



Snowshoe Hare Abundance in the Wiseman Area of Gates of the Arctic National Park and Preserve, Alaska

Fifth Annual Report



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EXECUTIVE SUMMARY

The snowshoe hare project has been tracking the hare population near Wiseman, Alaska, in Gates of the Arctic National Park and Preserve since 1997. The purpose of the study is to track the hare population through an entire cycle in order to provide managers with an index of the snowshoe hare population at each stage of this cycle. This report documents the fifth year of the snowshoe hare study, and the fourth year during which browse data was collected. Snow conditions during the 2001 survey were unfavorable for counting tracks, and more emphasis was placed on collecting additional browse data. This is the second year we collected data on the degree of browsing done by snowshoe hares.

While in a broad sense, more tracks were deposited along the densely vegetated transects than along the lightly vegetated transects, track deposition this year was more evenly distributed throughout the different habitat types. The average number of tracks ranged from 1.8-10.5 tracks/100m in lightly vegetated transects, 10.0-21.5 tracks/100m in moderately vegetated transects, and 8.7-26.5 tracks/100m in densely vegetated transects. Only 1 hare trail (where the number of tracks in one spot were too many to determine) was seen throughout the survey period.

Severe browsing by hares was evident on all species observed in this survey (willow, balsam poplar, spruce, alder and shrub birch) within every vegetation type. Diameter-at-point-of-browse (dpb) data were collected for the fourth year during this study; results are summarized in this report and compared with results from the previous three years. In addition to dpb measurements, a tally of browsed species within each habitat type revealed that hares had browsed nearly 85% of all species, at least to some degree.

As the hare track distribution data indicate, and in combination with browse data and other observations, we conclude that the hare population rose in 1998, peaked around 1999, then dropped some, holding fairly steady through 2001.

INTRODUCTION

In March 1997, resource personnel at Gates of the Arctic National Park and Preserve (GAAR) began a long-term monitoring program of the snowshoe hare (*Lepus americanus*) population in the eastern portion of the park (DiFolco 1997). This project was developed in response to a 5-year furbearer study that discovered unusual sex and age ratios in the lynx (*Lynx canadensis*) population in this area, possibly the result of food stress (Swanson 1994). The close association between lynx and their primary prey, snowshoe hares, has been well documented (Elton and Nicholson 1942, Brand et al. 1976, Brand and Keith 1979). Area residents regularly trap lynx for subsistence purposes; thus, park managers hope to gain a better understanding of the health of the lynx population by monitoring their primary prey, snowshoe hares, as well as continuing to collect information from local trappers. The snowshoe hare project plans to track the hare population through a complete cycle as the population grows from low numbers to a peak and then crashes to low levels again. The purpose of the study is to provide managers with an index of the snowshoe hare population at each stage of this cycle.

This report documents the fifth year of the snowshoe hare study, and the fourth year during which browse data were collected. Snow conditions were not favorable for counting tracks (although we conducted a survey anyway), and more emphasis was placed on collecting additional browse data. This is the second year we collected data on the degree of browsing done by snowshoe hares.

Once more, many thanks go to Michelle Reakoff, who provided excellent, reliable assistance in counting tracks, measuring browsed stems, and running snowmachines. Also, to my husband, Denny, who babysat all day for a week so I could run this survey.

STUDY AREA

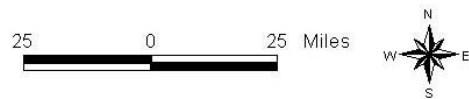
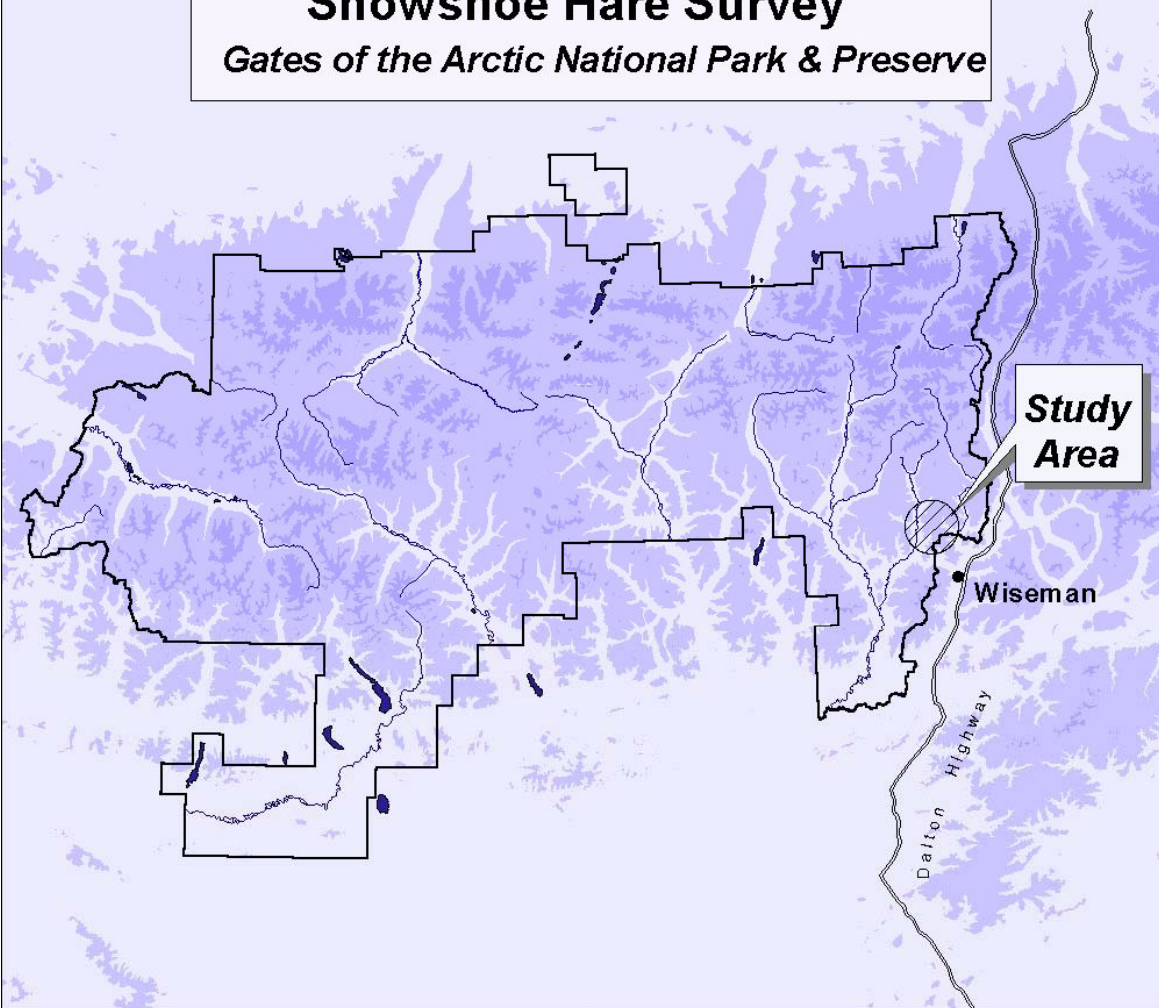
Gates of the Arctic National Park and Preserve is located north of the Arctic Circle (66° 33' N latitude) in the central Brooks Range, Alaska (Fig. 1). Two climate zones occur in the park and preserve: the subarctic zone at lower elevations south of the continental divide and the arctic zone to the north and at high elevations. Precipitation is low within the park and preserve and yearly averages fall between 30 - 45 cm in the west and 13 - 25 cm in the north (National Park Service 1986). Snowfall averages south of the divide range between 152 - 203 cm and averages of 89 - 127 cm are typical in the north. Yearly temperatures in the south fluctuate from an average July maximum of 21° C (70° F) to an average January minimum of -34° C (-30° F). Temperatures in the north fluctuate from an average July maximum of 18° C (65° F) to an average February minimum of -23° C (-10° F).

Boreal forest, tundra, and shrub thicket are the major vegetation communities in the park and preserve (National Park Service 1986). The snowshoe hare study area lies in the boreal



Snowshoe Hare Survey

Gates of the Arctic National Park & Preserve



Gates of the Arctic National Park and Preserve
Resources Division

Fig. 1. Study area for snowshoe hare survey near Wiseman, Alaska, in eastern Gates of the Arctic National Park and Preserve, March 2001.

forest, which covers the southern flanks and valleys of the Brooks Range and is composed of black spruce (*Picea mariana*), white spruce (*P. glauca*), paper birch (*Betula papyrifera*), shrub birch (*B. glandulosa*), aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Willow (*Salix* spp.) and alder (*Alnus* spp.) thickets up to 3.5 m in height occur along stream channels and gravel bars. The study was conducted near the eastern park boundary north of Wiseman (Fig. 1).

METHODS

Field Methods:

The 2001 study was conducted March 14-20, using the same methods as in the 1998 survey (DiFolco 1998, Golden 1994). We rode snowmachines from Wiseman to the study area and then conducted the survey on skis. The 11 100-m transects established in 1998 in 6 different vegetation cover and composition classes (VCCs; 4 in lightly vegetated areas, 4 in moderately vegetated areas, and 3 in densely vegetated areas) were relocated using a Precision Lightweight GPS Receiver (PLGR, Fig 2). We counted track deposition (the number of tracks deposited in one day) and retention (the number of tracks retained over time) on 6 consecutive days. Following each day's count, we erased tracks on the deposition side of the transect using leaf rakes to obtain replicate counts of the number of tracks deposited within the last 24 hours (since no fresh snow fell). We erased tracks on the retention side of the trail after the third day, and a second set of retention counts began on the fourth day. A track was defined as a single pass by one hare. Generally, up to 3 tracks could be distinguished when hares had passed over the same place. When more than 3 tracks had been deposited in the same place, it was called a trail because the number of tracks could no longer be determined. For track calculation purposes, a trail was conservatively approximated to equal 4 tracks.

We also collected browse data. In addition to measuring diameter at point of browse (dpb), we tallied degree of browsing (DiFolco 2000) by hares for each browsed species within each VCC. (Stems browsed by hares have a clean-cut, beveled edge, as distinguished from moose-browsed stems, which have a ragged, torn look.) The degree of browsing was divided into the following 5 categories: 1) stem clipped and completely girdled; 2) stem clipped and mostly girdled (>50% and <100%); 3) stem clipped and partly girdled (up to 50%); 4) stem clipped only; and 5) stem not browsed by hares. Clipped meant the hare had cut completely through the stem, and girdled meant the hare had chewed bark off the stem. Completely girdled meant the hare had chewed the bark off all the way around the stem. Whereas dpb measurements were taken only from stems clipped during the current winter, degree of browsing was tallied using all stems above snow level, regardless of age or whether it had been browsed recently, in previous years or not at all. This gave us a better picture of what was available, and how much of it had already been consumed by hares.

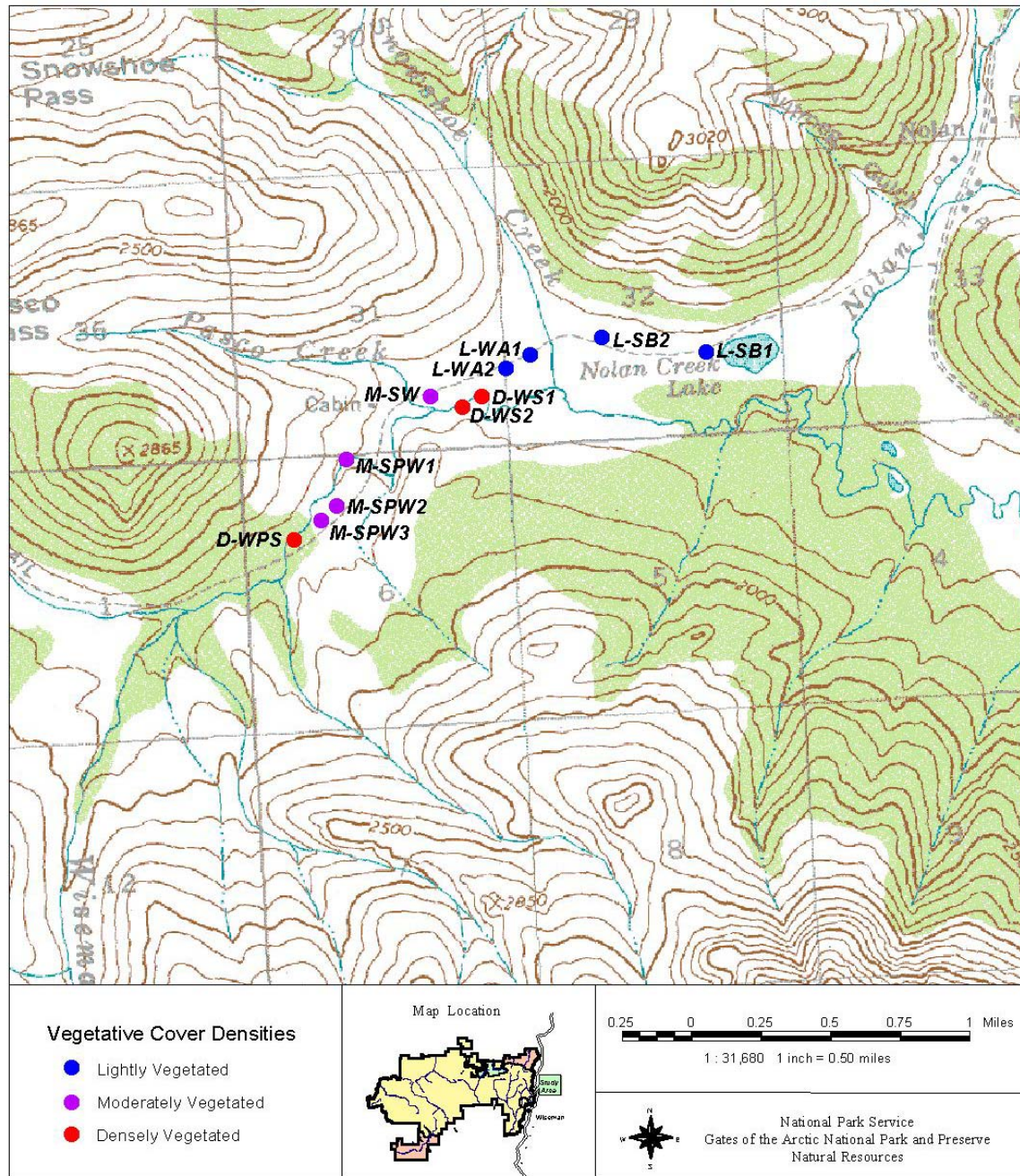


Fig. 2. Transect locations of the snowshoe hare survey near Wiseman, Alaska, in eastern Gates of the Arctic National Park and Preserve, March 2001.

