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Constraints to hunting and harvesting elk in a landscape dominated by private land

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While the harvest success rate of bull elk in Nebraska has been relatively high in recent years, antlerless harvest success is substantially lower inhibiting the ability of wildlife managers to effectively manage population numbers. We sought to explore differences in hunter behaviour based on the type of elk being hunted as well as how specific constraints affected each type of hunter's ability to hunt and harvest elk. Decreased antlerless-elk harvest rates were likely a product of the reduced frequency in which an antlerless-elk hunter would pay for the opportunity to hunt on property containing a comparatively higher probability of harvest. Antlerless-elk hunters reported being more constrained by time, and felt more strongly that the quantity of elk on the land that they hunted affected their ability to harvest. Our results reinforce the need for wildlife managers to work closely with private landowners and focus hunting pressure on land currently restricted to elk hunting.

Keywords: constraint negotiation, human–wildlife conflict, hunter attitudes, hunter surveys, recreational hunting constraints

Two important tenets of the North American Model of Conservation are that wildlife resources are a public trust and that democracy of hunting is standard (Geist et al. 2001, Organ et al. 2012). Wildlife resources as a public trust is a keystone component of the Model and describes the concept that wildlife is owned by no person and is held in trust for the benefit of present and future generations by the government (Geist and Organ 2004). Democracy of hunting describes the concept that all citizens, in good standing, have the right to hunt and not to be restricted to those who have special status, such as land ownership, wealth or other privileges. While these two components (among the other components) serve as the basis for federal, provincial and state wildlife agencies, there are criticisms (Peterson and Nelson 2017) and exceptions to these principles. For instance, big game permits (e.g. elk, mountain goat, big horned sheep and mountain lion) are managed by lotteries in US states that can require fees to 'build' points over many years before being selected. Furthermore, in some parts of the country, these 'special' hunts may require the permit holder to pay trespass fees to hunt on private land to increase the probability of harvest (Crank et al. 2010). The potentially high fees and need to pay landowners to target a public good, provide an interesting system to assess how hunters navigate these constraints to hunt and harvest big game.

In order for recreational hunting to successfully manage wildlife populations, hunters must be able to navigate hunting constraints. Jackson (1997) describes constraints as 'factors that are assumed by researchers and perceived or experienced by individuals to limit the formation of leisure preferences and to inhibit or prohibit participation and enjoyment in leisure.' Crawford et al. (1991) developed and refined a hierarchical model that described three constraint categories. An individual's intrapersonal constraints involve factors that exist within one's self. For example, intrapersonal constraints might include internal moral conflicts with taking the life of an animal, lack of confidence or feeling unwelcome within the hunting culture. Interpersonal constraints include those factors that involve other individuals such as work or family obligations as well as belonging to social circles that have no interest in hunting. Structural constraints involve the external environment. Examples of structural constraints are lack of land available for hunting, cost of permit or equipment, or lack of time. Jackson et al. (1993) later described that individual constraint types are not necessarily hierarchical due to the 'interaction proposition,' which states that insurmountable interpersonal or structural constraints may suppress the desire to participate in an activity. Subsequent

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research indicated that leisure constraints are not inherently insurmountable, and individuals can negotiate through constraints both cognitively and behaviorally (Scott 1991, Jackson and Rucks 1995). This theory of leisure constraint negotiation has been refined through the ‘constraint-effects-mitigation’ model, which states that when confronted with a constraint, negotiation strategies will be activated in an effort to limit the negative impact of the constraint on activity participation (Hubbard and Mannell 2001, White 2008, Metcalf et al. 2015, Stensland et al. 2017). Our study builds on this concept of leisure-constraints negotiation, within a framework of big game hunting dominated by a need for hunting access on private land.

The purpose of this paper was twofold. First, elucidate the specific set of constraints to hunting and harvesting elk by two groups of elk hunters (those targeting bull and those targeting antlerless elk). Second, assess how hunting behavior differs between those targeting bull and those targeting antlerless elk. This information will be useful for management decisions but also as a case study for other wildlife management agencies developing and adjusting regulations for hunting big game populations in a hunting system dominated by private land. In our area of study, the opportunity to acquire an antlerless-elk permit is more easily and frequently attainable than the opportunity to acquire a bull-elk permit (Nebraska Game and Parks Commission unpub.). Despite elevated opportunity to acquire an antlerless permit, bull-elk hunters experience a greater harvest success rate. We predicted antlerless-elk hunters may encounter more difficulty negotiating constraints to hunting opportunity and harvest success than bull-elk hunters once a permit is acquired (Table 1). As antlerless elk permits were more easily attained and could be attained more frequently, we predicted that hunters seeking to harvest an antlerless member of an

elk population were less likely to pursue permissions for access to private land, were less likely to be willing to pay for private-land access, and spent fewer days afield than hunters who sought to harvest an antlered animal.

