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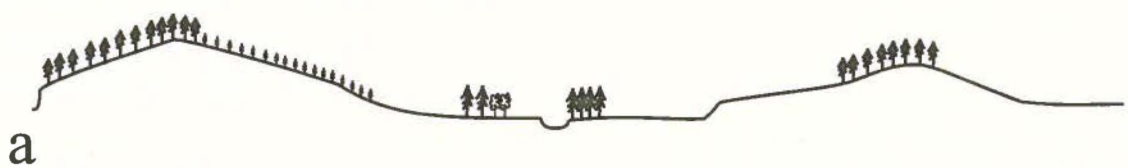

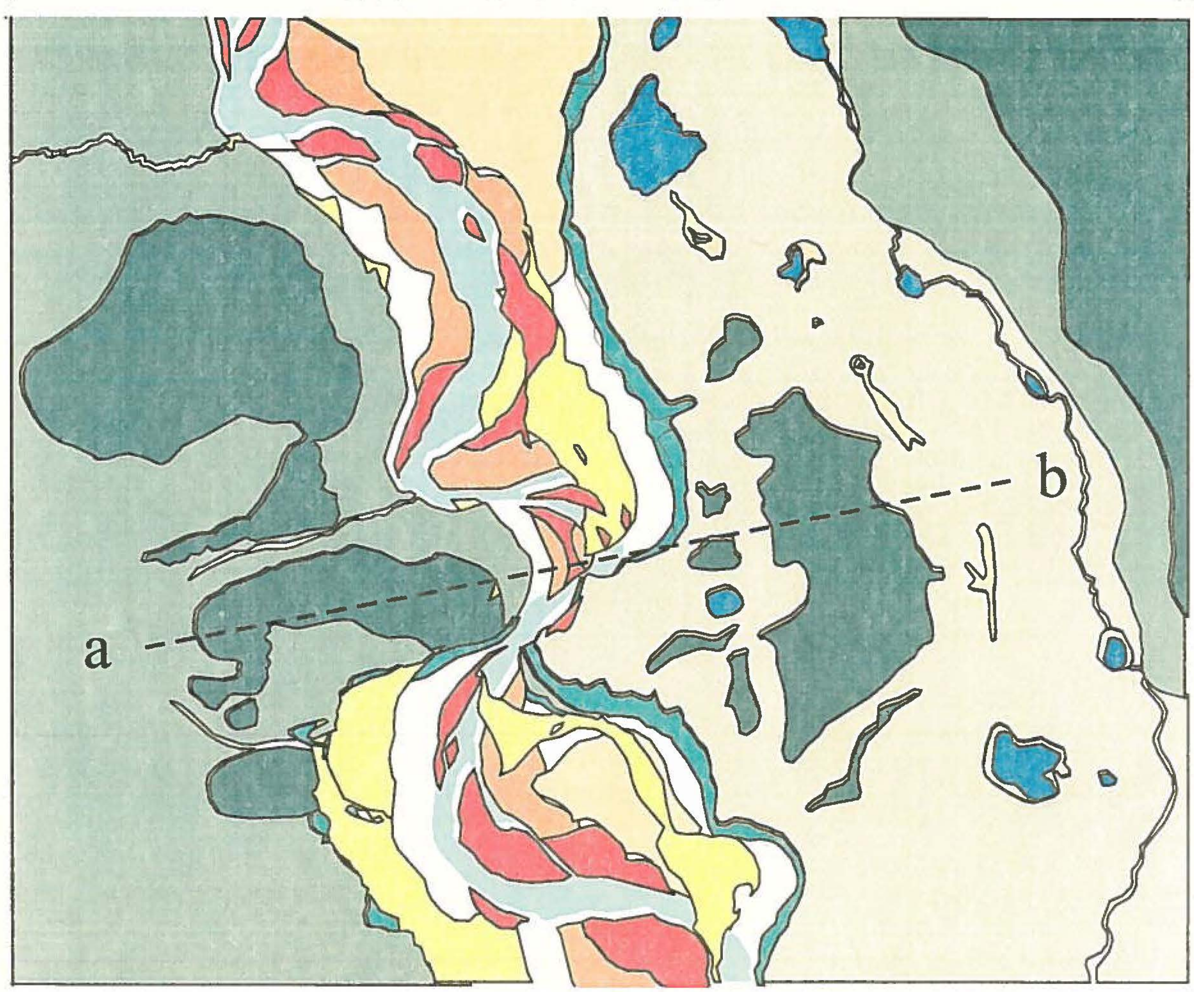

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Janet C. Jorgenson
Beverly E. Reitz
Barbara H. Boyle
Jay Johnson
Michael Emers

Arctic National Wildlife Refuge
U. S. Fish and Wildlife Service
101 12th Ave., Rm. 236
Fairbanks, Alaska 99701

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INTRODUCTION

PURPOSE

We established two long-term ecological monitoring sites in the Arctic National Wildlife Refuge in 1996 and three more will be established between 1997 and 1999. The sites were chosen to be representative of each of the five major ecosystems of the refuge, the saltmarsh/inshore waters area, coastal plain tundra, alpine tundra, forest-tundra ecotone, and boreal forest. These sites will be just one part of the refuge's overall inventory and monitoring plan, but will serve as focal points to concentrate the monitoring of some basic ecosystem components such as birds, invertebrates, small mammals, vegetation, and soils.

There are surprisingly few long-term ecological data sets in existence. After reviewing 749 papers published in the journal *Ecology*, Tilman (1989) reported that less than 2% of the studies lasted at least five field seasons. The current intense interest in long-term dynamics of ecosystems, especially in relation to human disturbance and global warming, has highlighted the unfortunate scarcity of baseline data in almost all fields. An example is the scarcity of baseline data from the Prudhoe Bay area before oil development, which has made it difficult to assess the effects of the development there. Land management agencies probably have a longer-term connection to the land they manage than do universities or other entities. An important contribution we can make to the understanding and conservation of ecosystems is to establish monitoring programs and commit ourselves to the discipline of maintaining the programs for many years. We can improve and add to the programs as our understanding or funding increases, but the important thing is to make a start.

The FWS has a stated goal to reach a standardized, long-term approach to monitoring the environmental health of refuge ecosystems. In the past, much emphasis has been placed on monitoring the larger vertebrates whose home ranges cover extensive areas. Habitats, vegetation communities and species with small home ranges or species closer to the bottom of the food chain have been largely ignored in this large species emphasis. Long-term monitoring of permanent study sites will allow inventory and monitoring of these ecological components over time.

Monitoring of flora, fauna, and environmental variables will be concentrated at five ecological monitoring sites over the years. The objectives are to:

1) Obtain baseline data on ecosystem components such as vegetation, soils, small mammals, birds, and invertebrates.
2) Accumulate a long-term spatial and temporal data base to allow elucidation of the relationships between these components.
3) Detect natural and human-caused changes by repeated monitoring of permanent plots through the years.

Monitoring programs at the sites will be established as needed, depending on management concerns and available funding. Some of the first ones we propose to set up are:

1. Permanent vegetation plots
2. Annual breeding bird survey
3. Invertebrate and small mammal trapping

Methods will be consistent with those used for other monitoring programs in Alaska. Not all components are monitored each year. For example, vegetation data could be collected only every five years but the bird survey needs to be done every year.

ECOSYSTEMS OF THE ARCTIC NWR

The Arctic NWR is one of the largest units in the National Wildlife Refuge System, with over 19 million acres. It is over 260 miles north to south and 220 miles east to west. The eastern segment of the Brooks Range, which is the highest and most rugged, lies wholly within the Refuge. The Refuge encompasses the entire drainage basins of 12 major rivers and substantial portions of 6 others, and contains entire regional populations or major sub-populations of several wildlife species during all or part of their life cycles. Many other species that use the Refuge migrate over large areas both within and sometimes far beyond the refuge boundaries.

The Arctic NWR contains a spectrum of landforms, habitats and species from the subarctic to the arctic. Together with adjacent lands in Canada, the Refuge provides a level of diversity relative to area size that is unparalleled in the circumpolar region. This is mainly due to steep environmental gradients caused by the proximity of mountains to the coast.

The Arctic NWR has a range of climatic conditions that mirror its diverse geography. The climate north of the Brooks Range is arctic. The summers are short, cool, and generally cloudy, with the temperatures of the warmest month (July) averaging 41°F . Winters are cold with temperatures of the coldest month (February) averaging -4°F. Extreme lows frequently drop below -40°F. High surface winds are common throughout the year. The average precipitation for the arctic coastal plain is 10 inches which includes 12 to 47 inches of snowfall. Most precipitation comes as summer rainfall. Due to low evaporation rates, permafrost, and generally level terrain, soils in the summer are mainly saturated.

The climate south of the Brooks Range is continental subarctic. Winter temperatures average -15° to -20° F with lows -50° F to -60° F not uncommon. Summer temperatures average around 60°F but can be very warm with highs reaching above 90° F. Precipitation at the closest recording station in Fort Yukon averages 7 inches annually. July and August average the most rainfall with 0.94 and 1.22 inches, respectively. Winter snow depths average 20 inches.

The refuge can be divided into five major ecological zones (Fig. 1). Areas of transition occur between all zones, and boundaries are not sharply defined.

The salt marsh/inshore waters zone is along the coast of the Arctic Ocean (Beaufort Sea). It includes salt marshes, estuaries, lagoons, and deltas of large rivers. This zone is used extensively for summer feeding and nesting by migratory shore birds, ducks, geese, and swans. It is also critical fish habitat and an important insect-relief area for caribou, and is used by muskoxen in all seasons.

The coastal plain tundra zone between the Brooks Range and the Arctic Ocean consists of rolling foothills, hilly coastal plains, small areas of thaw lake plain, and large floodplains. The zone is bisected by north-flowing braided rivers. Vegetation is dominated by low shrubs, sedges, and mosses. The zone is used by the Porcupine caribou herd during the calving and post-calving period in June and July. During this time, it is occupied by large numbers of terrestrial birds, small mammals and flying insects. Snow geese stage here in fall and muskoxen live in this zone year-round. Most terrestrial den sites for polar bears occur in the CM and CP zones which are in the Arctic Ecosystem unit.

The alpine zone is in the eastern Brooks Range and has sections in both the Arctic and Interior ecosystem units. Elevations range from <2000 feet to >9,000 feet. The very complex bedrock geology and differences in surface stability and snow-cover in winter provide for a variety of types of vegetation, mainly dominated by prostrate shrubs. Year-round residents include Dall sheep, ground squirrels, wolves and brown bears. Examples of summer residents include: Harlequin ducks, wandering tattlers, upland sandpipers, northern shrikes, and golden eagles.

The taiga zone lies on the south slopes of the Brooks Range and is within the Interior ecosystem. It is a broad transition zone between the boreal forest and the alpine tundra. It has open spruce woodlands, treeless tundra, and pockets of spruce forest in protected, south-facing sites. Caribou of the Porcupine herd often spend the winter in this zone. It is also inhabited year-round by moose, brown bears and wolves.

The boreal forest zone is in the Interior ecosystem unit and extends to the southern boundary of the Refuge. Crossed by south flowing rivers, it includes the only extensively forested region of the Refuge. The vegetation is a mosaic of spruce and hardwood forest types and shrublands, depending on soils, topography, and the frequent forest fires. The zone is inhabited by moose, lynx, marten, black bears and wolves year-round.

1996 STUDY SITES

Five potential study sites were chosen after a reconnaissance in 1995. Each is representative of its ecosystem and has reliable access by fixed-wing aircraft on a durable surface. A pilot-scale study was conducted during two weeks in summer of 1996. Two sites were established, one in the boreal forest and one in inland arctic tundra.

BOREAL FOREST STUDY SITE

A boreal forest site was established on the Coleen River, about 25 miles upstream from the confluence with the Porcupine River. A crew of three biologists and two biological technicians conducted five days of field work from June 19-23, 1996.

The Alaskan boreal forest consists of a vegetation mosaic resulting mainly from past wildfires (Viereck 1973). Our study site is located in the Porcupine River Uplands and is within a zone with some of the most frequent and extensive fires in the state (Gabriel and Tande 1983), resulting in vast areas of successional ecosystems. Estimated fire frequencies for forests in the Porcupine River drainage are 105 years for white spruce and 43 years for black spruce (Yarie 1981). We researched the fire history of potential study sites using records from the Alaska Fire Service (AFS) of the Bureau of Land Management. The records date back to 1970. We chose a site that included a mix of forest stand ages, including areas burned in 1950, 1986, and 1991, as well as long-time unburned areas.

Permanent Vegetation Plots

Methods

Two permanent vegetation plots were marked and sampled. The sampling protocol was developed at the Institute of Northern Forestry of the U. S. Forest Service (USFS) during several decades of forestry research in interior Alaska. It was adapted from USFS procedures from the north central U. S. (Ohmann and Ream 1971). It is in use at the well-established National Science Foundation Long-term Ecological Research (LTER) site at the Bonanza Creek Experimental Forest near Fairbanks (Van Cleve & Martin 1991), at USFS post-fire forest succession plots throughout interior Alaska (Foote 1983), and in the Denali National Park Inventory and Monitoring Project (Densmore et al. 1996). Detailed field sampling methods are described in Foote (1995, Appendix II) and are based on standard vegetation sampling procedures (Bonham 1989, Husch et al. 1982). This standardization of procedures makes our data comparable to data from other studies. Our site can serve as a representative of the fringe of the boreal forest for comparison to more centrally-located sites. It is located within 80 miles of the northern edge of the boreal forest and is at relatively high elevation (900 ft).
The methods were time-consuming and data-intensive but we felt that they should be very detailed, since we were going to the effort to mark and repeatedly revisit permanent plots. We were fortunate to have with us biological technician Shannon Nelson. She was Joan Foote's field assistant at USFS post-fire succession plots on the Porcupine River plots in 1995 and explained the methods to us.

Each intensive plot is 40 m by 30 m in size. A grid of 20 points, 10 m apart, was marked with stakes of metal conduit (Fig. 2). Three types of data were collected at each point. A 1-m^2 quadrat was used for ocular estimates of percent cover classes for species of low shrubs, herbs, non-vascular plants, and bare ground and litter categories (Fig. 3). A 4-m^2 quadrat was used to estimate percent cover classes, average height, and maximum height

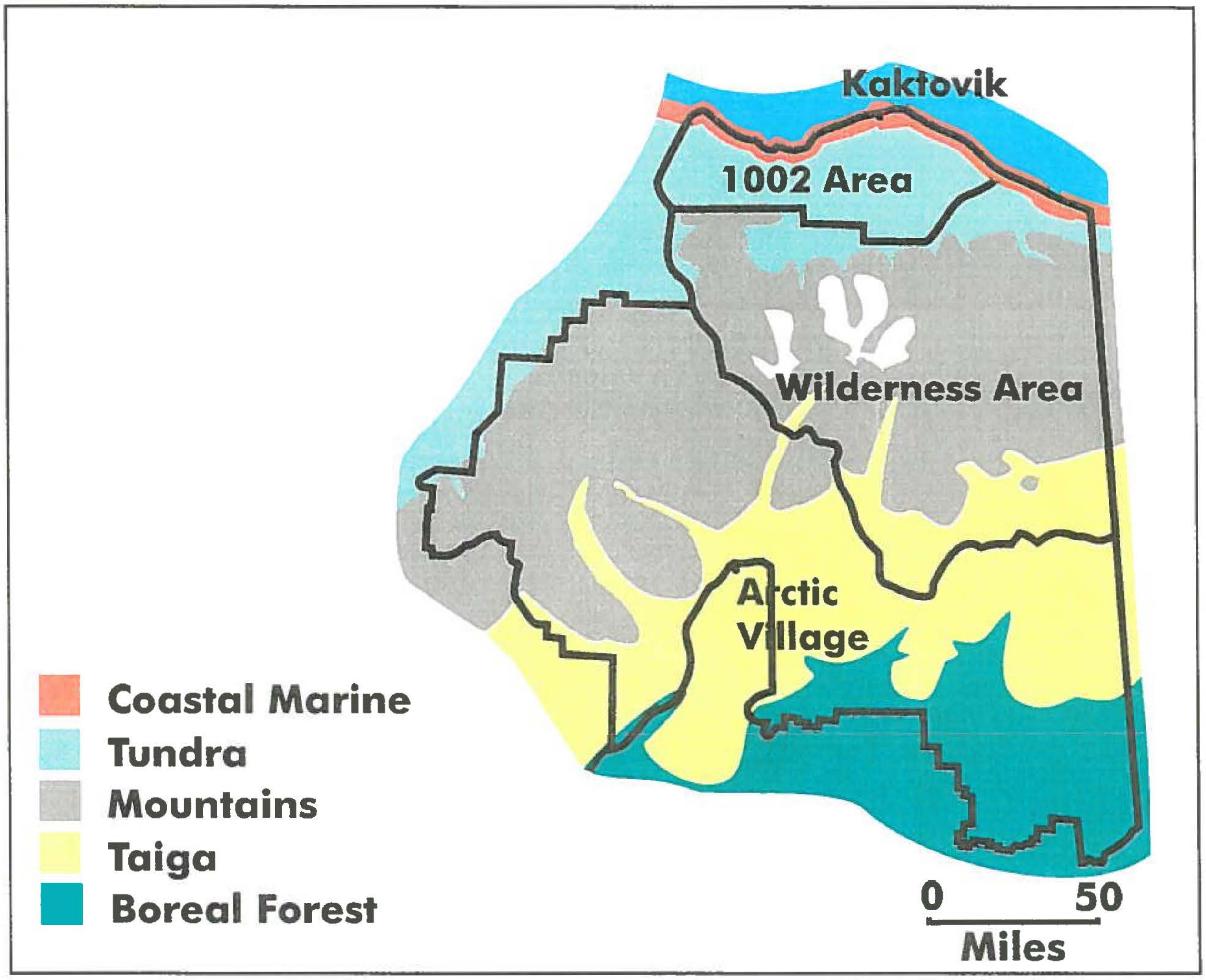

Figure 1. Ecological zones of the Arctic National Wildlife Refuge.

of tall shrubs and tree seedlings; to count stems by diameter classes for tall shrubs and tree seedlings; and to collect fire fuels data, including all woody litter and snags by size and rotting classes. Fire fuels methods are described in Brown (1974). A point-centered quarter plotless method (Cottam and Curtis 1956) was used to count and measure live and dead large trees and saplings. This method uses no fixed plot, but estimates stems per unit area based on measured distances between a center point and the nearest stems of each species. Tree canopy cover was estimated in four directions at each point using a canopy densiometer. Adjacent to each 1-m^2 quadrat, depth of organic soil was measured once and depth to permafrost was measured three times. Many photographs were taken, including at ½ of the 1-m^2 plots and at permanent photo points in the plot.

The largest trees in and adjacent to the plot were cored at the base using an increment-borer. Cores were mounted and sanded and tree rings were counted to estimate the minimum age since fire for the plot. Many of the largest trees were too rotten at the pith for rings to be counted, but seven successful cores were taken at Plot A and four at Plot B. At Plot A, rings of three trees representative of the smallest size class in the forest canopy were also counted, to estimate the length of time after fire that tree recruitment occurred.

Plot Coleen-A

Plot Coleen-A is in old-growth bottomland white spruce forest next to the Coleen River. Its floodplain position protects it from most wildfires. However, a narrow finger of a 1986 fire did penetrate through the old-growth all the way to the river bank about 1/3 mile south of Coleen-A. Plot Coleen-A has an open canopy of large, decadent white spruce that are about 181 years old. All trees that were aged by tree-ring counts are about the same age, indicating a single wave of tree recruitment following a stand-replacing fire. The diameters of the trees that were ring-counted varied from 6 cm to 33 cm, indicating the 'winners' and 'losers' in the battle for sunlight and canopy dominance. The heights of trees that were the same age varied from 6 to 29 m. The forest understory had a sparse shrub layer, thick feathermoss on the forest floor, and many forbs, including three orchid species. Table 1 is a summary of the ground vegetation. Table 3 is a summary for the trees and tall shrubs and Table 5 lists fire fuels data.

Ips beetle damage (*Ips perturbatus*) is evident in the stand and about half of the largest white spruce trees are dead. *Ips perturbatus* is the most damaging of the Ips beetles and causes more tree mortality in the interior forests of Alaska than the spruce bark beetle (*Dendroctonus rufipennis*), because it prefers warmer and drier host material. (The spruce bark beetle is currently devastating large areas of moister south-central Alaska.) The Ips beetle outbreak probably occurred about 8 or 9 years ago because of improved beetle nesting habitat in weakened and death white spruce in the adjacent forest during the 1986 wildfire. Ips beetle attacks occur within two years after an event that stresses the trees and last only a few years (Holsten et al. 1985). U.S. Forest Service entomologists conduct aerial surveys for beetle damage in the Porcupine River drainage every July. The only infestations mapped on the Coleen River between 1989 and 1996 were three small areas of *Ips* beetle damage more than 9 miles downstream from our site.

