Land Use Policy 58 (2016) 218–233

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

The role of wildlife-associated recreation in private land use and conservation: Providing the missing baseline

Luke Macaulay

University of California, Berkeley, Department of Environmental Science, Policy & Management, 327 Hilgard Hall #3114, Berkeley, CA 94720-3114, United States

ARTICLE INFO

Article history:
Received 16 June 2016
Accepted 18 June 2016

Keywords:
Hunting
Fishing
Incentives
Grazing
Forest
Agriculture

ABSTRACT

Successfully integrating human activities with ecosystem conservation forms the foundation of sustainability and is key to maintaining biological diversity. This is especially important in privately-owned lands in the U.S., which harbor high levels of biodiversity yet are often vulnerable to habitat degradation and loss. This study analyzes recreation as a sustainable use on private property, focusing on wildlife-associated recreation, defined here as fishing, hunting and wildlife watching. Eighteen national surveys implemented by three U.S. government agencies spanning 1999–2013 were analyzed to provide baseline information and an assessment of the conservation impact of recreation. Results show that approximately 440.1 million acres of private land, ~22% of the contiguous land area of the U.S., are either leased or owned for wildlife-associated recreation. Land utilized for hunting accounts for 81% of that total. Approximately 33% of private forestland, 18% of private grazing land and 4% of private cropland is used to earn revenue from recreational activities. Annual spending for wildlife-associated recreation on private land is estimated at $814 million in day-use fees, $1.48 billion for long-term leases, and $14.8 billion to own land primarily for recreation (2011 dollars). Hunters own or lease properties of larger size classes than anglers or wildlife-watchers, indicating that hunting may provide a greater economic incentive for maintaining large unfragmented properties that provide a variety of conservation benefits. On grazing and cropland, landowners who earn income from recreation are significantly more likely to participate in government conservation programs ($p < 0.001$) and to pay for private conservation practices ($p = 0.08$). This provides support that recreation incentivizes conservation at higher rates than agricultural activities alone. Three policy measures that could further enhance conservation benefits of recreation are discussed.

1. Introduction

Habitat loss is a major source of biodiversity decline and extinction worldwide and is continuing at a rapid pace (Morcatty et al., 2013). In the U.S., private land accounts for approximately 60% of land area and harbors high levels of biodiversity due to historical homesteading patterns where land with more productive natural resources was settled and privatized first (Scott et al., 2001). These lands, which are integral to the conservation of biodiversity, are often the most vulnerable to habitat degradation and loss through land-use conversion and fragmentation (Knight, 1999; Maestas et al., 2003). One of the most significant innovations for protecting private land in recent decades has come in the form of conservation easements, which have culminated in placing 47 million acres under protection as of 2011 (Land Trust Alliance, 2011). Although a major achievement, this land area represents only 3.6% of private land in the U.S., suggesting that additional mechanisms to incentivize conservation of private land are warranted. This study examines recreation as one such possible mechanism, with a focus on wildlife-associated recreation, defined here as fishing, hunting, and wildlife-watching.

Since at least 1930, recreation has been highlighted as an incentive to better conserve U.S. private lands (Leopold, 1930). Leopold suggested that a private landowner who is able to earn revenue from hunting wildlife would be motivated to manage the land to support wildlife habitat and game populations. Since then, studies in various locales have shown that under the correct governance structures, payments for wildlife-associated recreation can improve habitat conservation (Dickson et al., 2009; Lindsey et al., 2007). For example, in England, landowners with hunting on their property maintained and planted more woodland and hedgerows than those who did not have hunting (Oldfield et al., 2003).

E-mail address: luke.macaulay@berkeley.edu

http://dx.doi.org/10.1016/j.landusepol.2016.06.024
0264-8377/

These studies illustrate the potential of recreation to enhance conservation outcomes, but a good understanding of the scale, distribution, and conservation effect of recreational use on private land across the entire U.S. remains an important research need. National estimates of wildlife-associated recreation released every five years by the U.S. Fish & Wildlife Service (USFWS) suffer from unreported and relatively large standard error estimates as well as lack of detail on private land estimates (USFWS, 2011, 2006, 2001). Additional studies have evaluated nationwide recreational use on agricultural lands but those studies exclude vast areas of forestland in the U.S. and don't evaluate the connection of recreation to conservation (Bagi and Reeder, 2012; Brown and Reeder, 2007). Drawing upon multiple years and multiple sources of surveys, this study remedies many of these problems and provides the most detailed and precise estimates available of private land recreation in the U.S.

This study assesses the land area, land use, property size, spending, regional variation, and conservation practices of private properties utilized for recreation in the U.S. In addition to evaluating habitat conservation practices, this study seeks to shed light on the anticipated effect of recreation on land fragmentation, which is a major threat to ecosystems (Saunders et al., 1991). For example, if the economic return from certain types of recreation is higher on large properties compared to smaller properties, then they could provide an economic incentive to reduce fragmentation of land.

2. Methods

2.1. Data sources

Data from three independently conducted national surveys was used to assess recreational use on private land in the U.S.: (1) the U.S. Fish & Wildlife Service National Survey on Fishing, Hunting & Wildlife Associated Recreation (referred to in the text as the "National Survey"), (2) the U.S. Department of Agriculture (USDA) Agricultural Resource Management Survey (ARMS), and (3) the U.S. Forest Service National Woodland Owners Survey (NWOS). The National Survey was used for most of the estimates in this study, and was supplemented with data from the ARMS and NWOS to shed light on the primary land use associated with recreation, the conservation practices associated with recreation, and the motivation of owning forestland (Table 1). For this study, private land is defined as land that is not owned by federal, state or local governments, and includes land under conservation easements and land in federal land retirement programs.

The National Survey evaluates only the subset of recreation that refers to fishing, hunting and wildlife-watching, which is referred to as "wildlife-associated recreation." The ARMS uses a broad definition of recreation, which includes activities such as horseback riding or farm tours, which may not require wildlife or be dependent on wildlife. Throughout the paper, recreational use estimates from the ARMS data that includes all recreational activities is referred to as "recreation broadly defined" or "all types of recreation." The NWOS gathers information on two recreational categories: (1) hunting and (2) recreation other than hunting, which could include any recreation activities such as horseback riding, driving all-terrain-vehicles, and fishing.

Section 3.2 evaluates land uses associated with recreation, focusing on forestland, grazing land and cropland. The ARMS data, which surveys grazing land and cropland operators, requires respondents to choose a primary use based on revenue, meaning these land use categories are mutually exclusive, even though some cropland could be grazed as a secondary use (and vice versa). In contrast, forestland and grazing land estimates come from separate surveys (NWOS and ARMS) and likely contain some overlap, as grazing can occur on forestland. The USDA estimates that approximately 10% of forestland is grazed, with remaining grazing land primarily occurring on rangelands (USDA NRCS, 2003). To take this into account, when combining the land use area estimates as a comparison to land area used for wildlife-associated recreation in Section 3.2, grazing land area is reduced by the 10% of forestland area that is estimated to be grazed in order to avoid double-counting. Although overlap between cropland and forestland is possible, these land uses tend to be less compatible and overlap is likely to be small.

2.1.1. The National Survey

The National Survey gathers information every five years about participation in and spending for fishing, hunting, and wildlife-watching in the U.S. It is a multistage probability sample with coverage in all 50 states that was conducted by the U.S. Census Bureau. Each survey year the population was independently sampled and asked identical questions about what recreationists pay to access or own private land.

This study uses the National Survey datasets collected in 2001, 2006, and 2011. The three survey years were pooled to improve the precision of estimates, increasing the sample size to a total of 93,725 observations with 4957 observations of individuals who leased, owned or paid fees to access private land for wildlife-associated recreation. Prior to pooling, some subsets of the data had fewer than 200 observations in a single year resulting in large standard error estimates for many of the estimated parameters (for example in 2011, there were only 175 respondents with hunting leases). Pooling across time sacrifices temporal detail in order to improve geographical understanding (Verma et al., 2009). An analysis of variables of interest revealed few significant differences over time. As such, pooling the data resulted in improved geographical precision with minimal loss of detail about changes over time. As a result, the results reported are estimates for an average year over the course of 2001–2011.

The National Survey evaluates day-use fees, leases, and ownership as ways in which individuals accessed private land for wildlife-associated recreation. Day-use fees are payments to access or use private land during single or multi-day trips. Leases are agreements for seasonal or year-round access to private land that are renewed on an annual or multi-year basis. Estimates of land ownership for wildlife-associated recreation include only those landowners who self-identify as owning the land *primarily* for wildlife-associated recreation. The survey questionnaire requested a single value for the amount spent to own land, which included mortgage payments, down payments, taxes and maintenance expenses. The inclusion of these various payments into a single amount combines disparate types of expenses into a single value, leading to wide variation in annual spending to own land and comparatively large standard error estimates (see Appendix B).

The U.S. Census Bureau, in administering the National Survey, employs quality control procedures throughout the planning, collecting, and processing of data to minimize error (U.S. Census Bureau, 2016). Nonetheless, the estimates in this manuscript could contain non-sampling error such as measurement error or non-response error. Response rates ranged between 66% and 90%, which is relatively high compared to many survey studies, minimizing the risk of non-response bias (Groves, 2006). (See Appendix C for survey questions and additional details of the analysis).

The USFWS reports written every five years on the National Survey contain some similar estimates as calculated in this study. However, the analyses in those reports and in this article differ in several ways: (1) the estimates in this manuscript are much more precise due to the pooling of three survey years, (2) the estimates in this article treat missing data by omitting missing values from calculations (generally a more supported method of dealing with missing data (Allison, 2002)), (3) the estimates in this manuscript

Table 1
Description of data sources used in this analysis.

Data Source	Population	Sample Size	Survey Years	Role	Recreation categories
National Survey: USFWS National Survey on Fishing, Hunting & Wildlife-Associated Recreation	Wildlife-associated Recreational users i.e. hunters, anglers, and wildlife-watchers	93,725	2001, 2006, 2011	Estimating spending and land area used to access private land for wildlife-associated recreation. Assessing size class of properties utilized. Understanding regional variation.	(1) Fishing (2) Hunting (3) Wildlife-watching
ARMS: USDA Agricultural Resource Management Survey	Cropland and Livestock Operations with >$1000 in agricultural sales	242,608	1999–2012	Estimating cropland and grazing land used for recreation generally defined. Assessing conservation practices associated with recreational earners.	All types of recreation: including horseback riding, farm tours, and wildlife-associated recreation
NWOS: U.S. Forest Service National Woodland Owners Survey	Forestland Owners >10 acres	~18,000	2011–2013	Estimating forestland area used for hunting and non-hunting recreational leases and recreation as an ownership motivation.	(1) Hunting (2) Recreation Besides Hunting

report standard error estimates that are not provided in the reports, and (4) this manuscript contains numerous calculations that are not provided in the public reports, such as how spending varies with size of property used, and an analysis of regional variation in private land recreation (Appendix A).

2.1.2. Agricultural Resource Management Survey (ARMS)

Fourteen years (1999–2012) of ARMS data was used to provide insight about grazing land and cropland earning income from recreation, the conservation practices associated with recreational income earners, and to corroborate the National Survey lease estimates. The ARMS is an annual survey of farm businesses and operators that is independently sampled every year and designed to be representative of the continental U.S. The farm population includes all establishments that produced and sold, or would normally have sold, at least $1000 of agricultural products during the previous year. This survey asks farmers and ranchers about the total income from all types of recreational activities such as hunting, fishing, and horseback riding. Similar to the National Survey, the 14 years of data were pooled to improve precision, obtaining an overall sample of 242,600 farms and ranches, with 6417 of those farms and ranches earning income from recreation.

