Big game hunting satisfaction:

A test of diminishing marginal satisfaction of harvest

Geoffrey N. Kerr

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Abstract

This paper investigates the hypotheses that marginal utility from killing game animals in New Zealand big game hunts diminishes with number of kills, and that hunt motivations affect marginal satisfaction. In addition to comparison of mean satisfaction scores for hunters experiencing different measures of success, and measures of association based on correlations and analysis of variance, a random parameters ordered-logit model utilises panel data from a large number of hunters to model effects of success on satisfaction. Motivations are important determinants of satisfaction, with harvest-oriented hunters generally less satisfied than were other hunters, unless the harvest-oriented hunters made a kill. Sighting game significantly enhanced satisfaction, which increased more if the hunters killed a game animal. Making a kill had a smaller effect on satisfaction for high-avidity hunters. Results confirm diminishing marginal utility of kills, suggesting potential gains from management responses that spread the game harvest over a larger number of hunters.

Key words: Satisfaction, big game management, hunting, harvest, heterogeneity, ordered-logit

Chapter 1
Introduction

The role of the game manager frequently entails manipulating wildlife populations and hunter behaviours in order to enhance hunter satisfaction. This is a complex problem, requiring information on, amongst other things, the determinants of hunter satisfaction. Game harvests affect satisfaction, with the importance of harvest success depending somewhat on the context and measurement method. The theory of diminishing marginal utility (Gossen, 1983) suggests that, beyond initial success, additional harvest by the individual hunter or party may offer little increment to satisfaction. Hence, policies that limit individual or party harvest, spreading the harvest over a larger number of hunters, may increase aggregate satisfaction because they allow more hunters to harvest their most valuable first animal. However, before implementing any such policy it is important to confirm diminishing marginal utility from harvest of game animals. This paper has three main objectives:

1. Assess the role of harvest in overall hunt satisfaction, specifically testing the theory of diminishing marginal satisfaction from game animal harvest;
2. Identify whether motivations affect satisfaction from game animal harvest; and
3. Evaluate whether redistribution of harvest has the potential to increase aggregate hunter welfare.

The study context is New Zealand big game hunting, where harvests are unrestricted, providing sufficient harvest heterogeneity to test the hypothesis on an individual hunt basis.

Chapter 2
Satisfaction

There are numerous factors that affect hunters' satisfaction, with killing and sighting game often the most important (e.g. Brunke & Hunt, 2008; Decker, Brown & Gutiérrez, 1980; Frey, Conover, Bong & Messmer, 2003; Fulton & Manfredo, 2004; Gigliotti, 2000; Hammitt, McDonald & Patterson, 1990; Hayslette, Armstrong, & Mirarchi 2001; McCullough & Carmen, 1982; Shrestha et al., 2012; Sorg & Nelson, 1986; Vaske, Donnelly, Heberlein & Shelby, 1982). However, the relationship is not simple, because hunter motivations and other factors can influence the effects of harvest on satisfaction (e.g. Hammitt et al., 1990; Hayslette et al., 2001). Other important influences on satisfaction include game attributes (e.g. trophy quality), hunters' expectations, qualities of the physical environment, social aspects of the hunt, and stochastic events such as weather conditions and accidents (Fulton & Manfredo, 2004; Gigliotti, 2000; Hayslette et al., 2001). The low level of control that hunters (and anglers) exercise over many of these determinants of satisfaction helps to explain the consistently lower levels of satisfaction reported in consumptive recreation activities relative to satisfaction from non-consumptive recreation (Shelby & Heberlein, 1986; Vaske et al., 1982; Vaske & Roemer, 2013).

Messmer and Enck (2012) categorized motivations contributing to deer hunting satisfactions into four dimensions: appreciative motivations (such as seeing other wildlife and enjoying the environment), affiliative motivations (such as hunting with family and friends), achievement motivations (such as seeing or shooting a deer), and multiple motivations (such as exercising, or seeing others bag a deer). In addition, these motivations have temporal dimensions. For example, achievement motivations may include sighting in firearms prior to the hunting season, shooting a deer during the season, and eating venison post season. Manfredo, Fix, Teel, Smeltzer and Kahn (2004) also note the relationship between satisfaction and motivational goals, recognising that while different experience types entail different satisfactions within the multiple satisfactions framework, experiences differ in quality within motivations. An important motivating aspect of many satisfaction studies has been understanding the role of crowding (e.g. Shelby & Heberlein, 1986; Manning, 2011). Hunter density is an important determinant that can be either positive or negative, depending on the nature of the hunting context (e.g. Frey et al., 2003; Heberlein & Kuentzal, 2002). Higher hunter densities could be negative in contexts where hunters are seeking solitude, or where scaring game reduces harvest opportunities. Alternatively, higher hunter densities may be positive where hunting is socially motivated or where cooperation between hunters enhances harvest opportunities.

