

Vegetation structure and composition determine snowshoe hare (*Lepus americanus*) activity at arctic tree line

M.V.A. Ewacha, J.D. Roth, and R.K. Brook

Abstract: Snowshoe hares (*Lepus americanus* Erxleben, 1777) are keystone herbivores supporting many boreal-forest predators. Understanding habitat use of hares can help predict how hares and their predators will be affected by disturbances such as climate change, which will have a particularly strong effect at tree line. We examined hare activity at arctic tree line near Churchill, Manitoba, using fecal pellet transects established in August 2012. We counted all hare fecal pellets at two plots per transect and measured plant abundance and vegetation structure surrounding the plots, then used model selection to determine the combinations of habitat features or plant species that best explained hare activity or presence. Hare pellets occurred at a higher density where tall shrub cover was high. Pellet density also increased with increasing canopy cover, tree size, tree density, visibility, and small shrub cover, but was negatively correlated with medium-sized shrub and herb cover. Hares preferred areas with willow (genus *Salix* L.) and avoided areas with unpalatable black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.). With climate warming, tree line is expected to advance northward and the increased tall shrub and willow cover predicted with increasing temperatures should benefit hares by providing greater predator protection and food.

Key words: snowshoe hare, *Lepus americanus*, tree line, fecal pellets, climate change, boreal forest, habitat use.

Résumé : Les lièvres d'Amérique (*Lepus americanus* Erxleben, 1777) sont des herbivores clés qui supportent de nombreux prédateurs de la forêt boréale. La compréhension de leur utilisation de l'habitat peut aider à prédire l'incidence de perturbations comme les changements climatiques, dont l'effet sera particulièrement fort à la limite des arbres, sur les lièvres et leurs prédateurs. Nous avons examiné l'activité des lièvres à la limite forestière arctique près de Churchill (Manitoba) à la lumière de comptes de boulettes fécales le long de transects établis en août 2012. Nous avons compté toutes les boulettes fécales de lièvre dans deux parcelles par transect et mesuré l'abondance des plantes et la structure de la végétation entourant ces parcelles, puis nous avons utilisé la sélection de modèle pour déterminer les combinaisons de caractéristiques de l'habitat ou d'espèces de plantes qui expliquaient le mieux l'activité ou la présence des lièvres. Il y avait une plus grande densité de boulettes de lièvre là où la couverture de grands arbustes était plus importante. En outre, plus la couverture de la canopée, la taille des arbres, la densité des arbres, la visibilité et la couverture de petits arbustes étaient grandes, plus la densité des boulettes était importante, alors que cette dernière était négativement corrélée à la couverture d'arbustes moyens et d'herbes. Les lièvres préféraient les zones avec des saules (genre *Salix* L.) et évitaient les zones d'épinettes noires (*Picea mariana* (Mill.) Britton, Sterns et Poggenb.), dont ils n'aiment pas le goût. Avec le réchauffement climatique, la limite forestière devrait avancer vers le nord, et l'augmentation prévue de la couverture de grands arbustes et de saules combinée à des températures plus élevées devrait profiter aux lièvres en leur fournissant une meilleure protection contre les prédateurs et plus de nourriture. [Traduit par la Rédaction]

Mots-clés : lièvre d'Amérique, *Lepus americanus*, limite forestière, boulettes fécales, changement climatique, forêt boréale, utilisation de l'habitat.

Introduction

Determining the habitat use of a keystone herbivore is important for management and conservation decisions, especially when the species serves as an important food resource to predators (Boutin et al. 1995; Krebs et al. 1995; Thorton et al. 2012). Habitat-use information can also be beneficial when predicting the consequences of climate change, such as how changes in temperature and snow conditions, including snow depth and timing of melt, might affect forage availability and cover (Kielland et al. 2010; Kreyling et al. 2012; Yan et al. 2013).

Two predominant hypotheses may explain the habitat use of herbivores within forested areas. The first hypothesis suggests that forested habitat provides protection by reducing the visibility of prey to predators (Carreker 1985; Hodges 2000; Lewis et al. 2011).

Alternatively, forests yield important and diverse food sources for herbivores (Wolff 1978; Carreker 1985; Hodges 2000; Lewis et al. 2011). Both food and predator distribution can affect herbivore abundance or activity; therefore, these hypotheses are not mutually exclusive (Krebs et al. 1995).