We arranged for the entomologists to fly up the Coleen River to look for any current infestations. They could not survey the Coleen River area in July 1997 due to heavy smoke from wildfires, but will try to do so in 1998.

Plot Coleen-B

Plot Coleen-B is in an upland white spruce forest on a gentle south-facing hill top 100 ft. above the river. Stand age is about 156 years. It is in a narrow corridor of land along the river with no recorded wildfires, surrounded by recent burns. The open canopy of healthy white and black spruce has no sign of beetle damage. The understory is open, with a mat of 'reindeer lichens' and feathermoss. Table 2 is a summary of the ground vegetation. Table 4 is a summary for the trees and tall shrubs and Table 5 has fire fuels data.

Reconnaissance of vegetation

We used color-infrared (CIR) aerial photographs from July 1978 at a 1" = 1 mile scale for a base map. During a ground reconnaissance of vegetation, we visited thirty ground plots representing the range of the vegetation types in the area and four different ages since burning. We marked plots on enlarged CIR photographs and recorded some GPS locations. At each plot we listed dominant plant species, estimated approximate age since fire, took photographs, and assigned a vegetation type. At most plots, we estimated percent cover of each vegetative layer, listed the dominant species within each layer, and estimated average and maximum tree and snag heights. We assembled one page of information and photographs for each plot and assigned a vegetation class from the Alaska Vegetation Classification (Viereck 1992).

Site mapping

We made a map of geomorphic units of a 20 square mile area surrounding the study area using field data and photo-interpretation of the CIR aerial photographs (Fig. 4). The units on the map delineate areas with similar surficial geology, soil-forming processes, landforms, and water regime. This map is one level of an Ecological Land Classification, a hierarchical system for inventory, classification, and mapping of basic components of ecosystems. The system is best developed by Klijn and Udo de Haes (1994) and has been used extensively in Canada. Table 6 lists typical environmental relationships for each unit, including physiography, slope position, soil texture, water regime, permafrost status, and vegetation. It is modeled after a similar table from an ecological land classification of Fort Wainwright, Alaska, that was based on extensive sampling of environmental variables in geomorphic units (Jorgenson et al. 1996). Each geomorphic unit includes several vegetation types, but these types are usually related as different stages in a post-disturbance successional sequence. An Ecological Land lassification supplies more information on ecosystem structure and function than a simple map of current vegetation units, particularly in areas with frequent natural disturbance.

Figure 2. Plot Coleen-B in an approximately 150-year-old spruce forest.

Figure 3. A 1-meter quadrat on the forest floor of Plot Coleen-B.

Table 1. Summary ground vegetation statistics for Plot Coleen-A, Arctic NWR, 1997.

	Cover (%)	Frequency (%)
COVER TYPE TOTALS		
Low shrubs	15	100
Graminoids and forbs	22	100
Mosses and liverworts	68	100
Lichens	0	0
Dead wood litter	16	100
Leaf litter	20	100
Bare ground	0	0
LOW SHRUBS		
Linnaea borealis	11	95
Juniperus communis	3	50
Shepherdia canadensis	2	50
GRAMINOIDS		
Carex williamsii	6	65
Carex concina	5	95
Grass spp.	2	70
FORBS		
Galium boreale	2	100
Mertensia paniculata	2	95
Pyrola secunda	2	65
Hedysarum alpinum	1	75
Anemone parviflora	1	65
Equisetum arvense	1	30
Pyrola grandiflora	1	25
Anemone richardsonii	1	15
Plantanthera obtusata	<1	40
Cypripedium passerinum	<1	20
Zygadenus elegans	<1	30
Unknown composite seedling	<1	55
Goodyera repens	<1	5
Equisetum scirpoides	<1	5
Equisetum variegatum	<1	15
Lupinus arcticus	<1	5
Moneses uniflora	<1	25
Boschniakia rossica	<1	10
Arctostaphylos rubra	<1	5
MOSSES & LIVERWORTS		
Hylocomium splendens	45	95
Tomenthypnum nitens	8	55
Sanionia uncinata	4	60
Brachythecium sp.	3	40
Campylium sp.	1	15
Unk. moss on tree base	<1	5
Brachythecium sp.	<1	10
Dicranum sp.	<1	20
Abietinella abietina	<1	5
Scaponia sp.	<1	5

Columns are plant species, mean percent cover in plot based on 20 quadrats, and frequency of occurrence in plot expressed as the percentage of quadrats with that species.

Table 2. Summary ground vegetation statistics for Plot Coleen-B, Arctic NWR, 1997.

	Cover (%)	Frequency (%)
COVER TYPE TOTALS		
Low shrubs	13	95
Graminoids and forbs	4	100
Mosses and liverworts	33	100
Lichens	19	100
Dead wood litter	13	100
Leaf litter	21	100
Bare ground	<1	20
LOW SHRUBS		
Linnaea borealis	3	70
Dryas integrifolia	2	45
Vaccinium vitis-idaea	1	15
Arctostaphylos uva-ursi	1	35
Juniperus communis	1	10
Potentilla fruticosa	<1	5
Shepherdia canadensis	<1	20
GRAMINOIDS		
Carex concina	1	90
Calamagrostis purpurascens	<1	15
Festuca altaica	<1	10
FORBS		
Arctostaphylos rubra	4	40
Equisetum scirpoides	1	80
Arnica latifolia	1	45
Lupinus arcticus	1	45
Mertensia paniculata	<1	15
Anemone parviflora	<1	10
Pyrola grandiflora	<1	15
Stellaria sp.	<1	5
Geocaulon lividum	<1	5
Pyrola secunda	<1	10
MOSSES & LIVERWORTS		
Ptilidium ciliare	12	75
Tomenthypnum nitens	11	90
Dicranum sp.	4	85
Hypnum sp.	4	85
Hylocomium splendens	1	70
Pohlia cruda	1	10
Distichium sp.	<1	20
LICHENS		
Peltigera aphthosa	3	90
Cladina arbusculà	3	80
Cladonia spp. (cupped)	2	80
Cetraria cucullata	2	75
Peltigera malacea	2	60
Cladonia spp. (horned)	1	65
Cladina stellaris	1	5
Hypogymnia physodes	1	30
Cetraria nivalis	1	10
Cladina rangiferina	<1	15
Cladonia amaurocraea	<1	20
Stereocaulon alpinum	<1	15
Cetraria laevigata	<1	25
Cetraria pinastre	<1	20
Fuscopannaria praetermissa	<1	5
Mushrooms	<1	15

Table 3. Summary statistics for trees and tall shrubs for Plot Coleen-A, Arctic NWR, 1997.

	Cover %	Frequency %	Stems/ha (pt.qtr.)	Stems/ha (quadrats)	Mean ht. (m)	Max. ht. (m)	Mean DBH (cm)	Max. DBH (cm)
TREES								
Picea glauca (White spruce)								
Mature trees	9	35	841/ha	625	19	28	19	32
Dwarf trees/Saplings	0	0	5/ha	0				
Seedlings	1	60						
Seedlings Basal Dia.<1 cm				14250				
Seedlings Basal Dia.1-2 cm				375				
Populus balsamifera (Balsam Poplar)								
Mature trees	5	10	106/ha	125	17	17	23	23
Dwarf trees/Saplings	<1	5	141/ha	125	2	2	2	2
Seedlings Basal Dia.<1 cm	1	50		3375				
TALL SHRUBS								
Alnus tenuifolia (Alder)	9	60			0.87	3.00		
DBH<1 cm				4125				
DBH=1-2 cm				1000				
DBH=2-3 cm				0				
DBH=3-4 cm				375				
DBH=4-5 cm				125				
Rosa asicularis (Rose)	4	95			0.28	0.86		
DBH<1 cm				21875				
Viburnum edule (Highbush cranberry)	1	60			0.29	0.68		
DBH<1 cm				3875				
Salix glauca (Grayleaf willow)	1	30			0.72	2.60		
DBH<1 cm				1125				
DBH=1-2 cm				125				
Cornus stolonifera (Dogwood)	1	55			0.38	0.95		
DBH<1 cm				2625				

Cover = Mean percent cover in plot based on occular estimates in 20-1 m quadrats.

Tree categories: mature trees = >1.3 m tall and >2.5 cm diameter at breast height (DBH); dwarf trees/saplings = >1.3 m tall and DBH < 2.5 cm; seedling = <1.3 m tall.

Stems/ha (pt.qtr.) = Number of stems per hectare, calculated by a point-centered quarter plotless method.

Stems/ha (quadrats) = Number of stems per hectare, calculated from stem counts by size class in the 20 - 4 m quadrats.

Frequency = frequency of occurrence of a species in the plot expressed as the percentage of 20-1 m quadrats with that species.

Table 4. Summary statistics for trees and tall shrubs for Plot Coleen-B, Arctic NWR, 1997.

		Cover %	Frequency %	Stems/ha (pt.qtr.)	Stems/ha (quadrats)	Mean ht. (m)	Max. ht. (m)	Mean DBH (cm)	Max. DBH (cm)
TREES									
Picea glauca (White spruce)									
Mature trees		13	55	1699/ha	1875/ha	8.33	14.25	11	16
Saplings		1	10	188/ha	250/ha	2.04	2.40		
Seedlings	Basal Dia.<1 cm	0	35		2625/ha	0.47	1.00		
Picea mariana (Black spruce)									
Mature trees		7	70	2077/ha	2375/ha	6.06	13.92	9	17
Saplings		1	15	686/ha	1625/ha	0.02	0.02		
Seedlings		3	75			0.45	0.99		
Seedlings	Basal Dia.<1 cm				11,125/ha				
Seedlings	Basal Dia.=1-2 cm				1250/ha				
Populus balsamifera (Poplar)									
Mature trees				0/ha	0/ha				
Saplings				11/ha	0/ha				
Seedlings	Basal Dia.<1 cm	0	20		750/ha	0.43	0.61		
TALL SHRUBS									
Salix glauca (Grayleaf willow)		2	55			0.72	1.50		
	DBH<1 cm				3750/ha				
	DBH=1-2 cm				500/ha				
	DBH=2-3 cm				125/ha				
Salix bebbiana (Bebb willow)		4	45			1.58	3.10		
	DBH<1 cm				4500/ha				
	DBH=1-2 cm				750/ha				
	DBH=2-3 cm				125/ha				
	DBH=3-4 cm				125/ha				
Rosa asicularis (Rose)									
	DBH<1 cm	0	5		125/ha	0.10	0.10		

Cover = Mean percent cover in plot based on occular estimates in 20 - 1 m quadrats.

Tree categories: mature trees = >1.3 m tall and >2.5 cm diameter at breast height (DBH); dwarf trees/saplings = >1.3 m tall and DBH < 2.5 cm: seedling = <1.3 m tall.

Stems/ha (pt.qtr.) = Number of stems per hectare as calculated by a point-centered quarter plotless method.

Stems/ha (quadrats) = Number of stems per hectare, as calculated from stem counts by size class in the 20 - 4 m quadrats.

Frequency = frequency of occurrence of a species in the plot expressed as the percentage of 20 - 1 m quadrats with that species.

Table 5. Summary statistics for fire fuels, depth of organic soil, and depth to permafrost for Plots Coleen-A and Coleen-B, Arctic NWR, 1997.

	COLEEN-A			COLEEN-B		
	Cover %	Frequency %	Number	Cover %	Frequency %	Number
Woody litter 0-1/4" diam.	5	100		4	95	
Woody litter 1/4-1" diam.	4	100		6	100	
Woody litter 1-3" diam.	2	90		3	80	
Sound logs	1	5		0	0	
Rotting logs	4	45		3	60	
Rotton logs	1	15		2	35	
Snags <6" DBH			5			7
Snags >6" DBH			3			1
Sound snags			3			0
Rotting snags			5			8
Rotten snags			0			0
	Depth			Depth		
Fuel ht. (inches)	5			2		
Organic soil depth (cm)	9			8		
Depth to permafrost (cm)	27			30		

Cover = percent cover in plot based on cover estimates in 20 - 1 m quadrats.

Frequency = frequency of occurrence of a fuel type in the plot expressed as the percentage of 20 quadrats with that fuel type.

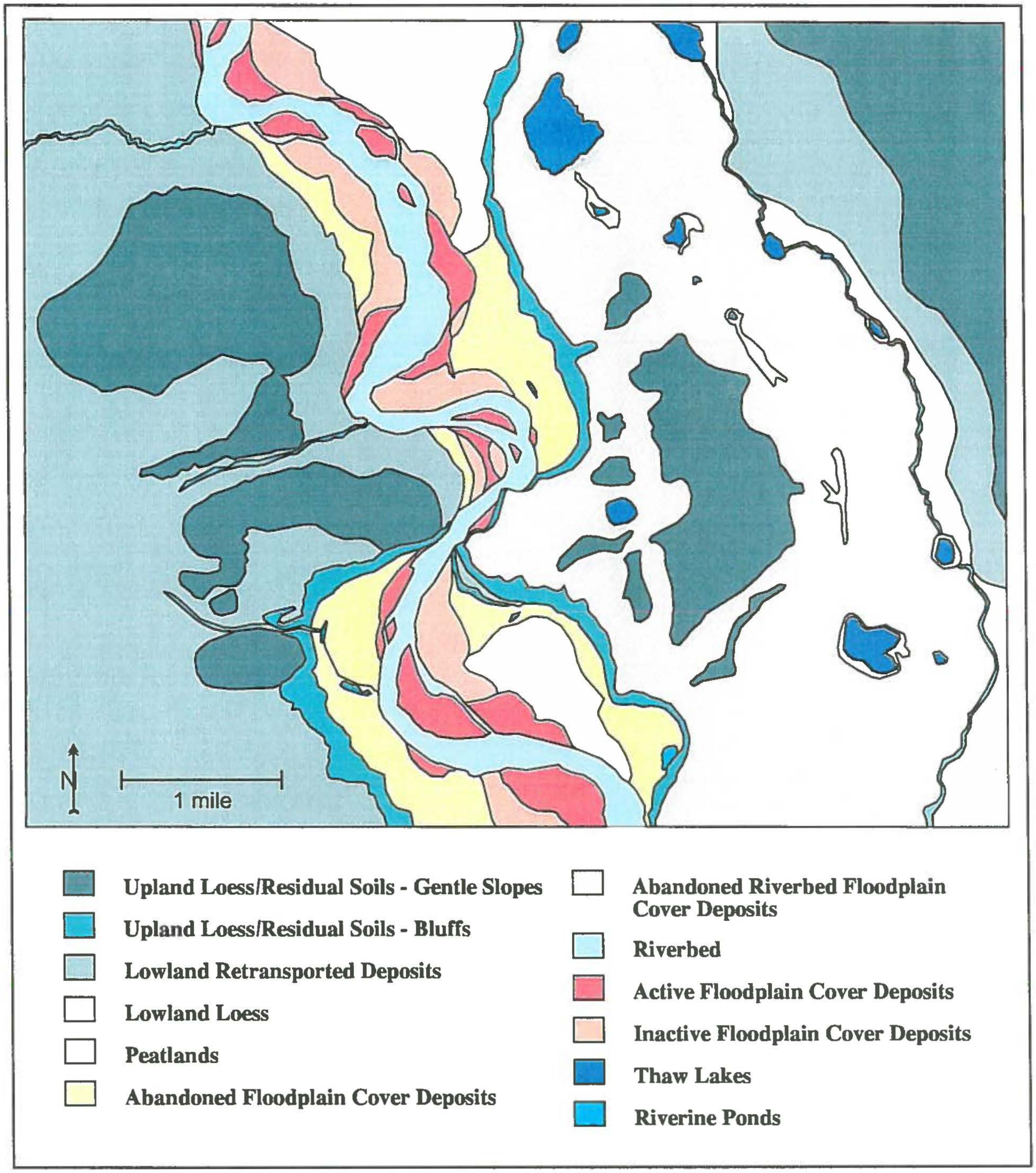

Figure 4. Geomorphology of the Coleen River long-term ecological monitoring site, Arctic NWR.

Table 6. Geomorphic units and environmental relationships for the Coleen River long-term ecological monitoring site in the Arctic NWR, based on descriptions from an ecological land classification of Ft. Wainwright, Alaska (Jorgenson et al. 1996).

Physio-graphy	Slope Position	Geomorphic Unit (code)	Soil Texture	Water Regime	Permafrost	Vegetation - typical plant communities
Upland	Upper and middle slope	Upland Loess/ Residual Soils - Gentle Slopes(US)	Fine	Well-drained	Unfrozen (frozen on N slopes)	Unburned = White Spruce forest (Black Spruce on N slopes). Post-burn =mixed shrub & deciduous forest.
	Steep bluffs and bluff-tops	Upland Loess/ Residual Soils - Bluffs (UB)	Fine	Well-drained	Unfrozen	White Spruce, post-burn shrub & deciduous forest, sage-grass bluffs, bare
Lowland - not floodplain	Lower slope	Lowland Retransported Deposits (LR)	Fine/ organic	Saturated/ imperfectly drained	Frozen, continuous	Black Spruce forest. Post-burn shrub & deciduous forest.
	Flat	Lowland Loess (LL)	Fine/ organic	Saturated	Frozen, continuous	Black Spruce forest, post-burn shrub, birch-ericaceous shrub bog
	Flat	Peatlands (P)	Organic	Saturated	Frozen, continuous	Collapse-scar bog, Sphagnum
Lowland - old floodplain	Flat	Abandoned Floodplain Cover Deposits (AF)	Fine/ organic	Saturated/ imperfectly drained	Frozen, continuous	Black Spruce forest, shrub meadow, bog
	Flat	Abandoned Riverbed Floodplain Cover Deposits (ARF)	Gravel	Well-drained	Unfrozen	White Spruce forest, post-burn shrub & deciduous forest, dwarf shrub
Riverine	Flat	Riverbed (R)	Gravel	Seasonally flooded (every 1 - 2 years)	Unfrozen	Bare or partially vegetated
	Flat	Active Floodplain Cover Deposits (A)	Fine	Well-drained (flooded ~ 3-5 years)	Unfrozen	Willow, alder, poplar
	Flat	Inactive Floodplain Cover Deposits (I)	Fine	Well-drained (flooded ~ every 5-25 years)	Unfrozen or discontinuous	White Spruce forest, poplar, shrub, wet meadow, Dryas dwarf shrub
	Various	Headwater Stream (S)	Fine	Saturated or well-drained	Unfrozen or discontinuous	Saturated = shrub, bog. Drained = forest, shrub.
Lakes	Flat	Thaw Lakes (TL)	Fine	Flooded	Frozen/unfrozen	Emergent aquatic plants or bog
	Flat	Riverine Ponds (RP)	Fine/gravel	Flooded	Unfrozen	Fen, emergent aquatic plants, or bog

Black and white aerial photographs from July 1995 and CIR aerial photographs from July 1978 were acquired for the study area. No other aerial photography is available. If we do more work at this site, acquisition of new aerial photographs will be a high priority. A preliminary map of the vegetation of the study area as it existed in 1978 was created based on photo-interpretation of a high-quality enlargement (4.75 inches = 1 mile) of a CIR photograph. We circled the area in a plane and took 48 oblique photographs. Each photograph was later referenced to the aerial photograph. Areas that burned after 1978 and therefore had different vegetation than that shown on the photograph were noted on the photograph. Over ½ of study area burned after 1978, so a map produced from those aerial photographs plus field notes would probably be unsatisfactory. We have now acquired a LANDSAT-TM satellite image from 1994 that includes the study area. We will use it to produce a land-cover map of the adjacent Yukon Flats NWR. When that image has been classified, a vegetation map of the Coleen River study area will be produced. It could simply be a segment of the Yukon Flats map, with the land-cover classes that can be successfully mapped for the whole satellite image. If greater detail and accuracy are wanted, a map of the study area could be produced by manual interpretation of the satellite image aided by reference to aerial photographs.

Figure 5 is a preliminary map of the recent fire history of the study area. It is based on Alaska Fire Service records, the 1996 field reconnaissance and photographs, 1955 and 1978 aerial photographs, and patterns visible on the 1994 LANDSAT-TM satellite image. More field work will be necessary to produce a reliable map. The AFS mapped boundaries of fires between 1970 and the present. In addition, a large fire in 1950 was mapped. Our field reconnaissance and aerial photographs showed that the burns were patchy, influenced by topography and the great differences in flammability between different vegetation types. The areas mapped by AFS tended to be smaller than the actual burns and included many unburned patches within them.