This ARMS survey has important differences from the National Survey in that it excludes any of the approximately 422 million acres of private forestlands in the U.S. that do not sell at least $1000 of agricultural products (Nickerson et al., 2011). Estimates of land area earning income from recreation by livestock and cropland operators are also based on a broader definition of recreation than that used in the National Survey, which evaluates only fishing, hunting and wildlife-watching. Conservation practices associated with recreation (Section 3.6) are evaluated using the ARMS, meaning that they are evaluated considering all types of recreation that occur on crop and livestock operations.

2.1.3. National Woodland Owners Survey (NWOS)

To better understand the use of private forestland for recreation in the U.S., preliminary results from the U.S. Forest Service (USFS) NWOS were obtained via direct communication with the survey administrators (Butler et al., 2014). The NWOS survey results represent the years 2011–2013 and are estimates based on all private forest ownerships (industrial and family owned) with greater than 10 acres (Butler et al., 2005). These data were used to assess the leasing of forestland for both hunting and non-hunting (fishing, horseback riding or camping) recreation, as well as to assess recreation as a motivation for owning private forestland.

2.2. Data analysis

The National Survey and ARMS administrators calculated the survey sampling weights that are used to estimate population totals. The concept behind sampling weights is that an individual surveyed with a sampling probability of π_i represents $1/\pi_i$ individuals in the population, where $1/\pi_i$ is the sampling weight. If X_i is a measurement of variable X on person i, the following equation is used to estimate the total for the population, $\hat{T}_X$, which is known as the Horvitz-Thompson estimator (Horvitz and Thompson, 1952):

$$\hat{T}_X = \sum_{i=1}^{n} \frac{1}{\pi_i} X_i \tag{1}$$

The variance calculation of the Horvitz-Thompson estimate of the total is:

$$\hat{\text{var}}\left[\hat{T}_x\right] = \sum_{i,j} \left(\frac{X_i X_j}{\pi_{ij}} - \frac{X_i}{\pi_i}\frac{X_j}{\pi_j} \right) \tag{2}$$

with π_{ij} being the joint inclusion probability of two individuals i and j, which is the probability that both individuals i and j are in the sample. X_j is the measurement of variable X on individual j, and π_j is the sampling probability of individual j.

Mean estimates are derived by dividing the estimated total, $\hat{T}_x$ (Eq. (1)), by the population size, $\hat{N}$, which is the sum of the sampling weights or:

$$\hat{N} = \sum_{i=1}^{n} \frac{1}{\pi_i} \tag{3}$$

Ninety-five percent confidence intervals for estimates were calculated by using a normal distribution for the estimate, i.e. by adding and subtracting 1.96 standard errors (Lumley, 2011). The sampling weight variables were originally developed to calculate national estimates of variables for an individual survey year. In order to obtain an average annual estimate from multiple survey years in a pooled data analysis, the sampling weights were divided by the number of survey years pooled (Lumley, 2011).

Regression results were obtained by fitting a generalized linear model that accounts for complex survey data with sampling

Table 2
Land area and property characteristics for wildlife-associated recreation, in particular a) fishing, b) hunting, c) wildlife-watching, and d) grand totals. Standard error estimates are italicized and in parentheses. Dollar amounts are in 2011 real U.S. Dollars. (Data source: USFWS National Survey, 2001, 2006, 2011).

a) Fishing

	Total Acres (in millions)	% of total within activity type	% of overall total	% of land area	Mean size of property (acres)	% in clubs	Mean number in club	Mean acres per person (adjusted for clubs)	Mean amount paid per person per acre
Lease Total	**6.8**	**19.8%**	**1.5%**	**0.3%**	**423.1**	**58.6%**	**71.0**	**33.4**	**685.3**
	(2)				*(167.9)*	*(4.9%)*	*(23.6)*	*(9.6)*	*(113.1)*
Northeast	0.2	0.4%	0.0%	0.1%	94.4	65.7%	141.5	4.7	515.1
	(0.1)				*(58.5)*	*(13.1%)*	*(83.4)*	*(2.7)*	*(127.1)*
Midwest	0.6	1.8%	0.1%	0.1%	34.5	64.8%	29.5	10.0	697.9
	(0.5)				*(19.9)*	*(8.4%)*	*(15.2)*	*(8.1)*	*(150.2)*
South	3.5	10.2%	0.8%	0.6%	680.5	47.9%	49.7	38.5	765.6
	(1.4)				*(329.3)*	*(6.9%)*	*(24.9)*	*(13.6)*	*(214.2)*
West[a]	2.5	7.3%	0.6%	0.2%	1,087.6	78.3%	148.4	141.8	472.5
	(1.4)				*(919.9)*	*(10.3%)*	*(96.6)*	*(81.5)*	*(156.9)*
Own Total	**27.5**	**80.2%**	**6.2%**	**1.1%**	**60.8**	**29.1%**	**45.5**	**32.0**	**3,084.6**
	(4)				*(9.5)*	*(2.3%)*	*(12.2)*	*(4.4)*	*(407)*
Northeast	0.5	1.4%	0.1%	0.4%	85.4	28.9%	179.2	5.3	3,714.2
	(0.2)				*(53)*	*(6.2%)*	*(74.3)*	*(1.9)*	*(1096)*
Midwest	9.3	27.0%	2.1%	1.8%	51.8	33.7%	13.4	29.0	2,340.1
	(2.2)				*(13.4)*	*(4.1%)*	*(5.4)*	*(6.8)*	*(599.8)*
South	17.2	50.2%	3.9%	2.9%	70.9	24.4%	48.9	45.3	3,512.7
	(3.3)				*(13.2)*	*(3.5%)*	*(22.1)*	*(8.2)*	*(707.5)*
West	0.6	1.6%	0.1%	0.0%	16.5	35.3%	33.1	8.0	3,183.1
	(0.1)				*(6.7)*	*(5.6%)*	*(19.9)*	*(2)*	*(938.6)*
Lease & Own Total	**34.3**	**100.0%**	**7.8%**	**1.4%**	**134.1**	**34.7%**	**55.2**	**33.0**	**2,675.0**
	(4.5)				*(34.6)*	*(2.2%)*	*(12.5)*	*(4.1)*	*(339.8)*

b) Hunting

	Total Acres (in millions)	% of total within activity type	% of overall total	% of land area	Mean size of property (acres)	% in clubs	Mean number in club	Mean acres per person (adjusted for clubs)	Mean amount paid per person per acre
Lease Total	**220.1**	**61.8%**	**50.0%**	**9.1%**	**2,399.1**	**90.9%**	**18.7**	**224.6**	**15.1**
	(39.2)				*(387.2)*	*(1.5%)*	*(2.2)*	*(37.5)*	*(3.1)*
Northeast	18.2	5.1%	4.1%	15.7%	859.2	79.1%	20.7	299.4	40.9
	(14.7)				*(308.1)*	*(7.8%)*	*(4.5)*	*(243.1)*	*(14.7)*
Midwest	23.2	6.5%	5.3%	4.4%	576.8	78.0%	12.3	172.2	41.5
	(7.3)				*(154.9)*	*(7.7%)*	*(3)*	*(57)*	*(17.8)*
South	149.5	42.0%	34.0%	25.4%	2,566.2	94.4%	17.7	193.8	8.1
	(24.1)				*(414.5)*	*(1.1%)*	*(2)*	*(25.6)*	*(2.1)*
West[a]	29.2	8.2%	6.6%	2.4%	14,873.3	70.6%	185.2	2,208.3	48.6
	(26.2)				*(11,813.4)*	*(11.2%)*	*(147.2)*	*(1942)*	*(29.4)*
Own Total	**135.8**	**38.2%**	**30.9%**	**5.6%**	**326.7**	**39.4%**	**11.8**	**108.6**	**263.6**
	(17.4)				*(105.9)*	*(2.2%)*	*(3.3)*	*(13.3)*	*(43.4)*
Northeast	13.1	3.7%	3.0%	11.3%	116.8	43.1%	7.6	62.5	440.6
	(3.7)				*(25.2)*	*(5.9%)*	*(1.6)*	*(16.4)*	*(164.7)*
Midwest	55.8	15.7%	12.7%	10.6%	147.5	35.4%	4.8	106.5	239.6
	(13.5)				*(27.3)*	*(3.3%)*	*(1)*	*(24.7)*	*(66)*
South	60.1	16.9%	13.7%	10.2%	614.8	42.5%	19.6	129.4	148.6
	(10.1)				*(282.2)*	*(3.7%)*	*(8.1)*	*(20.4)*	*(38.2)*
West	6.6	1.9%	1.5%	0.6%	462.2	43.5%	20.3	146.8	846.7
	(2.3)				*(148)*	*(6.5%)*	*(11.4)*	*(46.6)*	*(274.5)*
Lease & Own Total	**355.9**	**100.0%**	**80.9%**	**14.7%**	**1,324.9**	**63.5%**	**17.0**	**169.0**	**157.6**
	(43.2)				*(216.6)*	*(2%)*	*(1.9)*	*(19.4)*	*(25.1)*

c) Wildlife-Watching

	Total Acres (in millions)	% of total within activity type	% of overall total	% of land area	Mean size of property (acres)	% in clubs	Mean number in club	Mean acres per person (adjusted for clubs)	Mean amount paid per person per acre
Lease Total	**8.7**	**17.4%**	**2.0%**	**0.4%**	**298.1**	**75.2%**	**95.8**	**63.4**	**902.9**
	(3.2)				*(116.1)*	*(7%)*	*(46.8)*	*(21.1)*	*(374.5)*
Northeast[a]	0.0	0.0%	0.0%	0.0%	1.1	45.7%	4.5	0.8	12.0
	(0)				*(0.1)*	*(19.9%)*	*(0.7)*	*(0.2)*	*(403.8)*
Midwest[a]	1.3	2.6%	0.3%	0.2%	106.4	76.1%	80.4	49.7	264.3
	(0.8)				*(70.8)*	*(12.4%)*	*(71.8)*	*(30.5)*	*(102.2)*
South[a]	7.3	14.7%	1.7%	1.2%	464.0	80.1%	57.0	91.4	875.8
	(3.1)				*(188.3)*	*(9.2%)*	*(26.1)*	*(33.9)*	*(543.1)*
West[a]	0.0	0.0%	0.0%	0.0%	115.9	82.5%	478.2	0.5	2,161.7
	(0)				*(95.6)*	*(13.3%)*	*(319.9)*	*(0.1)*	*(1929.1)*