The multiple satisfactions approach (Hendee, 1974; Manning, 2011) suggests that levels of achievement of a range of objectives (individual satisfactions) can contribute to "overall satisfaction". Mediation models aggregate measures of multiple individual satisfactions to identify overall satisfaction (Graefe & Burns, 2013). However, direct measurement of overall satisfaction, without reference to its component parts, is also common (Vaske & Roemer, 2013). In a test of the mediation model Graefe and Burns (2013) found that individual satisfaction items provided significant predictive power of overall satisfaction, but that direct links between individual satisfactions and overall satisfaction were not significant when their model included mediating satisfaction domains.

Satisfaction is frequently defined in terms of incongruent expectations and outcomes (e.g. see Decker et al. 1980 for a hunting example), which can arise from faulty expectations, changed conditions, and stochastic events (storm, crowded hut, obnoxious people, illness, etc.), amongst other reasons. There are two broad approaches to prediction. Where expectations data are available, it is possible to model satisfaction as a function of differences between expectations and outcomes (Brunke & Hunt, 2007; Brunke & Hunt, 2008). However, in many situations expectations are unknown and are difficult or

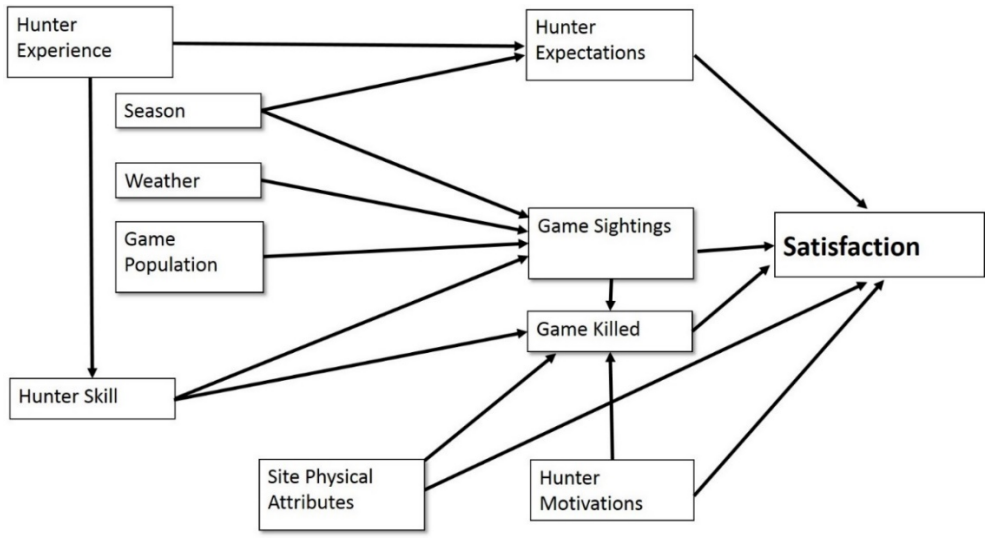
impossible to measure a priori, limiting satisfaction models to reliance on outcome-related variables. Brunke and Hunt (2007) compared these two approaches, preferring the simple outcome-based model because it had better predictive ability, but noting that difference data are extremely useful for developing management responses to enhance hunter satisfaction. Burns, Graefe and Absher (2003) took a somewhat different approach, comparing overall and individual item satisfaction with "gaps" between importance and satisfaction rather than assessing gaps between expectations and satisfaction.

Rollins and Romano (1989) identified four methodological difficulties in measuring satisfaction: self-selection, displacement, product shift, and cognitive dissonance. Self-selection and displacement are related in that they arise from recreationists selecting activities and settings that are suited to them and choosing to go elsewhere or pursue other activities if outcomes are unfavourable. Product shift and cognitive dissonance - and related concepts such as rationalization and multiple sources of satisfaction (Shelby & Heberlein, 1986) -are psychological adjustments and rationalizations that redefine activities or outcomes to avoid the need to change behaviour. Together, these responses suggest that measurements of recreationists' satisfaction should be generally high.

Multiple satisfactions form two broad classes; situational aspects that are controllable, such as animal sightings and harvest, and subjective aspects that are uncontrollable, such as comradeship and enjoyment of nature (Rollins and Romano, 1989). Tsaur, Liang and Lin (2012), employ different terminology, referring to instrumental aspects (e.g. harvest) and psychological aspects (e.g. social dimensions, excitement) of requirements-ability fit. McCullough and Carmen (1982) stress the importance of focusing research attention on variables under control of the manager (either situational or instrumental aspects, depending on the definition adopted), of which harvest limits are a good example.

Hunters' personal attributes, including motivations, can have both direct and indirect effects on satisfaction (Figure 1). Hunter skill is likely to be a determinant of whether the hunter sighted and/or killed game. Skills will develop with hunter experience. The hunter's motivations can also determine whether the hunter killed game. For example, a trophy hunter may encounter numerous animals but choose not to kill any of them if they do not fulfil their definition of trophy. In addition, game sightings and kills are influenced by exogenous factors, including terrain, animal presence, weather, and seasonality. Hence, motivations, kills, and sightings directly affect satisfaction, and sightings and motivations can have indirect effects moderated by kills.