Figure 6 shows a generalized topographic cross-section of the vegetation and landforms of the Coleen River study area. It spans from Plot B in upland white and black spruce forest on the left, through the Coleen River floodplains in the center where Plot A is located in lowland white spruce forest, and into an area that is a patchwork of recent burns on the right. We propose to locate more permanent plots in the future, representing other sections marked on the cross-section. The best might be floodplain poplar forest, abandoned floodplain shrublands, and upland black spruce on permafrost. In addition to data collected this year, we would collect data on soils and water table level. The finished 'transect' of plots would conform to the ecological monitoring methods outlined in Hammen (1989). The methods are summarized and proposed for ecological monitoring in Alaskan refuges by Talbot (1994). Major environmental factors controlling distribution of vegetation in the study area are age since fire or river flooding disturbance, soil type and soil moisture (determined by geomorphology, slope position, and disturbance), and permafrost distribution (determined by slope position and disturbance). All are interrelated. A transect of plots where both vegetation and environmental variables are measured provides information on the relationships between vegetation and physical properties such as surficial geology, soil morphology, soil moisture, permafrost, water table level, slope, and aspect.

Breeding Bird Survey

To evaluate long-term trends in relative population size, off-road point counts (Ralph et al. 1995) will be conducted every year as part of the Alaskan Partners in Flight land-bird monitoring program. Detailed methods are described in Ralph et al. (1993), Handel (1994a, Appendix II) and Handel (1994b, Appendix II). A reconnaissance of the area assisted in determining the location for a survey transect at the Coleen study site. When the survey is first conducted, 12 sample points will be permanently marked on the transect and habitat characteristics will be recorded for each. The survey should be conducted in June of each year. The June 1997 survey was canceled due to river flooding.

Future Work

A vegetation map of the study area will be produced.

Monitoring of wildlife species with small home ranges should be initiated when funding becomes available. The first projects of this type could be trapping of small mammals and insects to obtain information on species, abundance, and distribution across landscape and vegetation units.

High-altitude CIR aerial photography should be taken of the area at a 10 inches = 1 mile scale. Photography could thereafter be repeated every 10 or 20 years, which would allow a variety of change-detection studies. More permanent vegetation plots should be established and sampling should occur once every five years. A more detailed reconnaissance of the area should be done to locate past fire boundaries and to determine forest stand ages at many sites by ring-counts on tree pith cores and dating of fire-scars on tree trunks. Other natural disturbances to be monitored at the site include large changes in the location of the Coleen River bed and any further beetle infestations.

INLAND TUNDRA STUDY SITE

An inland tundra study site for long-term ecological monitoring was established by the Jago River 25 miles from the arctic coast. A crew of three biologists and two biological technicians did six days of field work from July 10-15, 1996.

Previous Work and Maps of the Site

Considerable field work was done at this site in the past, including 15 bird and vegetation plots from the USFWS tundra bird study in 1985, six vegetation plots from a caribou habitat study in 1988, and 19 vegetation plots done for land-cover mapping of the Arctic NWR coastal plain in 1989. Locations of plots that had detailed vegetation information are shown on Figure 7. Wooden stakes marking some of the bird study plots were still visible in 1996. The 1988 and 1989 plots were not marked in the field, but they were marked on 10 inches=1 mile CIR aerial photographs. That scale would allow approximate relocation of the plots if needed. The site is in the heart of the traditional

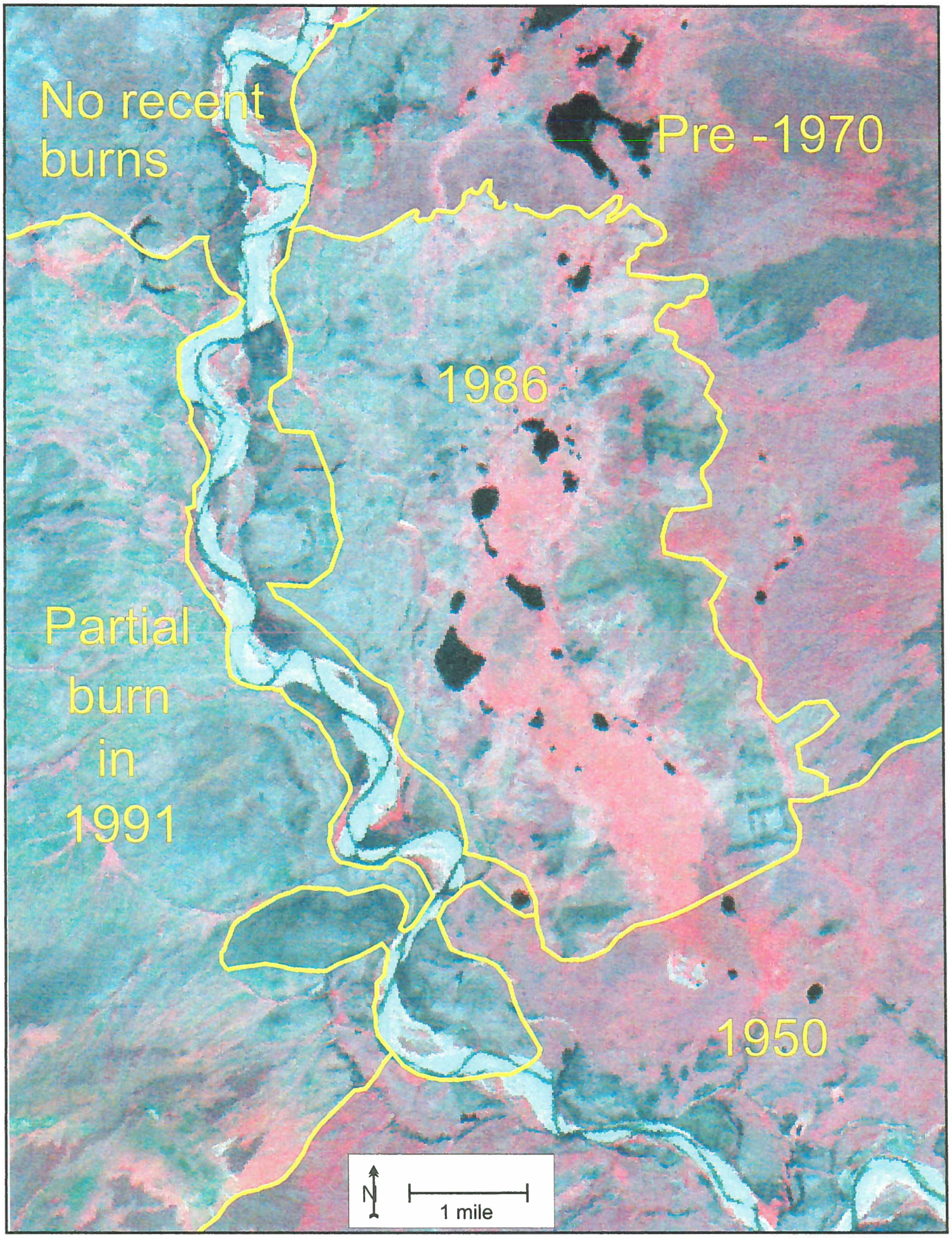

Figure 5. Recent fire history of the Coleen River long-term ecological monitoring site, based on Alaska Fire Service records and patterns visible on a July, 1994 LANDSAT-TM satellite image.

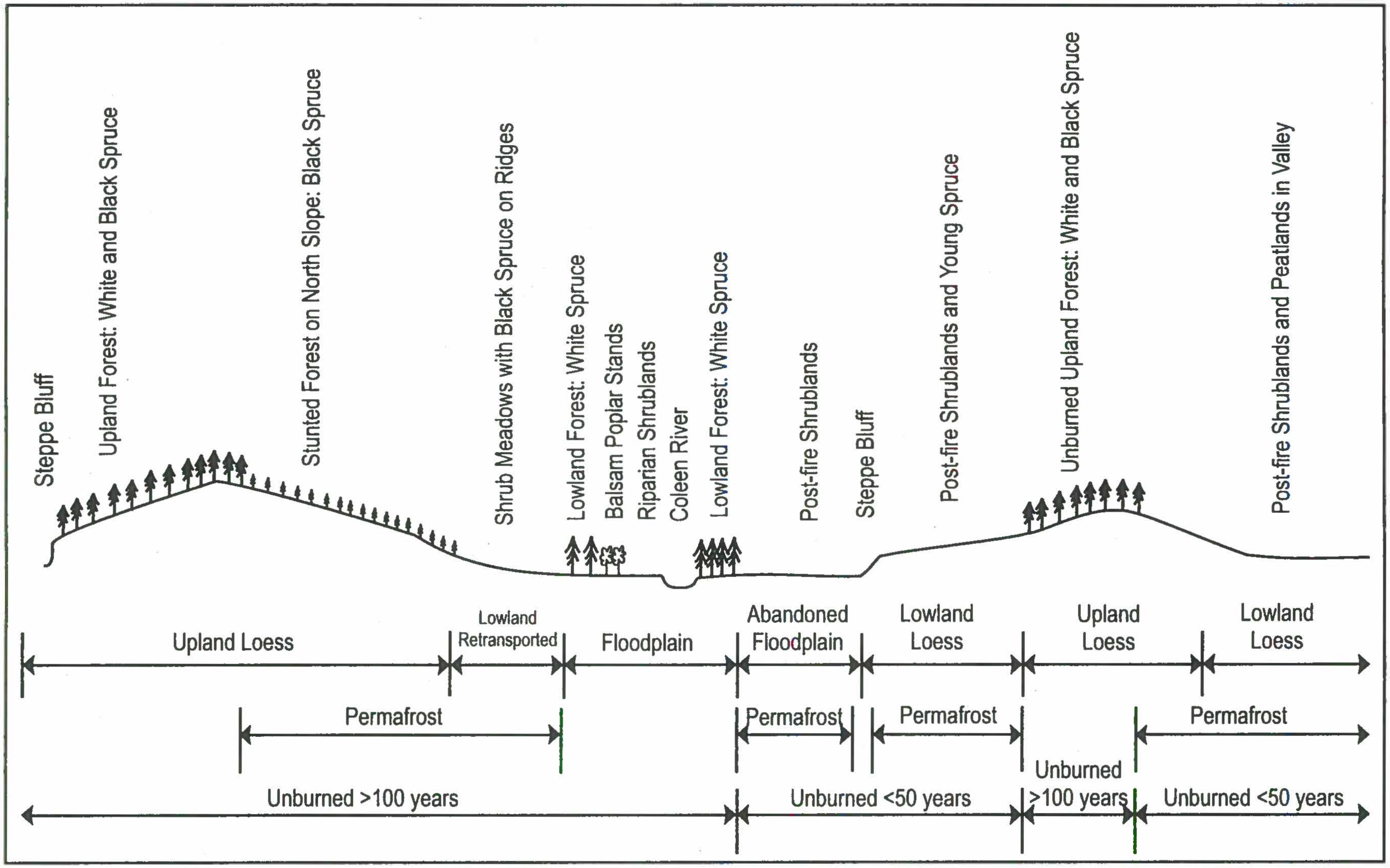

Figure 6. Gereralized topographic cross-section (SW to NE) across Coleen River long-term ecological monitoring site showing vegetation, simplified geomorphic units, permafrost distribution, and age since wildfire.

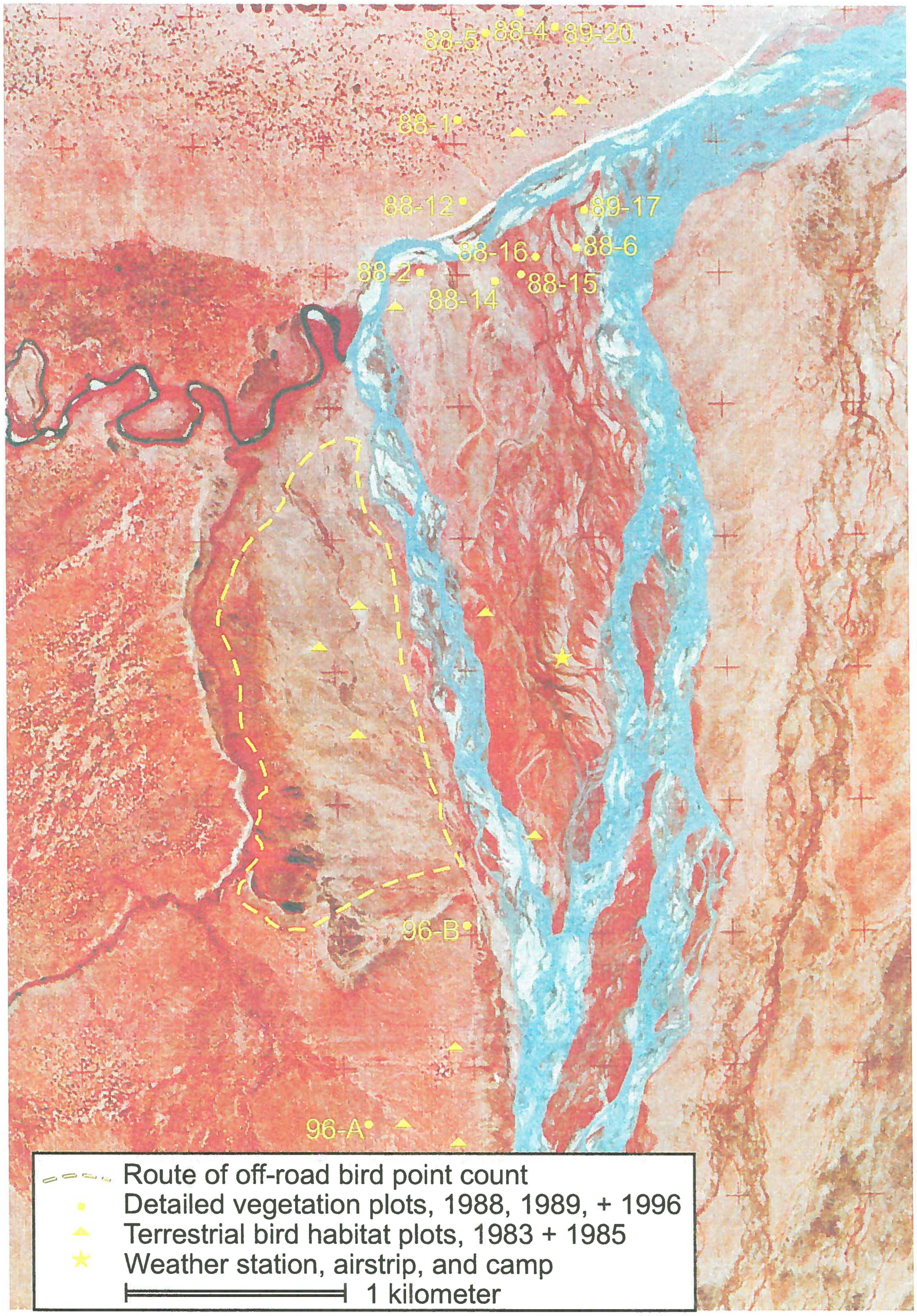

Figure 7. Jago River long-term ecological monitoring site, showing study plots on a 1978 color-infrared aerial photograph.

calving grounds of the Porcupine Caribou Herd. Therefore, many quick vegetation surveys were also done in the general area during caribou habitat studies between 1989 and 1994.

The vegetation of the coastal plain of the Arctic NWR has been mapped from LANDSAT-TM data (Jorgenson et al. 1994). Figure 8 shows the portion of the map covering the Jago River study area, with 14 land-cover classes mapped. Our field observations and a map accuracy check visit to this site in 1993 confirmed that the map is accurate for this area.

Permanent Vegetation Plots

Methods

We did a more detailed investigation of ground-level vegetation than at the boreal forest site, since there were no trees or tall shrubs on the tundra and there was already a large amount of vegetation data available for the area. Percent cover data for plant species have been collected at more than 700 plots on the coastal plain of the Arctic NWR in the past decade, so we wanted to do something different, preferably a very detailed investigation that could contribute to an understanding of long-term processes in the tundra both at large and small scales. We contacted several arctic vegetation researchers when determining what methods to use for our permanent vegetation plots in tundra. We chose the methods outlined in Walker et al. (1993) and described in detail in Walker (1995, Appendix II). In the Arctic, these methods are in use at the LTER tundra site at Toolik Lake (Alaska north slope), a National Science Foundation watershed study at Imnaviat Creek (Alaska north slope), and on the Russian tundra. They have been endorsed by the 'International Tundra Experiment', so will be put into practice at participating sites in all of the arctic countries.

We completed two plots in 1996. Ten permanently-marked 1 m^2 quadrats were established at each plot, spaced 10 m apart on a north-south transect (Fig. 9). Each quadrat location was marked with pieces of metal conduit at the SW and NE corners. The frame had two grids of cross-hairs, one an inch above the other. Each grid had 100 points evenly spaced 10 cm apart. When the upper and lower cross-hairs were lined up at each point, all species below them were recorded. The distance down to the top and bottom canopy were also measured, for mapping of micro-topography of both the ground and the vegetation canopy. Percent cover of plant species and lifeforms were calculated for the plot. Maps of microtopography and plant species occurrence were plotted for each quadrat using ARC-INFO.

Depth below the ground surface to permafrost was measured with a probe 10 times adjacent to the west side of each quadrat. Depth to the water table was measured with a ground-water tube 1 m east of each quadrat. A length of perforated 2-inch-diameter PVC pipe was driven into the ground and the water level in the tube was allowed to equilibrate for 24 hours. Distance between the ground level and the water in the pipe were measured. The pipes were left in place for future sampling.

We propose to resample the plots every five years. We expect to be able to document changes over time in vegetation composition and microtopography. These changes will be caused by natural successional processes about which very little is known in tundra, inter-specific competition, and changes in weather and growing conditions due to climate fluctuations and global climate change.

Plot Jago-A

One plot is in tussock tundra, the dominant vegetation type of the foothills on Arctic coastal plain. It is on the slopes of the hill known as VABM Jago-Bitty in the traditional calving area of the Porcupine Caribou Herd, and is the vegetation type that appears to provide the best caribou forage during the calving period. Tussock tundra is considered the 'climax' vegetation of the foothills, but it is dependent on chronic small-scale disturbance by frost boils for the establishment of tussocks, so the true climax is unknown. Long-term data on small-scale dynamics in tussock tundra do not exist and would be of great interest. Table 7 lists the plant species and lifeforms and their percent cover for the plot and Appendix I has maps of species locations and microtopography for each 1 m^2 quadrat. Table 9 has the depths below the ground surface of the water table and permafrost.

Plot Jago-B

The second plot is on a slope of moist sedge-Dryas tundra. This common vegetation occurs on younger soil surfaces than tussock tundra and has higher soil pH and greater frost-boil activity. Its appearance is similar to tussock tundra, but it has different dominant sedge, shrub, and moss species and the ground surface is rolling hummocks rather than cottongrass tussocks. Table 8 lists the plant species and lifeforms and their percent cover for the plot and Appendix I has maps of species locations and microtopography for each 1 m^2 quadrat. Table 9 has the depths below the ground surface of the water table and permafrost.

Breeding Bird Survey

Off-road point counts will be conducted in June of each year as part of the Alaskan Partners in Flight land-bird monitoring program. A transect of plots was located and 12 plots were marked with stakes. The survey was canceled in June 1997 because of flooding.

Weather Station

A Omni Data-logger remote weather station was installed at the site, the only weather station currently in the northern part of the refuge. The station was one of five that were in use from 1989 to 1996 at study sites on the Arctic coastal plain as part of the 1002 area studies and later the NBS simulated global warming study.

