costs of equipment ownership were

$$\begin{aligned} \text{Equipment ownership costs} \\ = \sum_j \text{Annual depreciation expense}_j + \text{Insurance} \\ + \text{Housing} \end{aligned}$$

for all  $j$  equipment (Johnson, 2020). We estimated annual equipment operating costs as the sum of annual maintenance and repair costs, fuel costs, and costs of labor used to repair equipment (e.g., mechanics; Johnson, 2020).

We estimated the total annual costs of bobwhite management as the sum of ownership and operating costs for equipment used in bobwhite management, salary and benefits for employees who worked on bobwhite management, and annual recurring costs associated with bobwhite management (i.e., purchase of chemicals, seed, supplemental feed for bobwhite, predator trap bait, road maintenance on bobwhite properties to allow equipment to be moved around the property, and office expenses that directly pertained to bobwhite management). We excluded all costs associated with hunting operations (e.g., the purchase and husbandry of hunting animals,

salaries and benefits for dog trainers), property taxes and property insurance from our calculations of the costs of bobwhite management. We divided total annual costs of bobwhite management by the land area dedicated to bobwhite management to calculate the cost per hectare of bobwhite management. A similar analysis was conducted to calculate hunting costs (see Supporting Information).

Time costs for different bobwhite management activities (a measure of effort) were estimated as

$$\text{Time cost} = \sum_i \text{Salary}_i \times \text{Time}_i$$

where  $\text{Salary}_i$  is the salary for each employee  $i$  participating in the activity and  $\text{Time}_i$  is the percentage of time each year employee  $i$  allocated to the activity. If landowners used contract labor, then we included contract expenses in estimated time costs. We estimated how the annual depreciation expenses of different equipment were apportioned to different management activities by calculating

$$\sum_j \text{Annual depreciation expense}_j \times \text{Time}_j$$

where  $\text{Time}_j$  the percentage of time each year that equipment  $j$  is used to perform the activity. Note that these costs did not include equipment operating, housing or insurance costs, and hence are conservative estimates of the costs of allocating equipment to different land stewardship activities.

If landowners did not harvest timber annually, then we estimated the expected value of timber production by calculating the net present value of revenues earned from timber sales, assuming a 4% discount rate (Callaghan et al., 2019; Straka & Bullard, 1996). If landowners harvested a percentage of their timber annually then we asked what revenues were generated by the most recent timber harvest. All other annual revenue streams were based on research participants' calculations of how much they earn annually from those activities, such as hunting and crop production (e.g., pecans, peanuts, cotton, corn, citrus fruits). We compared revenues and costs to ascertain whether landowners offset the costs of their wild bobwhite management.

We conducted regression analysis using R statistical software to determine whether hunting success was correlated with investment in bobwhite management. We measured hunting success as the average number of bobwhite coveys seen per hour. Finally, we conducted qualitative content analysis of all interview transcripts to identify non-financial motivations for wild bobwhite management (Lune & Berg, 2017; Strauss &

