

What's your game?

Heterogeneity amongst New Zealand hunters

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ABSTRACT

The introduction of the New Zealand Game Animal Council in 2014 heralds a new era for New Zealand big game management. Now that management of game animals to enhance benefits from sustained use is possible, it is important to understand who values game resources and the attributes that enhance benefits from their use. Choice experiments using a pivot design around actual travel distance identified salience of hunt-related attributes for recreational hunters of Himalayan tahr (*Jemlahicus Hemitragus*) and sika deer (*Cervus Nippon*). The choice experiments successfully used travel distance as the numeraire of value to overcome resistance to the commodification of hunting. Results show the high value of recreational hunting, and identify disparate preferences both within and between species. Understanding heterogeneity offers important insights into managing hunting experiences to enhance their value for recreational hunters.

KEYWORDS

Choice experiment, sika deer, Himalayan tahr, recreation, hunting, management, heterogeneity

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INTRODUCTION

The Game Animal Council Act 2013 (The Act) became operative in May 2014, creating the opportunity to manage large game animals to enhance economic and recreational benefits within environmental constraints. Where a herd of game animals has particular importance it may become a “herd of special interest” and be managed for hunting purposes consistent with broad overriding environmental considerations.

The Act defines criteria for establishing a herd of special interest, which must be of sufficient value to justify management. Other criteria include identification of objectives for management, and the ability to manage to achieve the stated objectives. However, because game hunting has been open-access, consistent with the past “pest” status of the quarry, there has been very little research on the demand side of hunting, and consequently the value of hunting and the contribution of specific hunt attributes to the satisfaction obtained from hunting is unknown, other than anecdotally. Hunting areas are akin to Hardin’s (1968) commons which, along with the implications of competing aerial hunting of the same resource, partly explains the comparatively low value of New Zealand deer hunting experiences (Kerr and Woods, 2010). Management objective setting for herds of special interest will not be straightforward because hunters have diverse motivations, capabilities and opportunities.

Hunting-related expenditures provide a measure of the importance of recreational hunting (Kerr and Abell, 2014), as does hunters’ consumer surplus, assessed here. The primary purpose of this paper is to estimate the current value of hunting for two game species, sika deer (*Cervus nippon*) and Himalayan tahr (*Hemitragus jemlahicus*), as an indicator of the importance of these species to hunters. This study also informs objective setting for recreational sika deer and tahr hunting management by identifying hunter heterogeneity, classifying hunters into groups with similar preferences, and identifying the relative importance of key hunt attributes for each group. In measuring the value gains from altered hunt attributes potential benefits of enhanced management of sika and tahr hunting are identified.

Sika deer were introduced to the North Island in 1905 to establish a hunting resource (Davidson, 1973), and by 2000 they occupied about 6000 km², principally in the Kaimanawa and Kaweka Ranges, of the central North Island (Fraser *et al.*, 2000). Sika range continues to expand accompanied by displacement of Red deer (Davidson and Fraser, 1991; Nugent *et al.*, 2001). Sika deer hunting now accounts for a significant proportion of New Zealand big-game hunting effort. Thirty one percent of big-game hunters responding to a national survey had targeted sika deer in the previous year, with hunts targeting sika deer accounting for eleven percent of annual big-game hunting effort (Kerr and Abell, 2014).

Tahr have extended their range to about 4200 km² of South Island mountain country since their original release near the Hermitage in 1904 (Fraser *et al.*, 2000). Sixty seven percent of tahr range is in Canterbury, on the eastern side of the Southern Alps. The Himalayan Tahr Control Plan (Department of Conservation, 1993) sets a desired upper limit on tahr abundance at 10,000 animals, with defined upper density limits in each management area. The Control Plan gives preference to management by recreational hunting, followed by commercial hunting and lastly government hunting. As with sika deer, recreational tahr hunting on public land is open-access except for some isolated restrictions in a small number of locations. Nugent (1992) estimated annual recreational harvest from lands of all tenure in 1988 was 772

tahr. There is no reliable recent estimate of either tahr population size, or harvests, but recent evidence suggests much bigger harvests than Nugent estimated (Kerr and Abell, 2014).

METHODS

Choice experiments assessed hunter heterogeneity and the relative value of hunt attributes for different types of hunter. Combined information on individual hunter attributes and behaviours collected in two earlier surveys (Kerr and Abell, 2014) and choice experiment data collected from sika deer and Himalayan tahr hunters who participated in the earlier surveys provided a comprehensive overview of hunters and their preferences. The choice experiments were run as internet surveys using the Qualtrics platform with a call-out to bespoke choice experiment software run on an alternative server. The transitions between the two systems were invisible to participants.