Yearly maintenance and data tape retrieval should be done when the breeding bird

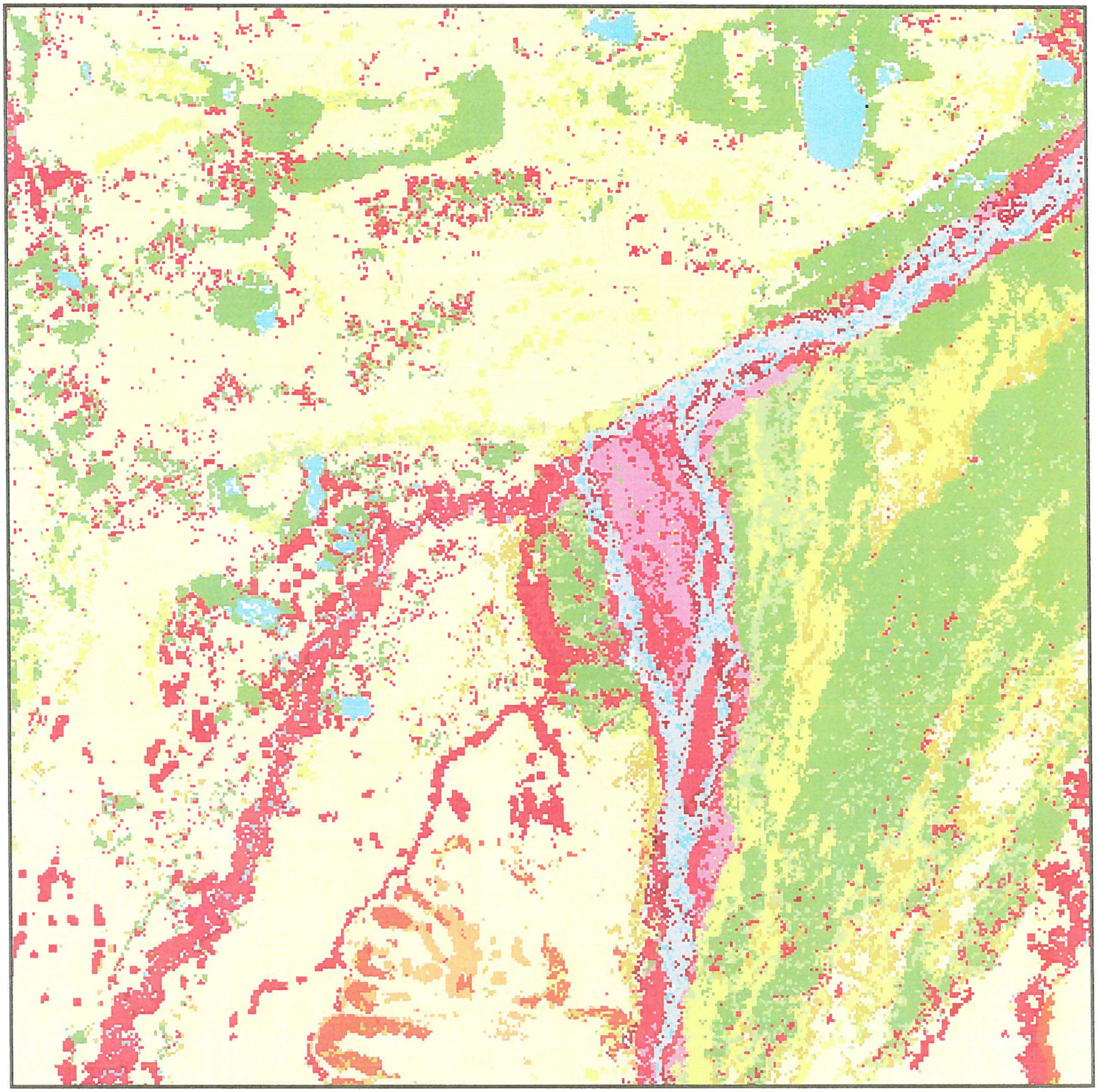

Figure 8. Vegetation of the Jago River study site, mapped from a LANDSAT-TM satellite image.

Figure 9. A 1-meter vegetation sampling quadrat at Plot Jago-B. Two biologists call out plant species and heights measured at 100 cross-hairs and a third records. Tube for ground water depth measurements is at left.

Table 7. Percent cover of plant species and lifeforms for Plot Jago-A, Arctic NWR, 1997.

	COVER (%)
TOTAL VEGETATION	120
SHRUBS	35
SEDGES AND GRASSES	25
FORBS	5
MOSSES AND LIVERWORTS	46
LICHENS	13
STANDING DEAD SEDGE AND GRASS	32
LITTER	23
BARE GROUND	0
SHRUBS	
BETULA NANA	11
SALIX PLANIFOLIA	8
LEDUM DECUMBENS	7
CASSIOPE TETRAGONA	5
VACCINIUM VITIS-IDAEA	5
SALIX PHLEBOPHYLLA	<1
SALIX RETICULATA	<1
ARCTOSTAPHYLOS ALPINA	<1
SEDGES AND GRASSES	
ERIOPHORUM VAGINATUM	19
CAREX BIGELOWII	5
ARCTAGROSTIS LATIFOLIA	1
FORBS	
POLYGONUM BISTORTA	2
PYROLA GRANDIFLORA	1
PEDICULARIS CAPITATA	1
POLYGONUM VIVIPARUM	<1
SENECIO SP.	<1
STELLARIA SP.	<1
MOSSES AND LIVERWORTS	
HYLOCOMIUM SPLENDENS	18
DICRANUM SP.	9
AULACOMNIUM TURGIDUM	7
TOMENTHYPNUM NITENS	5
SPHAGNUM SP.	4
AULACOMNIUM PALUSTRE	3
POLYTRICHUM JUNIPERINUM	1
POLYTRICHUM STRICTUM	<1
RHYTIDIUM RUGOSUM	<1
PTILIDIUM CILIARE	<1
UNKNOWN LEAFY LIVERWORT	<1
LICHENS	
PELTIGERA APHTHOSA	8
CRUSTOSE LICHEN	1
PELTIGERA CANINA	1
CETRARIA CUCULLATA	1
CLADONIA SP.	1
CETRARIA ISLANDICA	<1
DACTYLINA ARCTICA	<1
SPHAEROPHORUS GLOBOSUS	<1

Percent cover based on point sampling with 1000 points per plot.

Table 8. Percent cover of plant species and lifeforms for Plot Jago-B, Arctic NWR, 1997.

	COVER (%)
TOTAL VEGETATION	133
SHRUBS	39
SEDGES AND GRASSES	23
FORBS	8
MOSSES AND LIVERWORTS	61
LICHENS	5
STANDING DEAD SEDGE AND GRASS	22
LITTER	35
BARE GROUND	<1
SHRUBS	
SALIX PULCHRA	7
SALIX PHLEBOPHYLLA	6
SALIX RETICULATA	6
VACCINIUM VITIS-IDAEA	5
SALIX GLAUCA	5
CASSIOPE TETRAGONA	4
DRYAS INTEGRIFOLIA	4
BETULA NANA	2
ARCTOSTAPHYLOS ALPINA	1
VACCINIUM ULIGINOSUM	<1
SALIX ROTUNDIFOLIA	<1
SEDGES AND GRASSES	
CAREX BIGELOWII	14
ERIOPHORUM VAGINATUM	7
ARCTAGROSTIS LATIFOLIA	2
LUZULA SP.	<1
FORBS	
POLYGONUM BISTORTA	4
SENECIO SP.	1
PYROLA GRANDIFLORA	1
PEDICULARIS CAPITATA	1
SAUSSUREA ANGUSTIFOLIA	1
MINUARTIA ARCTICA	1
SAXIFRAGA PUNCTATA & STELLARIA SP.	<1
MOSSES AND LIVERWORTS	
HYLOCOMIUM SPLENDENS	15
AULACOMNIUM TURGIDUM	15
TOMENTHYPNUM NITENS	12
DICRANUM SP.	7
POLYTRICHUM JUNIPERINUM	5
AULACOMNIUM PALUSTRE	3
PTILIDIUM CILIARE	1
RHYTIDIUM RUGOSUM	1
POLYTRICHUM STRICTUM	1
HYPNUM SP. & HYPNUM SP.	<1
RHACOMITRIUM LANUGNOSUM	<1
UNKNOWN LEAFY LIVERWORT	<1
CAMPYLIUM STELLATUM	<1
THUIDIUM ABIETINUM	<1
LICHENS	
PELTIGERA APHTHOSA	2
PELTIGERA SP.	2
CLADONIA SP.	1
CRUSTOSE LICHEN	1
CETRARIA CUCULLATA & C. LAEVIGATA	<1
DACTYLINA ARCTICA	<1
THAMNOLIA SP.	<1

Table 9. Slope, aspect, and depths below ground surface (mean +/- SD) to water table and permafrost at Plots Jago-A and Jago-B.

	Slope	Aspect	Water Depth (cm)	Permafrost Depth (cm)
Jago-A (Tussock Tundra)	2%	N	5 +/- 4	27 +/- 8
Jago-B (Sedge-Dryas Tundra)	2%	N	12 +/- 9	30 /- 9

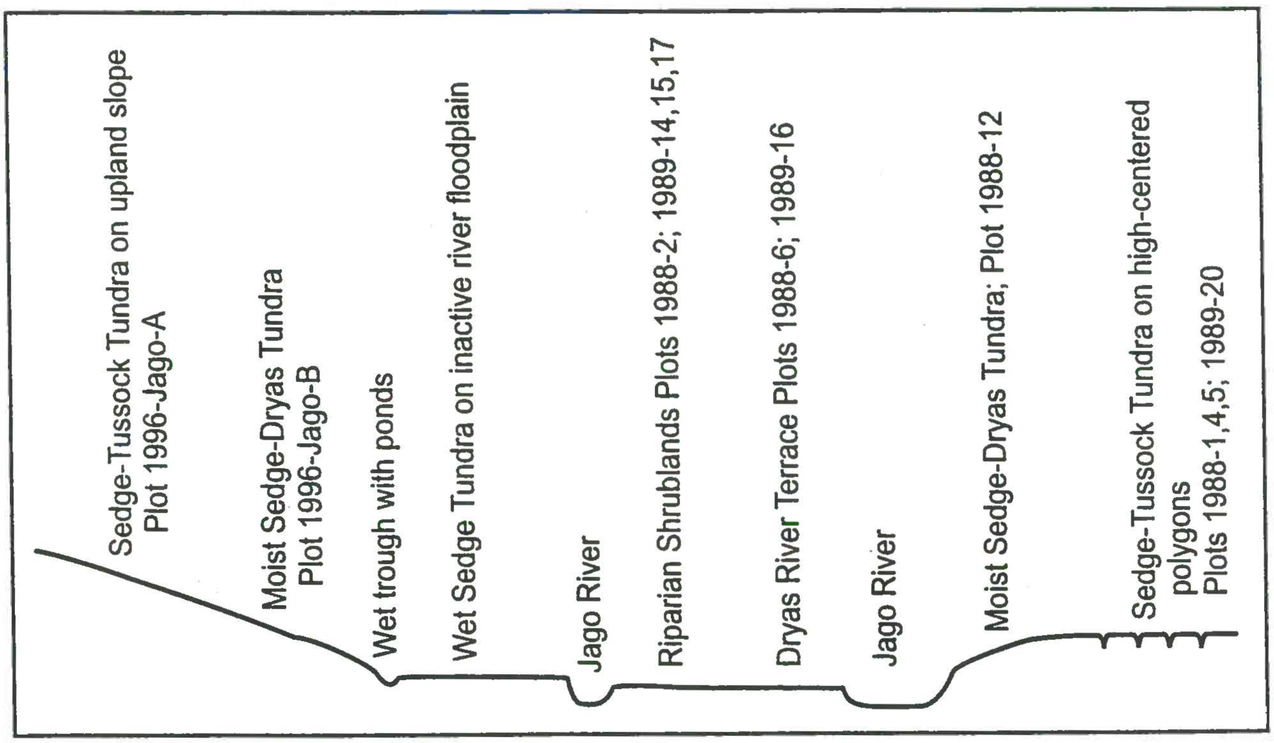

Figure 10.Generalized topographic cross-section (SW to NE) across the Jago River long-term ecological monitoring site, showing vegetation types and plots with quantitative vegetation cover data.

surveys are done. The other weather stations are in storage at Barter Island field station and could be installed at other long-term monitoring sites in the future. Refuge staff think that the stations may be too out-dated to warrant a maintenance effort. Refuge priorities should be reviewed to determine the importance of weather information and then a decision can be made on the future of these weather stations. The Jago River weather station was visited in 1997 but the data tape was not retrieved due to lack of tools.

The only weather station in the Arctic NWR is a 'Remote Assess Weather Station' (RAWS) at Helmet Mountain near the Sheenjek River, south of the Brooks Range. It is maintained by the Alaska Fire Service. There is another RAWS station near Graphite Lake in Yukon Flats NWR, 15 miles SW of the Coleen River study site. It has been recording weather data since 1991, with frequent data gaps in wintertime. Weather data have been collected at the LTER site at Toolik Lake since 1988. It is located along the Dalton Highway, 16 miles NW of Atigun Gorge. We established our third long-term ecological monitoring site in Atigun Gorge in July 1997 to represent the mountainous zone of the refuge. We propose to maintain a weather station only at the Jago River site.

Future Work

Monitoring of invertebrates, furbearers, and small mammals should be initiated when funding becomes available. The first projects of this type might be trapping of insects and small mammals to obtain information on species, abundance, and distribution across landscape and vegetation units.

High-altitude CIR aerial photography should be acquired for the study area at a 10 inches = 1 mile scale. Photography could thereafter be repeated every 10 or 20 years, which would allow a variety of change detection studies.

Permanent vegetation plots should be sampled once every five years. Figure 10 shows the location of the two permanent plots on a topographic cross-section of the vegetation gradient in the study area. Also shown are locations of other plots with plant species cover data from 1988 and 1989. If we are funded to do further work in the area, we would establish a permanent plot in the wet graminoid tundra on the inactive floodplain, the only major section of the gradient where no plots have been done. We would also gather data at all plots to complete a data set of environmental variables, such as depths to permafrost, water table level, and soil types.

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APPENDIX I: Graphics of plant species locations and ground layer and plant canopy microtopography for each 1 m^2 quadrat in plots Jago-A and Jago-B, Arctic NWR, 1996

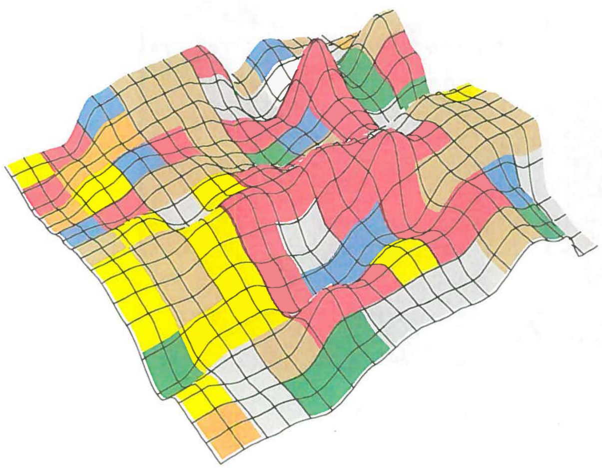
Vegetation at Jago-B, Quadrat 1, July 12, 1996

Canopy

CABI	SARE	POBI	GRAMX	GRAMX	ARAL	GRAMX	POBI	GRAMX	DAAR
SARE	DRIN	DRIN	GRAMX	GRAMX	LIT	LIT	CELA	LIT	DRIN
DRIN	CABI	POBI	SAPH	GRAMX	SARE	SARE	SAGL	AUTU	GRAMX
POBI	SAPH	GRAMX	GRAMX	GRAMX	POJU	SAPU	SAGL	AUTU	VAVI
GRAMX	CABI	LIT	CABI	SAGL	SAGL	GRAMX	SARE	LIT	HYSP
CABI	GRAMX	CABI	SAGL	SAGL	SAGL	SAGL	LIT	GRAMX	ERVA
CABI	GRAMX	CABI	SAGL	LIT	ARAL	SAGL	VAVI	GRAMX	GRAMX
TONI	CABI	CABI	SAGL	POBI	POBI	SAGL	GRAMX	GRAMX	GRAMX
CABI	LIT	GRAMX	SAGL	SAGL	CABI	SAGL	SAGL	POBI	LIT
DRIN	LIT	AUTU	DIEL	LIT	LIT	LIT	GRAMX	AUTU	LIT

Ground

TONI	GRAMX	POJU	AUTU	GRAMX	LIT	TONI	LIT	LIT	DAAR
LIT	LIT	LIT	HYSP	GRAMX	AUTU	LIT	CELA	AUTU	POJU
ARAL	LIT	THAB	THAB	HYSP	GRAMX	LIT	AUTU	AUTU	GRAMX
LIT	LIT	LIT	AUPA	POJU	POJU	LIT	HYSP	AUTU	LIT
GRAMX	GRAMX	DIEL	LIT	AUPA	LIVER	DIEL	DIEL	PTCI	HYSP
PELTI	LIT	GRAMX	POJU	LIT	LIT	DRIN	DIEL	GRAMX	HYSP
LIT	POJU	LIT	TONI	POJU	SARE	LIT	LIT	GRAMX	GRAMX
TONI	LIT	TONI	SAGL	LIT	TONI	HYSP	LIT	GRAMX	GRAMX
POJU	HYSP	PTCI	AUPA	LIT	POJU	AUTU	LIT	AUTU	TONI
LIT	TONI	AUTU	DIEL	CAST	TONI	LIT	AUTU	AUTU	HYSP



Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
DRIN	Dryas integrifolia
ERVA	Eriophorum vaginatum
POBI	Polygonum bistorta
SARE	Salix reticulata
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
TONI	Tomenthypnum nitens
DAAR	Dactylina arctica
SAPH	Salix phlebophylla
SAPU	Saxifraga punctata nelsoniana
LIVER	Leafy liverwort
POJU	Polytrichum juniperinum
ARAL	Arctostaphylos alpina
LIT	Litter
GRAMX	Standing dead graminoid
SAGL	Salix glauca
PELTI	Peltigera sp.
CELA	Cetraria laevigata
THAB	Thuidium abietinum

This copy of the report includes graphics for 10 of the 20 quadrats.

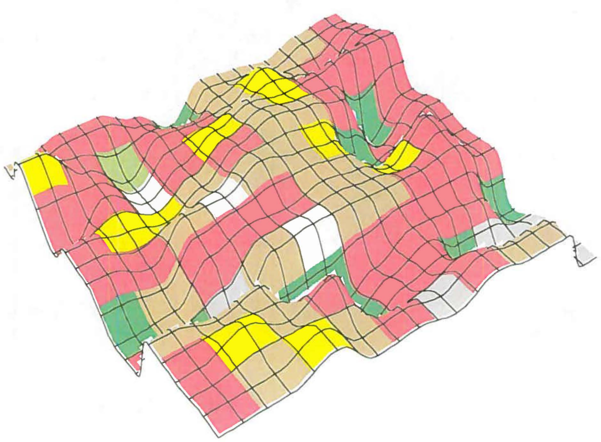
Vegetation at Jago-A, Quadrat 2, July 13, 1996

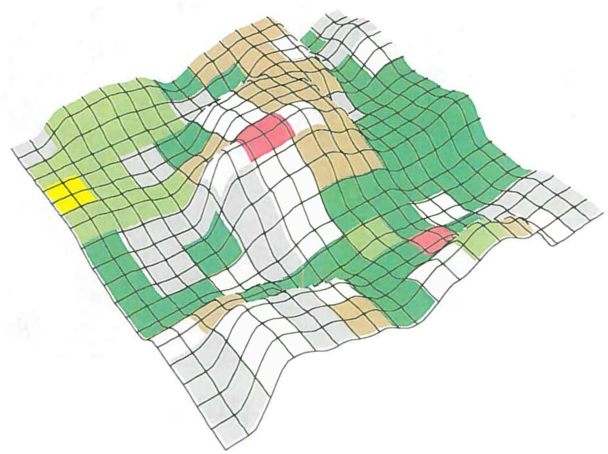
Canopy

GRAMX	LEDE	BENA	LEDE	AUPA	GRAMX	GRAMX	GRAMX	GRAMX	BENA
ERVA	SAPL	SPHAG	ARAL	LEDE	GRAMX	ERVA	GRAMX	BENA	BENA
SAPL	SAPL		SAPL	ERVA	GRAMX	ERVA	BENA	SAPL	BENA
SAPL	ERVA	ERVA	GRAMX	BENA	GRAMX	GRAMX	BENA	HYSP	SAPL
SAPL	BENA	GRAMX		GRAMX	GRAMX	ERVA	HYSP	BENA	BENA
HYSP	GRAMX	SAPL	BENA	VAVI	GRAMX	GRAMX	ERVA	BENA	BENA
SAPL	AUTU	LIT	GRAMX		GRAMX	GRAMX	BENA	BENA	BENA
GRAMX	GRAMX	GRAMX	TONI	HYSP	BENA	SAPL	SAPL	SAPL	HYSP
LEDE	ERVA	GRAMX	BENA	HYSP	BENA	SAPL	HYSP	LIT	LIT
BENA	GRAMX	ERVA	GRAMX	BENA	LIT	SAPL	GRAMX	GRAMX	LIT