Material and methods

Elk harvest in Nebraska

Acquisition of an elk permit in Nebraska is restricted to Nebraska residents and requires participation in a lottery drawing. Residents enter the lottery by specifying whether the hunting of a bull or antlerless elk is desired and which one of the seven Elk Management Units (EMUs) the hunter wishes to hunt. Each unit has a different number of bull and antlerless permits allocated and differing odds of successfully drawing a permit. Statewide, there were a greater number of antlerless elk hunting permits allocated than bull hunting permits for each year included in this study (2011–2016). Depending on the number of applicants of each type, hunters wishing to hunt an antlerless elk are more likely to successfully draw a permit than a hunter wishing to hunt a bull elk. Thus, given the fewer number of permits and the opportunity to only harvest one bull elk in a lifetime, there is a high incentive for those that draw a bull permit to find the best land in Nebraska. Alternatively, there may be less incentive for antlerless elk hunters to seek out the best and potentially more expensive land to hunt.

Non-residents are not eligible to apply for general elk hunting permits, and residents are only eligible to win a bull or antlerless permit once every five years. The legal description of an antlerless elk, in Nebraska, has ‘no antlers or antlers less than six inches in length’. While an elk hunter

Table 1. All constraints and associated predictions comparing antlerless and bull-elk hunters in Nebraska 2011–2016.

Constraint	Greater constraint	Reasoning
Hunting constraints		
Cost of permit	Antlerless	Greater value in trophy (bull) hunts ^a
Difficulty finding private property to hunt	Equally constraining	Equal availability of resources
Difficulty obtaining permission to hunt on private property	Antlerless	Greater value in trophy (bull) hunts ^a
The cost to hunt on private property	Antlerless	Greater value in trophy (bull) hunts ^a
Limited access to elk on private property belonging to other landowners	Equally constraining	Elk just as likely to be on neighboring land
Personal or family health	Equally constraining	Equal health risk
My time available for hunting was limited	Bull	Fewer hunting days available in bull season ^c
Harvest constraints		
I did not have sufficient experience hunting elk	Antlerless	Relative ease of antlerless-permit acquisition; fewer years of experience
I only had access to hunt on public land	Antlerless	Greater value in trophy (bull) hunts ^a
The landowner(s) that gave me permission to hunt had stringent rules	Bull	Limited access to specific animals
The terrain I hunted made it difficult to harvest elk	Equally constraining	Hunting similar terrain type ^b
Limited number of elk on the land where I had permission to hunt	Antlerless	Antlerless hunters hunting on public land ^b
Limited number of elk in the Elk Management Unit where I hunted	Equally constraining	Equally likely to hunt any given Unit
The weather made it difficult for me to harvest	Antlerless	Antlerless season occurs during winter months ^b
My time available for hunting was limited	Bull	Fewer hunting days available in bull season ^c

^a Scrogin and Berrens 1999.

^b Cooper et al. 2002.

^c Bhandari et al. 2006.

may only hold either a bull or antlerless elk hunting permit in a given year, possessing one type does not prohibit the hunter from possessing the other permit type within the subsequent five-year period. There is no limit to the number of antlerless elk a resident may harvest in their lifetime. Only one bull elk may be harvested in Nebraska during a hunter's lifetime.

Though the price of a general elk permit has increased over the course of several years, hunters were charged approximately \$190 for a permit (in 2016) if they were successfully drawn from the lottery. Exact season dates vary by year, but the antlerless elk hunting season took place between mid-August and late October as well as December. Bull elk hunting occurred between late September and late October. An early bull-hunting season also occurred each year from mid to late September, which was restricted to the use of archery equipment. All other elk seasons permitted the use of archery equipment, black powder, or high-powered rifle.

Our survey population contact information was provided by Nebraska Game and Parks Commission. A letter invitation to participate in an elk hunter survey was sent via postal mail to hunters who had a general elk hunting permit between the years of 2011 and 2016 and were at least nineteen years of age. We sent the survey to 990 Nebraska elk hunters. Respondents had the option to return the paper version of the survey or to take the survey online. Participants could respond to the survey between 30 August 2016

and 30 September 2016. A reminder postcard was sent to individuals on 15 September who had not yet submitted a completed survey. Elk hunters in possession of a 2016 permit could submit a completed survey through 31 January 2017. A reminder postcard was sent to 2016 elk hunters who had not yet submitted a completed survey by 13 January 2017.