Salient hunt attributes were identified from researcher field experience, a review of hunter motivations (Woods and Kerr, 2010), and discussions with experienced hunters, managers and researchers. The surveys were pre-tested by hunters with varying hunting experience and skill.

The vast majority of sika deer and Himalayan tahr live on public land, where hunting is permitted year round subject to possessing a hunting permit from the Department of Conservation. Obtaining a free hunting permit takes only a few minutes over the internet. However, historically it is common to hunt without a permit (Fraser, 2000). It was not practical to have a money-related attribute within the choice experiment design because of the emotionally and politically charged context of recreational hunting management. A significant section of the hunting community favours retention of the existing spontaneous, essentially open-access, hunting permit system. There has been strong resistance to the possibility that hunters may have to pay or use more onerous permitting systems to hunt on public lands. At the time of the choice experiments the possibility of such changes was a matter of strong speculation based on proposals for reform of recreational hunting management under the aegis of the proposed Game Animal Council.

However, hunters are familiar with making decisions about where to hunt based on their perceptions of alternative site attributes, including differences in travel distance. That experience was the basis for the choice experiment, in which hunters faced three alternative sika or tahr hunts described by different attribute levels entailing, *inter alia*, road travel distances. In addition to the three hunts in each choice situation, hunters could choose not to hunt sika or tahr (Holmes and Adamowicz, 2003). Hence, the value of alternative attribute levels could be measured in terms of willingness to travel. A pivot design was used to add realism to the survey (Boxall *et al.*, 1996; Rose *et al.*, 2008). The distances that hunters travel are largely determined by the individual hunter's residential location. It would not have been realistic to propose hunts that were closer than the nearest sika or tahr habitat, nor would it have been realistic to propose travel distances that would have taken hunters beyond available habitat. To overcome this difficulty the levels for the distance attribute were pivoted off the distance travelled by the individual hunter on a recent hunt for the species concerned. The three levels used for this attribute (0 km, 150 km, 250 km) were added to the distance each individual respondent stated they travelled to hunt (X_i km), so that an individual hunter observed the attribute levels X_i km, X_i+150 km, and X_i+250 km in their personal choice scenarios.

Each choice experiment was conducted in two phases in order to obtain efficiency gains from a revised experimental design based on responses to the first phase (Kerr and Sharp, 2010). Ngene software (Choicemetrics, 2009) was used to develop a D-efficient design for a multinomial logit model based on the relevant priors at each round. Attributes and their levels are summarised in Table 1. Sixty four choice scenarios were blocked into eight groups that were offered sequentially to ensure equal numbers of responses to each block, with each participant presented with eight choice scenarios.

Table 1: Choice experiment attributes (Base levels of variables are in bold)

Attribute	Description	Levels
Days	Time in the hunting area (days)	1,2, 3 ,5,7
Hut	Hut in the hunting area	No , Yes
Access	Options available to access the hunting site	(Sika) Walk only , Walk or 4WD, Walk or aircraft (Tahr) Walk only , Walk or 4WD, Walk or helicopter, All
Terrain	Difficulty of hunting terrain	Easy, Moderate , Difficult
Others	Other hunters in the area	No, Possibly , Yes
Density	Sika deer or nanny tahr density	Low, Moderate , High
Trophy	Trophy sika stag or bull tahr potential	Low, Moderate , High
Distance	Extra one way distance to the hunting site relative to the distance of a recent hunt (km)	0 , 150, 250

Surveying took place in September and October 2012 for tahr hunters, and in November and December 2012, for sika deer hunters. Survey invitations were sent to 300 sika hunters and 309 tahr hunters. Responses were received from 157 sika hunters (56.3%) and 192 tahr hunters (62.1%). After removal of incomplete surveys and responses from people who had not hunted the target species in the previous year, 128 sika surveys and 149 tahr surveys were available for analysis.

RESULTS

Models were estimated using Latent Gold Choice[®] software. We fitted two, three and four class latent class models, assessing goodness of fit with AIC, AIC3, CAIC and BIC scores. Typical of latent class analysis, there was disagreement between criteria about the optimal number of classes. Overall, three class models were preferred on these three criteria and are analysed here. The sika model is presented in Table 3 and the tahr model is presented in Table 4.

Significance of attributes

Significant ASCs in both models indicate that hunters in all classes would be willing to travel to participate in the base hunt rather than not hunt the species in question. The significant total

distance coefficients indicate that hunters attended to the non-hunt related opportunity costs of their choices.

In the sika deer model several attributes were not significant determinants of choices. These were the presence of a hut in the hunting area, availability of 4WD or aircraft access, and difficulty of the terrain. The number of days on site was modelled as a series of dummy variables, with a three-day hunt as the base. Alternatives were one, two, five and seven day hunts. No class distinguished between three-day and five-day hunts. Only one class (albeit the biggest one) preferred high numbers of sika deer. All classes preferred moderate numbers of sika deer to low numbers. In addition, Class 2 preferred certainty that no other hunters would be in the area, an attribute that was not significant for Classes 1 or 3.

