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PLANT PHENOLOGY STUDIES
1999 AND 2001 COMPARISON

JERICHO PROJECT, NUNAVUT

Submitted to:

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Toronto, Ontario

Submitted by:

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1.0 INTRODUCTION

Tahera Corporation collect plant growth stage (phenology) data from nine sites at the Jericho Project in 1999 and 2001. The 1999 data were previously reported (Burt 1999; Tahera 2003). This report provides a comparison of the previously reported 1999 data and the 2001 data. This supplemental report is in response to KIA/NTI Issue 80.

Plant growth stages are driven first by climate and second by microclimate. Differences seen from year to year must be put in the context of climate and any differences macro-climate makes to microclimate. By keeping the same plots and measuring the same species every year, much of the microclimate and species-specific variability is factored out.

The intended purpose of plant phenology studies is to detect changes in vegetation at the Jericho site caused by mining activity. Phenology studies must be combined with other monitoring techniques, such as lichen chemistry monitoring and transect studies perpendicular to sources for detecting effects of dusting. Phenology, because of its very high dependence on climate, may not be sensitive enough to detect subtle changes caused by mine stressors but a number of years data will be required to determine whether it is a useful tool or not.

2.0 METHODS

Methods were discussed in Burt and Tahera; they are repeated here for ease of reference.

Plant phenology is the study of the development of plants throughout the growing season. It is most easily observed by keeping track of changes in the leaves and non-reproductive parts of the plant, and in the flowers and structures related to the production of seeds.

Data collected in a single season is of limited use, due to the fact that local weather conditions can cause major variations in plant activity from one year to the next. However, data collected over several years can show trends and the effects of human activities in the region. It also becomes an important part of the monitoring program for a project. Phenology work in 1999 was designed to set up the plots and collect initial data; a follow-up study on the same plots was conducted in 2001 using the same techniques and plant species.

Plant communities important to wildlife were selected. Plots were established in an area convenient to Carat Camp, yet well out of the way of actual mining activities. Several are located west of the airstrip, between the strip and the north arm of Carat Lake. Others are located east of the junction of the main road and the road leading into camp.

Phenology plots were established in the following plant communities or associations:

Sedge community
- Non-tussock sedge association
- Tussock sedge association

Sedge-Heath Tundra transition
    Hummock association
Heath Tundra
Ridge complex (esker)
    Esker crest
    Heath tundra slope (windward slope)
    Birch/heath tundra slope (leeward slope)
Leeward slope (called early snowbank community in 1999)
Snowbank community
Birch Seep at lakeshore

One plot was established in each association. To be as consistent as possible with ITEX methodology, 5 m x 5 m plot sizes were used. Plots were semi-permanently marked in the center with re-bar stakes wrapped with flagging tape to increase visibility, and the co-ordinates of each location recorded with hand-held GPS units. In 2001, the corners of plots were semi-permanently marked with yellow plastic tent pegs.

Plant activity was observed and recorded weekly throughout the monitoring period (mid-May to September). Leaf and flower/seed development was recorded for several species in each plot.

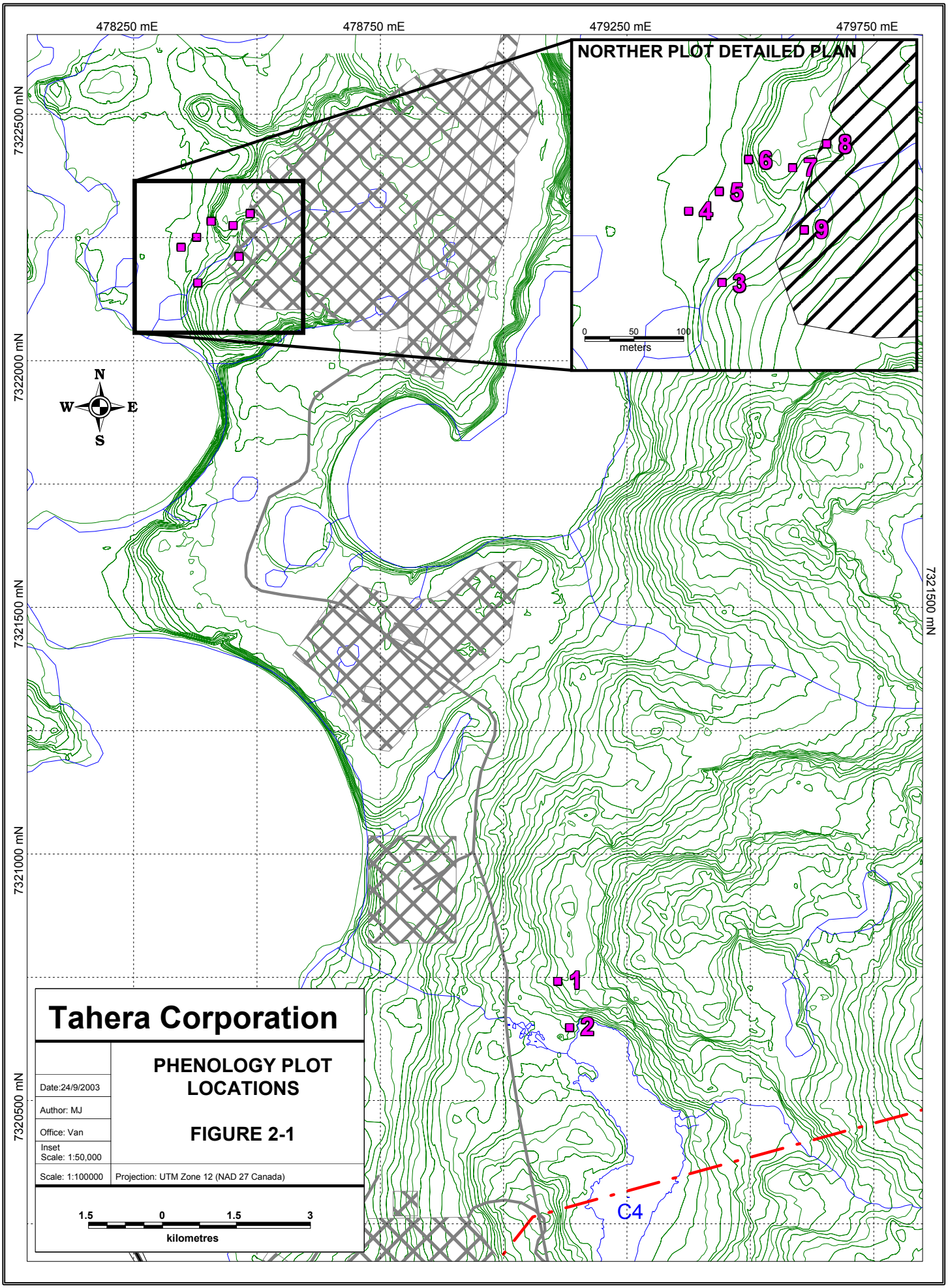
An initial study was run on each plot to establish edaphic and biological parameters.

Weekly checks established the following:

- Depth of the active layer at that point in time,
- State of the vegetative structures of representative species, and
- Point in the flowering cycle of the plant for each species.

Phenology studies being run at the Tundra Ecosystem Research Station at Daring Lake, 100 km to the south of the Jericho site, include daily checks on individual plants as well as continuous recording of temperature, humidity, wind speed, precipitation, and radiation. Daily checks were beyond the budget requirements of the Jericho study, but the results of the Daring Lake studies, because the site is so close, will be of use in studies on the Jericho site (Matthews and Clark, 1999).

Plot locations are shown on Figure 2.1.


478250 mE
478750 mE
479250 mE
479750 mE
7322500 mN
7322000 mN
7321500 mN
7321000 mN
7320500 mN
7321500 mN
NORTHER PLOT DETAILED PLAN
1
2
3
4
5
6
7
8
9
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50
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meters
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W
E
S
C4
Tahera Corporation
PHENOLOGY PLOT LOCATIONS
FIGURE 2-1
Date:24/9/2003
Author: MJ
Office: Van
Inset Scale: 1:50,000
Scale: 1:100000
Projection: UTM Zone 12 (NAD 27 Canada)
1.5
0
1.5
3
kilometres

3.0 RESULTS

3.1 Community Descriptions

3.1.1 Sedge Communities

Sedge communities typically occur in drainage basins, depressions, or at the edges of lakes and ponds. They are typically wetlands, with standing or slowly flowing water during enough of the growing season that the soil remains saturated.

Sedges (*Carex* sp.) or arctic cotton (*Eriophorum* sp.) make up the dominant vegetation in these communities. Arctic cotton is in the sedge family, but has such a distinctive flower that it has its own common name. It is also known as cottongrass.

3.1.1.1 Sedge Association – Non-Tussock

The non-tussock sedge association occurs in the center or deepest part of a drainage basin, and consists of non-tussock-forming sedges or cottongrasses. Some species of *Carex* and *Eriophorum* grow in tight clumps called tussocks; in other species, individual plants are connected by underground rhizomes, and are spaced evenly, not clumped.