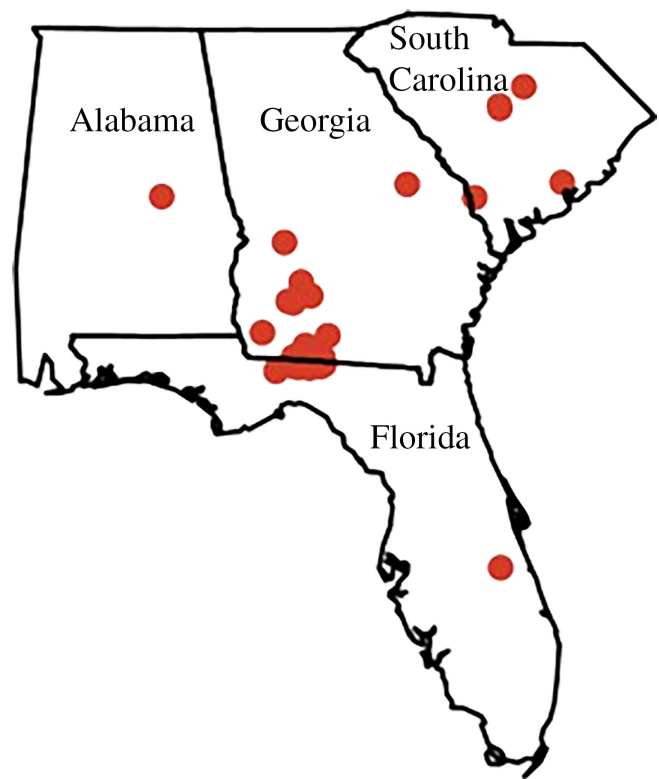


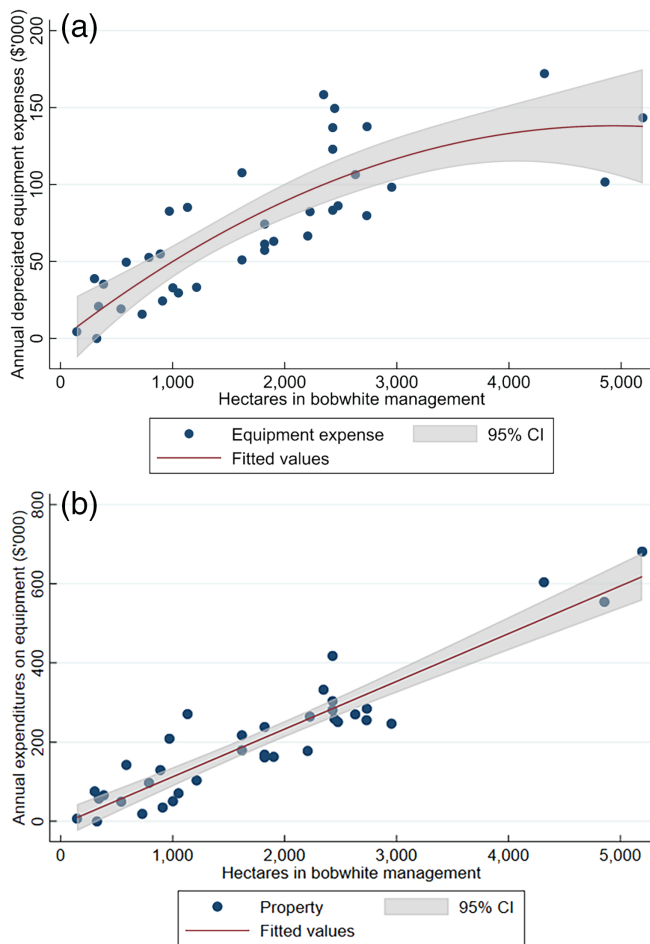
FIGURE 1 The approximate locations of the bobwhite properties included in our study (represented by red circles).

Corbin, 1998). Nimlos and Pienaar read through the transcripts to understand the data holistically and identified the meaning of ideas and sentences as units of analysis. We then labeled the units of analysis with codes (i.e., open coding process). We grouped the codes into categories and sorted them into common themes that we developed inductively.

## 4 | RESULTS

We interviewed 3 landowners and 34 managers of 37 properties that participated in Tall Timbers' bobwhite management programs in Alabama, Florida, Georgia, and South Carolina (Figure 1). Tall Timbers currently works with 192 wild quail properties, which means that we surveyed 19% of the properties with which they work. Managers work closely with landowners and keep detailed records of the property's expenses and budget. They therefore were able to accurately answer our questions when landowners were absent from interviews. Data collection occurred from May 18th, 2021 to February 8th, 2022. Each interview lasted approximately 1–3 h.

Most properties (78.4%) were located in the Red Hills region of North Florida ( $n = 18$ ; aggregate of  $\sim 36,800$  ha



**FIGURE 2** Annual depreciated equipment expenses and total annual expenditures on equipment (equipment ownership, operating, lease, and rental costs) needed for bobwhite management ( $n = 37$ ).

of bobwhite habitat) and the Albany region in Southwest Georgia ( $n = 11$ ; aggregate of  $\sim 18,200$  ha of bobwhite habitat). Properties ranged in the number of hectares managed for bobwhite habitat from 146 ha to 5194 ha (mean of 1792 ha, median of 1821 ha). On average, landowners managed 75% of their total property for bobwhite habitat (median = 84%). Landowners had owned bobwhite properties for a median of 50 years. Most properties were also managed for timber ( $n = 31$ , 83.8%), while less than half of the properties were managed for crop production ( $n = 16$ , 43.2%).