Table 3: Sika deer latent class model (Model 33)

	Class 1	Class 2	Class 3
Total Distance	-0.00170***	-0.00234***	-0.01801***
ASC Hunt	2.04844**	4.15333***	1.64445***
1 Day hunt	-1.23186***	-1.23216***	
2 Day hunt	-1.19020***		1.66720***
7 Day hunt			-1.98640***
No other hunters		0.25745**	
Definitely other hunters	-1.05565**	-0.63551***	
Low numbers of Sika	-0.77888***	-0.77888***	-0.77888***
High numbers of Sika		0.53090***	
Low trophy potential	-0.79391**	-1.04990***	
High trophy potential	-0.71432**	0.75694***	1.69276***
Class probability	0.2052	0.6661	0.1287
Modal probability	0.1875	0.6875	0.1250
Log-likelihood	-1086.0384		
Parameters	23		
Number of participants	128		
Choices	1018		
AIC	2218.0768		
AIC3	2241.0768		
CAIC	2306.6735		
BIC	2283.6735		

* for significance at 10% level, ** for 5%, *** for 1%

Similarly, several attributes did not influence tahr hunters' choices. As with sika hunters, tahr hunters' choices were unaffected by the presence of a hut in the hunting area. Notably, the density of nanny tahr in the area played no role in hunt choice, in contrast to the role of bull tahr trophy potential. No class of tahr hunters distinguished between two-day and three-day hunts. Access provisions influenced only Class 1 hunters, who disliked hunts in areas that could be accessed by all three access modes (walking, 4WD and helicopters). Class 2 hunters disliked difficult terrain. Class 3 tahr hunters were somewhat different from others. Only two site attributes influenced their choices, they disliked both the certain presence of other hunters and low trophy potential. Older hunters in Class 3 were less likely to choose a hunt option, an effect not found with any other group.

Table 4: Himalayan tahr latent class model (Model 14)

	Class 1	Class 2	Class 3
Total Distance	-0.00191***	-0.00281***	-0.00105**
ASC Hunt	2.54566***	4.47152***	0.80249***
1 Day hunt	-1.58061***	-0.99078***	
5 Day hunt	1.38499***		
7 Day hunt	1.17518***	-1.48541***	
All forms of access	-0.41762**		
Difficult terrain		-0.51899***	
No other hunters	0.41375***		
Definitely other hunters	-0.81941**	-0.42505**	-1.25718***
Low trophy potential	-1.91845***	-0.63851***	-1.72173***
High trophy potential	1.17508***	0.91617***	
Age of hunter - mean age			-0.07278***
Class probability	.4548	.2879	.2573
Modal probability	.4631	.2819	.2550
Log-likelihood	-1194.6837		
Parameters	25		
Number of participants	149		
Choices	1179		
AIC	2439.3750		
AIC3	2464.3750		
CAIC	2539.4737		
BIC	2514.4737		

* for significance at 10% level, ** for 5%, *** for 1%

Benefits: Willingness to Travel

Any attribute can be the numeraire of value. An obvious contender is distance. Non-market hunter benefits were measured as estimates of Willingness to Travel (WTT). With attributes at their base levels, and the utility of the non-hunt alternative defined to be zero, the ratio of the ASC to the coefficient on the total distance attribute is an estimate of consumer benefit in terms of gross WTT. Net WTT was derived by subtracting the actual distance travelled.

Similarly, dividing the coefficients for site-related attributes by the negative of the coefficient on distance derived WTT for attribute changes. For site attribute changes WTT is a measure of the extra (one-way) distance (km) a hunter would be prepared to travel to obtain the change in attribute level. These estimates are provided in Tables 5 and 6. Standard errors are Monte Carlo estimates from 10,000 draws.

Table 5. Sika hunt benefit estimates (Model 33): WTT is mean Willingness to Travel (km each-way/hunter/hunt). WTP is mean Willingness to Pay (\$/hunter/hunt).