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Statistical Methods:

Track deposition and retention data were entered into an Excel 97 spreadsheet. Each day's track deposition in each 100m transect was averaged for each VCC (tracks/100 m/day). The mean, standard deviation, and 95% confidence interval around the mean were calculated for each set of transect deposition data. Dpb and degree of browse data were entered into Access 97 databases, and graphs summarizing the data were developed using Excel 97.

RESULTS

For brevity, acronyms are used to describe the vegetation cover and composition types (VCCs). The first letter describes the cover classification: L = lightly vegetated, M = moderately vegetated, and D = densely vegetated. Main species composition is listed after the hyphen (in order of relative abundance): W = willow, P = poplar, S = spruce, B = shrub birch, and A = alder.

Weather, Track Deposition and Retention

Approximately 5 cm of snow fell during the three days prior to setting up the survey route. Weather during the 6-day count period was cool (ranging from -18 to -4°C), with calm winds and no precipitation (Appendix III). After erasing tracks following each day's count, the snow along the transects became hard packed and made tracks difficult to see.

More tracks were deposited along the densely vegetated transects than along the lightly vegetated transects, although track deposition this year was more evenly distributed throughout the VCCs (Fig. 3; Appendix I). The average number of tracks ranged from 1.8-10.5 tracks/100m in lightly vegetated transects, 10.0-21.5 tracks/100m in moderately vegetated transects, and 8.7-26.5 tracks/100m in densely vegetated transects. Only 1 trail, in D-WS, was seen throughout the survey period.

In general, the number of tracks counted increased during the two 3-day retention periods, although in some cases, the number of tracks remained the same or even decreased from one day to the next. A decrease in the number of tracks could be due to changing snow conditions (e.g. sublimation, blowing snow, etc.), flat light conditions, or observer error. Figs. 4-9 show the results of both 3-day sets of retention counts; Appendix II lists all retention data. In the 4 lightly vegetated transects, there were 3-27 tracks and 0-2 trails counted at the end of the first count period (March 15-17), and 8-25 tracks counted at the end of the second count period (March 18-20) (Figs. 4 and 5; Appendix II). In the 4 moderately vegetated transects, 33-51 tracks and 0-3 trails were retained after the first 3 days; 19-35 tracks were retained after the next 3 days (Figs. 6 and 7; Appendix II). In the 3 densely vegetated transects, 42-78 tracks and 1-3 trails were counted on the third day; 22-42 tracks were counted on the last day (Figs. 8 and 9; Appendix II). No trails were retained on any transects during the second 3-day retention count period.

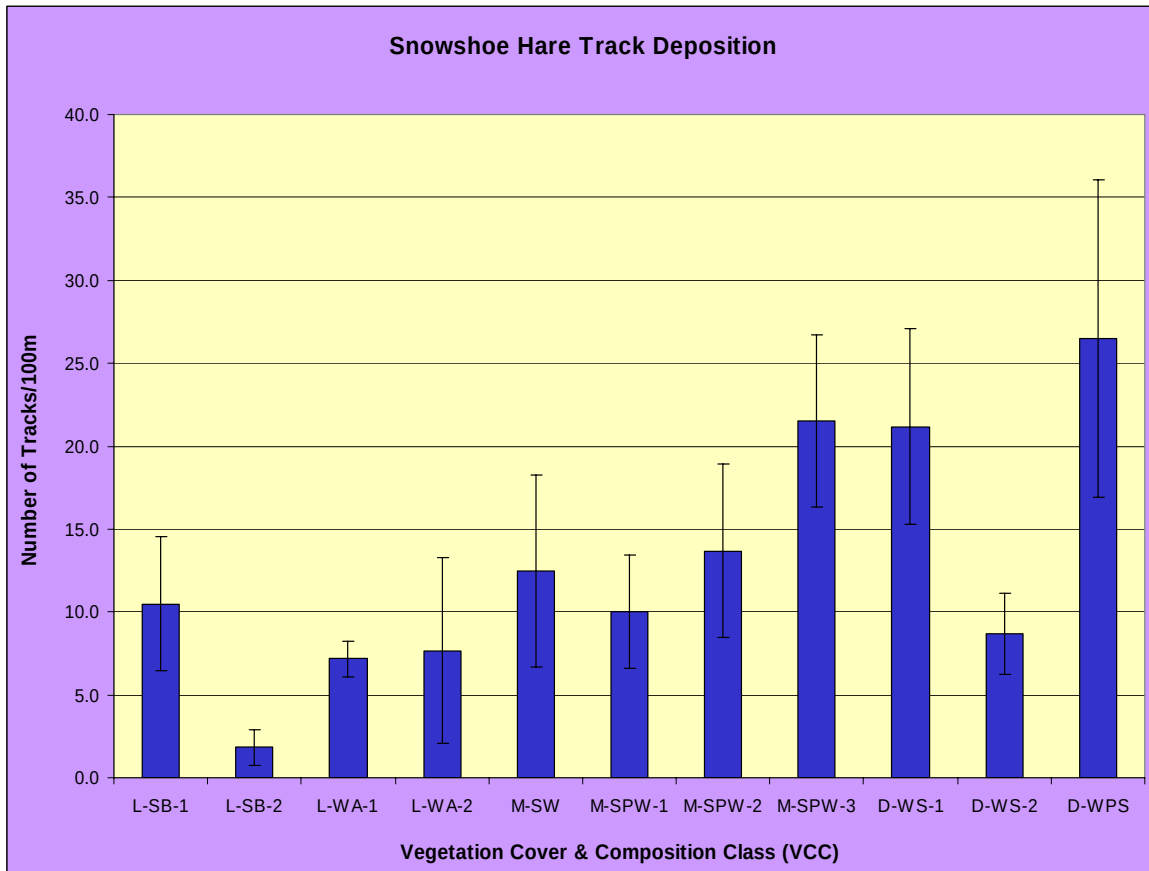


Fig. 3. Deposition of snowshoe hare tracks/100 m/day (with 95% confidence intervals) on 11 transects, snowshoe hare survey, March 2001, Gates of the Arctic National Park and Preserve, Alaska. VCC codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow; 1, 2 or 3 distinguishes transects within the same VCC.

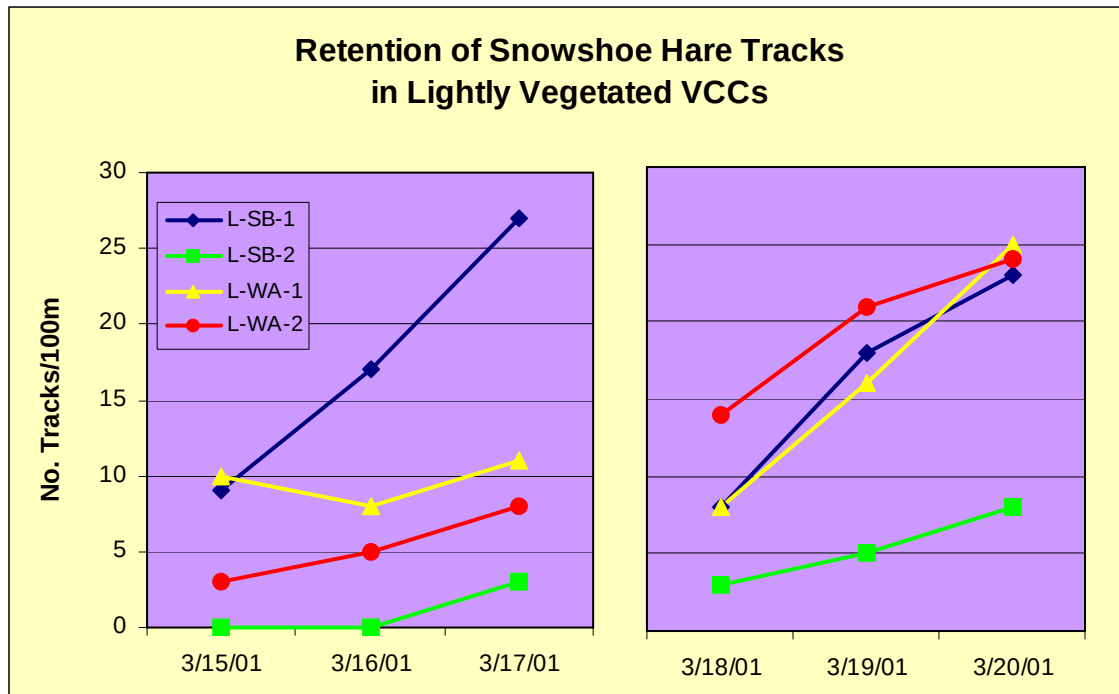


Fig. 4. Retention of snowshoe hare tracks on two 100m transects in lightly vegetated spruce-shrub birch (L-SB) habitat and two transects in willow-alder (L-WA) habitat in the Wiseman area of Gates of the Arctic National Park, Alaska, during two 3-day count periods, March 15-20, 2001.

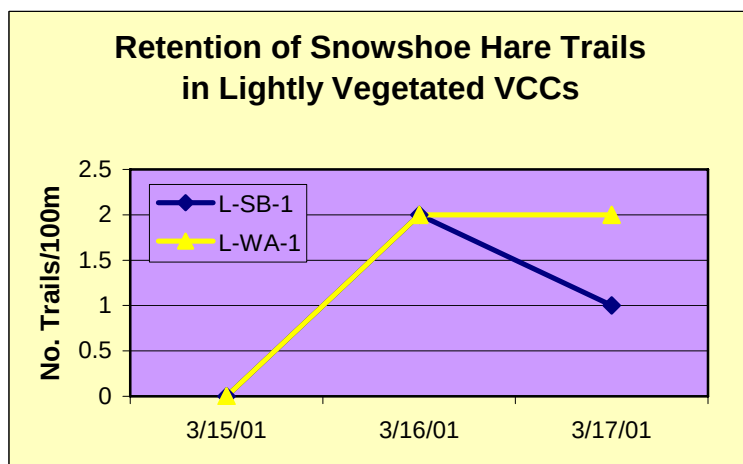


Fig. 5. Retention of snowshoe hare trails on 100m transects in lightly vegetated spruce-shrub birch (L-SB) and willow-alder (L-WA) habitats in the Wiseman area of Gates of the Arctic National Park, Alaska, March 15-17, 2001. No trails were found during the second count period, March 18-20. Trails were formed when 3-4 or more hares passed over the same path and individual tracks could not be distinguished.

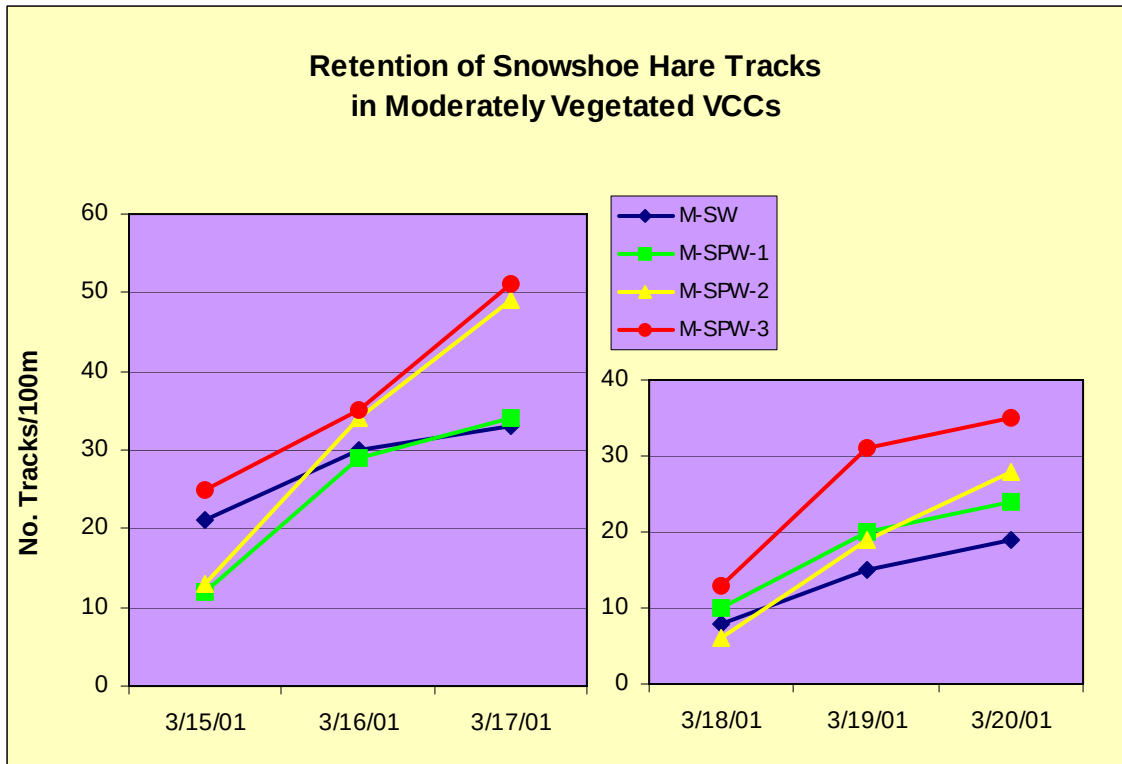


Fig. 6. Retention of snowshoe hare tracks on three 100m transects in moderately vegetated spruce-poplar-willow (M-SPW) habitat and one transect in spruce-willow (M-SW) habitat in the Wiseman area of Gates of the Arctic National Park, Alaska, during two 3-day count periods, March 15-20, 2001.

