

Vegetation Monitoring Field Manual

Tundra Ecosystem Research Station, Daring Lake, Northwest Territories



by

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PREFACE

The primary purpose of this manual is to provide guidance and instruction to those researchers and volunteers who find themselves collecting data for the Vegetation Monitoring program at the Tundra Ecosystem Research Station, Daring Lake, NT. It is intended to provide enough detail so that yearly measurements will be taken and recorded in a consistent manner even though most likely by different people. This is crucial to the program in that the less variation in how the data is collected the more accurate and valuable the data becomes. The guide is organized by species and by phenological event or measurement, allowing for quick reference. If you find that there is something missing or you have suggestions, please inform the Program Coordinator in Yellowknife. We consider this manual a “work in progress” and with continual input from users will only get better over time.

ACKNOWLEDGMENTS

The authors would like to thank Steven Matthews who provided them with the opportunity to be involved in the Vegetation Monitoring program at Daring Lake over the last few years. It is a result of that involvement that the production of such a manual was initiated. Thanks are also due to Anne Gunn (GNWT) who established the program, Greg Henry (UBC) who provided invaluable advice on design, all researchers and volunteers who have helped with data collection over the years, and those who reviewed and provided comment on drafts of this manual. This manual would not have been produced without support from the Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories and generous funding by Indian and Northern Affairs Canada.

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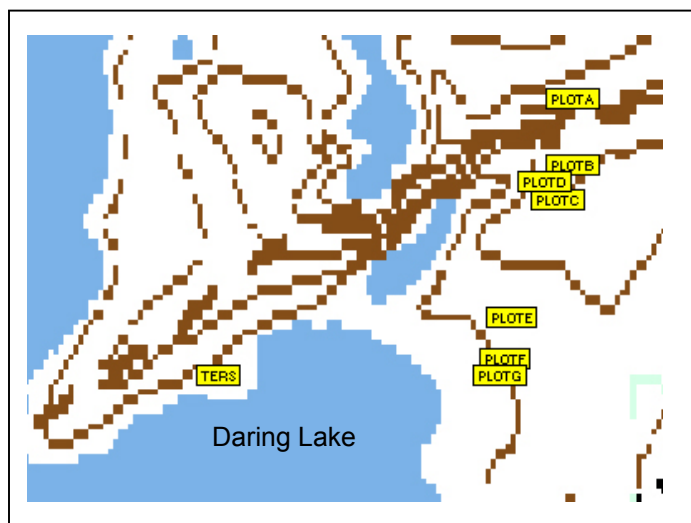
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INTRODUCTION

The vegetation monitoring program at Daring Lake is part of the International Tundra Experiment (ITEX). ITEX examines how tundra plants respond to climate. This is achieved through making observations of seasonal plant development, or phenology, taking measurements of plant growth and reproduction, as well as measuring climate. Simple experiments using open-topped chambers or mini-greenhouses, which warm the air and soil around the plants, can also be included. At the Tundra Ecosystem Research Station (TERS) at Daring Lake, we are monitoring eight different plant species, and have established open-topped chambers with three of the eight species.

During the summer, researchers and volunteers monitor the growth of tagged plants in each plot, and record the date on which different phenological events occur. Phenology is the timing of life cycle or developmental events (for example, the emergence of green leaves in the spring). The plant species are located in seven plots along the slope east of TERS (as shown in the figure below) and are as follows:

- Plot A = *Oxytropis nigrescens* (Locoweed)
- Plot B = *Ledum decumbens* (Labrador Tea), and *Vaccinium vitis-idaea* (Cranberry)
- Plot C = *Betula glandulosa* (Dwarf Birch)
- Plot D = *Salix* sp. (Willow)
- Plot E = *Saxifraga tricuspidata* (Prickly Saxifrage)
- Plot F = *Eriophorum vaginatum* (Cotton Grass)
- Plot G = *Carex aquatilis* (Water Sedge)



Plots B and F have four open-topped chambers (OTC's) surrounding them. Generally, there is one adjacent to each of the four sides of the plot. By monitoring the plants in these chambers we can predict how plants might respond to climate warming.

Many of these plants are small and close to the ground. The only way to observe the development of these plants is to get on the ground and get your face close to the plant! When you check the plants, have the datasheets with you so you can be certain of the particular event that you are looking for. Also it will be important to have an idea of the next few events that will be occurring soon, as some plants may be more advanced in their seasonal development than others. Also, events may not necessarily occur in the order they appear on the datasheet! While you are on the ground inspecting the plants be sure to pop your head up once in a while to watch for bears! You should be carrying appropriate bear deterrent equipment with you!

Dates of events are recorded in Julian days which is a numbering system that starts with January 1st as day 1 and numbers the days consecutively from 1 to 365. We use the day number in our statistical analyses because we can't use the month and day. There is a chart in the appendix of this manual that gives Julian days for leap and non-leap years. Quantitative measurements such as leaf length and plant diameter are taken at the same time every year, during the first week in August when the Tundra Science Camp is held. Students at the Science Camp can help with the measuring and learn about tundra plants at the same time!

There are approximately twenty marked plants in each plot and five in each chamber. Maps have been drawn showing where tagged plants can be found in each plot and chamber. They can be found in the appendix. If you do not have at least twenty or cannot find a tag (they occasionally get pulled up and chewed on by curious caribou and other creatures!) you will need to tag a new plant. The process for tagging new plants differs for each species. Details are given in the species specific descriptions below. Metal tags, wire and nails can all be found in a labeled box in the lab tent.

Remember it is important to take notes when you are out there! You can record them on the backs of the datasheets or in your field book. But be sure to transfer them later to datasheets so we have a record. If you are confused about what you are seeing, write it down. Things may become evident later on, or if not, you can ask the Program Co-coordinator in Yellowknife. Be sure to note when you see insects on the plants, eggs, obvious indications of animals having chewed on the plants, if the plant does not look healthy and if the plant does not progress through the typical phenological stages as listed. This information is valuable and will help us interpret the ITEX data.

You may have a laptop out at camp containing the spreadsheet for the ITEX data. If you are entering data into the spreadsheet just enter the numbers as you have recorded them on the paper datasheets. It will help if the plant identification numbers for each species are listed sequentially on the datasheets as this is how they are listed in the spreadsheet. Be sure to record numbers in the proper rows and columns (i.e. check the row and column headings every time) as additional columns are present in the spreadsheet that aren't present on the paper datasheets. These columns are usually for calculating means and other simple statistics from the data and are often done automatically in the file. These columns are highlighted in blue and should not be altered. Enter a "." for no data (i.e. if an event never occurred) and a "0" for cases where no buds, flowers or catkins were produced.

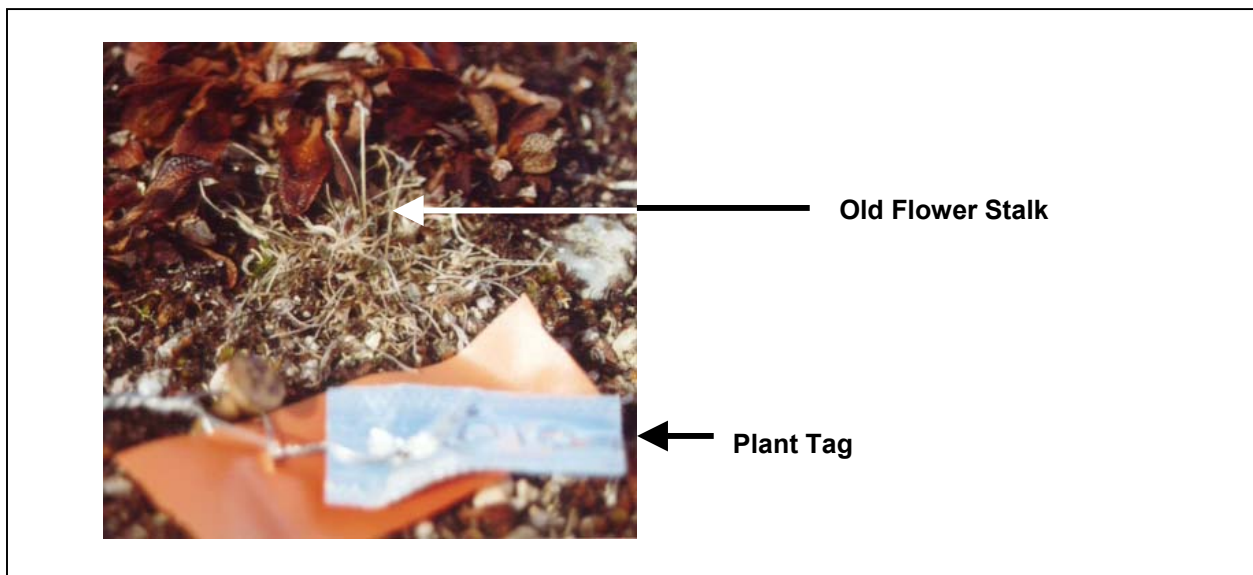
When recording data on the datasheets and spreadsheet, if you missed the day an event actually occurred but can see that it obviously happened between the time you last checked plants and the current day, enter the data in the following way. Write in the number of the last day that you checked the plants, followed by a ">" and then the day that you noticed the event had already happened. That will indicate that the event occurred some time between the last day the plant was checked and the first day that you recognized you missed the event. Please record on the datasheets all the days you were in camp and checked the plants.

The following manual will discuss the proper techniques for monitoring each of the species from Plot A (*Oxytropis*) to Plot G (*Carex*).

PLOT A: *OXYTROPIS NIGRESCENS*

Oxytropis nigrescens, a member of the legume or pea family, is a small dull green plant with an extensive root system. This plant can be difficult to locate at the beginning of the year, as only a small amount of dead plant material remains above ground over winter. Further, some of the marked plants are found within clumps of bearberry (*Arctostaphylos alpina* and *A. rubra*) or blueberry (*Vaccinium uliginosum*). Difficulty may also be encountered distinguishing between Sandwort, or Everlasting (pussytoes), and *Oxytropis* at the beginning of the season. You can familiarize yourself with these different species using the Daring Lake herbarium, or Vascular Plants of Continental Northwest Territories, Canada, by Porsild and Cody.

For our purposes, the best way to locate the plants is to look near the metal identification tags in Plot A! Each plant is found within 5cm of the tag. The dried flower stalks from the previous year are a good way to home in on the plant. However, sometimes nothing visible remains above ground. Don't worry, the green leaves will be fairly evident when they start appearing, you just have to be patient and look closely!



The flower buds and flowers are munched on by a variety of creatures (birds, ground squirrels, lemmings and caribou). To minimize losses, when the flower buds are visible, plants should be covered with a chicken wire "hat", nailed down in three places. This keeps it protected from harm (although in 2001, a caribou did remove a hat and ate one of the plants!). Hats are stored in the lab tent and can be placed over plants once buds become apparent. These seem to be the most desirable part to eat and therefore need most protection. The hats do somewhat obscure your view so wait until buds appear before you put them on.