Attribute (relative to base hunt)	Class 1			Class 2			Class 3		
	WTT	WTP	Z	WTT	WTP	Z	WTT	WTP	Z
	Differences from base hunt								
1-day hunt	-724	-598	1.79	-526	-435	5.36			
2-day hunt	-700	-578	1.84				93	76	3.49
7-day hunt							-110	-91	3.24
Definitely no others				110	91	2.13			
Definitely others	-621	-513	1.45	-272	-224	3.86			
Few sika	-458	-378	1.98	-333	-275	4.97	-43	-36	5.10
Many sika				227	187	3.53			
Low trophy potential	-467	-386	1.47	-449	-371	4.36			
High trophy potential	-420	-347	1.53	323	267	4.05	94	78	3.77
Hunt duration (other attributes at base levels)	Gross WTT								
1 day	480		2.09	1248		6.75	91		5.09
2 days	505		2.00	1775		7.60	184		7.09
3 or 5 days	1205		2.79	1775		7.60	91		5.09
7 days	1205		2.79	1775		7.60	-19		0.55
Hunt duration (other attributes at base levels)	WTP								
1 day		232	1.22		865	5.67		4	0.30
2 days		251	1.21		1301	6.75		81	3.77
3 or 5 days		830	2.32		1301	6.75		4	0.30
7 days		830	2.32		1301	6.75		-87	3.02

Base hunt: A three-day hunt, only walking access, moderate terrain, possibly other hunters in the area, moderate sika deer tahr density, moderate trophy stag probability.

Willingness to Pay

WTT was converted to monetary units by multiplying WTT estimates by the cost per km of travel. Hunter-provided estimates of money cost per kilometre (C_M) and time per kilometre (C_W), combined with a value of travel time were used to derive an estimate of the cost of travel (C_T) of \$0.826 per one-way kilometre for sika hunters and \$0.900 per one-way kilometre for tahr hunters. The cost of travel (C_T) is.

$$C_T = C_M + 2kC_W$$

Where C_M is the median transport cost per one-way kilometre per hunter, C_W is the median time (in hours) hunters took to travel one kilometre¹, and k is the mean of the values of travel

¹ For sika hunters $C_M = \$0.600$ per one-way km, $C_W = 0.0133$ hours per km, $C_T = \$0.826$
For tahr hunters $C_M = \$0.667$ per one-way km, $C_W = 0.0138$ hours per km, $C_T = \$0.900$

time for drivers and passengers in non-commuting, non-work travel in 2012 (\$8.47 per hour, NZTA 2013a and 2013b). Willingness to Pay (WTP) is then:

$$WTP_{ij} = C_T \cdot WTT_{ij} \quad \text{for Class } j \text{ for site attribute } i, \text{ and}$$

$$WTP_{kj} = C_T \cdot (WTT_{kj} - D_j) \quad \text{for Class } j \text{ for hunt } k$$

D_j is median distance travelled by hunters of Class j ².

Means of monetary benefit estimates per hunt of various durations, and for attribute changes, for the respective classes are reported in Tables 5 and 6. Standard errors are Monte Carlo estimates from 10,000 draws.

Table 6. Tahr hunt benefit estimates (Model 14): WTT is mean Willingness to Travel (km each-way/hunter/hunt). WTP is mean Willingness to Pay (\$/hunter/hunt).

Attribute (relative to base hunt)	Class 1			Class 2			Class 3		
	WTT	WTP	Z	WTT	WTP	Z	WTT	WTP	Z
Differences from base hunt									
1-day hunt	-827	-744	3.19	-352	-317	3.01			
5-day hunt	725	652	3.91						
7-day hunt	615	553	3.35	-528	-475	3.76			
All Access	-219	-197	1.81						
Difficult terrain				-184	-166	2.58			
Definitely no others	217	195	2.10						
Definitely other hunters	-429	-386	2.68	-151	-136	1.97	-1194	-1074	2.03
Low trophy potential	-1004	-903	4.26	-227	-204	2.32	-1635	-1471	2.23
High trophy potential	615	553	3.39	326	293	3.10			
Difference from mean age							-69.11	-62.17	2.21
Hunt duration (other attributes at base levels)									
WTT									
1 day	505		2.29	1238		6.66	762		2.73
2 or 3 days	1332		6.80	1591		7.94	762		2.73
5 days	2057		6.30	1591		7.94	762		2.73
7 days	1947		6.21	1062		6.02	762		2.73
Hunt duration (other attributes at base levels)									
WTP									
1 day		211	1.06		889	5.32		411	1.64
2 or 3 days		956	5.42		1206	6.69		411	1.64
5 days		1608	5.48		1206	6.69		411	1.64
7 days		1509	5.35		731	4.60		411	1.64

Base hunt: A three-day hunt, only walking access, moderate terrain, possibly other hunters in the area, moderate nanny tahr density, moderate trophy bull probability. Mean hunter age was 39.7 years.

² Sika hunters' median distance: Class 1, 220 km; Class 2, 200 km; Class 3, 86 km
Tahr hunters' median distance: Class 1, 270 km; Class 2, 250 km; Class 3, 305 km

Tables 5 and 6 report absolute values of Z scores, which are the same for WTT and WTP estimates of attribute change values. The requirement to subtract actual distance travelled from gross WTT to derive nett WTT, which is converted to monetary units through multiplication by C_T , results in smaller absolute Z-scores for WTP estimates. Hence, highly significant attributes in the latent class models can result in low significance of benefit estimates. See Class 1 sika hunters for an example.