Table 2 (*Continued*)

c) Wildlife-Watching

	Total Acres (in millions)	% of total within activity type	% of overall total	% of land area	Mean size of property (acres)	% in clubs	Mean number in club	Mean acres per person (adjusted for clubs)	Mean amount paid per person per acre
Own Total	**41.2** *(6.4)*	**82.6%**	**9.4%**	**1.7%**	**54.5** *(7.5)*	**24.8%** *(2.8%)*	**31.5** *(12.1)*	**41.3** *(6.2)*	**2,799.0** *(980.9)*
Northeast	3.7 *(0.9)*	7.4%	0.8%	3.2%	23.4 *(5.1)*	21.3% *(5.3%)*	12.2 *(4.8)*	16.7 *(3.5)*	1,506.4 *(314.5)*
Midwest	14.2 *(3.3)*	28.4%	3.2%	2.7%	55.4 *(12)*	20.2% *(5.2%)*	28.3 *(14.9)*	48.6 *(10.6)*	770.7 *(265.4)*
South	16.3 *(4.2)*	32.7%	3.7%	2.8%	69.5 *(15.4)*	28.2% *(5.1%)*	31.4 *(17.8)*	46.8 *(11)*	1,667.0 *(579.5)*
West	7.0 *(3.5)*	14.1%	1.6%	0.6%	64.8 *(27.1)*	31.4% *(6.9%)*	58.4 *(53.2)*	51.9 *(25.9)*	11,845.0 *(6248.5)*
Lease & Own Total	**49.9** *(7.2)*	**100.0%**	**11.3%**	**2.1%**	**86.8** *(17.7)*	**31.1%** *(2.9%)*	**52.1** *(17.1)*	**45.1** *(6.2)*	**2,616.6** *(880.9)*

d) Grand Totals

	Total Acres (in millions)	% of total within activity type	% of overall total	% of land area	Mean size of property (acres)	% in clubs	Mean number in club	Mean acres per person (adjusted for clubs)	Mean amount paid per person per acre
Total Leased	**235.6** *(42.5)*	NA	**53.5%**	**9.7%**	**493.8** *(155)*	**85.3%** *(2.3%)*	**25.8** *(5.7)*	**103.7** *(24.9)*	**132.8** *(31.7)*
Total Owned	**204.5** *(24.8)*	NA	**46.5%**	**8.4%**	**56.7** *(10.6)*	**33.1%** *(2.1%)*	**25.7** *(6.5)*	**54.8** *(7.2)*	**1,607.0** *(272.2)*
Total Leased & Owned	**440.1** *(50.9)*	NA	**100.0%**	**18.1%**	**58.8** *(15)*	**56.4%** *(2.2%)*	**25.76** *(6.1)*	**58.6** *(9.8)*	**152.6** *(44.6)*

[a] Indicates estimates based on fewer than 30 observations.

weights. The variables used for these regressions exhibited characteristics of the Poisson distribution and a quasi-Poisson link function was used in these regressions. These calculations were performed using the R statistical computing language using the 'survey' package (Lumley, 2014, 2004; R Core Team, 2015).

The National Survey includes two separate datasets for each survey year, one for sportspersons and one for wildlife-watchers. Calculating the overall totals across both surveys required summing the Horvitz-Thompson estimated totals and the associated standard error estimates. To calculate means across the two surveys, the Graybill-Deal estimator was used to create an unbiased composite mean between the two estimates while assuming independence of the mean estimates (Graybill and Deal, 1959). Using estimated means of the wildlife-watcher survey, μ_1, and sportsperson survey, μ_2, a weight, b, was calculated based on the estimated variance, S^2, of each mean using the following formula $b = {S_1}^2/({S_1}^2 + {S_2}^2)$. This weight was used to estimate the composite mean, μ^*, using the equation $\mu^* = (1 - b)\,\mu_1 + b\,\mu_2$.

Nominal U.S. Dollar amounts obtained from the National Survey were adjusted for inflation using the U.S. Department of Labor's Consumer Price Index. All dollar amounts in this manuscript are presented as 2011 real dollars. Regional estimates were broken down by U.S. Census Region (Fig. 1).

3. Results

3.1. Land area

Approximately 32.7% of the private land in the U.S. (440.1 million acres) is either leased or owned for wildlife-associated recreation. Hunting land is the primary contributor to the land area, accounting for 80.9% (355.9 million acres) of the total, followed by wildlife-watching at 11.3% (49.9 million acres) and fishing at 7.8% (34.3 million acres).

The total land area is divided into two categories for each type of recreation, leased and owned, which respectively account for 54% and 46% of the total. The majority of land used for fishing and wildlife-watching is owned primarily for that purpose accounting for 80.2% and 82.6% of that land area. Hunting was distinctive in that only 38.2% of its land area was owned primarily for that purpose; the majority of hunting land (61.8%) was leased.

Leased properties on average are significantly larger than owned properties across fishing, hunting and wildlife-watching ($p < 0.05$). However, a greater number of people who lease land do so as members of clubs compared to those who own land ($p < 0.05$). To control for this, the density of use, or mean number of acres used per-person, was compared across activity types. Density of use for fishing and wildlife-watching properties was relatively high and statistically similar (33.0 and 45.1 acres per person respectively). Hunting properties, however, were significantly different, with a much lower density of use (169.0 acres per person). Hunting *leases* has the lowest density of use (224.6 acres/person), while properties *owned* primarily for hunting had a higher density of use (108.6 acres per person).

On a regional basis, some of the largest contrasts in recreational use patterns occur in the proportion of land area used for hunting. The analysis revealed that 10.2%–11.3% of the land area of the South, Midwest, and Northeast are *owned* primarily for hunting, while less than 1% of the land in the West was owned for hunting. In terms of hunting *lease* lands, the South and Northeast have 25.4% and 15.7% of their respective land area used as hunting leases, whereas only 4.4% and 2.4% of the land area in the Midwest and West are leased for hunting, respectively (Table 2).

3.2. Land use

Approximately 33.5% (160.1 million acres) of private forestland is leased for recreation, followed by 18.2% (98.1 million acres) of

Table 3
Private forestland, grazing land and cropland earning income from all types of recreation. Standard error estimates are italicized and in parentheses. Data source: USDA Agricultural Resource Management Survey 1999–2012 for cropland and grazing land; USFS National Woodland Owners Survey 2011–2013 for forestland.

	Area (millions of acres)	Percent of area used	Number of Operators	Percent of operators
Forestland	160.1 (3.9)	33.5%	312,595 (26,537)	7.3%
Grazing land	98.1 (5.7)	18.2%	28,600 (1008)	2.3%
Cropland	15.7 (1.0)	4.1%	13,600 (680)	1.5%

private grazing land and 4.1% (15.7 million acres) of private cropland (Table 3). Owners with larger than average properties are more likely to earn revenue from recreation than landowners with smaller properties. For example, only 7.3% of forest landowners earn income from recreation, yet those individuals own 33.5% of all forestland, with similar patterns occurring in grazing land and cropland (Table 3).

Of the private forestlands leased for recreation, 97.4% (146.1 million acres) are leased for hunting and 30.9% (46.4 million acres) are leased for recreation other than hunting. Results suggest that hunting is compatible with other recreational uses as 92% (42.5 million acres) of the land leased for non-hunting recreation is leased in conjunction with hunting.

Hunting is "very important" or "important" to individuals who own 44.4% of private forestland (212 million acres). Non-hunting recreation is "very important" or "important" to people who own 37% of forestland (178 million acres). These estimates suggest that forestlands are a significant contributor to the total amount of private land owned primarily for wildlife-associated recreation (Section 3.1 above).

Because forestland, rangeland, and cropland together make up almost 90% of all private land in the U.S (Nickerson et al., 2011), the leased land area estimates from this section can be used as a comparison of estimates from the National Survey (Section 3.1 above). After reducing grazing land area by an estimated 10% of forestland that is grazed (USDA NRCS, 2003), the combined estimates of forestland, grazing land, and cropland results in an estimated 257.9 million acres earning income from recreation broadly defined. These estimates align with the findings of the National Survey analysis, which estimates 235.6 million acres leased for the more narrowly defined subset of wildlife-associated recreation, which excludes activities such as horseback riding, farm tours, etc.

3.3. Property size

Analysis of the National Survey reveals distinctive patterns in property size classes that are used for different types of wildlife-associated recreation. Hunters spend more to lease or own land of larger size classes compared to anglers or wildlife-watchers (Fig. 2). The majority of *spending* by hunters for leasing or owning land goes to properties greater than 50 acres, while the majority of spending by anglers and wildlife-watchers is on properties smaller than 50 acres (Fig. 2a & b). A similar pattern emerges when evaluating total land area leased in different size classes. Hunting leases greater than 1000 acres make up an estimated 40% of all land used for all types of wildlife-associated recreation (176 million acres SE 39.0 million acres) (Fig. 2c). In terms of land area owned primarily for fishing, hunting and wildlife-watching (Fig. 2d), each recreation

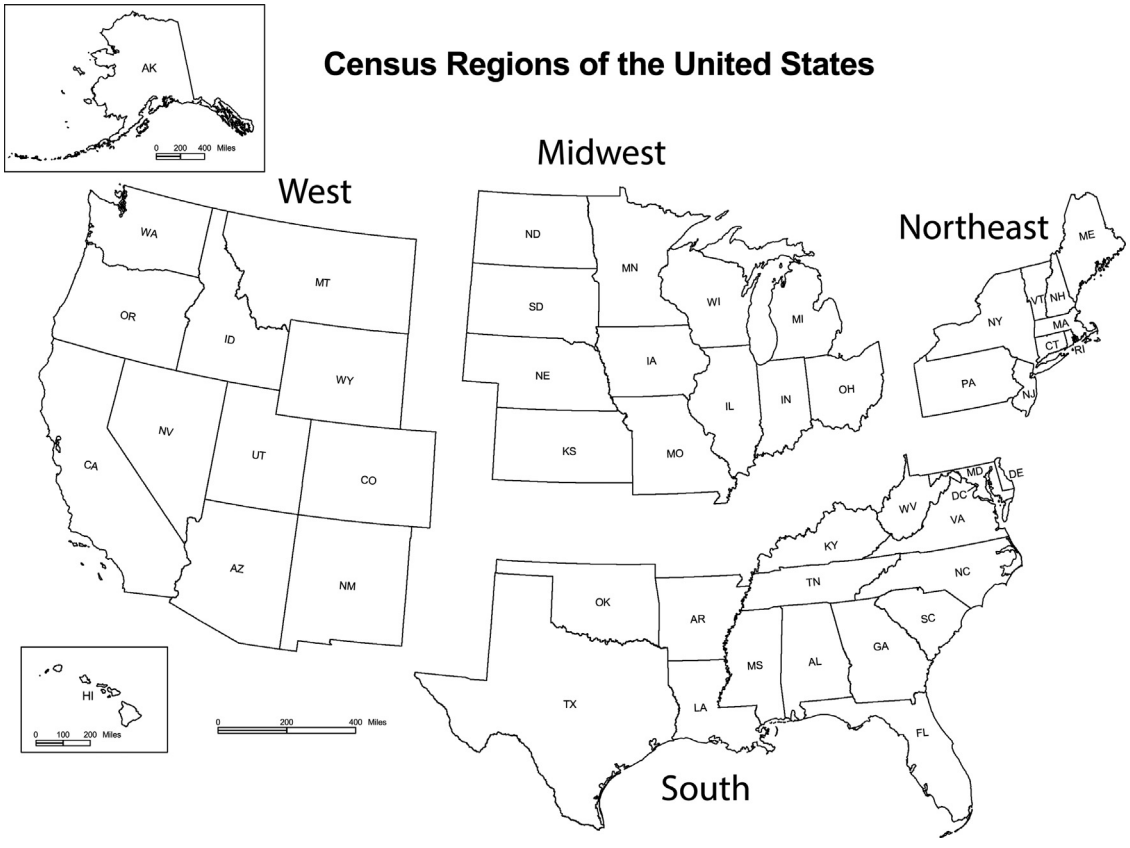

Fig. 1. U.S. Census Regions.