Snowshoe hares (*Lepus americanus* Erxleben, 1777) are keystone herbivores found across Canada (Krebs 2011). They feed on deciduous and coniferous vegetation, specifically leafy vegetation during summer and woody tissue throughout winter (Wolff 1978; Carreker 1985; Hodges 2000). We focused on snowshoe hare activity rather than abundance because we wanted to identify areas hares used most frequently and were most active in, particularly since hares excrete their pellets while they are active and not while resting (Hodges 2000). Determining snowshoe hare activity is important for conservation and forest management because

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hares are an important food resource for specialist predators, such as Canada lynx (*Lynx canadensis* Kerr, 1792) (Lewis et al. 2011). Hares also affect the structure and composition of vegetation along tree line by browsing on tree and shrub species, thus increasing plant defenses and the growth of tissues that are less palatable (Bryant et al. 1983; Hodges 2000).

Previous forest management studies have focused on determining the habitat use of snowshoe hares, particularly where lynx occur (Murray et al. 2002; McCann and Moen 2011). Many studies have focused on the variation of snowshoe hare abundances across forest-stand types (McCann et al. 2008; Lewis et al. 2011) or in response to forest-stand management, such as clear-cutting or precommercial thinning (Newbury and Simon 2005; Griffin and Mills 2007; Thornton et al. 2012). However, few studies have examined how snowshoe hare activity varies with microhabitat features (Fuller and Harrison 2010; Lewis et al. 2011; Berg et al. 2012), such as tree density or understory cover, and no published studies have looked at how snowshoe hare activity varies at arctic tree line.

Arctic tree line marks an important transition between the boreal forest and the open tundra, which is determined primarily by summer temperatures (Grace et al. 2002). With the growing concern of climate change, it is important to understand how atmospheric warming might alter the structure and composition of plant communities at tree line, and how these changes might affect the habitat use of other species. Thus far, studies have demonstrated that climate warming causes the northward advancement of tree line (Harsch et al. 2009) and supports greater canopy height and tall shrub cover (Walker et al. 2006; Myers-Smith et al. 2011; Elmendorf et al. 2012), in particular greater willow (genus *Salix* L.), alder (*Alnus* Mill.), and American dwarf birch (*Betula glandulosa* Michx.) cover (Tape et al. 2006; Olofsson et al. 2009; Myers-Smith et al. 2011). Increases in plant abundance and shifts in community structure and composition could affect forage quality, and thus affect hare distribution. Changes in plant structure and cover might also affect a predator's ability to locate hares.

The objective of this study was to determine how snowshoe hare activity varied with habitat features and plant composition at arctic tree line. Based on the predator protection hypothesis, we predicted that hares would be more active in areas with greater vegetation cover, as it would reduce hare visibility from avian and terrestrial predators, such as hawks, eagles, Canada lynx, red foxes (*Vulpes vulpes* L., 1758), and grey wolves (*Canis lupus* L., 1758) (Carreker 1985; Hodges 2000). Under the food resource hypothesis, we predicted that shrubby and herbaceous species would be important dietary components for hares (de Vos 1964; Wolff 1978; Ferron and Ouellet 1992; Hodges 2000), and hares would prefer areas with good-quality forage and avoid areas with unpalatable forage. Because dense vegetation cover can limit light penetration to shrub and herb understory (Hart and Chen 2006), and hares consume shrubs and herbs during summer, we also expected that hares would be less active in areas where food availability was limited by low light conditions (i.e., closed canopy should reduce shrub and herb cover, reducing food availability to hares).

Materials and methods

Study area

We established transects to assess snowshoe hare activity and vegetation characteristics in August 2012 within the Churchill Wildlife Management Area (CWMA) of northeastern Manitoba (Goose Creek Road, about 5 km from the Hudson Bay coast). The CWMA is 850 000 ha in size and includes a range of habitats dominated by peatland (86%), with areas of treed and treeless bog and fen (Brook 2001). For our study, we focused transects within treed bog habitats along tree line, which represents a broad transition zone approximately 80 km wide (Brook 2001).