Figure 1
Hunt Satisfaction



Chapter 3
Method

This study assesses the relationship between harvest and overall satisfaction, without moderation by expectations or site attributes, but while controlling for other variables known to influence satisfaction, including specific hunt motivations and hunter attributes. Achievement motivations are not the primary motivations for many hunters or for specific hunts (Woods & Kerr, 2010). However, based on prior research findings (Brunke & Hunt, 2008; Decker, Brown & Gutiérrez, 1980; Frey, Conover, Bong, & Messmer, 2003; Fulton & Manfredo, 2004; Gigliotti, 2000; Hammitt, McDonald, & Patterson, 1990; Hayslette, Armstrong & Mirarchi, 2001; McCullough & Carmen, 1982; Shrestha et al., 2012; Sorg & Nelson, 1986; Vaske, Donnelly, Heberlein & Shelby, 1982), game sightings and killing game are hypothesized to be significant determinants of hunt satisfaction. It is also hypothesized that the effects of sighting and killing game vary by primary hunt motivations (Hammitt et al., 1990; Hayslette et al., 2001). These hypotheses are tested in this study.

Data are from hunts randomly selected each month over a thirteen month period from a panel of New Zealand big game hunters (Kerr & Abell, 2014). Hunting media advertisements and the Department of Conservation hunting permit web site hosted invitations for big game hunters to participate in an initial survey. This self-selection approach, which is likely to entail some avidity bias (Alessi & Miller, 2012; Cornicelli & Grund, 2011), was unavoidable because there was no database of New Zealand game hunters, or any other way to draw a random sample of hunters. The initial survey collected personal information about hunters, including measures of their hunting activity, motivations, demographics, and game species targeted. The initial survey also included an invitation to register to participate in a longitudinal study to report on hunting activity monthly. Monthly reports provided information on (*inter alia*) transport mode, travel distance, travel cost, number of party members, personal hunt motivations, game species targeted, animal sightings, game harvests, and satisfaction for a single hunt. Hunts were randomly selected by the survey administrators in order to avoid potential biases from hunters reporting their most successful hunts. Matched data from the initial survey and the monthly activity surveys provides a comprehensive description of individual hunters, their activities throughout the year, and aspects of the individual hunt. Expert informants aided the development of both surveys, which were extensively pre-tested. Both surveys were approved by the Lincoln University Human Ethics Committee.

The initial survey was open from May 2011 to November 2011. Invitations to participate in each monthly activity survey, as well as a follow-up to non-respondents about ten days later, were sent by email early each month to cover hunts over the period from June 2011 to June 2012. Of 1,466 active game hunters who chose to participate in the initial survey, 1,251 provided complete, useable surveys that were subsequently analysed. The majority of those hunters (n=961) elected to participate in the monthly activity surveys. This study analyses 4,588 individual hunts by 821 different hunters who provided responses to the key variables included in this analysis.

This approach is broadly similar to the panel used by Fulton and Manfredo (2004), which tracked satisfaction over several years to identify the impacts of regulatory changes. Whereas Fulton and Manfredo's (2004) Colorado context embodied short seasons with harvest limited to one animal per season, the New Zealand context is somewhat different. There are no bag limits, closed hunting seasons, or reporting requirements in New Zealand, hence the ongoing monthly data collection to reduce recall bias. However, New Zealand game animals are relatively scarce, focusing management attention on the potential benefits of interventions that have the potential to increase sightings and harvests, or to redistribute harvest. The panel data allow for control of inter-personal heterogeneity by recognising correlations of individuals' responses.

Motivations that were available for participants to choose from for the specific hunt were based on an a synthesis of motivations identified in an earlier review of hunting motivations in international and New Zealand studies (Woods and Kerr, 2010). The motivations were; *Trophy, Meat, Excitement, Social, Enjoy the outdoors, Solitude, Develop or use skills, Get away from civilization*, and *Exercise*.

Species hunted include Himalayan tahr (*Hemitragus jemlahicus*), chamois (*Rupicapra rupicapra*), feral pigs (*Sus scrofa*) and seven species of deer. In New Zealand it is often possible to harvest several different big game species on the same hunt and there are no restrictions on numbers, sex or trophy status of animals harvested on public land. Harvest information measured the numbers of animals of each species harvested but, because of limitations on survey length and complexity, did not differentiate by the sex or trophy status of the animals harvested. Sightings and kills were aggregated across species for this exploratory analysis.

Overall satisfaction with the hunt was evaluated by responses to the invitation to "rate this hunt" on a scale of *Very Unsatisfied* (1), *Unsatisfied* (2), *OK* (3), *Satisfied* (4), *Very Satisfied* (5). This approach is similar to Fulton and Manfredo's (2004) seven point overall satisfaction scale that ranged from "strongly dissatisfied" to "strongly satisfied", the six-point quality of hunting experience scale used by Shrestha et al. (2012), and the large number of studies reported by Vaske and Roemer (2013).