#### 4.1 | Costs of equipment and infrastructure used for wild bobwhite management

Landowners purchased a variety of equipment to conduct necessary activities associated with bobwhite

management, including prescribed burning, the cultivation of fallow fields, removal of hardwood trees or invasive plants, trapping of predators, and supplemental feeding of bobwhite (Table S2). On average, landowners ( $n = 37$ ) purchased \$1.09 million in equipment to conduct land stewardship and bobwhite management (range of \$0 to \$2.7 million; median cost of equipment = \$1.1 million). One landowner had purchased no equipment and relied on contractors to maintain the property. The mean annual depreciated expense for equipment used in bobwhite management was \$74,330/property (median = \$70,450/property; range of \$4412–\$172,072/property) for the 36 properties where landowners had purchased equipment. Typically, the annual depreciated expense of equipment increased as the number of hectares in bobwhite management increased, albeit at a diminishing rate (Figure 2). Landowners purchased equipment sheds and pole barns to house the equipment used in bobwhite management (mean cost = \$384,347; median cost = \$300,000; mean depreciation expense = \$7687/year; median depreciation expense = \$6000/year). Taking both housing and equipment insurance costs into account, annual ownership costs for equipment averaged \$83,414/property ( $n = 36$ ; median = \$83,232/property; Table 1).

Landowners spent an average of \$66,088/year on maintenance and repair for equipment and equipment housing they owned ( $n = 36$ ; median = \$44,123/year) and \$48,067/year on fuel and oil (median = \$36,000/year). As such, annual equipment operating costs averaged \$111,485/year ( $n = 36$ ; median = \$91,221/year; Table 1). In addition to purchasing equipment, 12 landowners spent an average of \$55,386/year on the rental and lease of equipment (median = \$42,000/year; Table 1). Taking equipment ownership, operating, lease and rental costs into account, landowners spent an average of \$213,361/year on equipment and infrastructure needed for bobwhite management ( $n = 36$ ; median = \$193,532/year; Figure 2).

#### 4.2 | Costs of land stewardship on wild bobwhite properties

Landowners financed a variety of different land management activities to maintain or increase bobwhite populations and secure hunting opportunities. As part of their efforts to maintain pine savannas, landowners financed prescribed burning, removal of exotic plants and hardwoods through mechanical and chemical treatments, fallow field management, nest predator reduction, and supplemental feeding of bobwhite. Most landowners ( $n = 34$ , 91.9%) employed land managers and 15 landowners (40.5%) also hired assistant managers to oversee

**TABLE 1** Annual costs for land stewardship and bobwhite management in the southeastern United States ( $n = 37$ ), excluding any costs associated with purchasing and caring for hunting animals (horses, mules, bird dogs).

	Mean	Median	First quartile	Third quartile	Number of properties that reported expense
Ownership costs for equipment used in bobwhite management (depreciated annual costs)	83,414	83,232	43,721	117,309	36
Variable costs (includes salaries, benefits, and contract labor costs) <sup>a</sup>	548,037	543,573	243,150	664,950	37
Equipment operating costs (fuel and oil, equipment and equipment housing maintenance and repairs)	111,485	91,221	38,974	141,957	36
Equipment rental and lease costs	55,386	42,000	26,585	82,833	12
Land stewardship and bobwhite management (chemicals, predator trap bait, seeds, supplemental bird feed, road repair materials)	79,071	60,157	41,370	105,425	36

<sup>a</sup>These costs do not include property insurance, property taxes, utilities, or any husbandry and other costs associated with hunting animals.

their bobwhite properties. Twenty-nine landowners (78.4%) hired an average of 4 field technicians to conduct necessary land stewardship activities (Table S3). In addition to their base salaries, most employees received health care, retirement benefits, and workers' compensation. Landowners also purchased chemicals (e.g., herbicides), seeds, material to repair access roads on the property, supplemental bird feed, and bait for predator traps, in order to conduct land stewardship and bobwhite management activities (mean annual cost = \$79,071; median annual cost = \$60,157;  $n = 36$ ; Table 1). The variable costs of land stewardship and bobwhite management averaged \$548,037/year (median of \$543,573/year;  $n = 37$ ; Table 1). On average, expenditures on salaries, benefits and contract labor accounted for 64.5% of the variable costs associated with land stewardship and bobwhite management.