Pellet transects

Our transects were established as part of a long-term study to monitor annual changes in snowshoe hare populations using counts of fecal pellets (Krebs et al. 1987; Murray et al. 2002; Mills et al. 2005; McCann et al. 2008; Berg and Gese 2010). We established six transects that were placed at least 1 km apart. Each 300 m transect consisted of 10 plots (1 m² circle) placed 30 m apart. To determine hare activity, we counted and cleared fecal pellets within all plots. Although pellet counts on previously uncleared plots may overestimate annual snowshoe hare activity (Murray et al. 2002; Hodges and Mills 2008), uncleared plots were still useful for comparing snowshoe hare activity between vegetation sites.

Vegetation estimates

For each of the six transects, we estimated vegetation cover at plots three and eight ($n = 12$). We chose these particular plots because they covered a range of pellet densities (from 0 to 58 pellets/plot) and included a sufficient number of plots with no pellets ($n = 5$) so we could compare vegetation in the presence and absence of hares. Because we were interested in comparing hare activity between vegetation sites, we treated plots as the unit of replication.

To collect habitat feature data, we first established a 5 m × 5 m quadrat around the center of each pellet plot. Within each quadrat, we counted all trees (>175 cm tall), measured tree diameter at breast height (DBH), and visually estimated percent cover of tree canopy (>175 cm tall), tall shrub (150–175 cm tall), medium-sized shrub (50–150 cm tall), small shrub (<50 cm tall), and herb (Brook and Kenkel 2002). We also quantified visibility by estimating the percentage of the cover board not covered by vegetation; visibility was estimated for the bottom 50 cm of the board at a distance of 15 m (modified from Nudds 1977). We chose this height to correspond to the approximate height of a snowshoe hare at ground level. We did not estimate visibility for winter because many of the shrubs at our study site would have been buried under snow or would have lost their leaves. Finally, to collect plant species data, we randomly selected coordinates to determine the placement of a 1 m × 1 m quadrat within each 5 m × 5 m quadrat, and estimated plant species cover within the 1 m × 1 m quadrat.

Data analysis

We used these vegetation variables to refine our predictions about how hare activity would respond under each hypothesis. Under the predator protection hypothesis, we predicted that hares would be more active in areas with greater canopy cover, tree density, tree DBH, and tall and medium-sized shrub cover. Alternatively, we expected that hares would be less active in areas where visibility was high, and where small shrub and herb cover were high because this vegetation would not provide sufficient protection from predators. Under the food resource hypothesis, we also predicted that hares would be more active in areas with greater shrub (tall, medium-sized, and small) and herb cover, and less active under low light conditions as a result of dense canopy cover, greater tree density, and larger tree DBH. We also predicted that hares would prefer areas with good-quality forage (*Salix* spp., genus *Vaccinium* L., genus *Carex* L., etc.) and avoid areas with unpalatable forage (black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.), Labrador tea (*Rhododendron groenlandicum* (Oeder) Kron & Judd), bog birch (*Betula nana* L., etc.) (Wolff 1978; Bryant and Kuropat 1980; Carreker 1985).

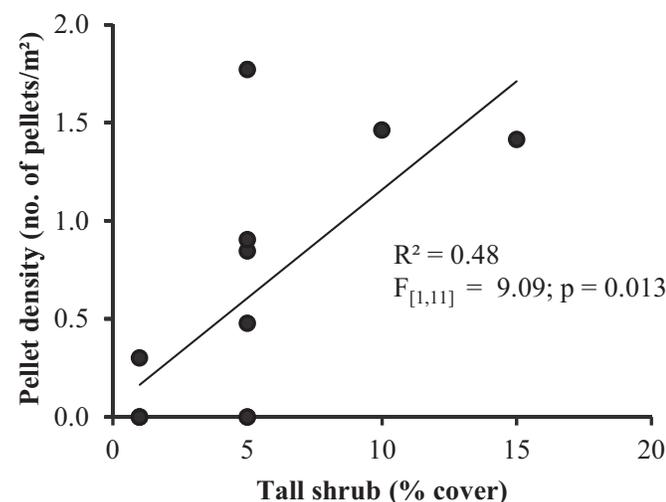
We log ($x + 1$) transformed pellet density to normalize its distribution and used a series of linear regression models to determine which habitat features best predicted hare activity, first eliminating variables with high multicollinearity ($|r| > 0.7$). Because our plant species residuals were not homogenous, we used a series of logistic regression models to determine how abundance of individual plant species predicted the presence

Table 1. Comparison of linear regression models* explaining snowshoe hare (*Lepus americanus*) activity (log-transformed pellet density) based on habitat features using Akaike's information criterion corrected for small sample sizes (AIC_c).