Ground

LIT	SPHAG	SPHAG	SPHAG	AUPA	GRAMX	GRAMX	GRAMX	HYSP	LIT
SPHAG	SPHAG	SPHAG	SPHAG	LIT	HYSP	GRAMX	PECA2	LIT	LIT
ERVA	SPHAG	LIT	HYSP		GRAMX	GRAMX	GRAMX	HYSP	PECA2
SPHAG	SPHAG	SPHAG	GRAMX		GRAMX	GRAMX	LIT	HYSP	HYSP
AUTU	LIT	LIT		LEDE		GRAMX	HYSP	HYSP	HYSP
HYSP	LIT	AUTU	LIT	PECA2	GRAMX	GRAMX	HYSP	HYSP	HYSP
HYSP	HYSP	PEAP	LIT	PEAP	AUPA	AUPA	HYSP	HYSP	AUPA
PEAP	GRAMX	TONI	TONI	HYSP	SPHAG	HYSP	PEAP	HYSP	HYSP
LIT		LIT	PEAP	HYSP	AUPA	ARAL	HYSP	LIT	LIT
LIT		LIT	GRAMX	HYSP	PEAP	SPHAG	GRAMX	PEAP	LIT





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

ARAL	Arctostaphylos alpina
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
BENA	Betula nana
ERVA	Eriophorum vaginatum
HYSP	Hylocomium splendens
LEDE	Ledum decumbens
LIT	Litter
PEAP	Peltigera aphthosa
PECA2	Peltigera canina
SAPL	Salix planifolia
SPHAG	Sphagnum sp.
GRAMX	Standing dead
TONI	Tomenthypnum nitens
VAVI	Vaccinium vitis-idaea

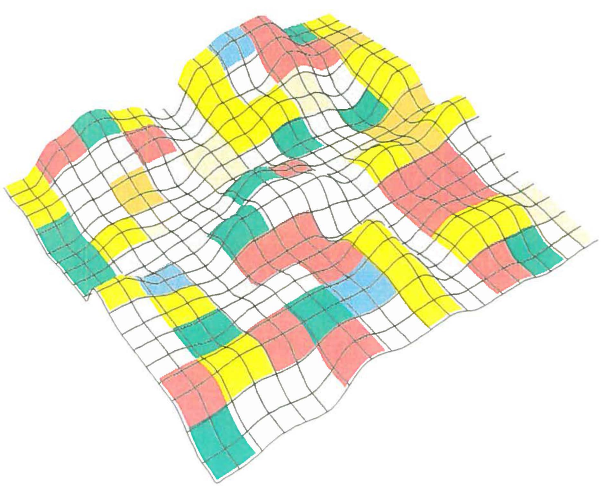
Vegetation at Jago-B, Quadrat 3, July 12, 1996

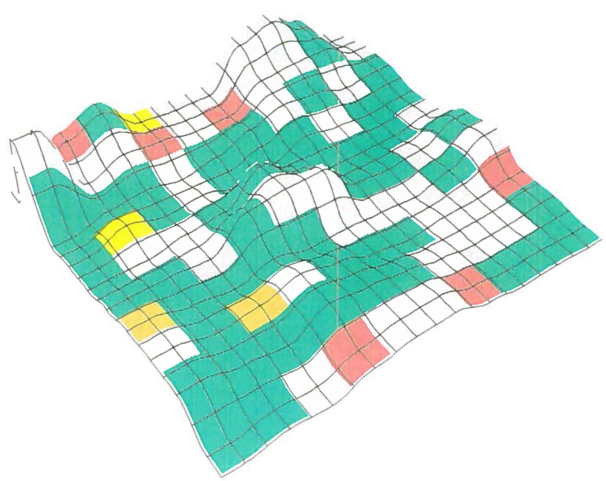
Canopy

CABI	VAVI	AUTU	ERVA	LIT	CABI	POBI	SARE	DIEL	CABI
CABI	LIT	LIT	SARE	LIT	CABI	LIT	SARE	SARE	DRIN
AUTU	LIT	DRIN	LIT	GRAMX	CABI	CABI	GRAMX	LIT	CABI
DIEL	CABI	GRAMX	LIT	GRAMX	LIT	HYSP	LIT	TONI	CABI
HYSP	LIT	LIT	LIT	DIEL	SARE	LIT	GRAMX	CATE	CATE
CABI	POBI	LIT	AUTU	LIT	LICHEN	LIT	CABI	CATE	ERVA
LIT	CABI	LIT	SARE	SARE	LIT	LIT	SARE	SARE	LIT
LIT	AUTU	LIT	PELTI	VAVI	CABI	LIT	SARE	SARE	LIT
SAPH	ERVA	SAGL	DIEL	SENEC	CABI	LIT	CABI	CABI	GRAMX
AUTU	LIT	LIT	SAGL	LIT	CABI	LIT	SARE	TONI	GRAMX

Ground

LIT	VAVI	AUTU	CABI	LIT	LIT	LIT	LIT	DIEL	LIT
LIT	PEAP	LIT	SARE	LIT	VAVI	LIT	LIT	DIEL	LIT
AUTU	TONI	AUTU	LIT	AUTU	HYSP	LIT	DIEL	LIT	TONI
DIEL	CABI	TONI	LIT	TONI	HYSP	HYSP	CECU	TONI	HYSP
HYSP	LIT	LIT	AUTU	DIEL	POJU	TONI	TONI	HYSP	LIT
HYSP	PTCI	LIT	AUTU	LIT	LICHEN	TONI	TONI	LIT	POJU
DRIN	HYSP	AUTU	AUTU	POJU	LIT	LIT	LIT	TONI	LIT
LIT	AUTU	CATE	PELTI	AUTU	TONI	TONI	LIT	LIT	VAVI
AUTU	DIEL	POJU	DIEL	POJU	DIEL	LIT	LIT	LIT	TONI
AUTU	TONI	LIT	VAVI	LIT	LIT	VAVI	AUTU	TONI	TONI





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
CATE	Cassiope tetragona
DRIN	Dryas integrifolia
ERVA	Eriophorum vaginatum
POBI	Polygonum bistorta
SARE	Salix reticulata
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
TONI	Tomenthypnum nitens
CECU	Cetraria cucullata
PEAP	Peltigera aphthosa
SAPH	Salix phlebophylla
POJU	Polytrichum juniperinum
SENEC	Senecio sp.
LIT	Litter
GRAMX	Standing dead graminoid
SAGL	Salix glauca
LICHEN	Crustose lichen
PELTI	Peltigera sp.

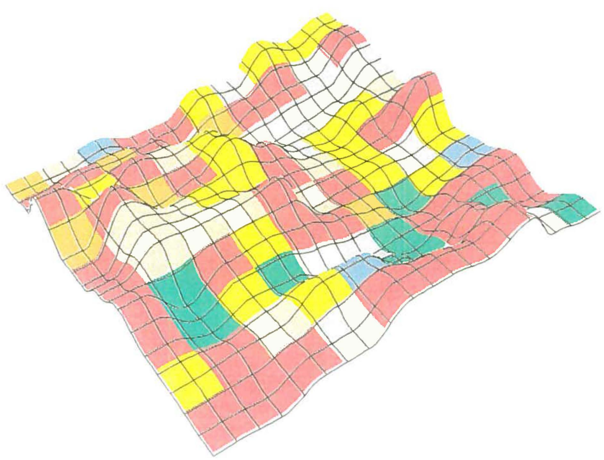
Vegetation at Jago-B, Quadrat 4, July 12, 1996

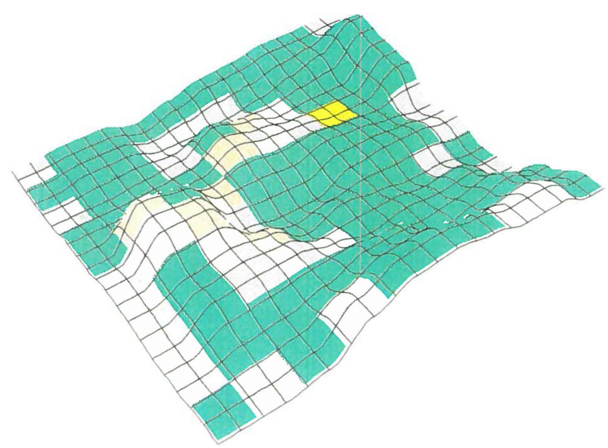
Canopy

CATE	GRAMX	SENEC	SARE	SAPL	ERVA	LIT	CABI	ERVA	ARLA
SAPL	SAPL	CATE	BENA	LIT	DRIN	SAPL	SARE	LIT	SAPL
SAGL	CABI	SAGL	GRAMX	ERVA	GRAMX	LICHEN	LIT	LIT	LIT
CATE	BENA	CATE	SAGL	ERVA	BENA	LIT	LUZUL	ERVA	GRAMX
SARE	GRAMX	GRAMX	ERVA	ERVA	SAPL	GRAMX	ERVA	SARE	SAGL
BENA	GRAMX	GRAMX	GRAMX	SAGL	GRAMX	BENA	ERVA	LIT	CABI
SAGL	AUTU	BENA	ERVA	SAPL	SAGL	DRIN	TONI	CABI	PECA
SAPL	AUTU	ERVA	AUTU	PEAP	LIT	HYSP	SAPH	SAGL	SAGL
CABI	BENA	GRAMX	ERVA	PECA	DIEL	POJU	SAGL	DIEL	SARE
BENA	SARE	ARAL	LIT	BENA	BENA	SAGL	SAGL	LICHEN	POJU

Ground

LIT	HYSP	HYSP	HYSP	TONI	AUPA	PTCI	HYSP	HYSP	LIT
TONI	TONI	TONI	LIT	LIT	LIT	HYSP	HYSP	AUTU	AUTU
LIT	TONI	TONI	LIT	AUTU	GRAMX	LICHEN	TONI	TONI	AUTU
HYSP	TONI	TONI	AUTU	GRAMX	LIT	LIT	LUZUL	HYSP	AUTU
HYSP	GRAMX	TONI	GRAMX	HYSP	HYSP	HYSP	POJU	PTCI	LIT
LIT	LIT	GRAMX	LIT	TONI	TONI	TONI	HYSP	HYSP	LIT
LIT	AUTU	LIT	GRAMX	TONI	AUTU	TONI	TONI	LIT	AUTU
LIT	AUTU	LIT	LIT	PEAP	HYSP	HYSP	TONI	TONI	LIT
LIT	AUTU	AUTU	LIVER	POJU	DIEL	POJU	AUPA	DIEL	TONI
AUTU	LIT	HYSP	LIT	DIEL	RHRU	RHRU	THSU	LICHEN	TONI





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
CATE	Cassiope tetragona
DRIN	Dryas integrifolia
ERVA	Eriophorum vaginatum
SARE	Salix reticulata
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
PEAP	Peltigera aphthosa
THSU	Thamnolia subuliformis
SAPH	Salix phlebophylla
BENA	Betula nana
LIVER	Leafy liverwort
POJU	Polytrichum juniperinum
ARAL	Arctostaphylos alpina
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SENEC	Senecio sp.
LIT	Litter
GRAMX	Standing dead graminoid

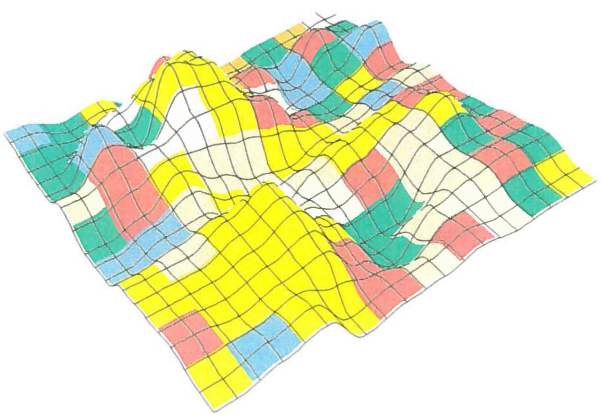
Vegetation at Jago-B, Quadrat 5, July 12, 1996

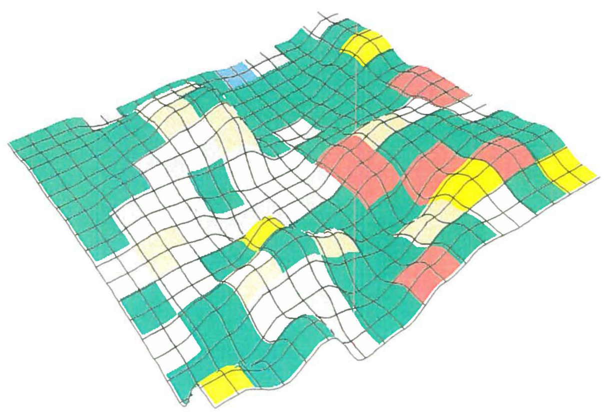
Canopy

PYGR	HYSP	CABI	POJU	BENA	TONI	DRIN	HYSP	DRIN	PEAP
HYSP	HYSP	CLADO	ERVA	ERVA	CATE	SAPL	PYGR	BENA	AUPA
RHRU	PECA	AUTU	CABI	ERVA	ERVA	LIT	PYGR	HYSP	PECA
GRAMX	ARAL	LIT	LIT	ERVA	SAPL	BENA	HYSP	CABI	SAPL
AUTU	SAPH	CABI	GRAMX	GRAMX	CABI	ERVA	GRAMX	SENEC	GRAMX
PYGR	SENEC	GRAMX	CABI	LIT	GRAMX	ERVA	ERVA	BENA	VAVI
CABI	GRAMX	ARLA	ERVA	GRAMX	LIT	VAVI	GRAMX	ARLA	AUPA
CABI	CABI	ERVA	ERVA	ERVA	MNIUM	TONI	GRAMX	AUTU	BENA
BENA	CABI	ERVA	ERVA	SAPL	PTCI	GRAMX	GRAMX	BENA	AUTU
ERVA	SENEC	ERVA	ERVA	BENA	GRAMX	BENA	PEAP	AUTU	ERVA

Ground

AUTU	HYSP	LIT	POJU	TONI	TONI	PYGR	LIT	HYSP	PEAP
HYSP	HYSP	POJU	GRAMX	GRAMX	TONI	HYSP	HYSP	HYSP	AUPA
DIEL	AUTU	AUTU	GRAMX	HYSP	HYSP	HYSP	HYSP	HYSP	ERVA
AUTU	HYSP	LIT	LIT	GRAMX	TONI	LIT	HYSP	HYSP	AUTU
AUTU	LIT	LIT	TONI	LIT	LIT	TONI	HYSP	HYSP	VAVI
PELTI	GRAMX	LIT	LIT	LIT	LIT	VAVI	GRAMX	PEAP	VAVI
HYSP	LIT	HYSP	ERVA	PTCI	PTCI	VAVI	HYSP	AUTU	PEAP
LIT	AUTU	GRAMX	HYSP	GRAMX	MNIUM	TONI	VAVI	AUTU	AUTU
CAST	AUTU	LIT	LIT	PTCI	PTCI	GRAMX	CABI	BENA	AUTU
ERVA	DIEL	AUTU	LIT	TONI	VAVI	AUTU	PEAP	AUTU	ERVA





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
CATE	Cassiope tetragona
DRIN	Dryas integrifolia
ERVA	Eriophorum vaginatum
PYGR	Pyrola grandiflora
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
PEAP	Peltigera aphthosa
SAPH	Salix phlebophylla
BENA	Betula nana
CLADO	Cladonia sp.
MNIUM	Mnium sp.
POJU	Polytrichum juniperinum
ARAL	Arctostaphylos alpina
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SENEC	Senecio sp.
LIT	Litter

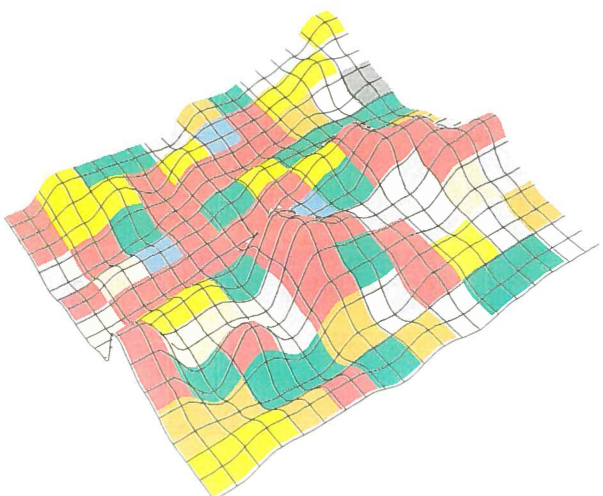
Vegetation at Jago-B, Quadrat 6, July 12, 1996

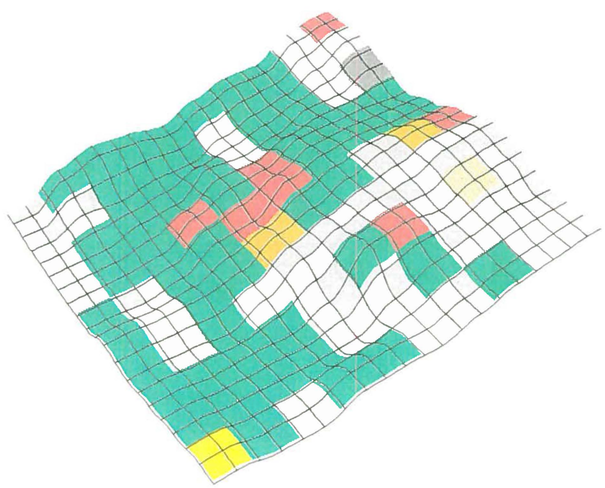
Canopy

SARE	CABI	DIEL	RHRU	LIT	CATE	DIEL	CLADO	CELA	CABI
SARE	CABI	CABI	VAVI	CABI	POBI	SARO	CABI	CABI	PELTI
LIT	SARE	AUTU	SARE	SAPH	SAPH	SARE	CATE	PEAP	SOIL
SARE	GRAMX	SAPU	VAVI	AUPA	CABI	DIEL	AUTU	AUTU	HYSP
LIT	SARE	SAPH	SARO	VAVI	SAPH	CABI	SAGL	HYSP	DRIN
LIT	CABI	ARLA	TONI	SAGL	POBI	DIEL	SAGL	SAGL	LIT
SAGL	GRAMX	GRAMX	LIT	SAGL	SAGL	LIT	LIT	SAGL	SAGL
SAGL	AUTU	SAGL	LIT	SAGL	RHRU	SAPH	LIT	GRAMX	LIT
CATE	CATE	HYSP	HYSP	CATE	LIT	VAVI	CABI	LIT	DRIN
PLANT	CABI	CATE	SAPL	AUTU	CATE	LIT	HYSP	PTCI	CLADO

Ground

LIT	DIEL	DIEL	RHRU	DIEL	DIEL	DIEL	DIEL	CELA	VAVI
LIT	LIT	TONI	AUTU	POJU	PELTI	AUTU	AUTU	LICHEN	PELTI
LIT	AUTU	AUTU	DIEL	AUTU	PELTI	DIEL	AUTU	PEAP	SOIL
LIT	HYSP	AUPA	VAVI	AUPA	SAPH	DIEL	AUTU	AUTU	HYSP
POJU	LIT	TONI	AUTU	VAVI	SAPH	DIEL	HYSP	HYSP	HYSP
AUTU	CLADO	AUTU	TONI	DRIN	AUTU	DIEL	LIT	DRIN	VAVI
MOSS	LIT	POJU	PELTI	LIT	LIT	LIT	LIT	LIT	LIT
AUTU	AUTU	HYSP	HYSP	LIT	RHRU	SAPH	LIT	GRAMX	LIT
HYSP	POJU	HYSP	HYSP	LIT	LIT	RHRU	LIT	LIT	LIT
PLANT	TONI	LIT	AUTU	AUTU	PELTI	LIT	HYSP	PEAP	CLADO





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

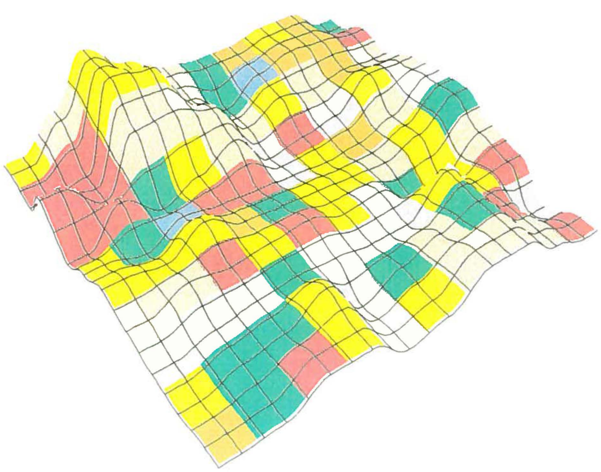
Plant Species Codes

CABI	Carex bigelowii
CATE	Cassiope tetragona
DRIN	Dryas integrifolia
POBI	Polygonum bistorta
SARE	Salix reticulata
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
PEAP	Peltigera aphthosa
SAPH	Salix phlebophylla
CLADO	Cladonia sp.
SAPU	Saxifraga punctata nelsoniana
MOSS	Unknown moss
POJU	Polytrichum juniperinum
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SOIL	Soil
LIT	Litter
GRAMX	Standing dead graminoid