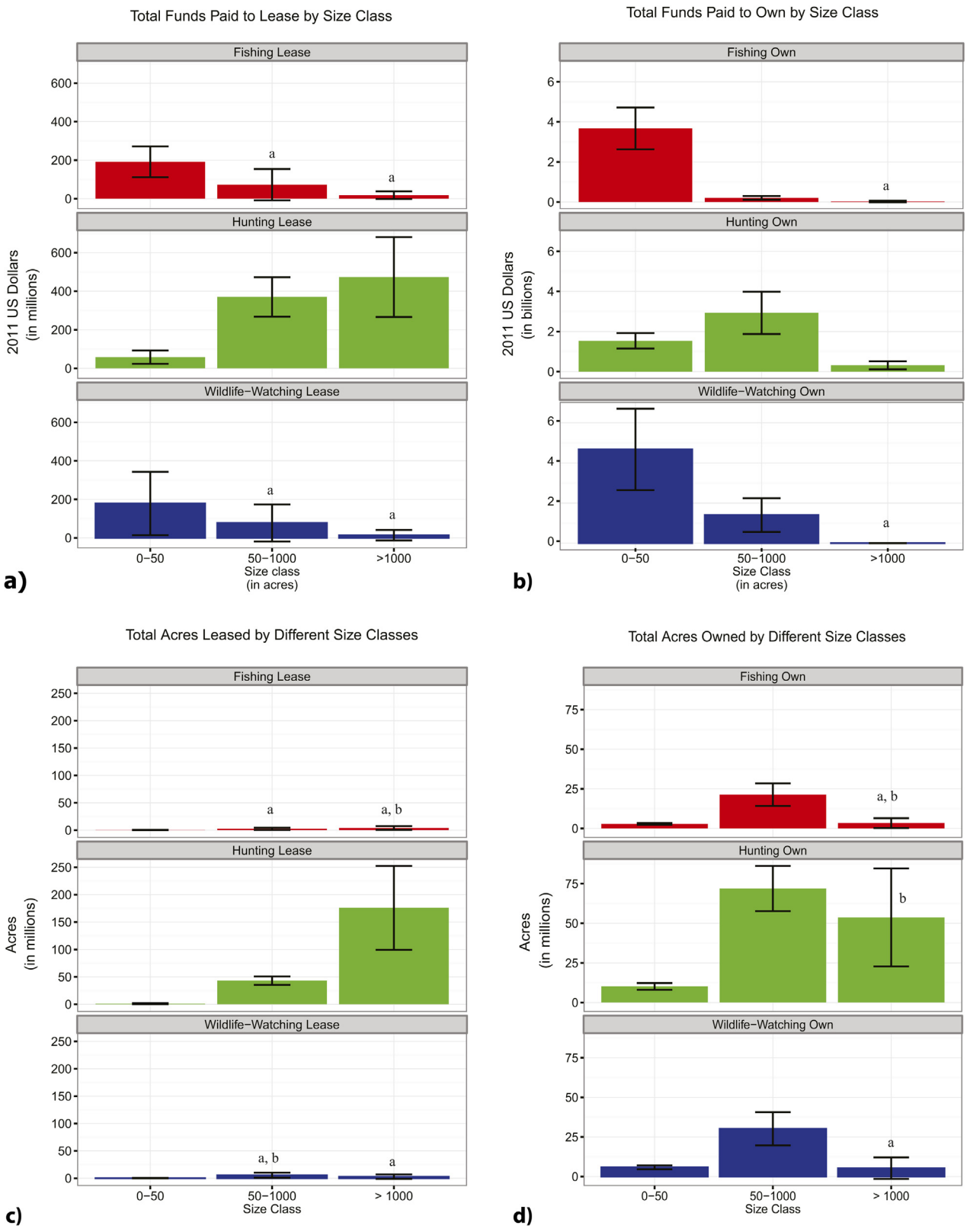

Fig. 2. How recreation types utilize different sized properties. Hunters as a whole tend to lease and own properties in larger size classes than anglers or wildlife-watchers. (a) Total annual expenditures for leases (95% CI). (b) Total annual expenditures to own land primarily for recreation (95% CI). (c) Total land area under lease for wildlife-associated recreation (95% CI). (d) Total land area owned primarily for wildlife-associated recreation (95% CI). Note: y-axis scales are independent of one another. [a]Estimates that are based on less than 30 observations. [b] Indicates subsets of data that have greater than 10% of their observations top-coded to protect the anonymity of respondents, which could result in greater uncertainty in these estimates than standard error bars indicate. Data source: USFWS National Survey, 2001, 2006, 2011.

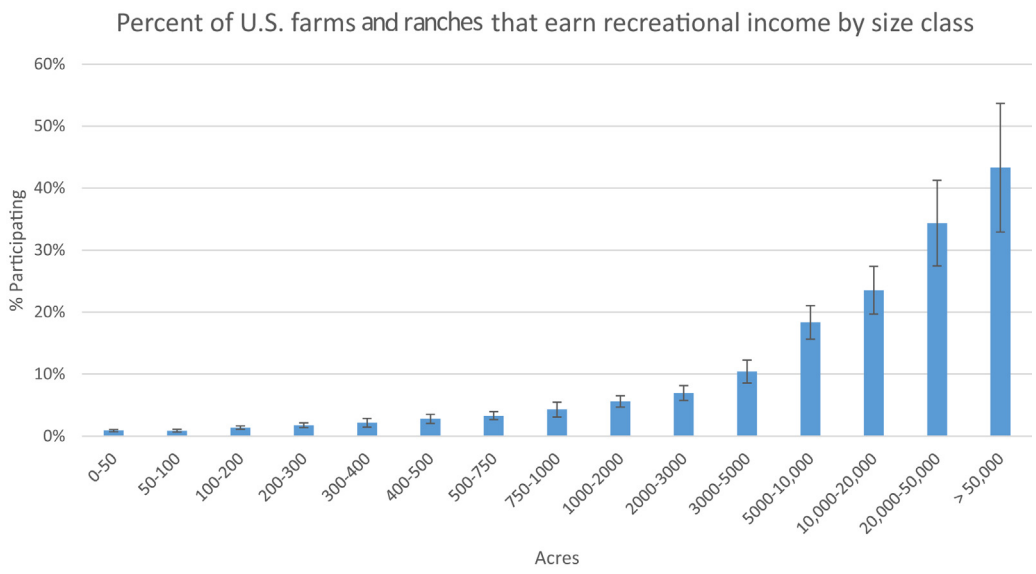

Fig. 3. Percent of farms and ranches participating in earning all types of recreational income based on size class (95% CI). Data source: USDA Agricultural Resource Management Survey, 1999–2012.

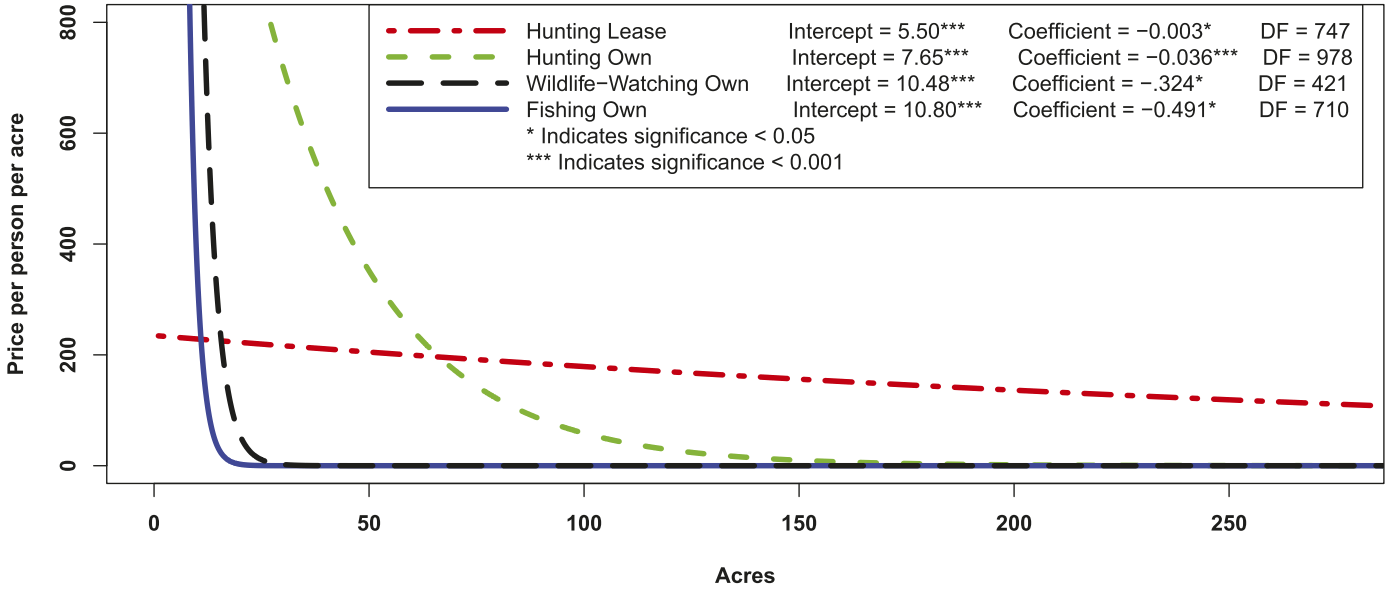

Fig. 4. Regression results showing how price paid per acre declines with size of property for different activity types. The decline in price paid for hunting leases is the slowest, while mean price paid per person per acre to own wildlife watching and fishing properties declines substantially after approximately 25 acres. This suggests hunters are willing to pay higher prices than anglers and wildlife-watchers for larger properties. GLM regression run using quasi-Poisson family, and predicted lines are back-transformed to the scale of the response variable. Data source: USFWS National Survey, 2001, 2006, 2011.

type has the majority of its land in the 50–1000 acre size class, but hunters own more land in all three size classes ($p < 0.05$), with the greatest differences in the two largest size classes (Fig. 2d).

The ARMS data, which measures income from all types of recreation, shows a pattern of increasing percentage of farm and ranch landowners earning income from recreation as the size of the property increases (Fig. 3). This further illustrates how low overall participation rates (i.e. 2.3% of livestock operators) belie a much larger area of land (18.2% of private grazing land) that is used to earn income from recreation.

In order to evaluate how price paid per acre responded to increasing property size, a generalized linear model applied to the National Survey revealed that recreationists generally pay less per acre as property size increases (fishing and wildlife-watching *leases* had small sample sizes with no significant differences and are not reported). Properties *owned* for fishing and wildlife-watching exhibited the strongest decline in price paid per acre with increasing property size (coefficients = −0.49 and −0.32 respectively), while properties owned and leased for hunting exhibit much slower declines in price paid per acre (coefficients = −0.04 and −0.003 respectively). This suggests that while land area used for wildlife-associated recreation exhibits the characteristic of diminishing returns with increasing property size, the pattern is least pronounced for hunting properties—especially hunting leases (Fig. 4).

3.4. Expenditures and participation

According to the National Survey, hunters, anglers, and wildlife-watchers in the U.S. spend $17.1 billion annually to lease, access, and own private land for recreation. Spending to own property

accounts for approximately 87% ($14.8 billion) of the total, with leases and fees comprising 9% ($1.48 billion) and 5% ($814 million) respectively (Table 4). In terms of ownership of land, annual spending is not significantly different between fishing, hunting, and wildlife-watching. However, for leases and day-use fees, total annual spending is significantly higher for hunters. The larger amount spent for hunting leases is driven mostly by the greater number of hunters who lease land (~1 million hunters lease private land compared to 212,000 anglers and 144,000 wildlife-watchers). In contrast, the higher overall spending for day-use fees by hunters, is driven by the average amount of money paid for access—hunters spend an average of $591, while anglers and wildlife-watchers pay on average $128.3 and $73.3 respectively (Table 4). Individuals on average pay significantly more to own properties for wildlife-associated recreation than they do to lease property, likely due to the greater variety of costs (mortgage payments, taxes, maintenance, etc.) and benefits (exclusive control, investment benefits, etc.) associated with owning land versus leasing land.