Candidate models	R ²	SSE	N	K	AIC _c	ΔAIC _c	AIC weight
Tall shrubs (%)	0.48	2.53	12	3	-9.67	0.00	0.237
Tall shrubs, canopy cover (%)	0.64	1.74	12	4	-9.46	0.21	0.213
Canopy cover	0.44	2.72	12	3	-8.81	0.85	0.154
Tall shrubs, canopy cover, visibility (%)	0.77	1.12	12	5	-8.45	1.22	0.129
Tall shrubs, medium-sized shrubs (%)	0.57	2.06	12	4	-7.41	2.26	0.077
Visibility	0.35	3.14	12	3	-7.10	2.57	0.065
Canopy cover, visibility	0.53	2.29	12	4	-6.16	3.50	0.041
Medium-sized shrubs	0.25	3.61	12	3	-5.40	4.26	0.028
Tall shrubs, canopy cover, medium-sized shrubs	0.68	1.54	12	5	-4.61	5.05	0.019
Herb (%)	0.19	3.94	12	3	-4.37	5.30	0.017
Visibility, medium-sized shrubs	0.39	2.95	12	4	-3.12	6.54	0.009
Tree density (no. of stems/ha)	0.04	4.64	12	3	-2.40	7.26	0.006
Diameter at breast height (DBH; cm)	0.01	4.78	12	3	-2.05	7.62	0.005

*Models are summarized by the coefficient of determination (R²), error sum of squares (SSE), sample size (N), number of parameters (K), AIC_c score, ΔAIC_c score, and the probability of each model (AIC weight).

Fig. 1. Relationship between snowshoe hare (*Lepus americanus*) pellet density (log-transformed) and tall shrub cover, which is the single variable in the best-fit model for habitat features.



or absence of hares, first eliminating variables with high multicollinearity ($|r| > 0.7$).

We determined habitat feature and plant species models to include in our comparisons by selecting individual variables or combinations of variables that were highly correlated with pellet density, as done by other studies (Greaves et al. 2006; Burkepile et al. 2013; Lohr et al. 2013). We then ranked each set of candidate models based on Akaike's information criterion corrected for small sample sizes (AIC_c) and also calculated the Akaike weight of each model (the probability of being the best model of those considered). Finally, we calculated relative importance of each predictor variable by summing the weights of all models containing that variable to determine which independent variables had the greatest influence on hares (Burnham and Anderson 2002). For a valid comparison of variable influence, each variable should be used in the same number of models (Burnham and Anderson 2002), so we divided the relative importance of each variable by the number of models containing that variable to obtain a mean variable weight per model (Kittle et al. 2008). All analyses were completed using JMP® version 10.0.1 (SAS Institute Inc., Cary, North Carolina, USA) using a significance level of $\alpha = 0.05$.

Table 2. Summary of habitat features (with units), correlations with snowshoe hare (*Lepus americanus*) pellet density (log-transformed), and relative importance (mean variable weight per model) for each variable based on the models compared in Table 1.

Habitat features	Mean ± SE	Correlations with pellet density	Relative importance
Tall shrubs (%)	5±1	0.69	0.135
Canopy cover (%)	7±2	0.66	0.111
Visibility (%)	22±6	0.59	0.061
Medium-sized shrubs (%)	19±3	-0.50	0.033
Herbs (%)	18±3	-0.43	0.017
DBH (cm)	6±1	0.11	0.005
Tree density (no. of stems/ha)	2000±400	0.20	0.006

Note: DBH, diameter at breast height.