Non-tussock formers typically grow in the wetter parts of a basin, where water tends to remain on the ground longer, or tends to flow in shallow channels, producing an intermittent flow of slowly moving water a few centimeters deep.

Characteristic species of this association in the Local Study Area include: *Carex aquatilis*, *C. bigelowii, C. membranacea, Eriophorum angustifolium,* and *E. scheuchzeri*.

Occasionally woody plants like willows *(Salix arctica*, *S. arctophila*, *S. glauca* ssp. *callicarpaea*, *S. fuscescens*, *S. planifolia*, and *S. tyrellii*) occur in this association, but usually are quite small. Moisture-tolerant forbs like marsh five-finger (*Potentilla palustris*), *Saxifraga foliolosa*, bulblet saxifrage (*S. cernua*), Sudetan lousewort (*Pedicularis sudetica*) also occur here. Occasionally legumes, including the arctic crazyweed (*Oxytropis arctica)* and (rarely*) O. bellii* were encountered, usually growing on mounds.

Grasses are uncommon in this association as it usually is too wet, but *Calamagrostis neglecta*, and *Luzula confusa* were occasionally found here.

The non-tussock association blends into the tussock association wherever the ground is higher or drier in the drainage basins. In places the two, plus hummocky tundra, form a mosaic of different associations, with any mound providing drier habitat that supports species more typical of the heath tundra communities.

Photo 1 shows the non-tussock sedge community at the beginning of August 2001.

3.1.1.2 Sedge Association – Tussock

The tussock sedge association occurs at the edges of a drainage basin, where water only occasionally flows in a thin sheet over the ground. Standing water may be present in the spring or after a rain, but does not persist long.

The sedges and cottongrasses of this association usually form durable "tussocks", clumps of stems and leaves attached to a network of roots and growing in a flexible clump like a tuft of hair. These tussocks form a visible tufted pattern.

Tussock zone sedge and cottongrass species include: *Carex aquatilis*, *C. membranacea*, *Eriophorum brachyantherum*, and *E. callitrix*. Non-tussock species may occur here, amidst the tussocks.

Heath (and other) species invade the tussocks, and mosses become established in the interstices between the tussocks. Commonly, bog rosemary (*Andromeda polifolia*) and cloudberry (*Rubus chamaemorus*) become established in the sides of the tussocks, while blueberry (*Vaccinium uliginosum*), cranberry (*Vaccinium vitis-idaea*), and Labrador tea (*Ledum decumbens*) grow from the tops. Lapland lousewort (*Pedicularis lapponica*), and bistort (*Polygonum viviparum*) also often grow in and around tussocks.

Dwarf birch (*Betula glandulosa*) and willows (*Salix arctica, S. fuscescens*, *S. arctophila*, and occasionally *S. herbacea* or *S. reticulata*) also gain footholds in the tussocks. The birches can attain sizes of over 20 cm, but the willows seldom exceed 10 cm in this association.

The tussock association is often transitional between the non-tussock association and the surrounding heath tundra. As the drainage basin ages, it receives organic material, especially at the edges, which impedes the flow of water, and actually raises the level of the land. This causes the upper layers of the soil to be drier, which allows other species to become established.

As they age, the tussocks lose their tufted shapes due to the growth of non-sedge species. They eventually become rounded humps and the association blends into hummocky tundra.

Photo 2 shows the tussock sedge community at the beginning of August 2001.

3.1.2 Birch Communities

These associations occur where there is a consistent and reliable supply of water throughout the growing season, but where water does not pool or stand on the ground. They are characterized by the fact that the dwarf birch (*Betula glandulosa*) is the dominant species. They vary in their location due to the amount of water available throughout the growing season.

The birch communities provide nesting habitat for small passerine (perching) birds that usually nest in trees in the southern parts of their ranges, shelter for roosting ptarmigans, and cover for

other mammals, like the tundra voles and lemmings. Short-tailed weasels also utilize their cover for hunting.

Birch Seep

Birch "seeps" are rarely associated with constantly flowing streams, but usually occur where water flows out of a boulder field, at the edge of an esker, on the margin of a slope, or where the active layer has slipped. The flow of water is not generally visible on the surface of the land, but is reliable. They are quite visible as a low but solid growth of dwarf birches, often in a crescent shape on a hillside. This plant association is often associated with large boulder groups or at the edges of boulder fields or areas of felsenmeer (shattered bedrock that has been somewhat rearranged by glaciation, but retains its angular forms).

Where the birch "grove" is thick enough, only leaf litter and a few scraggly mosses occur beneath the birches. If sunlight penetrates, however, birch seeps can support an understory of heaths (blueberry, Labrador tea, mountain cranberry) crowberry, mosses, buttercups (*Ranunculus lapponicus*), large-flowered wintergreen (*Pyrola grandiflora*), and bublet saxifrage (*Saxifraga cernua*). Several willows (*Salix glauca*, *S. arctophila, S. herbacea, S. tyrrellii*) occur here in this protected environment, as well as sedges (*Carex aquatilis*, *C. bigelowii*, *Eriophorum scheuchzeri*) and grasses (*Arctagrostis latifolia*, *Hierochloe alpina, Calamagrostis inexpansa, C. neglecta,* and *Poa arctica*).

Photo 3 shows the birch seep community at the beginning of August 2001.

3.1.3 Heath Tundra Communities

The heath tundra is the climax community in the Contwoyto Lake area, and covers most of the upland where the soil is stable or deep enough to support rooted plants. The term "heath" refers to plants of the family Ericaceae, and is used as a general term to describe this group of plants, which often grow in association with each other in the tundra.

The heath tundra community is characterized by a mixture of heaths, forbs, small xeric sedges, and grasses. The composition of the vegetation of the heath tundra community is governed by the amount of water in the soil, soil amount and type, and exposure to wind.

Terrain features are the most important cause of variations in the heath tundra community, especially those that affect the amount of water available to plant roots or those that cause the soil to be more exposed to winds in winter than in surrounding areas.

Upland Heath Tundra

This association occurs on most slopes and fairly well-drained level ground which is covered by a blanket of snow in winter, preventing wind erosion of the vegetation.

Characteristic plants of the upland heath tundra include Labrador tea, blueberry, mountain cranberry, and bearberry, black bearberry (*Arctostaphylos alpina*) on the drier sites, and red bearberry (*A. rubra*) where there is more moisture. Crowberry is often intermingled in the mat of vegetation, and dwarf birch is also an important component of this community, but grows in a scattered fashion, not in dense "groves". Willows (*Salix glauca* ssp. *callicarpaea, S. arctica, S. tyrrellii)* also occur throughout the upland heath tundra, and are mostly small and prostrate due to the shallow snow cover in winter.

Arctic bluegrass (*Poa arctica*), alpine holygrass (*Hierochloe alpina*), wood rush (*Luzula confusa*), and dryland sedges like *Carex bigelowii, C. membranacea, C. rotundata, C. rupestris,* and *C. vaginata* grow scattered throughout the upland heath tundra, not in pure stands. Alpine holygrass occurred in almost every plot we studied, except where the ground was saturated.

In windswept areas where the snow cover is likely quite thin in winter, mat plants like alpine azalea (*Loiseleuria procumbens*) or *Diapensia lapponica* can become established. Mountain avens (*Dryas integrifolia*) also occurs in thin snow areas.

Photo 4 shows the heath tundra community at the beginning of August 2001.

3.1.4 Snowbank Community

In the lee of a south or east-facing slope, deep snowbanks accumulate, and often do not disappear before July, drastically shortening the growing season for the plants beneath the snow. A characteristic plant association develops in these areas. Typical of most snowbank communities is the least willow (*Salix herbacea*), Labrador tea, and the white arctic heather. Mountain sorrel (*Oxyria digyna*), *Saxifraga punctata, S. nivalis*, and *Antennaria eckmaniana* are often also present.

The higher the bank or cliff which causes the snowbank to form, the deeper the snowbank, and more pronounced its effect on the local vegetation. We found particularly distinct snowbank communities at the west end of Long Lake, which is located to the southwest of the portal. Here, steep cliffs some 10 m tall cause snow accumulation and distinct local microclimates.

Wind turbulence in these valleys causes snowbanks to develop on both south and north-facing slopes. However, due to longer exposure to direct sunlight, the south-facing cliff bases tend to become snow free earlier than those facing north. These south-facing slopes are protected from drying winds, and have a reliable source of moisture throughout most of the growing season. The plant community that develops here consists of a number of species that are much more common further south, near Lac de Gras, Jolly Lake, and Courageous Lake.

Among the normal snowbank indicator species, we found bog-laurel (*Kalmia polifolia*), mountain heather (*Phyllodoce coerula*), Richardson's anemone (*Anemone richardsonii*), *Sibbaldia procumbens*, and in places a species of violet tentatively identified as *Viola epipsala* ssp. *repens*.

Arctic hares and ptarmigans apparently use the shelter of these cliffs in harsh weather. Here, we found many fecal deposits of both species, as well as unusual fecal pellets of arctic hares. These pellets seem to be covered with a fine mud veneer, and are composed of much finer plant material than are the typical pellets. Each pellet we opened also contained one to three small pieces of gravel. The reason for the formation of these atypical pellets is unknown, and a cursory search of the literature revealed no descriptions that fit.