Information on expectations and measures of individual dimensions of satisfaction were unavailable. Consequently, difference and gap analyses of satisfaction were not possible. However, the relationship between overall satisfaction, motivations, game sightings and harvest was evaluated using various methods previously applied in the hunting context. Methods included factor analysis to reduce the number of dimensions required to characterise hunters (Hayslette et al., 2001), comparison of group mean satisfaction scores (Gigliotti, 2001), correlations between personal attributes, hunt attributes and satisfaction (Gigliotti, 2001), and ordered logit analysis of satisfaction (Frey et al., 2003).

Chapter 4
Data analysis

Factor analysis (using alpha factoring with oblimin rotation) identified associations between personal attibutes, including hunting activity levels and hunt motivations. Factors with eigenvalues in excess of unity were retained. Cronbach's Alpha tested factor reliability, and sampling adequacy was evaluated with the Kaiser-Meyer-Olkin test.

Following Gigliotti (2001), mean satisfaction scores are reported for each of a range of hunt motivations, for three different observed hunt success categories: (i) did not see any big game, (ii) saw big game but did not kill any, and (iii) killed at least one big game animal. Analysis of variance of differences in satisfaction between these success groups for the full sample of hunters tests the significance of the association between hunt success and satisfaction. Again following Gigliotti (2001), significance of Pearson correlations between satisfaction and attributes of the hunter and the hunt are used to identify significant associations, differentiated by hunt motivation to account for effects identified in previous studies.

The relationship between game sightings and game killed is an important consideration for recreational hunting because the rifle and bow hunters studied must sight their quarry before killing it, but not all sightings result in a kill, yet previous studies have shown that game sightings influence satisfaction. Bivariate Pearson correlations measured the significance of relationships between sightings and kills, both at the dichotomous and continuous levels.

Frey et al. (2003) used the ordered logit model to identify items influencing satisfaction of pheasant hunters. I follow a similar approach. First, satisfaction was collapsed from five into three ordered categories to ensure that sufficient responses occurred in each category for reliable statistical analysis. Satisfaction responses were explored through ordered logit models that included a variety of independent variables, including attributes of the individual and the party, attributes of the hunt, and interactions between these. The ordered logit model simultaneously controls for correlations between the multiple responses of each individual, controls for multiple influences on satisfaction, and permits interactions. The panel ordered logit model permits exploration of respondent heterogeneity. Both random parameters and latent class models were tested, with the random parameters model having better statistical fit on a broad range of R^2 and information criteria scores. Consequently, only the random parameters model results, estimated in NLOGIT, are reported here.

The ordered logit model is a latent regression with an unobserved dependent variable y_i^*:

$$y_i^* = \beta' \mathbf{x}_i + \varepsilon_i$$

The error term (ε_i) has a standard logistic distribution with mean of zero and variance of 1. When specified as a random parameters model, allowing heterogeneity across individuals, this becomes:

$$y_i^* = \beta_i' \mathbf{x}_i + \varepsilon_i \qquad \text{where } \beta_i = \beta + u_i$$

The coefficient vector β_i is different for each individual. Predictions of the observed dependent variable arise from censoring the latent dependent variable:

$y_i = 0$ if $y_i^* \leq \mu_0$

$y_i = 1$ if $\mu_0 < y_i^* \leq \mu_1$, etc. where each μ_i is a threshold parameter.

The effect of alternative allocation policies was derived by comparing aggregate satisfaction under three alternative scenarios in the simple situation where three hunters have the opportunity to kill three deer. The scenarios are: (1) each hunter kills one deer, (2) one hunter kills 2 deer, one hunter

kills 1 deer, and one hunter kills no deer, and (3) one hunter kills three deer, two hunters kill no deer. Distributions of differences in aggregate satisfaction, modelled with random parameters logit model harvest-related coefficients, were assessed with 10,000 Monte Carlo replications. Estimated satisfaction (S_i) in each scenario is:

$S_1 = \gamma + 3\beta_{k1}$	where β_{k1} is the estimated coefficient on the first kill, and γ is an unknown constant
$S_2 = \gamma + \beta_{k1} + \beta_{k2}$	where β_{k2} is the estimated coefficient on the second kill
$S_3 = \gamma + \beta_{k3}$	where β_{k3} is the estimated coefficient on the third kill

The unknown constant γ disappears when differences are derived, e.g. $S_1 – S_2 = 2\beta_{k1} - \beta_{k2}$.

Chapter 5
Results

Hunters in the sample were nearly all male (98%), engaged in an average of 16.9 annual game hunting trips (SE = 0.8), entailing an annual total of 32.8 days of hunting (SE = 1.1). The hunters' mean age was 40 years (SE = 0.5), and they had an average of 22 years of hunting experience (SE = 0.5). Thirty three percent were New Zealand Deerstalkers' Association members.

The average hunt was 2.14 days (SE = 0.03), entailed a one-way travel distance of 125 km (SE = 2.6), taking 3.16 hours (SE = 0.12), and the return journey cost NZ$114 (SE = 3.6). On average, 0.78 (SE = 0.03) game animals were killed per hunter each hunt, and the median number of kills was zero.

