

VEGETATION TRANSECTS
IN
GATES OF THE ARCTIC NATIONAL PARK AND PRESERVE

A SUMMARY OF THE DATA COLLECTED 1982 - 1988
AND AN EVALUATION OF OBJECTIVES AND METHODOLOGY

BY

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Since 1982, vegetation transects in selected human impact sites in Gates of the Arctic National Park have been resampled periodically, but no comprehensive summary, analysis, or critique of this work has been done. In addition, in resampling sites and attempting to analyze the data collected, many questions have arisen as to whether the transect methodology is meeting its objectives and how these objectives relate to Park management objectives. The purpose of this report is to summarize the work that has been done, evaluate the transect process, and make some recommendations for future work.

Background

The vegetation transect objectives and methodology were developed and first used in the 1982 field season. The stated objectives are as follows:

The human impact/vegetation transects allow for scientific baseline data collection in impacted areas. Not only will this provide GAAR with descriptions of current vegetation, but it will document the continuum from the undisturbed to disturbed vegetation in a given microhabitat. Data using percent cover figures can show degrees of impact in areas.

Besides a good description of current vegetation GAAR wants to document impact. The Park specifically wants to document impacted locations, amounts of trash, species indicative of impact, exotic species, mineral soil exposed, the effect of impact on loss of soil cover, and the change in species over time.

The methodology, in brief, consists of one or two transect lines that stretch across the impacted area and run out into undisturbed vegetation. Along a line, meter square plots are located, not randomly, but on the basis of whether they are "representative" of undisturbed, transition, and disturbed vegetation. Within the meter square plot the percent cover of the vegetation species is recorded, as well as categories including rocks, mineral soil, bare ground, litter, garbage, feces, charcoal, trail formation, and disturbance. Since one of the objectives was to document changes in plant species over time, transects have been resampled generally every two to four years. For purposes of relocating, the lines are defined by tagged endpoints, magnetic compass directions and verbal descriptions. Plots are designated by the distance along

the transect and which side of the line (N,S,E,W). For further details of the mechanics of setting up and sampling a transect, see the methodology section in the 1982 Human Impacts/Vegetation Transects report (Appendix A).

Site Summaries

Since 1982, a total of 18 transects have been established in GAAR (see map, Appendix B). There are four in the Arrigetch (#2,3,4,5) and one at Circle Lake, five in the N Fork of the Koyukuk area (Summit Lake, Bombardment Creek, Rainbow Creek, Red Star Lake #1 and 2), four in the Noatak (Pingo Lake, Kugrak, and two at Matcharak Lake), three at Walker Lake (Outlet, Site A, and Peninsula), and one at Narvak/Selby Lake. Site data will be discussed in terms of changes in percent cover of the various plant species and the "disturbance" categories within each plot. Several indexes of similarity (Bray and Curtis' version of the Sorensens' similarity index and Spatz' version of Jaccard's index - see Chambers 1983) were investigated as methods of mathematically expressing the degree of similarity in a plot between years and so assessing change. It was decided, however, to compare changes in individual species or categories since the ecological processes were of more importance than being able to look at one number as a measure of change.

Arrigetch/Circle Lake

Arrigetch #2 Lichen Knoll

This transect is located at a badly impacted campsite, HIS# 109, on the south side of Arrigetch on a prominent spruce-lichen knoll approximately one mile upstream from the mouth of Arrigetch Creek. The transect was established in early July 1982 and was resampled in early August 1984, in late July 1986, and late July 1988; four different sets of observers collected data. A total of seven plots were sampled along two perpendicular lines with two undisturbed, four transition, and one compacted vegetation type represented. Plot photos

were taken in 1984, 1986, and 1988.

Plot 1: The vegetation type remained transition and the organic layer variable from 1982 to 1988. Plot photos taken in 1984, 1986, and 1988 show the plot in about the same place; the 1988 plot, however, is approximately 0.1 m farther downhill than the 1984 and 1985 locations. Much of the data for this plot, both for vegetation and the other categories, consists of sets of fluctuating percentages that are probably more a function of observer bias/error than real processes. Moss cover was at 5% in both 1982 and 1984, jumped to 40% in 1986 and dropped to 20% in 1988. There was probably an overall increase in moss from 1982 to 1988 (the most dominant moss was Polytrichum juniperinum, a common pioneer moss on mineral soil). It is not clear whether there really was such a large increase in 1986 and then a drop in 1988 or if these changes are a result of observer bias. Similarly, lichen cover, was 15% in 1982, dropped to 10% in 1984, rose to 30% in 1986, and dropped to 20% in 1988. Litter cover was 40% in 1982, dropped to 15% in 1984, rose to 50% in 1986, and then dropped to 25% in 1988. The mineral soil cover fluctuates too, but the data is more consistent if bare ground and mineral soil are lumped into an exposed soil category. The 1982 - 1984 soil data may be evidence of observer confusion over mineral soil vs. bare ground since no mineral soil was recorded in 1982, but 40% bare ground was, and then, in 1984, 50% cover by mineral soil was recorded, but no figure for bare ground. The category that one can probably say something valid about is that disturbance increased from 1982 (5%) to 1988 (85%).

Other vegetation data of note: The grass Elymus innovatus increased from 1% to 10% from 1982-1986; the forb Oxytropis campestris increased from 1% to 15% from 1982-1988. (The 1986 figure for O. campestris was also 15%, but that looks too high, based on the photo). Eriophorum angustifolium was recorded for 1986, but for no other years. The occurrence of this sedge in this plot is unlikely since it is found in wet areas and this site has dry mineral soil. The forb Epilobium latifolium, however, which is recorded for all the other

years, and which is clearly present in the 1986 slide, is not recorded for 1986. Possibly the observer confused the sedge name with the name of another fireweed species, Epilobium angustifolia. Another species clearly in the 1986 photo, but not recorded, is Vaccinium vitis-idaea. Of interest is that the V. vitis-idaea looks healthy in 1986, but is brownish and dead-looking in 1988. Whether this could be due to disturbance or the extremely dry weather in the summer of 1988 cannot be said.

Plot 2: Comparison of the photos from 1984, 1986, and 1988 shows that the 1984 and 1988 plots look the most similar (based on location of the tree root); the 1986 plot appears to be shifted to the east, perhaps about 0.1 m. There has not been any substantial change in this plot. The vegetation type remained transition and the organic layer variable from 1982 to 1988. It consisted overwhelmingly (95%) of spruce litter, needles, and sticks. A trace of Ledum was present in 1982 and 1984, but disappeared in later years. A trace of a grass, Calamagrostis canadensis, was recorded in 1982, but not in subsequent years. Another grass, Elymus innovatus, was recorded in 1986, but no other years; this may be due to the plot shift. Moss (5%) was recorded in 1984, but not in any other years. No figure for Vaccinium vitis-idaea was recorded for 1986, although it was clearly present in the photo; an estimate of 20% was made from the photo. The percentage of the plot considered to show "disturbance" probably varied the most, but perhaps more due to observer bias as to what to consider "disturbed" than to actual changes. In 1982, just a question mark was recorded, 10% was considered disturbed in 1984 and 1986, while in 1988, an uncertain 65% was recorded.

Plot 3: The photos reveal that the 1984 and 1988 plots were very close to the same, based on the location of several rocks embedded in the soil. The 1986 plot has fire remains in it and it is difficult to say how it relates to the other years' plots. The vegetation type in this plot was considered to be

compacted in 1982 and 1984, but transition in 1986, but back to compacted in 1988. This plot is virtually devoid of vegetation. The organic layer remained compacted from 1982 to 1988. The most substantial vegetation change is the recording of moss (12%) in 1988; it had not been recorded for any other years. The other change, the 10% dead spruce roots in 1988, appears, from the photos, to be a case of figures placed in the wrong column; no roots are visible in the plot 3 photo, but are visible in the plot 4 photo. There seems to be confusion over bare ground vs. mineral soil here. In 1982, 5% mineral soil was recorded and 90% bare ground, 95% and 99% mineral soil were recorded in 1984 and 1986, respectively, but no bare ground, and in 1988, 30% mineral soil and 50% bare ground were recorded. Charcoal took a big leap in 1986, to 30%, with the remains of a campfire present. The decrease in 1988 may be due either to plot relocation or dispersal of the previous charcoal.

Plot 4: Comparison of the 1984, 1986, and 1988 photos shows that the 1986 plot is shifted about 0.3 m to the N of the 1984 location, so about 2/3 of the plot is the same. The 1988 plot, in relation to the 1984 plot, is shifted about 0.30 m to the N, but also about 0.1 m to the W. The figures between these years, therefore, are not strictly comparable. In 1982 and 1984, the vegetation type in this plot was transition; this changed in 1986, when it was considered to be compacted and that status continued into 1988. The organic layer condition remained variable from 1982 to 1988. One real trend that the figures reflect and the photos do show is the increasing exposure of roots from 3% in 1982 to 10% by 1988. (1984 does not show any number for Picea glauca, but roots are evident in the photo, so an estimate was made later). Another real process, based on the photos, is a loss of Vaccinium vitis-idaea; the plants in the 1988 photo look like they are dying. There was no mineral soil exposed in 1982, but there has been some in the years since, although no clear upward trend is present. The increase in the percentage of the plot considered to be disturbed may be more a result of observer bias or shifts in plot location than a real

increase. A question mark followed by trampled was recorded in 1982; in 1984, 20%, roots exposed; and in 1986 and 1988, 100%. These later figures could be too high, the 1984 figure too low; it is not clear what this plot looked like in an undisturbed state. Was it much more vegetated or has it been largely spruce litter for a long time?