Prescribed burning was the most costly land stewardship activity, in which land managers, assistant managers and field technicians typically all participated for approximately 1–3 months each year (depending on the property size and weather conditions) between March and May (Table 2). During prescribed burns, burn equipment, disks, four-wheelers, fuel and water tanks, harrows, mowers, and tractors are used to prepare fire breaks, prescribe burn, and clean up post-burn. Landowners who engaged in prescribed burning (which included post-burn mowing) invested an average of \$50,500/year (mean of \$30.26/ha/year or \$12.25/acre/year) in labor and equipment required to conduct prescribed burning. Hardwood removal (mean of \$27,754/year; \$7.73/acre/year; \$19.11/ha/year) tended to be more costly than other exotic plant removal because feller bunchers, front end loaders, and

tractors were used to cut and remove hardwoods, whereas less equipment and time was needed to engage in chemical control of invasive plants. To increase bobwhite populations, landowners also financed the trapping and removal of predators (armadillos, bobcats, coyotes, foxes, opossums, and skunks; mean of \$20,850/year; \$4.86/acre/year; \$12.02/ha/year) and supplemental feeding of bobwhite using feed spreaders to distribute sorghum (mean of \$14,209/year; \$3.69/acre/year; \$9.12/ha/year; note these costs increased to a mean of \$17.83/acre/year and a median of \$17.73/acre/year when the costs of supplemental feed were included). It is important to note that these estimated stewardship costs did not include fuel, maintenance, equipment housing and insurance, or other supplies. Equally importantly, we averaged costs across the entire property area that was managed for bobwhite, which means that estimated costs per hectare for activities such as hardwood removal that occur on small portions of a property were deflated. On average, the cost of land stewardship and wild bobwhite management was \$381/ha/year (\$154/acre/year; median of \$143/acre/year or \$352/ha/year; 95% confidence interval of \$131–\$177/acre/year or \$325–\$437/ha/year; Figure 3). The per hectare cost of land stewardship and bobwhite management was not correlated with property size (Table 3).

### 4.3 | Costs of infrastructure, equipment, and animals used in wild bobwhite hunting

Thirty-one landowners owned bird dogs (mean cost of \$133,011/property to purchase dogs), 30 landowners

**TABLE 2** Annual time costs and depreciation expenses for allocating equipment to land stewardship and bobwhite hunting on wild bobwhite properties in the southeastern United States ( $n = 37$ ).

Activity	Mean	Median	Properties that engaged in activity
Land stewardship and bobwhite management:			
Prescribed burning (pre/post burn mowing and chopping, fire breaks, pile burning, general burning)			35 <sup>a</sup>
Time cost (\$)	45,495	34,833	
Allocation of equipment (\$)	5005	2969	
Cost per acre (\$) <sup>b</sup>	12.25	7.46	
Hardwood removal			22
Time cost (\$)	27,508	10,000	
Allocation of equipment (\$)	246	130	
Cost per acre (\$)	7.73	3.22	
Applying chemicals			30
Time cost (\$)	7890	2769	
Allocation of equipment (\$)	328	236	
Cost per acre (\$)	2.53	1.00	
Fallow field management			30
Time cost (\$)	6362	3455	
Allocation of equipment (\$)	1222	565	
Cost per acre (\$)	1.78	1.28	
Supplemental feeding of bobwhite			35
Time cost (\$)	11,385	8586	
Allocation of equipment (\$)	2824	1407	
Cost per acre (\$)	3.69	2.71	
Predator management			29
Time cost (\$)	17,801	9962	
Allocation of equipment (\$)	3049	2620	
Cost per acre (\$)	4.86	3.47	
Road maintenance			32
Time cost (\$)	10,463	5214	
Allocation of equipment (\$)	1484	411	
Cost per acre (\$)	3.78	1.30	
Mowing roads			14
Time cost (\$)	13,928	11,241	
Allocation of equipment (\$)	1938	803	
Cost per acre (\$)	3.30	3.62	
Bobwhite hunting:			
Hunting dog training			25
Time cost (\$)	22,102	13,793	
Allocation of equipment (\$)	1168	474	
Cost per acre (\$)	4.70	2.90	
Mowing and chopping hunting lanes			33
Time cost (\$)	23,136	24,569	
Allocation of equipment (\$)	3630	2572	
Cost per acre (\$)	6.10	5.22	



TABLE 2 (Continued)

Activity	Mean	Median	Properties that engaged in activity
Pasture maintenance			21
Time cost (\$)	2778	1183	
Allocation of equipment (\$)	350	151	
Cost per acre (\$)	0.79	0.34	

Note: These cost estimates pertain to equipment that landowners had purchased, and do not include operating expenses associated with equipment (e.g., fuel, housing, maintenance) or other inputs to bobwhite management (e.g., supplemental feed, seed).