Results

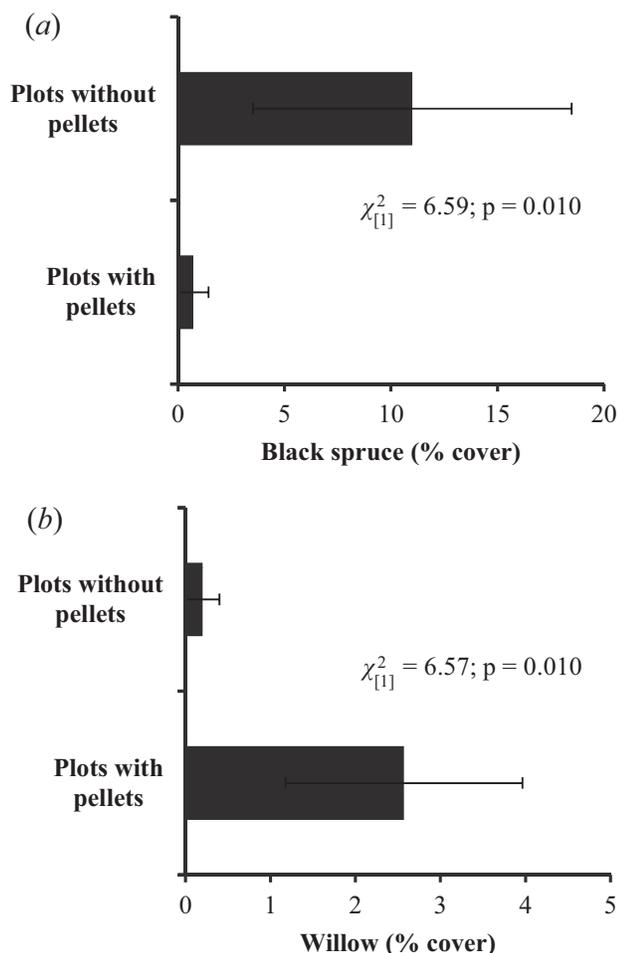
Small shrubs and visibility were highly correlated ($r = -0.87$; Spearman's rank = -0.81 ; $p = 0.002$); therefore, we excluded small shrubs during model selection because visibility explained the most variance and had the strongest correlation with pellet density ($r = 0.59$; Spearman's rank = -0.41 ; $p = 0.188$). The linear regression model with tall shrubs provided the best explanation of hare activity based on habitat features (Table 1); pellet density increased with increasing tall shrub cover ($R^2 = 0.48$; $F_{[1,11]} = 9.09$; $p = 0.013$) (Fig. 1). Habitat features such as canopy cover, visibility, DBH, and tree density also increased with increasing pellet density, whereas medium-sized shrub and herb cover were negatively correlated with pellet density (Table 2). Based on relative importance of habitat features, tall shrub cover was the most influential variable, followed by canopy cover (Table 2).

Coltsfoot (*Tussilago farfara* L.), Baltic rush (*Juncus balticus* Willd.), and bayberry (genus *Myrica* L.) were highly correlated with other plant species abundances, thus we eliminated these variables during model selection. The logistic regression model with black spruce and willow cover provided the best explanation for hare presence based on relative abundance of individual plant species ($\chi^2_{(2)} = 10.76$; $p = 0.005$) (Table 3); pellets were absent in areas with abundant black spruce ($\chi^2_{(1)} = 6.59$; $p = 0.010$), and present in areas with abundant willow ($\chi^2_{(1)} = 6.57$; $p = 0.010$) (Fig. 2). Black spruce and willow cover were also the most important plant species variables, and Labrador tea also had good support (Table 4); pellets were absent in areas with abundant Labrador tea ($\chi^2_{(1)} = 6.06$; $p = 0.014$).

Table 3. Comparison of logistic regression models* explaining the presence of snowshoe hares (*Lepus americanus*) based on individual plant species using Akaike's information criterion (AIC_c).