Plot 5: The vegetation type and organic layer remained undisturbed and good, respectively, from 1982 to 1988. In 1988, the last meter of transect Line A was 49.6 to 50.6, rather than 49.5 to 50.5., so that is what was sampled then.

In comparing the photos for 1982, 1984, and 1988, the only apparent difference is the prominence of the spruce branches and this may be due to the different angles from which the photos were taken, since the spruce figures are fairly similar between years. The figure for Betula papyrifera in 1986 is most likely just misplaced, and should be in the Betula glandulosa row. Betula nana was recorded in 1982 (5%), but in 1984 and 1988, B. glandulosa was recorded as being present. Whatever the species, the increase between 1982 and 1984 is fairly large (5% to 30%); it is not clear if it could have actually increased that much in two years, or similarly, if the increase from 30% to 50% between 1984 and 1986 could have occurred. The large fluctuation between the years in Ledum, 60% to 20% to 60% to 15%, would seem to have to be due to plot shifting, since these would be very large observer errors. The explanation for the large difference in the litter cover in 1986 (100%) as opposed to the other years (approx. 25% to 30%) is not clear. As was true of the other plots on this transect, no figure was recorded for Vaccinium vitis-idaea, where in fact, it was obviously present in the photo; a figure of 60% was assigned from the photo. Another questionable figure is the drop in lichen from 30% to 15% (1982 to 1984) and then its increase from 15% to 40% (1984 to 1986).

Plot 6: This and plot 7 are on line B. The photos show a plot location that has shifted, at least since 1984. The 1984 and 1986 plots have only

approximately a third of their areas in common and the 1986 and 1988 plots have about half their areas in common. All three share only about a quarter of a plot so comparison of the data is not meaningful. Perhaps the plot shifts explain why the vegetation type was undisturbed in 1982, transition in 1984, back to undisturbed in 1986 and transition in 1988. The organic layer has remained variable for all sampling years. The classification of the 1986 plot as undisturbed may be a combination of the different plot location and a subjective interpretation.

Plot 7: Comparison of the photos from 1984, 1986, and 1988 show substantial shifts in location. The 1984 and 1986 plots have about half their areas in common; the 1986 and 1988 plots have about a third in common. All three plots share only about a quarter of a meter square plot. Comparison of the data, therefore, is not meaningful. A general observation from viewing the photos, however, is the dying of some of the Vaccinium vitis-idaea and browning of some of the Empetrum nigrum.

Arrigetch #3 "Forks" Campsite- Upper Arrigetch

This transect is located approximately a half mile downstream from the Fork in Arrigetch Creek, on the S side of the Creek. It is the site of HIS# T1-8. The vegetation is open white spruce forest, open shrubs - Salix and Alnus, and Dryas hummocks. The transect was established in early July 1982 and was resampled in late July 1984, late July 1986, and late July 1988. Four different sets of observers collected data. In 1982, six plots were sampled, one undisturbed, three transition, and two compacted vegetation types. In 1984, because of a tent being on the original plot, a new plot was established, and in 1986 and 1988, both of these plots were sampled, for a total of seven. Plot photos were taken in 1984, 1986, and 1988.

Transect Changes: The 1982 information on the T2-2 to T2-3 line length was recorded as 15 m; in 1988, the line length to the creek bank alone (not over the creek to the boulder itself that marks T2-3) was measured at 28.3 m. The 15 m must be an error.

Plot 1: The vegetation in this plot was undisturbed in 1982 and the organic layer was good. In 1984 the vegetation was described as transition and the organic layer as variable, but a note on the data sheet indicates that this may be due to a slight shift in the transect line location. Both the 1986 and 1988 data, however, also were transition and variable, so, unless the transect line was shifted relative to the 1982 line for all the years, then these changes are probably real. On the other hand, the plot locations of 1984, 1986, and 1988 are shifted somewhat relative to each other, based on photo comparisons. The 1986 plot appears to be shifted about 0.1 m to the S and 0.1 m to the W of the 1984 location, while the 1988 plot location may be shifted a few cm W of the 1986 plot. Even these relatively small shifts in the plot location, and not knowing how they relate to the 1982 location make it difficult to do much meaningful analysis of the data, but a few things stand out as problems in data collection. According to the data, Carex scirpoidea increased substantially between 1982-1984 (5% to 25%) and between 1984-1986 (25% to 45%). There is no way of knowing if the 1982-84 change is a result of location shift. The 1984-86 change may be due to a combination of real growth and observer bias; in the 1984 photo the sedges are trampled and so may appear to cover less than the untrampled 1986 sedges. Aster sibiricus increased from 5% (1984) to 30% (1986), but, as with the sedges, the trampled plants in the 1984 plot may just have appeared as less. In an apparent case of misidentification, the data shows no Hedysarum alpinum in 1986, although it was present in 1982, 1984, and 1988 and appears in the 1986 photo, but Polemonium acutiflorum is recorded in 1986, but not in any other year. If no flowers were present, the leaves of the two plants could conceivably be confused. The increase in the Hedysarum

alpinum which occurred between 1984 and 1988 (from 2% to 15%) may be another case of observer bias combined with some real growth. A real change observed from the photos: the increased exposure of roots.

Plot 2-1982: Comparison of the 1986 and 1988 photos shows that the 1988 plot location was shifted about 0.1 m to the S and at least 0.25 m to the W of the 1986 location, so that at least a third of the meter square is not shared by the 1986 and 1988 plots, which makes meaningful data comparison difficult. (This plot was not sampled in 1984). From comparing the photos, it is clear that at least two of the changes between 1986 and 1988 are due to the plot shift alone, i.e. the decrease in Carex scirpoidea and the increase in Aster sibiricus. In addition, since no photos were taken of the plot in 1982 and there is no way of knowing how the 1982 plot location relates to the 1986 and 1988 locations, nothing concrete can be said about whether the large increases in Carex, Dryas, and Aster are real between 1982 and 1986.

Plot 2-1984: This plot was established in 1984, when a tent was located on the original plot 2; it is 2 m away from the 1982-plot 2. The vegetation type remained compacted 1984-1988 as did the organic layer. The photos for 1984, 1986, and 1988 reveal the plot locations were shifted in 1986 and 1988, in relation to the 1984 location as well as in relation to each other. The 1986 plot appears to be shifted approximately 0.25 m W of the 1984 plot, while the 1988 plot appears to be shifted approximately 0.5 m W and 0.1 m S of the 1984 plot. When comparing any two plots then, about half the meter square areas will not be shared. Once again this makes analysis of the data between years inappropriate.

Observations from the photos: Greater root exposure between 1984 and 1988 and possibly more rocks exposed.

Plot 3: The vegetation type remained transition from 1982 to 1988, but the

organic layer was originally good, changed to variable in 1984, to compacted in 1986 and back to variable in 1988. Based on the photos, these changes may be a result more of observer bias than real changes. The photos also show that the plot locations for 1984 and 1986 look very similar, but the 1988 plot may be shifted to the N and W so that the patch of sedges on the NW section of the plot has grown in area in the 1988 plot relative to the 1984 and 1986 plots while the patch of sedges on the SE section has diminished. The changes between 1986 and 1988, most of them not major, could be a result of this plot location shift. The largest change was in bare ground (from 55% to 20%), but this change looks more like observer differences in the definition of bare ground than real change. Possible trends from 1982 to 1986 (assuming the 1982 location is the same as 1984 and 1986), are an increase in the sedge Carex scirpoidea, (from 8% to 20%), the forb Aster sibiricus (from 1% to 10%), moss (from 1% to 15%), and trail formation and disturbance (both from 15% to 55%).

Plot 4: The vegetation type was defined as transition in 1982 and remained that way to 1988. The organic layer remained good from 1982 to 1988. The photos show that the 1986 and 1988 plot locations were shifted in relation to the 1984 plot (no photo for 1982). The 1986 plot appears to be shifted approximately 0.15 m to the N of the 1984 location, while the 1988 plot appears to be shifted 0.15 m to the N, but also 0.1 m to the W of the 1984 and 1986 plots. The 1986 plot contains about 85% of the 1984 plot (plus .15 m² new area) and the 1988 plot contains about 75% of the 1984 plot (plus .25 m² new area). The 1988 plot contains 90% of the 1986 plot (plus .1 m² new area). As seen in plot 3, it is difficult to discount these plot shifts as reason for much of the data changes between years. The increase in bare ground between 1984 and 1986 (from 0% to 5%) is definitely due to the plot shift. Some of the differences between years also appear due to observer biases.

It is difficult to determine what are the real changes.