Missing tags

If you notice that some tags are missing, try to locate the plant with the missing tag on the map. It is best to retag the same plant with the same number if at all possible. Check the map in the appendix of this plot, if you cannot locate the same plant you will need to tag a new one. To tag new *Oxytropis* plants you will need to wait until enough green growth has come up for you to identify the plants. You can choose any untagged plant within the plot. Give the new plant a unique number following the same scheme as the others. These plants are labeled consecutively from O-1 onwards (with the odd numbers from past years). Choose the next number in the series, say O-12. Do not use an old number from a lost plant. Metal tags and nails can be found in the lab tent in a labeled bin. Be sure to mark on the map where the newly marked plant is located.

P1: Snow-Free Date

Because of high winds over the winter, not much snow accumulates on the top of the eskers. Therefore, this plot will be snow-free quite early in the spring and typically before melting actually occurs. **To record snow-free date in Plot A look at each tag and write down the date when a 20 cm area surrounding the tag is snow-free.**

P2a: First Green Leaf



P2a: First green leaf

As mentioned above, there is not much plant material that remains above ground over the winter. However, there may be some dried flower stalks or leaves from the previous year's growth. From within the centre of dried-up structures from last year (if there is any at all), new green leaves will emerge. They will appear light grey-green and slightly fuzzy. **Record P2a as soon as you can see faint trace of green in the brown leaves from last year.** In 2000 and 2001, this occurred around the same time as the other plots were becoming snow-free. The faint green will become lush quite quickly, and flower buds will soon appear.

P2b: First Flower Bud Visible

The flower buds are little fuzzy green ovals with brown fringes on the end and are quite large in comparison to the plant. They will appear at the base of the leaves and can be partially obscured when they first appear, so look carefully. **Record P2b as soon as you notice the first flower bud.** Not all of the plants will flower, but continue checking plants occasionally until buds start to open to ensure you don't miss the appearance of any late buds.



Oxytropis flower bud

Q1: Number of Buds

The number of buds should be noted as soon as they start appearing (in case an animal decides to dine on them!!). **Keep an on-going record of the number of buds, and when you are satisfied that no more will appear, record this as Q1.** Be sure to record the date on the datasheet when the final count was recorded (at top of Q1 column).

P3: First Flower Open

The flower will start to push through the green bud case, first as a yellowish-purple mass, then it will elongate into a purple protrusion and finally unfurl into the *Oxytropis* flower. It only takes a few days for the bud to open into a flower, so once things start happening, the plants should be monitored daily. **Record P3 when the flower is fully open.**



P4: First Petal Dropped, P5: Last Petal Dropped

The petals will wilt and brown quite quickly, but some may cling on tenaciously. Don't touch the plants, but just watch carefully for when the petals have finally fallen off the bud. **Record P4 when the first petal of any of the flowers on that plant has fallen off. Record P5 when the last petal of all the flowers on that plant has fallen off.**

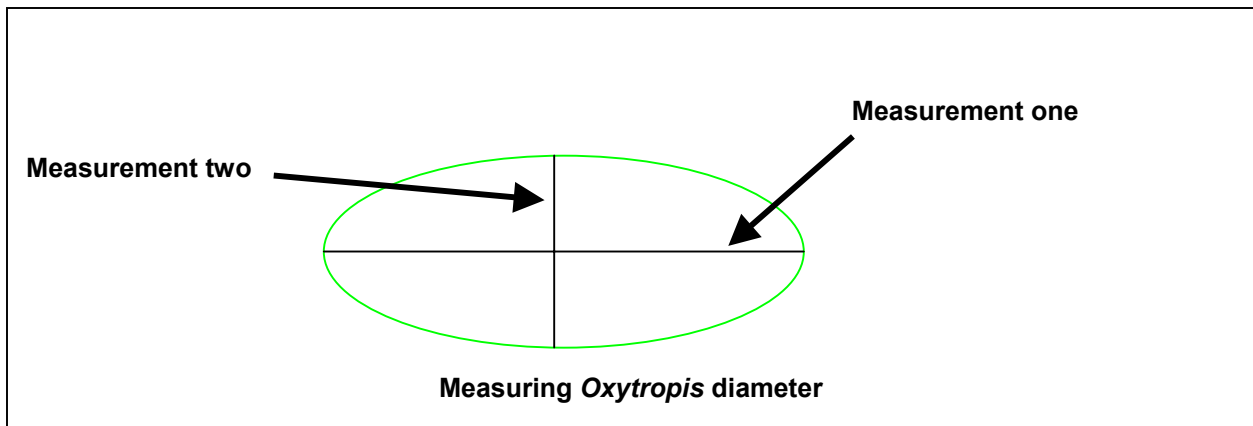
P6: First Seeds Dropped

The base of the flower will develop into a structure that looks like a pea pod (*Oxytropis* is in the Pea family after all). The green sides of the pod will dry out into paper-like pods and will split down the middle and you will see dark seeds inside. We assume that when the pod splits open, seeds will drop. **Record P6 when the pod has split open.**



Q2: Diameter of Plant

The diameter of the plant (Q2) is an average of two measurements that bisect the plant and stretch from leaf tip to opposite leaf tip. If the plant was oblong, measurement should be taken of the length and width. **Try to take a measurement of the longest diameter and the shortest to get a good estimate of average diameter. This should be measured during the first week in August.** Be sure to record the date that this measurement was taken (at the top of the Q2 column on the datasheet).

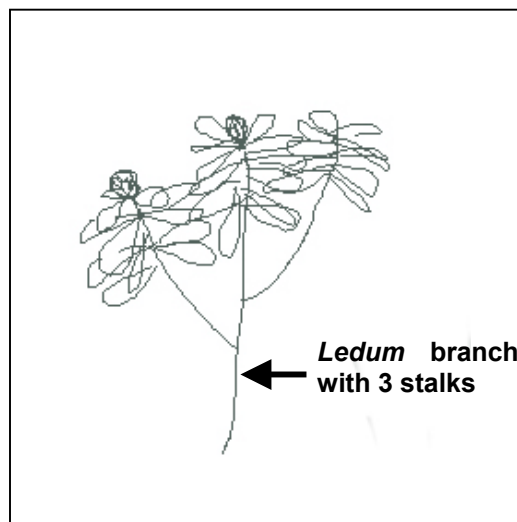


PLOT B: *LEDUM DECUMBENS*

Two species are monitored in Plot B, Labrador tea (*Ledum decumbens*) and Cranberry (*Vaccinium vitis-idaea*). You will notice that Plot B also has four chambers or greenhouses surrounding it, one adjacent to each of the four sides of the plot. You will be monitoring plants both in the plot and in the chambers.

Labrador Tea is a low shrub, seldom exceeding 20cm in height. It has narrow, alternate leaves that are rolled under at the margins and have a rusty fuzz underneath. Labrador tea is an evergreen so does not shed its leaves in the fall.

Labrador tea generally has many branches extending from an extensive underground root system. In this plot, there are remnants of old cotton grass tussocks on which Labrador tea grows. Tussocks are permanently tagged and from year to year we mark specific branches of the plant to monitor. The theory is that all of the branches extending out from an old tussock are part of the same individual (i.e. same root system). Therefore, we are monitoring the same individual each year, even if we look at different branches. The first branch to show a flower bud is chosen to be monitored for that season. Many *Ledum* branches have more than one stalk, and you should monitor all of the stalks on that branch. A branch should be a single branch coming out of the ground, where as stalks are attached to the main branch above the ground (see adjacent figure).



This plot has suffered damage from people walking and sitting in it as they do the vegetation monitoring. Please walk lightly and if at all possible keep your feet and body out of the plot (you will only be able to do this for plants on the edge of the plot). For the chambers, you will have to stay out but lean into them to observe the plants.

Missing tags

If you can't find one of the marked tussocks and think that the tag is missing, check the map in the appendix. You should be able to distinguish the tussock and can simply replace the tag using the same number. If you can't figure out which tussock has lost its tag you can tag a new one giving it a new number. If it was B10 that is missing, label the new tussock B10a trying to place it in the same general area as B10. Tags and flagging tape can be found in a labeled bin in the lab tent.

P1: Snow-free Date

Snow in this plot may be relatively deep as the winter winds blow over the top of the esker and deposit snow here. As it melts you will notice tagged tussocks. **Record P1 as soon as an approximately 30 cm radius around the tag is free of snow.**

P2: Flower Buds Visible

Labrador tea produces spherical buds at the tips of their branches. These buds can either be leaf buds or flower buds, and are difficult to distinguish when they are small. The flower buds swell into a spherical shape and are slightly whitish in colour, whereas leaf buds elongate and develop a rusty fuzz on the outside of the bud. In general, the flower buds will appear before the leaf buds.



Check for flower buds as soon as the snow is free as buds are formed in the fall and over-winter. They may not be visible on the snow-free date, however. You will need to keep checking every day until a flower bud can be distinguished. Check within a 15 to 20cm radius of the tagged tussock (this is approximate). Mark the first branch you find with a flower bud on it (tie a piece of flagging around the base of the branch), and monitor this branch only for the rest of the season (even if it is not the first branch to proceed through the other phenological stages). **Record P2 as soon as you can distinguish a flower bud on any branch of the tagged tussock.** If you are unsure if the bud is a flower bud or a leaf bud, wait a few more days. If you are still uncertain, mark down the date and monitor two or three branches until you are sure that one of these in fact has a flower bud (i.e. it swells and become whitish). When you are confident that one of the branches has a flower bud you can stop watching the others.

P3: First Flower Open

As the flower buds mature, they will swell further and the scales surrounding the bud will split open to reveal a lumpy white surface. These lumps represent individual flower buds, which will further separate and spread out on stalks before opening up into flowers.



Record P3 as soon as you can distinguish space between the petals of the first flower to open. Only look at the branch that you tagged, and record the date of the first flower to open on any of the stalks on that branch (see above for an explanation of stalks versus branches).

Q1: Number of Flowering Stalks

A Labrador tea branch typically has one, two or three flowering stalks. It can have three stalks of which only one or two is flowering. Often, as well as having a stalk that is flowering this year, a branch will have stalks that have flowered in previous years. In this case, you will be able to see the remnants of the previous year's fruits. **The number of flowering stalks can be counted as soon as the first flower opens.** Be sure to count only the number of stalks that are flowering (or have swelled flower buds) this year. Record the date that you recorded this count at the top of the Q1 column on the datasheet.