Vegetation at Jago-B, Quadrat 7, July 12, 1996

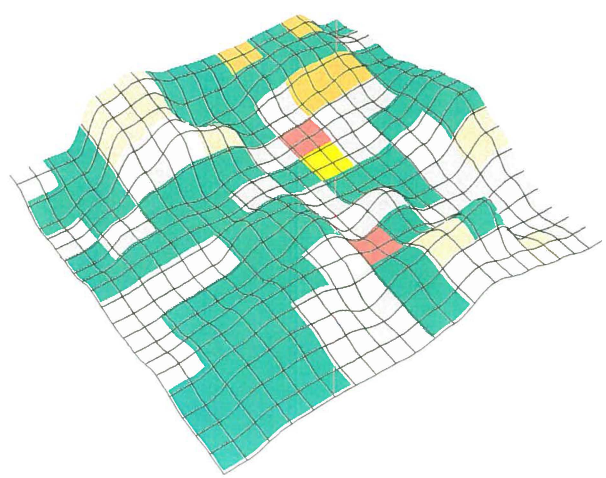
Canopy

ERVA	GRAMX	ERVA	ERVA	GRAMX	AUTU	DRIN	CABI	DRIN	AUTU
SAPL	SARE	ERVA	ERVA	GRAMX	DIEL	POBI	DRIN	DRIN	SARE
SAPL	SARE	GRAMX	GRAMX	GRAMX	GRAMX	CABI	GRAMX	DRIN	GRAMX
SARE	SAPL	AUPA	CABI	GRAMX	LIT	SARE	LIT	CABI	GRAMX
ERVA	TONI	SENEC	SARE	SARE	LIT	LUZUL	DRIN	GRAMX	CLADO
CABI	CABI	CABI	DRIN	HYSP	ARLA	CABI	GRAMX	CABI	AUTU
GRAMX	GRAMX	SAPL	ERVA	ARAL	ERVA	LIT	HYSP	CABI	GRAMX
LIT	LIT	LIT	HYSP	PELTI	LIT	LIT	ARLA	ARLA	SARO
ERVA	AUTU	DIEL	CABI	LIT	AUTU	GRAMX	AUTU	SAPL	LIT
DRIN	AUTU	SAPL	CABI	CECU	ARLA	GRAMX	GRAMX	GRAMX	SAPL



Ground

PELTI	HYSP	GRAMX	GRAMX	TONI	AUTU	DRIN	AUTU	DRIN	AUTU
TONI	AUTU	GRAMX	GRAMX	HYSP	DIEL	AUTU	AUTU	AUTU	LIT
LIT	AUPA	LIT	PELTI	GRAMX	TONI	LIT	DRIN	DRIN	TONI
TONI	LIT	AUPA	TONI	TONI	LIT	SARE	LIT	LIT	HYSP
TONI	TONI	AUPA	TONI	LIT	HYSP	LUZUL	LIT	HYSP	DIEL
LIT	LIT	PELTI	DIEL	HYSP	LIT	HYSP	HYSP	LIT	AUTU
LIT	AUTU	AUTU	AUTU	AUTU	LIT	LIT	HYSP	LIT	GRAMX
LIT	AUTU	HYSP	HYSP	PELTI	VAVI	DIEL	LIT	LIT	LIT
TONI	AUTU	DIEL	LIT	LIT	AUTU	GRAMX	AUTU	LIT	LIT
DIEL	AUTU	DIEL	LIT	LIT	AUTU	LIT	PEAP	GRAMX	LIT



Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
DRIN	Dryas integrifolia
ERVA	Eriophorum vaginatum
POBI	Polygonum bistorta
SARE	Salix reticulata
VAVI	Vaccinium vitis-idaea
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
TONI	Tomenthypnum nitens
CECU	Cetraria cucullata
PEAP	Peltigera aphthosa
CLADO	Cladonia sp.
ARAL	Arctostaphylos alpina
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SENEC	Senecio sp.
LIT	Litter
GRAMX	Standing dead graminoid
PELTI	Peltigera sp.
SARO	Salix rotundifolia
LUZUL	Luzula sp.

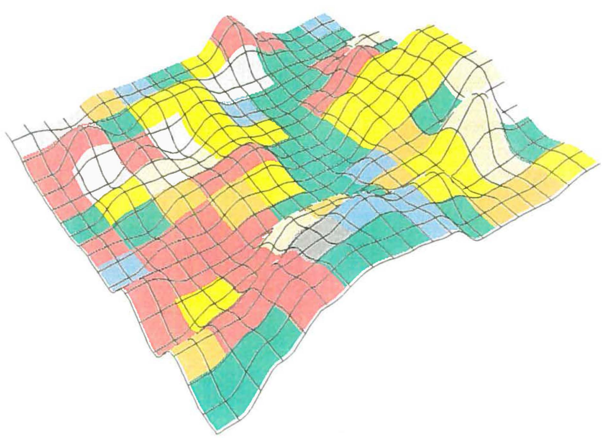
Vegetation at Jago-B, Quadrat 8, July 12, 1996

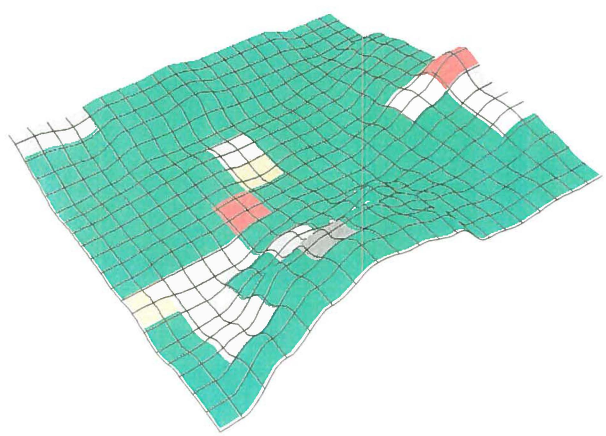
Canopy

LIT	LIT	DRIN	PYGR	POJU	CABI	SAPL	SARE	HYSP	SENEC
SAPL	SAPL	AUTU	ARLA	CABI	LIT	LIT	POJU	HYSP	HYSP
BENA	LIT	SAPL	LIT	CABI	PYGR	HYSP	TONI	ARAL	GRAMX
HYSP	CABI	GRAMX	GRAMX	CABI	CABI	HYSP	VAUL	SAPL	HYSP
SAPL	POJU	CATE	SAPL	SAPL	DIEL	AUTU	CABI	CABI	CABI
SAAN	ARAL	SAPH	CATE	CABI	TONI	TONI	CABI	CABI	CABI
SAPL	ARAL	ARAL	SARE	HYSP	AUTU	SENEC	DRIN	HYSP	GRAMX
SAPH	CABI	SAPH	GRAMX	CATE	HYSP	DRIN	CABI	GRAMX	CLADO
CATE	VAVI	ARAL	SOIL	PECA	SAPU	CABI	CABI	GRAMX	AUTU
HYSP	DIEL	SAPH	DIEL	POJU	POBI	HYSP	CATE	DRIN	CABI

Ground

LIT	LIT	POJU	POJU	POJU	HYSP	HYSP	HYSP	HYSP	HYSP
HYSP	HYSP	AUTU	RHRU	POJU	POJU	HYSP	POJU	HYSP	HYSP
HYSP	PTCI	TONI	PTCI	POJU	HYSP	HYSP	TONI	HYSP	HYSP
HYSP	AUTU	HYSP	POJU	LIT	HYSP	HYSP	DIEL	HYSP	HYSP
AUTU	POJU	AUPA	AUTU	GRAMX	DIEL	AUTU	HYSP	HYSP	DIEL
HYSP	AUTU	HYSP	SAPH	HYSP	TONI	TONI	AUTU	PELTI	SAPH
GRAMX	LIT	LIT	DIEL	HYSP	AUTU	TONI	TONI	HYSP	LIT
HYSP	LIT	DIEL	LIT	HYSP	HYSP	HYSP	HYSP	HYSP	CLADO
RHRU	LIT	DIEL	SOIL	DIEL	TONI	HYSP	HYSP	HYSP	AUTU
HYSP	DIEL	DIEL	DIEL	POJU	DIEL	RALA	HYSP	RALA	HYSP





Lifeform Codes

- Deciduous Shrub
- Evergreen Shrub
- Graminoid
- Forb
- Moss
- Sphagnum Moss
- Lichen
- Standing Dead Graminoid
- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
CATE	Cassiope tetragona
DRIN	Dryas integrifolia
POBI	Polygonum bistorta
PYGR	Pyrola grandiflora
SARE	Salix reticulata
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RALA	Racomitrium lanugnosum
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
SAPH	Salix phlebophylla
BENA	Betula nana
CLADO	Cladonia sp.
SAPU	Saxifraga punctata nelsoniana
POJU	Polytrichum juniperinum
ARAL	Arctostaphylos alpina
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SENEC	Senecio sp.

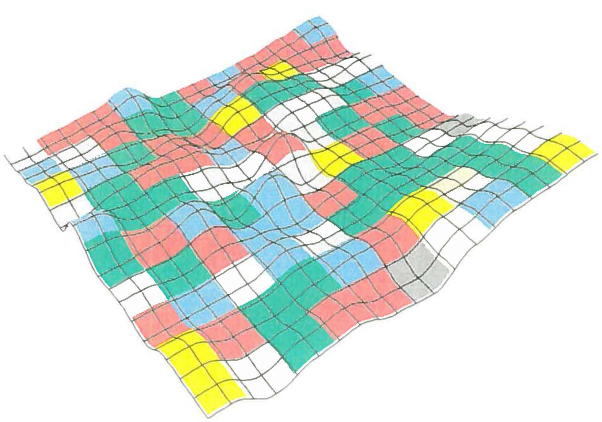
Vegetation at Jago-B, Quadrat 9, July 12, 1996

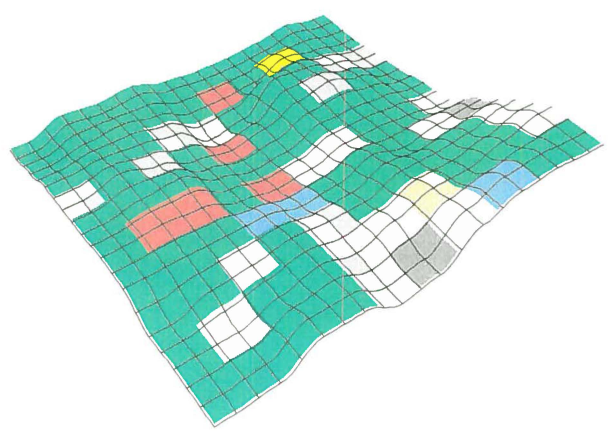
Canopy

LIT	SAPH	SAPH	PECA	AUTU	SAPH	POBI	SAPH	SAPH	POBI
POBI	LIT	SAPH	AUPA	AUTU	POBI	SAPH	GRAM	SAPH	SAPH
CABI	POBI	AUTU	SAPL	SAPH	CABI	POJU	POJU	LIT	LIT
LIT	DIEL	SAPL	SAPL	POBI	SAPH	LIT	LIT	POJU	SAAN
POBI	AUPA	AUPA	LIT	LIT	SAPL	LIT	AUPA	SAPH	SAPH
AUTU	SAPH	POBI	AUTU	POBI	LIT	ARLA	SAPH	AUTU	SAPH
LIT	AUPA	SAPH	MIAR	MIAR	SAPH	DIEL	POST	LICHEN	SOIL
SAPL	MIAR	PEAP	POBI	LIT	AUTU	HYSP	POST	POST	LICHEN
ARLA	SAPH	AUTU	AUTU	POBI	SAPH	CABI	GRAMX	DIEL	CECU
ARLA	LIT	DIEL	SAPL	SAPH	SOIL	PELTI	MIAR	DIEL	CABI

Ground

AUTU	DIEL	HYSP	HYSP	AUTU	TONI	AUTU	HYSP	HYSP	HYSP
DIEL	AUTU	AUTU	AUPA	AUTU	SAPH	AUTU	GRAM	AUTU	AUTU
DIEL	POJU	AUTU	LIT	LIT	AUTU	POJU	POJU	LIT	LIT
LIT	DIEL	LIT	AUTU	SAPH	AUTU	POJU	LIT	POJU	TONI
RHRU	AUPA	AUPA	HYSP	HYSP	AUTU	AUTU	AUPA	POJU	DIEL
AUTU	SAPH	SAPH	AUTU	SAPH	PELTI	PELTI	AUPA	AUTU	PEAP
AUTU	AUPA	AUPA	MIAR	MIAR	AUPA	DIEL	POST	LICHEN	SOIL
AUPA	AUPA	PEAP	AUTU	LIT	AUTU	HYSP	POST	POST	LICHEN
TONI	PEAP	AUTU	AUTU	LIT	PEAP	GRAMX	POJU	DIEL	CECU
HYSP	TONI	DIEL	POST	LIT	SOIL	PELTI	MIAR	DIEL	RHRU





Lifeform Codes

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- Litter
- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
POBI	Polygonum bistorta
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
CECU	Cetraria cucullata
PEAP	Peltigera aphthosa
SAPH	Salix phlebophylla
POJU	Polytrichum juniperinum
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
GRAM	Unknown graminoid
SOIL	Soil
LIT	Litter
GRAMX	Standing dead graminoid
POST	Polytrichum strictum
LICHEN	Crustose lichen
PECA	Pedicularis capitata
PELTI	Peltigera sp.
SAAN	Saussurea angustifolia
MIAR	Minuartia arctica

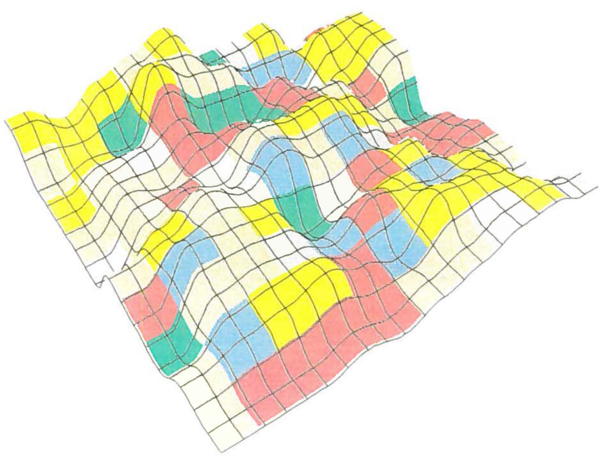
Vegetation at Jago-B, Quadrat 10, July 12, 1996

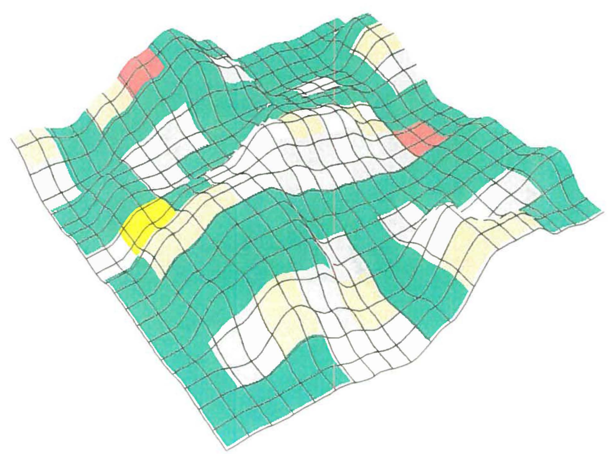
Canopy

ERVA	ERVA	CABI	GRAMX	ERVA	AUTU	LIT	CABI	LIT	VAVI
GRAMX	CABI	AUTU	ERVA	GRAMX	GRAMX	POBI	SENEC	ERVA	ERVA
CABI	GRAMX	LIT	SAPL	TONI	TONI	SAPL	PELTI	ERVA	ERVA
GRAMX	GRAMX	GRAMX	SAPL	SAPL	DIEL	VAVI	GRAMX	SAPL	GRAMX
PEAP	GRAMX	SAPL	PEAP	GRAMX	ERVA	ERVA	ERVA	GRAMX	AUTU
GRAMX	ERVA	GRAMX	LIT	POBI	GRAMX	POBI	LIT	VAVI	SAPL
VAVI	POBI	GRAMX	ERVA	AUTU	LIT	SAPL	ARLA	VAVI	VAVI
HYSP	GRAMX	GRAMX	LIT	PECA	SAPL	ERVA	POBI	CABI	GRAMX
GRAMX	POBI	ERVA	CABI	SAPL	POBI	ERVA	ERVA	CABI	LIT
GRAMX	SAPL	SAPL	SAPL	SAPL	GRAMX	GRAMX	LIT	CABI	LIT

Ground

GRAMX	AUPA	GRAMX	VAVI	AUTU	AUTU	HYSP	HYSP	HYSP	AUPA
LIT	AUPA	AUTU	RHRU	POST	LIT	TONI	TONI	POJU	HYSP
HYSP	AUTU	LIT	LIT	TONI	TONI	HYSP	PELTI	AUTU	GRAMX
HYSP	POJU	LIT	POJU	HYSP	DIEL	HYPNU	HYPNU	TONI	LIT
PEAP	CABI	DIEL	PEAP	PEAP	GRAMX	PEAP	GRAMX	TONI	AUTU
TONI	GRAMX	GRAMX	LIT	LIT	LIT	LIT	LIT	VAVI	AUTU
AUTU	AUTU	AUTU	AUTU	AUTU	DIEL	HYPNU	AUTU	POJU	AUTU
HYSP	AUTU	AUTU	AUTU	LIT	TONI	LIT	HYSP	HYSP	AUTU
POJU	LIT	GRAMX	LIT	GRAMX	TONI	PEAP	PEAP	LIT	LIVER
AUTU	POJU	AUTU	PEAP	LIT	PTCI	GRAMX	GRAMX	AUTU	AUPA





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- Lichen
- Standing Dead Graminoid
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- Soil
- Rock
- Water

Plant Species Codes

CABI	Carex bigelowii
ERVA	Eriophorum vaginatum
POBI	Polygonum bistorta
VAVI	Vaccinium vitis-idaea
PTCI	Ptilidium ciliare
AUPA	Aulacomnium palustre
AUTU	Aulacomnium turgidum
DIEL	Dicranum sp.
HYSP	Hylocomium splendens
RHRU	Rhytidium rugosum
TONI	Tomenthypnum nitens
PEAP	Peltigera aphthosa
HYPNU	Hypnum sp.
LIVER	Leafy liverwort
POJU	Polytrichum juniperinum
ARLA	Arctagrostis latifolia
SAPL	Salix planifolia
SENEC	Senecio sp.
LIT	Litter
GRAMX	Standing dead graminoid
POST	Polytrichum strictum
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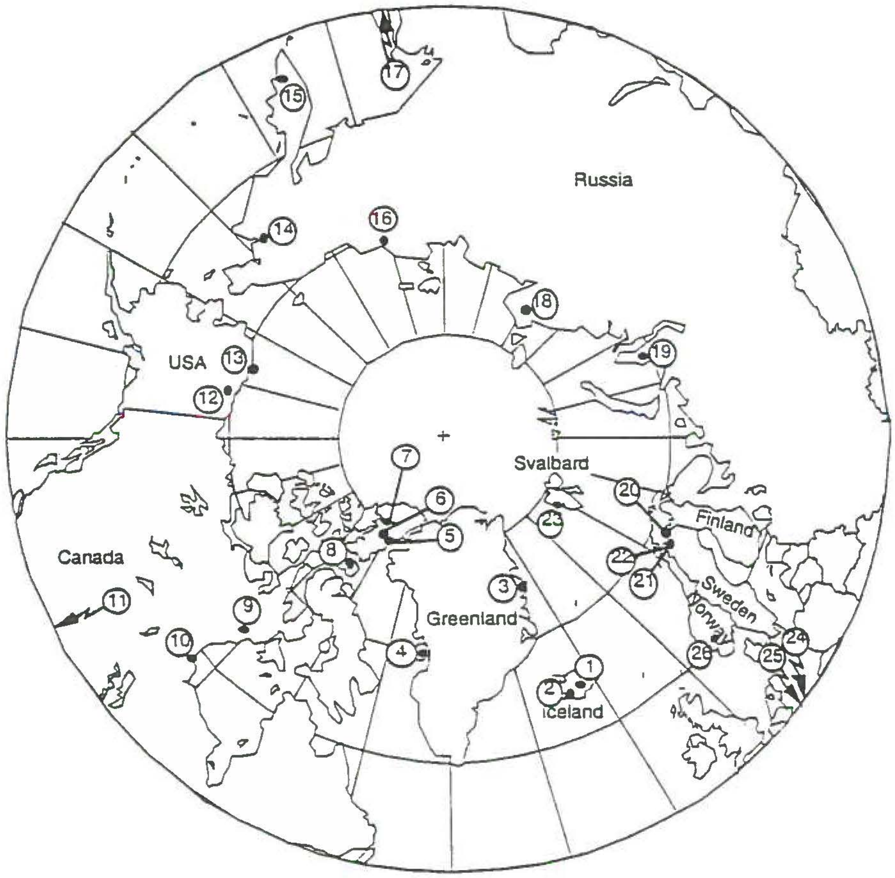
PELTI	Peltigera sp.