Candidate models	LogL	N	K	AIC _c	ΔAIC _c	AIC weight
Black spruce (<i>Picea mariana</i>), willow (<i>Salix</i> spp.)	2.77	12	3	14.55	0.00	0.277
Labrador tea (<i>Rhododendron groenlandicum</i>)	5.12	12	2	15.58	1.03	0.166
Black spruce, Labrador tea	4.14	12	3	17.28	2.73	0.071
Black spruce	6.06	12	2	17.45	2.90	0.065
Willow	6.07	12	2	17.47	2.93	0.064
Threeleaf false lily of the valley (<i>Maianthemum trifolium</i> (L.) Sloboda)	6.11	12	2	17.55	3.01	0.062
Labrador tea, willow	4.58	12	3	18.16	3.61	0.045
Black crowberry (<i>Empetrum nigrum</i> L.)	6.52	12	2	18.37	3.82	0.041
Black spruce, Labrador tea, willow	2.42	12	4	18.55	4.00	0.037
Bog blueberry (<i>Vaccinium uliginosum</i> L.)	6.85	12	2	19.03	4.48	0.029
Dwarf raspberry (<i>Rubus arcticus</i> subsp. <i>acaulis</i> (Michx.) Focke)	6.93	12	2	19.20	4.65	0.027
Cloudberry (<i>Rubus chamaemorus</i> L.)	7.21	12	2	19.75	5.21	0.020
American dwarf birch (<i>Betula glandulosa</i>)	7.30	12	2	19.94	5.39	0.019
Sedges (<i>Carex</i> spp.)	7.55	12	2	20.43	5.88	0.015
Bog rosemary (<i>Andromeda polifolia</i> L.)	7.55	12	2	20.44	5.89	0.015
Alpine bearberry (<i>Arctous alpina</i> (L.) Nied.)	7.58	12	2	20.49	5.95	0.014
Tamarack (<i>Larix laricina</i> (Du Roi) K. Koch)	7.64	12	2	20.61	6.06	0.013
Horsetail (genus <i>Equisetum</i> L.)	7.80	12	2	20.93	6.39	0.011
Lingonberry (<i>Vaccinium vitis-idaea</i> L.)	8.10	12	2	21.53	6.99	0.008

*Models are summarized by the log-likelihood (LogL), sample size (N), number of parameters (K), AIC_c score, the difference between the AIC_c for that model and the lowest AIC_c for any model (ΔAIC_c), and AIC weight (model probability).

Fig. 2. Percent cover of (a) black spruce (*Picea mariana*) and (b) willow (*Salix* spp.), which are the two variables in the best-fit model for plant species predicting snowshoe hare (*Lepus americanus*) presence, at plots with pellets (N = 7) and without pellets (N = 5).**Table 4.** Summary of plant species, percent cover (mean ± SE), and their relative importance (mean variable weight per model) based on the models compared in Table 3.

Plant species	Percent cover	Relative importance
Black spruce (<i>Picea mariana</i>)	5±3	0.112
Willow (<i>Salix</i> spp.)	2±1	0.106
Labrador tea (<i>Rhododendron groenlandicum</i>)	3±1	0.080
Threeleaf false lily of the valley (<i>Maianthemum trifolium</i>)	0.2±0.1	0.062
Black crowberry (<i>Empetrum nigrum</i>)	5±2	0.041
Bog blueberry (<i>Vaccinium uliginosum</i>)	13±4	0.029
Dwarf raspberry (<i>Rubus arcticus</i> subsp. <i>acaulis</i>)	0.2±0.1	0.027
Cloudberry (<i>Rubus chamaemorus</i>)	0.1±0.1	0.020
American dwarf birch (<i>Betula glandulosa</i>)	3±1	0.019
Sedges (<i>Carex</i> spp.)	5±2	0.015
Bog rosemary (<i>Andromeda polifolia</i>)	0.5±0.4	0.015
Alpine bearberry (<i>Arctous alpina</i>)	0.1±0.1	0.014
Tamarack (<i>Larix laricina</i>)	1±0.7	0.013
Horsetail (<i>Equisetum</i> spp.)	2±1	0.011
Lingonberry (<i>Vaccinium vitis-idaea</i>)	1±0.6	0.008

Discussion

As predicted by the predator protection and food hypotheses, we found pellet density increased with increasing tall shrub cover, suggesting that tall shrubs provide hares with protection from terrestrial predators (e.g., Canada lynx, red foxes, and grey wolves), as well as food resources (Wolff 1980; Hik 1994; Krebs et al. 1995; Hodges 2000). Although habitat features other than tall shrubs did not contribute to our best-fit model, we still found results that corresponded with our original predictions. Canopy cover had a high relative importance and a strong, positive correlation with pellet density, suggesting that hares are more active in areas with greater forest cover, which provides protection from avian predators, such as hawks and eagles (Stefan 1998; Hodges 2000; Thorton et al. 2012). We also found pellet density increased with increasing tree density and DBH. Previous studies have found that medium-sized trees (10.3–27.9 cm DBH) provide sufficient protection from predators, while promoting optimal understory growth as food (Lewis et al. 2011; Thorton et al. 2012). At our treed bog study area, trees are small, and canopy cover and tree density

do not significantly reduce snowshoe hare activity through lack of understory growth.