Class membership

The influence of person-specific characteristics on class membership was investigated through incorporation of class membership variables as endogenous parameters in the latent class models. Characteristics tested were: main reason for hunting, age, hunting experience, occupation, income, educational qualifications, and employment status. None of these was significant. Further evaluation of class membership differences compared member attributes, after allocation of hunters to classes according to maximum class membership probabilities for each hunter (Modal probabilities in Tables 3 and 4). Probabilistic class allocation in the latent class model means this process has some potential limitations. However, the high entropy scores for these models (0.854 for sika and 0.739 for tahr) suggest the modal probabilities should be reasonable.

For sika hunters there is very little concern about allocation to Class 3, where the maximum probability of any hunter belonging to another class is 0.0913. The distinction is less clear between classes 1 and 2, where the maximum probability of belonging to the other class is 0.4457. However, mean probabilities of belonging to other classes are substantially less than the maxima. The mean probability of any sika hunter allocated to modal Class 1 being a member of Class 2 is 0.105.

Consistent with the lower entropy score, the probabilities of belonging to alternative classes are somewhat higher overall for tahr hunters. Whilst the maximum probability of belonging to another class is 0.4069 (probability of membership of Class 1 for a hunter assigned to modal Class 3), the minimum is 0.2769. Again, means are substantially lower, ranging from 0.041 to 0.072.

Personal attributes collected in the earlier demographic survey are described in detail in Kerr and Abell (2014). Sika and tahr hunt attributes refer to a hunt in the previous year, randomly selected by the survey software after the hunter had stated how many tahr or sika hunts they had been on in the previous year. Key personal and hunt attributes by class are reported in Table 7. Differences between classes are discussed in the following sections. Some reference is made to results not reported in Table 7 in the interests of parsimony.

Table 7: Mean personal and hunt attributes by class (standard errors of means). Shaded cells are significantly different to each other at the 5% level. **Bold** items are different to both others at the 5% level.

	Sika hunters			Tahr hunters		
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
Sika/tahr hunt attributes						
Annual sika/tahr hunts	4.29 (0.66)	7.56 (1.25)	8.69 (1.54)	3.06 (0.30)	3.76 (0.81)	3.42 (0.55)
Annual sika/tahr kills	1.79 (0.33)	3.48 (1.46)	1.75 (0.63)	4.96 (0.85)	12.43 (6.10)	8.11 (1.31)
Hunt duration (days)	4.38 (0.46)	3.61 (0.28)	1.81 (0.32)	3.55 (0.24)	4.19 (0.40)	4.42 (0.72)
Distance one way (km)	226 (17)	229 (28)	113 (21)	367 (40)	316 (46)	376 (61)
Transport cost per trip (\$)	227 (27)	237 (39)	72 (21)	228 (27)	287 (54)	384 (62)
Used 4WD access (%)	13 (4)	11 (4)	13 (8)	54 (6)	40 (8)	34 (6)
Used helicopter access (%)	33 (6)	32 (6)	13 (8)	20 (5)	26 (7)	34 (6)
Personal attributes						
Annual big game hunts	9.4 (0.9)	17.0 (2.1)	14.8 (2.3)	21.7 (3.2)	13.5 (1.3)	16.3 (2.7)
Annual days big game hunting	25.6 (1.8)	39.1 (4.0)	24.9 (3.6)	46.0 (4.3)	31.6 (3.1)	39.2 (6.4)
Years since started big game hunting	22 (2)	26 (2)	28 (4)	26 (2)	22 (2)	22 (4)
Age (years)	42 (2)	41 (2)	47 (3)	41 (2)	39 (2)	37 (6)
Urban resident (%)	75 (6)	59 (7)	88 (8)	65 (6)	66 (7)	58 (9)
Main Reason: Enjoy the outdoors (%)	33 (6)	51 (7)	38 (12)	54 (6)	55 (8)	47 (8)
Main Reason: Meat (%)	25 (6)	11 (4)	19 (10)	13 (4)	5 (3)	13 (2)
Main Reason: Trophy (%)	4 (3)	10 (4)	6 (6)	14 (4)	7 (4)	13 (2)
Employed full time (%)	88 (4)	86 (5)	81 (10)	67 (6)	74 (7)	71 (12)
Income over \$100,000 (%)	22 (5)	20 (6)	6 (6)	9 (3)	7 (4)	13 (2)
Degree (%)	42 (7)	27 (6)	13 (8)	35 (6)	38 (8)	42 (7)

Sika hunters

Small group sizes and large variances in some cases result in seemingly large differences being statistically insignificant. For example, Class 2 hunters killed about 3.5 sika in the previous year, which appears more than the 1.8 sika killed on average by Class 1 and Class 3 hunters. However, high within-class variances mean the differences are not significant.