Survey design

Survey respondents were instructed to complete the survey for the most recent year that they hunted elk in Nebraska. Questions pertained to several aspects of the respondent's individual hunt as well as questions pertaining to interactions with landowners (Table 2). Questions included in the survey were developed jointly by NGPC wildlife biologists and researchers at the University of Nebraska - Lincoln.

Each respondent was asked to indicate their agreement with how strongly each of several constraints affected the respondent's ability to both hunt and harvest an elk. Specific constraints affecting the respondent's hunting opportunity included the following: 'the cost of the permit,' 'difficulty finding private property to hunt,' 'difficulty obtaining permission to hunt on private property,' 'the cost to hunt on private property,' 'limited access to elk on private property belonging to other landowners,' 'personal or family health,' and 'my time available for hunting was limited.' Specific constraints affecting the respondent's opportunity to harvest

Table 2. Description of variables and corresponding response levels included in study questionnaire distributed to 2011–2016 Nebraska bull and antlerless-elk hunters.

Variable	Levels
Aspects of hunt	
Type of permit held	Bull, antlerless
Type of land used for hunting	Private land, public land
Seasons actively hunted ^a	Early antlerless, early bull, regular season, late antlerless
Number of days hunted ^b	–
Number of landowners contacted ^b	–
Number of landowners granting permission ^b	–
Number of landowners paid for permission ^b	–
Seasons in which permission was granted ^a	Early antlerless, early bull, regular season, late antlerless, no permission granted, no permission sought
Hunting constraints	
Cost of permit	Strongly disagree, disagree, neutral, agree, strongly agree
Difficulty finding private property to hunt	Strongly disagree, disagree, neutral, agree, strongly agree
Difficulty obtaining permission to hunt on private property	Strongly disagree, disagree, neutral, agree, strongly agree
The cost to hunt on private property	Strongly disagree, disagree, neutral, agree, strongly agree
Limited access to elk on private property belonging to other landowners	Strongly disagree, disagree, neutral, agree, strongly agree
Personal or family health	Strongly disagree, disagree, neutral, agree, strongly agree
My time available for hunting was limited	Strongly disagree, disagree, neutral, agree, strongly agree
Harvest constraints	
I did not have sufficient experience hunting elk	Strongly disagree, disagree, neutral, agree, strongly agree
I only had access to hunt on public land	Strongly disagree, disagree, neutral, agree, strongly agree
The landowner(s) that gave me permission to hunt had stringent rules	Strongly disagree, disagree, neutral, agree, strongly agree
The terrain I hunted made it difficult to harvest elk	Strongly disagree, disagree, neutral, agree, strongly agree
Limited number of elk on the land where I had permission to hunt	Strongly disagree, disagree, neutral, agree, strongly agree
Limited number of elk in the Elk Management Unit where I hunted	Strongly disagree, disagree, neutral, agree, strongly agree
The weather made it difficult for me to harvest	Strongly disagree, disagree, neutral, agree, strongly agree
My time available for hunting was limited	Strongly disagree, disagree, neutral, agree, strongly agree

^a Indicates variables that permitted multiple responses.

^b Indicates variables that required an open-ended response.

elk included the following: 'I did not have sufficient experience hunting elk,' 'I only had access to hunt on public land,' 'the landowner(s) that gave me permission to hunt had stringent rules,' 'the terrain I hunted made it difficult to harvest elk,' 'limited number of elk on the land where I had permission to hunt,' 'limited number of elk in the Elk Management Unit where I hunted,' the 'weather made it difficult for me to harvest,' and 'my time available for hunting was limited.'

Multiple-choice questions pertaining to aspects of the hunt included the type of permit that was held and the type of land that was primarily used when hunting elk. Respondents were asked to indicate the season(s) they had actively hunted, and how many days they spent hunting elk in Nebraska (i.e. days afield). Respondents were further asked to answer questions pertaining to aspects of hunters' interaction with landowners. Questions associated with landowner interaction included the following: the number of landowners the hunter had contacted to seek hunting permission, the number of landowners who granted the hunter permission to hunt, the number of landowners the hunter had paid for permission to hunt, and which season(s) landowners had granted hunting permission.

Data analyses

A check for non-response bias was conducted by comparing mean differences in age between respondents of the survey and non-respondents. We evaluated relative non-response bias of respondents using methods described in Callegaro et al. (2015). Hunter age-data were acquired from the respondent list provided by the NGPC. Standard relative non-response benchmarks are between 5% and 10% (Callegaro et al. 2015). Data pertaining to hunter gender were not provided in our contact list.