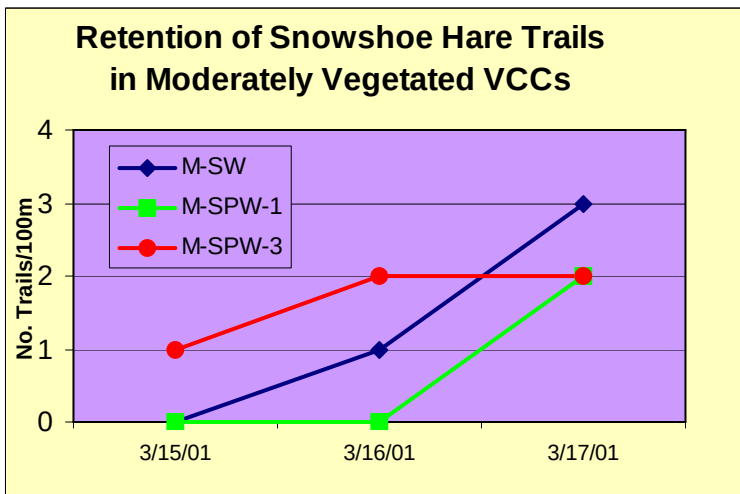


Fig. 7. Retention of snowshoe hare trails on two 100m transects in moderately vegetated spruce-poplar-willow (M-SPW) habitat and one transect in spruce-willow (M-SW) habitat in the Wiseman area of Gates of the Arctic National Park, Alaska, during one 3-day count period, March 15-17, 2001. No trails were found during the second count period, March 18-20. Trails were formed when 3-4 or more hares passed over the same path and individual tracks could not be distinguished.

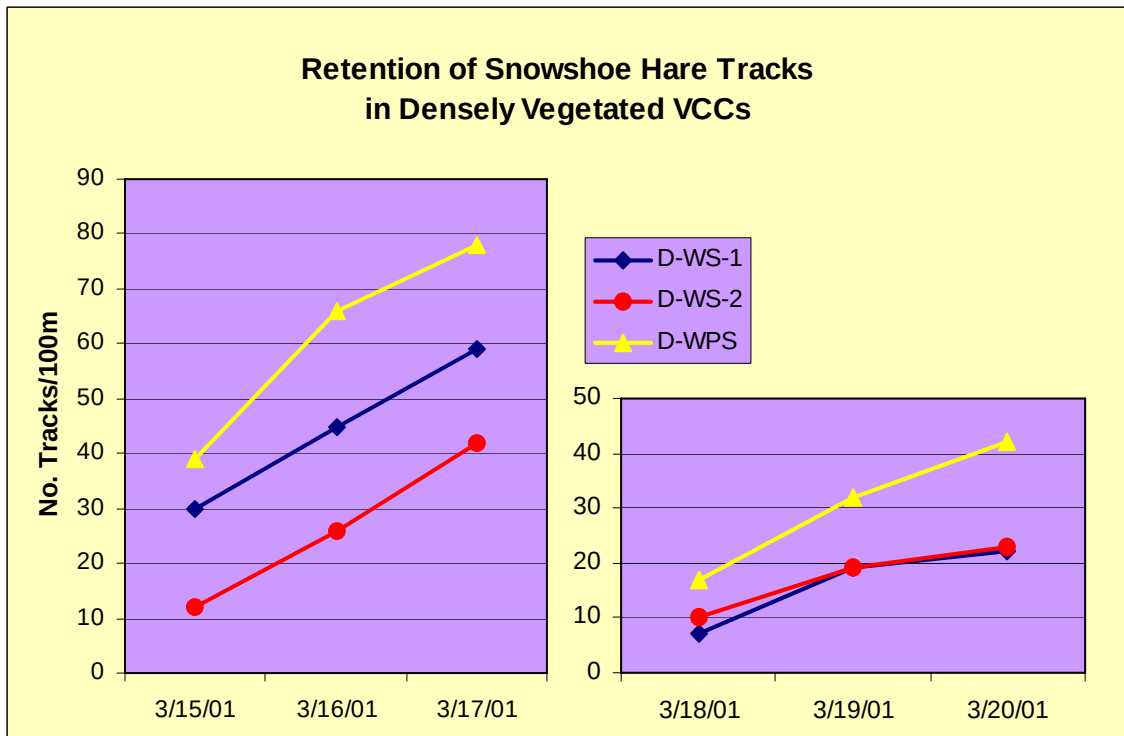


Fig. 8. Retention of snowshoe hare tracks on two 100m transects in densely vegetated willow-spruce (D-WS) habitat and one transect in willow-poplar-spruce (D-WPS) habitat in the Wiseman area of Gates of the Arctic National Park, Alaska, during two 3-day count periods, March 15-20, 2001.

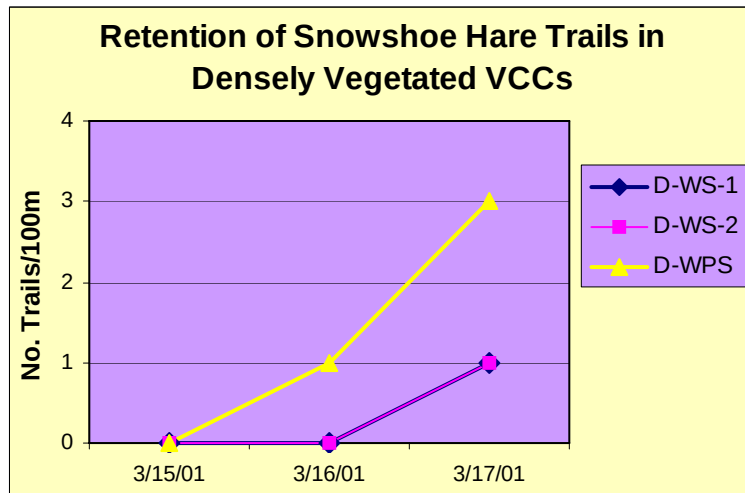


Fig. 9. Retention of snowshoe hare trails on two 100m transects in densely vegetated willow-spruce (D-WS) habitat and one transect in willow-poplar-spruce (D-WPS) habitat in the Wiseman area of Gates of the Arctic National Park, Alaska, during one 3-day count period, March 15-17, 2001. No trails were found during the second count period, March 18-20. Trails were formed when 3-4 or more hares had passed over the same path and individual tracks could not be distinguished.

A comparison of this year's data with the previous 4 years is discussed later and in Figs. 22-25.

Browsed Vegetation

Severe browsing by hares was evident on all species observed in this survey (willow, balsam poplar, spruce, alder and shrub birch) within every vegetation type. Diameter-at-point-of-browse (dpb) data (Table 1) were collected for the fourth year during this study; results are summarized below and compared with results from the previous three years (Figs. 10-15). One note on dpb data: In many instances, hares had not only clipped the stem, but had also chewed off all the bark around it. Measurements, therefore, may not include the thickness of the bark, and in many cases, some of the wood of the stem, too. This occurred most often in the more densely vegetated areas where browsing by hares was the most severe. Thus, some of our measurements may be less (perhaps by about 2 mm) than what was actually browsed.

In addition to dpb measurements, a tally of browsed species within each VCC revealed that hares had browsed nearly 85% of all species, at least in some degree (Figs. 16-21).

Diameter-at-Point-of-Browse:

Willows—*Salix* spp. were browsed and girdled in all 6 vegetation types found along the survey route. The average diameter dpb ranged from 4.2mm (n=15) in L-SB to 7.2mm (n=15) in M-SW. The smallest browsed willow stem measured 1.5mm (in L-WA) whereas the largest measured 10mm (in M-SW and M-SPW).

Balsam Poplar—Average dpb of *Populus balsamifera* ranged from 3.5mm (n=4) in L-SB to 5.2mm (n=15) in L-WA. Measurements of browsed stems ranged from 2.5mm (in L-SB) to 8.5mm (in L-WA). In many areas where poplars were common, most notably in M-SPW, hares had already severely browsed and girdled the younger poplars, leaving only the larger trees with thick bark at the base and no small branches, making it difficult to locate a stem browsed during the current year. In M-SPW, only one browsed stem from the current year was located (measuring 4mm). No freshly browsed poplars were found in the D-WPS or M-SW.

Spruce—*Picea* spp. also were browsed and girdled in all vegetation types. Browsed spruce stems averaged 3.6mm (n=15) dpb in D-WS, where stem diameters ranged from 1.5-6mm. In L-SB the average browsed spruce stem measured 5.2mm (n=15) dpb, where stem thickness ranged from 3-9mm.

Shrub Birch—Browsed *Betula glandulosa* was observed in four of the six VCCs this year (L-WA, L-SB, M-SW and M-SPW), and girdling was noted in all but L-WA. Diameter-at-point-of-browse averaged 2.5mm (n=15) in L-SB and 5.7mm (n=5) in M-SPW, with stem thickness ranging from 1mm in L-WA and L-SB to 7.5mm in M-SPW.

Table 1. Browse data collected from 6 vegetation cover and composition (VCC) classes along the snowshoe hare survey transect, near Wiseman, Alaska, in eastern Gates of the Arctic National Park and Preserve, March 2001. In VCCs, the letters stand for the following: L=light vegetation, M=moderate vegetation, D=dense vegetation, W=Willow sp., P=poplars, S=spruce, B=shrub birch, A=alder. DPB=diameter at point of browse. The "Girdled?" column refers to whether or not the bark on the stems of that species within that VCC had been completely chewed off by snowshoe hares.

Species	VCC	Girdled?	Average DPB	Min.	Max.	Count
Alder	L-WA	yes	5.07	3	8	15
Shrub Birch	L-WA	no	3.13	1	5	15
Shrub Birch	L-SB	yes	2.53	1	5	15
Shrub Birch	M-SW	yes	3.67	2	5.5	15
Shrub Birch	M-SPW	yes	5.70	4.5	7.5	5
Spruce	L-WA	yes	4.27	2.5	7.5	15
Spruce	L-SB	yes	5.20	3	9	15
Spruce	M-SW	yes	4.97	3	7	15
Spruce	M-SPW	yes	4.37	2.5	8	15
Spruce	D-WPS	yes	4.93	3	7.5	15
Spruce	D-WS	yes	3.63	1.5	6	15
Poplar	L-WA	yes	5.17	3	8.5	15
Poplar	L-SB	yes	3.50	2.5	5	4
Poplar	M-SPW	yes	4.00	4	4	1
Poplar	D-WS	yes	4.65	3	7	10
Willow	L-WA	yes	5.13	1.5	7	15
Willow	L-SB	yes	4.23	2	9	15
Willow	M-SW	yes	7.20	4	10	15
Willow	M-SPW	yes	5.90	2.5	10	15
Willow	D-WPS	yes	5.30	3	8	15
Willow	D-WS	yes	4.77	2	8	15

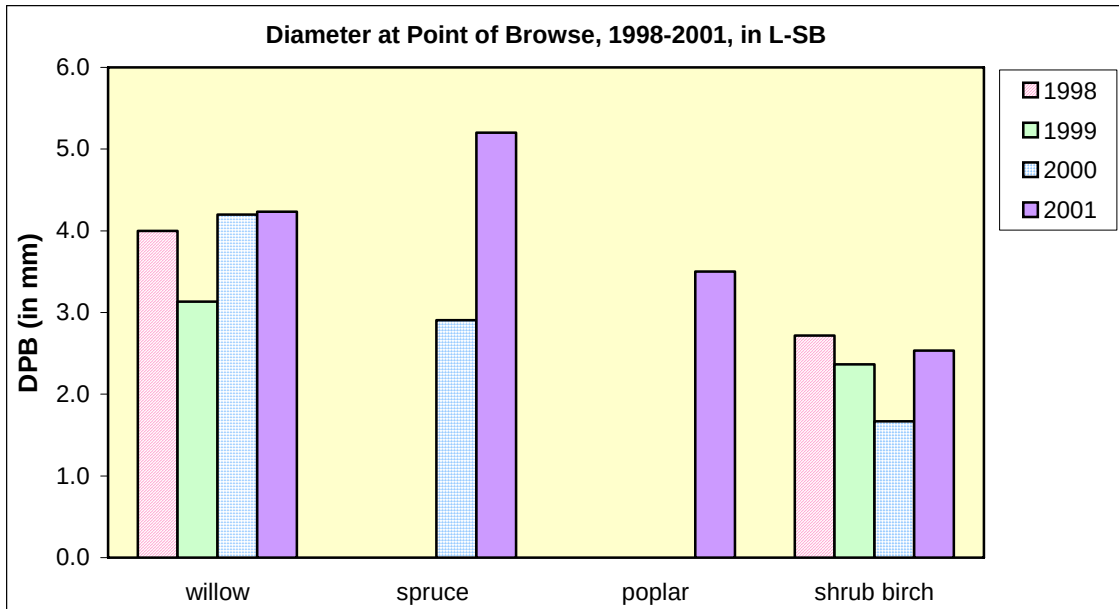


Fig. 10. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in L-SB (lightly vegetated transect dominated by spruce and shrub birch). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