Sika hunt attributes

Hunters in the three classes used walking and 4WD access in similar proportions and hunted in areas with similar perceived densities of sika deer. There are some notable differences in previous sika hunt attributes across the three classes. Class 1 hunters participated in the fewest sika hunts in the previous year. Unlike the other groups, the majority of Class 1 sika hunts were in the Kaimanawa Ranges. On the other hand, Class 3 hunters participated in the most sika hunts (although not significantly more than Class 2), but these were qualitatively different from the hunts of other class members. Class 3 hunts were of shorter duration, entailing more day hunts. They were also significantly less expensive, consistent with the mean travel distance being about half of that for the other classes. Class 3 hunters were least likely to have used a helicopter for access and made the lowest proportion of hunts in the Kaimanawa Ranges.

Personal attributes

There are no significant differences between classes in hunter age, hunting experience, income, or motivations for hunting. The most commonly cited primary motivation for all classes was enjoyment of the outdoors, which ranges between 33% (Class 1) and 51% (Class 2), although differences are not significant.

Class 1 hunters were the most likely to have a university degree. Class 3 had the largest proportion of urban members. Hunters in Class 2 (the biggest class, with 69% of sika hunters) made the most annual hunting trips for all big game species and spent the most annual days hunting big game. They were the class most likely to hunt other species in addition to sika deer. This group was the least urban, and had the biggest proportion of Maori membership.

Summary

Class 2 hunters were the most avid overall, but spread their hunting effort over several species. In contrast, Class 3 hunters tended to specialise more in sika hunting. They made a large number of short duration trips within relatively close proximity to their homes and were infrequent helicopter users. Class 1 hunters took few sika hunts, mostly in the Kaimanawa Ranges.

Tahr hunters

As with sika hunters, small group sizes and large variances can result in seemingly large differences being statistically insignificant. For example, Class 2 hunters killed about 12 tahr in the previous year, which is not significantly more than the 8 tahr killed on average by Class 3 hunters and 5 killed by Class 1 hunters. Members of the three classes are very similar in many ways. For example, each class travelled an average of about five hours, over a distance of about 350 km to hunt tahr. They spent about 4 days in the area, encountering similar numbers of other hunters, and their hunting areas had similar perceived nanny tahr density and trophy bull potential. The single most important reason for hunting (ranging from 47% for Class 3 to 55% for Class 2) was enjoyment of the outdoors.

Tahr hunt attributes

Class 1 members (46% of hunters) shot the fewest nanny tahr and bull tahr in the preceding year. They hunted proportionately more in East Coast catchments than did other classes, which probably explains their more frequent use of 4WD access. Class 3 is notable for shooting the most bulls annually, the highest rate of camping out, and the most use of helicopter access.

Personal attributes

Class 1 hunters made the most annual big game hunting trips, and spent the most days hunting annually. They were the class least motivated by viewing wild animals. Class 2 hunters were the group least often targeting other big game species. They also had the lowest frequency of motivation for meat.

Summary

Prior tahr hunting experiences distinguish Classes 1 and 3. Class 3 experiences are suggestive of specialised trophy bull hunters, whereas Class 1 hunters are less successful tahr hunters who more commonly access easier East Coast terrain. The high frequency of big game hunting in general for Class 1 suggests they are non-specialised tahr hunters. Class 2 hunters, on the other hand, were most likely to target tahr and killed more nanny tahr annually than the other classes.

Differences and similarities between sika hunters and tahr hunters

There are some differences between tahr and sika hunters. Tahr hunters had lower educational attainment and lower incomes, and fewer are in full time employment. Tahr hunters annually spent more days hunting big game. Tahr hunts entailed more frequent use of 4WD access than did sika hunts. Tahr hunts, in general, entailed longer travel distances, more travel expense, and were of longer duration than sika hunts. The average hunter of relevant types made fewer tahr hunts annually than sika hunts, but kills of tahr were higher.

Tahr and sika hunts were both valued highly, although in each case there is a group of hunters whose benefits from hunting were significantly less than benefits of other hunters (Class 3 hunters in each case). In the case of sika hunters this is a group of local hunters who made a large number of short duration sika hunts. These hunters had low sensitivity to the presence of other hunters, trophy potential and abundance of deer. In comparison, Class 3 tahr hunters appear to be trophy specialists, whose participation decreased with age, and who were strongly averse to the presence of other hunters. They frequently used helicopters for access, and their gross WTT was smaller than other classes. Compounding low WTT with greater distance travelled results in low WTP. Hence, the reasons for each group obtaining lower benefits are likely to be different.