Photo 5 shows the snowbank community at the beginning of August 2001.

3.1.5 Ridge Complex

Eskers and kame deltas are common in the Jericho area; the airstrip is built on a large esker that runs north from Carat Camp. These large systems encompass a number of plant communities, but some (such as the ridge crest communities) are characteristic only of the esker/drumlin/kame complexes, as they occur on the less stable sand/gravel substrates exposed to wind erosion.

3.1.5.1 Ridge Crest

Due to exposure to winds and the instability of the sand or gravel material of the esker or ridge crests, very specific plant communities develop there. These typically consist mostly of mats of vegetation (blueberry, crowberry, black bearberry, Labrador tea, mountain avens), semi-succulent plants (*Antennaria* sp., prickly saxifrage, *Draba glabella* and *D. lactea*), deeply-rooted cushion plants like moss campion (*Silene acaulis*), or clumps of grass (*Poa* sp. , *Arctagrostis latifolia*, *Festuca brachyphylla*, or *Arctophila* sp.). The tiny sandwort, *Minuartia rubella*, can also be found in some of these very dry, very unstable sites. A few legumes also can find a foothold here, including *Oxytropis arctica* and *Astragalus alpinus*.

Where the winds are particularly severe, due to topographical features and funneling, the snow cover in winter may be nonexistent and the soil may be so eroded and unstable that it cannot support any kind of rooted vegetation. In these areas, sand “blowouts” occur, which do not have any visible vegetation at all. More stable crests with thin snow cover may develop a thin veneer of black lichens.

Photo 6 shows the ridge crest community at the beginning of August 2001.

3.1.5.2 Ridge Slope Communities

The slopes of eskers can vary in exposure, orientation, and steepness, and the plant communities occupying them vary also. Slopes facing away from the prevailing winds may support a fringe of dwarf birches with an understorey of crowberry, blueberry, Labrador tea, arctic heather, mountain cranberry, and occasionally large-flowered wintergreen and *Antennaria* spp. These lee slopes usually face south or southeast.

Snowdrifts collect on these slopes and help protect the vegetation. They also ensure a more reliable supply of water, enabling the dwarf birches to survive there. Snowbank communities may occupy the lower portions of lee slopes that accumulate deep snowdrifts. Windward slopes usually are covered with heath tundra.

Photo 7 shows the leeward slope community at the beginning of August 2001, and Photo 8 shows the windward (NW) slope at the same period.

3.1.6 Transition Communities

In some cases, the transition zone between two plant communities is occupied by an association that contains elements of each, but that is clearly definable on its own.

An example of this is the hummock zone, which occurs in the transition between the sedge community and heath tundra. This association, because of its diverse microclimates, is a complex mosaic, with a high number of plant species, each occupying a specific niche.

A turf hummock is defined (Van Everdingen, 1998), as a “hummock consisting of vegetation and organic matter with or without a core of mineral soil or stones”. Occasionally, hummocks are ice-cored, especially in areas where there is considerable flow of water in the fall, when freezing and thawing occur each day.

Turf hummocks may originate as sedge tussocks are invaded by heaths. These are mounds developed initially from the tussocks of certain species of *Carex* and *Eriophorum* sedges, a tight but flexible mass of stalks, leaves, and roots. Bird (1967) states that this is the most common form of hummock in northern Canada.

Heath growth usually starts in the drier places on a tussock, with blueberry, Labrador tea, mountain cranberry, and occasionally red bearberry (*Arctostaphylos rubra*) rooting in the sides and top of the tussock, and gradually displacing the sedges. Mosses cover the ground between the tussocks, and add to their bulk by growing up the sides. Cloudberry (*Rubus chamaemorus*) and bog rosemary (*Andromeda polifolia*) become established in the moss, and gradually the structure ceases to resemble a tussock and becomes a mound of heaths and related species.

Moss mats that become established in sedge meadows may be an alternate source of hummocks (Pielou, 1994). The thickening growth of mosses insulate the ground in specific places, allowing ice lenses to develop when water percolates through the system in the fall. These enlarge each year, and, with the vegetation growth, cause the hummock size to increase. Plant species are similar, heaths, mosses, cloudberries, and a few forbs like bistort (*Polygonum viviparum*), Labrador lousewort and Lapland lousewort.

Toward the sides of the drainage basin or depression, there is less water in the soil, and colonization by heaths is more complete. Heaths fill the interstices between the mounds, and the surface becomes undulating, gradually merging with the surrounding heath tundra.

Photo 9 shows the tussock transition community at the beginning of August 2001.

3.2 Year 1999

Studies run at Daring Lake (Matthews and Clark, 1999) are done on individual plants; no attempt is made to collect individual data on plants in different vegetation associations. "The eight species monitored at Daring Lake are *Oxytropis nigrescens**[1], *Ledum decumbens, Vaccinium vitis-idaea, Betula glandulosa, Salix* sp., *Saxifraga tricuspidata, Eripohorum vaginatum*, and *Carex aquatilis*."

Raw data are provided in the Appendix A.

The summer of 1999 was in general a cold summer. Some species (especially some species of arctic cotton) had few blooms, and in many cases did not even "green up" as fully as would be expected. Some plants did not bear fruit at all.

Once the ground was snow free, leaf and flower development was very rapid. Late June/early July was the time of swiftest leaf development and flowering in most dicots. In some plants (bearberry and crowberry, for example), flowering precedes the development of the leaves, or change to the summer leaf colour. Plants like the bearberry and blueberry went from tight buds to petal fall in a single week. Cloudberry took even less time, with each plant blooming only 3-4 days.

It is important to point out that many flower buds actually develop almost a year prior to flowering, and are hidden deep in the axils of the leaves, or in a basal rosette at ground level (Savile, 1972, and Porsild, 1951)

We had few willows in the plots studied, but noted that the new leaves on willows were present in the third week of June in this area. During the early weeks of data collection, it is almost impossible to find willows in the plots; they are apparent only when the leaves begin to unfurl. New leaves on willows are preferentially browsed by muskox in early summer, making willow phenology important in areas frequented by muskox. If muskox are present around a site, it may be possible to reduce activity during the time the ox are browsing the willows, thus minimizing disturbance to the animals.

Some plots were tentatively established before all the snow was off the ground; this is necessary to ensure that data is collected as early as possible. In a couple cases, the vegetation revealed by the melting snow was not typical of the vegetation association needed, so the locations of a couple plots were shifted in 1999 to ensure they were located in a community that was clearly one type or another.

[1] Note from Burt (1999); this is likely an incorrect identification; *O. nigrescens* is found in the Mackenzie Mountains – this is likely *O. arctica* or *O. arctobia*.

A late snowbank community plot was established in early July. By the end of July, the plants in the late snowbank community plot were at the same stage as areas that had become snow-free in mid-June. One ravine area did not become snow-free until mid-July. It was not studied as a plot, but was watched carefully. As of late July, flowering of *Saxifraga rivularis* and *S. nivalis* had just begun.

Forbs (generally including non-woody, non-graminoid species) tend to develop very rapidly. An example is chickweed (*Stellaria monantha*). Often no sign of the plant appears above ground prior to the beginning of that year's development. Once it starts, the plant appears, stem extends, and leaves unfurl very quickly, often within the span of a single week. Flowers usually are open by the next week.

3.3 Year 2001

2001 was a heavy spring snow year. Snow left the ground two to four weeks later than in 1999, depending on location on the site. The summer was slightly warmer than 1999, however, with more sunshine, somewhat less rain and infrequent snow showers throughout the summer period. Table 3.1 provides a degree day (sum of days x average daily temperature) and total precipitation comparison for the period 1 June through 31 August (essentially the growing season). These differences are mirrored in the phenology results.

Table 3.1: Degree-day – Total Precipitation Comparison

Year	Degree Days	Total Precipitation (mm)
1999	691	99.2
2001	724	81.2

Figure 3.1 provides a daily graphic comparison between 1999 and 2001 for precipitation and temperature for the period 1 May through 31 August.

Plant growth started later in 2001 in all areas due to the snow cover and largely remained behind 1999, despite the warmer summer. Table 3.2 provides a community comparison. Dates provided are the first occurrence of the stage from any monitored plants in the community, so the table simplifies plant reaction to weather conditions for the purposes of comparison.