The mean satisfaction score on the five-point scale for the 4588 hunts evaluated by 821 individual hunters was 4.00 (SE = 0.02), which corresponds to "satisfied" (Table 1). Consistent with several previous deer hunting studies (e.g. Decker et al., 1980; Hammitt et al., 1990; Heberlein & Kuentzal, 2002; McCullough & Carmen, 1982), most hunters were satisfied with their hunts. A notable exception is Shrestha et al. (2012), who found that Oregon big game hunters were somewhat dissatisfied.

In accord with Gigliotti (2000), mean hunt satisfaction increased when big game were seen, but not killed, and increased even more when big game were killed (Table 2), irrespective of hunt motivation. Shrestha et al. (2012) also found that harvesting deer significantly improved the quality of hunter experiences. ANOVA results for test of differences in means for the different motivations within each success category are reported at the foot of Table 2. Mean satisfaction scores were significantly different across motvations in the two cases where game were not killed. However, differences were not significant when at least one big game animal was killed by the individual - hunters who made a kill were satisfied irrespective of their primary motivation for the hunt. When no game was seen, the least satisfied hunters were those motivated by meat and excitement, whereas the most satisfied hunters were those motivated by social matters, development and use of skills, solitude, or enjoyment of the outdoors. Based on Tukey test scores (unreported) the differences in satisfaction means between meat hunts and these other four motivations are statistically significant. The only statistically significant difference in mean satisfaction when game is seen is between meat hunts and hunts motivated by enjoyment of the outdoors. Meat hunters are not more satisfied than others when they kill game, but are less satisfied than other hunters when they don't.

Table 3 reports results of an ANOVA test of differences in mean satisfaction scores across the three success categories, aggregated over all motivations, and shows a highly significant effect, $F(2,4370) = 215.86$, $p<.001$. The Tukey HSD comparisons test evaluates differences in mean satisfaction scores between the three pairs of success categories, with all three tests supporting the significance of the differences ($p<.001$).

Table 1
Satisfaction scores using five-point and three-point scales

Satisfaction level	N	% of Responses	Satisfaction level	N	% of Responses
Very unsatisfied (1)	217	4.7			
Unsatisfied (2)	130	2.8			
OK (3)	825	18.0	Not satisfied (1)	1172	25.5
Satisfied (4)	1688	36.8	Satisfied (2)	1688	36.8
Very satisfied (5)	1728	37.7	Very satisfied (3)	1728	37.7
Total	**4588**	**100.0**		**4588**	**100.0**
Mean	4.00			2.12	
Standard deviation	1.05			0.79	
Standard error	0.02			0.01	

Table 2
Impact of individual game animal sighting and individual harvest on mean satisfaction by hunt motivation. Five-point satisfaction scale

Hunt motivation	No big game seen	Big game seen but not killed	Big game killed	% increase for game seen (v no game seen)	% increase for killed (v game seen)	% increase for killed (v no game seen)
Trophy	3.35	3.98	4.37	19	10	31
Meat	3.11	3.79	4.27	22	13	37
Excitement	3.23	3.89	4.25	20	9	31
Social	3.68	3.97	4.17	8	5	13
Enjoy the outdoors	3.67	4.09	4.32	11	6	18
Solitude	3.85	4.19	4.28	9	2	11
Develop or use skills	3.71	4.05	4.48	9	11	21
Exit civilisation	3.54	3.93	4.46	11	14	26
Exercise	3.35	3.88	4.06	16	4	21
Aggregate	3.46	3.97	4.30	15	8	24
F value	8.72	2.71	1.38			
Degrees of Freedom	8/856	8/1524	8/1966			
P(F)	<.001	.006	.200			
η^2	.075	.014	.006			

Table 3
Mean hunting satisfaction, individual animal sighting and individual harvest. Five-point satisfaction scale. All motivations combined

Success	Mean Satisfaction	95% Confidence Interval	
No sightings	3.46	3.40 ~ 3.52	
Game animals sighted	3.97	3.92 ~ 4.02	
Game harvested	4.30	4.25 ~ 4.35	
Tukey HSD comparisons test	**Difference**	**Standard Error**	**Significance**
No sighting-Sighting	-0.52	.04	< .001
No sighting-Harvest	-0.84	.04	< .001
Sighting-Harvest	-0.33	.03	< .001

Factor analysis revealed limited commonalities, producing two factors, a three-item motivation factor (harvest) and a two-item participation factor (avidity) (Table 4). Chronbach's alpha scores (Harvest α = .721, Avidity α = .846) exceeded the norm for reliability ($\alpha \geq 0.7$), indicating good internal consistency. The correlation matrix determinant (Det = 0.198) confirmed multicollinearity was not problematic. The Kaiser-Meyer-Olkin statistic (0.570) and Bartlett's test of sphericity, χ^2 (10) = 1306.54, p<.001, reveal significant relationships between variables, yielding distinct factors (Hutcheson and Sofroniou, 1999). The two factors explain 61.0% of cumulative variance, and the eigenvalues are 1.497 (harvest) and 1.554 (avidity), comfortably greater than one.