There are no large regional differences in *mean payments* within the same activity and form of access, however, *participation rates* vary regionally for hunting only. The South has significantly higher participation rates of hunters leasing land (16.4% vs. ≤6.0% for other regions) and paying day-use fees (10.6% vs ≤3.6% for other regions), resulting in much greater total spending in the South. In contrast, participation rates of individuals who *own* land primarily for hunting are statistically similar (9.8%–12.7%) across the Northeast, Midwest, and the South, but are significantly lower in the West (2.4%, $p < 0.05$).

3.5. Recreation types

The National Survey gathered information on day-use fee spending for specific subsets of hunting (big game, small game, migratory game, and other animals) and fishing (saltwater, freshwater, great lakes). Hunting accounted for 68% of the $814 million spent annually in day-use fees, with big game hunting accounting for half of all day-use fee spending across all activity types (Table 5). Wildlife-watching and fishing day-use fee spending were comparatively low ($174 million and $90 million respectively). Estimates of types of game hunted on leases followed similar patterns (see Appendix D).

3.6. Conservation practices

The ARMS data contains information on payments to landowners for government conservation programs as well as spending by landowners for professional conservation practices. This analysis reveals that livestock and cropland operators who earn recreational income (recreation broadly defined) are significantly more likely to participate in government cost-share programs and land retirement programs ($p < 0.01$) (Table 6). Landowners who earn recreational income are also more likely to pay for private professional conservation practices at the 10% significance level ($p = 0.08$). The significant differences in mean amounts spent/received remain even after controlling for the size of property in a generalized linear model.

4. Discussion

Results show the importance of wildlife-associated recreation to land use and conservation due to the vast land area used (440.1 million acres), high annual spending ($17.1 billion), and because these lands host wildlife resources and habitat. For context, three major conservation initiatives, conservation easements, the Conservation Reserve Program, and the Pittman Robertson act, *combined* impact approximately 81.8 million private land acres, only 18.6% of the private land area used by wildlife-associated recreation. These programs together cost approximately $4.7 billion annually, which is 27.6% of annual spending for wildlife-associated recreation on private land (Land Trust Alliance, 2011; U.S. Fish and Wildlife Service, 2013; USDA, 2012). The scale of recreational use compared to these programs illustrates the enormous influence that recreational use has on private land and wildlife habitat in the U.S. Furthermore, because hunting is the largest contributor to the land area used for recreation, these findings suggests that hunters, particularly big game hunters, can be especially influential in affecting management practices on significant areas of wildlife habitat in the U.S.

The type of land used for wildlife-associated recreation also points to its impact on conservation. Private grazing lands and forestlands maintain relatively intact ecosystems and provide habitat for wildlife and support biodiversity (Brunson and Huntsinger, 2008; Goldstein et al., 2006). These lands are utilized heavily for recreation, with 18% of grazing lands and 33% of forestlands generating income from recreation (broadly defined), not including a substantial area of land that is used or owned for recreation that does not generate income (Table 2d.; Butler and Workman, 1993). Freshwater resources and wetlands associated with the 34 million acres used for fishing, while small in comparison with hunting lands, are critical for conservation as freshwater resources host increased biodiversity, many rare and endangered species, and often entirely different species pools than surrounding habitats (Dudgeon et al., 2006). The 50 million acres of land owned and leased for the primary purpose of wildlife-watching may also have important conservation value, due to high amenity values that often correlate with other important natural resource features, such as designated wilderness areas and increased environmental quality (Smith and Krannich, 2000).

This study uncovered a positive correlation between conservation practices and recreation broadly defined, with recreational income earners on grazing land and cropland more likely to participate in government conservation programs and to pay for private conservation practices (Table 6). The economics of recreational use, with distinct preferences for land sizes for different activities, could also influence fragmentation patterns. Because fragmentation is a major threat to ecosystems (Saunders et al., 1991), hunters, with their preference for larger properties, could provide a conservation benefit as they may help to reduce subdivision of large tracts of land (Figs. 2 and 4).

Previous research has found a saturation effect of property size on landowner's willingness to pay for amenity values such as recreation or personal enjoyment of a property. One study found that as the size of property increased beyond a certain threshold, landowners obtained few additional personal benefits from amenity values (Oviedo et al., 2012). The findings of this study provide support for such an effect with recreation, but uncovers an important distinction between hunters and other types of recreational users, i.e. hunters appear to have a much higher threshold property size than wildlife watchers or anglers. The lower threshold for wildlife-watchers or anglers could result in higher densities of development and increased land fragmentation for prime fishing and wildlife-watching areas compared to hunting areas.

Diversified revenue streams are another mechanism to enhance conservation of working lands by encouraging a more heterogeneous landscape and reducing the volatility of cash flows associated with activities such as livestock operations (Bowman and Zilberman, 2013; Goldstein et al., 2006; Macaulay, 2015; Wetzel et al., 2012). Recreational income has been shown to provide a stable and complementary income source for ranchers (DeLaney, 2011). Because financial stress from drought or fluctuations in agricultural or forestry markets could drive negative environmental impacts such as overgrazing or subdivision of

Table 4
Descriptive statistics on the annual expenditures and participation rates of owning land, leasing land, or accessing through day-use fees for a) fishing, b) hunting, c) wildlife watching, and d) grand totals. Total participants do not sum due to overlap of activities. Standard error estimates are italicized and in parentheses. Spending amounts in 2011 real U.S. Dollars. Data source: USFWS National Survey 2001, 2006, 2011.

a) Fishing

	Annual Spending (in millions)	% of overall total	% of total within activity type	Mean Payment	Participants (in 000s)	% of Rec. Users Participating Within Activity Type
Fee Total	**174.0**	**1.0%**	**4.0%**	**128.3**	**1,355.9**	**4.2%**
	(30.1)			*(21.4)*	*(83.5)*	*(0.3%)*
Northeast	49.5	0.3%	1.1%	1,502.9	174.2	3.9%
	(19)			*(1211)*	*(36)*	*(0.8%)*
Midwest	27.5	0.2%	0.6%	103.1	353.7	3.9%
	(5.5)			*(37.2)*	*(39.2)*	*(0.4%)*
South	69.1	0.4%	1.6%	55.8	536.7	4.2%
	(21.4)			*(9.3)*	*(60)*	*(0.5%)*
West	28.0	0.2%	0.6%	120.2	291.3	5.0%
	(5.5)			*(42.7)*	*(24.5)*	*(0.4%)*
Lease Total	**284.7**	**1.7%**	**6.5%**	**1,563.2**	**212.1**	**0.7%**
	(59)			*(264.4)*	*(21.6)*	*(0.1%)*
Northeast	23.0	0.1%	0.5%	920.4	33.1	0.8%
	(7.1)			*(255)*	*(9.3)*	*(0.2%)*
Midwest	48.9	0.3%	1.1%	879.5	65.9	0.7%
	(11.7)			*(149.2)*	*(12.7)*	*(0.1%)*
South	202.2	1.2%	4.6%	2,377.6	93.4	0.7%
	(57.2)			*(484.6)*	*(13.2)*	*(0.1%)*
West[a]	10.5	0.1%	0.2%	641.4	19.6	0.3%
	(4.7)			*(122.8)*	*(6.6)*	*(0.1%)*
Own Total	**3,906.2**	**22.9%**	**89.5%**	**4,968.5**	**874.2**	**2.7%**
	(535.2)			*(627.3)*	*(46.3)*	*(0.1%)*
Northeast	455.1	2.7%	10.4%	5,217.1	90.8	2.1%
	(160.9)			*(1730.5)*	*(13.4)*	*(0.3%)*
Midwest	1,275.0	7.5%	29.2%	4,527.4	325.1	3.6%
	(272.3)			*(809.7)*	*(28.5)*	*(0.3%)*
South	1,692.0	9.9%	38.8%	4,803.8	381.1	3.0%
	(411.3)			*(1109.4)*	*(32.9)*	*(0.3%)*
West	484.0	2.8%	11.1%	7,434.7	77.2	1.3%
	(131.7)			*(1984.5)*	*(8.6)*	*(0.1%)*
Fee, Lease and Own Total	**4,364.9**	**25.6%**	**100.0%**	**1,963.6**	**2,322.8**	**7.2%**
	(540.3)			*(240.5)*	*(96.5)*	*(0.3%)*

b) Hunting

	Annual Spending (in millions)	% of overall total	% of total within activity type	Mean Payment	Participants (in 000s)	% of Recreational Users Participating Within Activity Type
Fee Total	**556.4**	**3.3%**	**8.9%**	**591.1**	**941.3**	**7.2%**
	(57.6)			*(51.2)*	*(52.2)*	*(0.4%)*
Northeast	28.9	0.2%	0.5%	324.1	84.7	4.3%
	(8.2)			*(83.7)*	*(11.8)*	*(0.6%)*
Midwest	99.4	0.6%	1.6%	453.7	212.9	5.1%
	(33.7)			*(137.2)*	*(31.7)*	*(0.7%)*
South	352.0	2.1%	5.6%	674.5	533.3	10.6%
	(42.5)			*(64.7)*	*(38)*	*(0.7%)*
West	76.1	0.4%	1.2%	618.7	110.5	6.0%
	(17.5)			*(110.2)*	*(12.3)*	*(0.6%)*
Lease Total	**912.6**	**5.3%**	**14.6%**	**946.5**	**1,037.4**	**8.0%**
	(119.4)			*(83.5)*	*(72.1)*	*(0.5%)*
Northeast	41.7	0.2%	0.7%	700.2	68.4	3.6%
	(19.8)			*(299.2)*	*(11)*	*(0.6%)*
Midwest	100.6	0.6%	1.6%	779.1	129.5	3.1%
	(39.3)			*(300.2)*	*(26.2)*	*(0.6%)*
South	756.1	4.4%	12.1%	991.5	818.6	16.4%
	(110.9)			*(86.7)*	*(66.1)*	*(1.2%)*
West[a]	14.2	0.1%	0.2%	1,099.9	20.9	1.1%
	(5.2)			*(205.9)*	*(4.8)*	*(0.3%)*
Own Total	**4,780.0**	**28.0%**	**76.5%**	**4,248.6**	**1,268.2**	**9.8%**
	(580.8)			*(496.4)*	*(60.5)*	*(0.5%)*
Northeast	743.3	4.4%	11.9%	3,794.2	205.6	10.8%
	(173.2)			*(889.4)*	*(26.2)*	*(1.3%)*
Midwest	2,366.8	13.9%	37.9%	5,163.7	530.8	12.7%
	(440.5)			*(901.8)*	*(41)*	*(0.9%)*
South	1,317.7	7.7%	21.1%	3,080.8	487.2	9.8%
	(314.3)			*(714.2)*	*(35.7)*	*(0.7%)*
West	352.2	2.1%	5.6%	8,173.2	44.7	2.4%
	(121.5)			*(2648.5)*	*(5.7)*	*(0.3%)*
Fee, Lease and Own Total	**6,249.0**	**36.6%**	**100.0%**	**2,443.5**	**2,722.2**	**20.8%**
	(599.6)			*(224.1)*	*(98.9)*	*(0.7%)*