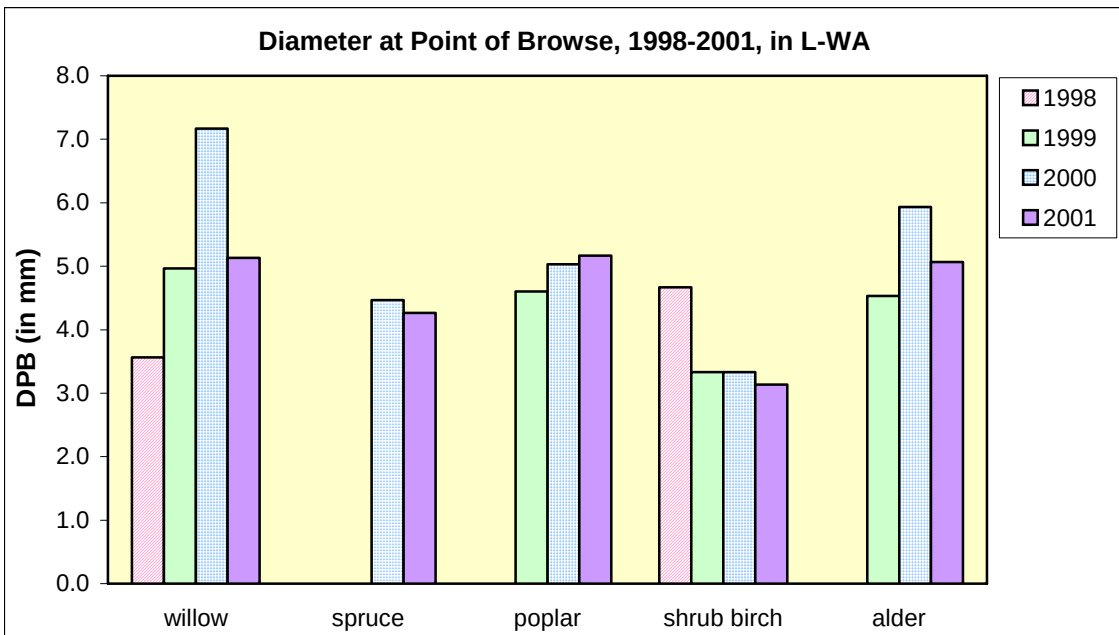


Fig. 11. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in L-WA (lightly vegetated transect dominated by willow and alder). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

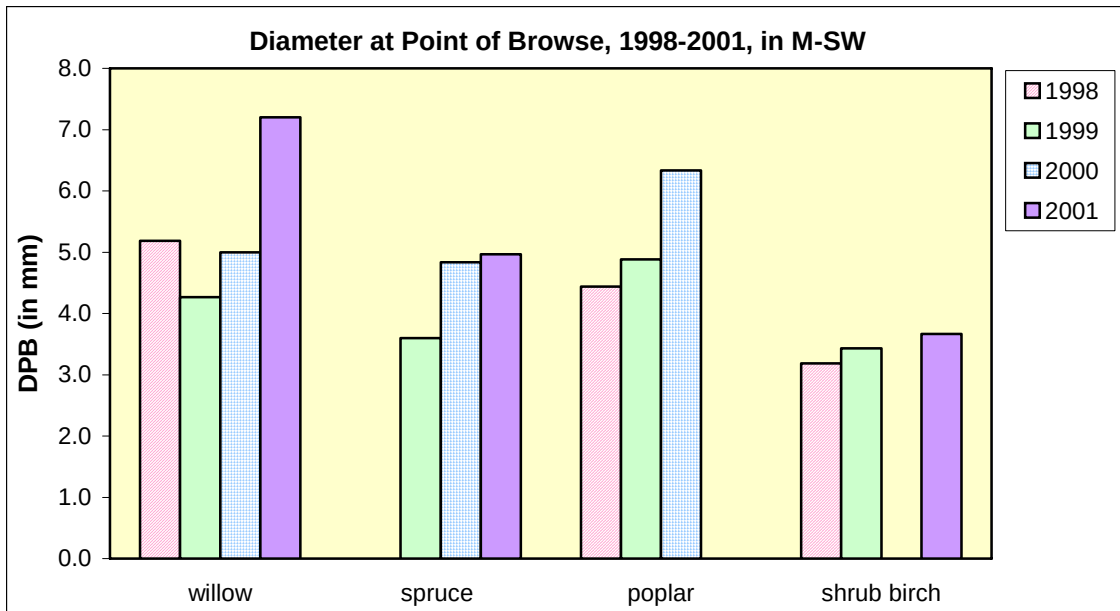


Fig. 12. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in M-SW (moderately vegetated transect dominated by spruce and willow). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

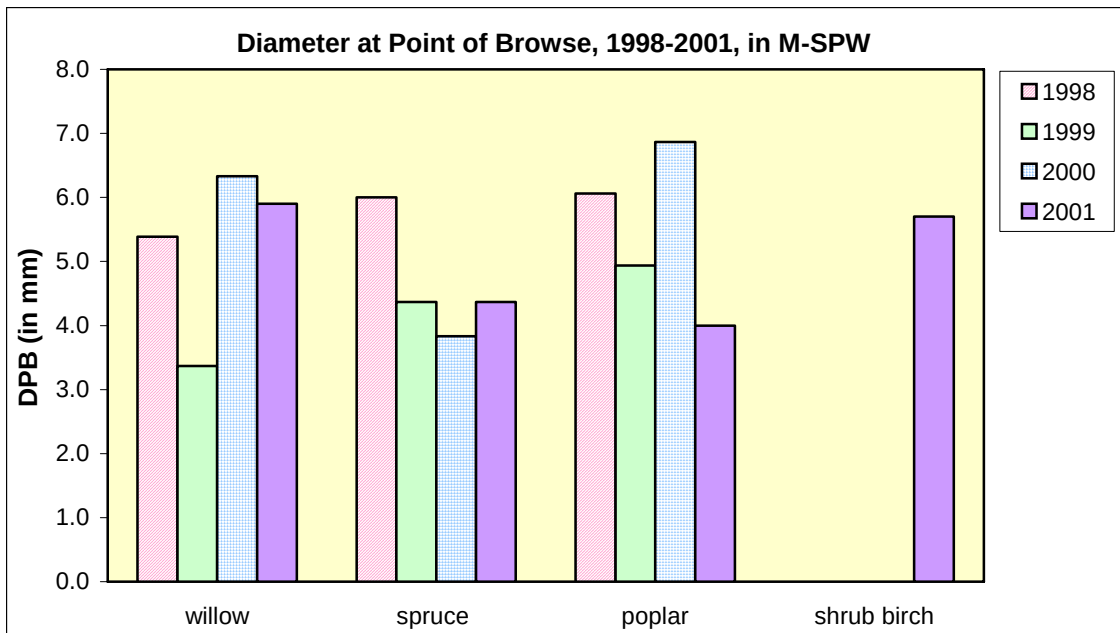


Fig. 13. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in M-SPW (moderately vegetated transect dominated by spruce, balsam poplar and willow). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

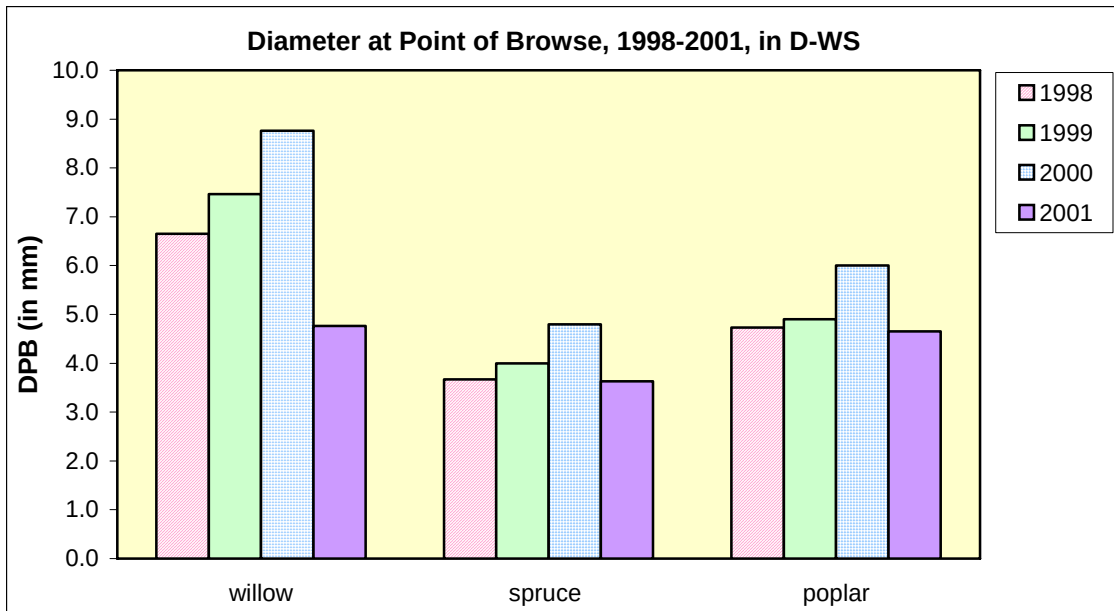


Fig. 14. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in D-WS (densely vegetated transect dominated by willow and spruce). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

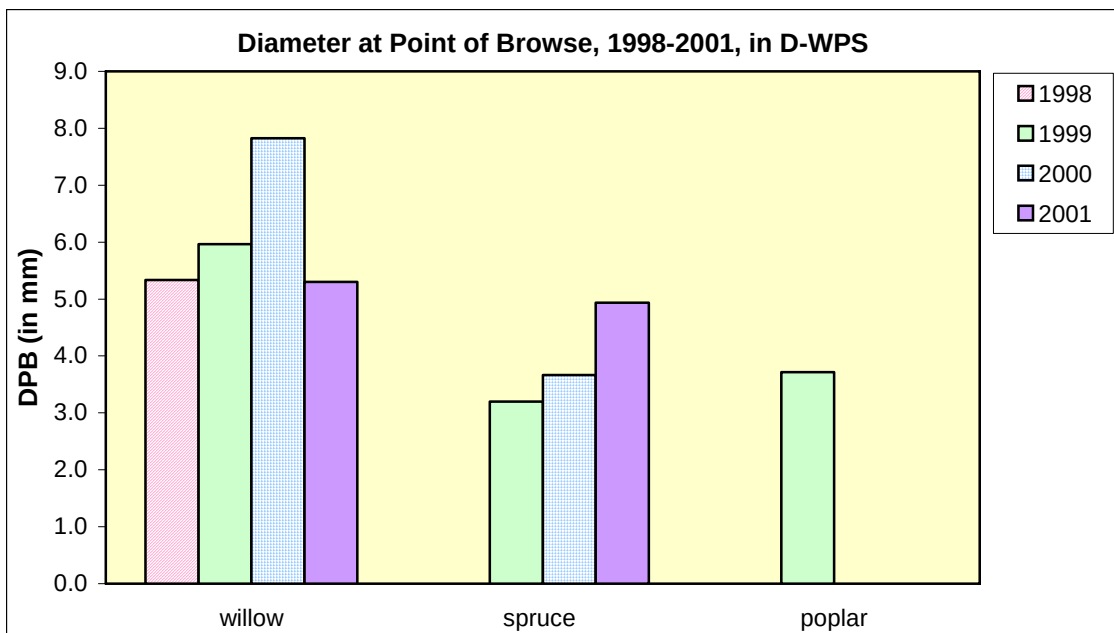


Fig. 15. Comparison of diameter at point of browse data from snowshoe hare surveys, Gates of the Arctic National Park and Preserve, Alaska, from 1998-2001 in D-WPS (densely vegetated transect dominated by willow, balsam poplar and spruce). Due to varying snow conditions between years, measurements were not always collected from all species each year. Hares generally "prefer" browse that is 3 mm in diameter or smaller (Pease et al. 1979, Wolff 1980).

Alder— In L-WA, hares browsed *Alnus* sp. stems 3-8mm thick, with an average dpb of 5.1mm (n=15). Alder stems were girdled also.

Degree of Browsing:

L-SB—Spruce trees dominate this VCC, which are mostly older trees. Nevertheless, 46% (n=104) of the spruce trees tallied had been browsed (mostly just clipped lower branches and twigs) by hares. Of the sparse covering of willow and shrub birch found above snowline, 83% (n=59) of the willows and 87% (n=68) of the shrub birch had been browsed by hares, roughly half that amount both clipped and at least partially girdled (Fig. 16).

L-WA—This VCC is a relatively open, sparsely vegetated area. The spruce in this area are mostly young trees and saplings; 81% (n=58) had been browsed by hares, one-third at least partially girdled. Roughly 90% of willow (n=53), shrub birch (n=47), and alder (n=58) had been browsed by hares, while all the poplars tallied (n=61) had been browsed (Fig. 17).

M-SW—Large white spruce dominate this VCC, with an undergrowth of willows mixed with shrub birch, poplar and spruce saplings. Seventy-two percent of the spruce (n=67) were browsed, roughly a third of them at least partially girdled. Of the willows tallied, 90% (n=101) were browsed, 83% girdled at least in some degree, 37% completely girdled. Ninety-nine percent of the shrub birch (n=101) were browsed, over half of these partially to completely girdled, and 67% of the poplars (n=54) were browsed and at least partially girdled (Fig. 18).

M-SPW—Ninety percent or more of the spruce (n=112), poplar (n=108), and shrub birch (n=71) were browsed by hares. Of the willows tallied, 79% (n=128) were browsed, 70% of them girdled at least partially. The poplars were most severely browsed, with 51% of them completely girdled (Fig. 19).

D-WS—In this densely vegetated area, 91% (n=113) of the willows had been browsed, with 88% at least partially girdled (53% completely girdled). We noted that most of the willows in D-WS1 appeared dead due to overbrowsing by hares. Ninety-four percent of the poplars (n=52) were browsed, also with a high degree of girdling. The poplars that were not browsed by hares were large trees. Over half of the spruce tallied had been girdled at least in some degree, with 85% of all spruce (n=156) browsed by hares (Fig. 20).

D-WPS—Ninety-eight percent of the willows (n=160) in this area were browsed by hares, the remaining 2% of unbrowsed stems being old, thick trunks with coarse bark. Only a few willows were just clipped; 74% of them had been mostly girdled as well, if not completely so. All of the spruce tallied (n=56) had been browsed in some degree, half clipped only, and half partially or mostly girdled. Of the poplars, 2% had been clipped and mostly girdled by hares; the rest were large trees with thick bark (Fig. 21).