We used ordinal logistic regression to compare constraints to hunting elk and constraints to harvesting elk as described in Bilder and Loughin (2014). We used four separate models, with post hoc Bonferroni corrected p-values, to compare severity of constraints to hunting and harvesting within each permit type (e.g. hunting constraints to bull hunters, harvest constraints to bull hunters, hunting constraints to antlerless hunters, and harvest constraints to antlerless hunters) using the package `ordinal` (Christensen 2015) in R (www.r-project.org). Comparisons of constraint severity between bull- and antlerless-hunters were conducted using the same method, though each constraint to hunting and harvesting was modelled separately, using permit type as the independent variable in each model. A likelihood ratio test was used to assess the significance of permit type in each model. The likelihood of an individual constraint affecting a hunter's ability to hunt or harvest elk was presented as the odds ratio (OR) and calculated using the `lsmeans` package (Lenth 2016) in R. We used Cramér's V (ϕ_c) to test association between bull and antlerless-elk hunters. Missing values for hunting and harvesting constraints were imputed using the 'proportional odds' (`polr`) method in the `mice` package in R (Buuren and Groothuis-Oudshoorn 2011).

We used logistic regression to analyse separate models for each of the following probabilities: contacting a landowner, receiving permission from a landowner to hunt, and paying a landowner for permission to hunt. We included

the type of permit held (bull or antlerless) as the independent variable. We used the χ^2 test to compare probability of landowner contact, landowner permission, and paying a landowner between bull and antlerless-elk hunters. We used Student's t-test to compare differences in the number of days spent afield, number of landowners contacted, number of landowners permitting hunting, and number of landowners paid. Respondent values for days afield and number of landowners contacted and paid were log transformed to meet the normality assumption prior to conducting t-tests.

Results

There were 990 hunters invited to participate in the survey, who represented our target population of Nebraska residents who had drawn an at least one elk permit between 2011 and 2016. A total of 460 returned surveys indicated whether the respondent had targeted bull or antlerless elk, and thus were included in our analyses, for an overall response rate of 46%. Average age of respondents to the survey (51 years) was higher than the average age of non-respondents (46 years) and the population invited to participate (48 years, 7% relative non-response bias). Of all respondents, 412 indicated that they had hunted either a bull or antlerless elk. A greater proportion of respondents indicated that they had most recently hunted an antlerless elk since 2011 (57%) as opposed to a bull. While hunters may have hunted on both private and public land in their most recent hunting season, both bull and antlerless-elk hunter groups most frequently indicated that they had primarily hunted private land. A total of 199 antlerless-elk hunters indicated that they primarily hunted on private land (83% of antlerless-elk hunters). There were 155 bull-elk hunters who primarily hunted private land (85% of bull-elk hunters). Over 50% of survey respondents had hunted either in Hat Creek or Bordeaux EMU, located in the northwest corner of the Nebraska panhandle (Fig. 1).

Constraints to hunting elk

Factors presenting the greatest constraints to elk hunting by both bull and antlerless-elk hunters were 'difficulty finding private property to hunt,' 'difficulty obtaining permission to hunt on private property,' the 'cost to hunt on private property,' and 'limited access to elk on private property belonging to other landowners' (Table 3). Few respondents felt that the 'cost of the permit,' 'personal or family health,' or that 'my time available for hunting was limited' affected their opportunity to hunt elk. Antlerless-elk hunters agreed more strongly than bull-elk hunters that 'my time available for hunting was limited' (Table 4).

Constraints to harvesting elk

Overall, hunters did not feel that the following constraints had affected their opportunity to harvest an elk: 'I did not have sufficient experience hunting elk,' 'I only had access to hunt on public land,' the 'landowner(s) that gave me permission to hunt had stringent rules,' the 'terrain I hunted