Q2: Number of Flowers per Stalk

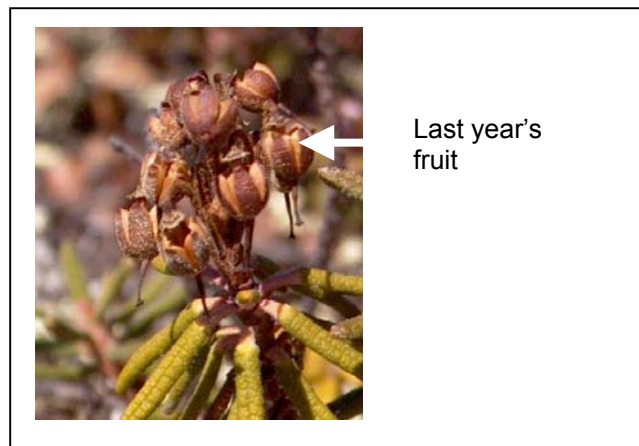
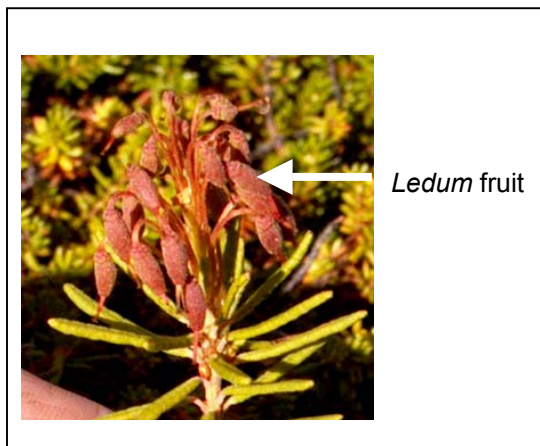
The number of flowers per stalk ranges anywhere from 1 to 18 flowers (perhaps more). These flowers can open at very staggered intervals or all at once. This makes the flowers very difficult to count, as they may not all be open at the same time, or if they are, they are so crowded that individual flowers are difficult to count. To facilitate this count, you may wish to make a preliminary count when you can distinguish the individual flower buds (when bud starts to separate), and re-count when flowers have fully opened, keeping an eye out for very late-opening flowers. **Flowers per stalk can be counted as soon as most of the flowers have opened.** Be sure to count all the flowers on each stalk and enter them on the data sheet separately so that an average number per stalk can be calculated.

P4: First Flower Shed and P5: Last Flower Shed

After opening, a flower will remain in full bloom for roughly a week. It will then start to wilt and ultimately fall off. In general, the entire flower will fall off at once. Just as flowers on a single branch opened at various times, flowers will be shed at different times. First flower shed is when one entire flower drops. **Record P4 as soon as the first flower on any stalk of the tagged branch has fallen off.** This can be hard to spot if there are many flowers in the cluster. The easiest way is to keep an eye out for an empty flower stalk. Try not to touch the branch as you examine it, as disturbing the flowers can cause them to prematurely fall off. **Record P5 when the last flower is shed from all of the stalks.**

P6: First Fruit Visible

A few days after the flower drops, the fruit will begin to become obvious. The base of the pistil above the attachment point of the petals will swell into the fruit of *Ledum*. It will be a round, greenish-brown swelling that turns brown as the season progresses. **Record P6 as soon as there is an obvious swelling where a flower had been.** Be sure to wait for the swelling, as some flowers will not be fertilized and will not form fruit.

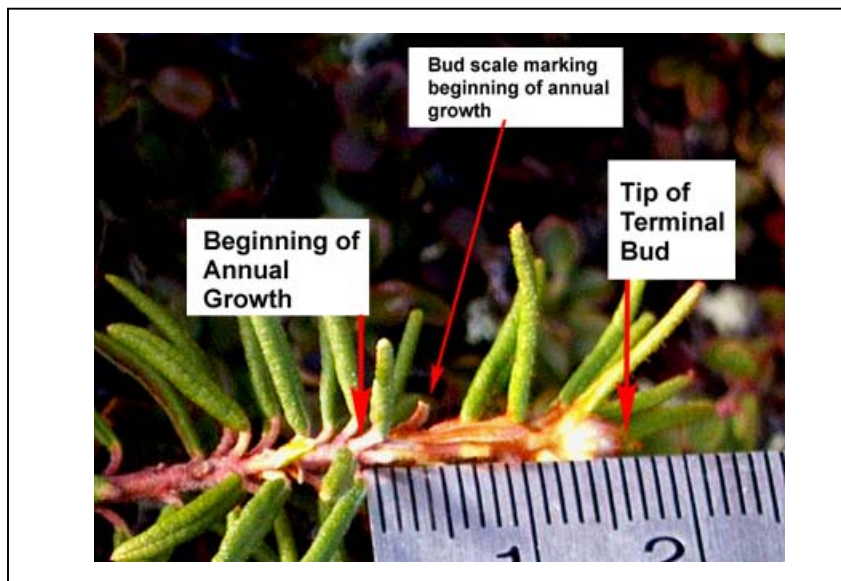


Q3: Number of Fruit per Stalk

As the fruits mature they will become oblong, brown little “nutlets” on the end of the flower stalks. Continue to watch these plants after the flowers drop to observe the development of the fruits. **When you no longer see any more fruits developing, record Q3.** It is important to wait a while for the fruit to develop after the flowers drop for two reasons. First, fruit will become larger and easier to count. And secondly, not all flowers will produce fruit so you want to know for sure that all the fruit that is going to develop, has done so.

Q4: *Ledum* Growth Measure (3 longest)

The amount that a plant grows in a year is called the annual growth increment. We measure the growth increment as an indication of how conducive environmental conditions are to supporting growth in a particular year. *Ledum* grows from the tip of the stalk and the new growth produced this year will be obviously lighter green and “fresher” looking. There will be a noticeable color change from old stalk to new stalk. Typically, old growth is a dusty pink colour, where as new growth is more orangey. You will also be able to see bud scales (brown, triangular shaped) around the stalk where growth started. **Measure the growth of *Ledum* during the first week of August. Measure from the remains of the bud scale on the stalk to the tip of the stalk.**



Take this measurement on three branches on the tussock with the longest growth increments. Do not measure new branches that have only one year's growth. If you are uncertain about where this year's growth begins, choose a different branch. Record the date that you took these measurements at the top of the Q4 column on the datasheet.

PLOT B: VACCINIUM VITIS-IDAEA

Cranberry (sometimes called lingonberry) is a ground-hugging plant with shiny green oval leaves. Its evergreen leaves are slightly curled under at the edges. Unlike Labrador tea, Cranberry generally has single-stalked branches emerging from the ground. The Cranberry plant produces small, bell-shaped flowers that are white to pink. The shape of the flowers helps trap warm air so that ovules are kept at a temperature suitable for development.

As with Labrador tea, we assume that all of the cranberry plants on a tussock are part of the same individual (i.e. same root system). Cranberry is monitored in the same plot as Labrador tea and the same process of marking new branches is taken. Tussocks are permanently labeled. A specific cranberry plant must be tagged once flower buds appear and monitored for the rest of the season. As with Labrador tea you will be monitoring plants in the plot and in the chambers.

Missing tags

For details on retagging tussocks in the event of one missing check the Missing Tags section under the *Ledum* heading.

P1: Snow-free

This will be the same for Cranberry as for Labrador tea since they are in the same plot and use the same marked tussocks. Refer to the discussion for P1, Labrador tea for details.

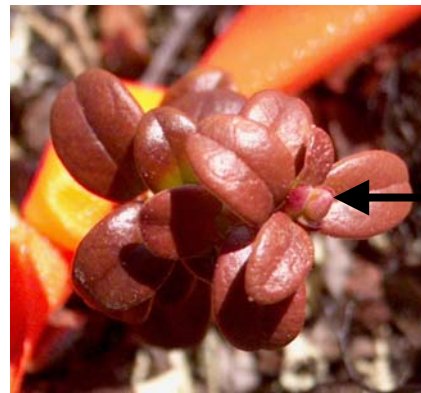
P2: Flower Buds Visible

Cranberry, like many arctic flowering plants, produces flower buds the year prior to the current season. Therefore, as soon as the snow melts you may notice flower buds right away. They will look red or pinkish and will be evident at the end of the shoot. It may be hard to distinguish between a flower bud and a leaf bud, but it will become evident with time.

Look for buds within a 15 to 20cm radius of the tag on the tussock. The buds appear anywhere from 2 to 10 days after the snow-free date, so begin keeping an eye out for buds as soon as the snow is gone. ***When one shoot on the marked tussock shows a bud that is noticeably pink, record P2.*** If you have doubts, check other plants in the area that may be more advanced (top of esker, under birch bushes). This will help you to become familiar with the stage you are looking for before it occurs in the plot. Also, you may want to record the date but tag and watch a few plants until you are certain that what you are looking at are flower buds. At this point you can remove any excess markers.

You will need to tag the Cranberry shoot on the marked tussock once you have recorded P2. A piece of flagging tape that has been torn in half along its length works well. Just tie it around the base of the shoot. But not too tight! Monitor only this tagged shoot for the rest of the

summer even if it doesn't seem representative of the rest of the plants on the tussock (you will want to note this on the datasheet, however).



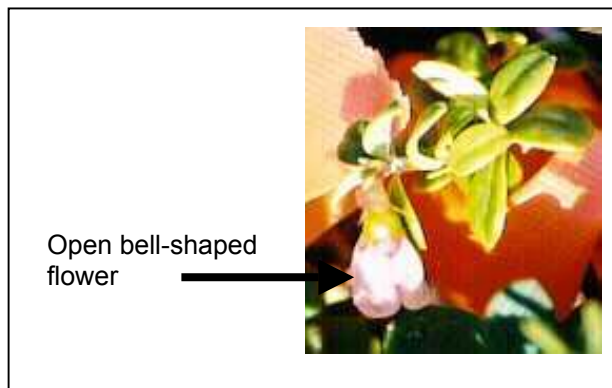
Cranberry flower bud



Leaf bud that has opened

P3: First Flower Open

Cranberry flowers typically open soon after Labrador tea flowers open. They are delicate bell-shaped flowers that hang down from the tip of the shoot. It can be difficult to see when the buds are actually open because they are so close to the ground. You may have to carefully tilt the buds up towards you to determine if there is any open space between the petals at the tip of the bell. **Record P3 when you can see space between petals of any flower on the tagged plant.**



Q1: Number of Flowers

Cranberry will produce anywhere from one to six flowers per shoot. They will open at slightly different times. Some may have dropped their petals before the last flower opens, so it is best to keep an ongoing record of number of flowers as they open. **Record Q1 as soon as all of the flowers have opened (keeping a running total as they open, if necessary).** Another benefit of keeping a running total of flowers is that they may get grazed by little critters. In that case, we still want to know how many there were before they were eaten!

P4: First Flower Shed and P5: Last Flower Shed

After opening, a flower will remain in full bloom for roughly a week. It will then start to wilt and ultimately fall off, although some flowers may remain attached for some time after wilting. The petals of the Cranberry flower are fused so the entire flower is shed at once. Flowers, however, will not be shed all at once but will be dropped over a number of days. **Record P4 when the first entire flower drops off the marked shoot. Record P5 when the last flower drops off the marked shoot.** Try not to touch the branch as you examine it, as disturbing the flowers can cause them to prematurely fall off.

P6: First Fruit Visible

Fruit first becomes visible as small 2mm berries about 7 – 14 days after flowers open. They are green but will turn red as the season progresses. **Record P6 as soon as there is a noticeable swelling where the flower was dropped.** As the fruit swelling occurs slowly and can occur before the petals are shed, it is difficult to exactly determine when the fruit is “visible”. Generally, once the sides of the base are curved outwards or slightly rounded, record this event. It is important to wait for the swelling, as some flowers will not be fertilized and will not form fruit.