Unlike our original predictions under the predator protection hypothesis, we found a positive correlation between visibility and pellet density. Visibility only contributed moderate support to our pellet density model ($\Delta AIC_c > 2$; Burnham and Anderson 2002), and our sample size was small, thus we could not infer much from this relationship. Nonetheless, visibility estimates may have reflected density of medium-sized shrubs, which were negatively correlated with pellet density. Hares might avoid certain medium-sized shrub species because they are unpalatable or they are not an important food source within the hare's diet (Wolff 1978; Bryant and Kuropat 1980; Bryant et al. 1983; Carreker 1985). Bryant and Kuropat (1980) suggest that forage is based on the palatability and toxicity of the plant and not its tissue or nutritional content. In our treed bog sites, the predominant medium-sized shrub species include American dwarf birch and Labrador tea, which produce antiherbivory defenses that are potent to browsing snowshoe hares (Bryant and Kuropat 1980; Bryant et al. 1983; Chapin et al. 1986; Reichardt et al. 1990; de Groot et al. 1997). We found that pellets were absent in areas with high Labrador tea cover, suggesting that hares do find this plant unpalatable.

Visibility of hares would also vary between seasons, particularly during winter when shrubs are buried under snow and they lose their leaves (Wolff 1980; Hodges 2000). Less vertical plant cover during winter could increase a hare's risk to predators. Furthermore, we found a positive correlation between small shrub cover and pellet density despite hares having limited access to small shrubs during winter. These results suggest that small shrubs are an important food source for hares during summer (Wolff 1980). Contrary to the predictions of the food resource hypothesis, however, herb cover and pellet density were negatively correlated. Newbury and Simon (2005) found a similar relationship and suggested that the duration of snow on the ground might limit the hares' ability to feed on herbaceous species. Hares might also consume more small shrubs and avoid certain herb species because they are unpalatable.

Finally, we found that hares avoided areas with black spruce, but preferred areas with willow. Hares typically avoid browsing on black spruce because it produces carbohydrates and resins that make the leaves toxic and unpalatable year round (Bryant and Kuropat 1980; Bryant et al. 1983; Carreker 1985). Furthermore, black spruce bog is typically dominated by ericaceous shrubs (e.g., Labrador tea) and lichen, which are unpalatable for hares. Nevertheless, hares still reside in forests dominated by black spruce because it provides important protection from predators (Wolff 1980). Hares also seek out willow shrub fen islands in black spruce bog because they provide both protection from predators and good-quality forage (Bryant and Kuropat 1980; Wolff 1980; Bryant et al. 1983; Carreker 1985).

Although our sample size was low, we still found much of the variation in snowshoe hare fecal pellet density was explained by statistically significant models containing tall shrubs and black spruce and willow cover, suggesting that these variables are important and can be used to predict snowshoe hare activity at arctic tree line. Knowing the habitat use of snowshoe hares can help explain their distribution and influence on predator populations. We can also attempt to predict how climate change will impact snowshoe hare activity, specifically how hares will adjust to changes in plant structure and composition at tree line. Climate warming is causing the northward advancement of tree line (Grace et al. 2002; Gamache and Payette 2005; Harsch et al. 2009), as well as increased plant abundance and changes in community composition that affect ecosystem processes, including nutrient and carbon cycling, productivity, decomposition, and food availability (Aerts et al. 2009; Elmendorf et al. 2012; Kaarlejärvi et al. 2012). Warmer temperatures in the Arctic support greater tall shrub cover, in particular greater willow, alder, and American dwarf birch cover

(Tape et al. 2006; Walker et al. 2006; Olofsson et al. 2009; Myers-Smith et al. 2011; Elmendorf et al. 2012). Our results suggest these predicted habitat changes would favour snowshoe hares by providing refuge from predators as well as food sources.

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