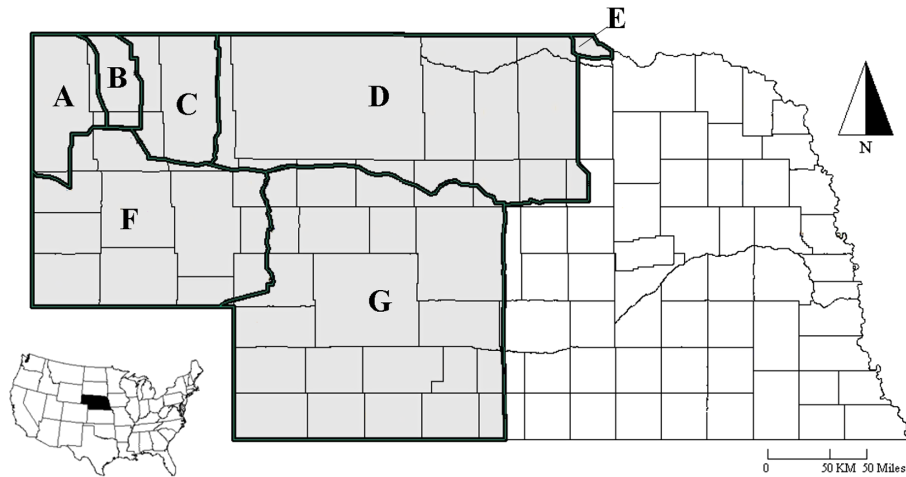


Figure 1. A map of where hunting elk could occur (shaded area) in Nebraska during permit year 2016, divided into seven Elk Management Units. A = Hat Creek (104 respondents), B = Ash Creek (51 respondents), C = Bordeaux (116 respondents), D = Niobrara River (31 respondents), E = Boyd (6 respondents), F = North Platte River (70 respondents) and G = Box Elder (51 respondents).

made it difficult to harvest elk,' 'limited number of elk in the Elk Management Unit where I hunted,' and the 'weather made it difficult for me to harvest' (Table 3). The greatest harvest constraint to both bull and antlerless-elk hunters was 'limited number of elk on the land where I had permission to hunt.' Antlerless-elk hunters indicated that 'limited number of elk on the land where I had permission to hunt' and 'limited number of elk in the Elk Management Unit where I hunted' affected their opportunity to harvest more than bull-elk hunters (Table 4). Antlerless-elk hunters also felt more strongly than bull-elk hunters that the 'terrain I hunted made it difficult to harvest elk,' the 'weather made it difficult for me to harvest,' and 'my time available for hunting was limited' constrained their harvest success.

Permission to hunt by landowners

Nearly every elk hunter (95%) had sought permission to hunt on private land from at least one landowner, and we found no difference in the probability of bull and antlerless-elk hunters contacting at least one landowner. Of those elk hunters who had sought hunting permission, bull-elk hunters sought permission from a greater number of landowners ($\bar{x} = 6.2$, $SE = 0.47$, $n = 172$) to hunt than did antlerless-elk hunters ($\bar{x} = 4.4$, $SE = 0.37$, $n = 227$; log transformed $t_{356} = -4.00$, $p < 0.01$).

We found no difference in the probability of gaining permission from a landowner nor the average number of landowners who had granted permission. Of the bull-elk

Table 3. Post hoc comparisons of 2011–2016 Nebraska bull and antlerless-elk hunters among severity of seven constraints to respondents' ability to hunt elk and eight constraints to respondents' ability to harvest an elk. Severity of constraints are ranked alphabetically (e.g. A is more severe than B) and are significant at the $p < 0.05$ level.

Constraint	Constraint severity ^a	
	Bull permit	Antlerless permit
Hunting constraints	model $\chi^2 = 1073.9$, $p < 0.01$	model $\chi^2 = 1497.3$, $p < 0.01$
Cost of permit	BC	C
Difficulty finding private property to hunt	A	A
Difficulty obtaining permission to hunt on private property	A	A
The cost to hunt on private property	A	A
Limited access to elk on private property belonging to other landowners	A	A
Personal or family health	B	B
My time available for hunting was limited	C	D
Harvest constraints	model $\chi^2 = 1424.7$, $p < 0.01$	model $\chi^2 = 1912.7$, $p < 0.01$
I did not have sufficient experience hunting elk	C	B
I only had access to hunt on public land	BC	B
The landowner(s) that gave me permission to hunt had stringent rules	ABC	B
The terrain I hunted made it difficult to harvest elk	BC	BC
Limited number of elk on the land where I had permission to hunt	A	A
Limited number of elk in the Elk Management Unit where I hunted	ABC	CD
The weather made it difficult for me to harvest	BC	BC
My time available for hunting was limited	AB	AD

^a Only comparable within permit and constraint type.

Table 4. Comparison between 2011 and 2016 Nebraska bull and antlerless-elk hunter agreement with seven constraints having affected the respondents' ability to hunt elk and eight constraints having affected the respondents' ability to harvest an elk. β parameter estimates with standard errors (SE), chi-square test statistics (χ^2), p values (p), odds ratios (OR), odds ratio 95% confidence interval (95% CI) and Cramér's V (ϕ_c) depict directional transition from bull hunters to antlerless-elk hunters.