Figure 3.1: 1999 - 2001 Temperature and Precipitation Comparison

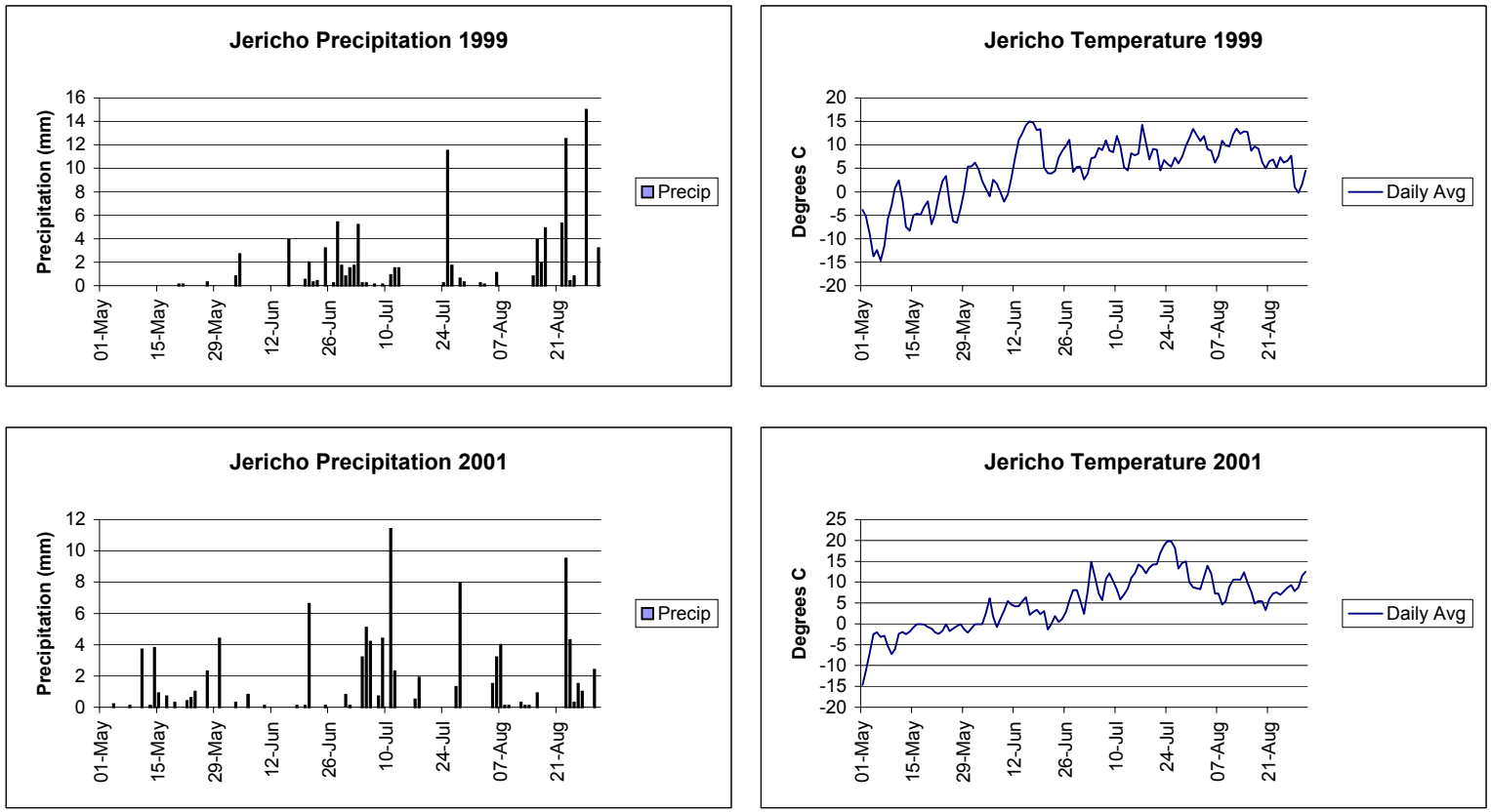

Table 3.2: 1999 – 2001 Plant Community Phenology Comparison

Plant Community	Stage	1999	2001	2001 Delay
Non-Tussock Sedge Plot 5	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 19	July 4	15
	Fruit developing	July 15	August 8	24
	Fall colour	Sept 2	Sept 12	10
Tussock Sedge Plot 4	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 19	July 4	15
	Fruit developing	July 15	August 1	16
	Fall colour	August 27	August 29	2
Birch Seep Plot 2	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 19	July 4	15
	Fruit developing	July 15	August 8	24
	Fall colour	Sept 2	Sept 5	3
Heath Tundra Plot 1	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 21	?
	1st flowers open	June 21	July 4	13
	Fruit developing	July 8	August 1	23
	Fall colour	August 27	August 29	2
Snowbank Plot 9	Snow free	July 3	July 18	15
	New leaves	July 8	July 18	10
	1st flowers open	July 15	August 1	16
	Fruit developing	August 4	August 14	10
	Fall colour	Sept 2	Sept 5	3
Ridge Crest Plot 7	Snow free	prior to June 19	prior to June 14	?
	New leaves	prior to June 19	prior to June 14	?
	1st flowers open	June 19	June 21	2
	Fruit developing	July 8	July 25	17
	Fall colour	August 20	August 29	9
Leeward Slope Plot 6	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 19	July 11	22
	Fruit developing	July 15	August 8	24
	Fall colour	Sept 2	Sept 5	3
Windward Slope Plot 8	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 19	July 4	15
	Fruit developing	July 15	August 8	24
	Fall colour	Sept 2	Sept 5	3
Hummock Transition Plot 3	Snow free	prior to June 19	June 14	?
	New leaves	prior to June 19	June 14	?
	1st flowers open	June 21	July 4	13
	Fruit developing	July 15	August 8	24
	Fall colour	August 27	August 29	2

Snow free conditions were not caught in 1999, nor the first leaves on most plants except for the snowbank community, thus these two stages cannot be compared for most communities. The snowbank community was 15 days later in becoming snow free in 2001 than in 1999; new leaves appeared 10 days later.

For all monitored communities, the first flower openings were approximately two weeks behind in 2001, fruit development was delayed approximately two to three weeks but fall leaf coloration was very close to 1999 (two to three days delayed). Later stages, e.g., main leaf fall were not caught in the monitoring period either year.

Raw data are attached in Appendix A. Both 1999 and 2001 data are presented in the data tables to facilitate comparisons.

Soil temperatures were not measured as part of phenology studies, however the depth of the active layer was measured by means of a steel rod inserted at the same location (each year) at each plot each week monitoring was conducted in 1999 and 2001. The active layer depth indicates the depth to frost in soil and is therefore an indirect measure of relative soil warmth. Table 3.3 provides a comparison.

Not all plant communities had a discernable pattern in active layer growth between years; the birch seep community was bedrock bound and thus the active layer could not be measured. Communities with discernable patterns included non-tussock sedge, tussock sedge, heath tundra, windward slope and hummock transition. The general pattern was for the active layer to be deeper in 1999 from mid June until about the beginning of August and then for the reverse to be the case, i.e., the active layer was deeper in 2001. Different soil types reacted somewhat differently but the general trend can be explained by the late snow melt and generally warmer summer temperatures in 2001. However, the observed difference in active layer depth (and indirectly in soil temperature) was not mirrored in plant growth advancement, possibly because the soil temperature in 2001 did not catch up with 1999 until the beginning of August, by which time in 1999 most plants had borne fruit.

Table 3.3: Active Layer Depth Comparison

Plant Community	Date	1999 Depth (m)	2001 Depth (m)	2001 Difference (m)
Non-Tussock Sedge Plot 5	Mid June	0.17	0.08	0.09
	Beginning of July	0.23	0.20	0.03
	Mid July	0.31	0.30	0.01
	Beginning of Aug	0.36	0.40	-0.04
	Mid August	--	0.64	?
	Beginning of Sept	0.46	0.54	-0.08
Tussock Sedge Plot 4	Mid June	0.14	0.15	-0.01
	Beginning of July	0.23	0.23	0
	Mid July	0.27	0.30	-0.03
	Beginning of Aug	0.33	0.40	-0.07
	Mid August	--	0.45	?
	Beginning of Sept	0.39	0.48	-0.09
Birch Seep Plot 2 (bedrock control)		na	na	na
Heath Tundra Plot 1	Mid June	0.58	0.50	0.08
	Beginning of July	0.57	0.61	-0.04
	Mid July	0.59	0.63	-0.04
	Beginning of Aug	0.56	0.63	-0.07
	Mid August	0.56	0.63	-0.07
	Beginning of Sept	0.58	0.63	-0.05
Snowbank Plot 9	Mid June	snow cover	snow cover	na
	Beginning of July	0.17	snow cover	na
	Mid July	0.53	0.31	0.22
	Beginning of Aug	0.70	0.58	0.12
	Mid August	0.73	0.81	-0.08
	Beginning of Sept	0.86	0.80	0.06
Ridge Crest Plot 7	Mid June	0.37	0.35	0.02
	Beginning of July	0.34	0.26	0.08
	Mid July	0.35	0.22	0.13
	Beginning of Aug	0.29	0.31	-0.02
	Mid August	0.29	0.37	-0.08
	Beginning of Sept	0.26	0.23	0.03
Leeward Slope Plot 6	Mid June	0.49	0.30	0.19
	Beginning of July	0.57	0.28	0.29
	Mid July	0.54	0.28	0.24
	Beginning of Aug	0.49	0.29	0.20
	Mid August	0.48	0.35	0.13
	Beginning of Sept	--	0.25	?
Windward Slope Plot 8	Mid June	--	0.20	?
	Beginning of July	0.67	0.57	0.10
	Mid July	0.65	0.60	0.05
	Beginning of Aug	0.57	0.69	-0.12
	Mid August	0.73	0.55	-0.18
	Beginning of Sept	0.56	0.83	-0.27
Hummock Transition Plot 3	Mid June	0.23	0	0.23
	Beginning of July	0.3	0.25	0.05
	Mid July	0.39	0.46	-0.07
	Beginning of Aug	0.63	0.69	-0.06
	Mid August	0.75	0.81	-0.06
	Beginning of Sept	0.86	0.89	-0.03

4.0 CONCLUSIONS

The disappearance of snow from plant communities in the spring has a profound influence on the timing of subsequent plant development in all communities monitored at the Jericho site, so much so, that it is unlikely that subtle changes due to mine operations would be detectable using plant phenology as a monitoring tool. A general pattern mirroring when snow disappeared in the spring is followed in plant development, i.e., the delay is snow melt is carried through until senescence shown in the appearance of fall colours (loss of the photosynthetic pigment chlorophyll).