Table 4
Factor Analysis Structure Matrix

Factor	Item	Mean	SD	Factor loading	Chronbach's alpha	Variance explained
Harvest	Killing game motive	1.89	0.78	.846	.721	29.9%
	Taking meat home motive	2.51	0.86	.531		
	Shooting at game motive	1.79	0.77	.700		
Avidity	Annual hunts	16.9	22.0	.884	.846	31.1%
	Annual days hunting	32.8	30.9	.878		

Whilst more items would be preferable, the avidity factor recognises two distinctly different aspects: a large number of hunts and a large number of days spent hunting. This is reasonable because of different personal contexts shaping hunter behaviour. In some cases hunters may undertake only a few hunts annually, but those hunts can be of considerable duration. Other hunters, who have easy access to hunting areas or who have limited time, may make a large number of short duration hunting trips. The avidity factor simultaneously considers these effects to provide a single measure of hunter participation.

Table 5
Pearson correlations between satisfaction and other variables, by hunt motivation (five-point satisfaction scale)

Variable	Trophy	Meat	Excitement	Social	Enjoy the outdoors	Develop or use skills	Exit civilization	Exercise	Aggregate
No. of animals seen by individual	.065	.095[2]	.015	.110	.075[2]	.140[1]	.082	.040	.076[2]
No. of animals killed by individual	.149[2]	.272[2]	.000	.133[1]	.086[2]	.140	.186[2]	.233[2]	.129[2]
Individual saw Animals	.250[2]	.352[2]	.347[2]	.152[2]	.225[2]	.270[2]	.287[2]	.296[2]	.272[2]
Individual killed	.234[2]	.343[2]	.303[2]	.127[2]	.185[2]	.288[2]	.312[2]	.217[2]	.242[2]
Cost	.050	-.033	.037	.039	.042	.050	.158[2]	-.071	.033[1]
Distance	.024	.061[1]	.148[1]	-.012	.043	.014	.123[1]	-.122	.050[2]
Travel time	.000	-.031	.161[1]	.045	-.016	.010	.111	.085	.010
Experience	.037	.048	.094	.003	.075[2]	-.031	-.064	.145	.050[2]
Harvest factor	-.008	-.069[1]	.034	.047	-.038	-.204[2]	-.008	.039	-.041[2]
Avidity Factor	.035	-.039	.081	.008	.030	-.034	-.038	.124	.005

Scale: 1 = Very unsatisfied, 2 = Unsatisfied, 3 = OK, 4 = Satisfied, 5 = Very satisfied.

[1] Significant at 0.05 level (2-tailed). [2] Significant at 0.01 level (2-tailed).

Correlations between independent variables and satisfaction underscore the importance of animal sightings and harvest (Table 5). Because of low numbers of hunters motivated by solitude, that particular motivation was excluded. Game sightings and killing game are both strongly positively correlated with satisfaction. These effects are stronger when sighting and killing game are dichotomous rather than numeric. The avidity factor had no significant effect. Significant negative correlations between the harvest factor and satisfaction indicate that more highly achievement-oriented hunters were less satisfied.

Independent variables investigated using random parameters ordered logit models included primary motivation for the specific hunt, whether game animals were sighted, the number of game animals the hunter killed, whether the party made a kill when the individual did not, individual hunters' harvest and avidity factor scores, factor score interactions with kills, hunter age, and membership of a prominent hunting organisation (the New Zealand Deerstalkers' Association). Excluded hunt motivations were *Meat hunting*, which was the most common objective and was used as the base against which others were evaluated, as well as *Excitement* and *Exercise,* which were never significant.

Party and individual harvests were highly correlated, explainable in large part by the 30% of hunts that were solo, and 43% of hunts that involved parties of two hunters. Consequently, party kills and individual kills were difficult to include in the same model. Analysis focuses on individual kills, which had greater explanatory power.

I checked independent variables correlations prior to model specification to detect potential multicollinearity issues. Correlations between sightings and kills were generally low, but significant. At the dichotomous level, the correlation between seeing and killing game animals was low ($r = .451$, $p < .001$, $N = 4373$). The correlation between the number of game animals seen and the number killed was even lower ($r = .403$, $p < .001$, $N = 4306$). These relatively low correlations suggest that both sightings and kills can be included in the same models without multicollinearity issues.

High correlations limited the factor score x sighting and factor score x harvest interactions that could be included in the model because hunters who killed more than one animal on a hunt were very likely to be avid hunters with strong harvest motivations. For example, the correlation between harvest factor score and the interaction between seeing game and harvest factor was $r=.890$ ($p<.001$, $N=4509$). The corresponding correlation for the avidity factor was $r=.929$ ($p<.001$, $N=4509$). Hence, the only factor score interactions that could be included were those involving the dichotomy of whether an animal was killed or not.