<sup>a</sup>All properties participated in prescribed burning; however, 2 properties hired contractors to conduct prescribed burns.

<sup>b</sup>The cost per acre was calculated based on the total number of acres managed for bobwhite habitat, rather than the number of acres on which the activity was conducted.

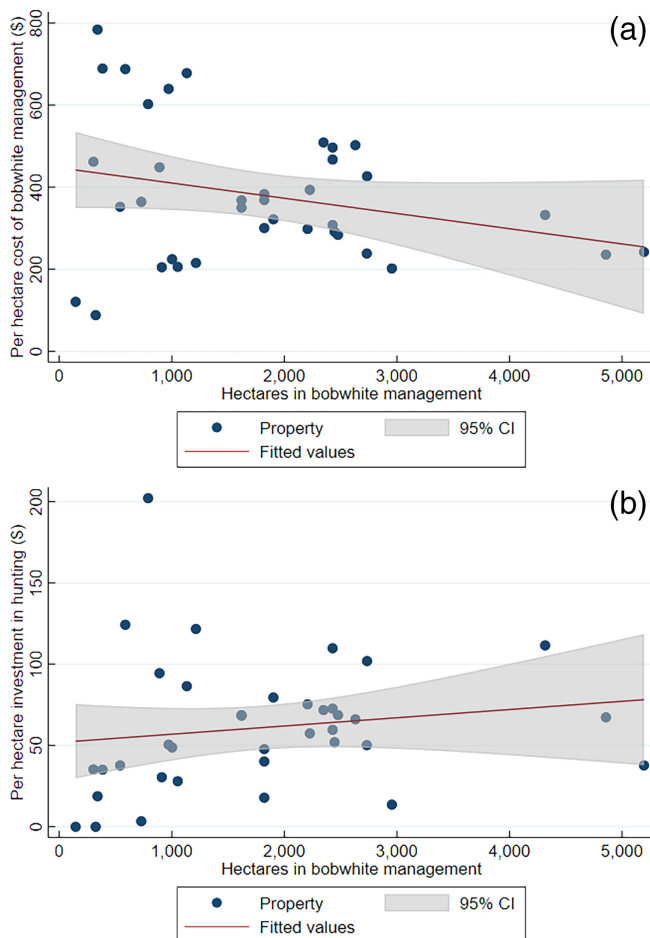


FIGURE 3 The per hectare costs of wild bobwhite management and per hectare investment in bobwhite hunting for wild bobwhite properties in the southeastern United States ( $n = 37$ ).

owned horses for hunters to ride (mean cost of \$90,897/property to purchase horses), and 19 landowners owned mules to draw hunting wagons (mean cost of \$42,105/property to purchase mules). Assuming that bird dogs hunt for 8 years and that horses and mules are used for 15 years for hunting, the mean annual depreciated

expense for hunting animals averaged \$22,075/property (median = \$18,933/property;  $n = 35$ ). Landowners with hunting animals invested in infrastructure (dog kennels, horse barns, pasture fences) to house animals (mean cost = \$811,165/property; median cost = \$526,400/property; mean depreciation expense = \$16,223/year; median depreciation expense = \$10,528/year; Table S4). Landowners also invested in equipment to transport animals (e.g., horse trailers) and to facilitate bobwhite hunts (e.g., saddles, hunting wagons with dog boxes; mean depreciation expense = \$6903/property; median depreciation expense = \$5535/property; mean cost = \$114,539/property; median cost = \$100,000/property; Table S4). On average, landowners spent \$23,125/year on veterinarian and farrier costs (median = \$19,500/year), \$21,305/year on feed (median = \$18,615/year), and \$29,246/year on dog training (median = \$8260/year). Taking infrastructure and pasture maintenance, animal purchases, depreciated equipment and infrastructure expenses, husbandry and training costs into account, landowners spent an average of \$123,432/year on their hunting operations (median = \$111,077/year), which equated to an average of \$64/ha/year (median = \$60/ha/year; mean = \$26/acre/year; median = \$24/acre/year; Figure 3).