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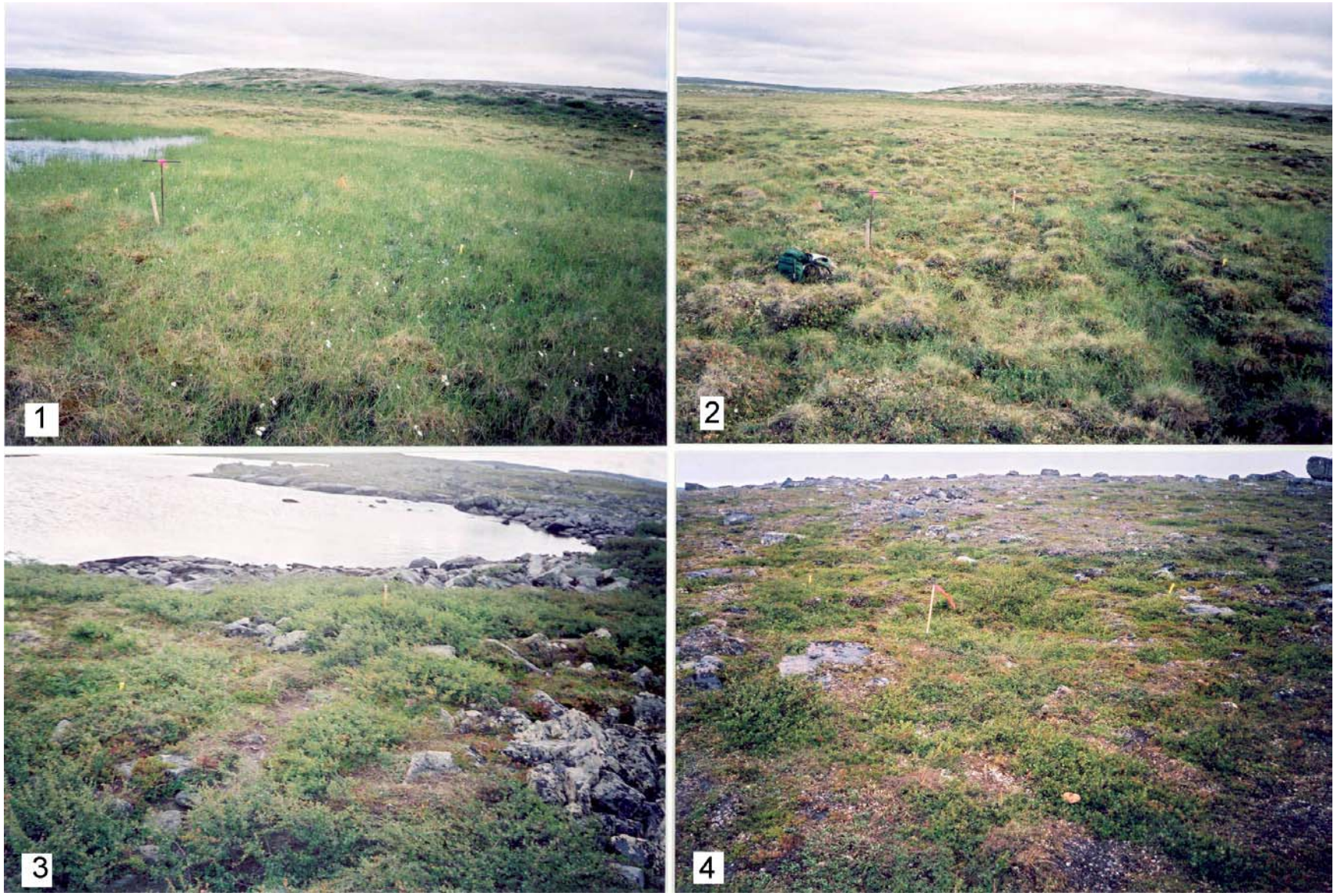
PHOTOS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APPENDIX A

Plant Phenology Data

HEATH TUNDRA/HUMMOCKS		Date (day/month) of phenology checks; record in column heads below:																										
Dates -> 1999 & 2001		14-Jun	19-Jun	21-Jun	21-Jun	26-Jun	27-Jun	03-Jul	04-Jul	08-Jul	11-Jul	15-Jul	18-Jul	21-Jul	22-Jul	25-Jul	01-Aug	04-Aug	08-Aug	12-Aug	14-Aug	20-Aug	22-Aug	27-Aug	29-Aug	02-Sep	05-Sep	12-Sep-01
Plot #: 3	Coord: 0478317E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer		active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
	7327422N																											
Hummock transition		0 m	0.23 m		0.11 m	0.28 m	0.14 m	0.3 m	0.25 m	0.32 m	0.38 m	0.39 m	0.46 m		0.49 m	0.57 m	0.69 m	0.63 m	0.775 m	0.75 m	0.81 m	0.66m	0.865 m	0.85 m	0.85 m	0.86 m	0.89 m	0.92 m
arctic cotton (tuss.)		SF - SF	L3/F5	L3/F6	SF - SF	L3/F6	L1 - F1	L4/F6	L1 - F4	L4/F6	L3 - F5	L5/F7	L4 - F5		L5/F9	L4 - F5	L4 - F5	L4/F7	L5 - F6	L5/F9	L5 - F7	L5/F9	L5 - F9	L5/F10	L5 - F9	L6/F10	L5 - F9	L6 - F10
Labrador tea		SF - SF	L3/F2	L4/F2	L2 - F1	L4/F3	L2 - F2	L4/F3	L3 - F2	L3/F5	L4 - F2	L4/F6	L4 - F3		L3/F6	L4 - F5-6	L4 - F6	L4-5/F7	L4 - F7	L5/F9	L5 - F7	L5/F8	L5 - F8	L5/F9	L5 - F9	L6/F10	L5 - F9	L6 - F9
bog rosemary		L3 - F1	L3/F2	L4/F2	L3 - F2	L4/F3	L3 - F2	L4/F4	L3 - F2	L5/F5-6	L4 - F4	L5/F5-6	L4 - F5		L5/F6	L4 - F5	L4 - F5	L5/F7	L4 - F6	L5/F9	L4 - F7	L5/F9	L4 - F8	L6/F10	L4 - F9	L6/F10	L5 - F9	L6 - F10
blueberry		SF - SF	L3/F2	L4/F3	L2 - F1	L4/F3	L2 - F1	L5/F3	L2-3 - F2	L5/F3	L4 - F4	L5/F5	L4 - F4		L5/F7	L4 - F6	L4 - F6	L4/F7	L5 - F6	L5/F8	L5 - F7	L5/F8	L5 - F8	L6/F8	L5 - F8	L6/F8	L5 - F8	L8 - F8
cloudberry (akpik)		SF - SF	L2/F1	L2/F1	SF - SF	L3/F2-3	SF - SF	L3/F4	SF - SF	L3/F6	L3 - F1	L4/F6	L4 - F4		L5/F7	L4 - F6	L4 - F7	L5/F1	L5 - F7	L5/F1	L5 - F6	L5/F2	L5 - F6	L6/F2	L6 - F10	L6/F2	L6 - F10	L9 - F10
Other: Willow sp.		- -	L3/F3	L3/F4	L2 - F2	L3/F4	L2 - F2	L3/F5	L3 - F3-4	L4/F6	L3 F5	L4/F7	L4 - F5		L3/F7	L4 - F5	L4 - F6	L4/F9	L4 - F6	L4/F10	L4 - F7	L5/f10	L5 - F7	L6/F10	L5 - F9	L6/F10	L6 - F9	L7 - F9
Plot #: 1	Coord: 0479114E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer		active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
	7320737N																											
Heath tundra		0.5 m	0.58 m		0.61 m	0.53 m	0.61 m	0.57 m	0.61 m	0.59 m	0.615 m	0.59 m	0.63 m	0.58 m		0.63 m	0.63 m	0.56 m	0.63 m	0.56 m	0.63 m	0.57 m	0.62 m	0.5 m	0.62 m	0.58 m	0.63 m	0.62 m
blueberry		SF - SF	L4/F2	L4/F2	SF - SF	L5/F2	SF - SF	L5/F2	L2-3 - F2	L5/F6	L4 - F4	L5/F6	L4 - F5	L5/F7		L5 - F6	L5 - F7	L5/F1	L5 - F7	L5/F1	L5 - F8	L5/F1	L5 - F8	L6/F9	L5 - F8	L6/F9	L6 - F8	L8 - F8
mt. cranberry		SF - SF	L4/F2	L4/F2	L2 - F1	L4/F2-3	L2 - F1	L4/F3	L4 - F2	L5/F3	L4 - F2	L5/F4	L5 - F2	L5/F5		L5 - F3-4	L5 - F5	L5/F6	L5 -F6	L5/F7	L6 - F7	L5/F8	L6 - F8	L5/F8	L6 - F8	L6/F8	L6 - F8	L6 - F8
Labrador tea		SF - SF	L3/F2	L4/F2	L3 - F2	L4/F2-3	L3 - F2	L4/F3	L3 - F2	L4/F4	L4 - F2	L4/F4	L4 - F3	L3/F6		L4 - F4-5	L4 - F6	L4-5/F7	L4 - F7	L5/F9	L4 - F7	L5/F9-10	L5 - F9	L5/F9-10	L5 - F10	L5-6/F10	L5 - F10	L6 - F10
arctic heather		SF - SF	L3/F2	L3/F3	SF - SF	L3/F4	L2 - F2	L4/F4	L3 - F2	L4/F6	L4 - F4	L4/F6	L4 - F5	L3/F7		L4 - F6	L4 - F6	L4-7/F6	L5 - F7	L4-7/F8	L4 - F7	L5/F9-10	L4 - F8	L5/F10	L4 - F9	L5-7/F10	L4 - F9	L6 - F9
bearberry		SF - SF	L3/F3	L3/F3	L2 - F1	L4/F4	L2 - F1	L4/F4	L2 - F3	L5/?	L4 - F3	L5/F7	L4 - F5	L5/F7		L4 - F6	L4 - F7	L5/F7	L4 - F7	L5/F1	L5 - F7	L6/F2	L5 - F8	L6/F2	L6 - F8	L6/F2	L6 - F8	L8 - F8
Other: Crowberry		SF - SF		L5/F6	L2 - F1	L5/F6	L2 - F1	L5/F6	L3 - FF1	L5/F7	L4 - F1	L5/F7	L4 - F1	L5/F7		L4 - F1	L4 - F1		L4 - F7	L5/F8	L4 - F7	L5/F9	L5 - F8	L5-5/F9	L5 - F8	L5-6/F10	L5 - F8	L6 - F8