Estimated random parameters ordered logit model coefficients are reported in Table 6. Random parameter scale parameters were not significant for the two hunt motivations *Enjoying the outdoors* and *Developing and using skills*, or for killing at least one game animal. Consequently, these variables were treated as non-random parameters. For the random parameters, the scale parameters are large relative to the means, indicating a high level of heterogeneity amongst hunters. The positive signs on all the hunt motivation variables in the model indicate that hunters with these motivations were generally more satisfied than hunters whose primary motivations were *Meat*, *Exercise* or *Excitement*. Seeing game had a significant positive effect, independent of whether the hunter made a kill. Killing a game animal enhanced satisfaction, but with diminishing marginal returns. Killing a second animal had a smaller positive effect on satisfaction than killing the first animal, but this diminution effect was absent for the third and subsequent animals killed. While satisfaction increased with more kills, it did so at a declining rate. Notably, killing at least one game animal was non-random – there was little inter-hunter variance, so killing the first animal was a universal enhancer of satisfaction. However, parameters for subsequent kills were random, and there are large differences between individual hunters in the role of subsequent

kills in their satisfaction. Older hunters were more satisfied than other hunters, *ceteris paribus*. Membership of the New Zealand Deerstalkers' Association was not significant.

The interaction between avidity and killing a game animal was negative - high avidity hunters gained less satisfaction from killing a game animal than did low avidity hunters. This is consistent with decreasing marginal satisfaction when a longer time perspective is taken because of a small, but significant and positive association between hunting avidity and annual kills ($r = 0.147$, $p < .001$).

Table 6
Random parameters ordered logit model.
The dependent variable is satisfaction, measured on a three point scale:
Unsatisfied, Satisfied, Very Satisfied. 500 Halton draws

Parameter	Coefficient Mean	Scale parameter
Non-random parameters		
μ_0 (category threshold)	-1.01***	
μ_1 (category threshold)	2.59***	
Killed at least one game animal	1.56***	
Motivation: Enjoy the outdoors	0.54***	
Motivation: Develop or use skills	0.55***	
Random parameters		
Saw game animals	1.34***	0.37***
Killed at least two game animals	0.67***	1.46***
Killed at least three game animals	0.71***	1.54***
Motivation: Trophy	0.55***	0.99***
Motivation: Social	0.40***	1.04***
Motivation: Solitude	1.11***	1.29***
Motivation: Exit civilization	0.64***	0.67***
Age	0.01***	0.03***
Harvest factor score	-0.46***	0.61***
Harvest factor * Killed at least one animal	0.57***	0.85***
Avidity factor * Killed at least one animal	-0.14***	0.20***
Individual did not kill, but the party did	1.11***	1.34***

*** Significant at p<.01

McFadden's $R^2 = 0.162$ -LL = 3838.279 N = 4237 K = 29

Normalized fit measures: AIC = 1.825, AIC3 = 1.832, CAIC = 1.843, BIC = 1.837, ABIC = 1.827

Marginal effects (Table 7) are significant for all independent variables in the ordered logit model. Seeing game animals reduced the probability of being unsatisfied by 20%, and increased the probability of being very satisfied by 25%. The marginal effect for very satisfied was a 34% increase for the first animal killed, a further 14% for the second animal killed, and another 17% for the third and subsequent animals killed.

Table 7
Ordered logit model marginal effects

Parameter	"Not satisfied"	"Satisfied"	"Very satisfied"
Saw game animals	-.202	-.046	.249
Killed at least one game animal	-.058	-.166	.341
Killed at least two game animals	-.060	-.083	.142
Killed at least three game animals	-.064	-.105	.169
Motivation: Enjoy the outdoors	-.058	-.064	.122
Motivation: Develop or use skills	-.055	-.084	.139
Motivation: Trophy	-.054	-.075	.129
Motivation: Social	-.040	-.053#	.093
Motivation: Solitude	-.085	-.185	.270
Motivation: Exit civilization	-.059	-.092	.151
Age	-.002	-.001	.003
Harvest factor score	.053	.050	-.102
Harvest factor * Killed at least one animal	-.065	-.061	.125
Avidity factor * Killed at least one animal	.017	.016	-.032
Individual did not kill, but the party did	-.093	-.173	.266

significant at 2% level. All other effects are significant at the 1% level or better.

The data support the hypothesis that kills by other members of the hunting party partially compensate for lack of individual kills. Hunters who did not personally kill an animal were more satisfied when another member of their party made a kill (β_a = 1.11, Z = 9.43, p<.0001). The marginal satisfaction obtained from a personal kill (β_b = 1.56) significantly exceeded marginal satisfaction from a kill by other members of the party when the individual does not make a kill ($\beta_b - \beta_a$ = 0.45, Z = 3.71, p = .0001 (1-tailed)).

Diminishing marginal effects of harvest imply that the value of a marginal kill should decrease as harvest increases. This expectation is partially supported. Marginal satisfaction from the first kill (β = 1.56) is significantly higher than for the second kill (β = 0.61, Z = 5.36, p < .001 (1-tailed)), and third and subsequent kills (β = 0.71, Z = 3.81, p < .0001 (1-tailed)). However, there is no significant difference in marginal satisfaction between the second kill and the third and subsequent kills (Z = -0.35).