Plot 5: The original 1982 plot had a compacted vegetation type and a compacted organic layer. Not much can be said about the data for this plot because of the plot location shifts. In 1984, the plot was purposely relocated between 19.5 m to 20.5 m rather than the original 19 m - 20 m because of the presence of a tent on the original plot. The 1986 plot is supposed to be at the original location, but appears to be in about the same area along the transect line as the 1984 plot and shifted about 0.25 m to the N. The 1988 plot, on the other hand, appears to be located about 0.5 m to the E of the 1986 plot and 0.15 m to the N. The one real qualitative change that can be seen in the photos is what appears to be the loss of organic soil between 1984 and 1986. In the 1984 photo the soil around the prominent rock is dark brown, while in the 1986 and 1988 photos, there is a little bit of organic material, but the basic substrate is sand. It is unclear what part human impact may have played in causing this loss of organic soil (loss of vegetative cover?) and what part may be due to other causes (flooding from the creek?).

Plot 6: Comparison of the photos from 1984, 1986, and 1988 suggest major shifts in the plot locations between each of those years, although the exact locations in relation to each other cannot be determined. Therefore, it may be the changed plot locations that has caused the change in the vegetation type from compacted to transition to undisturbed and the percentage of the plot considered disturbed from 30% in 1982, to 25% in 1984, and to 0% in the 1986 and 1988 plots.

Arrigetch #4 -Arrigetch Creek Upper Campsite

This transect is located approximately a quarter mile above the first major forks in Arrigetch Creek and about a half mile above the "Forks" transect (#3). It is the location of HIS# 79. The vegetation is an open Salix/Betula community with moist Carex and Dryas hummocks and few mosses and lichens. The transect was established in early July 1982, and was resampled in late July

1984, late July 1986, and late July 1988. Four different sets of observers collected data. Four plots were sampled in 1982 with one undisturbed, two transition, and one compacted vegetation types represented.

Transect Changes: The tag T2-4 was found on the boulder, but no tag was found on an appropriate white spruce tree at N 10° approximately 150 m from the boulder; there was no tree at this compass heading. We finally sighted on one at N 25° the most obvious candidate for the original endpoint, but did not leave a tag.

Plot 1: Comparison of the 1984, 1986, and 1988 photos shows that the plot location has shifted. The 1988 plot appears to be shifted about 0.25 m N of the 1984 plot). The 1986 plot appears to be shifted 0.75 m to the N of the 1984 plot. In addition, the 1984 data sheet has a note about the difference in the vegetation type (transition in 1982, undisturbed in 1984) being probably due to a slight difference in the line location. Most of the data changes could be accounted for by the location shifts. A real difference evident between the 1984 and 1988 photos is a patch of Dryas which is green and healthy looking in the 1984 plot, but is dead-looking in the 1988 plot. This may be a consequence of increased trampling between 1984 and 1988 (from 2% to 15%).

Plot 2: From comparison of the 1984, 1986, and 1988 photos, it appears that the location of the 1988 plot is shifted about 0.3 m to the W in relation to the 1984 location; landmarks in common with the 1984 or 1988 plots could not be found in the 1986 plot, so there is no way of telling how it relates to the others. The fact that there is Dryas cover of about 25%-30% in 1982, 1984, and 1988, but none in the 1986 plot may indicate a significant shift in the plot location. In light of these shifts, it is difficult to say anything meaningful about any trends in the data.

Plot 3: Comparison of the photos for 1984, 1986, and 1988 reveals major location shifts; between the 1984 and the 1986 plots and the 1988 and the 1986 plots there is no common area. The eastern third of the 1984 plot is shared with the 1988 plot. It is not possible to say how the 1982 plot relates to any of the other plots, but a note on the 1984 data form says differences such as the change in vegetation type from compacted to transition may be due to a plot shift. Any analysis of the data in terms of the changes between years would be meaningless.

Plot 4: Comparison of the 1984, 1986, and 1988 photos does not clearly reveal how each year's location relates to the others; there are no distinctive features. Since the other plots were shifted, however, it is likely that these are, too. If the location were constant, some of the trends would be from undisturbed to transition vegetation type, good to variable organic layer, increased disturbance (from 0% in 1982 and 1984, to 100% in 1986, but 25% in 1988), increased sedge cover (Carex scirpoidea) (from 5% to 70%), and increased Dryas cover (from 15% to 50%)

Arrigetch Creek #5 Birch Knoll

This transect is located at the uppermost birch lichen knoll on the first grouping of knolls that are encountered near Arrigetch Creek. It is about 1 1/2 mi SW of the Alatna River and 200 m above Arrigetch Creek. It is the site of HIS# 67. The transect was established in late July 1984 and was resampled in late July 1988. Two different sets of observers collected data. Four plots were sampled in 1984, one undisturbed, two compacted, and one transition vegetation type.

Transect Change: The original transect consisted of two lines, T1 (a white spruce) to T2, an unmarked point in a fire pit at a compass bearing of 320° and 19 m from T1. Another line ran from the fire pit to a birch tree at a bearing

of 332°. When the transect was resampled in 1988, the line T1 to T2 could not be set up with the given bearings and still locate plots 2 and 3 where they appeared to be in the diagram. Also, there was no fire ring present in 1988, just a depression that could have been the former fire ring, so it wasn't obvious where the endpoint should be. A new endpoint was set up at a bearing of 314° and 19 m from T1, and the 1984 plot 4 was abandoned. Plot 1, 2, and 3 were resampled.

Plot 1: Comparison of the 1984 and 1988 photos shows the plot locations to be very similar. Based on the photos and the data, this plot has suffered increased disturbance since 1984 (from 30% to 70%). Trends include a decrease in Vaccinium vitis-idaea (from 20% to 10%), an increase in lichens (from 5% to 25%) with the increase being in squamules, the primary stage of the fruticose lichen, and an increase in exposed rocks (from 0% to 5%) and bare ground (from 0% to 10%)

Plot 2: The 1984 photo is missing, so nothing is known about how the locations of 1984 and 1988 compare. The plot had compacted vegetation and organic layer in both 1984 and 1988. Trends include increasing grass (from 0% to 4%), moss (from 10% to 50%), and rocks (from 0% to 3%). The status of lichen is unclear; the 1984 total was 15%, but then, the different lichen species total cover equals 28%. The 1988 total was 15%. No figure was collected for bare ground in 1984, but in 1988 there was 25% cover by bare ground. In 1988, the disturbance resulting from the trail remained at the 1984 level of 90%.

Plot 3: The 1984 plot photo is missing, so again no comparison can be made of plot locations. The vegetation type remained mostly undisturbed, but, in 1988, there was a strip of disturbed vegetation on the W side of the plot, paralleling the trail. No clear trends are evident in the data.

Plot 4: As stated above, this plot was not resampled because it could not be relocated with any confidence.

Circle Lake

This transect is located on the west side of Circle Lake, just in from the peninsula. The transect was established in early July 1982 and was resampled in late July 1986. The site vegetation was described as open black spruce with dense shrub cover of Salix, Betula, and Alnus spp. with an open area of tussock type tundra characterized by Carex Bigelowii. Five plots were sampled, representing two undisturbed, one transition, and two compacted vegetation types. Two different sets of observers sampled the plots. Plot photos were taken only in 1986, so plot locations cannot be evaluated.

Plot 1: The vegetation type remained undisturbed and the organic layer good. There were increases in almost all of the vegetation categories, some major. Moss cover increased from 5% to 53%; almost all of the moss is Sphagnum. Other major increases were in Vaccinium vitis-idaea (from 1% to 25%), Ledum palustre ssp. decumbens (from 5% to 40%) and Betula glandulosa (from 25% to 45%). Smaller increases occurred in Carex Bigelowii (from 40% to 50%) and Vaccinium uliginosum (from 50% to 65%). While the live vegetation was increasing, the litter cover dropped by almost 50%.

While percent cover increases would be expected over four years, without knowing the growth rates of Sphagnum and V. vitis-idaea, it is difficult to evaluate whether these large increases could be real changes or must be accounted for by an error in plot relocation.

Plot 2: The vegetation type remained transition and the organic layer variable.

The major changes are the appearance and predominance of grass (Calamagrostis canadensis - 60% cover) and the increase in moss from 1% to 70%. While grass increased, however, the sedge Carex Bigelowii decreased (25% to 15%). Betula glandulosa and Betula hybrids increased by 12%.

Not surprisingly, while the vegetative cover was increasing, the percent bare ground was decreasing, 20% to 1%. Litter dropped by half.

The appearance and predominance of Calamagrostis canadensis in this plot is not unexpected; this grass is a common invader of disturbed sites in interior Alaska. Details on the moss would be helpful to indicate whether this large increase was due to pioneer moss species. (The 1986 photo does not clearly show the moss).

Plot 3: The vegetation type changed from compacted to transition, while the organic layer remained compacted. The major changes were the large increases in graminoids and moss. In this plot the sedge Carex Bigelowii that was present in 1982 increased (from 40% to 75%) and grass (Calamagrostis canadensis) appeared and increased to 15%. Moss increased from 8% to 50%; according to the data, Sphagnum appeared and increased to 15% while Polytrichum disappeared. Again, as would be expected, bare ground dropped, from 60% to 5%.

Contrary to the previous "recovering" Plot 2, where litter dropped, here the percent cover by litter rose dramatically from 2% to 75%. The percent cover of disturbance fell from 100% to 0% as regrowth occurred.