CODES: LEAVES

S = snow
SF = snow free but no activity
L1 = new leaves on grasses/sedges/arc. Cotton
L2 = leaf buds swelling
L3 = new leaves open/new green in evergreen plants
L4 = fully leafed out
L5 = 1st leaf colour change
L6 = Fall colour
L7 = leaf withering/chg. To fall bronze in evergreens
L8 = first leaf fall (few coloured leaves on ground)
L9 = main leaf fall/leaves withering
L10 = Inactive state: all leaves shed/winter colour

FLOWERS

S = snow
SF = snow free, no activity
F1 = no sign of flowers
F2 = buds appear in axils
F3 = 1st open flower
F4 = full flower, pollen on anthers
F5 = pollen on stigmas
F6 = 1st petals/corollas falling/fading
F7 = fruits/seeds developing (swelling calyx)
F8 = berries ripe
F9 = seed capsules mature (appear to be dry)
F10 = seeds being released (capsules splitting)

Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:

1999 and 2001 combined.
1999
2001

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Heath Tundra and Hummocks

SNOWBANK/RIPARIAN	Date (day/month) of phenology checks; record in column heads below:																								
Dates -> 1999 & 2001	14-Jun	19-Jun	21-Jun	21-Jun	26-Jun	27-Jun	03-Jul	04-Jul	08-Jul	11-Jul	15-Jul	18-Jul	21-Jul	22-Jul	25-Jul	01-Aug	04-Aug	08-Aug	12-Aug	14-Aug	20-Aug	22-Aug	27-Aug	29-Aug	02-Sep	05-Sep	12-Sep
Plot #: 9 Coord: 0478450E							active		active		active	active		active	active	active	active	active	active	active	active	active	active	active	active	active	active
7322450N							layer		layer		layer	layer		layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer
Snowbank Community							0.17 m		0.31 m		0.53 m	0.305 m		0.62 m	0.48 m	0.58 m	0.70 m	0.625 m	0.73 m	0.81 m	0.62 m	0.85 m	0.84 m	0.77 m	0.86 m	0.80 m	0.855 m
dwarf birch	S			S		S	SF	S	L2/SF	S	L3/F2	SF		L3/F2	L4 - F1	L4 - F2	L4/F7	L4 - F3	L4/F8	L4 - F4	L5/F8	L4 - F5	L5/F8	L4 - F5	L5-6/F8	L5 - F7	L6 - F9
least willow	S			S		S	ND	S	L2/SF	S	L3/F2	SF		L3/F2	L3 - F3	L4 - F3	L4/F4	L4 - F4	L4/F5	L4 - F4	L5/F7	L4 - F5	L5/F8	L4 - F5	L5-6/F8	L5 - F7	L9 - F10
Labrador tea	S			S		S	L1/F1	S	L2/SF	S	L3/F1	SF		L3/F3-F4	L4 - F2	L4 - F3-4	L4/F4	L4 - F3-4	L4-5/F6-9	L4 - F4	L4-5/F7	L4 - F4	L5/F8-9	L4 - F7	L6/F10	L5 - F9	L6 - F9
alpine arnica	S			S		S	ND	S	SF/SF	S	SF/SF	SF		SF/SF	- -	- -		- -		- -		- -		- -	ND	- -	- -
cranberry	S			S		S	ND	S	L3/SF	S	L5/F1	SF		L4/L5/F1	L3 - F1	L4 - F2		L4 - F3		L5 - F4		L5 - F4		L5 - F6		L5 - F8	L6 - F8
arctic heather	S			S		S	L1/F1	S	L3/F2	S	L4/F3-4	SF		L4/F5	L4 - F2-4	L4 - F4	L4/F7	L4 - F4	L4-7/F8-9	L4 - F7	L3-4/F8	L4 - F8	L5/F9	L5 - F9	L6/F9-10	L5 - F9	L6 - F9
Blueberry	S			S		S		S		S		SF		L5/F3	SF	L4 - F1		L4 - F4		L4 - F7		L4 - F7		L5 - F8		L6 - F8	L8 - F8
Plot #: 2 Coord: 0479053E	active	active	active	active	active	active	active	active	active	active	active	active	active		active	active	active	active	active	active	active	active	active	active	active	active	active
7320819N	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer		layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer	layer
Riparian (birch seep)	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--
dwarf birch	L2 - F1	L4/F4	L4/F4	L2-L3 - F2	L4/F4	L2-3 - F2	L4/F4	L3-4 - F4	L4/F5	L4 - F4	L4/F7	L4 - F5	L4/F7		L4 - F5	L4 - F5	L4/F7	L5 - F5	L4/F8	L5 - F5	L5/F8	L5 -F5	L5/F8	L5 - F9	L5-6/F10	L6 - F9	L8 - F10
crowberry	SF - SF	L3/F5	L4/F6	L2 - F1	L4/F2	L2 - F1	L4/F6	L3 - F1	L3/F7	L4 - F1	L4/F7	L4 - F1	L3+L5/F7-8		L4 - F1	L4 - F1	L4-5/F7	L4 - F1	L5/F8	L4 - F1	L6/F8	L4 - F8	L6/F9	L5 - F8	L5-6/F8-9	L5 - F8	L6 - F8
Labrador tea	L2 - F1	L3/F2	L4/F2	L3 - F2	L4/F2	L3 - F2	L4/F3-4	L3 - F2	L3/F4	L4 - F3	L4/F4	L4 - F4	L3+L5/F6		L4 - F5	L4 - F6	L5/F7	L4 - F7	L5/F8-9	L4 - F7	L5/F8	L4 - F7	L5/F8	L5 - F9	L5-6/F10	L5 - F9	L6 - F9
cranberry	L2 - F1	NONE	NONE	L2 - F1	ND	L2 - F1	ND	L3 - F2	ND	L4 - F2	ND	L5 - F2	ND		L5 - F4	L5 - F5	L4-5/F4	L5 - F6	ND	L5 - F6	L5/F7	L5 - F7	L5/F7	L5 - F8	L5/F7	L5 - F8	L6 - F8
sedge	SF - SF	L3/F2	L3/F3	SF - SF	L4/F3	SF - SF	L4/F3-4	L1 - F1	L4/F6	L2 - F3	L4/F6	L4 - F4	L4/F9		L4 - F5	L4 - F6	ND	L5 - F6	L4/F8-9	L5 - F9	L5/F9	L5 - F9	L5/F9	L5 - F9	L5-6/F10	L5 - F9	L5 - F9
Other: bog rosemary	SF - SF	L4/F2	L4/F2	SF - SF	L4/F3	L2 - F2	L4/F3-4	L3 - F2	L4/F4	L4 - F3	L4/F4	L4 - F4	L3+L5/F6		L4 - F5	L4 - F5	L4/F7	L4 - F6	L5/F9	L4 - F7	L5/F10	L4 - F7	L5/F10	L5 - F9	L5-6/F10	L5 - F10	L6 - F10