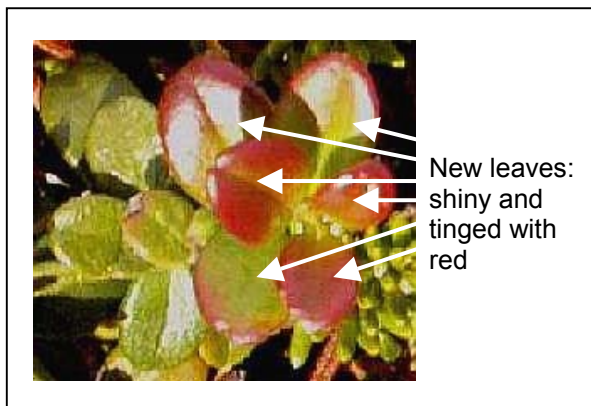


Q2: Number of Fruit

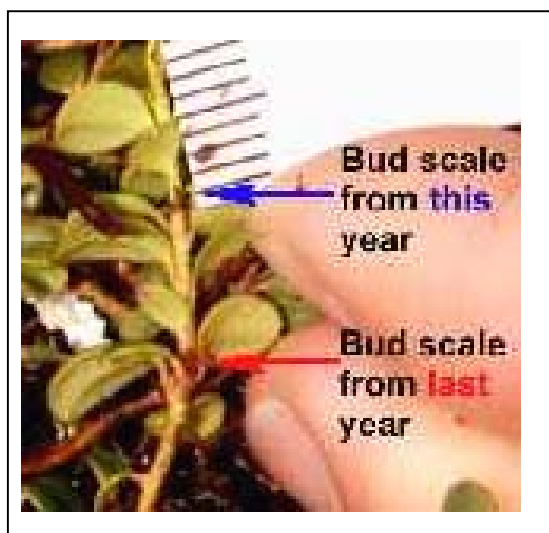
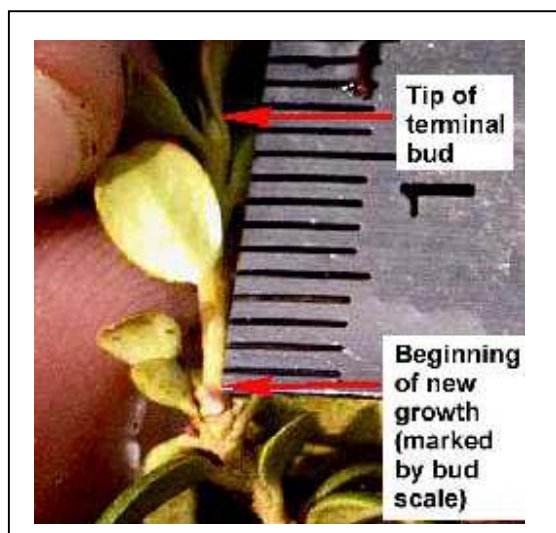
The number of fruit on the tagged shoot can be recorded after all flowers have dropped and fruit begins to turn red. The number of fruit can be compared to the number of flowers to give us a measure of reproductive success (how well the plant did in producing seeds compared to the amount of investment made in producing flowers). Record the date of this count at the top of the data column on the datasheet.

Q3: *Vaccinium* Growth Measure (3 longest)

Cranberry shoots will produce new growth that has light green leaves with reddish tips. The amount of new growth may vary from 0.5cm to 2.5cm. New growth can be distinguished from old by the remains of the bud scales on the shoot (where the growth started from last year's bud). The new growth (growth increment) is measured from the remnants of the bud scale to the terminal bud (not the tip of the leaves).



By looking at the stem, you can generally see a colour difference in this year's growth, but the best indicator is the presence of bud scales. Make sure you are measuring only this year's growth as bud scales from previous years can still be present as well.



Take this measurement on three branches with the longest growth increments within 30cm of the tag on the tussock. This measurement should be during the first week of August. Record the date of measurement on the top of the data column on the datasheet. Do not measure new branches that have only one year's growth. If you are uncertain about where this year's growth begins, choose a different branch.

PLOT C: *BETULA GLANDULOSA*

Dwarf birch, as the name implies, is a low shrub whose young twigs are densely covered with resinous wart-like glands. Leaves are round and coarsely-toothed. In this region, Dwarf birch typically grows to 50 or 60cm in height. However, it may grow quite tall (1 metre) in areas that accumulate snow (in the lee of eskers, rocky outcrops or in protected valleys) as the snow protects the plant from wind damage in the winter. The “flowers” of birch are borne in catkins (simply a collection of flowers) but do not look at all like flowers; they are oblong structures approximately 1 to 1.5cm in length. Catkins are familiar as “pussy willows” on other trees but on birch they look different. Male catkins are oblong, brown-coloured structures that produce pollen in the spring. Female catkins emerge as green, pinecone-like structures that produce the ovules that will give rise to seeds. On birch, male and female catkins will appear on the same branch.

One branch on each bush is monitored rather than the entire plant. This makes it easier when we are counting catkins, although we can have upwards of 70 or 80 catkins on a branch! For an indication of when to start looking for the various phenological stages, you may want to look at birch located near the shore of the lake. These will begin to develop earlier than the birch in the plots and will therefore give you warning of when to start looking for the various events in the plot.

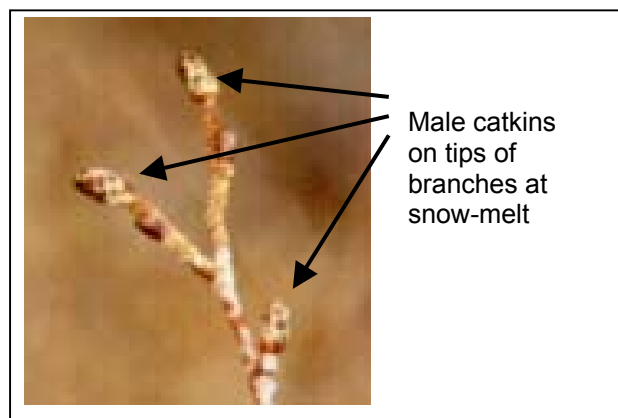
Missing tags

If the monitored branch appears to be dead or if you have located the bush but cannot find the tagged branch, choose an adjacent branch on the same plant and give it the same number with an “a” at the end. Please note on the datasheet what has occurred and how you marked a new branch. If you have referred to the map and still cannot locate a tagged bush, choose a neighbouring bush to monitor, select a single branch and assign it a new number. Again, please note on the datasheet what you did. Metal tags can be found in the lab tent in a labeled box.

P1: Snow-free

This plot may accumulate snow similar to Plot B as it is in the lee of the esker and the strong North winds deposit snow here. **Record P1 when there is no snow under the marked bush.**

P3a: First male catkins visible



Male catkins will likely be present at snow melt as they are produced in the late summer of the previous year. They will be obvious at the ends of branches as brown, oblong structures similar in appearance to a tiny pinecone. **Record the date you first see male catkins.**

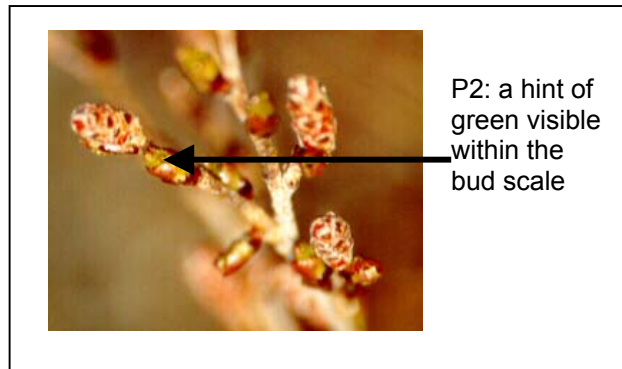
Q1: Number of male Catkins

Count the catkins every few days for a week or so to ensure that you have counted them all. Keep a running total of male catkins as they will decrease as they are eaten by songbirds and other critters. Also, once the pollen is dispersed they become dry and blow away. Keep notes of your tallies and the date they were taken. **Record Q1 as the highest number of catkins you counted and record the date you counted it.** Be sure to note if you think someone has been munching on them!

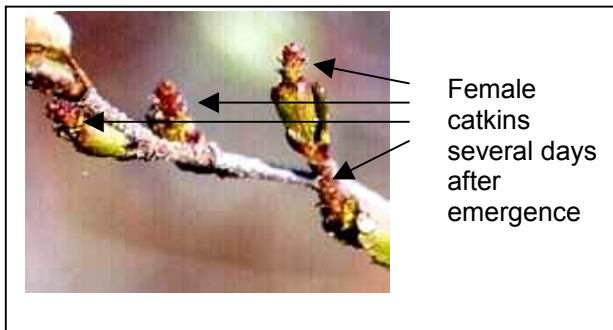
Watch closely for pollen shed (P4b). It will occur not long after the leaf buds burst and the first female catkins emerge.

P2: First Leaf Bud Burst

Birch leaf buds are formed the previous year and are covered with brown scales. Watch for the bud scales to open slightly and the green leaves to protrude. They will be slightly sticky as they open. **First bud burst (P2) can be recorded when the first bit of green leaf can be seen protruding from the scales.**



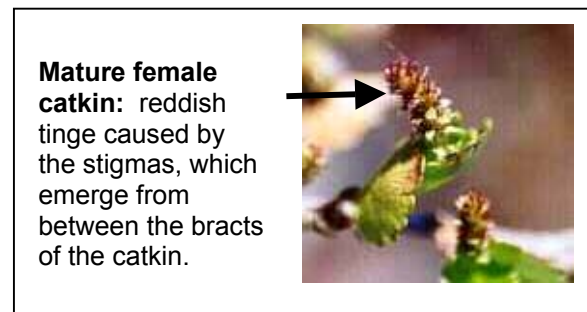
P3b: First Female Catkins Visible



The female catkins will first appear like a small, green “cone” and will come from within a leaf bud encased in surrounding leaves. Female catkins are small, soft and greenish. **Record P3 when the first female catkin becomes visible from within an opening leaf bud.**

P4a: First Stigmas Visible

The purplish-red-coloured female stigmas emerge from between the bracts (or “scales”) of the catkin and appear a few days after the female catkin becomes visible. The catkins will enlarge and then the stigmas will elongate and make them look slightly fuzzy. **When you see the red stigmas sticking out from each “scale” of the “cone”, record P4a.** This usually occurs after the pollen has been released in the male catkin.