Plot 4: This is another recovering plot. It was the site of a fire pit. The vegetation type changed from compacted to transition while, as in plot 3, the organic layer remained compacted. This was the most impacted plot on the transect with 98% bare ground in 1982. Again, large increases were seen in graminoids and moss cover. The sedge Carex Bigelowii showed the largest increase (of vascular plants) in this plot (from 0% to 35%), while the grass Festuca altaica appeared (from 0% to 15%) and Calamagrostis canadensis remained at a very low percent cover. Moss invaded and increased to 70%.

Rocks increased (from < 1% to 10%), charcoal decreased (from 25% to 15%), trail formation decreased (from 15% to 0%), and overall disturbance decreased (from 100% to 50%).

Plot 5: This was an undisturbed plot that remained undisturbed with continuing good organic layer. There was no consistent pattern of all plants present in 1982 increasing in cover. Some species were lost, some new ones appeared. Salix padophylla (25%) and Sphagnum moss (20%) present in 1982, were gone in 1986, while Betula, not present in 1985, rose to 85% cover in 1986. Carex Bigelowii and Vaccinium uliginosum both showed a decline, while Ledum and Calamagrostis increased. No changes were noted for the other categories, other than the existence of a small amount of charcoal and a trace of garbage.

The loss and appearance between 1982 and 1987 of a number of species with significant percent cover could point to an error in plot relocation. Information about growth rates could help in determining if it would be possible, for instance, for shrub birch to go from 0% to 85% in 4 years.

N Fork of the Koyukuk

Summit Lake

The Summit Lake transect was established in late August 1982 and it was resampled in June 1984. Summit Lake is the lake near the headwaters of the N Fork of the Koyukuk and near the Continental Divide. The line ran from the NE corner of the private cabin to a boulder and then turned 90° and ran to the lake edge. Due to its location on private land, this transect has been abandoned.

The vegetation of the area was described as moist sub-arctic tundra characterized by Salix pulchra and sedges along the lake, and, at higher elevations, rock and dry arctic tundra. Five plots, two undisturbed and three transition were sampled. None of the transition plots seem to have been badly impacted, i.e., none had a compacted organic layer and none had any significant exposed mineral soil or bare ground. Trampling seems to have been the extent of the impact to the transition plots. There were almost no changes recorded in the vegetation for any of the plots. The percentage of disturbance changed

to zero for even the "transition" plots. Of these transition plots, Plot 1 consists of moss, Salix reticulata, S. pulchra, and small amounts of forbs; Plot 4 consists of moss, S. reticulata, and small amounts of S. pulchra, graminoids and forbs; and plot 5 consists of moss, Dryas, S. reticulata, and small amounts of graminoids.

The moss-dwarf willow ground cover present in these plots may be very resistant to impact, but without knowing the extent of impact that these plots had received, nothing firm can be said. Certainly they seem to have recovered from the relatively minor impact present in 1982.

Bombardment Creek

This transect is located on the S side of the N Fork of the Koyukuk River, W side of Bombardment Creek. This is the site of an old hunting camp. The transect line runs from an old tent pad to a food cache across two trails. The vegetation of the area is a transition zone between open spruce forest and subarctic tundra. Dominant species are Picea glauca, Salix alaxensis, and Alnus crispa. Five plots (one undisturbed, two transition, and two compacted) have been sampled three times, in late August 1982, in 1984, and mid-July 1987, by three different sets of observers. Plot photos were taken only in 1987, so plot locations cannot be compared.

Transect Change: The transect line was measured to be 21 m when it was established in 1982; in 1987, it was found to be 20.6 m long. See Plot 5 for possible consequences of this discrepancy. It is not known what effect this measurement difference had on the other plot locations and so the comparability of their data between years.

Plot 1: In 1982, the vegetation type of the plot was compacted, as was the organic layer. By 1987, although the organic layer was still compacted, the vegetation present, largely moss and Arctostaphylos rubra, was not; "early

transition" was used to describe it. There appeared to be slight increases in moss (from 25% to 30%) and the A. rubra (from 1% to 5%). Bare ground decreased (from 7% to 1%) as litter cover (leaves) increased (from 85% to 95%). These differences occurred between the 1984 and 1987 sampling.

These slight changes could be accounted for partly by observer biases; the change in bare ground vs. litter cover and the increase in A. rubra stand the best chance of being real.

Plot 2: There was no change in the status of the vegetation type, (transition) or of the organic layer (variable). There were no changes between 1982 and 1984 other than the appearance of Arctostaphylos rubra in one corner of the plot. The significant vegetation change between 1984 and 1987 was increased Equisetum scirpoides (from 1% to 10%). In addition there was a large increase in litter cover and a decrease in bare ground.

The changes in Equisetum and litter cover are probably real processes, assuming a constant plot location. The appearance of A. rubra could be accounted for either by expansion of clumps into the plot or by a slight shift in the plot location.

Plot 3: The vegetation type, undisturbed, has remained the same from 1982-87, and the organic layer remained good. Slight increases in cover by Pyrola sp. (leaves only), Empetrum nigrum, and Vaccinium vitis-idaea were reported between 1984 and 1987. The largest and most puzzling change is in the total moss cover. The figure reported in 1982 was 97% cover, the total recorded for 1984 was 50%, but the 1987 observer agreed with the 1982 figure of 97%. No other changes were noted.

The increase in Pyrola sp. is large enough (2-10%) that it could be real; the increases in Empetrum and Vaccinium are small enough that they could be due to observer bias. The 1984 moss total would seem to be an error; even slight

shifts in the plot location would not produce a plot with a moss cover this low (50%) In addition, the moss in the 1987 plot is not an invasion type that could have recovered the plot in 3 years if, in fact, moss cover had dropped from almost 100% in 1982 to 50% in 1984.

Plot 4: The vegetation type remained compacted as did the organic layer from 1982-1987. The only significant change in this plot was a 53% increase in the total moss cover; the predominant moss was a tiny moss so this moss invasion could be real, again assuming constant plot location.

Plot 5: The vegetation type and the condition of the organic layer continued to be transition/undisturbed and good, respectively, although the percent cover of disturbance increased from 0% to 5% from 1982-87. A trace of grass appeared in 1987, a small amount of Hedysarum alpinum was recorded first in 1984, and a Pyrola sp. increased slightly between 1982-87. The 1987 moss total increased from 70% to 90%.

As stated earlier, the transect line was found to be 0.4 m shorter than was initially recorded in 1982. When it came time to resample Plot 5, it was found that the only way a small white spruce tree could be within the plot was if the plot ran from 21.6 m to 22.6 m, so this change was made.

Rainbow Creek

The Rainbow Creek transect has only been sampled once, in late August 1983. Three plots were sampled and were identified as "Empetrum & Hylocomium", "path", and "Hylocomium splendens", rather than by the transect terminology. An attempt was made to relocate this site in 1987 using the FIREPRO helicopter, but it was not clear exactly where "Rainbow Creek" is located (it is neither on the map nor a common name), and the Koyukuk water level was very high at the time so it was decided to try to locate it later in the summer. This was never done due to the loss of the helicopter in August. Later on in October, a

report by Jack Major was found which mentioned an airstrip at Rainbow Creek. This must mean the strip near where J. Stansel had his cache and campsite (now referred to as Boreal Creek by GAAR staff). No attempt was made to locate it in 1988 since other transects were given priority.

Red Star Lake #1

This is one of two transects which are located at the N end of the middle Red Star Lake (see Red Star Lake #2 below). This transect runs toward the lake from a spruce 148 m from the lake edge to a point 62 m from the tree. The vegetation was described as tree limit spruce forest/subarctic vegetation around the lake and arctic vegetation on the slope above the lake. This transect was set up in late August 1982 and resampled only in late July 1987. Two different sets of observers collected data. Ice was still on the lake at the end of June 1984 and part of this transect was covered, so Red Star Lake transect #2 was set up. Plot photos were taken only in 1987, so plot locations cannot be compared.

Plot 1: The vegetation type remained undisturbed and the organic layer good between 1982 and 1987. There may have been slight increases in the moss (from 1% to 50%) and sedge (Carex scirpoidea -from 2% to 6%- and C. membranacea - from 1% to 4%) cover, the appearance of Epilobium latifolia (5%), and an increase in Dryas integrifolia cover from 40% to 90%.

The slight increases in the sedges and moss and the appearance of E. latifolia seem reasonable. Without knowing what the growth or expansion rate of Dryas is, however, it is impossible to say if the large increase is a reasonable change over 5 years or could only be due to shifting of the plot location when it was resampled.

Plot 2: The vegetation type remained transition although there were no signs of recent disturbance; the organic layer remained variable. There were large differences in the percent cover by several of the plant species. Carex scirpoides increased from 1% to 20% and moss increased from 20% to 40%, whereas

Dryas integrifolia decreased from 50% to 30%. In the non-vegetation categories, there were increases in the cover by rocks (from 5% to 35%) and bare ground (from 2% to 15%). The little mineral soil present in 1982 (2%), however, disappeared. Litter was reduced by half (from 50% to 25%). Disturbance, recorded as 100% in 1982, was considered to apply to only 25% of the plot in 1987.