APPENDIX II: Papers presenting detailed methods used at long-term ecological monitoring sites, Arctic NWR, 1996

ITEX Manual

Second Edition



Edited by
Ulf Molau & Per Mølgaard

Danish Polar Center
June 1996

COMMUNITY BASELINE MEASUREMENTS FOR ITEX STUDIES

By Marilyn Walker

Measurement of species cover before and during ITEX manipulations is critical to the inter-pretation of the species data. Observed responses may be due as likely to changes in the biotic environment caused by shifts in species abundance and competitive regime as to changes in the abiotic environment. It is also important that the compositional data be based on a quantitative measure such as percentage cover rather than on a visual estimate or cover-abundance scale, as these may be too coarse to detect change. In particular, the Braun-Blanquet cover-abundance scale, which is very appropriate for relevés that conform to minimal sampling areas (in terms of complete community representation within the sample), is inappropriate for small-scale studies such as ITEX, which encompass much less than the minimal area required for the community.

The recommended standard method for ITEX plots is a fixed, square point frame, with 100 measurements spaced equidistantly within the frame. The frame size can vary slightly to fit your chamber configuration, but in most cases should range between 75 and 100 cm on a side. The distance between points is determined by the side length of the frame divided by 10, so that a 75 cm frame has points separated by 7.5 cm, and a 100 cm frame has points separated by 10 cm. Placing the points much closer than 7 cm will result in oversampling of a very small area and repeated sampling of the same individuals in many ecosystems (this will happen in any case, but as the size gets smaller it becomes more of a problem).

Construction details

(see Figure 1): The frame is constructed of 3-sided angular aluminum tubing, approximately 2 cm across and 2 mm in thickness. Four pieces cut to the length of the frame sides plus 2 x the width of the material (if you use material that is 2 cm across and wish to make a 1 m frame, the pieces should be 100 + (2x2) = 104 cm) are mitered 90 deg at the corners. Thus, the inside measure of the frame is the important dimension. Corners are stabilized using 90 deg angle braces on the outside, and also with cross braces across the bottom of the frame, approximately 15 cm out from the side (i.e., forming a triangle in the corner of the frame). Screws are used to attach braces to the frame. The four corners of the frame are assigned a letter code A, B, C, and D in the following manner: A in the lower left, B in the lower right, C in the upper left, and D in the upper right. Adhesive metric measuring tape is attached permanently to the top of each side of the frame, with the numbers running from A to B and C to D and from A to C and B to D. The tape is used to identify a coordinate system for recording and tracking data. Small (approx. 1-1.5 mm diameter) holes are drilled at appropriate sampling intervals through the center of each side of the frame. For a 100 cm frame, the first hole is drilled 5 cm from the left side, continuing every 10 cm. For a 70 cm frame, the first hole is drilled 3.5 cm from the left side, continuing every 7 cm. Holes should be drilled very cleanly in order to avoid ripping or tearing the string with rough edges. The frame can now be strung with nylon fishing line. We have found white line to be the easiest to see and work with. String each distance with a separate piece, otherwise breaks will result in having to restring the entire frame. String is drawn through both holes on one side of the frame, stretched across the center until taut, and then strung through both holes on the other side. This results in two parallel sets of strings running across the top and bottom of the frame. Four intersecting strings then define each sampling point within the frame. Attach a small bubble level to each side of the frame in the center.

Legs are made of solid aluminum rods approximately 1.5 cm diameter; length should be great enough to allow the frame to be placed level on the steepest slope likely to be encountered in your study. We have found 1 m long legs to work in almost any situation, but shorter (50 cm) legs are easier to use. Having two sets of legs, one long and one short, is the most flexible solution. Holes are drilled in each corner of the frame approximately 1 mm greater than the leg diameter. Legs are placed through the holes, with the pointed end down, and stabilized with rubber grommets that fit snugly around the legs (they should move up and down the legs only when minor force is exerted) placed on either side of the frame.

Permanent marking plates and leg holes are also part of the construction. Four leg holes and 3-4 permanent marking plates are needed for each plot. These will remain in the field. Leg holes and marking plates are both made of small, flat circles, of rustproof material, approximately 3 cm in diameter. These are available through forestry supply catalogs as marking tags. For the permanent marking plates, a cross, with a precise 90 deg angle, should be stamped on the center of the tag. Three to four small holes are drilled around the perimeter of the tag. These are used to fasten the tag to the ground using nails. The hole should be large enough to let the nails through easily, but smaller than the head of the nail. The leg holes are similarly drilled for nails, and a circle is drilled through their center such that the legs of the frame can fit easily through it.

Data sheets

Data sheets consist of a grid of 100 squares (or rectangles) arranged in a 10 x 10 matrix on the page. It is helpful to have a dashed line through the horizontal center of each square. Each square is used to record the information from a single point, and are arranged spatially to match their arrangement on the frame. The X and Y axes of the matrix, on both top and bottom and left and right sides, should be labeled with the appropriate coordinates. For example, in a 100 cm square, X coordinates should begin on the left with 5, and continue with 15, 25, 35, etc., up to 95. Y coordinates begin at the bottom row and continue upward in a similar manner. Thus, the lower left square is defined as 5,5, corresponding to the string intersection at 5,5 on the frame. The letters A, B, C, and D are written on each corner of the data sheet corresponding to their position on the frame (A in lower left, B lower right, etc.), and a small line for recording is drawn next to each letter. The bottom of the data sheet should have a section entitled "Other species" and a place to record the names of species in the plot that were not encountered. There should also be a section for recording notes.

Set-up

Remove the chamber if present. Slip a leg hole marker over each leg, and place the frame on the ground with the "A" corner in the southwest. The legs may be driven gently into the substrate to help stabilize the frame. Adjust the frame so that it is above the canopy and not disturbing it, and roughly level by sliding the corners of the frame up and down on the rubber grommets (it should not be precise at this time). Nail the leg holes into the substrate. Now level the frame precisely and stabilize the corners. To do this, begin at the "A" corner (or anywhere, it doesn't matter), and firmly clamp the frame to the legs with a C-clamp around the rubber grommets holding the legs in place. Level the AB side precisely, and clamp the B corner down. Continue around each side in the same manner; the final side should be level with no further adjustment. If it is not, you will need to make a minor adjustments until all four sides are precisely level. The final set-up step is to place the permanent marking tags inside the plot. These tags will replace the underlying vegetation, and should be placed in a relatively flat, stable position, ideally at the four corner points of the frame, but at least three positions. At each of these points, place the tag on the ground, and line the cross on the tag up precisely with the intersection of the strings at that point. Nail the tag to the ground. Be careful not to bump or reposition the frame during this process or during the recording. It is very important that the tags be placed in a stable spot and that they be located precisely. Although only two tags are necessary to relocate the frame, the additional points provide additional security in the case of disturbance.

Recording

Before recording for each point, measure the distance from the ground surface to the bottom of the frame at corners A, B, C, and D, and record on the data sheet. For each point, record the following information: Site down to the first species encountered, and call it out. Measure the distance from the bottom string intersection to the point to the nearest 0.5 cm. The scribe should record the species code** and distance in the top half of the square for that point. Then gently move the point away, being careful to minimize disturbance to the canopy, until you can site the "ground" surface, which may actually be a moss or lichen carpet, a litter layer, bare soil, rock, or even a leaf or branch of a shrub. Again, call out the species and measure the distance from the bottom string intersection to the point. Record these values on the bottom half of the square. In many cases, there will be no "second" hit. In all cases, record an X for a permanent marker, but still measure the distance.

** species codes: 6 or 8 letter species codes can be used by combining the first letters of the genus with those of the species. However, it is critical to keep track of the codes as they are developed and to assure that they uniquely identify all of your species. D. Murray and V. Razzhivin have offered to make the Panarctic flora codes available to ITEX.

Unless otherwise noted, the assumption is that the species hit was live, and that the hit was on leaf or other green material (unless the species is a moss or lichen). If this is not the case, the following letter codes should be added to the data sheet immediately following the species code: d (dead - meaning that entire specimen is dead but still attached to the substrate), w (woody), sd (standing dead - meaning a non-green portion of a vascular plant, such as a brown leaf, attached to a living plant). In some cases more than two of these may be used, for example if a woody branch of a completely dead Dryas octopetala were encountered, it would be recorded as dryoct w d. If a leaf of the same plant were encountered, it would simply be dryoct d. Detached material, whether green or alive, should be recorded simply as litter, except in the case of certain lichen species that do not attach to the substrate.

The final point of information that should be recorded is a subjective determination of the repeatability of the sample, that is, does the caller think that if the sample were repeated in a year, and the plot very precisely relocated, that the same species (or lack of species, such as rock), would be recorded there? Determination of this subjective measure requires a combination of common sense and some knowledge of the species. For example, a hit that is firmly in a solid, single species Sphagnum mat, or a rock, will be very repeatable. Upper hits may occasionally be in this category, for example a large leafed species such as Rubus chamaemorus will likely regrow over the same position in future years. Similarly, a dense shrub cover will most likely be there again, although the hit will be on a new leaf. If the caller believes this to the case, he should say "good" after calling out the species name, and the scribe should circle the species code on the data sheet. This information is not used in any cover calculations but may prove invaluable in future years when sampling is repeated. A change of the "good" hits may be taken more seriously as a true indication of change at that point than the other hits.

Once all the points have been recorded, the caller and scribe should do a visual search of the plot for species present but not encountered. These are recorded as present at the bottom of the data sheet, and will be given a value of less than 1% cover.

The most common mistake that can occur in the recording phase, and one which wastes a lot of time, is for the scribe to record the data in the wrong location on the sheets. This may happen for many reasons, such as lack of clarity about starting a new point, the caller losing track of where he is and skipping to a new row or column, etc. We recommend beginning at the 5,5 coordinate and continuing across the first row, then moving up to 95,10, and back down the 10 row. The caller and scribe should always verify with each other when a new row is begun. If there is disagreement, then it can be straightened out before serious damage is done. Once the first half of the frame is done, the caller should move to the other side, and both parties should again verify the starting point and direction of movement across the frame. The scribe should be careful not to get confused by the fact that he will begin writing in the lower left corner of the data sheet, rather than the upper left, and that he may sometimes move right to left and other times left to right.

Take down and future use

The legs should be carefully removed from the hole markers in order to avoid disturbing the markers. The leg hole and permanent markers can be used to precisely relocate the plot in the future.

Calculation of cover values

Calculate an index of absolute cover for each species as the total number of hits on that species divided by (100 minus the number of permanent tags) times 100. This is not a true measure of absolute cover, since points intermediate between the top and bottom of the canopy are not included. Species present but not encountered can be assigned a value of <1% cover. Standing dead specimens should be included in the cover values, but dead specimens should be excluded.

Calculation of microtopography

Simplification: If time is a serious constraint, the following measures can be considered optional. Deleting any of these measures will necessarily result in a loss of information and in increased difficulty in interpretation of results, however there are always trade-offs to be made in time invested and information. At the very minimum, the critical information is relative cover for all experimental and control plots. The following deletions will still maintain that basic information.

1. The frame does not have to be precisely relocated each time. However, the information on change will be much more coarse.
2. Height is not necessary unless information on canopy structure is desired

Vegetation survey work procedures. Pacific N. W. Forest & Range Experimental Station, USFWS. M. J. Foote. 1995.

Vegetation Survey Work Procedures:

1. Locate Stand.

If returning to an old location, locate all plot points. If going to a new stand do the following:

A. Make sure the area is homogeneous and at least 2 hectares in size.

B. Write down your general impression of the stand; its general vegetation type, dominant species, dominant vegetation structure, patchiness and any other feature that seems important or that impresses you.

C. Establish a grid (usually 4 by 5 points) near the middle of the area. The points are usually 10 meters apart. (See Fig. 1)

D. Pound a metal stake at each point.

E. Number the points in sequence from 1 to 20. (See Fig 2) You may start numbering in any corner and may go in either a clockwise or a counter-clockwise direction.

F. Record the primary compass direction (I.E. from point 1 to point 5).

.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Figure 1

1	2	3	4	5
10	9	8	7	6
11	12	13	14	15
20	19	18	17	16

Figure 2

2. Establish the line of travel.

Orientate yourself. You will move through the stand proceeding from plot 1 to plot 2, from plot 2 to plot 3, etc and finishing by going from plot 20 to plot 1 to close the circle. You use this line of travel to orient the placement of the nested sample plots and quadrants.

3. Establish and/or locate the nested sample plots and quadrants with respect to the plot stake (See Figure 3):

A. Establish the quadrants using the forward line of travel. Extend it both forward and backward from the numbered plot stake. Now add a line perpendicular to it that passes through the numbered plot stake. Number the quadrants I to IV moving in a clockwise direction.
B. Establish the 1-meter-square square plot. It always goes in front of the stake and to the right of the line of travel or in quadrant I.

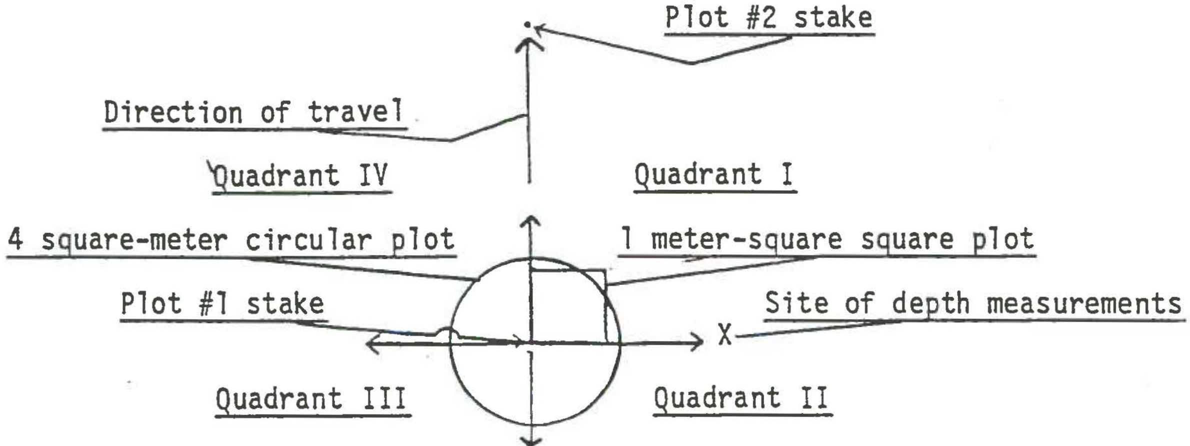


Figure 3

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4. Begin the survey.

To minimize trampling of plot information always stand on the outside of the 4 square-meter plot circle and proceed in the following sequence: A) Photographs, B) 4 square-meter plot, C) 1 square-meter plot, and D) quadrants 1 to 4. The depth measurements (litter, permafrost, etc), stand age information, stand location data, and biomass collections can be done at any time. Whenever necessary ask Joan or Les for clarification.

As you proceed with the survey apply the following general rules:

When estimating percent cover

--Values between 0 and 10 and between 90 and 99 are recorded in increments of 1 percent.

--Values of 100 are recorded as 99 on the EI-3 forms and as 100 on the EI-4 & 5 sheets.

--Values in between 10 and 90 are recorded to the nearest 5 percent.

--When all percent cover values are completed at a given plot, stop and check the group totals against the sum of the separate species within that group. IE. check the Total-herb value against the sum of all the herb species values. They may or may not be similar, however the following two conditions must be met. 1) The sum of the herb species can add up to or be more than the Total-herb (group) value but not visa versa, and 2) the Total-herb (group) value must be equal to or more than the highest single herb species value. (See examples A, B, & C.)

Example A		Example B		Example C	
Epilobium	= 50%	Epilobium	= 50%	Epilobum	= 20%
Equisetum	= 55%	Equisetum	= 25%	Equisetum	= 40%
Cornus	= 10%	Cornus	= 2%	Cornus	= 50%
Sum total	115%	Sum	77%	Sum	110%
Total-herb value	60%	Total-herb	90%	Total-herb	40%

Example A is fine. Conditions 1 & 2 have both been met. The sum of all the species, 115, is greater than the Total-herb value, 60. (The greater the difference between the sum of species values and the total herb value the more the various canopies overlap.) And the highest species value or 55 is less than the Total-herb value, 115.

Example B is not acceptable. Condition 1 has not been met. The Total-herb value, 90. is greater than the sum of all the herb species. Something has been overlooked or over-valued!!! Check and adjust.

Example C is also not acceptable. Condition 2 has not been met. The Total-herb value, 40, is less than the species (Cornus) value which is 50. You have miscalculated somewhere. Again check and adjust your firgures. It is best to do this in the field when you can view the plot.

When measuring

--Use metric units-mm, cm, dm, or m.

--State the units used in the appropriate location on each field form.

--Height measure are made from the ground surface to the top of the tallest growing branch tip or to the base of the terminal bud. When a thick moss layer covers the ground the surface is defined by laying the open hand on the moss layer and compressing it slightly. When the tree is growing on a hill take your measurements on the uphill side of the tree.

--Distance measurements are made from the center of the tree trunk or stem to your destination point. To estimate the position of the tree center use a point at the side of the tree that is midway between the front and back of the tree.

--Diameter measurements are taken usually at breast height (1.37 m) but sometimes at the base (10 cm). If branches, knots, or other growths are present move either up or down the stem to a point that would best approximate what the diameter would be if the growths were not there.

A) Photographs

Black and white or color photographs are taken of four plots, usually plots 1, 9, 13, & 17, and two to three general stand views usually looking into the stand from plots 1, 6, 16, or 20. The object is to record what is typical and distinctive of the stand. If additional photographs are needed take them.

Plot photographs are taken of the meter-square plot usually looking in the direction of travel and taken so the entire plots fills the photograph.

It is useful to record the stand no., ~~and~~ plot no., and date on a chalk borad and include it in the picture. It is also useful to include the F-stop, speed, type of film, and content of each photo taken somewhere in your notes.

When possible half of the photographs are taken in black and white and half in color. When not possible you take what you can.

X B) The four-square-meter circular plot

This plot is used to sample tree seedlings, tall shrubs and some tree information, IE canopy values. It has a radius of 114 cm. = ~ 2 m diameter circle

1) Tree seedlings are the small plants of any tree species that are less than 1.37 Meters (breast height) tall.

The seedlings of each species are to be counted, a canopy cover value is to be estimated, and the average and maximum heights taken. This information is to be recorded on the EI-4 field forms.

In addition a total canopy and a total live-wood cover value is to be estimated for all seedlings, saplings, and mature trees taken together. This information is to be recorded on the EI-3 field forms.

2) Tall shrubs are the large and small plants of all species that are classified as tall shrubs. See the tall shrubs species list. If you can not find one see Joan.

The stems of each species are to be counted, a canopy cover value is to be estimated and the average and maximum heights taken. In shrub clumps the main stems are counted at a heights of 10 cm (the width of a hand) above the ground. Occasionally the counts are done by diameter class. You will be informed if and when this is to be the case. This information is to be recorded on the EI-5 field forms.

In addition a total tall shrub canopy value will be estimated. This information will be recorded on the EI-3 field forms.

3) Tree and sapling information The only information on these that is gathered in the 4 square-meter plot is the tree-sapling-seedling canopy and live wood values that have already been discussed (in 1 above). It is to be estimated to the nearest 5 percent and is recorded on the EI-3 field forms.