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F9 = seed capsules mature (appear to be dry)
F10 = seeds being released (capsules splitting)

Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:

1999 and 2001 combined
1999
2001

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Snowbank and Riparian Birch Seep

SEDGE COMMUNITIES		Date (day/month) of phenology checks; record in column heads below:																								
Dates -> 1999 & 2001		14-Jun	19-Jun	21-Jun	21-Jun	26-Jun	27-Jun	03-Jul	04-Jul	08-Jul	11-Jul	15-Jul	18-Jul	22-Jul	25-Jul	01-Aug	04-Aug	08-Aug	12-Aug	14-Aug	20-Aug	22-Aug	27-Aug	29-Aug	02-Sep	05-Sep	12-Sep
Plot #: 5	Coord: 478429E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
	7322442N																										
Non-tussock assn:		0.08 m	0.17 m		0.13 m	0.23 m	0.14 m	0.23 m	0.195 m	0.31 m	0.25 m	0.31 m	0.295 m	0.33 m	0.35 m	0.405 m	0.36 m	0.905 m	--	0.635 m	0.35 m	0.665 m	0.50 m	0.49 m	0.46 m	0.52 m	0.54 m
arc.cotton (tuss.)		L1 - F1	L1/F4	L3/F5	L1 - F1	L3/F5	L1 - F1	L4/F5	L1 - F4	L4/F6	L3 - F4	L5/F7	L4 - F5	L5/F9	L4 - F6	L4 - F6	L5-6/F6	L4 - F6	L4-5/F7	L4 - F9	L5/F9	L4 - F10	L5/F9	L5 - F10	L6/F10	L5 - F10	L7 - F10
bog rosemary		L3 - F1	L4/F2	L4/F2	L3 - F2	L4/F3	L3 - F2	L4/F3-4	L3 - F2	L4/F4	L4 - F4	L5/F5	L4 - F5	L5/F6	L4 - F5	L4 - F5	L4/F6	L4 - F6	L4-5/F9	L4 - F6	L5/F10	L4 - F7	L6/F10	L4 - F9	L6/F10	L5 - F9	L7 - F10
Carex sp.		SF - SF	L3/F1	L3/F1	L1 - F1	L3/F1	L1 - F1	L3/F1	L1 - F1	L3/F2	L3 - F1	L3/F2	L4 - F3	L3+I5/F6	L4 - F4	L4 - F6	L4/F5	L5 - F5	L4/F7	L5 - F5	L5/F9	L5 - F5	L5/F9	L5 - F9	L6/F9	L5 - F9	L7 - F9
grass		- -	L3/F1	L3/F1	- -	L3/F1	- -	L3/F1	- -	L3/F2	- -	L3/F2	- -	?	- -	- -	ND	- -	ND	- -	ND	- -	ND	- -	ND	- -	- -
arc.cotton (non-tuss)		SF - SF	L2/F4	L3/F5	L1 - F1	L3/F5	L1 - F1	L3/F5	L1 F1	L4/F6	L3 - F4	L4/F7	L4 - F5	L5/F8	L4 - F6	L4 - F6	L4/F6	L5 - F6	LR/F7	L5 - F9	L5/F9	L5 - F9	L5/F10	L5 - F9	L6/F10	L5 - F9	L7 - F10
Other:			L4/F3	L4/F4		L4/F4		L4/F4		L2/F1		L3/F2		L3+L5/?			L4/F10		L5/F1		L6/F10		L6/F10		L6/F10		
Plot #: 4	Coord: 478397E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
	7322450N																										
Tussock assn:		0.15 m	0.14 m		0.17 m	0.21 m	0.17 m	0.23 m	0.23 m	0.23 m	0.25 m	0.27 m	0.30 m	0.31 m	0.35 m	0.40 m	0.33 m	0.42 m	--	0.445 m	0.32 m	0.44 m	0.34 m	0.45 m	0.39 m	0.48 m	0.48 m
arc. cotton (tussock)		L1 - F1	L1/F5	L3/F6	L1 - F1	L3/F5	L1 - F1	L3/;F6	L1 - F4	L3/F6	L3 - F4	L4/F6-7	L4 - F5	L4/F9	L4 - F6	L4 - F6	L4/F4	L5 - F7	L4/F9	L6 - F4	L5/F9	L6 - F10	L5/F9	L6 - F10	L6/F10	L6 - F10	L6 - F10
Labrador tea		L1 - F1	L4/F2	L4/F2	L3 - F2	L4/F2	L3 - F2	L4/F3-4	L3 - F2	L3/F5	L4 - F2	L4/F6	L4 - F3	L3+L5/F7	L4 - F5	L4 - F6	L4-5/F9	L4 - F7	L4-5/F9-10	L4 - F8	L5/F9	L4 - F9	L5/F9-10	L5 - F9	L6/F10	L5 - F9	L6 - F9
birch		SF - SF	L4/F3	L4/F4	L2 - F2	L4/F4	L2 - F2	L4/F4	L3 - F4	L5/F6	L4 - F5	L5/F7	L4 - F5	L3/F7	L4 - F5	L4 - F5	L4/F7	L4 - F5	L4-5/F9-10	L4 - F5	L5/F9	L5 - F6	L6/F9	L6 - F10	L6/F10	L6 - F10	L8 - F10
bog rosemary		L3 - F1	L4/F2	L4/F2	L3 - F2	L4/F3	L3 - F2	L4/F3-4	L3 - F2	L4/F4	L4 - F4	L5/F5	L4 - F5	L3+L5/F7	L4 - F5	L4 - F6	L5/F1	L4 - F5	L5/F8	L4 - F7	L5/F8	L4 - F8	L6/F9-10	L5 - F9	L6/F10	L5 - F9	L6 - F10
mt.cranberry		L2 - F1	L3/F1	L3/F1	L3 - F1	L4/F2	L3 - F1	L4/F2	L3 - F1	L5/F2	L4 - F1	L5/F2	L4 - F1	L3+L5/F6	L4 - F1	L4 - F1	L4-5/F1	L4 - F1	L4-5/F1	L6 - F1	L5/F1	L6 - F6	L5-6/F1	L5 - F8	L6/F1	L5 - F8	L6 - F8
Other: Cloudberry		- -	L2/F1	L2/F1	SF - SF	L3/F2-3	SF - SF	L3-4/F4	L2 - F1	L5/F6	L3 - F1	L5/F6	L4 - F4	L5/F6	L4 - F6	L4 - F7	L4-5/F1	L4 - F7	L4-5/F1	L5 - F7	L5/F2	L5 - F7	L6/F8	L6 - F10	L6/F8	L6 - F10	L9 - F10

CODES: LEAVES

S = snow
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L1 = new leaves on grasses/sedges/arc. Cotton
L2 = leaf buds swelling
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L5 = 1st leaf colour change
L6 = Fall colour
L7 = leaf withering/chg. To fall bronze in evergreens
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F8 = berries ripe
F9 = seed capsules mature (appear to be dry)
F10 = seeds being released (capsules splitting)

Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:

1999 and 2001
1999
2001

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Sedge Associations

LEEWARD SLOPE	Date (day/month) of phenology checks; record in column heads below:																								
Dates -> 1999 & 2001	14-Jun	19-Jun	21-Jun	21-Jun	26-Jun	27-Jun	03-Jul	04-Jul	08-Jul	11-Jul	15-Jul	18-Jul	22-Jul	25-Jul	01-Aug	04-Aug	08-Aug	12-Aug	14-Aug	20-Aug	22-Aug	27-Aug	29-Aug	02-Sep	05-Sep	12-Sep
Plot #: 6 Coord: 0478428E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
7322468N																										
Leeward Slope	0.30 m	0.49m	--	0.24 m	0.54 m	0.31 m	0.85 m	0.29 m	0.57 m	0.275m	0.54m	0.275m	0.52 m	0.29 m	0.29 m	0.49 m	0.32m	0.32 m	0.345 m	0.48 m	0.36 m	0.46 m	0.26 m	--	0.25 m	0.25 m
dwarf birch	SF - S	L4/F4	L4/F5	L2 - F2	L4/F5	L2 - F2	L4/F5	L3 - F4	L4/F5	L4 - F5	L4/F5	L4 - F5	L3/F7	L4 - F5	L4 - F5	L4/F7	L5 - F6	L4/F8	L5 - F6	L4/f9	L5 - F7	L5/F8	L5 - F10	L6/F9	L6 - F10	L9 - F10
least willow	- -	NONE	NONE	- -	ND	- -	ND	- -	ND	- -	ND	- -	ND	- -	- -	ND	- -	ND	- -	ND	- -	ND	- -	S	- -	- -
Labrador tea	L2 - F1	L3/F2	L4/F2	L3 - F2	L4/F2	L3 - F2	L4/F2-3	L3 - F2	L4/F3	L4 - F2	L5/F4	L4 - F5	L3+L5/F5	L4 - F5	L4 - F6	L4-5/F7	L4 - F7	ND	L4 - F7	L4-5/F7	L4 - F8	L5/F8-9	L5 - F9	S	L5 - F9	L6 - F9
saxifrage	SF - SF			L3 - F1		L3 - F1		L3 - F1		L3 - F2		L4 - F3		L4 - F5-6	L4 - F6		L4 - F7		L5 - F7		L5 - F9		L6 - F9		L6 - F10	L7 - F10
cranberry	L2 - F1			L3 - F1		L3 - F1		L3 - F2		L4 - F2		L4 - F2		L4 - F4	L4 - F6		L4 - F6		L5 - F8		L5 - F8		L5 - F8		L5 - F8	L6 - F8
arctic heather	SF - SF	L3/F2	L3/F2	L3 - F2	L3/F3	L3 - F2	L3/F3-4	L 3 - F2	L4/F6	L4 - F4	L5/F7	L4 - F5	L3+l5/F7	L4 - F6	L4 - F6	L4-7/F7	L5 - F6	L4-7/F10	L5 - F7	L3-4/F8	L5 - F8		L5 - F9	S	L5 - F9	L6 - F9
bearberry	- -			- -		- -		- -		- -		- -		- -	- -		- -		- -		- -		- -		- -
blueberry	SF - SF			L2 - F1		L2 - F1		L3 - F2		L3 F3		L4 - F3		L4 - F6	L4 - F6		L4 - F7		L5 - F8		L5 - F8		L5 - F8		L6 - F8	L8 - F8