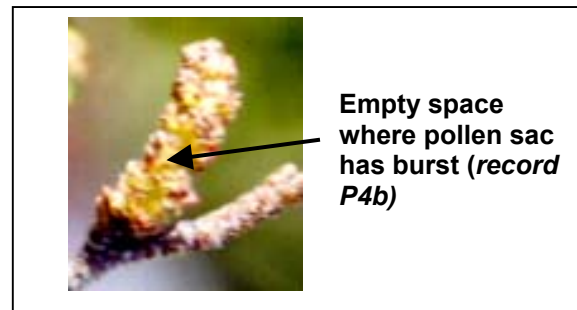
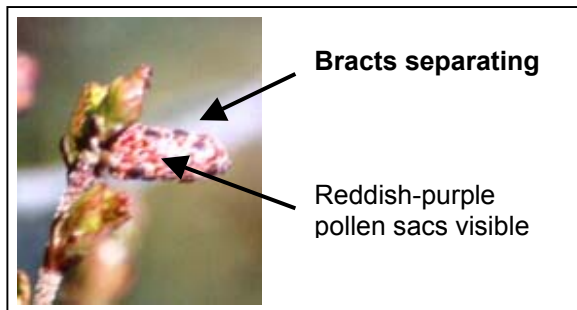


Q2: Number of Female Catkins

Count the number of female catkins once stigmas are visible and then every few days after. Female catkins will continue to emerge over a week or two. Counting them every few days will ensure that you catch any that are late to emerge. **Record Q2 as the largest number of female catkins you counted once you are sure that no more are being produced. Record the date of the largest number at the top of the Q2 column on the datasheet.**

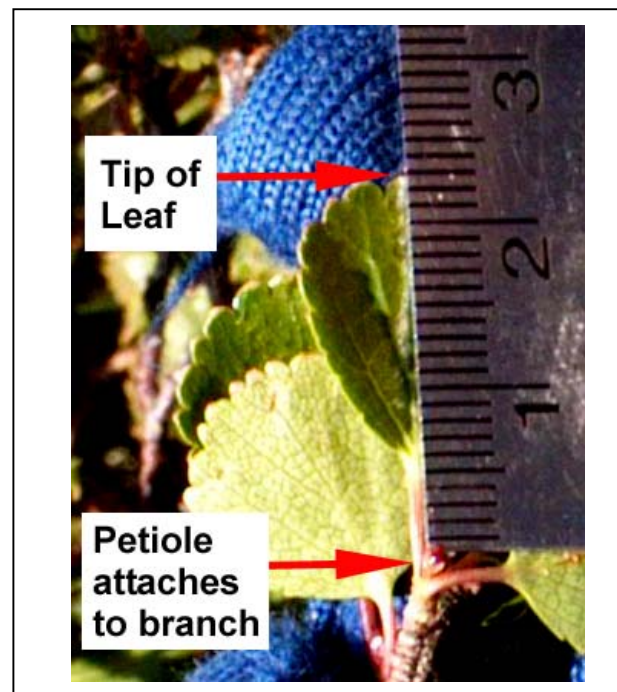
P4b: First Pollen Shed

The male catkins start off small and tight but loosen and pull apart to release the pollen. When the catkin “opens” the reddish pollen sacs become visible. Pollen is shed when the sacs open and a yellow powder is released. You will notice puffs of powdery pollen when the branch is moved as you check it and also as you walk through adjacent bushes. ***Pollen shed (P4b) can be recorded when yellow pollen is visible in the “open” catkin.***



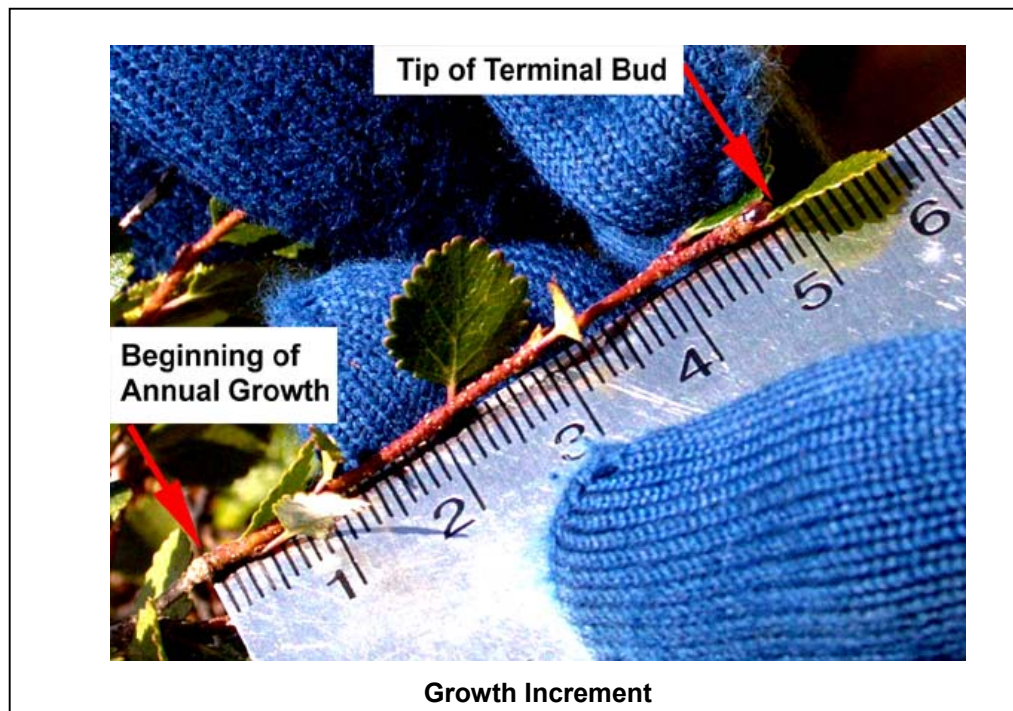
Q3: Leaf Length (3 longest)

Leaf size reflects the environmental conditions of the current year and provides a good measure of how well the plant is doing. In “good” years leaves will be larger whereas in “bad” years they will be smaller. Measurements are typically done with calipers (although a steel ruler will do in a pinch). Measurements should be done at the end of the season (end of July / beginning of August). Be sure to record the date on which you take both this and the subsequent quantitative measurements (Q3 and Q4). Choose 3 of the longest leaves that you can find on the tagged branch. Measure their length from the base of the petiole (the stem of the leaf, which attaches to the branch) to the tip of the leaf. Place the ruler on the inside of the leaf so that it can rest in the notch created by the petiole and the branch. ***Measure the 3 largest leaves on the tagged branch at the end of July or early August. Measure from the tip of the green leaf to the end of the petiole (where the leaf attaches to the branch).***



Q4: Birch Growth Measure (3 largest)

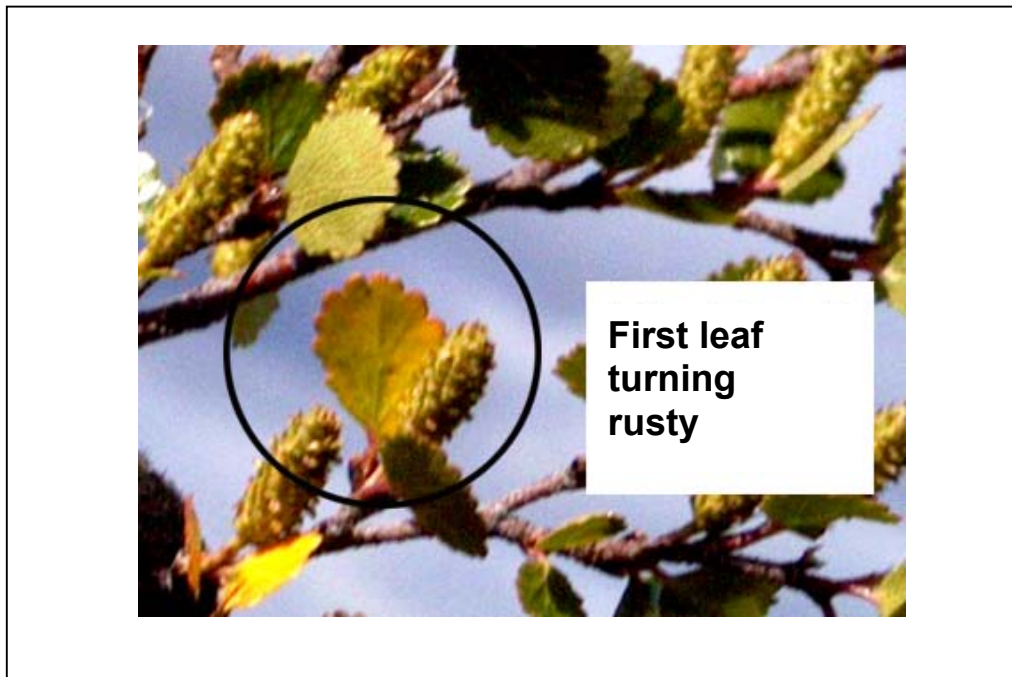
The birch branch will grow in length from all the tips that come off the main branch. Some tips will grow more than others. It will appear reddish in comparison to the old growth, usually extending from a small bulge in the branch. There is an obvious colour difference between new and old growth, but this colour varies between individuals. In general, the bark of old growth is a dusty pink colour with white glands, whereas the bark of new growth is more brownish-red with green glands and has a “fresh” look to it. When measuring the growth increment (the amount of new growth) on the tagged branch, measure what appear to be the three largest increments. **Measure from where growth started (the bulge in the branch) to the tip of the terminal bud on the branch (a leaf may extend beyond this).** Take measurements in the first week of August, during Science Camp.



If you cannot find the growth increment on a branch, it is possible that the branch has not grown. Record the fact that no growth increment could be discerned.

P5a: First Green Leaf Turning Rusty

Birch is a deciduous bush meaning that it sheds its leaves every fall and grows new ones in the spring. Before shedding leaves, the plant will conserve nutrients by moving them from the leaves into other parts of the plant for storage. Birch leaves turn a beautiful red in the fall as chlorophyll and plant nutrients are translocated to other organs in preparation for winter. **First leaf turning rusty (P5a) can be recorded when one leaf on the branch begins to turn yellow or rusty (as opposed to turning brown from predacious insects).**



P5: Last Green Leaf Turning Rusty

Generally there is no one in the field to record the last few stages of development (P5, P6, P7). These usually occur in late August to mid-September. If you happen to be in camp at this time this information would be useful to collect. **Record P5 when the last green leaf begins to turn red or orange.**

P6: First Abscission of Leaves and P7: All Leaves Shed

After most of the nutrients in the leaves have been moved to storage organs in the plant, the leaves will dry up and fall off. **Record P6 when the first leaf falls off the branch. Record P7 when the last leaf falls off the branch.**

PLOT D: SALIX SP.

Willows are important sources of food for many animals. Caribou, musk ox, ptarmigan and lemmings all browse on the branches, leaves or catkins. There are 42 species of willow in the Northwest Territories. They are often difficult to identify because they can hybridize (cross breeding between two separate species). You will notice, as a result, that we have not identified our willows to the species level.

Like birch, we monitor only one branch on each tagged willow “bush”. The willow bushes in our plot are small, often twisted, prostrate plants (calling them bushes might be a stretch!!). Each plant is either male or female meaning that they either produce male catkins (pollen producers) or female catkins (seed producers). The catkins ARE the pussy willows. The sex of our plants is noted on the datasheets. It will be important to know the sex of the plant you are watching, as in some cases the event you are watching for depends on the sex.