C) The one-square-meter square plot

This plot is used to sample mosses, lichens, herbs, low shrubs, most vegetation category totals, as well as litter and soil surface type (or all species and categories not treated on either the tall shrub or tree species list.)

For each species and/or category the canopy cover is to be estimated and recorded on the EI-3 field forms.

In addition a total cover value will be estimated for each group, IE. for all mosses, for all lichens, for all herbs, and for all low shrubs. This will also be recorded on the EI-3 field forms.

D) The Quadrants I to IV

These are used to sample mature trees and saplings. They are pie-shaped divisions of space that begin at the plot stake, have a variable radius up to a maximun of 33.3 meters, and an angle of 90 degrees. The line separating quadrant I from quadrant IV lies on the forward line of travel. (See Fig. 3) Remember at the end of each line the direction of travel changes (See Fig. 2,).

Trees and saplings are sampled using the point-centered quarter method of Cottam and Curtis (1956).

In each quadrant the following information is to be obtained and recorded on the EI-2 field forms.:

1) Distance to the closest tree. If it is a dead tree record the distance but also move to the closest live tree and record the distance from the plot stake to the live tree. If no tree is encountered in 33.3 meters record that value in the distance column.

or you leave the Type

2) Diameter at breast height (1.37 meters) for the closest tree in each quadrant. Minimum diameter for trees is 2.5 centimeters. (Smaller trees are sampled as saplings or seedlings.)
3) Tree species. Each tree species as a number; 90- for mature trees. See tree species list or field froms for the actual species numbers.
4) Repeat 1) above but for saplings instead of trees and do only live saplings unless other directions are given.
5) Repeat 2) above but only for live saplings unless other direction are given. Saplings have a maximun diameter of 2.49 centimeters and a minimun height of 1.37 meters. (Smaller trees are sampled as seedlings and larger as mature trees)
6) Repeat 3) above but only for live saplings unless other directions are given..
7) Quadrant number. This is already on the forms for the live trees and saplings but not for the dead trees. Record it for each dead tree.
8) The total number of dead trees. This will be 1, 2, 3, or 4.

This information is to be recorded on the EI-2 field forms. Distances are recorded in decimeters, diameters in milimeters and species as 90- for trees and 91- for saplings. The information for live trees and saplings is column specific. The information for dead trees is left adjusted. Note you must record the quadrant number for each dead tree.

General stand information: identification number, geographic & topographic location, age, plot layout map, and notes.

This information is best gathered in the field but some IE. latitude, longitude, stand age, and date can be obtained in the laboratory. It is to be recorded on the EI-1 field forms.

Stand numbers are assigned, usually in an increasing sequential order, at the time of the first visit to the stand. Each year a site is revisited it is given a new number. If a site is to be revisited regularily it may also be given a name, IE midslope white spruce or WS1, that always remains the same.

Site location and elevation are determined on a topographic map. The location is recorded by quadrangle code number, latitude, longitude and when possible also by township, range, section, and quarter section etc. The elevation can be recorded in either feet or meters but state which.

Names of the field crew menbers are recorded.

The date(s) the survey was undertaken are recorded.

Average or general percent slope and aspect are best measured in the field but sometimes can be determined from a topographic map.

The position on the slope is recorded. Unless stated otherwise, IE spur ridge, bluff face etc, the position is assumed to relate to the main topographic feature relevant in the area.

A stand and plot layout map is to be drawn. Some long-lasting reference point is to be included. This can be an identifiable point of the river, a known distance from a road junction, milage point, or bridge. Be creative but remember you might be the one who must relocate the stand in five years!

Height, DBH, and species information is gathered on the five biggest, maybe oldest, trees in the stand. These trees are also cored as low on the trunks as possible or cross-sectioned. From the cores or cross-sections age determinations are made by counting rings. The cores and cross-sections are labeled with the following information: stand number, tree number, core number, DBH, height, and distance from the ground where it was taken. If a tree is too rotten to gather this information this is noted and a new tree is selected.

Additional information may be included when it helps to summarize the general stand or some unique feature about it.

When revisiting a site it is useful, but not necessary, to record both the newly assigned stand number and the last stand number, as well as the stand name if it has one. previously used

5. Collect other information as assigned:

This may involve the site, the stand or the actual plots. It may be gathered by the field crew or by scientists. It will relate to what studies are to be undertaken and by whom. Proceedure may vary from site to site. The appropriate direction will be given when needed.

The following types of additional information are commonly but not always gathered:

A. Organic layer thickness

This information is measured just outside of the meter square plot and on the line between quandrants I an II. See figure 3.

The organic layer is defined as the upper soil layers which are primarily organic in nature. This layer is bounded below by mineral soil or bed rock and above by the ground surface and is sometimes subdivided into sublayers (living moss, undecomposed litter and decomposing material).and/or horizons.

Use a knife or shovel to cut through the organic layer. Separate the two sides of the cut so the clean, cut surface is exposed. A centimeter ruler is them used to measure the depth to mineral soil. Sometimes the thickness of each of the sublayers or horizons is also recorded. This information is recorded on the EI-3 field form.

B. Active layer thickness

A calibrated steel rod is used to detect permafrost or the thickness of the active layer. The rod is pushed into the ground until it stops. With practice one can tell if its ice, rock, or deep sticky mud. This is done 2-3 times around each X-site and the average value in centimeters is recorded on the EI-3 field forms.

C. Stand age sturcture

Tree cores are taken from 1) the five biggest trees in the stand, 2) three trees representitive of the main diameter classes found in the stand, and/or 3) the live tree in quadrant 1 of all odd-numbered plots. When the trees are cored their height and diameter at breast height (DBH) are taken and the species is noted. Cores are placed in straws to be returned to the lab. Tree species, diameter and height values, and core and stand numbers are recorded on each straw. This information is also placed on a blank sheet of paper. The cores are to be used to determine stand age.

D. Biomass determination of trees, shrubs, and/or herbs.

E. Soil profiles.

F. Records of fire scars.

G. Species list of site. This will include species found either in or out the the study plots.

H. Collection and identification of voucher specimens, especially if the plants are rare, difficult to identify, or represent range extensions.

6. Process data

This will be done where ever necessary and as soon as possible. It will include but may not be limited to the following:

A. Prepare the field forms for computer processing. Are they complete? Check for stand numbers, species code numbers, appropriateness of cover and count values. Does the data look reasonable?
B. Enter the data into the computer.
C. Process all plant specimens. Dry them, give them a collection number, identify, prepare label information, record appropriate information in the collection book.
D. Count tree rings on cores and cross-sections. Record this information on the appropriate field sheet. Construct diameter class and age profiles.
E. Tabulate photograph information. Process film. Mount and/or label photographs, negetatives, and/or slides.
F. Run computer programs as assigned.

These proceedures are based on those of Ohmann and Ream (1971) and have been adapted to the local Alaskan scene by Joan Foote and Les Viereck.

Literature cited

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Instructions for Conducting Off-road Breeding Bird Point Counts in Alaska

Sponsored by Alaska Partners in Flight
Alaska Fish and Wildlife Research Center
1011 E. Tudor Rd
Anchorage, Alaska 99503

Please note that all changes for 1994 procedures have been italicized.

REQUIREMENTS: The observer needs to be able to identify by sight, song, and call all species likely to be encountered. All observers should study the visual descriptions as well as songs of the less common species. Audio cassette tapes are available for study. Acute hearing is a must.

SCOUTING: All census routes must be carefully planned, measured and marked before conducting the official census. A practice run should be completed as well. Because these routes are off-road, markers and turns can easily be missed, costing valuable time. From year to year significant alterations or disturbances may also have occurred along the route, and a scouting trip will save time and frustration. Conducting a test run will also familiarize the observer with the techniques and census forms.

WHEN TO CONDUCT COUNTS: In Alaska we will be running most of our census routes between 10 June and 30 June. Censuses can be conducted as early as 1 June in the Aleutian Islands and extreme southeastern Alaska. *Early July appears to be too late for northern Alaska and should be avoided.* The most suitable period is that which will be most stable from year to year in detections of breeding birds. In general, a date as near as possible to last year's date is most preferable.

STARTING: Always start at the predetermined starting point and run the route in the same direction, keeping the census points in the same order. Begin counting at census point number 1 no earlier than official sunrise and no later than 30 minutes (min) after sunrise. In the arctic, counts should begin no earlier than 03:00 AST. Censusing should begin within 15 min of the first year's starting time. Allow yourself time to record weather data before you begin.

COUNTING: One and only one observer should detect and count. The same observer should do all census points on one route and repeat the same route each year. A second person may be present but must not interfere by asserting his or her own detections. However, the companion CAN help with species identification if the observer has detected a bird but needs help identifying it. *It is best for the observer to record his or her own observations in the booklets, since relaying the information to another person could result in making transcription errors or missing other birds during the conversation.* The census point should be approached with as little disturbance to the birds as possible. Immediately upon arriving at the census point the observer should take a compass bearing and begin the count.

Each count is to be precisely 5 min long, but birds detected during the first 3 min are recorded separately from those detected during the final 2 min. The species are recorded in the order in which they are observed. For each species, the number of individuals within a circle of radius 50 meters (m) around the observer (the census "point") are recorded separately on the census form from those which are detected beyond 50 m (to an unlimited distance) in any direction from the census point. The location is that at which it was <u>first</u> observed. All birds that are not actively using the census area but are only flying over are counted and recorded separately (see the data sheets). If a bird is flushed by the observer either when the observer arrives or during the count it should be included according to its take-off position. For birds near the 50-m border, distances can be determined by measuring paces to the border after the 5-min count is over.

A bird that is detected during the count but not identified may be identified after the count if more careful observation is required, the bird is still present, and time permits. A flock that is present at some time during the count may also be followed after the count to determine its species composition and size. Visual identifications should be made whenever possible, and are always preferable to identification by song or call alone. Absolutely no method of attracting birds should be used during the count. The route should be completed within 4-5 hours of sunrise because bird activity changes significantly after that time.

WHICH BIRDS TO COUNT: Count all individuals of all species seen or heard at any time during the 5-min period. Do not attempt to guess what species or numbers you may be missing. Be careful not to count any individuals known or strongly suspected to have been previously counted at another census point. *Please mark birds that have been previously counted on the map with a special notation, but do <u>not</u> put them on the tally sheet. We will look at the frequency of duplicate detections when we make final recommendations for spacing of points.*

Any species that are detected only BETWEEN the 5-min census periods should be listed in the notes section underneath the circular map. At the end of the route, compile a list on the "Miscellaneous Field Notes" page of those species that were not recorded on any of the point counts but only between them. This way we will have a complete list of species along the entire route.

RECORD-KEEPING: Use the point count data forms included. They can be copied onto waterproof (e.g., "Rite-in-the-Rain") paper and folded into a booklet form. Use dark pencil to record. Do not wait until the 5-min interval is over: record individuals as they are identified.

USING THE CIRCULAR MAP: Use the circular map and the list of symbols provided to minimize the danger of counting the same bird twice. The center of the circle is the position of the observer (the census "point"). As soon as you arrive at the census point you should take a compass bearing and record it in the box at the top of the circular map. (An alternative is to note the direction of north and always orient your map with north at the top of the circle.) Record the start time for each census point. Then immediately set a stopwatch, and begin recording the birds detected, sketching the position of individuals on the circular map. Draw the symbol indicating the type of detection (e.g., a singing male) at its approximate position (see inside of back cover for symbols).

Write the 4-letter species code inside the symbol. *Please use the 4-letter codes provided on the back of the booklet; if the species is not listed, spell out the name completely. Identify subspecies that are easily distinguished by plumage, such as Slate-colored and Oregon Juncos, and Myrtle and Audubon's Warblers. If a bird is unidentified to species, spell out the closest identification, e.g., unidentified sparrow.*

In the final data compilation the only important position factor is inside or outside of 50 m, but sketching within the 4 quadrants of the map is helpful when high numbers of birds are present. Recording movements can also be helpful, but be very careful to only COUNT one time a bird which has moved. Use an ASTERISK to indicate individuals detected AFTER the first 3 minutes. You should familiarize yourself with the symbols before the actual census. See the attached example.

As soon as each census point has been completed, the species and numbers of individuals in each distance and time category should be counted and transcribed on the facing tally sheet. *You should tally the position and time interval of each bird when it was first detected, regardless of its subsequent movements during the census. For each species, record the total number of individuals detected by each type of detection method. For example, in the 0-3* *min block < 50 m you might have the following entry for TOWA: 2S, 1V, 2P (see codes inside back cover). Keeping track of the type of detection will help us determine optimal periods of detectability for each species in different regions.*

TALLY SHEETS: If the tally sheet alone is used, use *"code"* marks in the appropriate column. When the field work is over, *the total number of each type of detection* in each distance and time category can be written in pencil or permanent ink.

ACCEPTABLE WEATHER: Routes must be run only under conditions of good visibility, little or no precipitation, and light winds. Occasional light drizzle or a very brief shower may not affect bird activity but fog, steady drizzle, or prolonged rain should be avoided. See the data sheets for weather codes. Remember to record weather data at the beginning and end of the count.

ALL FORMS MUST BE COMPLETED AND RETURNED BY JULY 15: Please send the census booklets, your route map, and the habitat booklet to Colleen M. Handel, Alaska Fish and Wildlife Research Center, 1011 E. Tudor Rd., Anchorage, AK 99503, as soon as possible after completion of the count. You will want to keep a copy of your data so that you can check the computer printout that will be sent at a later date.

PROCESSING OF RESULTS: Upon receipt of the booklets, the tally sheets will be checked against the circular maps. Data will be entered into the computer and run through an edit program. A printout will be mailed to each observer. Data from this pilot effort will be analyzed to refine methodology for a statewide monitoring program. Results and recommendations will be provided to all participants when available.

INCOME TAX DEDUCTIONS: U. S. citizens who itemize deductions on their Income Tax Returns may make a deduction for mileage necessary for the scouting and running of official survey routes. Costs of motels, campgrounds, etc., involved with the scouting and running of routes are also deductible. Please check your 1040 instructions each year; it could change.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION IN THE OFF-ROAD BREEDING BIRD SURVEY.

April 1994

Instructions for Collecting Habitat Data
Alaska Off-road Point Counts

Sponsored by Alaska Partners in Flight
National Biological Survey
1011 E. Tudor Rd.
Anchorage, Alaska 99503

May 1994

Introduction

Please fill out one booklet for each route that you census this summer. Habitat data should be collected during June or early July. This information can be collected on the same day that the route is censused, but should not interfere with the bird censusing. For example, the route can be censused for birds in one direction and habitat data can be collected on the return hike.

The information collected on these forms will enable us to characterize habitat according to classifications outlined by Kessel (1979) and Viereck et al. (1992). We will be testing experimental data collected this summer by cooperators across the state to see which information may be useful in analyzing broad patterns of bird distribution.

Important: This version incorporates the changes suggested at the December 1993 meeting of Alaska Partners in Flight. Please provide us with constructive feedback!!!

Information about the route

Biogeographic region: Check the map in Kessel and Gibson (1978) for the region of Alaska in which your route falls. If in doubt, leave blank.

Study area: Give the name of your land management unit (park, refuge, forest, etc.) or general study area.

Route name: Assign a unique name to indicate the specific locality of the route.

Route number: Will be assigned by Alaska Partners in Flight.

Point 1: Give the latitude and longitude (to nearest tenth of a minute) of the first point on the route. <u>The first year a route is run, submit a detailed topographic map showing the location of the route and all census points.</u>

Date: Indicate the date you gathered habitat data.

Start and end time: Indicate the starting and ending time for characterizing habitats on the route in 24-hour local time (Alaska Daylight Time for most of the state): 0001-2400 hrs.

Observer's name, contact person, address, phone numbers: and assistant recorder : Give full name, affiliation, and other information so that we can easily contact the observer or a more permanent contact person if we have any questions. If another person assists in collecting or recording habitat data, please list his or her full name.

Information about each point

You will be recording data on habitat **within a circle with a radius of 50 m** around each census point. You will get some information about the area by walking through it during the census, but may also need to walk around the circle somewhat to get an unbiased view of the habitat that it contains.

For each census point you will need to complete a **minimum** of one page of the habitat booklet. A few census circles may encompass more than one major habitat. For example, the 50-m circle surrounding a point may hit an edge between a black spruce bog and an upland mixed paper birch-white spruce forest. For this type of situation, you may use more than one page per census point. You will then need to indicate the number of habitats you are describing, and the approximate percentage of the 50-m circle that each habitat comprises. Aerial photos of the area may help. Each booklet contains six extra pages to accommodate the few circles that will encompass more than one major habitat type. Use more than one booklet if necessary.

Most census circles should have only one habitat. If you are consistently recording more, and are not in a disturbed area, then you are probably assessing habitat at a finer scale than we intended. Step back and try to assess the habitat at a grosser scale.

Point #: Indicate the census point you are describing.

Elevation: List the elevation in **meters**, at the census point itself. This can be measured with an altimeter or estimated from a topographic map. You can record elevation in feet and convert later.

Aspect: List the direction in degrees true north that the slope at the census point is facing. If it is flat, leave blank.

Slope: Estimate or measure with a clinometer the slope in **degrees** at the census point. You should estimate slope over a distance of about 20 m.

Location: Determine the latitude and longitude of the census point. Use of a global positioning system (GPS) will allow accuracy up to 0.001 minute.

Water: Check the appropriate box indicating what type of water, if any, is present within the 50-m circle. Ephemeral water is present only for a portion of the breeding season.

Disturbance: Describe any type of disturbance that you detect within the area. You may want to record more detailed notes on the back of the booklet.

Habitat #: If you are describing more than one major type of habitat for the 50-m census circle, indicate which one you are describing here and what percentage of the circle it comprises. An aerial photo may help you estimate the coverage. The information listed below should then be collected for each habitat type within the circle.

Photo roll and frame: Record roll and frame number of any photos taken.

TREE canopy cover: Check the box indicating the estimated coverage of the sky by foliage from all trees and shrubs greater than 3 m in height. This can be measured with a densiometer.

% coniferous: Check the box indicating the estimated proportion of the canopy cover (above 3 m) that is coniferous (needleleaf).

TREE LAYER species: List, in order of % canopy cover, up to four species of trees taller than 3 m that dominate the tree canopy layer. Trees are defined here as woody plants with a single stem ≥ 7.5 cm in diameter at breast height, a more or less definitely formed crown of foliage, and a height of at least 3 m (Viereck and Little 1972, Viereck et al. 1992). Willows or alders of tree size but with multiple trunks are also considered trees. For each species, check the box showing the average height of the canopy. If a single species forms two distinct sublayers, list it twice, with that contributing the greater canopy cover listed first. Use scientific names where possible to indicate species. If you abbreviate, use first three letters of the genus and the species; give a master list of species in the notes.

DWARF tree or SAPLING (< 3 m): Trees with a single stem but less than 3 m in height are considered dwarf trees (e. g., black spruce in a bog or mountain hemlock at timberline). Saplings are defined as woody plants with a single stem < 7.5 cm in diameter at breast height. Check whether or not the foliage of dwarf trees or saplings shorter than 3 m tall covers less than 10% of the census circle. Then, for up to two layers, indicate the average height (to nearest 0.1 m), % of circle covered by foliage of the layer, and dominant species comprising the layer.

SHRUB LAYERS (< 3 m): Shrubs are defined as woody plants with multiple stems less than 3 m in height. Check whether or not foliage of shrubs covers less than 25% of the census circle. Then, for each shrub layer in descending order of height, give the average height (to 0.1 m), % of circle covered by foliage of the layer, and dominant species comprising the layer.

HERB LAYER: Within the herb (non-woody) layer, estimate the % ground cover provided by graminoids (grasses, sedges, rushes), other herbaceous (flowering) plants, ferns, and horsetails. List the dominant species within each if possible.

MOSS/LICHEN LAYER: Estimate the % ground cover provided by mosses and hepatics (liverworts), lichens, litter (dead leaves), and bare ground or talus. List the dominant species within each if possible.

SOIL: Check appropriate box for soil moisture.

CLASSIFICATION: If you are familiar with the classification systems, indicate the alphanumeric code for the habitat type as classified by Viereck et al. (1992) and Kessel (1979). Leave blank if you do not know them. These will be used to assure that this form is allowing us to determine the correct classification.

Please send completed booklets by July 15 to:

Colleen M. Handel
National Biological Survey
1011 E. Tudor Rd.
Anchorage, AK 99503-6199
907-786-3418

References

Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet 60:86-94.

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Viereck, L. A., and E. L. Little, Jr. 1972. Alaska trees and shrubs. Agriculture Handbook No. 410. U. S. Dept. Agriculture, Forest Service, Washington, D. C.

May 1994