CODES: LEAVES
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Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:
1999 and 2001
1999
2001

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Leeward Slope

LEEWARD SLOPE 2	Date (day/month) of phenology checks; record in column heads below:										
Dates -> 2001	29-Aug	05-Sep	12-Sep								
Plot #: 12 Coord: 479242E 7323086N	Active Layer	Active Layer	Active Layer								
Leeward Slope	0.40 m	.48 m	.57 m								
dwarf birch	L5-6 - F8	L6 - F10	L8 - F10								
~~willow~~											
Labrador tea	L5 - F9	L5 - F9	L6 - F9								
Moss campion	L5 - F10	L5 - F10	L7 - F9								
cranberry	L5 - F8	L5 - F8	L6 - F8								
arctic heather	L5 - F9	L5 - F9	L6 - F9								
Poa sp.	L6 - F9	L6 - F9	L7 - F9								
blueberry	L6 - F8	L6 - F8	L8 - F8								

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Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Leeward Slope

RIDGE COMPLEX	Date (day/month) of phenology checks; record in column heads below:																								
Dates -> 1999 & 2001	14-Jun	19-Jun	21-Jun	21-Jun	26-Jun	27-Jun	03-Jul	04-Jul	08-Jul	11-Jul	15-Jul	18-Jul	22-Jul	25-Jul	01-Aug	04-Aug	08-Aug	12-Aug	14-Aug	20-Aug	22-Aug	27-Aug	29-Aug	02-Sep	05-Sep	12-Sep
Plot #: 7 Coord: 478467E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
7322462N																										
Crest	0.35 m	0.37 m		0.28 m	0.34 m	0.28 m	0.34 m	0.26 m	0.35 m	0.22 m	0.35 m	0.22 m	0.31 m	0.24 m	0.31 m	0.29 m	0.36 m	0.29 m	0.365	0.29 m	0.375 m	0.27 m	0.23 m	0.26 m	0.225 m	0.25 m
blueberry	L2 - F1	L3/F3	L4/F4	L3 - F1	L3/F2	L3 - F1	L3/F2	L3 - F1	L5/F6-7	L4 - F3	L5/F6-7	L4 - F3	L5/F7	L4 - F6	L4 - F6	L4/F1	L4 - F6	L4-5/F1	L4 - F8	L6/F8	L5 - F8	L6/F8	L5 - F8	L6/F8	L6 - F8	L8 - F8
bearberry	L2 - F2	L3/F1	L4/F2	L3 - F3	L4/F2	L3 - F3	L4/F2	L3 - F6	L5/F2	L4 - F6	L5/F2	L4 - F6	L3+L5/F2	L4 - F6	L4 - F6	L4/F7	L4 - F7	L5/F1	L5 - F7	L5/F2	L5 - F8	L6/F2	L6 - F10	L6/F2	L6 - F10	L8 - F10
prickly saxifrage	L3 - F1	L3/F2	L3/F2	L3 - F1	L3/F2-3	L3 - F1	L3/F4	L2-3 - F2	L5/F3	L3 - F3	L5/F4	L4 - F4	L5/F5	L4 - F6	L4 - F6	L4-5/F7	L4 - F6	L5/F9	L5 - F7	L6-7/F9	L5 - F9	L6-7/F9-10	L6 - F10	L6-7/F10	L6 - F10	L7 - F10
moss campion	L3 - F1	L3/F3	L4/F4	L3 - F2	L4/F4	L3 - F2	L4/F5	L4 - F 4-5	L4/F6	L4 - F4-5	L4/F6	L4 - F5	L4/F7	L4 - F6	L4 - F6	L4/F7	L4 - F6	L5/F9	L4 - F6	L3/F10	L4 - F9	L3/F10	L7 - F10	L5/F10	L7 - F10	L7 - F10
Other: Potentilla nivallis	L3 - F1	L4/F4	L4/F4	L3 - F1	L4/F4	L3 - F1	L4/F4-5	L4 - F4	L4/F4-5	L4 - F4-5	L4/F6	L4 - F5	L5/F7	L4 - F6	L4 - F6	L5/F7	L4 - F6	L4/F9	L4 - F6	L5-6/F10	L4 - F6	L6-7/F10	L5 - F9	L7/F10	L6 - F10	L7 - F10
Plot #: 8 Coord: 478476E	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer	active layer
7322528N																										
Windward slope (N or NW)	0.2 m			0.47 m	0.62 m	0.52 m	0.67 m	0.57 m	0.66 m	0.58 m	0.65 m	0.60 m	0.65 m	0.64 m	0.69 m	0.57 m	0.71 m	0.55 m	0.73 m	0.54 m	0.75 m	0.53 m	0.80 m	0.56 m	0.83 m	0.87 m
dwarf birch	SF - S	L4/F3	L4/F3	L2 - F2	L4/F3	L2 - F2	L3/F3	L3 - F4-5	L3/F6	L4 - F5	L4/F6	L4 - F5	L4/F7	L4 - F5	L4 - F5	L4/F7	L5 - F7	L4-8/F8	L5 - F7	L5/F8	L5 - F7	L5/F8	L6 - F10	L6/F9	L6 - F10	L8 - F10
blueberry	L2 - F1	ND	ND	L3 - F1	ND	L3 - F1	ND	L3 - F2	ND	L4 - F3	ND	L4 - F3	ND	L4 - F5	L4 - F6	ND	L4 - F6	ND	L5 - F7	ND	L5 - F8	ND	L5 - F8	ND	L6 - F8	L8 - F8
Labrador tea	SF -SF	L4/F3	L4/F3	L1 - F2	L4/F3-4	L2 - F2	L4/F4	L3 - F2	L3/F6	L4 - F2	L4/F6	L4 - F3	L3+L5/F7	L4 - F5	L4 - F6	L5/F7	L4 - F7		L5 -F7	L5/F8	L5 - F8	L5/F8-9	L5 - F9	L5-6/F9	L5 - F9	L6 - F9
mt. cranberry	L2 - F1	L3/F3	L4/F2	L3 - F1	L4/F4	L3 - F1	L4/F4	L3 - F2	L4/F4	L4 - F2	L5/F6	L4 - F2	L3+L5/F6-7	L4 - F4	L4 - F5	L4-5/F7	L4 - F6	L4-5/F7	L5 - F7	L5/F7	L5 - F8	L5/F8	L5 - F8	L5-6/F8	L5 - F8	L6 - F8
arctic heather	SF - S	L3/F3	;3F4	L3 - F2	L4/F4	L3 - F2	L4/F4	L3 - F2	L4/F4	L4 - F4-5	L4/F6	L4 - F5	l3+L5/F7	L4 - F6	L4 - F6	L5-7/F7	L4 - F7		L5 - F7	L5/F8	L5 - F8	L5-6/F9	L5 - F9	L6/F10	L5 - F9	L6 - F9
Other: Grass (Poa sp.)	SF - S	L3/F3	L3/F3	SF - SF	L4/F4	SF - SF	L4/F4	L1 - F1	L4/F4	L3 - F3	L5/F9	L4 - F4	l3+L5/F10	L4 - F5	L4 - F6	ND	L4 - F6	ND	L5 - F6	L5/F10	L5 - F7	L5/F10	L5 - F10	L6/F10	L6 - F10	L7 - F10

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Directions: record dates in col. Heads
Rec. codes opposite each species.
Leaf & flower codes in same box

NOTES:

1999 and 2001

1999

2001

TAHERA CORPORATION
Vegetation Baseline Phenology Studies
Ridge Complex