Constraint	Estimate (SE)	χ^2	Odds ratio	95% CI	p	ϕ_c
Hunting constraints						
Cost of permit	0.28 (0.18)	2.64	1.33	0.94–1.87	0.11	–
Difficulty finding private property to hunt	–0.29 (0.18)	2.76	0.75	0.53–1.05	0.10	–
Difficulty obtaining permission to hunt on private property	–0.29 (0.17)	2.82	0.75	0.53–1.05	0.09	–
The cost to hunt on private property	–0.13 (0.17)	0.84	0.88	0.63–1.24	0.47	–
Limited access to elk on private property belonging to other landowners	0.09 (0.18)	0.24	1.09	0.77–1.54	0.63	–
Personal or family health	0.06 (0.18)	0.13	1.07	0.76–1.50	0.72	–
My time available for hunting was limited	0.42 (0.17)	5.97	1.53	1.09–2.14	0.01	0.13
Harvest constraints						
I did not have sufficient experience hunting elk	0.31 (0.18)	3.15	1.37	0.97–1.93	0.08	–
I only had access to hunt on public land	0.17 (0.18)	0.93	1.19	0.84–1.68	0.33	–
The landowner(s) that gave me permission to hunt had stringent rules	–0.06 (0.18)	0.12	0.94	0.67–1.33	0.72	–
The terrain I hunted made it difficult to harvest elk	0.36 (0.18)	4.16	1.42	1.01–2.02	0.04	0.15
Limited number of elk on the land where I had permission to hunt	0.58 (0.17)	11.24	1.79	1.27–2.51	<0.01	0.18
Limited number of elk in the Elk Management Unit where I hunted	0.46 (0.17)	6.93	1.58	1.12–2.23	<0.01	0.15
The weather made it difficult for me to harvest	0.39 (0.17)	5.09	1.48	1.05–2.08	0.02	0.16
My time available for hunting was limited	0.63 (0.17)	13.09	1.88	1.33–2.64	<0.01	0.18

hunters who sought permission, 94% were granted by at least one landowner. Ninety percent of antlerless-elk hunters who had sought permission from a landowner were granted. Of the elk hunters who had received permission, the average number of landowners who had granted permission to a bull-elk hunter was 2.3 (SE=0.15, n=157), while antlerless-elk hunters were granted permission by an average of 2.2 landowners (SE=0.12, n=201). Of all bull-elk hunters who had been granted permission from a landowner to hunt, 25% had permission to hunt in the September archery season, and 99% had permission during the regular October hunting season. Of all antlerless-elk hunters who had been granted permission from a landowner to hunt, 44% had permission to hunt during August and September; 44% had permission to hunt during the regular October hunting season, and 74% had permission in the month of December. However, we did not capture information pertaining to the season(s) hunters sought permission.

Hunting effort

Between 2011 and 2016, bull-elk hunters could actively hunt from the middle of September through the month of October, though only bow hunting was permitted during the month of September. Of all responding bull-elk hunters, 22% hunted during the month of September and 93% hunted during the month of October. Antlerless-elk hunters had the opportunity to hunt between the middle of August through the end of October as well as the month of December. Antlerless-elk hunters had no weapon restrictions during any season. Of all responding antlerless-elk hunters, 36% hunted in the months of August and September, 60% hunted in the month of October and 55% hunted in December.

We found no significant difference in the average number of days spent hunting despite antlerless-elk hunters having nearly three times as many hunting days available. On average, bull-elk hunters spent 6.4 days (SE=0.47, n=175, mode=1) hunting elk during their most recent elk hunting season. Antlerless-elk hunters spent, on average, 7.1 days (SE=0.46, n=234, mode=4) hunting elk during their most recent elk hunting season.

Permission fees

If a hunter sought permission to hunt, the probability of paying a fee for that permission was significantly greater for bull-elk hunters ($\chi^2_1=64.65$, $p<0.01$). Of the bull-elk hunters who had sought hunting permission, 58% paid some amount for that permission. Only 19% of permission-seeking antlerless-elk hunters paid a landowner for permission to hunt elk on their property. We found no difference in the number of landowners who hunters paid for permission to hunt. On average, bull-elk hunters, who had paid for hunting permission, paid 1.2 landowners (SE=0.04, n=99), while the average number of landowners paid by antlerless-elk hunters was 1.3 (SE=0.09, n=43).

Discussion

Constraints to hunting activity has become an increasingly important research topic as wildlife biologists work to manage game populations, fund agency operations, and make hunting activities available to constituents (Backman and Wright 1993, Barro and Manfredo 1996, Metcalf et al. 2015, Quartuch et al. 2017). Herein, we examined the constraints to hunting and harvesting big game in a hunting

system where permit acquisition is restricted and access to hunting opportunities is largely controlled by private landowners. Primarily, Nebraska antlerless-elk hunters were more constrained than bull hunters by factors directly related to harvest success. Antlerless-elk hunters were also less likely to pay a landowner for hunting permission. Our study built on the concept of leisure-constraints negotiation, within a framework of big game hunting dominated by a need for hunting access on private land. We highlight the comparatively greater ability of bull-elk hunters to negotiate constraints to time and securing suitable hunting access and the need to address antlerless-hunter constraint severity when population control is an agency objective.