Table 4 (*Continued*)

c) Wildlife-Watching

	Annual Spending (in millions)	% of overall total	% of total within activity type	Mean Payment	Participants (in 000s)	% of Recreational Users Participating Within Activity Type
Fee Total	**83.7**	**0.5%**	**1.3%**	**73.3**	**1,045.3**	**1.5%**
	(22.6)			*(20.2)*	*(82.8)*	*(0.1%)*
Northeast	34.4	0.2%	0.5%	159.2	205.0	1.6%
	(21.1)			*(89.4)*	*(44.2)*	*(0.3%)*
Midwest	4.6	0.0%	0.1%	37.5	199.9	1.1%
	(1.4)			*(7.7)*	*(34.8)*	*(0.2%)*
South	29.9	0.2%	0.5%	85.9	352.3	1.5%
	(7.2)			*(19.9)*	*(46.9)*	*(0.2%)*
West	14.8	0.1%	0.2%	38.7	288.1	2.0%
	(2.6)			*(5.4)*	*(38.9)*	*(0.3%)*
Lease Total	**279.6**	**1.6%**	**4.3%**	**2,155.6**	**144.0**	**0.2%**
	(98.7)			*(719.5)*	*(26.4)*	*(0%)*
Northeast[a]	15.4	0.1%	0.2%	912.0	20.6	0.2%
	(7.2)			*(403.8)*	*(7.6)*	*(0.1%)*
Midwest[a]	23.1	0.1%	0.4%	904.2	33.7	0.2%
	(11.4)			*(453.3)*	*(11.5)*	*(0.1%)*
South[a]	162.2	1.0%	2.5%	2,201.6	79.4	0.4%
	(66)			*(733)*	*(21.8)*	*(0.1%)*
West[a]	78.9	0.5%	1.2%	5,801.1	10.4	0.1%
	(72.1)			*(5779.2)*	*(5.6)*	*(0%)*
Own Total	**6,090.9**	**35.7%**	**94.4%**	**6,800.1**	**1,006.6**	**1.5%**
	(1122)			*(1181.6)*	*(64.4)*	*(0.1%)*
Northeast	849.7	5.0%	13.2%	4,107.0	213.6	1.8%
	(197.8)			*(871.4)*	*(30.3)*	*(0.2%)*
Midwest	1,223.5	7.2%	19.0%	5,017.2	292.9	1.7%
	(360.2)			*(1429.9)*	*(35.3)*	*(0.2%)*
South	1,945.0	11.4%	30.1%	6,105.7	348.6	1.6%
	(505.9)			*(1494.1)*	*(39.8)*	*(0.2%)*
West	2,072.7	12.1%	32.1%	16,396.9	151.5	1.1%
	(913.7)			*(6141.7)*	*(20.6)*	*(0.1%)*
Fee, Lease and Own Total	**6,454.2**	**37.8%**	**100.0%**	**3,210.1**	**2,124.7**	**3.0%**
	(1127.8)			*(552)*	*(106.8)*	*(0.2%)*

d) Grand Totals

	Annual Spending (in millions)	% of overall total	% of total within activity type	Mean Payment	Participants (in 000s)	% of Recreational Users Participating Within Activity Type
All Fees	**814.1**	**4.8%**	NA	**162.7**	NA[b]	**2.3%**
	(87.6)			*(23)*	NA[b]	*(0.2%)*
All Leases	**1,477.0**	**8.7%**	NA	**1,087.1**	NA[b]	**0.3%**
	(233.6)			*(119.1)*	NA[b]	*(0%)*
All Ownership	**14,777.0**	**86.6%**	NA	**5,200.8**	NA[b]	**2.3%**
	(1919.7)			*(572.5)*	NA[b]	*(0.1%)*
All Wildlife-Associated Recreation	**17,068.2**	**100.0%**	NA	**2,479.8**	NA[b]	**4.6%**
	(1951.7)			*(244.4)*	NA[b]	*(0.2%)*

[a] Indicates estimates based on fewer than 30 observations.
[b] Unable to calculate due to overlapping participation across activities.

properties, recreational income could provide financial stability to reduce these impacts. Data from the NWOS suggests that hunting is quite compatible with other recreational pursuits given that 92% of non-hunting leases co-occur with hunting leases. However, additional research on the compatibility of recreation with agricultural or forestry operations, as well as compatibility of specific intra-recreational pursuits such as hunting and wildlife-watching is warranted to further evaluate the potential of recreation to contribute to diversified revenue streams (Clawson and Stewart, 1966).

Regional differences in wildlife-associated recreation appear to be affected by state policies and regional social mores. In terms of state policy, several states in the Midwest have implemented programs to incentivize free public access on private land, which could drive low leasing participation in that region. For example, Wisconsin's Forest Tax law and Michigan's Commercial Forest Act together give tax breaks on 5.2 million acres of forestland under the condition of providing free access for recreation (Michigan DNR, 2011; Rickenbach, 2011). With respect to culture, Gentle et al. (1999) suggested that the predominant ancestry of the European immigrants who settled each region of the U.S. could be a driver of regional differences. Although the expansive areas of public land in the West that are open to free recreation may reduce demand for private recreation, recent research on private land hunting in California (a state that is about 50% public land) did not find a lack of demand by hunters as a reason for not leasing (Macaulay, 2015). Instead, landowner's lack of trust of hunters and the perceived potential to interfere with ranching operations appeared to be of greater concern. Additional research into regional variation could yield insights into the effect of policy, culture and availability of public land on recreational use.

Despite the positive conservation potential of wildlife-associated recreation, it is important to note that conservation impacts can vary depending on governance, the intensity of use, and land management practices (Macaulay et al., 2013; Reed and Merenlender, 2008). The conservation benefits of hunting depend on a system of scientifically-developed game laws and effective enforcement, which curtails problems of over-harvesting and poaching. Some land managers oriented towards recreation are careful to maintain and improve ecological conditions for wildlife through practices like protecting riparian zones to enhance habitat for wildlife (DeLaney, 2011). On the other hand, game managers who breed deer in containment fences for larger antlers or who

Table 5
Total annual day-use fees for different types of recreation on private land. Standard error estimates are italicized and in parentheses. Spending amounts in 2011 real U.S. Dollars. Data source: USFWS National Survey 2001, 2006, 2011.

Day-Use Fee Type	Total Annual Spending (in millions)	% of Total
Fishing Fee Total	**174.0** *(30.1)*	**21.4%**
Freshwater	89.5 *(10.1)*	11.0%
Saltwater	74.0 *(28)*	9.1%
Great Lakes	10.5 *(4.0)*	1.3%
Hunting Fee Total	**556.4** *(57.6)*	**68.3%**
Big Game	407.0 *(51.1)*	50.0%
Migratory Bird	72.6 *(17)*	8.9%
Small Game	69.2 *(12.8)*	8.5%
Other Animals[a]	7.6 *(3.3)*	0.9%
Wildlife-Watching Fee Total	**83.7** *(22.6)*	**10.3%**
Fee Total	**814.1** *(87.6)*	**100.0%**

[a] Indicates estimates based on fewer than 30 observations.

plow native grasslands to plant food plots can create a host of conservation problems ranging from spread of disease to introduction of invasive species. In a similar way, anglers may work to enhance stream habitat, but they may also introduce exotic fish species that can disrupt the aquatic ecosystem. Individual wildlife-watchers who build homes in areas with abundant wildlife may work to improve wildlife habitat, but because they tend to own relatively small properties (Fig. 2), land subdivision and increased housing density in these areas may result in a cumulative loss of habitat and wildlife. Finally, land that is used for wildlife-associated recreation may not be permanently conserved or managed to benefit threatened & endangered species. Because of the possibility of negative impacts associated with recreation, policy mechanisms can be an important way to enhance the positive conservation outcomes of recreation, while minimizing the negative ones.

5. Policy implications

Three policy mechanisms to incentivize positive conservation practices and discourage problematic practices are currently in place in particular states and are relevant for discussion: (1) state incentive programs that provide regulatory flexibility in exchange for conservation practices, (2) use-value property tax policies, and (3) recreational use statues. State incentive programs are generally voluntary programs that provide landowners with increased flexibility of timing and amount of hunting harvest in exchange for implementing wildlife habitat improvement (CDFW, 2015; TPWD, 2015). Evaluating the successes and challenges of these state programs could be an important step in identifying sound policies that can then be expanded to other states and to recreational uses besides hunting.

Secondly, use-value property tax policies could provide additional conservation benefits if tailored to recreational use. Use-value property tax assessment is a widespread policy tool that is used to maintain open space usually by appraising property at the value of its agricultural or forestland use rather than at its highest and best use (Anderson, 1993). This tool is used to reduce tax burdens on agricultural producers who keep their land in agricultural production instead of developing it into more intensive land uses. In some states, land devoted to wildlife management purposes is eligible for use-value assessment (Oklahoma, 2014; TPWD, 2014), and Texas explicitly requires landowners to perform specific wildlife management practices on their property to qualify for the assessment. However, in other states, land used for recreation or wildlife management instead of agriculture is not eligible for the use-value assessment (Kansas, 2014; New York State, 2014). Making wildlife-associated recreation eligible for use-value property tax benefits has the potential to discourage conversion of these lands to other uses, to reduce the intensity of agricultural production, and yield improved conservation practices by tying the assessment to implementation of conservation practices.

Thirdly, state recreational-use statutes redefine the duty of care that landowners owe recreational users, often providing some form of liability protection for allowing recreational use. This reduces risk to landowners for having recreational users on their property. All states have implemented these statutes with details varying

Table 6
Conservation practices and payments for private U.S. farms and ranches by recreational income earning status. Standard error estimates are italicized and in parentheses. Spending amounts in 2011 real U.S. Dollars. Significance for means remained the same after controlling for size of property using a generalized linear model. Significance codes: ⋅ = 0.1, * = 0.05, ** = 0.01, *** = 0.001. Working lands payments include the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). Land retirement programs include the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP), and the Wetlands Reserve Program (WRP). Data source: USDA Agricultural Resource Management Survey 1999–2012.

	No Recreational Income	Recreational Income Earners	
% Paying for Professional Conservation Practices	0.6% *(0.06%)*	1.2% *(0.47%)*	.
Mean Dollars Paid for Professional Conservation Practices	$11.7 *(1.4)*	$37.0 *(24.4)*	
% Receiving Working Lands Payments (EQIP, CSP)	1.6% *(0.04%)*	5.5% *(0.53%)*	***
Mean Working Lands Payments (EQIP, CSP)	$166.2 *(4.4)*	$841.3 *(98.1)*	***
% Receiving Land Retirement Payments (CRP, CREP, and/or WRP)	10.5% *(0.2%)*	12.9% *(0.8%)*	**
Mean Land Retirement Payments (CRP, CREP, and/or WRP)	$642.5 *(13.6)*	$1,438.7 *(128.1)*	***
% Receiving Working lands or Land Retirement Payments	14.6% *(0.2%)*	21.8% *(1.0%)*	***
Mean Working Lands and Land Retirement Payments	$1,010.4 *(16.0)*	$2,801.0 *(177.1)*	***

among them (Centner, 2001), however, few if any tie conservation practices or land protection to the benefits provided. These statutes could be modified to encourage implementation of conservation practices for wildlife and discourage practices that can have negative environmental consequences.

Finally, given the major role of hunting in private land recreation, regulatory proposals to limit or ban hunting should consider the potential unintended environmental consequences that could result from such regulations. These impacts include potential changes to the conservation practices that are correlated with recreational use as well as the reduction in revenue and value of land used for hunting that could make it more vulnerable to subdivision or development to alternative uses.