#### 4.4 | Hunting success and revenues generated on bobwhite properties

Hunting success ranged from 1.5 to 15.5 coveys seen per hour for different properties, averaging 5.7 coveys seen per hour (median of 5.5 coveys seen per hour). Hunting success was positively correlated with the number of hectares in wild bobwhite management ( $p < .001$ ), and the per hectare investment in land stewardship at the  $p = .083$  level (Table 3).

Landowners often generated supplemental income to help offset the costs of bobwhite management (Table S5). Most commonly, revenues were generated through

**TABLE 3** Log transformation regression analysis of whether the per hectare costs of land stewardship and bobwhite management were correlated with land area in bobwhite management (Model 1) and whether hunting success was correlated with investment in wild bobwhite management and land area in bobwhite management (Model 2).

	Model 1					Model 2				
	Dependent variable: Per hectare cost of land stewardship and bobwhite management					Dependent variable: Hunting success				
	$\beta$	SE	<i>t</i>	<i>p</i>	95% CI	$\beta$	SE	<i>t</i>	<i>p</i>	95% CI
Constant	5.831	0.699	8.34	<.001	4.412, 7.251	-3.491	1.233	-2.83	.008	-6.003, -0.979
Land area in bobwhite management (ha)	0.001	0.096	0.01	.990	-0.194, 0.197	0.464	0.086	5.37	<.001	0.288, 0.640
Cost of land stewardship (\$/ha)						0.293	0.164	1.79	.083	-0.041, 0.626
<i>n</i>	37					35				
Adjusted <i>R</i> <sup>2</sup>	0.029					0.449				

agricultural production (an average of \$358,967/year from crop production or land leases;  $n = 13$ ), timber sales (an average of \$138,846/year for the 15 properties that harvested timber annually; an average net present value of \$353,216 for the nine properties that did not harvest timber every year;  $n = 24$ ) and bobwhite hunts (both half- and full-day hunts; mean = \$300,577/year; median = \$210,000/year;  $n = 13$ ). Timber sales were generated by thinning bobwhite woods and from the commercial harvest of pine stands outside the bobwhite woods. Likewise, livestock and agricultural operations were situated outside the bobwhite woods, but bobwhites utilized habitat on the field borders. Landowners sold bobwhite hunts to trusted clients, company employees, and friends at an average of \$14,000/day for a hunting party (range of \$4500 to \$22,500 per full-day hunt). The price charged for a bobwhite hunt varied depending on the lodging, food, and transportation provided. Most hunting parties did not exceed four people, depending on the size of the hunting wagon or if the party was hunting by foot or horse. Landowners also offset their land stewardship and bobwhite management costs by allowing clients to hunt on their property in return for financing a percentage of the property's operating budget. Finally, hunting revenues depended on how intensively landowners hunted their properties, that is, whether they ran one or two hunting wagons and the number of hunts they chose to sell each year. During interviews landowners and managers noted that maximizing bobwhite harvests and hunting revenues were not their objectives. In most cases, the revenues generated by bobwhite properties did not offset the costs of bobwhite management.

#### 4.5 | Non-financial motivations for investing in wild bobwhite management

Although landowners' motivations for wild quail management were not a part of our formal questionnaire, 32 research participants (3 landowners and 29 managers) spoke about non-financial motivations for working on wild bobwhite properties and why landowners invested in these properties. Because land managers work closely with landowners, they are well positioned to speak about landowners' motivations for, and attitudes towards, land stewardship and wild bobwhite. Ten landowners and land managers expressed a strong emotional connection to the land and pride in their habitat management (27%), for example "I've always developed a relationship with the land itself. When I groomed it and people say, man this is pretty, I take pride in that. I'm more connected to the land than I am anything else. I have spent blood, sweat, and tears on it, and I don't want to leave it." Research participants also expressed a strong emotional connection to bobwhite, such as "Watching the bobwhite fly and knowing we raised a bunch of them, that's what makes me passionate about it." Fifteen participants (41%) differentiated between the tradition of hunting wild quail as opposed to paying to hunt pen-raised quail: "You are coming out to have an experience, not kill a lot of birds. If you want to kill a lot of birds, you go to a pen-raised place."