Missing tags

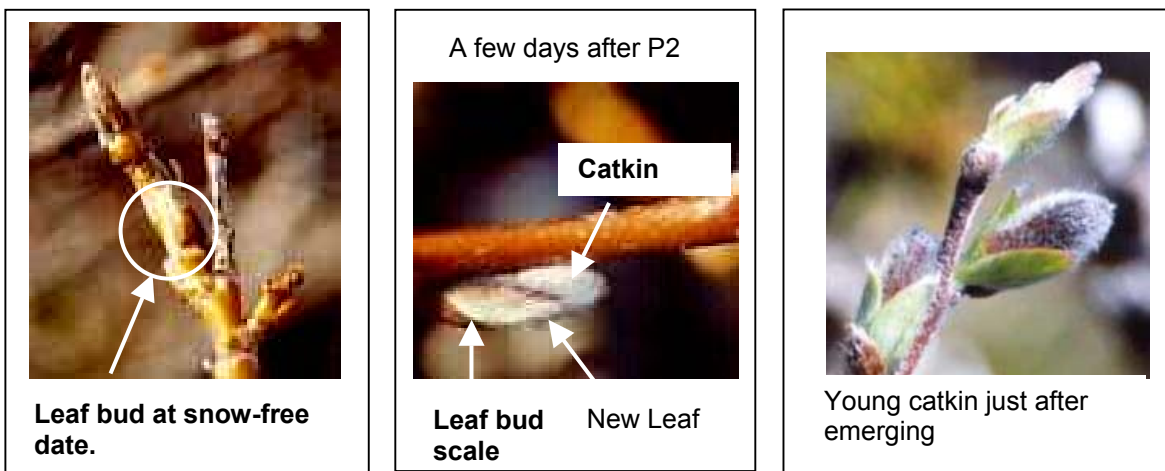
If you are unable to locate a tag and believe it is missing (after you have checked the map and the plot a few times) or if a tagged branch is dead, you will need to tag a new branch. Make sure that you tag a new branch **on the same bush**. Use the map to locate the bush (if tag is missing) and choose any branch on that bush. Give it the same number with an “a” (e.g. 101a) and make note on the datasheet what you have done. If you cannot find the same bush select a new bush, tag one of the branches on the bush and give it an entirely new number in the same series (e.g. 122). Metal tags can be found in the lab tent in a labeled box.

P1: Snow-free

This area does not accumulate much snow as a result the willows are small and twisted because of wind and snow abrasion. **Record P1 when there is no snow beneath the tagged bush.**

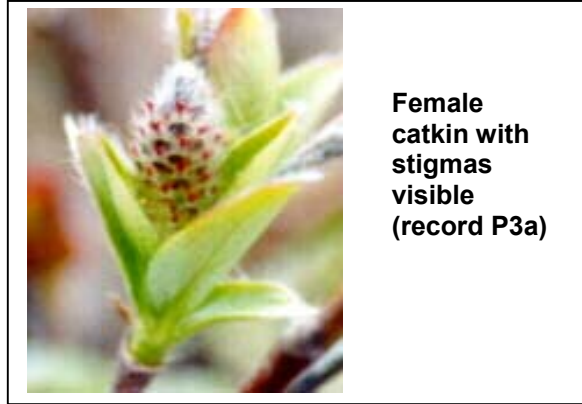
P2: First Leaf Bud Burst

The leaves on this species of willow will burst out of buds that have over wintered. The buds appear as brown pointed structures and the leaves will look a fuzzy grey-green as the leaves push out. **Record P2 when you can see a green/grey leaf protrude from any of the bud scales on the tagged branch.** The catkins arise from this same bud after the leaves have expanded slightly. When young, both the female and male catkins look fuzzy and grey.



P3a: First Stigmas Visible

You will need only to watch the female bushes for this stage. The stigma is the part of the female catkin that receives the male pollen. The stigma is at the tip of the pistil which encloses the ovule. The female catkin is a collection of these pistils (see picture of mature female catkin, Q5, below). Female catkins emerge as gray and fuzzy. Stigmas will become visible after the female catkin emerges and will be an obvious red color. **Record P3a as soon as you notice red at the tips of the female catkin.**



P3b: First Pollen Shed

You will need only to watch the male bushes for this stage. The male catkin will emerge as a typical grey, fluffy pussy willow with an underlying hint of red. The pollen is shed from the ends of the stamens which will stick out from the fuzz a few days after the catkins emerge. Stamens will be red at the tips at first (these are the pollen sacs) and then turn yellow as pollen is released. **Record P3b when you see the stamens turn yellow.**

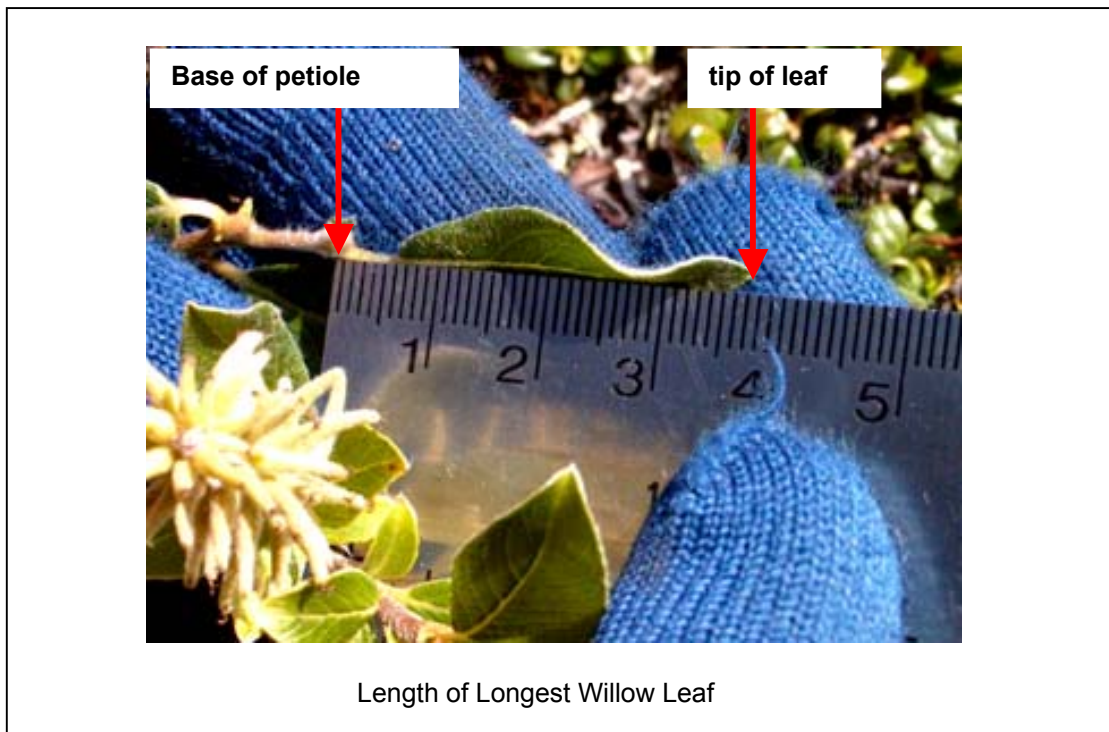


Q1: Total Number of Catkins

All catkins on a branch will emerge within a few days of each other. Count the number of catkins as they appear. Most catkins should be visible during the P3 stages, so this is a good time to do an overall count. However, it is good to do a preliminary count previous to this in case any drop off before this date. Similarly, make a point of examining the plants after this stage in case any catkins develop very late. **Record the total number of catkins that were produced on each tagged branch after you have recorded P3a and P3b. Record the date of each count.**

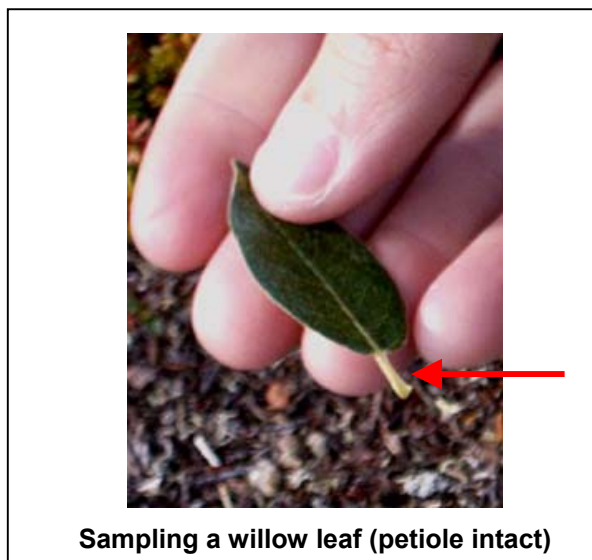
Q2: Length of Longest Leaf (mm)

Similar to the leaf measurements in birch, we measure willow leaves from the base of the petiole to the leaf tip. For willow, however, we only measure the longest leaf and not the three longest. **Measure the length of the longest leaf on each tagged branch from the base of the petiole (stem that attaches the leaf to the branch) to the tip of the leaf.** This measurement should be done during the first week of August (record the date).



Q3: Weight of Largest Leaf (mg)

Weight of the largest leaf is another measure of plant growth. The weight (or mass of the leaf) can be plotted against the length to establish a relationship between length and mass. We can then examine how this relationship changes with different environmental conditions from year to year. **After you measure the length of the longest leaf, pick it and place it in a labeled paper bag (plant id #, date, what it is).** Paper sampling bags can be found in the lab tent in a blue bin labeled “plant press/sampling equipment”. Leaves will be dried and weighed after two months. Make sure that the petiole remains intact when you pick the leaf. We want the leaf and the petiole together.