6. Conclusion

The results of this study suggest that recreation on private land can be a win-win for landowners and conservationists by providing revenue while encouraging conservation practices. It also illustrates an enormous private sector recreation market that can be harnessed to encourage positive conservation outcomes and reduce negative impacts. This analysis shows that private land recreation warrants consideration in land use planning and conservation agendas due to both economic impact (over $17.1 billion annually) and land area utilized (440.1 million acres). Landowners with recreational income implement conservation practices at higher rates than those without, giving support to the concept that recreation incentivizes conservation. The economic benefits of recreation disproportionately goes to forest and grazing land, which are particularly important for maintaining wildlife habitat and biodiversity. Hunting dominates the land area used for recreation, and is unique from other types of recreation in that spending goes to larger properties, which may reduce economic pressures to fragment land. Expanding efforts to work with policymakers, hunters, and other recreational users to implement sustainable management practices and ecosystem enhancement could yield conservation benefits on millions of acres of wildlife habitat.

Acknowledgements

I thank R. Barrett, L. Huntsinger, J. Brashares, D. Zilberman, J. Bartolome, P. Brownsey, S. Evans, M. Sorice, T. Lumley, T. Keller, R. Aiken, H. Wood, A. Arcos, M. Graham, R. Dubman, B. Butler, J. Hewes, the Huntsinger Lab, the UC Berkeley Rangeland Ecology Lab, the USDA National Agricultural Statistics Service and Economic Research Service, the U.S. Forest Service Forest Inventory and Analysis program, the U.S. Fish & Wildlife Service's Wildlife and Sport Fish Restoration Program, and finally three anonymous reviewers for helpful comments in revising this manuscript. The Goertz Chair in Wildlife Management, The Golden Gate Chapter of Safari Club International, and the UC Berkeley Department of Environmental Science, Policy, and Management provided financial support to conduct this research and prepare this article. Financial supporters were not involved in conducting any aspects of the research or in the preparation or submission of the manuscript.

Appendix A. Differences between this analysis and U.S. Fish and Wildlife Survey reports:

This Appendix provides a detailed explanation on the differences between the estimates found in this manuscript and those that are provided in U.S. Fish & Wildlife Service (USFWS) reports (USFWS, 2001, 2006, 2011). It details the improvements in precision of estimates achieved by pooling the data, disusses how missing data is treated, and describes reporting of standard error estimates.

To illustrate the improvement of this analysis on already published estimates, the Table A1 compares estimates published in USFWS National Survey of Fishing, Hunting and Wildlife-Associated Recreation reports to calculations performed according to the methods in the manuscript. It compares estimates from the public reports (Table A1.a), to estimates calculated by the author with deletion of missing data (Table A1.b, and discussed further below), and finally provides estimates that are based on pooling the three survey years (Table A1.c). The table illustrates how single year estimates provided in the public reports have varied considerably, with an estimated 440 million acres leased for hunting in 2011 (in bold), which is approximately double the estimate from 2006 and 2001. Similarly, fishing leases were estimated to cover 1.3 million acres in 2001, which is far below the estimates of more than 9 million acres in 2006 and 2011. Pooling these three years of data increases sample sizes and provides a far more precise estimate of the land area used for wildlife-associated recreation than has been provided in the public reports. While Table A1 provides an example of the improvements to the estimates that occur in acreage utilized, a similar improvement in precision occurs across all the estimates in this manuscript as a result of the increased sample size obtained by pooling three survey years.

Secondly, the estimates provided in the public reports in some cases treated missing values in a problematic way. In calculating acreage estimates, one must divide the number of acres reported by the number of individuals in the club that owns or leases that property to avoid double counting of acreage. In several instances, there is data on the number of acres owned or leased, but missing data for the number of people in the club. The government calculations treated these instances as having a club of one individual, which likely overestimates the number of acres used, especially in cases where the missing data would have contained many members in a club. The analysis performed in this paper used a more traditional approach in dealing with missing values by using list-wise deletion and omitting these observations from calculations (Allison 2002; Howell 2007). The government's analysis method resulted in an estimation of the hunting lease acres in 2011 of nearly twice the amount of previous years, very much influenced by this treatment of missing data. Correctly omitting missing data yielded results that were in line with previous years' estimates, which can be seen in Table A1.b.

Third, the National Survey reports report only a few selected standard error estimates. Although the reports contain parameters for calculating approximate standard error for some high-level estimates, they do not include parameters to calculate error associated with the estimates that are provided in this manuscript.

Appendix B. Ownership data

This Appendix provides information about what is included in spending estimates for ownership of land for wildlife-associated recreation. The survey questionnaire requested a single value for the amount spent to own land, which included mortgage payments, down payments, taxes and maintenance expenses. The inclusion of these various payments into a single amount aggregates different accounting concepts (capital expenditures, capital costs, and operating costs) into a single value. Down payments and the portion of mortgage payments that pay for the principle could be considered capital expenditures invested into a fixed asset (the land), or under some circumstances could be considered capital costs. Taxes, maintenance, and interest paid are generally considered operating costs, (although some may be considered capital costs). Additionally, some individuals who own land, may have inherited it, or

Table A1
Estimated acres owned & leased for wildlife-associated recreation (in millions of acres). Estimates with large deviation from other years are in bold. Standard error is reported beneath estimates in parentheses and italics.

a) Nationally reported land area used for wildlife-associated recreation (in millions of acres). Note hunting lease estimate for 2011 and fishing lease estimate for 2001 which deviate significantly from other year estimates.

	Fishing Own	Hunting Own	Wildlife-Watching Own	Fishing Lease	Hunting Lease	Wildlife-Watching Lease
2001	24.0	117.8	44.1	**1.3**	225.3	10.5
	unreported	*unreported*	*unreported*	*unreported*	*unreported*	*unreported*
2006	33.4	134.3	38.3	9.6	216.8	11.9
	unreported	*unreported*	*unreported*	*unreported*	*unreported*	*unreported*
2011	25.2	155.2	39.4	10.0	**420.0**	3.6
	unreported	*unreported*	*unreported*	*unreported*	*unreported*	*unreported*

b) Author's estimation dropping missing values and reporting standard error. Note hunting lease estimate for 2011 aligns more closely with previous survey years through dropping missing values which skewed results.

	Fishing Own	Hunting Own	Wildlife-Watching Own	Fishing Lease	Hunting Lease	Wildlife-Watching Lease
2001	24.0	117.8	44.6	**1.3**	224.8	10.5
	(7.4)	(38.3)	(12.5)	(0.6)	(81.3)	(6.4)
2006	33.4	134.3	39.6	9.3	201.4	11.9
	(7.1)	(22.8)	(9.4)	(3.9)	(52.4)	(6.8)
2011	25.2	155.2	39.4	9.7	**234.2**	3.6
	(6.3)	(27.2)	(11.2)	(4.6)	(67)	(2)

c) Author's estimation based on pooled data 2001–2011

	Fishing Own	Hunting Own	Wildlife-Watching Own	Fishing Lease	Hunting Lease	Wildlife-Watching Lease
Pooled Estimate	27.5	135.8	41.2	6.8	220.1	8.7
	(4)	(17.4)	(6.4)	(2)	(39.2)	(3.2)

already purchased it in full, thus only reporting tax and maintenance costs even though they may own very large properties. Finally, capital appreciation and the opportunity cost of capital are not included in this value. As a result the values for ownership are difficult to compare to other standard measures, and exhibit relatively large standard errors. This survey question could be improved in the future so that analyses can create estimates comparable to general accounting measures. Nonetheless, these estimates provide valuable insight into the level of spending and investment in land for the primary purpose of wildlife-associated recreation.

Appendix C. Methods

This Appendix provides additional methodological detail for this analysis and provides considerations about various sources of non-sampling error. This includes information about treatment of zero values for amounts spent to own or lease private land, how acreage estimates were calculated, consideration of non-sampling error, and consideration about the potential of non-adjacent properties to influence the results in Fig. 2.

Survey data prior to 2001 was not used due to changes in several key questions between 1996 and 2001. In estimating mean values of payments for ownership and leasing, zero values for the amount spent to own land were included due to the potential of those records to be individuals with land owned outright that require no costs. However, when calculating means for leases zero values were excluded due to the definition of leasing involving a payment for access. Due to the nature of shared ownership of properties, calculations of total acreage requires the division of the reported acreage by the number of members in the group or club to avoid double counting acreage of club or group members.

Questions that were used to calculate the values in this research included the following:

- In 20XX, did you own, in part or whole, property (*in the case of wildlife-watching:* "more than a mile from your home") in the United States PRIMARILY for the purpose of [hunting/fishing/"the purpose of observing, photographing, or feeding wildlife"]?

  1–Yes
  0 – No

- How many acres did you own? If less than one acre, enter 1.
- Were you part of a club or group, including a family group, owning this land in 20XX?

  1 – Yes
  0 – No

- How many others were members of this group or club?
- What did you spend in 20XX for YOUR SHARE of the land which was owned PRIMARILY for hunting? Include mortgage, taxes, maintenance, and down payment cost if purchased in 20XX. Do not include the cost of a cabin if reported earlier.
- When you were [hunting/fishing] in the U.S. chiefly for/in [big game/small game/migratory birds/other animals/saltwater/freshwater/great lakes] during 20XX, how much was spent for YOUR SHARE of private land-use or access fees? Do not include leases.
- On your [wildlife-watching] trip(s) during 20XX in the U.S. at least a mile from home how much was spent for YOUR SHARE of private land-use or access fees? Do not include leases.

The questions in this survey were pre-tested and passed established U.S. Census Bureau quality control procedures (U.S. Census Bureau, 2011). Nonetheless, the estimates in this manuscript could contain non-sampling error such as measurement error or non-response error. An example of potential measurement error that could affect the estimates is the possibility of interviewees misunderstanding questions. For example, one potential source of measurement error could involve the case of individuals who own land primarily for recreation and at the same time lease out that same land to others for recreation, thus providing the same answer to questions about acres leased and owned. This would result in the same land being counted twice. To test the potential impact of such error, data for land owned or leased for hunting was examined, revealing that only 29 out of 1766 observations have the same

acreage reported for ownership and leasing, which account for 6.7 million acres of land, of the total 440.1 million acre estimated for leasing and owning. Even if all of these cases were the result of measurement error as described (which is not necessarily the case) they account for less than 2% of the total estimate of lands leased or owned for hunting and is far smaller than the standard error estimate of 43.2 million acres. This suggests that potential double counting in this manner does not significantly affect the results. Despite the potential for upward bias of results due to measurement error such as this, acreage estimates about land utilized for wildlife-associated recreation remain conservative for the following reasons: (1) the survey did not collect information about the land area used for day-use fees, which would include even greater areas of land, and (2) owned acreage was only accounted for if it was owned *primarily* for wildlife-associated recreation, meaning that lands owned with a secondary purpose of wildlife-associated recreation were not counted.

Regarding the interpretation of Fig. 2, there is the possibility for some cases of leases being composed of multiple, non-adjacent properties possibly owned by different individuals. However, literature examining fee hunting operations in the U.S., and interviews with landowners in ongoing research suggests that these cases are rare and would not substantially affect the results (Rasker et al., 1992; Butler and Workman 1993).

Additional details on the sampling procedure are contained in Appendix D of each of the annual reports (USFWS, 2001, 2006, 2011).

Appendix D. Specific types of recreation

This Appendix provides additional information about the types of hunting occurring on leased and owned hunting lands (Table 5 only provides sub-categories of hunting for private land associated with day-use fees). This is provided because the survey questionnaire does not directly gather information on particular sub-categories of hunting on properties that are owned or leased for hunting. These values were estimated by using a ratio of the number of days spent in pursuit of the four sub-categories of hunting on private lands, i.e. big game, small game, migratory birds, and other animals (information about days spent in pursuit of sub-categories of wildlife-watching and fishing on private land was not collected). As illustrated by Table D1, these estimates show similar proportions as seen in the day-use fee access calculations reported in Table 5, with big game hunting being the most significant pursuit on both leased and owned private lands, showing similar interest levels in specific types of hunting across different forms of private land access (owned, leased, or day-use fees).