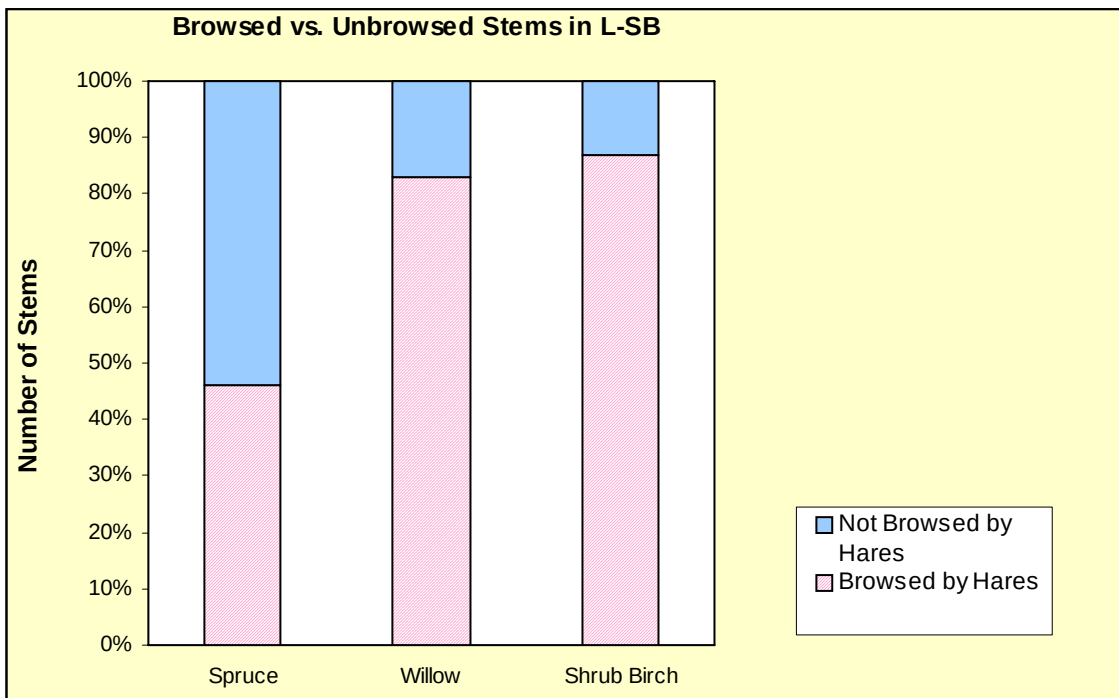
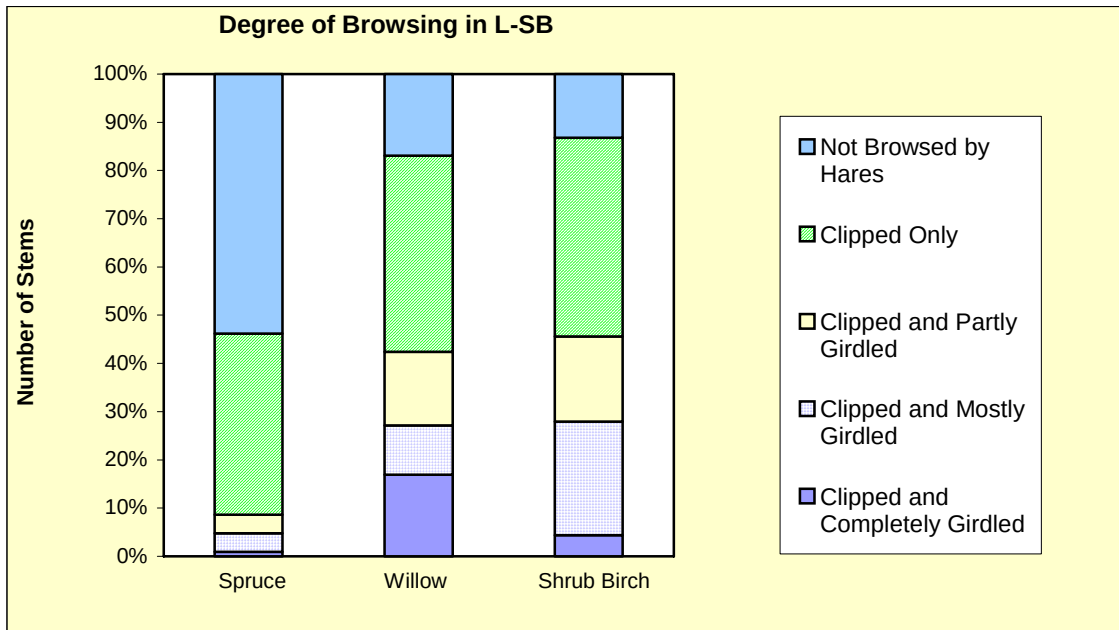


Fig. 16. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in L-SB (lightly vegetated transect dominated by spruce and shrub birch). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

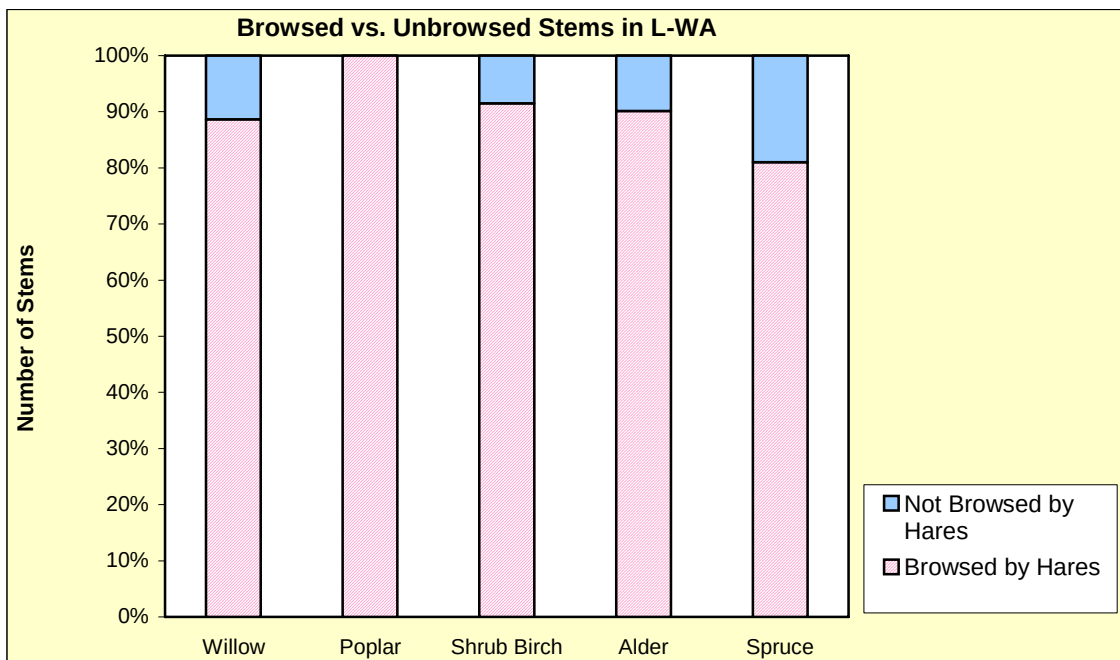
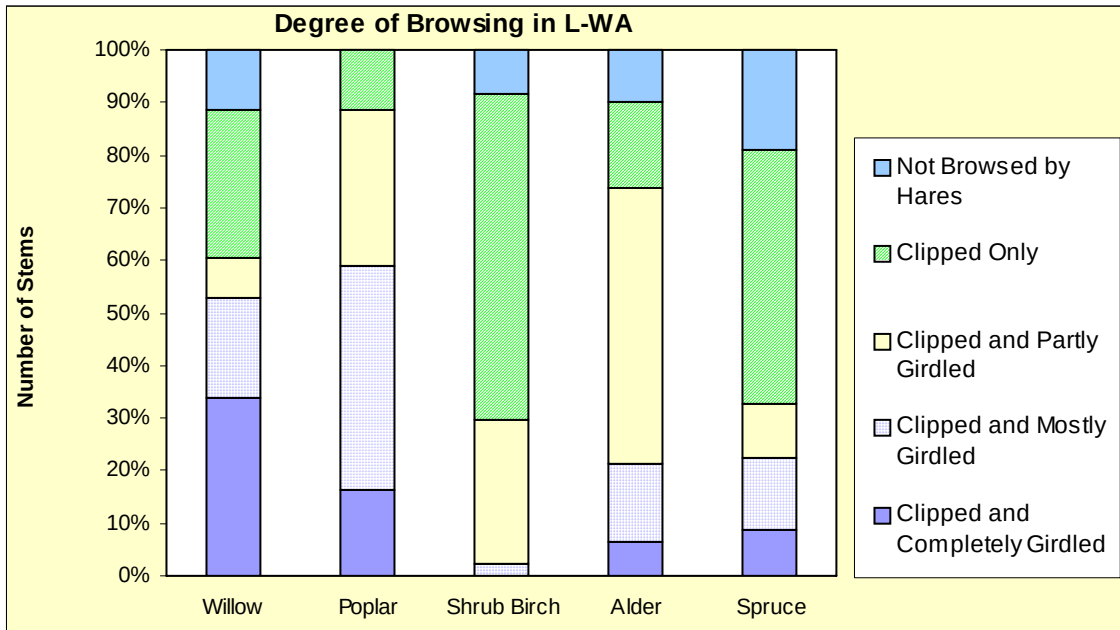


Fig. 17. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in L-WA (lightly vegetated transect dominated by willow and alder). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

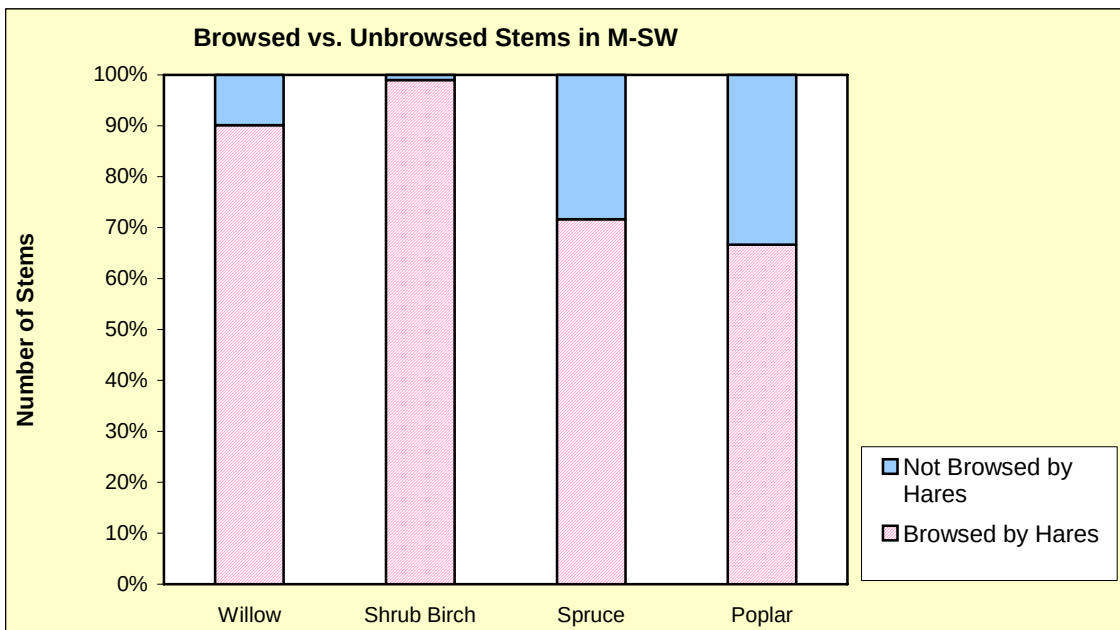
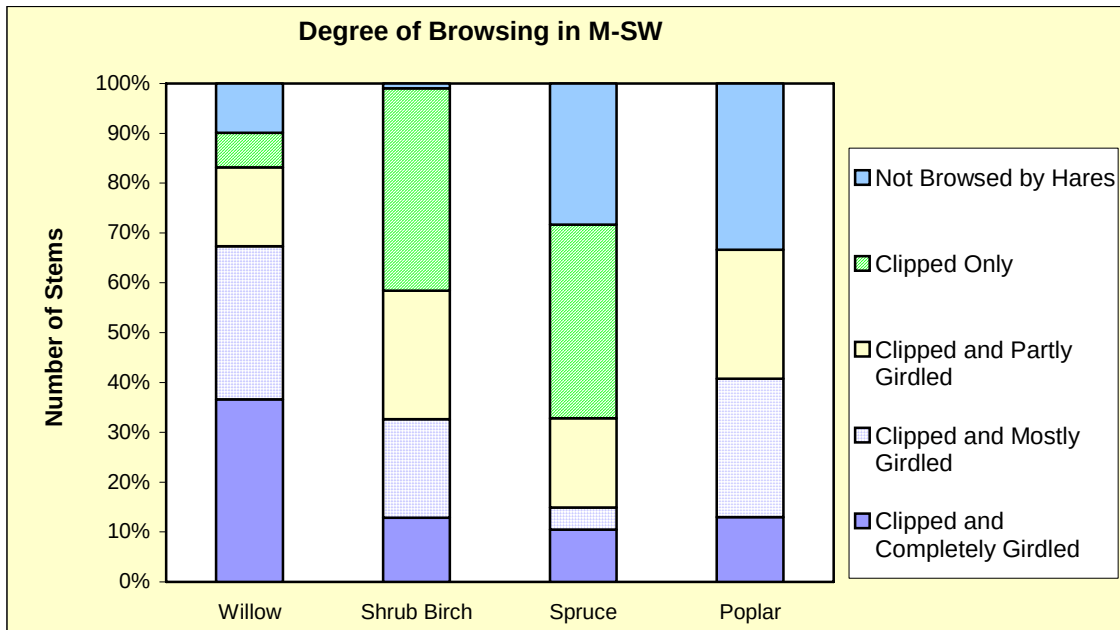


Fig. 18. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in M-SW (moderately vegetated transect dominated by spruce and willow). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