Land stewardship was underpinned by the culture of a rural, hunting lifestyle. Sixteen participants (43%) discussed the importance of the outdoors lifestyle. Eighteen interviewees (49%) spoke about a family heritage of owning or working on wild bobwhite properties, for example

“I grew up on these [properties]... I've been on every single one of these properties at some point or another in my life.” They expressed concerns that wild bobwhite properties may not persist if younger generations do not embrace the cultural heritage of maintaining wild bobwhite properties. Finally, 20 participants (54%) discussed their struggles with hiring and retaining reliable, hard-working employees who take pride in wild bobwhite management and land stewardship, for example “We had an employee who worked here since he was 12 until he was 98. You won't find that anymore. Everyone is out to find something better.”

#### 4.6 | Limitations

Despite best efforts to accurately record the costs of bobwhite management, several limitations to this study must be mentioned. First, the costs that were not included in property budgets were estimated by landowners and land managers, and thus, this economic analysis was developed on some estimated costs. Second, this study only included bobwhite properties working with Tall Timbers in Alabama, Florida, Georgia, and South Carolina. Tall Timbers typically engages with wealthy landowners who can finance intensive wild bobwhite management. As such, our estimated costs are likely to exceed the costs for smaller operations or for agricultural properties that do not primarily focus on bobwhite management. Future economic analyses should be performed in more states with a larger sample size of bobwhite properties. Finally, our results are most reflective of established bobwhite properties because few new properties existed or were not part of our sample.

### 5 | DISCUSSION

Wild bobwhite properties in the Southeast play a critical role in the conservation of grasslands (including pine savannas), which have been degraded or lost owing to habitat conversion and fragmentation, climate change, alterations to natural land disturbance regimes, and species invasions (USDA NRCS, 2022). To help recover bobwhite, the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) is working with private landowners to implement conservation practices on ~7 million acres (~2.8 million ha) from 2022 to 2026, including enrollment of 165,000 acres (66,773 ha) in the Conservation Stewardship Program (CSP) and the placement of conservation easements on 3200 acres (1295 ha; USDA NRCS, 2022). This strategy assumes that landscape-scale restoration is most likely to

be successful when well-managed lands stabilize (or anchor) habitat availability while allowing for flexible management of surrounding private lands such that landowners' economic objectives are met while also securing wildlife populations and habitat (USDA NRCS, 2022). Importantly, the USDA has recognized that “easements and fee title purchases are not always protective because landscape context, disease outbreaks, contaminants, and climate conditions can reach across ownership boundaries and diminish conservation values. We can't buy or regulate our way to healthy landscapes as the financial and social costs are too high. Therefore, our challenge is to build shared visions with landowners and industries to identify conservation approaches that are palatable to those controlling the land throughout most of the U.S.” (USDA NRCS, 2022: 1). It is thus notable that the 37 wild bobwhite properties included in this study (19% of the properties with which Tall Timbers works) actively manage >160,000 acres (64,750 ha) of pine savannas and grasslands for bobwhite (~97% of the area that USDA plans to enroll in the CSP to benefit bobwhite across the United States).

Owners of wild bobwhite properties in the Southeast are providing critical conservation benefits, largely at their own expense. The costs of land stewardship to restore and maintain bobwhite habitat and populations are considerable. We estimated that the annual costs of bobwhite management averaged \$548,037/property/year with an average property size of 1792 ha, which was equivalent to an average of \$381/ha/year (\$154/acre/year). As part of their land stewardship practices, landowners financed prescribed burning and hardwood removal to restore pine savannas and secure bobwhite habitat. Additionally, they invested in supplemental feeding of bobwhite and predator removal to maintain or increase bobwhite populations on their properties. On average, 34 landowners invested an additional \$123,432/year to facilitate bobwhite hunts, which equated to an average of \$64/ha/year (\$26/acre/year). The combined land stewardship and hunting costs for the properties we surveyed averaged \$744,390/year (median = \$703,938/year; mean = \$442/ha/year; median = \$401/ha/year; mean = \$179/acre/year; median = \$162/acre/year).

Most landowners did not offset their land stewardship and bobwhite management costs through hunting revenues or other sources of income from land management. Potentially, these properties could generate a profit from bobwhite management and hunting if landowners elected to hunt their lands more intensively. However, landowners appear to be subsidizing bobwhite management because they value the cultural heritage of bobwhite management, although they do value the opportunity to hunt. Consistent with other studies on motivations for private land stewardship, we found that

owners and managers of bobwhite properties have a strong emotional attachment to the land, bobwhite, and a rural lifestyle (Gill et al., 2010; Gooden & Grenyer, 2019). Landowners and managers took pride in their habitat management, in particular the conservation of abundant populations of wild bobwhite and game species and pine savannas that support native and imperiled species.