Constraints to hunting and harvesting elk

Overall, the most highly rated constraints to hunting opportunity were finding private land for hunting access, obtaining permission to hunt on private land, costs affiliated with securing hunting permission, and a lack of access to elk that were present on inaccessible land. We expected these four constraints to be the most limiting, as elk hunting opportunity in Nebraska is (mostly) limited to privately-owned land, and hunters who acquire a general elk permit typically do not own land where elk herds reside. Our findings are consistent with recent studies that revealed that constraints related to finding places to hunt, obtaining permission to hunt and cost of hunting on private land can be highly limiting (Wright et al. 2001, Miller and Vaske 2003, Duda et al. 2010). Lack of access to elk present on inaccessible land was viewed as a constraint to hunting opportunity as equally limiting as finding, securing, and affording private land access. Past research has revealed that a lack of game can be a highly limiting constraint to hunting participation (Miller and Vaske 2003, Metcalf et al. 2015). However, it is interesting that hunters in our study viewed lack of access to game so highly limiting to their ability to hunt (as opposed to limiting to harvest an elk). This suggests hunters may perceive successful harvest as an unrealistic expectation, thereby reducing hunting effort, and ultimately constraining their ability to hunt. Perhaps just as interesting, we found no differences in constraint severity of finding private property, securing permission, cost of obtaining permission or lack of access to elk on the property between bull and antlerless hunters. Based on relatively lower harvest success of antlerless-elk hunters, we expected bull-elk hunters would more easily negotiate hunting constraints related to land access, cost, and access to game. In fact, limited time available for hunting was the only hunting constraint in which severity varied between bull and antlerless-elk hunters. Antlerless-elk hunters viewed time as greater constraint to elk hunting than bull-elk hunters, which refuted our prediction. However, as antlerless-elk hunting also occurs in the month of December, opportunity can be compromised by inclement weather (blizzards and severe cold) as well as holiday-related obligations.

Overall, limited time was ranked as the least limiting constraint to hunting opportunity for both hunter types. Diminutive time constraints conflicts with other research focused on leisure constraints negotiation in hunting activities

(Miller and Vaske 2003, Schroeder et al. 2012, Metcalf et al. 2015). Referenced strategies for negotiating time, as a constraint to hunting, include planning ahead to make time for hunting, setting aside time for hunting activities, fitting hunting around other commitments, hunting close to home and hunting when the field is less crowded (Metcalf et al. 2015). We suspect hunters were more capable of negotiating time limitations than other hunting constraints because they were able to plan ahead and set time aside for hunting before the hunting season began, particularly because the opportunity to hunt elk in Nebraska is a uniquely rare opportunity. Many elk hunters likely recognized the specialized nature of their opportunity and made arrangements, prior to the onset of the hunting season, in order to navigate those commitments most likely to constrain time for hunting effort, such as work, school or family (Stensland et al. 2017). Arrangements may even have been made prior to participating in the lottery, in the event that a hunting permit were to be drawn.

A lack of access to elk in the location where hunting occurred, was the only constraint that clearly stood out as one of the most limiting factors to harvest success, for both bull and antlerless-elk hunters. It is concerning that Nebraska elk hunters view the lack of access to game as the greatest constraint to harvest, as harvest opportunity has routinely been cited as one of the most important determinants of hunter satisfaction (Hammitt et al. 1990, Gigliotti 2000, Frey et al. 2003, Schroeder et al. 2018, Gruntorad et al. in press). By increasing public or private land availability, management agencies may provide more areas to hunt and indirectly decrease conflicts among hunters (potentially increasing harvest success) (Fontaine et al. 2019, Wszola et al. in press).

Limited time was also viewed as highly limiting to harvest (as opposed to hunt) elk by many hunters in both hunter groups. Why hunters view lack of time as a relatively easily negotiable constraint to hunting and a relatively highly constraining limitation to harvest is confounding. One explanation is that hunters felt they had adequate time to apply hunting effort in the field (unconstrained by work, school and family obligations), but simply did not have enough time to encounter a harvest opportunity. Several studies have documented time as a major constraint to hunting participation (i.e. purchasing a permit) (Backman and Wright 1993, Miller 2003, Metcalf et al. 2015, Shrestha and Burns 2016, Stensland et al. 2017), however research addressing the effects of time constraints, specifically to harvest success, is sparse. Further research devoted to exploring the complexities of time as a constraint to multiple hunting processes (permit purchase, hunting effort and harvest success) may provide valuable insight to the role of time in leisure constraints.