The effect of harvest allocation under three scenarios [(1) each hunter kills one deer, (2) one hunter kills 2 deer, one hunter kills 1 deer, and one hunter kills no deer, and (3) one hunter kills three deer, two hunters kill no deer] was assessed by Monte Carlo estimation of utility differences between the scenarios. Scenario 1 yields significantly more aggregate satisfaction than either Scenario 2 (Z = 5.36, p<.0001) or Scenario 3 (Z = 6.52, p<.0001), and Scenario 2 yields higher aggregate satisfaction than Scenario 3 (Z = 3.81, p<.0001). These results suggest potential welfare gains from policies (such as bag limits) that distribute harvest more evenly.

Chapter 6
Discussion

This analysis has addressed hunters' satisfaction with their hunts, as an antecedent to consideration of the implications of management that could change game animal sighting and harvest probabilities. This is a distinctly different, but complementary, focus to the approach in Miller and Graefe's (2001) model of harvest as a strong predictor, *inter alia*, of satisfaction "with management". We identify harvest as an important component of satisfaction in a context where, currently, there is no management.

Fulton and Manfredo (2004) questioned whether dramatic regulation changes might trigger thresholds that generate changed satisfaction responses, whereas incremental changes might not do so. The implementation of a bag limit in New Zealand, where public land game hunting remains unmanaged, would be a dramatic regulation change with potential to generate potentially significant satisfaction responses, both for unsuccessful hunters and for hunters who kill several animals per hunt. Declining marginal satisfaction from harvest identified in the ordered logit model supports Fulton and Manfredo's (2004) suggestion. Limiting harvest from three to two animals had a non-significant effect on marginal satisfaction, although it did reduce total satisfaction. Killing the first animal provided a large increment in satisfaction relative to subsequent kills. Diminishing marginal satisfaction is particularly important where some hunters struggle to make a kill. Limiting harvests from particularly intensive harvesters to permit others the opportunity to see more animals and to harvest an animal when they otherwise would not have done so could be particularly beneficial. This suggests a further potential line of research that extends the analysis from the individual hunt to a longer period, say annually, in which harvest disparities are even more pronounced and marginal benefit differences may be more apparent.

There were significant differences in mean satisfaction scores for hunters with alternative specific-hunt motivations. In particular, hunters motivated by meat, exercise and excitement were less satisfied than others. Harvest-oriented hunters required a kill to attain a similar level of satisfaction to non-harvest-oriented hunters who did not kill a game animal. Unexpectedly, trophy motivated hunters were more satisfied than the base group. The probability of obtaining a trophy is very low for most hunts, and is zero at many times of the year for antlered species. Hence, trophy motivated hunters have an even lower level of control than hunters who have other harvest-related objectives, suggesting that trophy hunters' satisfaction should be relatively low. The role of expectations may be important in explaining this apparently anomolous result. If trophy hunters are highly experienced, and have a good appreciation of the probability of harvesting a trophy, there may be little divergence between their expectations and outcomes, and therefore no satisfaction gap. This hypothesis merits further research.

Older hunters were more satisfied with their hunts than were other hunters. The causes are unknown, but at least two hypotheses are consistent with this observation. One possibility is that older people are inherently more satisfied, as has been demonstrated in studies of self-assessed well-being (e.g., Blanchflower & Oswald, 2008; Stone, Schwartz, Broderick & Deaton, 2010) and job satisfaction (Riza, Ganzach & Liu, in press). Decker et al. (1987) proposed an increase in appreciative satisfaction over time, leading to a "mellowing out" of hunters as they age. Recent evidence on this hypothesis in an alternative context is mixed (Child & Darimont, 2015). Another possible explanation arises from the importance of seeing and killing game. Recent increases in New Zealand game animal populations are likely to have increased hunt satisfaction compared to the relatively recent past when it was extremely difficult to sight or kill game animals. This is the obverse of the "last settler syndrome" (Neilsen, Shelby & Haas, 1977). In the case of New Zealand hunting, expectations of the younger hunters are based on recent experiences of relatively abundant game, whereas older hunters' expectations may be tempered by past experiences of extremely scarce game (Kerr, 2012). The gap between expectations and outcomes

for older hunters may be positive, but not for younger hunters. Clarification of the causes of age-related satisfaction effects is deserving of further study.

Chapter 7
Conclusions

This study adds to the body of evidence of the roles of motivations, animal sightings, and kills in satisfaction with big game hunting experiences. The random parameters ordered logit model utilized panel data, accounted for hunter heterogeneity, and identified interactions between independent variables. Motivations for hunting in general and motives for the current hunt were both significant. Harvest-oriented hunters were less satisfied than were others, unless they made a kill. High avidity hunters gained a smaller increment in satisfaction from making a kill than did less avid hunters. The central hypothesis of diminishing marginal satisfaction from killing game animals was partially supported, with significant decreases in marginal satisfaction between the first and second kills on a particular hunt. These findings provide some support for investigation of management responses that have the potential to increase aggregate satisfaction by allowing a larger number of hunters to kill game animals, and by transferring harvest from high avidity, harvest-oriented hunters to others. Mechanisms for achieving these outcomes were not investigated, but include bag limits and changes in accepted practices, achieved through education.

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