This could be a plot in which further disturbance after 1982 might have reduced the percent Dryas, while exposing more rocks and bare ground, but has since been recovering, i.e. increased sedge and moss cover. The sharp decrease in the percentage of the plot considered to be "disturbance" would seem to reflect this recovery. On the other hand, the method in which this plot was established (the transect runs from a tree to a point that must be located in relation to another tree using compass readings) leaves room for error in relocating the plot and there is no way to rule this out as a reason for the 1987 plot differences.

Plot 3: The vegetation type changed from compacted to compacted/transition while the organic layer continued to be compacted. The trend for all the plant species in the plot was increasing cover. Total cover by all sedges (Carex aquatilis, C. scirpoidea, and C. membranacea) increased from 2% to 16%. Of these carexes, only C. scirpoidea was reported in 1982. Dryas integrifolia may have increased slightly. Salix arbusculoides appeared, covering 10% in 1987. Moss cover increased most dramatically, from 2% to 50%. At the same time, cover by rocks, litter, bare ground and disturbance all decreased by large percentages. (Rock: 30% to 15%; litter: 50% to 10%; bare ground: 30% to 0%; disturbance: 100% to 80%) Charcoal increased greatly from 6% to 75%. This was the site of a fire ring in 1982; this increase in cover by charcoal is most likely due to the breaking up of the fire ring and scattering of the charcoal.

Red Star Lake #2

Red Star Lake transect #2 is located E of transect #1. It runs from near the lakeshore up a small hill across a trail to a large white spruce, then 90° W to another white spruce. The transect was set up in late June 1984 and then resampled in late July 1987. In 1987, plots 1 and 2 were sampled on 7/2, but a tent was pitched on plot 3, so the site was revisited on 8/18 to finish the transect.

Plot 1: The vegetation type, transition/disturbed and organic layer status, partly compacted/some natural, remained the same from 1984 to 1987. Differences between the two years consist of many increases and decreases with no clear pattern of increased or decreased disturbance. Total coverage by sedges (Carex spp.) increased from 5% to 10%. Dryas cover increased from 5% to 30% while moss cover decreased about the same amount. Small percentages of the forbs Tofieldia coccinea and Hedysarum alpinum and the dwarf shrubs Andromeda polifolia and Vaccinium uliginosum were no longer present in 1987, while small amounts of Equisetum, Shepherdia canadensis, and Parnassia palustre appeared in 1987. A small amount of Salix was present both years, but was identified as S. glauca in 1984 and S. alaxensis in 1987. White spruce seedlings that were present in 1984 were not present in 1987. Cover by rocks decreased from 20% to 1% in 1987 and litter increased from 0% to 75%. The litter increase was due to the presence of a log in the plot. In August when the third plot was sampled, this log was gone. Trail formation was not present in 1984, but 80% of the plot had trail formation in 1987. Disturbance, however, was seen as decreasing (from 100% to 75%) between the two dates.

Plot 2: The vegetation type and organic layer remained undisturbed and good, respectively. Large increases occurred in the cover percentages of moss, the forbs Hedysarum alpinum, Epilobium latifolia, and the shrub Potentilla fruticosa. Lichen cover increased from 10 to 15%. Small amounts of Equisetum and the forbs Polygonum viviparum and Tofieldia were new with the 1987 sampling, while the dwarf shrub, Andromeda polifolia, disappeared. Litter shot

up from 5% to 50%, a trace of rocks appeared, and the 5% bare ground in 1984 disappeared.

Growth, as evidenced by increases in percentage cover, would be expected in an undisturbed plot. The appearance of small amounts of Equisetum, Polygonum, and Tofieldia is not surprising. It is not clear why there was such a large increase in litter in an undisturbed plot; details on what the litter consists of would help in interpreting such changes. No change in the Dryas cover over three years creates questions, if the increase in Dryas in plot 1 during the same time period is real. It may simply reflect the difference between processes in an undisturbed plot and a "transition" plot or could be due to plot location shifts.

Plot 3: One of the end points for this part of the transect was described as "Picea glauca; forked tree". The only tree that fit this description had fallen down by 8/18/87, but no tag was found. The transect line and plot 3 were relocated as near as possible to what it might have been in 1984. A new tag was attached to a large root of the downed tree.

The vegetation type remained transition/disturbed while the organic layer changed from compacted, some natural to compacted, no natural. The tiny amount of grass, Hierochloe alpina, disappeared by 1987 leaving no vascular plants and only moss (Polytrichum - a pioneering moss on mineral soil) and lichen (much of it flattened). Both moss and lichen increased. The lichen increase is probably due to the fragments being spread around rather than any growth (the lichens present were the slow growing Cladina and Cetraria types). Mineral soil appeared (2%), while bare ground decreased, perhaps covered by litter; litter increased from < 1% to 20%. Disturbance increased from 5% to 100%. The decrease in rocks could represent campers moving rocks to improve a tent site.

The loss of one stable endpoint on this portion of the transect casts doubt on the exact duplication of the 1984 plot location. The reduction of

vegetation cover from the extensive lichen cover to the hardier Polytrichum moss layer is probably a real process in this vegetation community.

Noatak

Pingo Lake (Embryo Lake)

Although the lake was referred to as "Embryo Lake" when the transect was set up, it is, at least now, more commonly known as "Pingo Lake". It is a well-used drop-off point for Noatak River trips. The transect site is located on the E side of the lake, between the lake and the portage trail to the Noatak River. The general vegetation of the area is open Salix community with ground cover of sedges, grasses, and mosses. There are two transect lines, one roughly perpendicular to the lake shore, Line A, and the other parallel to the lake shore, Line B. Line A (Plots 1 and 2) runs through undisturbed vegetation while Line B (Plots 3 and 4) runs through an area which was impacted at the time the transect was established in 1982. The transects were resampled in early August 1985 and early July 1987. Different sets of observers sampled the sites each time. Plot photos were taken in 1985 and 1987.

Transect Changes: In 1985, the original compass bearing (magnetic) for T3-1 to T3-2 was changed from N 90° to 82°. In 1987, the lengths of both lines were found to be different than the original measurements. The length of T3-1 to T3-2 (Line A) was measured (using a 30 m tape) as 52.5 rather than 51 m. The length of T3-3 to T3-4 (Line B) was measured as 10 m rather than 10.5 m. It is unclear if this discrepancy effected the between-year plot locations.

Plot 1: The vegetation in this plot, dominated by sedges (Carex spp.) and mosses, showed no substantial change 1982-85-87. The vegetation type remained undisturbed and the organic layer good. Trail formation and disturbance, however, increased from 10% to 20% 1982-85.

While comparison of the 1985 and 1987 photos shows similar plot locations, this plot may have been slightly shifted between the 1982 and 1985 sampling

dates because the 1982 description mentions "game trails on either side of 1 m sq", whereas, in 1985 and 1987, a game trail ran through the NW section of the plot itself. In addition, in 1985 there was an "old trail along the E side of meter sq". The difference in measured line length between 1982 and 1987 makes it likely that the location of the plot was shifted. This could account for the increase in trail formation/disturbance (from 10% to 20%) between 1982 and 1985, 1987, and some of the slight vegetation differences.

Plot 2: The vegetation type remained undisturbed and the organic layer good from 1982 to 1987. As in plot 1, there were no substantial changes in this plot. The plot photos have no distinctive features so it is impossible to say how the relative locations compare. The minor changes (decrease in Carex cover 75% to 60%; increase in Dryas 10% to 15%; appearance of a trace of Salix reticulata) could be due to slight plot shifts, observer bias, as well as any natural processes.

Plot 3: There are no distinctive features in the 1985 and 1987 plot photos, so it is difficult to tell how the locations relate. From 1982 to 1985, the vegetation type changed from transition/heavily trampled to apparently undisturbed and remained that way in 1987. The organic layer was variable and compacted in 1982 and variable, but not overly compacted in 1985 and 1987. Between 1982 and 1987, the data show a steady increase in sedges (mainly Carex membranacea) from 20% to 40%. The sedge Eriophorum angustifolium was first recorded in 1987 (4%). Grass appeared in 1985 (5%) and had similar cover in 1987, although the identification of the grass species differed between the two years (Festuca altaica in 1985 and Arctagrostis latifolia in 1987). The assortment of other changes (slight increase in the dwarf willow Salix reticulata and in the forbs, the appearance of Gentiana prostrata, the disappearance of Anemone parviflora, and the slight increase in Dryas) could be due to differences in observers or plot relocation shifts as well as any real

processes. In the non-live categories, litter showed a steady decline from 50% to 25% (1982-87) and the percentage considered disturbed fell from 25% in 1982 to 0% in 1987.

Plot 4: Despite the line length discrepancy, comparison of the 1985 and 1987 photos show the plots to be similarly located. The vegetation type changed from transition, heavily trampled to transition/untrampled from 1982 to 1985 and remained untrampled in 1987. The organic layer was consistently variable. The area that was perceived as "disturbance" dropped from 20% to 0% between 1982 and 1985. In plot 3, there was an increase in sedges (Carex spp.) from 1982 to 1987 (from 20% to 40%). During the same time period, grass (Festuca altaica) increased slightly, from 20% to 25%, between 1982 and 1985, but then dropped to just 3% in 1987. Another grass (Arctagrostis latifolia) increased from 1% to 5% between 1985 and 1987. Dryas increased from 1% to 15% between 1982 and 1985 and Salix reticulata made a similar increase. Traces of forbs both appeared (Pedicularis verticillata) and disappeared (Polygonum viviparum, Stellaria laeta, Potentilla palustre, Astragalus umbellatus) between 1982 and 1987. A gentian was identified in 1982 and 1985, G. propinqua, but the trace of gentian present in 1987 was identified as G. prostrata.