Table D1
Estimated annual spending for different types of hunting on leased and owned private land. Standard error estimates are italicized and in parentheses. Spending amounts in 2011 real U.S. Dollars.

	Total Annual Spending (in millions)	% of Total
Total Hunting Leases	**860.4**	**100.0%**
	(152.6)	
Big Game	653.7	76.0%
	(110.9)	
Small Game	68.5	8.0%
	(13.2)	
Migratory Bird	92.5	10.8%
	(15.3)	
Other Animals	45.7	5.3%
	(13.3)	
Total Hunting Owned	**4,472.2**	**100.0%**
	(799.9)	
Big Game	3,140.4	70.2%
	(431.1)	
Small Game	699.8	15.6%
	(204.6)	
Migratory Bird	473.4	10.6%
	(128.5)	
Other Animals	158.6	3.5%
	(35.7)	

Source: USFWS National Survey 2001, 2006, 2011.

References

Allison, P.D., 2002. Missing data: quantitative applications in the social sciences. Br. J. Math. Stat. Psychol. 55, 193–196.

Anderson, J.E., 1993. Use-value property tax assessment: effects on land development. Land Econ. 69, 263–269, http://dx.doi.org/10.2307/3146592.

Bagi, F.S., Reeder, R.J., 2012. Factors affecting farmer participation in agritourism. Agric. Resour. Econ. Rev. 41, 189.

Bowman, M.S., Zilberman, D., 2013. Economic factors affecting diversified farming systems. Ecol. Soc. 18, http://dx.doi.org/10.5751/es-05574-180133.

Brown, D.M., Reeder, R.J., 2007. Farm-Based Recreation: A Statistical Profile (Economic Research Report No. 56445). United States Department of Agriculture, Economic Research Service.

Brunson, M.W., Huntsinger, L., 2008. Ranching as a conservation strategy: can old ranchers save the new West? Rangel. Ecol. Manage. 61, 137–147, http://dx.doi.org/10.2111/07-063.1.

Butler, L.D., Workman, J.P., 1993. Fee hunting in the Texas Trans Pecos area: a descriptive and economic analysis. J. Range Manage., 38–42.

Butler, B.J., Leatherberry, E.C., Williams, M.S., 2005. Design, implementation, and analysis methods for the National Woodland Owner Survey.

Butler, B.J., Hewes, J.H., Dickenson, B., Andrejczyk, K., Markowski-Lindsay, M., Butler, S.M., 2014. National Woodland Owner Survey 2011–2013: Preliminary Results. U.S. Department of Agriculture, Forest Service Northern Research Station, Newtown Square, PA.

CDFW, 2015. Private Lands Management (PLM) [WWW Document], https://www.wildlife.ca.gov/Hunting/PLM accessed 8.17.15.

Centner, T.J., 2001. Revising state recreational use statutes to assist private property owners and providers of outdoor recreational activities. Buffalo Environ. Law J. 9, 1.

Clawson, M., Stewart, C.L., 1966. Land Use Information: A Critical Survey of US Statistics Including Possibilities for Greater Uniformity. Resources for the Future.

DeLaney, D., 2011. Business Management of Hunting Enterprises on Working Ranches.

Dickson, B., Hutton, J., Adams, B., 2009. Recreational Hunting Conservation and Rural Livelihoods: Science and Practice. John Wiley & Sons.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.-I., Knowler, D.J., Lévêque, C., Naiman, R.J., Prieur-Richard, A.-H., Soto, D., Stiassny, M.L.J., Sullivan, C.A., 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. Biol. Rev. 81, 163–182, http://dx.doi.org/10.1017/S1464793105006950.

Gentle, P., Bergstrom, J., Cordell, K., Teasley, J., 1999. Private landowner attitudes concerning public access for outdoor recreation. J. Hosp. Leis. Mark. 6, 47–65, http://dx.doi.org/10.1300/J150v06n01_04.

Goldstein, J.H., Daily, G.C., Friday, J.B., Matson, P.A., Naylor, R.L., Vitousek, P., 2006. Business strategies for conservation on private lands: koa forestry as a case study. Proc. Natl. Acad. Sci. U. S. A. 103, 10140–10145, http://dx.doi.org/10.1073/pnas.0600391103.

Graybill, F.A., Deal, R.B., 1959. Combining unbiased estimators. Biometrics.

Groves, R.M., 2006. Nonresponse rates and nonresponse bias in household surveys. Public Opin. Q. 70, 646–675, http://dx.doi.org/10.1093/poq/nfl033.

Horvitz, D.G., Thompson, D.J., 1952. A generalization of sampling without replacement from a finite universe. J. Am. Stat. Assoc. 47, 663–685, http://dx.doi.org/10.2307/2280784.

Howell, D.C., 2007. The treatment of missing data. The Sage Handbook of Social Science Methodology, 208–224.

Kansas, 2014. Kansas Statutes: Property Valuation, Equalizing Assessments, Appraisers And Assessment of Property [WWW Document], http://kansasstatutes.lesterama.org/Chapter_79/Article_14/79-1476.html accessed 10.21.14.

Knight, R.L., 1999. Private lands: the neglected geography. Conserv. Biol. 13, 223–224, http://dx.doi.org/10.1046/j.1523-1739.1999.013002223.x.

Land Trust Alliance, 2011. 2010 National Land Trust Census [WWW Document], http://www.landtrustalliance.org/land-trusts/land-trust-census accessed 8.27.13.

Leopold, A., 1930. Report to the American Game Conference on an American game policy. Transactions of the American Game Conference, 284–309.

Lindsey, P.A., Frank, L.G., Alexander, R., Mathieson, A., Romañach, S.S., 2007. Trophy hunting and conservation in africa: problems and one potential solution. Conserv. Biol. 21, 880–883, http://dx.doi.org/10.1111/j.1523-1739.2006.00594.x.

Lumley, T., 2004. Analysis of complex survey samples. J. Stat. Softw. 9, 1–19.

Lumley, T., 2011. Complex Surveys: A Guide to Analysis Using R. Wiley.

Lumley, T., 2014. Survey: analysis of complex survey samples.

Macaulay, L.T., Starrs, P.F., Carranza, J., 2013. Hunting in managed oak woodlands: contrasts among similarities. In: Mediterranean Oak Woodland Working Landscapes. Springer, pp. 311–350.
Macaulay, L.T., 2015. Evaluating recreational hunting as an incentive for habitat conservation on private land in California. USDA For. Serv. Gen. Tech. Rep.
Maestas, J.D., Knight, R.L., Gilgert, W.C., 2003. Biodiversity across a rural land-use gradient. Conserv. Biol. 17, 1425–1434, http://dx.doi.org/10.1046/j.1523-1739.2003.02371.x.
Michigan DNR, 2011. Michigan's commercial forest act [WWW document]. Dep. Nat. Resour., http://www.michigan.gov/dnr/0,4570,7-153-10366_46403_63473-252819–,00.html accessed 8.2.13.
Morcatty, T.Q., El Bizri, H.R., Carneiro, H.C.S., Biasizzo, R.L., de Oliveira Almeri, C.R., da Silva, E.S., Rodrigues, F.H.G., Figueira, J.E.C., 2013. Habitat loss and mammalian extinction patterns: are the reserves in the Quadrilátero Ferrífero, southeastern Brazil, effective in conserving mammals? Ecol. Res. 28, 935–947.
New York State, (Department of Taxation and Finance), 2014. Agricultural Assessment Program [WWW Document], http://www.tax.ny.gov/research/property/assess/valuation/ag_overview.htm accessed 10.21.14.
Nickerson, C., Ebel, R., Borchers, A., Carriazo, F., 2011. Major Uses of Land in the United States, 2007. United States Department of Agriculture, Economic Research Service.
Oklahoma, (Tax Division), 2014. Oklahoma Property Taxes, 2014: Taxpayer's Rights, Remedies and Responsibilities.
Oldfield, T.E.E., Smith, R.J., Harrop, S.R., Leader-Williams, N., 2003. Field sports and conservation in the United Kingdom. Nature 423, 531–533, http://dx.doi.org/10.1038/nature01678.
Oviedo, J.L., Huntsinger, L., Campos, P., Caparrós, A., 2012. Income value of private amenities assessed in California oak woodlands. Calif. Agric. 66.
R. Core Team, 2015. R: A Language and Environment for Statistical Computing. R Found. Stat. Comput., Vienna Austria.
Rasker, R., Martin, M.V., Johnson, R.L., 1992. Economics: theory versus practice in wildlife management. Conserv. Biol. 6, 338–349.
Reed, S.E., Merenlender, A.M., 2008. Quiet, nonconsumptive recreation reduces protected area effectiveness. Conserv. Lett. 1, 146–154, http://dx.doi.org/10.1111/j.1755-263X.;1;2008.00019.x.
Rickenbach, M., 2011. Changes ahead for wisconsin's managed forest law program [WWW document]. News Coop. Ext., http://fyi.uwex.edu/news/2011/05/12/changes-ahead-for-wisconsin%E2%80%99s-managed-forest-law-program/ accessed 8.2.13.
Saunders, D.A., Hobbs, R.J., Margules, C.R., 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5, 18–32, http://dx.doi.org/10.1111/j.1523-1739.1991.tb00384.x.
Scott, J.M., Davis, F.W., McGhie, R.G., Wright, R.G., Groves, C., Estes, J., 2001. Nature reserves: do they capture the full range of America's biological diversity? Ecol. Appl. 11, 999–1007.
Smith, M.D., Krannich, R.S., 2000. Culture clash revisited: newcomer and longer-term residents' attitudes toward land use development, and environmental issues in rural communities in the Rocky Mountain West*. Rural Sociol. 65, 396–421, http://dx.doi.org/10.1111/j.1549-0831.2000.tb00036.x.
TPWD, (Texas Parks & Wildlife Department), 2014. Agricultural Tax Appraisal Based on Wildlife Management: Legal Summary of Wildlife Management Use Appraisal [WWW Document], http://www.tpwd.state.tx.us/landwater/land/private/agricultural_land/legal-summary.phtml accessed 10.21.14.
TPWD, 2015. Managed Lands Deer Permits [WWW Document], https://tpwd.texas.gov/business/permits/land/wildlife_management/mldp/ accessed 8.17.15.
U.S. Census Bureau, 2016. Statistical Quality Standards [WWW Document], http://www.census.gov/about/policies/quality/standards.html accessed 3.4.16.
U.S. Fish Wildlife Service, 2013. Fiscal Year 2013 Budget Justifications: Pittman-Robertson Wildlife Restoration. U.S. Fish and Wildlife Service.
USDA NRCS, 2003. Chapter 2 – Grazing Lands Resources, in: National Range and Pasture Handbook.
USDA, 2012. USDA ERS – Conservation Programs: Background [WWW Document], http://www.ers.usda.gov/topics/natural-resources-environment/conservation-programs/background.aspx accessed 11.27.13.
USFWS, 2001. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.
USFWS, 2006. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.
USFWS, 2011. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.
Verma, V., Gagliardi, F., Ferretti, C., 2009. On Pooling of Data and Measures. Università di Siena, Dipartimento di metodi quantitativi.
Wetzel, W.C., Lacher, I.L., Swezey, D.S., Moffitt, S.E., Manning, D.T., 2012. Analysis reveals potential rangeland impacts if Williamson Act eliminated. Calif. Agric. 66, 131–136, http://dx.doi.org/10.3733/ca.v066n04p131.