However, for properties that have been owned by the same family for multiple generations, the net financial expense associated with bobwhite management may result in the sale of the property if heirs do not wish to continue funding bobwhite management. Even with diversified income streams (e.g., timber and agricultural production on other sections of the property), our analysis suggests that properties that are primarily managed for wild bobwhite tend not to be profitable unless there is a clear strategy in place to sell wild quail hunts. It is therefore not surprising that research participants expressed concerns about the sale of bobwhite properties and the conversion of these lands to other uses. However, to date, wild bobwhite properties have been purchased by wealthy individuals with the financial resources to continue bobwhite management even if they do not have a family heritage of bobwhite hunting.

It is important to note that the costly, time-intensive land stewardship practices implemented on the wild bobwhite properties we surveyed generate an array of positive externalities, largely without any investment of public funds. State wildlife agencies in the Southeast prioritize the conservation of bobwhite and other native and imperiled species, but they typically lack the necessary funding or resources to enroll large areas of private lands in wildlife conservation (Jewell et al., 2020). Moreover, private lands conservation is often not mandated by the Endangered Species Act even though one-third of ESA-listed species rely exclusively on private lands for their continued existence and another third occur on private lands (Epanchin-Niell & Boyd, 2020). Voluntary stewardship and conservation by owners of wild bobwhite properties support threatened (e.g., gopher tortoises, eastern indigo snakes) and endangered species (e.g., red-cockaded woodpeckers) that rely on pine savannas, although we recognize that the control of native predators is disputed on ethical grounds (Bergstrom, 2017; Moreno-Opo et al., 2015). Owners of bobwhite properties are contributing to the conservation of native game and non-game species and imperiled species by restoring pine savannas (Engstrom & Palmer, 2005; USDA NRCS, 2022; Van Lear et al., 2005) and translocating wild bobwhites to assist in range-wide efforts to recover bobwhites (Sisson et al., 2012, 2017). Multiple landowners also managed their properties for duck habitat, thereby benefiting waterfowl which are a

conservation priority in North America (Brasher et al., 2019). Finally, landowners' restoration of pine savanna landscapes has secured ecosystem services that benefit the larger public, including carbon storage, pollination, and groundwater recharge (Dixon et al., 2022). In common with other private landowners who operate multifunctional landscapes, owners of wild bobwhite properties in the Southeast provide a public good in the form of biodiversity conservation and the protection of threatened and endangered species and ecosystem services (e.g., carbon sequestration, nutrient cycling, hunting; Burger et al., 2019; Hendee & Flint, 2014; Lute et al., 2018; Plieninger et al., 2015). In addition to these conservation outcomes, private lands that are managed for wild quail generate economic benefits and employment for local communities (Fleckenstein, 2018, 2020).

Wildlife agencies and non-profit organizations can use our findings to inform future landowners of the costs they may incur when intensively managing pine savannas for wild bobwhite, and how they can offset those costs through hunting. Our findings also suggest that efforts to engage landowners in bobwhite management should appeal to non-financial motivations for land stewardship, such as love of the land and cultural heritage. Further research is needed to assess what financial and non-financial incentives are needed to engage smaller or less wealthy landowners in bobwhite management on their properties, and how bobwhite management may complement landowners' existing land management practices. Moreover, studies should be conducted to ascertain how the public values the biodiversity and ecosystem services that are secured by bobwhite properties, even if the public cannot access these lands.

#### AUTHOR CONTRIBUTIONS

James A. Martin, William E. Palmer, Elizabeth F. Pienaar, and D. Clay Sisson conceptualized this research. William E. Palmer acquired the funding to support this research. Elizabeth F. Pienaar supervised the research. Nicole M. Nimlos, Elizabeth F. Pienaar, and D. Clay Sisson collected the data. Nicole M. Nimlos and Elizabeth F. Pienaar developed the methodology, conducted the formal analysis, and visualized the data. Nicole M. Nimlos wrote the original draft. All authors were responsible for review and editing of the manuscript.

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## CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to disclose.

## DATA AVAILABILITY STATEMENT

Deidentified data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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