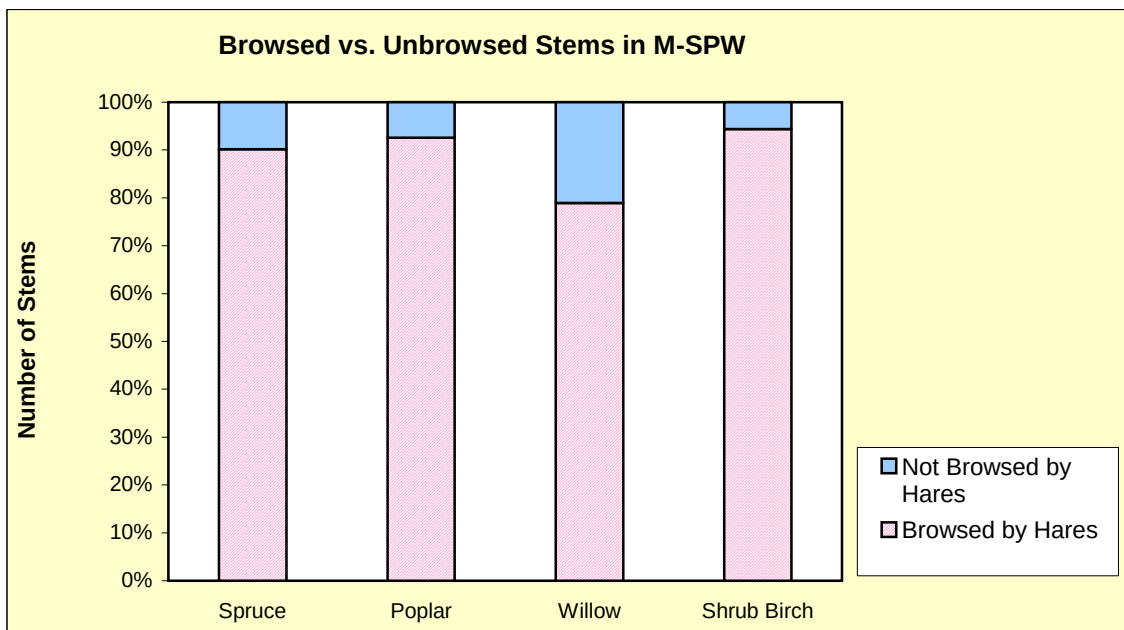
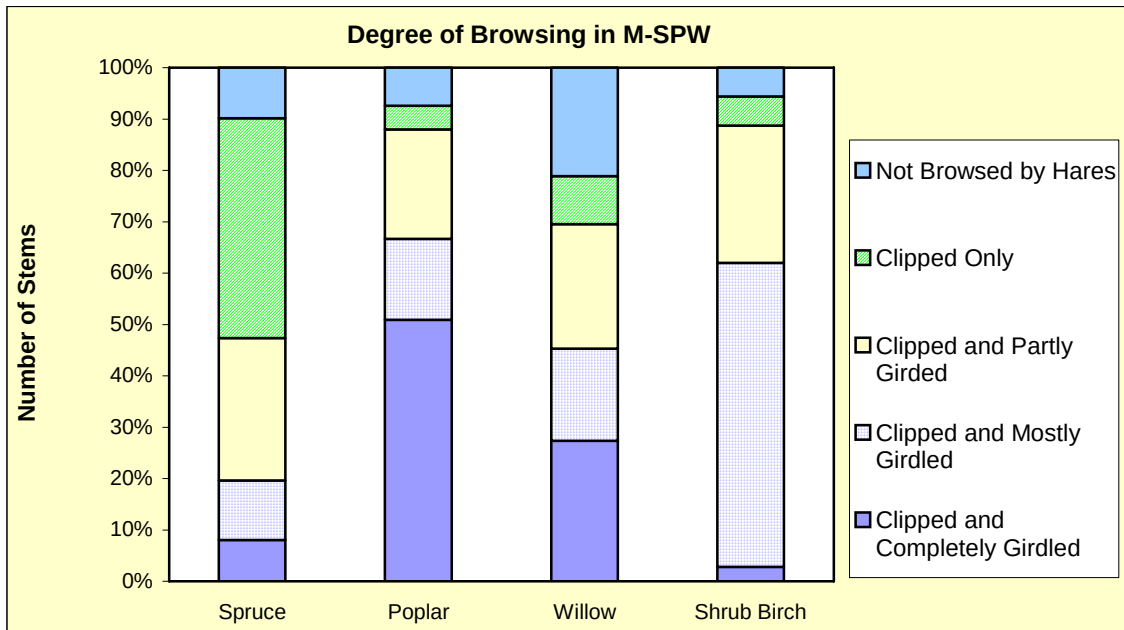


Fig. 19. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in M-SPW (moderately vegetated transect dominated by spruce, poplar and willow). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

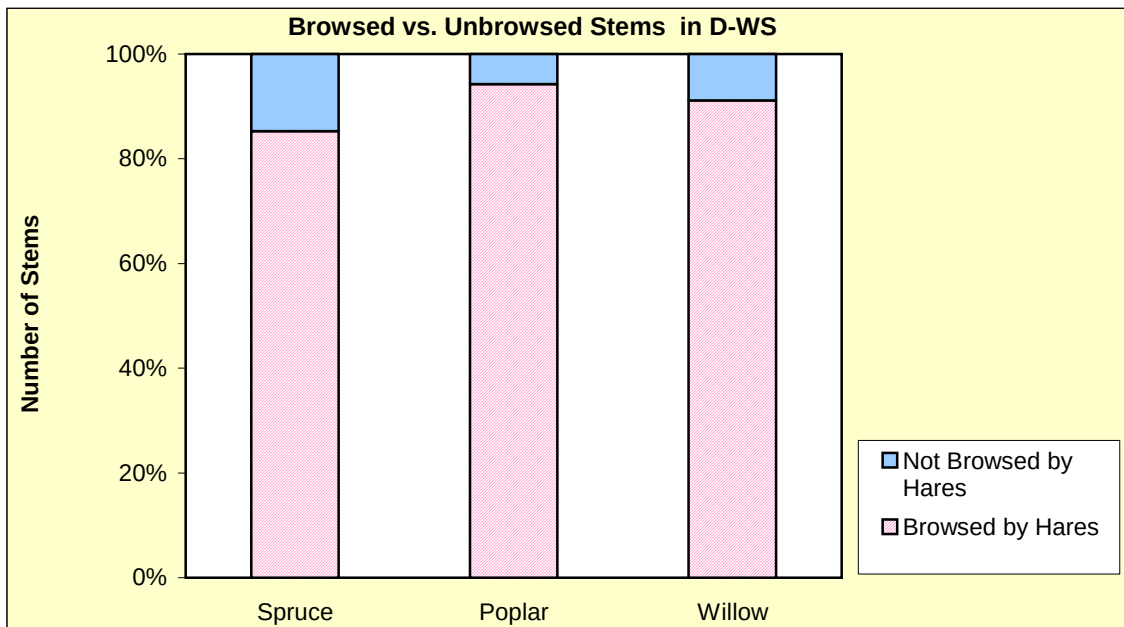
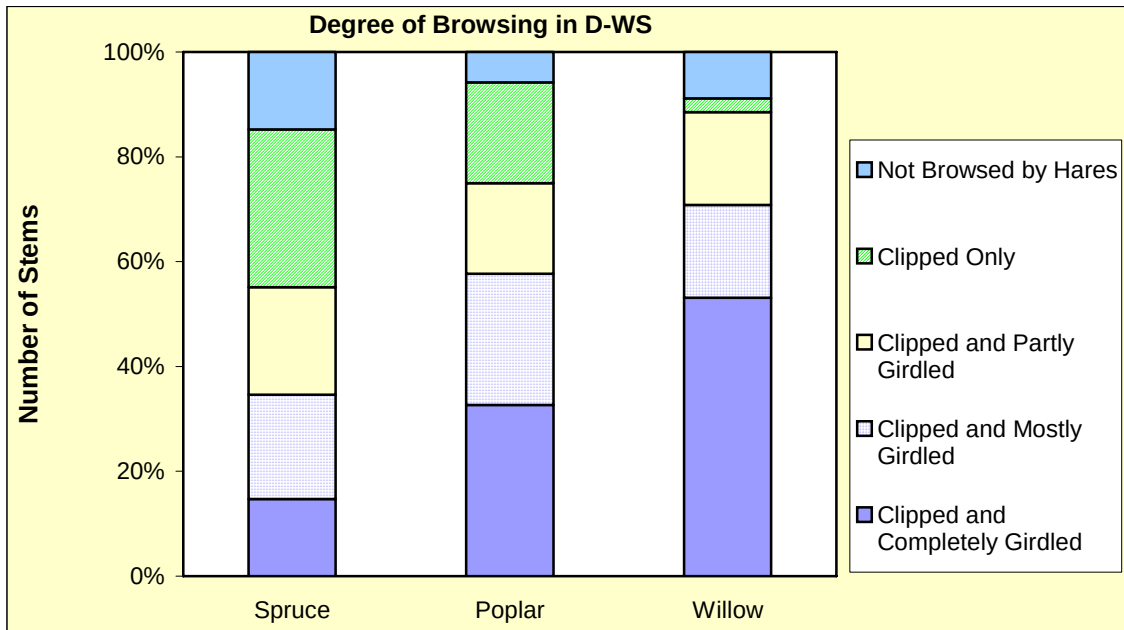


Fig. 20. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in D-WS (densely vegetated transect dominated by willow and spruce). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

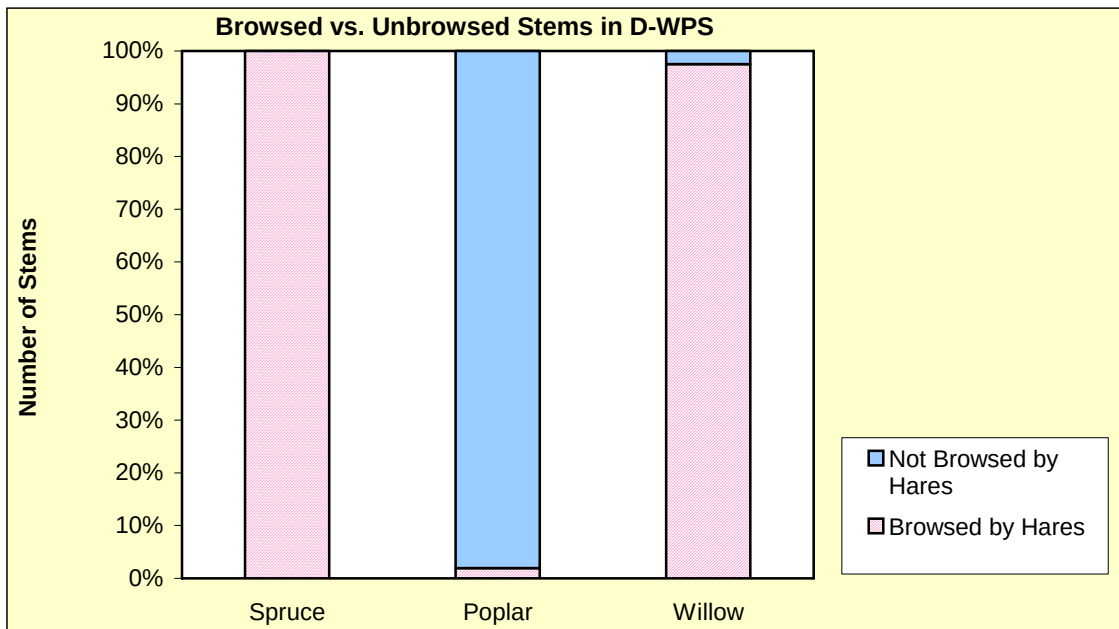
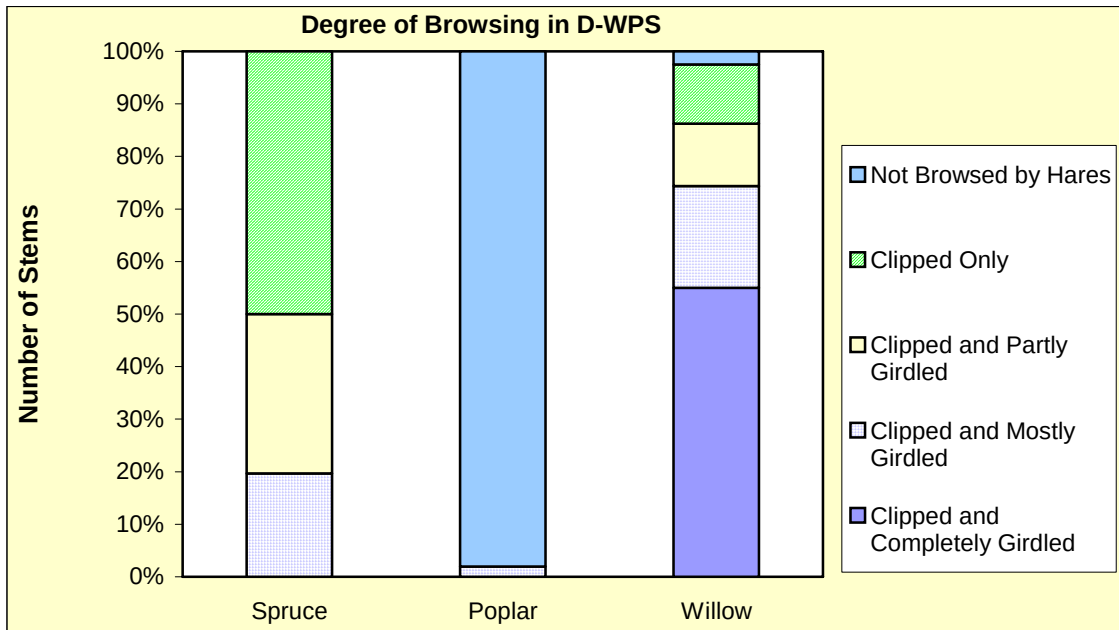


Fig. 21. Degree of browsing (top) and browsed vs. unbrowsed stems (bottom) in D-WPS (densely vegetated transect dominated by willow, poplar and spruce). Data from the four browsed categories shown in the top graph were combined to form the single "browsed" category in the bottom graph. The number of stems tallied were converted to form percentages to make comparisons between different species and transects easier. Snowshoe hare survey, Gates of the Arctic National Park and Preserve, Alaska, March 2001.