Q4: Total Number of Mature Female Catkins

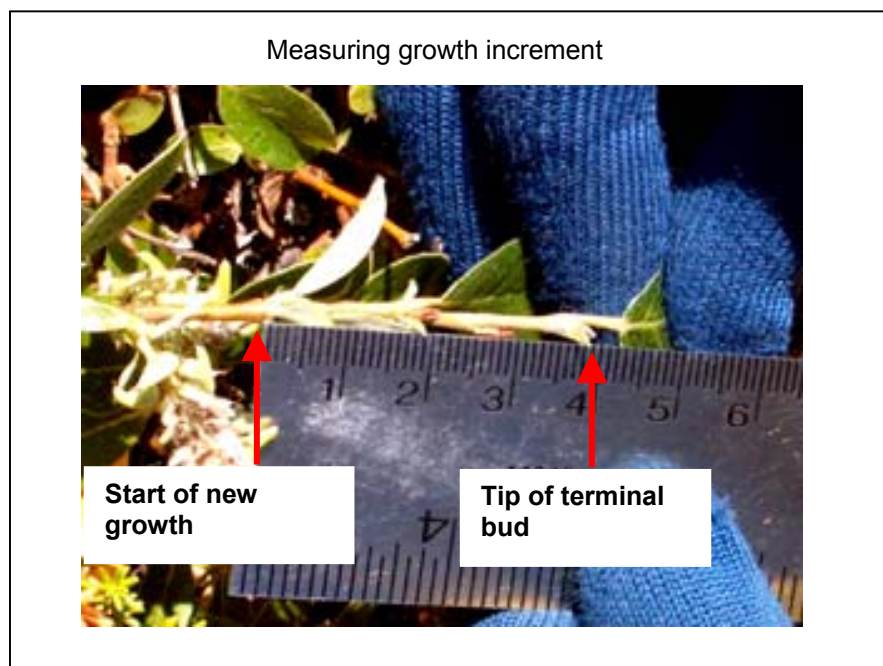
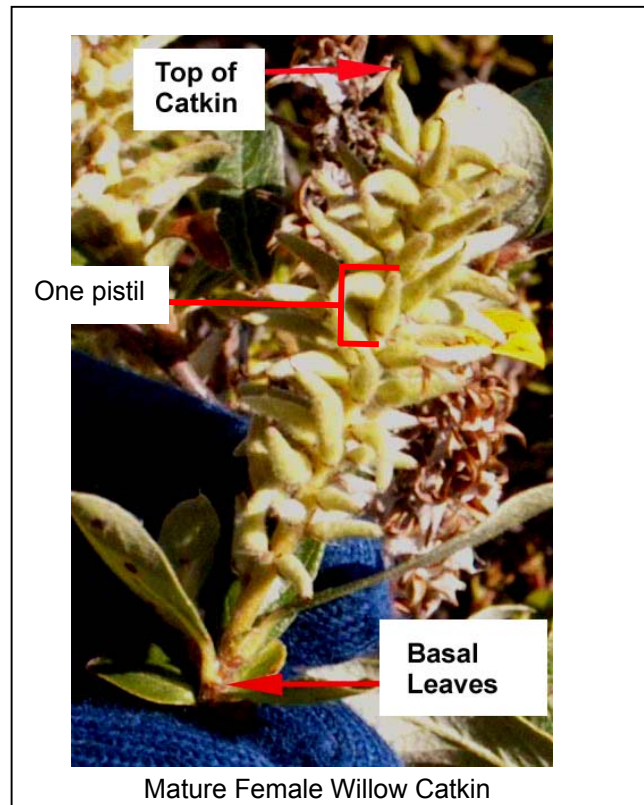
Some of the female catkins will not be fertilized or only a portion of the ovules contained on them will be fertilized. Those ovules that are not fertilized are termed “aborted”. If climatic conditions are not suitable, the plant will not invest energy into setting seed, and thus more ovules will be aborted. ***During the first week of August, count the number of female catkins on each tagged plant that have swollen and expanded (see the figure below). (Note: you will only be doing Q4 & Q5 for the female plants!)***

Q5: Length of Mature Female Catkins (mm)

The length of the mature female catkins gives us an idea of how successful the plant was at reproduction. A smaller catkin would indicate lower success and a larger one, greater success. ***Measure all the female catkins on the tagged branch from where the catkin joins the branch to the tip of the terminal pistil. This should be done in the first week of August (record the exact date).***

Q6: Willow Growth Measure (3 largest)

This year’s growth (growth increment) will appear as lighter green and perhaps a bit thinner than the rest of the branch. There will be an obvious bulge where the new shoot has come out of the old. ***Measure three of the largest increments on the tagged branch, from where the new growth comes out of the old branch, to the tip of the terminal bud. These measurements should be taken in the first week of August (record exact date).***



P4: First Yellowing of Leaves and P5: Last Green Leaf turning Yellow

Typically, observers are not in camp when these last stages occur (P4-P8). If you happen to be in camp it would be useful to record the occurrence of these stages. ***When one of the leaves on the tagged branch has started to turn yellow, record P4. When the last green leaf begins to turn yellow, record P5.***

P6: First Abscission of Leaves and P7: All Leaves Shed

Willows are deciduous bushes. They shed all their leaves in the fall after they have turned yellow and produce new ones the following spring. ***When the first yellow leaf falls off, record P6. When the last leaf falls off, record P7.***

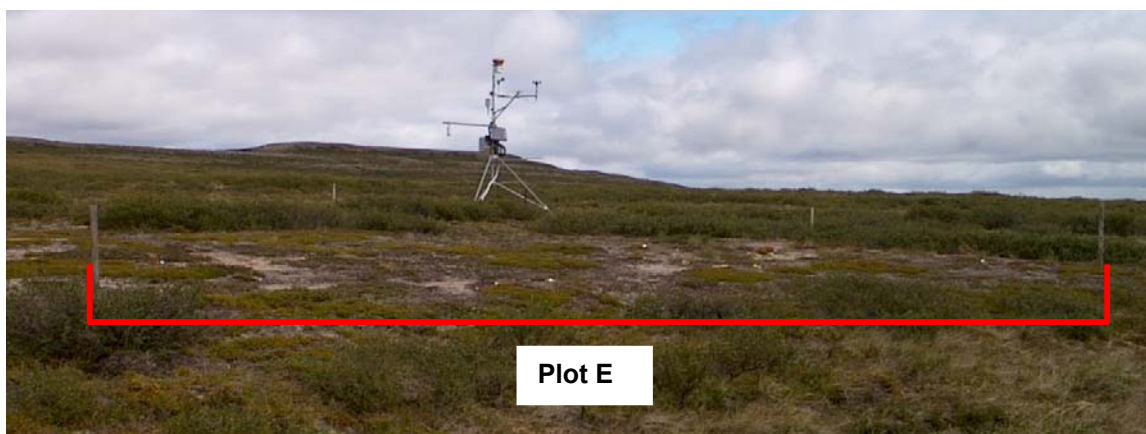
P8: Onset of Seed Dispersal

At end of season, the female catkins will fluff out and fall apart. Some of them may hang on until the following season. ***Record onset of seed dispersal when you can tell for certain that part of the catkin has blown away.***

PLOT E: *SAXIFRAGA TRICUSPIDATA*

Prickly Saxifrage is an evergreen species. The leaves will turn red in the fall and then green up again the following spring, but they are not shed. The prickles are found on the leaves which have three points on the ends. Another name for this plant is Spotted saxifrage in reference to the orange spots on the white flowers. The plant grows in mats on the ground and can be virtually covered in white blossoms in late June. In the spring, old, dry flower stalks from last year will be present extending from the clumps.

Plot E is located on a raised gravel area that appears to be an historic beach when water levels in Daring Lake were much higher. The meteorological station is right beside it. Patches or clumps of Saxifrage are tagged and the whole clump should be monitored for particular stages (we will simply refer to the clump as “the plant”).



Plot E

Missing tags

These tags seem to go missing frequently, likely because caribou nibble on them as they walk along the raised beach. If you do notice missing tags, first check the map to locate the previously tagged plant. If at all possible, retag the same plant with the same number. If you cannot locate the plant, tag a new one and give it a new number in the same series. Be sure to mark on the map where the newly marked plant is located.



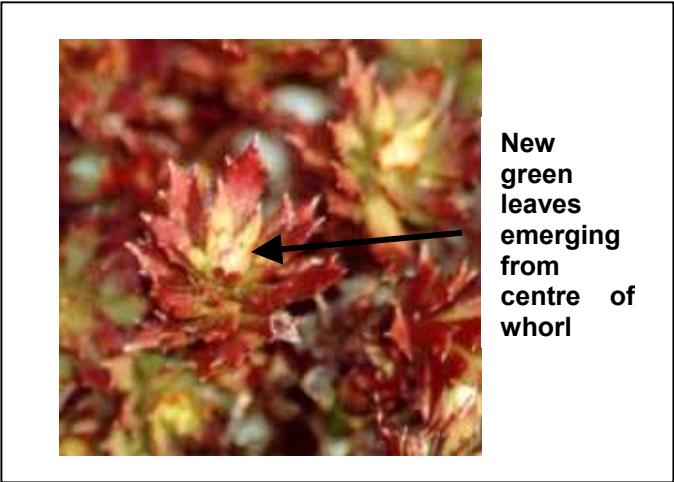
Clump of *Saxifraga tricuspidata*

P1: Snow-free

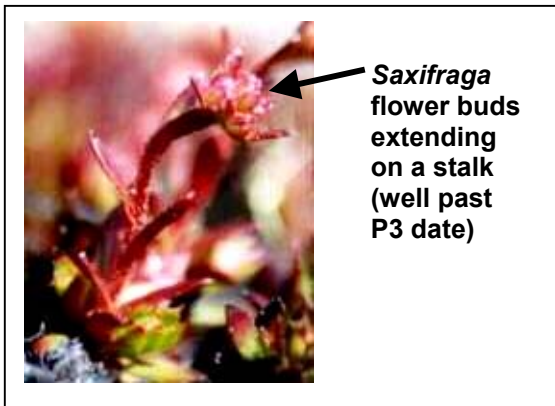
Snow accumulation in this plot is not great. It will, therefore, become snow-free fairly quickly in the spring. **Record P1 when the entire tagged saxifrage plant is free of snow.**

P2: First New Leaf

New, green leaves will emerge from the centre of each shoot, usually appearing late in the spring (approximate mid June). Old leaves are red as they first become snow-free. They will slowly turn green as the weather warms but usually the tips remain red. It is after the old leaves green up that new leaves are produced. Watch the end of each shoot of the plant carefully. You will notice a small oblong swelling, light, fresh green in color, protrude from the center of the whorl of leaves. It will slowly enlarge and will open to present three or four separate leaves that are entirely green. **Record P2 when the old leaves at the end of the shoot open slightly to reveal small leaves on at least one shoot of the tagged plant.**



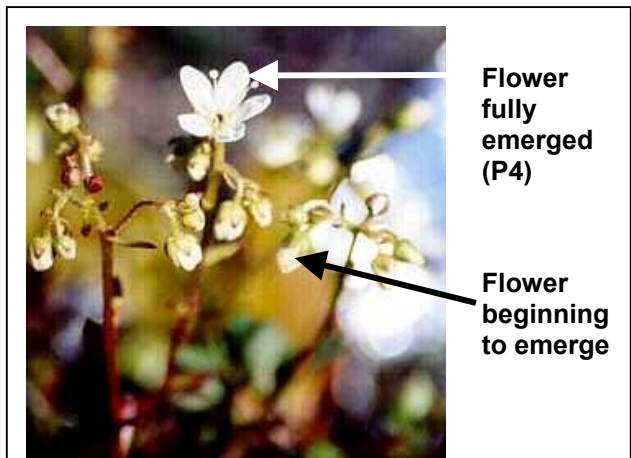
P3: Flower Buds Visible



Some shoots will produce flowers, not new leaves. They will emerge from the centre of a shoot as small, whitish balls instead of the oblong green swellings of new leaves. They are contained on the end of a stalk that will elongate to 10 to 20 cm. However, you will notice the buds long before the stalks are that length. **Record P3 as soon as you can distinguish the buds at the end of the shoot from new leaves.**