The large drop in the cover by grass is the most substantial change in this plot. Grasses are common in disturbed areas and it is not uncommon for sedges to eventually outcompete grasses as a site recovers.

Kugrak

The Kugrak transect is located at the confluence of the Kugrak and Noatak Rivers at the campsite (HIS# 52) on the bank on the east side of the easternmost braid of the Kugrak. It was established in early August 1982 and was resampled in early August 1985 and early July 1987. For some unknown reason, the only vegetation data collected in 1982 for all of the plots was the moss and lichen cover. The transect runs north-south and five plots were

sampled: one with relatively undisturbed, two with transition, and two with compacted vegetation types originally. Three different sets of observers sampled the plots. The vegetation of the area was described as "subarctic... characterized by Salix alaxensis, sedges and grasses".

The site, although on a bank generally above the river level, is very likely subject to periodic flooding, so some of the "disturbance" occurring here may be due to other than human impact.

Transect Changes: In 1987, the length of both sections of the transects were found to be different than the 1982 measurements. T3-5 to T3-7 was 24.7 m rather than 25 m and T3-7 to T3-6 was 23.7 m not 22 m, making the total length of the transect 48.4 m rather than 47 m. A 30 m tape was used to measure the line in 1987; it is not known what was used to measure the line in 1982. This discrepancy is disturbing because it could make accurate relocation of the plots in 1985 and 1987 difficult and so all the data suspect.

Plot 1: Comparison of the 1985 and 1987 photos reveal that the 1987 plot may be shifted about 0.1 m to the north, introducing some uncertainty about comparing some of the changes between those years. The vegetation type in this plot remained relatively undisturbed and the organic layer remained good from 1982 to 1987. There was a trend toward increases in (Castilleja caudata, Hedysarum alpinum) or the appearance of (Tofieldia pusilla, Astragalus aboriginum, Pedicularis sp.), forbs. A grass (either Arctagrostis or Calamagrostis) was recorded in 1985 (5% cover), but was not seen in 1987, whereas a sedge (Carex Krausei?) was seen in 1987 (5% cover), but not in 1985. A trace of Salix reticulata was recorded in 1985, but it was not seen in 1987. Arctostaphylos rubra, however, was recorded in 1987 and it looks superficially like S. reticulata, so this may be a case of misidentification. The only substantial non-live vegetation change was the increase in litter (from 5% to 50%) between 1982 and 1985.

Plot 2: The vegetation type remained "transition" and the organic layer remained variable from 1982 to 1987. There were no major changes in the vegetation between 1985 and 1987. As in Plot 1, the grass (either Arctagrostis or Calamagrostis) was recorded in 1985 (5%), but not seen in 1987, whereas the sedge (Carex Krausei?) was not seen in 1985, but was seen in 1987 (3%). Two forbs, Castilleja caudata and Tofieldia pusilla, appeared in 1987. Moss may have increased slightly between 1985 and 1987 (from 75% to 80%). In the non-vegetation categories, the only major difference was in bare ground cover: 5% in 1982, 30% in 1985 and 15% in 1987. Also, the ground was not trampled in 1985 as it was in 1982. It is not clear if all the vegetation, other than moss, was gone in 1982.

Despite fears about shifts in plot locations because of the line measure discrepancy, the photos of at least this plot taken in 1985 and 1987 show basically the same plot. Without knowing more about the vegetation cover of this plot in 1982, it is difficult to interpret the changes in bare ground cover. Was there further disturbance to the plot between 1982 and 1985 that removed vegetation, increasing the bare ground exposure, so that between 1985 and 1987 we are seeing revegetation? The lack of much difference in total cover by vegetation in 1985 and 1987 doesn't strongly support this. Is this just a case of observer biases? These questions can't be answered.

Plot 3: The photos of the 1985 and 1987 plots show the locations to be similar. The vegetation type changed from "compacted sand" in 1982 to transition in both 1985 and 1987. The organic layer in this plot is really only represented by an organic component to the sand. The sand remained compacted from 1982 to 1987. Between 1982 and 1985, moss increased from less than 1% to 10% and lichen appeared and covered 25% of the plot. Between 1985 and 1987, the vegetation changes consisted of the appearance of new plants (Salix arctica, Carex Krausei?, Juncus biglumis, Pedicularis sp.) in tiny amounts and the slight increase in plants existing in 1985 (Equisetum

variegatum, moss, and lichen - small gray crustose covering the soil). In the non-live vegetation categories, litter increased from 1982 to 1987 (from 1% to 10%). Mineral soil was recorded as covering 95% of the plot both in 1982 and 1985, but dropped to 10% in 1987. In addition, in 1985, bare ground was documented as covering 75% of the plot. The "disturbance" remained at 95% from 1982 to 1985, but was considered to have dropped to 75% in 1987.

There are problems with the 1985 and 1987 data. In the 1985 data, the numbers for mineral soil and bare ground, both exclusive categories, add up to 170%. Notes on the 1985 data sheet indicate "moss starting to invade - bare ground is more appropriate term than mineral soil". Perhaps the data recorder just forgot to change one of the categories. It does suggest, however, that the mineral soil vs. bare ground distinction is not always clear and could account for some year to year changes in the data. The 1987 data for some of the categories must be too low, because the total for the vegetation, litter, mineral soil, and bare ground only equals ~80%; it should be at least 100%. This underlines how difficult it is sometimes to accurately estimate cover.

Plot 4: From 1982 to 1987, the vegetation type remained transition and the organic layer (as far as it existed at this transect) variable. Between 1982 and 1987, lichen became established and rose to 20% cover; this was a tiny gray crustose lichen on the soil surface. The trend for moss is puzzling with 50% in 1982, dropping to 25% in 1985, and back up at 60% in 1987. In the vascular plants, between 1985 and 1987, several graminoids appeared in small percentages (Carex Krausei?, Juncus biglumis, and Trisetum spicatum - the latter may be the unknown grass of 1985, however), several decreased (Arctagrostis) or disappeared (Festuca altaica). In the forbs, Pedicularis sp. increased slightly, while Hedysarum alpinum disappeared. In the other categories, mineral soil declined from 25% to 5% between 1985 and 1987. There was no bare ground present in 1982 or 1987, but there was 10% cover in 1985. That area considered disturbance remained the same for all 3 sampling dates.

It is possible that this plot has been relocated in slightly different places each time it has been sampled. Looking at the 1985 and 1987 photos suggests this as well as some of the data discrepancies: the fluctuating moss data, the fact that Hedysarum alpinum was located in the plot in 1985, was not present in 1987, but was seen approximately 0.1 m outside the plot. Another source of confusion is the discrepancy between the data and some of the explanatory notes. In 1982, bare ground cover is recorded as "0%", but the note at the bottom of the data sheet says "bare ground, veg gone". This may just be a case of someone using the term "bare ground" loosely, rather than in the strict sense of the transect methodology. In the 1985 data, bare ground is 10%, mineral soil is 25%, but the explanatory note says "some bare ground, but no real mineral soil". Items such as these make confident data interpretation difficult.

Plot 5: Comparison of the photos taken in 1985 and 1987 indicates, from the position of the fire pit, that the plot location in 1987 was shifted approximately 0.75 m to the S of the 1985 location so that only about a quarter of the 1985 plot was represented in the 1987 plot. With no photos of the 1982 plot, there is no way of knowing how it compared with the 1985 or 1987 plots. The general location of the plot is a fire pit area largely denuded of vegetation as of 1982. Although the data between years cannot be compared, they do suggest possible trends such as increasing cover by moss, Equisetum, and lichen (tiny, gray crustose on the soil). An observation on the data collection: As has been seen before, the bare ground - mineral soil data is confusing. The 1985 figure of 90% for each of these categories cannot be right; their total cannot be more than 100%.

Matcharak

This transect was established in 1985 on the W side of Matcharak Lake, near the end of the portage trail from the Noatak. Two plots were sampled, a transition plot and an undisturbed plot. An attempt was made to locate it in

1987, but no tags were found.

Matcharak Knoll

This transect was established in 1987 at the HIS# 40 site on the W side of Matcharak Lake, on the higher flat area. It has not been resampled. Four plots were sampled, one undisturbed, two transition and one compacted.

Walker Lake

Site A

This transect is located about 30 m back in from the shoreline at the point W of the outlet (S end) at Walker Lake. It is the location of HIS# 11. It was established in mid-July 1984 and resampled in early July 1986, and mid-July 1988. One observer was present in both 1984 and 1986, but two new observers sampled in 1988. The transect consists of three lines forming a triangle in the most heavily impacted area. Along these lines are a total of 7 plots. The vegetation of the general area consists of a very open white spruce - lichen woodland with scattered shrub birch.