We found a greater number of disparities for harvest constraints between bull and antlerless-elk hunter than hunting constraints. While limited time was the only hunting constraint having imposed disparate limitations between the two hunter groups, antlerless-elk hunters felt more strongly than bull hunters that difficult terrain, limited access to elk, limited elk in their EMU, weather conditions and time constrained their ability to harvest. We predicted antlerless hunts would be more constrained by weather, but we did not expect bull hunters to more easily negotiate time

constraints to harvest. Similar to hunting constraints, inclement weather and holiday-related time commitments may play a greater role in antlerless-elk hunters' harvest constraints than bull hunters as antlerless-elk hunting in December is most preferred by the majority of antlerless-elk hunters, while bull hunting during this time is not even permitted. We suspect variable severity of constraints related to terrain, game access and limited elk in the EMU, may be linked to specific differences between the permissions acquired by bull and antlerless-elk hunters, and the permission fees to which each type of hunter consents.

Permission and harvest

The second objective of this study was to compare the hunting behavior between Nebraska bull and antlerless-elk hunters. Nebraska is unique in that it contains little public land available for hunting elk, relative to adjacent western states. Therefore, most elk hunters depend on private landowners for the opportunity to hunt. Our findings revealed the only difference between Nebraska bull and antlerless elk hunters in terms of landowner-interaction were the number of landowners contacted for permission, the proportion of hunters receiving hunting permission within each season, and the probability of paying a landowner for hunting permission. Bull-elk hunters sought permission to hunt from a greater number of landowners, which may suggest a combination of scenarios. The first is that bull hunters may have contacted a greater number of landowners in an effort to maximize either the probability of harvest or the quality of trophy to be harvested, thereby exercising more constraint negotiation effort (Hubbard and Mannell 2001). Though we found no studies documenting differences between effort expended contacting landowners by elk hunters, other research has indicated that buck and trophy deer hunters exhibit greater hunting effort than doe hunters (Heberlein and Kuentzel 2002). Bull-elk hunters may have alternately been forced to contact a greater number of landowners than antlerless hunters before permission was granted.

Our study examined the social interactions between hunters and landowners within an environment where hunting opportunity hinges on the need to pay landowners to target a public good. Although the North American Model of Conservation implies hunting opportunity is not limited to those with land ownership or wealth, we found bull-elk hunters were more willing to pay landowners for hunting permission than antlerless-elk hunters, which likely contributed to comparatively high harvest success. However, according to the theory of leisure constraint negotiation, antlerless-elk harvest success should increase if hunters are able to more easily negotiate those constraints related to securing access to hunt on private land where harvest opportunity exists. Specifically, we demonstrated the inherent importance for big game hunters to acquire access to private land for hunting privileges when population control is included as an objective to the hunt permitting system. The findings in our study may serve wildlife management agencies internationally, tasked with managing specialized hunter populations in a landscape where hunting opportunity and harvest success are largely dependent on landowner cooperation for access to hunting opportunities.

Management implications

In principle, wildlife resources in North America are a public trust. However, we find clear discrepancies in the ability for hunters to access these resources when the resources reside predominately on privately owned land. It is difficult for managers to provide hunting opportunities for everyone, when the 'costs' of hunting is being determined by private entities. Many landowners market their property specifically to high-paying hunters who are seeking a trophy bull. The dilemma of a public good on privately-owned landscapes is not unique to elk hunting in Nebraska and continues to be a concern in the United States (Benson 1989, Butler et al. 2005, Haggerty and Travis 2006, Larson et al. 2014). There is a strong need to better understand factors affecting access to private hunting lands (Poudyal et al. 2012) and to find solutions to open more land access to hunters (Haggerty and Travis 2006).

Though the majority of hunters were able to successfully negotiate their constraints, our study ultimately demonstrates a need to ease antlerless-hunter constraints for both time and acquisition of suitable hunting access. Easing of these constraints is especially important when harvest rates fall below management recommendations. If hunters are the primary means of elk population control, it may be unrealistic to expect a segment of the hunter population to pay greater costs than the relative intrinsic value of the elk harvest (Mensah and Elofsson 2017). However, we do not know whether landowners who charge an access fee are only offering access to bull-elk hunters or whether antlerless-hunters are less willing to pay access fee costs. In a system dominated by private lands, a firm understanding about which hunters are being excluded from access to these premium hunting sites is essential in order to effectively manage hunting opportunity and wildlife populations.

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