DISCUSSION

Distribution of Tracks throughout the Study Area

Over the past 5 years of the hare survey, the usefulness of counting tracks has come into question. Comparisons of the tracks counted each year would indicate that the hare population rose dramatically from 1997 to 1998 and 1999, then dropped nearly as quickly in 2000 and 2001 (Fig. 22). However, accurate counts of tracks depend heavily on snow conditions and the weather. Fresh snow, and also wind and temperature, can have a tremendous impact on the visibility of tracks. Other than in 1998 when light snowfalls aided track detection, most years have seen very little to no fresh snow throughout the survey period. Hard-packed snow conditions have plagued every survey thus far. Ideal conditions for counting tracks would be for about 5 cm of snow to fall 12 – 24 hours before the count began (Golden 1994), with additional fresh snow half-way through the 6-day survey period. Even a single millimeter of fresh snow can help considerably in spotting tracks once the snow becomes hard packed. Following yet another year without enough fresh snow at the appropriate times to make accurate track counts, we thought perhaps we should eliminate the track count portion of the survey and just collect browse data. However, while the *number* of tracks may not be representative of the actual population, the data appear useful for comparing changes in the relative *distributions* of tracks among the different VCCs from one year to the next. The distribution of tracks throughout the different habitat types in the study area may also indicate hare population density (Wolff 1980, Fuller and Heisey 1986).

To compare the relative use of habitats (VCCs) between years, track deposition data were converted to percentages for each VCC in each year (Figs. 23-25). Figure 23 shows how, in 1997 when the population was still low, hares were more concentrated in D-WPS compared to the other VCCs than during the next 4 years when their numbers were much greater. Figure 24 shows the same data, only grouped by year. The affinity of hares to the densely vegetated areas, particularly to D-WPS in 1997 is readily apparent, as is the more even distribution of hares throughout the study area in 2001. Figure 25 illustrates yet another perspective, showing the trends in use of the 6 vegetation types over the 5 years of the hare study. Note how the level of use in the more lightly vegetated areas (L-WA, L-SB and M-SW) has increased somewhat over time, while the use of the more densely vegetated areas (M-SPW, D-WPS and D-WS) has remained about the same (M-SPW) or decreased over time.

Fuller and Heisey (1986) and Wolff (1980) also saw changes in the distribution of snowshoe hares from low to high population levels in northcentral Minnesota and interior Alaska, respectively. During population lows, hares retreated to areas with dense cover. During population highs, hares utilized all vegetation types, but fewer were in types with less cover. The distribution of tracks in our study area appears to be following a similar trend. This study began in 1997 when the snowshoe hare population was recovering from a very low level, and a few tracks were recorded in lightly vegetated areas. When the population suddenly increased in 1998, more tracks

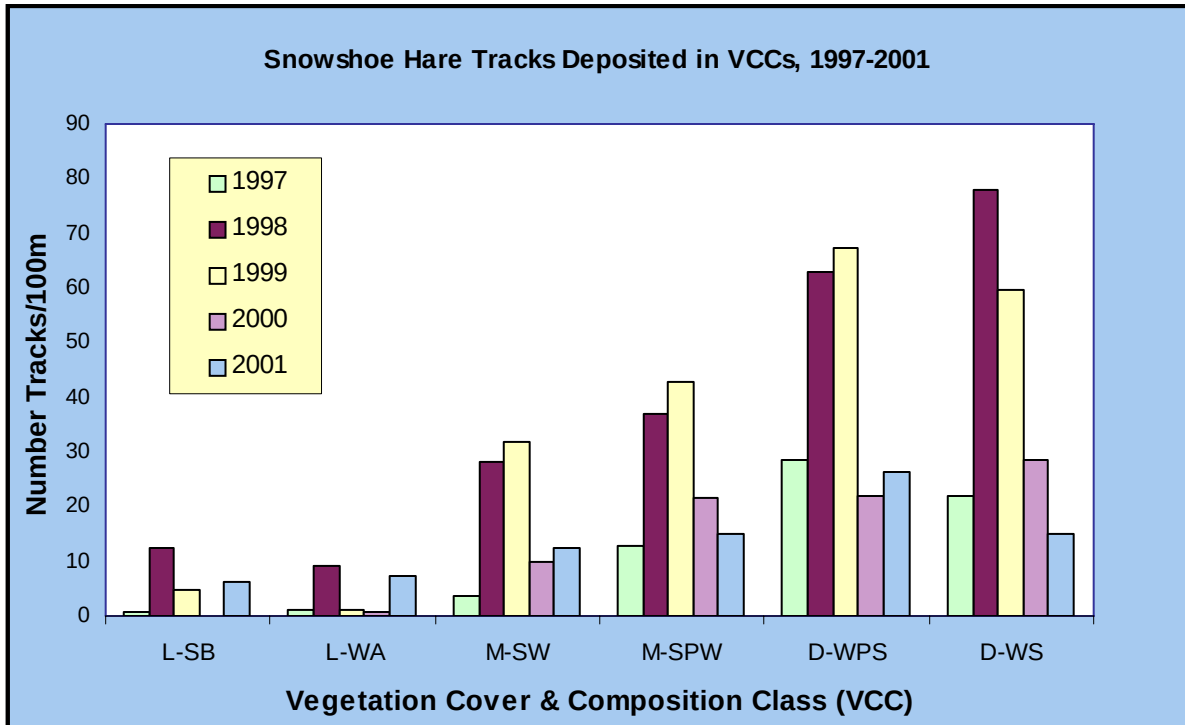


Fig. 22. Deposition of snowshoe hare tracks within six vegetation cover and composition classes (VCCs), snowshoe hare survey, 1997-2001, Gates of the Arctic National Park and Preserve, near Wiseman, Alaska. VCC codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow.

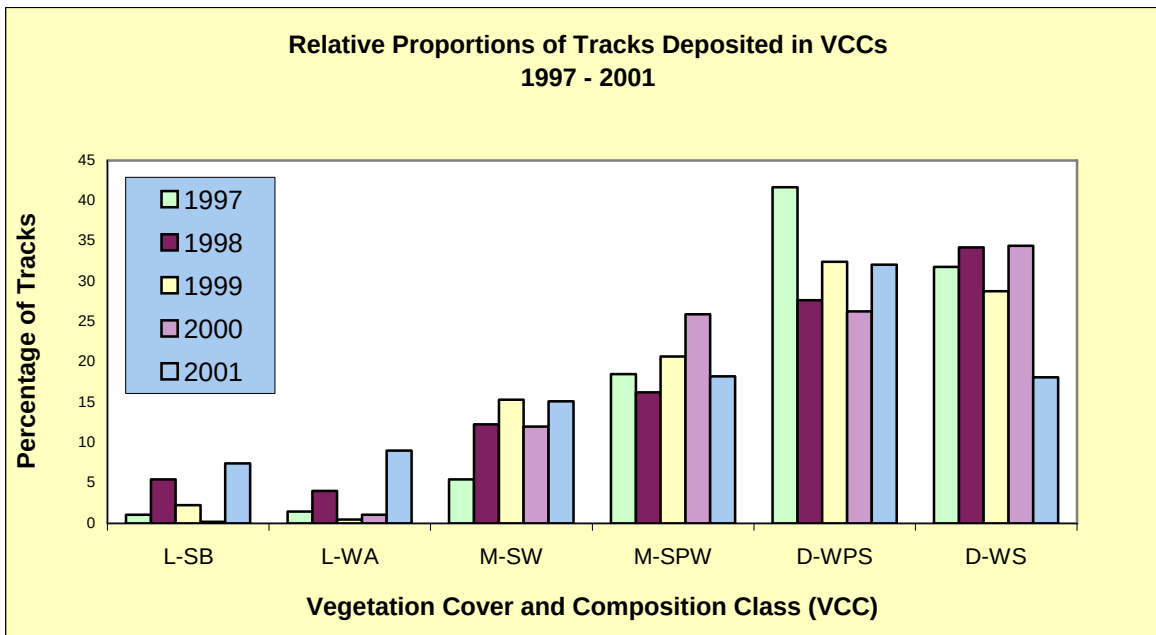


Fig. 23. Percentages of snowshoe hare tracks deposited within six vegetation cover and composition classes (VCCs) over 5 years of the snowshoe hare survey, 1997-2001, Gates of the Arctic National Park and Preserve, near Wiseman, Alaska. VCC codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow.

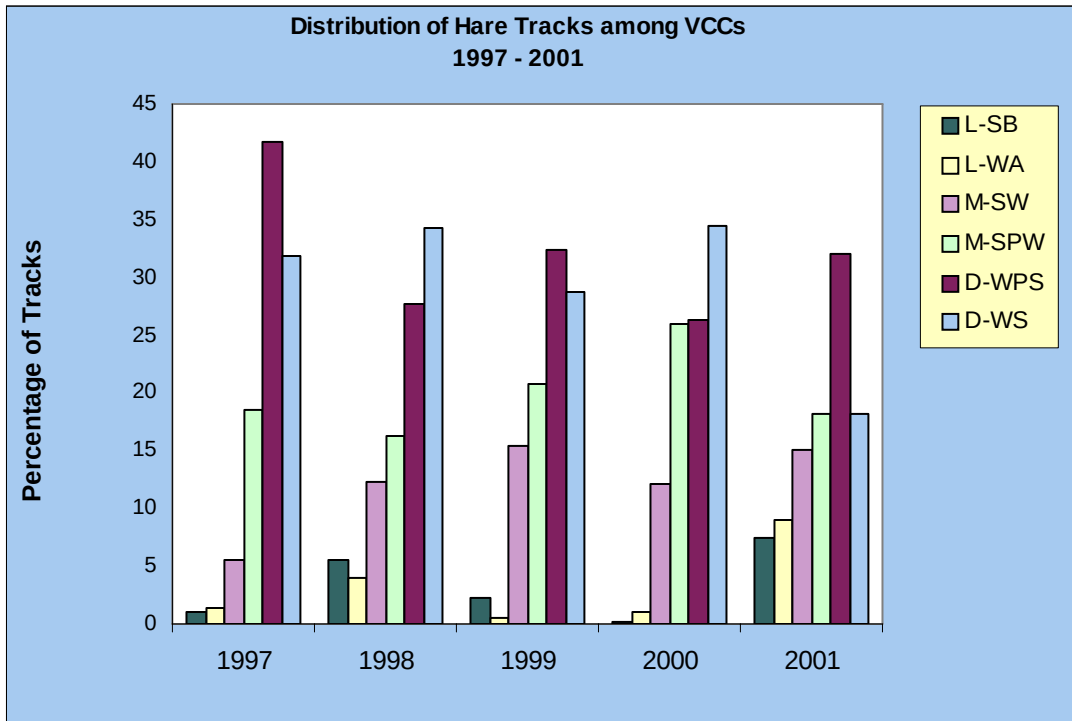


Fig. 24. Summary of the distribution of snowshoe hare tracks deposited within six vegetation cover and composition classes (VCCs) from 1997 to 2001, snowshoe hare survey, Gates of the Arctic National Park and Preserve, near Wiseman, Alaska. Bars represent the percentage of tracks deposited within each VCC during each year's survey. VCC codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow.

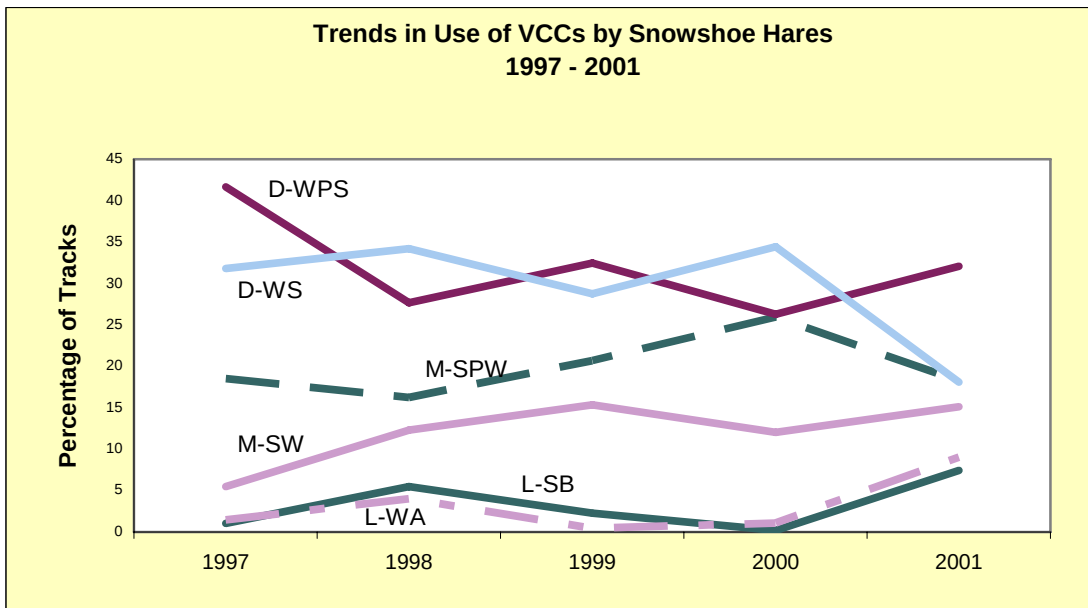


Fig. 25. Trends in the deposition of snowshoe hare tracks among six vegetation cover and composition classes (VCCs) during the annual snowshoe hare survey, 1997-2001, Gates of the Arctic National Park and Preserve, near Wiseman, Alaska. VCC codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow.

were found in *all* the VCCs, not just the densely vegetated areas. [The increase in the number of tracks in the lightly vegetated areas in 1998 may be a phenomenon due more to the new moon phase at that time than to population pressures. Hares tend to move about more when it's dark and they are less visible to predators (J. Reakoff, Wiseman trapper, pers. commun.)] Distribution of hares during the next 2 years was about the same, with few in the lightly vegetated VCCs and most in the moderate and dense VCCs. Then, in 2001, we counted relatively more tracks in the lightly vegetated VCCs than in previous years, causing a more even distribution of hares throughout the study area. While there were still more tracks counted in the dense VCCs than in the light VCCs, it seemed that many hares had moved out of the more densely vegetated areas into more open areas. This apparent exodus was probably due to a combination of more hares competing for the same resources and very little browse left in the thickets.