Transect Changes: Discrepancies between the 1988 and 1984 line lengths and compass bearings were common. The distance between T10 and T11 was measured at 8 m in 1984, but 7.8 m in 1988. The compass bearing for T10 to T11 was recorded to be 10° (magnetic) in 1984, but 350° in 1988. The length of T-11 to T2-8 was recorded to be 9.67 m in 1984, but 8.81 m in 1988. The compass bearing (magnetic) was 323° in 1984, but 214° in 1988. The distance from T2-8 to T-10 was measured to be 6.33 m in 1984, but 6.13 m in 1988.

Plot 1: There were no photos of the 1984 plot so only the 1986 and 1988 plot locations can be compared. They appear to be approximately in the same place, but there are no plot markers visible in the 1986 photo to make the comparison more accurate. The vegetation type remained largely undisturbed except for a

small area of crushed lichen (5%) in the 1988 plot. The organic layer was not recorded according to the transect instructions in 1984 and 1986, but was most likely in the "good" category as it was in 1988. There are no clear trends in the data. The loss of Betula glandulosa could be the result of slight plot shifts as well as actual loss; the decrease in Vaccinium vitis-idaea (from 15% to 10%) could be due to observer bias as well as real. The increase in moss (from 3% to 15%) may be real, but the identification of the moss types may be in conflict, unless there was an actual change. In 1984 and 1986, feathermosses were reported; these could be species such as Hylocomium splendens or Pleurozium schreiberi, common in undisturbed sites. In 1988, however, Polytrichum was reported, and no feathermosses were seen. These mosses are fairly distinctive, but Polytrichum is "feathery" looking so perhaps there was some confusion over identification.

It should be noted that there was trampling of lichen just outside of the plot; this is very likely an effect of the transect work since the observer has to move around the outside edge of the plot to set it up, record data, etc.

Plot 2: The plot locations for 1986 and 1988 look similar, (no photo for 1984) although the 1988 plot may be slightly shifted. (Little bit of spruce recorded for the plot in 1984 and 1986, but spruce just outside the plot in 1988). The 1986 plot looks "deader" than the 1988 plot, but this may be a combination of different lighting and the fact that it had rained heavily, although briefly, shortly before the 1988 transect was done. This is a plot with transition vegetation type and variable organic layer. Moss cover increased from 8% to 25%, between 1984 and 1986, Litter cover increased from 10% to 30% between 1984 to 1986 (most likely from the increase in detached broken lichen), which in turn was a result of the increase in trail formation and disturbance (from 0% to 20%). The disturbance was not to the point of exposing much bare ground (2%) or any mineral soil.

Plot 3: The 1986 and 1988 plot photos show similar locations although there may be slight shifts. This was a plot with disturbed vegetation in 1984, although the percent cover was not recorded, and 100% disturbance in 1986 and 1988. The loss of Betula glandulosa, from 1984 to 1986, may be due to a plot shift because there was a small plant just outside the plot. Moss increased from 0% in 1984 to 20% in 1988. Intact lichen decreased (from 10% to 3%), while litter (largely detached, broken lichen) increased (from 70% to 80%). There was no bare ground exposed in 1984, but 5% mineral soil. In 1986, there was no mineral soil exposed, but 30% bare ground and in 1988, 20% bare ground.

It is not clear if there really was mineral soil exposed in 1984 and not in the other years or if this is case of confusion over mineral soil vs. bare ground.

Plot 4: The plot photos from 1986 and 1984 are not very helpful in determining if the locations are the same; it is a rather nondescript plot. Trends in this plot include a decrease in lichens (30% to 0%), increase in both mineral soil and bare ground, the appearance of a fire ring and charcoal, and the increase in disturbance from 10% in 1984 to 100% in 1986. It is not clear what was being counted as lichens, as opposed to litter, in 1984 since there is a note that says "broken" next to the lichen figure. Broken lichens appear to have been counted as litter in 1986 and 1988. The moss data create questions: 3% feathermosses were recorded in 1984, no mosses in 1986, and 5% Polytrichum in 1988. Does this represent an actual change in the type of moss or disagreement in identification?

Plot 5: The 1986 plot photo is too dark to be able to compare it with the 1988 photo. The trends, if not a result of location shift, include an increase in Betula glandulosa from 1984 to 1986, the appearance of grass in 1986, but its death by 1988, a slight increase in litter, and the increase in moss (from 20% in 1984 to 40% in 1986 and 1988). As seen before, the 1984 data is reported as feathermosses while the 1988 mosses are identified as Polytrichum. It is not

clear if disturbance increased much in this plot since no figure is recorded for the percent cover of disturbance in 1984, but it is 15% in 1986 and 20% in 1988.

Plot 6: As for plot 5, the 1986 photo is too dark to be able to compare it with the 1988 photo to check on the location. This plot was characterized as having undisturbed vegetation in 1984 and it remained that way in 1986 and 1988. The only changes in the data were an increase in lichen cover (from 70% in 1984 to 95% in 1988), possibly a slight increase in litter (from 15% to 20%), and a tiny amount of disturbance, < 1% broken lichen (1988). These changes, however, could easily be due to plot shifts or observer biases.

Plot 7: The photos for 1986 and 1988 show a nondescript plot; it is impossible to tell how nearly the locations match. The major trend here was the decrease in lichen cover, from 85% in 1984 to 10% in 1986, and the concurrent rise in litter (including broken lichen) from 15% in 1984 to 85% in 1988. The plot had 100% disturbance since 1984, but the degree of disturbance (trampling) increased. As in the other plots at this transect, the initial recording of mosses is under feathermosses while the 1988 data shows Polytrichum to be present.

Outlet

This transect is located at the outlet of Walker Lake, on the E side of the creek, approximately 80 m from the mouth and 30 m from the lake shore. It is the location of HIS# 64. The transect was established in early July 1984 and resampled in early July 1986 and mid-July 1988. One observer was common to both 1984 and 1986, but two new observers sampled the site in 1988. Three plots were sampled, representing one undisturbed and two transition vegetation types. Plot photos were taken in 1986 and 1988, but not in 1984.

As in Site A, the general vegetation is open white spruce - lichen woodland

(extensive lichen cover, Cladina types) with scattered shrub birch.

Transect Changes: In 1988, the T-9 tag could not be located (it was later found out that Park personnel had removed the tag thinking that it was a duplicate tag for the Human Impact Site). The tree that seemed the one that had most likely been tagged was retagged. It was, however, 42.41 m from T-6, rather than 42 m; it is not clear what this line length discrepancy means in terms of plot location. It should be noted that there is a small trail of crushed lichens leading to the T-9 spruce, probably a result of transect work.

Plot 1: The 1986 and 1988 photos reveal that the 1988 plot location may be shifted, approximately 0.1 m to the S and 0.05 m to the E. There were only a couple of changes between years. One of the changes consisted of no aspen trees in 1988, only two small stems and one large stem; in both 1984 and 1986, two aspen "trees" were noted (in addition to 1 "sprout" noted in 1986). This was puzzling in 1988, because there was no sign of any aspen "trees" having been anywhere near the plot. The only other substantial change was the appearance of disturbance in the plot from 0% in 1986 to 10% in 1988. This disturbance consisted of slightly trampled lichen, a result perhaps of the plot location shift causing the plot to include an area formerly on the outside of the plot which had received trampling, probably from the transect work.

Plot 2: The relation of the 1988 location to the 1986 location is not clear since there are no definite matching landmarks. The plot had a transition vegetation type and variable organic layer in all three years. It is on the edge of the tent pad area (in fact a tent was pitched on one corner of the plot when it was sampled in 1988). If the location is the same, there was an increase in the grass cover from 5% in 1986 to 15% in 1988, and a substantial decrease in the moss cover (Polytrichum) from 60% to 35% between those same years.

Plot 3: This plot has a trail through it. The 1986 and 1988 plot locations appear similar, but there may have been some shifting. The vegetation type was considered transition in 1986 and compacted in 1988 while the organic layer was considered slightly compacted in 1984 and 1986 and compacted in 1988. The substantial changes consisted of decreasing moss cover (from 30% to 15%), increasing mineral soil (from 3% to 25%), and increasing disturbance (from 60% in 1984 and 1986 to 90% in 1988) from more trampled lichen. Although between 1984 and 1986 the data show an increase in lichen, from 20% to 30%, there was a decrease in lichen between 1986 and 1988 (from 30% to 12%). There may have been a slight increase in bare ground exposed between 1984 and 1986 (from 4% to 10%).

Peninsula

This transect is located on the peninsula on the eastern side of Walker Lake, which points toward Swan Island. The site, the location of HIS# 49, is on the NW shore, about midway down the peninsula. The transect was established in early July 1984 and resampled in early July 1986 and mid-July 1988. There was one observer constant in 1984 and 1986, but two new ones in 1988. Plot photos were taken in 1986 and 1988, but not in 1984.

Plot 1: There was not much light when the 1986 photo was taken, so it is hard to tell how the 1986 and 1988 plot locations compare; all that can be said is that they seem to contain the same vegetation type (undisturbed). The plots may be shifted in relation to the 1984 plot because, while the 1986 and 1988 plots had 60% cover from overhanging black spruce branches, the 1984 plot had only half that. It is not clear if growth alone could account for that change.