The high consumers' surplus sika hunters (Class 2) were sensitive to all attributes in Table 5. They were an avid group of hunters, but have few other distinguishing characteristics. The high consumers' surplus tahr hunters (Class 1) were also avid hunters, sensitive to most attributes – the exception being terrain. This group had a marked preference for longer duration hunts and made frequent use of 4WD access.

DISCUSSION

There has been one descriptive study of recreational tahr hunting in a single New Zealand management unit (Davys *et al.*, 1999), but there have not been any non-market valuation studies of tahr hunting. There have been three non-market valuation studies of New Zealand recreational deer hunting (Sandrey and Simmons, 1984; Nugent and Henderson, 1990; Kerr, 1996), of which only Sandrey and Simmons valued sika deer hunting. Using data collected in early 1982 by Groome *et al.* (1983a), Sandrey and Simmons applied the travel costs method to estimate mean consumers' surplus from hunting in the Kaimanawa and Kaweka Forest Parks to be \$94 per hunt (SEM=\$4)³. A very similar result was obtained by Kerr (1996), who estimated consumers' surplus from hunting in the Greenstone and Caples valleys at \$107 per hunt (SEM=\$10). Even lower values were obtained by Nugent and Henderson (1990), who estimated consumers' surplus from hunting in the Oxford Recreational Hunting area in 1986-1988 at \$27 per hunt (\$20 per day). These results from the 1980s are much less than aggregate mean consumers' surpluses for 3 or 5 day hunts in the present study, which are in the order of \$1,000 for sika hunters and \$1,200 for tahr hunters.

The difference between values estimated in the current study and by Sandrey and Simmons (1984) is not explained by duration of the hunt. The average 1982 hunt in the Kaimanawa and Kaweka Forest Parks lasted 3.4 days (Groome *et al.*, 1983b), which conforms with the base hunt in the current study. However, success rates have changed markedly. Groome *et al.* (1983a, p.167) noted "Figures from hunters in the Central North Island show ... [f]or deer hunters only three out of four report that they have been successful in killing one animal in the past two years. Significant numbers have not killed, and some have not even seen, their chosen game species in this time." In contrast, hunters in our study reported much more success. Seventy percent of our sika hunters had killed a sika deer in the previous year, on average killing 0.477 Sika deer per hunt (SEM=0.045), amounting to a mean of 3.16 sika deer per year (SEM=0.78). The discrepancy with Nugent and Henderson (1990) can be explained by a combination of shorter duration hunts (mean = 1.36 days), extremely low success rates (one deer killed per 14.5 days hunted), and better availability of substitutes for the relatively small Oxford Recreational Hunting area in their study.

Substantial daily consumers' surplus estimates in the current study, and values in the order of \$800 to \$1,600 per hunt, indicate that Class 1 and Class 2 hunters value their sika and tahr hunting very highly, and are willing to travel large distances and/or pay substantially above their present costs to hunt these species⁴. This value is high in comparison with other recreational activities. Yao & Kaval (2011) evaluated 88 New Zealand recreation studies with mean consumer surplus of \$65 per day (SEM=\$12). Estimates of the mean value of angling on premier New Zealand fishing waters (all in 2012 values) are; Tongariro River \$44 per day (McBeth, 1997), Caples/Greenstone Rivers \$95 per trip (Kerr, 1996), and Rangitata River \$63 per trip (Kerr and Greer, 2004). All of these value estimates are considerably less than the daily values of hunting estimated in the present study. Our results support the contention that sika deer and Himalayan tahr hunting are high value recreational activities, a claim that underpinned calls for changes in the way that game hunting is managed and which have led to passage of the Game Animal Council Act 2013.

³ All money values are expressed in Quarter 4 2012 NZ\$, adjusted using the all sectors Consumers' Price Index.

⁴ Note that these estimates of value are distinct from transport costs incurred to hunt (e.g. \$214 per hunt for sika hunters, SEM=\$23), or overall hunting-related expenditures. See Kerr and Abell (2014) for expenditure information.

Special Interest status under The Act may aid retention of existing hunting opportunities, or it may serve to enable management to enhance the value of hunting. Establishment of herds of special interest will require justification of “specialness”. That could occur for any species in a specific location by providing evidence of any of at least three matters:

1. The value of the specific hunting experience is high relative to other game hunting experiences,
2. The aggregate value of hunting is high relative to alternative uses of the resource,
3. Enhanced management could significantly increase the value of hunting experiences.

A requirement similar to 1 occurs for Water Conservation Orders, for which the usefulness of non-market valuation evidence has been endorsed (Kerr and Greer 2004). In the absence of information on the value of other big game hunting opportunities the high values reported here do not of themselves provide sufficient evidence of “special interest”, suggesting the need for further research. However, the relatively high values of sika deer and Himalayan tahr hunting relative to other high value recreational activities suggest there are *prima facie* cases for investigation.