Thus, as the hare track distribution data suggests, and in combination with browse data and other observations, we conclude that the hare population in our study area rose in 1998, peaked around 1999, then dropped some, holding fairly steady through 2001. We suspected that after 4 years of a high snowshoe hare population in the area, the population would crash before the next survey in 2002. However, in recent (January 2002) discussions with Jack Reakoff, a Wiseman resident who traps near our study area, I've learned that the population *still* has not crashed, although it appears to be somewhat lower than last year.



Willows browsed by snowshoe hares in D-WPS. The larger diameter willows on the right were completely girdled in a previous year, apparently resulting in the death of the shrub.

Browsing Intensity

Other than shrub birch in L-SB, where hares have browsed stems averaging <3 mm since 1998, the average diameter at point of browse for all species ranged from about 3 mm to 9 mm, and bark girdling has been readily apparent throughout the study area. Since hares generally prefer browse <3 mm in diameter, consumption of the larger stems is considered an indication of food stress (Pease et al. 1979, Wolff 1980). The diameter at point of browse in our study was less than that of Wolff (1980), who observed >10 mm dpb and 100% browsing intensity during the 2 winters the snowshoe hare population peaked in the early 1970s near Fairbanks, Alaska, just before that population “crashed.” In our study area northwest of Wiseman, the degree of browsing is virtually at 100%, since even mature trees were

included in our calculations. (Trees, and not just saplings, were counted in our tallies because, since I was uncertain as to how large a diameter tree hares would browse, I did not want to exclude mature trees. Hares chewed the bark and twigs off the lower branches of some very large trees—usually spruce trees—so those would be categorized appropriately as browsed. Most observations of unbrowsed stems, however, were from mature trees, and others we suspected to be dead.) We also noted an increased occurrence of willow and young spruce tree mortality throughout the study area. Spruce tree mortality was predicted in the 2000 survey (DiFolco 2000) when severe browsing of spruce saplings was noted at that time.

In addition to browsing on vegetation above the snowline, hares dig through the snow to reach browse. We have frequently observed hare diggings (to an estimated 25 cm) to access buried shrub birch.

Hares in the study area also dig through the snow to graze on *Equisetum* before the snow becomes too deep (J. Reakoff, Wiseman trapper, pers. commun.). These observations counter those of Keith (1983) who wrote, “I have never seen snowshoe (hares) dig for food, nor have I encountered reports of such behavior.”



These young spruce trees in D-WS were killed after being completely girdled in 2000 by snowshoe hares.



An excavation by snowshoe hares to reach shrub birch. Diggings such as this are common in the study area, although other researchers have not reported seeing such behavior in other areas.

The Long Hare “High”

A combination of winters with deep snow, a rainy summer, and the finite supply of carbon reserves of the deciduous shrubs within the plant community may have helped the hare population

in the Wiseman area to maintain its “peak” for an unusually long time. Wolff (1980) reported peaks in hare populations near Fairbanks lasting only one year, while Fuller and Heisey (1986) reported a hare peak lasting 3 years in Itasca County, Minnesota. The hare population in our study area has continued for 4 years. After the initial jump in the hare population in 1998, severely browsed deciduous shrubs in the more densely vegetated VCCs likely boosted production of secondary compounds by growing juvenile-form stump sprouts (Bryant and Kuropat 1980, Bryant et. al. 1983, Fox and Bryant 1984, and Bryant et. al. 1985). This coincides with our observations in 1999 of hares browsing on the larger stems of shrub birch and poplar but rejecting the smaller stems and buds. The next two winters (1998-1999 and 1999-2000) however, saw periods of heavy snowfall, which helped the hares reach higher than usual on the shrubs, enabling them to reach mature-form, palatable twigs (Bryant et al. 1985). Then followed a very rainy summer in 2000. Production of the carbon-based secondary compounds requires energy in the form of sunshine. Experimental studies have shown that shading decreases the production of carbohydrates and secondary compounds, meaning less antiherbivory defenses and increased palatability to hares (Bryant et. al. 1983, Bryant 1987). Also, Bryant, et. al. (1983) found that *repeated* pruning of juvenile plants *increased* palatability, probably because the plants’ carbon reserves were reduced to such low levels the plants could not continue producing secondary compounds. It’s possible, that by the winter of 2000-2001, many of the plants had diminished stores of underground carbon, and therefore, had reduced production of secondary compounds.

The Hare-Lynx “Connection” and the Mineral Question

Another factor that may be affecting the health of the hare population, and subsequently the health of lynx, is the consumption of minerals. Long-time Wiseman resident and trapper Jack Reakoff (pers. commun.) has observed the past 4 snowshoe hare cycles, and has noted an interesting correlation between the hares’ diet, their vivaciousness (or lack thereof), and the body condition of lynx. Hares in the study area seek out and consume mineral soil when the population is high and the vegetation has been heavily browsed. Hares in neighboring areas, such as at Marion Creek, do not visit mineral licks, even though cut banks exist along the creek where they could easily access the soil. During times when hares are visiting the mineral licks, they appear lethargic and can be easily approached. This behavior was particularly evident during the 2000 survey when we were able to approach some hares to within 10 feet before they would slowly hop away. We also noticed in 2000 where hares had been visiting exposed soil patches along the survey route. Earlier that year, Reakoff had found a dead hare that had “not been killed by anything.” Lynx were abundant also, but trapped specimens were reportedly “skinny” despite the abundance of hares. The following year, after the rainy summer of 2000, hares again appeared lethargic early in the trapping season. They were evidently visiting soil licks at that time and the lynx trapped in the area were thin and the kits small. Later that winter, however, the hares stopped

visiting the mineral licks, became more energetic, and lynx correspondingly became fatter (J. Reakoff, Wiseman trapper, pers. commun.). Our observations during the 2001 survey confirmed that the hares appeared more “normal,” by energetically eluding our presence.

In an attempt to determine what hares may be craving by visiting the mineral licks, samples of mineral soils where hares had frequented were collected (DiFolco 1998, DiFolco 1999). Additional samples were collected from Marion Creek, where hares had not visited (DiFolco 2000). Each sample was analyzed for concentrations of sodium, calcium, magnesium, potassium, and chloride. Results showed that the soils which hares visited had greater concentrations of calcium than the soils they did not visit (DiFolco 2000). An experiment done during the summer of 2000 in the study area tested the preference of hares for these 5 minerals. Plates holding samples of each mineral were set out in different vegetation types (5 plates in each vegetation type). In each case, hares consumed more calcium than any other mineral. Other minerals were also consumed to a degree, but not as readily as calcium (J. Reakoff, pers. commun., M. Reakoff, unpublished data). We can only speculate that additional calcium may be aiding the hares by binding some of the secondary compounds produced by the plants in much the same way that the calcium in an antacid drug like “Tums” neutralizes acids (Dr. Jerry Steed, pharmacist, Carrs Quality Center Pharmacy, pers. commun.). The lethargy observed during periods when hares consume the soil may be a symptom resulting from the consumption of plant toxins, or from another element in the soil (perhaps heavy metals?) not yet identified.

Incidental Observations and Comparisons with Neighboring Areas

Several hares were sighted incidentally each day along the survey route, and fresh lynx tracks also were seen daily in every VCC except M-SW. Remains of a snowshoe hare were found at the end of D-WPS, appearing there on the third day of the survey. Sightings of hares and lynx tracks during the surveys each year and the observations of local residents (J. Reakoff, S. Schoppenhorst, Wiseman trappers, pers. commun.) correlate positively with our conclusion that the hare population peaked around 1999, then dropped some, holding fairly steady through 2001.

The apparent abundance of hares and lynx in our study area was in striking contrast to neighboring areas such as Marion Creek (about 10 miles south of the study area), where no hares were seen, and virtually no hare tracks either. One lynx track was seen in the upper Marion Creek area. Even more striking, however, was the difference in the degree to which snowshoe hares had browsed the vegetation in the two areas. While the two areas are similarly vegetated, the willows along Marion Creek appeared to be only lightly browsed, with relatively little girdling, and browsing was not evident at all on the spruce there. In contrast, browsed stems of willow, spruce, alder and poplar were very obvious in the study area northwest of Wiseman. (Browsing on shrub birch was not as conspicuous due to the small stature of that species, except where hares had dug down through the snow to reach it.)

The snowshoe hare populations in the region have been linked to fluctuations in other animal populations. We have already discussed the abundance of lynx in the study area and the diminished presence of lynx in neighboring areas such as at Marion Creek. A owl survey in Kanuti National Wildlife Refuge (in Kanuti River Canyon, about 100 miles southwest of Wiseman), reported that the great-horned owl population there has “crashed,” following the crash of the hare population in that area. While owl surveys were not conducted in Wiseman area, we have noted hearing great-horned owl calls there for the past 2 years. Also, golden eagles were observed wintering in the study area during 2000-2001, which is uncommon. (J. Reakoff, Wiseman trapper, pers. commun.),

RECOMMENDATIONS TO MANAGEMENT

1. Continue monitoring the snowshoe hare population. Data has been collected for 5 years now, and each year adds more value to this long-term data set.
2. If no snow falls during the survey period, count tracks for only 3 days (instead of 6).
3. For the 2002 survey, collect browse samples (clippings) for nutritional analysis and secondary compound concentrations. Also collect additional soil samples from areas already sampled to test for cadmium, arsenic and copper.
4. This project has led us to some interesting questions regarding the dynamics involved in this ecosystem. For example, why do hares consume particular mineral soils, and only at certain times during their population “cycle”? Why do lynx in our study area exhibit poor health during the peak of the hare cycle when one would expect them to be healthy? Why does this phenomenon not occur in neighboring populations? As stewards of the resources in Gates of the Arctic National Park and Preserve, the National Park Service is obliged to strive toward understanding the processes involved in this complex ecosystem. There is, apparently, some connection in our study area between the geology and the hare and lynx populations that results in conditions not found in other areas. Therefore, I encourage park managers to investigate further the hare population and its relationships to the soils and vegetation that they consume and the lynx that prey upon these hares.

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Appendix I. Deposition of tracks (including 1 trail) on 100m transects from the 2001 snowshoe hare track count survey near Wiseman, Gates of the Arctic National Park and Preserve, Alaska. Deposition of tracks was counted on each of 6 days and is the number of tracks (or trails) deposited in a 24-hr period. Vegetation cover and composition (VCC) codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow; 1, 2 or 3 distinguishes transects within the same VCC.

VCC	3/15/01	3/16/01	3/17/01	3/18/01	3/19/01	3/20/01	TOTAL	MEAN	SD
L-SB-1	6	19	5	12	11	10	63	10.5	5.01
L-SB-2	1	0	1	3	3	3	11	1.8	1.33
L-WA-1	8	6	6	6	9	8	43	7.2	1.33
L-WA-2	3	1	4	20	11	7	46	7.7	6.98
M-SW	23	19	12	7	4	10	75	12.5	7.23
M-SPW-1	10	17	11	11	6	5	60	10.0	4.29
M-SPW-2	16	25	14	7	8	12	82	13.7	6.53
M-SPW-3	34	22	20	16	20	17	129	21.5	6.50
D-WS-1	25	26	30	21	11	14	127	21.2	7.36
D-WS-2	11	13	6	6	6	10	52	8.7	3.08
D-WPS	49	31	22	19	18	20	159	26.5	11.98

Note: On 3/15/01, 21 tracks and one trail was deposited in D-WS1. For calculation purposes, the trail was included in that day's count as 4 tracks (bringing the count for that day to 25).

Appendix II. Retention of tracks and trails on 100m transects from the 2001 snowshoe hare track count survey near Wiseman, Gates of the Arctic National Park and Preserve, Alaska. Track retention was counted in two 3-day sessions and is the number of tracks or trails retained over time. Vegetation cover and composition (VCC) codes are as follows: L, M and D = lightly, moderately and densely vegetated cover, respectively; A = alder, B = shrub birch, P = poplar, S = spruce, W = willow; 1, 2 or 3 distinguishes transects within the same VCC.

VCC	3/15/01 trails		3/16/01 trails		3/17/01 trails		3/18/01	3/19/01	3/20/01
L-SB-1	9	0	17	2	27	1	8	18	23
L-SB-2	0	0	0	0	3	0	3	5	8
L-WA-1	10	0	8	2	11	2	8	16	25
L-WA-2	3	0	5	0	8	0	14	21	24
M-SW	21	0	30	1	33	3	8	15	19
M-SPW-1	12	0	29	0	34	2	10	20	24
M-SPW-2	13	0	34	0	49	0	6	19	28
M-SPW-3	25	1	35	2	51	2	13	31	35
D-WS-1	30	0	45	0	59	1	7	19	22
D-WS-2	12	0	26	0	42	1	10	19	23
D-WPS	39	0	66	1	78	3	17	32	42

Appendix III. Weather data from the 2001 snowshoe hare track count, conducted March 15 - 20, near Wiseman, Alaska, in eastern Gates of the Arctic National Park and Preserve. "Precip" refers to depth of precipitation in the last 24 hours.

DATE	TIME		TEMP (C)		WIND		SKY		PRECIP
	Start	Finish	Start	Finish	Start	Finish	Start	Finish	
3/15/01	11:11	13:06	-5.5	-4	calm	calm	thin overcast	thin overcast	0
3/16/01	11:20	13:33	-6	-6	calm	calm	overcast	thin overcast	0
3/17/01	11:31	13:44	-17	-13	calm	calm	clear	clear	0
3/18/01	11:35	13:18	-15	-12	calm	calm	clear	clear	0
3/19/01	11:58	13:51	-15.5	-14	calm	calm	clear	clear	0
3/20/01	11:51	13:17	-18	-13	calm	calm	thin overcast	light haze	0