The plot is relatively unchanged from 1984 to 1988. Two discrepancies may be due to misidentification. In 1984 and 1986 Rubus arcticus is recorded, at 3% and 8%, respectively. No R. arcticus was seen in 1988, but Rubus chamaemorus

covered 10% of the plot. A leaf in the 1986 photo is clearly R. chamaemorus. Ledum palustre ssp. decumbens was recorded at 1% cover in both 1984 and 1986, was not seen in 1988, but Andromeda polifolia, which looks like Ledum at first glance, covered 1% of the plot in 1988. A plot shift might also account for this difference. The presence of 5% cover by rock in the 1986 and 1988 plots, but 0% in the 1984 plot could also be the result of a location shift or the addition of a rock from a fire ring being broken up.

Plot 2: Comparison of the 1986 and 1988 photos reveals that the 1988 plot location is shifted about 0.5 m to the N of the 1986 plot (based on the location of a small spruce tree). This shift may explain the increase in black spruce as well as some other differences. Since half of the plot is different, at least between the 1986 and 1988 plots, analysis of the differences will not be too meaningful. It seems likely, however, that this general area has received increased disturbance.

Plot 3: At first glance, the 1986 and 1988 photos show two very different plot locations. They may be in the same general area, but since 1986 the spruce tree overhanging the plot appears to have been cut down (there is a stump just outside the plot) and the big rock present in 1986 as part of a fire ring possibly was moved from the depression visible in the 1988 photo. There is no way to know how the 1984 location relates to the other two years. Between 1984 and 1986, the few substantial differences include the increase in the shrub Spiraea, the loss of grass, the appearance of Linnaea borealis, the appearance of rocks, and the decrease in bare ground. They could easily be due to a plot shift, however. There, undoubtedly, was increased disturbance between 1986 and 1988, although the plot shift makes it meaningless to analyze the details.

Narvak/Selby Lake

This transect was just established in July 1988, due east of the

promontory that separates Narvak and Selby Lakes, in the site of an old hunting camp. Four plots were sampled: one undisturbed, two transition, and one compacted.

Transect Evaluation

The transect project will be evaluated first on how well the methods achieve the objectives that were set forth in 1982 and then how these objectives relate to current Park management objectives.

The first stated objective for which the transects were established was to "allow for scientific baseline data collection in impacted areas" which will "not only provide GAAR with descriptions of current vegetation, but ... will document the continuum from the undisturbed to disturbed vegetation in a given microhabitat." In as far as the vegetation data are accurate (see discussion of problems below), they do add to the knowledge about the plant species and associations present in the Park. As for giving any accurate picture, however, of the three designated vegetation types at a site - undisturbed, transition, and compacted - the methodology is inadequate to do so; although the area of each plot is relatively large (1 m²), the total area sampled for each vegetation type is small because few of these are sampled (1-2 of each vegetation type).

The second objective is "to document impacted locations, amounts of trash, species indicative of impact, exotic species, mineral soil exposed, the effect of impact on loss of soil cover, and the change in species over time." Based on the problems encountered in resampling a transect and analyzing several years of data, this objective has not been accomplished. The reasons for this conclusion follow.

X First, as discussed for the objective above, the small total areas sampled provide an inadequate database to be able to draw conclusions of any accuracy.

Certainly, no generalizations about the processes going on at an impacted site as a whole can be made based on these small sample areas.

X Secondly, even if sampling a small number of plots were adequate, the methodology employed here does not ensure that the data collected reflect real vegetation processes rather than sampling error. Since there is no permanent marking of the plots themselves, only of the endpoints, there is room for error

in relocating, and so resampling, the same plot each time. It would seem that a location between meter 5 and 6 along a line defined by two permanent endpoints would be permanent itself, but differences in who is measuring, with what measuring device, and how the line is laid out (i.e., how a line goes around obstructions such as trees and shrubs) appear to make a difference. Discrepancies between years in the total line length at some sites also introduced uncertainty about accurate plot relocation.

X In a methodology in which accurate plot relocation is so critical, careful photo documentation of each plot should have been an essential step. For some of the years at some of the sites, photos were taken of the plots, and comparison of these photos often revealed substantial location shifts. Even minor shifts are enough to introduce uncertainty about data changes of small magnitude. The fact that plot location shifts were common in the sites in which photos were taken at different sampling dates makes it difficult to have confidence in the data that were undocumented by photos.

The other major source of problems is with observer bias/error. At most of the sites, for each separate site visit a different observer or set of observers sampled the transect. Each one of those observers might estimate cover percentages slightly different even if they were given the same instructions for how to do so. The method of estimating the percent cover, however, was not clearly stated in the transect methods. Vegetation percent cover may be estimated by looking at the actual space the plant takes up horizontally. Another common method is one in which the sampler visualizes polygons drawn around each plant of a species and the percent cover of all the polygons for a species is estimated. This latter method will give higher percentages, so if different means of estimating are being used each year, it would be difficult to separate changes due to sampling technique from real processes.

Other problems affecting the accuracy of the data were encountered while the data were being analyzed. Several suspected cases of misidentification

occurred with species having similar names or similar appearance. A few cases involved the failure to record a species which was clearly evident in the plot photo.

Other cases of data discrepancy may have involved confusion over category definition, such as between mineral soil and bare ground. Another problem noticed during the transect sampling when two observers were making estimates is that some categories such as "litter" seemed to be subject to large between-observer differences in cover estimates for the same plot.

The second focus in this evaluation of the transect project is how the objectives, as they were stated in 1982, relate to current Park management objectives as set forth in the General Management Plan (GMP) developed in 1986.

X The prime objective that relates to conflicts between human use and Park natural resources is to "determine and only allow levels of human use that park resources can withstand without impairing their integrity or condition" (GMP 1986). In order to carry out this objective, the plan states that "research will be needed to monitor and adjust standards and prescribe management" and further states that research is needed into "the relationship between the levels of use and campsites, trail formation...and littered sites". The transect work as developed in 1982 does not address the question of how use level relates to impacts; there is no way of knowing what the use level was at any of the transect sites, let alone on a particular m² plot. At best, the number of people that the commercial operators take into a general area per summer is available, but there is no accurate and practical way of estimating how many times a site within that area has been used.

RECOMMENDATIONS

Due to the problems and limitations of the methodology, after seven years of sampling the vegetation transects, we have gained little reliable data about the responses to impact or recovery of the vegetation communities within the Park. We still do not know what level of use, for instance, a cover of Cladina lichens, a Dryas mat, or a sedge area can withstand, the type of information focused on in the GMP. For these reasons, it is recommended that the transect project as it currently exists be ended. In all fairness, it would be difficult to design a project in these remote areas which could accurately assess use level and its impact. Any controlled research would have to involve unimpacted "sacrifice" areas which would be subjected to deliberate disturbance, much like the ATV studies carried out in Wrangell-St. Elias; such destructive research would not be appropriate in Gates of the Arctic.

Should a redesigned vegetation transect project be carried on? Park management needs to decide what information it wants and can realistically obtain regarding human impact on vegetation. Are the details of plant species of enough importance to management to justify the time and cost involved? If so, the questions being asked need to be clearly defined and the methods used "statistically and scientifically sound" (GMP 1986). A modified vegetation transect project would need to include a greater area sampled (more, but smaller plots), fewer and better trained people doing the sampling, a well-defined method of estimating percent cover, and more precisely defined categories. If enough small plots were done in each vegetation type (undisturbed, transition, and compacted) so that the calculated mean percent cover data would adequately represent each type, then accurate relocating of individual plots and precise photo documentation of these plots would not be critical as it is under the current methodology. On the other hand, maybe the major concern is knowing where and what the problems are in terms of vegetation damage, i.e., ground cover removal or firewood collection. It is this information which will be most helpful in guiding the formulation of

backcountry management plans, making decisions about bans on fires, etc. The monitoring and inventory of campsites and trails within a system such as the mostly qualitative Human Impact Site Inventory, used in GAAR since 1986, but combined with some means of quantifying the extent, for instance, of soil exposure, may be the most appropriate way to document and monitor areas of vegetation damage in the Park. In the current system, the location and types of impacts present are documented, and a map of the site is drawn. If observers were diligent about making accurate maps, searching a site for all impacts, and taking photos from the same photo points with the same cameras, it should be possible, theoretically, to detect at least gross impact changes. With different observers, different cameras, etc., however, this may prove to be subject to its own share of problems. In an effort to find a way of quantifying impacted areas so that changes between years can be accurately measured, funding has been requested in FY89 for a project in which low level aerial, color infrared photos of selected impact sites will be taken, analyzed, and compared with ground-truthed information. Depending on how much can be seen in the photos, the function of the infrared photos may be limited to detecting vegetation removal and soil exposure; ground visits may still be necessary if details on other impacts are wanted.

A comment should be made here about the impact of the transect work itself on the sites. In the process of setting up the transect line and plots and standing around the plots recording data, some trampling has been unavoidable.

It is especially noticeable in the areas of extensive lichen cover such as at the Walker Lake transects, Site A and Outlet. If future ground work is done in such sites, care should be taken that they not be sampled when the lichens are dry since they are so easily crushed; even when the lichens are moist, great care should be taken not to displace the lichen mat.

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APPENDIX A

APPENDIX B