Measurement of total hunting effort is difficult because there is no monitoring and hunting is essentially open access. Nugent (1992) estimated there were 5,983 (SE=1,076) sika deer hunters in 1988. He did not estimate the number of sika deer hunts those hunters participated in, but he estimated they spent 8.87 days per year (SE=1.34) hunting sika deer. In 2011 the average hunter took 15.6 hunts per year (Kerr and Abell, 2014), with eleven percent of those hunts targeting sika deer (1.7 hunts per year). The same study found that 31.5% of hunters targeted sika deer the previous year. Combining this information with estimates of the total big-game hunting population (30,000 to 50,000 hunters: Woods and Kerr, 2010), Suggests there is somewhere in the range of 50,000 to 110,000 sika deer hunts annually. At an indicative value of \$1,050 per hunt, aggregate consumers’ surplus is in the order of \$52m to \$115m per annum. There are no reliable estimates of contemporary participation in tahr hunting to permit an estimate of total value.

Gains from management can be estimated by assessing how the value of the hunting experience changes under alternative scenarios (see, for example, Bullock *et al.* (1998), who estimated the values for different groups of hunters of alternative hunting packages in Scotland).

Hunt duration has mixed effects. Increasing the duration of sika hunts from three/five to seven days does not add significant value to the hunting experience, and for Class 3 hunters detracted from the experience. Allowing use of hunting areas for longer than five days will diminish the total benefits all hunters obtain from the area, *ceteris paribus*. A somewhat different situation exists for tahr hunters, because nearly half the tahr hunters prefer five and seven day hunts. Low numbers of sika deer detract from the value of the experience for all classes of hunter, and high numbers of sika enhance the experience for most hunters. This result is consistent with the findings of Bullock *et al.* (1998) in the Scottish Highlands. It is also consistent with concerns that management for recreational hunting has the potential to increase deer numbers with the possibility of subsequent environmental degradation. However, if more hunters hunt an area, even if they each do so for a shorter period, they may actually reduce animal numbers and thereby have a negative effect on the experience. The environmental effects of any change in sika deer numbers would need consideration. Further research on these trade-offs and their implications for management is indicated. Again, the

situation is different for tahr hunters, who are strongly focussed on trophy potential and do not have preferences high levels of nanny tahr. Consequently, the prospects of managing tahr to enhance trophy potential while enhancing conservation values are much more favourable.

Trophy potential was important for sika hunters, again consistent with Bullock *et al.* (1998). Increasing trophy potential from low to high increases the value of the hunt by over \$700 for Class 2 hunters. Whilst these hunters prefer longer duration hunts, the \$180 loss in benefits from restricting them to two days of hunting is more than offset by an increase in trophy potential, whether it is from low to moderate, moderate to high, or low to high. This suggests a possible management strategy to increase value by decreasing total hunting effort and managing that effort to enhance trophy potential. Similarly, for Class 1 tahr hunters a reduction in hunt duration from five days to two or three days would reduce WTP by \$650, which would be more than offset by increasing trophy potential from low to moderate (\$900), but not from moderate to high (\$550).

The definite presence of other hunters in the area diminishes the value of the hunt substantially for all except Class 3 sika hunters. This appears to support a move from open access to sole occupancy hunting areas, or at least diminishing the chances of encountering others. However, that conclusion may not be valid when loss of spontaneity and the costs of securing access are considered. These matters have not been addressed in the current study.

In summary, this research has successfully identified three unique classes of sika deer and Himalayan tahr hunters. A small group of predominantly local sika hunters obtains low value from hunting and prefers one or two day hunts. The other hunters receive very large personal benefits from hunting, but seek somewhat different experiences. In particular, there is a significant group with a trophy focus and a preference for long duration hunts. In contrast, most tahr hunters have strong preferences for better trophy potential. There is a small group of tahr hunters who obtain relatively small benefits from hunting. The definite presence of other hunters and low trophy potential independently eliminate consumers' surplus for these hunters. Guaranteeing absence of other hunters and high trophy potential do not increase hunt benefits for this group. Provision of alternative experiences may result in this group choosing not to hunt tahr.

Of note is the non-significance of attributes that could have been considered important, notably the presence of hut accommodation and the possibility of motorised access to the hunting area. The expense of provision of huts and roads is not supported for the hunters in this study. However, they do not significantly detract from the hunting experience either, so provision for other reasons is not invalidated because of impacts on hunters, at least in the aggregate. The majority of sika deer and Himalayan tahr hunters obtain substantial benefits from hunting and attributes of the hunting experience affect their benefits. This situation is supportive of management of these species as recreational hunting resources, and provides some guidance on improved management of the resource for the three different classes of hunter identified for each of these species.

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