P4: First Flower open

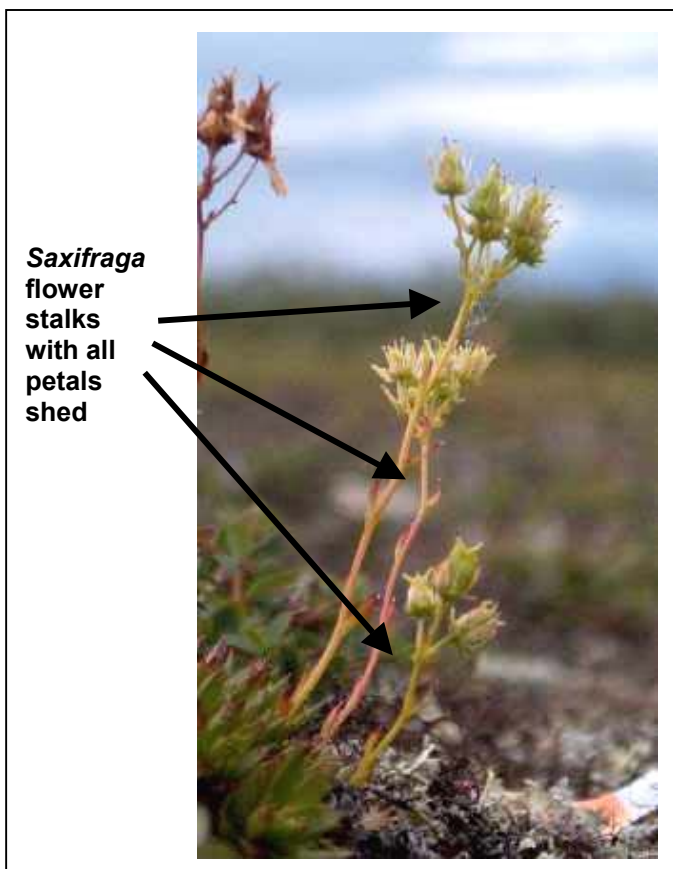
A single saxifrage plant will produce many flower stalks with several flowers on each stalk. Saxifrage flowers generally give you a few days warning before opening completely. They will first emerge slightly from their buds, showing a hint of white, and then open fully. The flower is considered open when you can see space between the petals of a flower. **Record P4 when you can see space between the petals of any flower on any of the stalks on the marked plant.**



Q1: Number of Flower Stalks

The flower stalk extends from the end of the shoot and carries a number of flowers. Be sure to count only the stalks that arise from the shoots and not those that hold each flower. Either immediately before or immediately after the P4 stage is a good time to count the number of flower stalks. At this stage almost all stalks are well developed, but there are very few or no flowers to clutter your view. However, make sure to look carefully for smaller stalks, as not all stalks in a patch develop at the same time. **Count the total number of flowering stalks on the marked plant as soon as flowers start to open.**

P5: First Petal Shed and P6: Last Petal Shed



Saxifrage flowers will stay in bloom for approximately a week to ten days. The pistil in the centre of the flower will swell into a large green protuberance with two tips to it. The petals will fall off individually. **Record P5 as soon as the first petal on any flower in the patch has been dropped.** You will have to look carefully to catch this event.

Record P6 when the last petal has fallen from the stem. Sometimes a petal will cling even after it has wilted. Use your judgment for this measurement. But keep your eye out for late blooming flower buds; sometimes a late flower will bloom after the other flowers have already dropped their petals.

Q2: Diameter

The diameter of the clumps of Saxifrage are measured every year in the first week of August. **Three measurements are taken (this differs from Plot A where only two are taken). Typically we try to take a measurement along the longest width, the narrowest and then an approximation of the diagonal.** Measurements should stretch from the tips of the outermost shoots along the line you are measuring. If there are shoots on the outside of the patch, only measure to the edges of the live leaves. However, if the patch extends on either side of a group of dead leaves, include the dead leaves in the diameter.



Saxifraga patch



Length of patch



Width of patch



Diagonal of patch

PLOT F: *ERIOPHORUM VAGINATUM*

Eriophorum vaginatum is one of several species of cotton grass that form tussocks in the low arctic tundra. Tussocks appear as large raised “clumps” of vegetation ranging in size from 30cm to 150cm. When in bloom, Cotton grass has white fluffy heads that wave in the breeze. The flowering structure is termed an inflorescence as it is really a collection of flowers. Despite its name Cotton grass is not really a grass but a sedge! Sedges are often found in wet areas but not always.

Cotton grass is one of the earliest flowering species on the tundra. It is extremely important to caribou as they head for the calving grounds as a new source of nutrition after a winter of dried vegetation and lichen. Be sure to watch this plot closely in the early spring. Snow will still remain in the plot when the inflorescence buds emerge from the tussock. **All the phenological stages will occur very quickly. You will need to spend a lot of time early in the spring watching these plants.**

This plot has greenhouse chambers surrounding it so you will be monitoring plants within the chambers and in the plot. In both plot and chambers the whole tussock is monitored. Tags will be located in approximately the centre of the tussock and the boundaries are usually obvious (e.g. surrounded by water in spring). In general, we defined a tussock as the largest area we could determine as a tussock (i.e. if a large tussock had a few subunits to it, we used all of the subunits as the tussock). However, there were a few tussocks that were not defined in this manner (i.e. a subunit was used). Maps of the plot and chambers are included in the appendix of this manual. You can refer to these maps for approximate shapes and sizes of tussocks to be monitored.

Missing tags

If you cannot find the tag on one of the marked tussocks you should be able to determine from the map (in appendix) where the tussock is. Locate the tussock and, using a nail and metal tag (from box in lab tent), place a new tag on the tussock and give it the same number. If you cannot locate the same tussock, select a new one and give it a new number in the same series as other plants. Be sure to mark on the maps where this new tussock is and detail on the datasheet what you have done.

P1: Snow-free

A fair amount of snow accumulates in this plot and will remain after most of the plots upslope are snow-free. Tussocks will become snow-free first while the troughs will melt later on. Because there tends to be water in the plot in the summer, there will also be a fair amount of ice in the troughs of the tussocks. **Record P1 when the entire marked tussock is free of snow. Watch for P2 and P3 even when the plot is not snow-free. These stages will occur while snow is present.**

P2: First New Leaf Visible

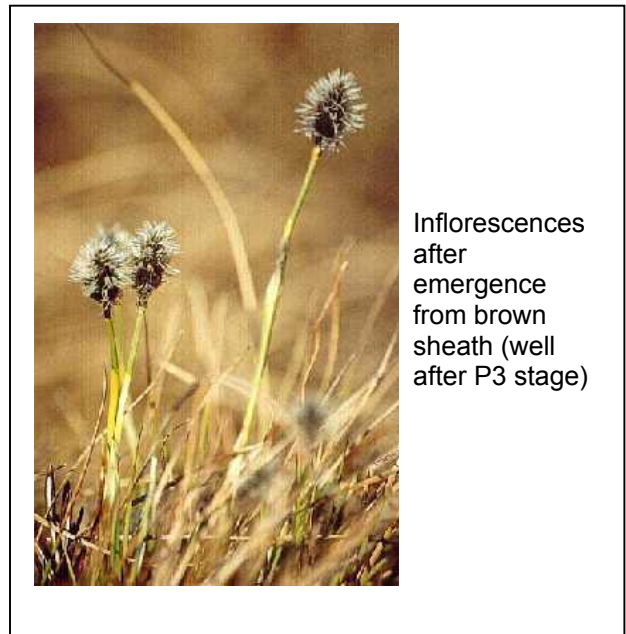
The cotton grass tussock has a number of different species growing on it, including other sedges. *Eriophorum* leaves are difficult to distinguish from *Carex* leaves (they both just look like grass!). However, probably the easiest way to tell them apart is that *Carex* comes out of the ground in a bunch, whereas *Eriophorum* emerges as single leaves. New *Eriophorum* leaves from this year will be entirely green. A leaf that is green on bottom and brown on top is a leaf that has overwintered. **Record P2 when you see an entirely green leaf emerging from anywhere on the tussock.**

The best way to distinguish between *Eriophorum* and *Carex* leaves is to look where the leaves come out of the ground. *Eriophorum* leaves emerge individually from the tussock, whereas *Carex* leaves emerge in a bunch. Also if you grasp a single leaf blade in your fingers and tug, *Eriophorum* leaves, because they grow individually, generally pull out from the base fairly easily, whereas *Carex* leaves, because they grow in a bunch, generally break.



P3: First Inflorescence Bud

Inflorescence buds (an inflorescence is a collection of flowers) will emerge from the tussock as a brown torpedo shaped structure wrapped in a sheath. It appears dry and can look like something left over from last year! The sheath will open to reveal a soft, silvery bud that looks somewhat like a pussy willow. Buds often emerge before all the snow is gone. **Record P3 when you notice the buds with the sheaths still covering them.**



P4: First Exposed Anthers

Once the grey inflorescence head appears it will gradually dry and become fluffy. Within a day or two whitish yellow stamens will extend out. The stamens will mature until golden yellow anthers are displayed. **Record P4 when the inflorescence head turns bright yellow.** After the yellow anthers have been displayed they will turn brown and wither somewhat. If you notice a bud after it has turned brown, you have missed the exposed anther stage. If this happens (and it will, because these stages happen so quickly!) write down the date you first notice the bud and the stage it is at. Take the first measurement of inflorescence shaft length after you have recorded this stage (see Q2).



Yellow anthers first exposed (record P4)



Yellow anthers further elongating



Anthers darkening and wrapping around head

Q1: Number of flower stalks

Cotton grass tussocks usually produce several inflorescence stalks. However, some tussocks may not produce any. Our tussocks typically do not produce a lot. Or if they do, they get eaten! Buds are tasty snacks and often go “missing”. Count them as soon as possible before they are lost! **Count the number of inflorescence stalks on the entire tussock as soon as all have displayed their anthers.**

Q2: Inflorescence shaft length (2X)

The inflorescence shaft length will grow throughout the season. The length of the shaft indicates how well ovules are being fertilized and seeds developing. We take two measures of length, one shortly after buds emerge, the other after seeds have developed. **Take one measurement shortly after the anthers become visible (right after you have recorded P4) and another after P5, first seed shed or during the first week in August, whichever comes first). Measure all the inflorescence shafts on the tussock.** You don't have to keep track of which measurement is from which shaft. Measurements will be averaged and compared. Be sure to record the date when the measurements were taken.

Q3: Mean Length of 10 Longest Leaves (mm)

Measure ten leaves on each tussock that appear to be long relative to the rest of the leaves. Don't worry too much about getting the ten longest. It is sufficient to choose leaves that appear to be long. An easy way to do this is to identify a group of *Eriophorum* leaves, place the ruler at the base of the leaves, hold several leaves along the length of the ruler, and read off the length of the longest leaf. Take this measurement in the first week of August remembering to record the exact date.

Q4: Tussock Diameter to tips of Leaves (cm)

Tussock diameter does not change much from year to year. But over longer periods of time, 10 years for instance, changes may be distinguishable. **Tussocks are measured from the tip of leaves to tip of leaves (unextended – just as they hang) in the first week of August.** Take two measurements, length and width. Some tussocks are easy to distinguish while others are more difficult. If you are unsure, look at the maps in the appendix of this manual; they will give an approximation of shape and size of the tussocks. Generally, it will be the largest clump that you can comfortably say is separate from other clumps (there may be low areas within a tussock)



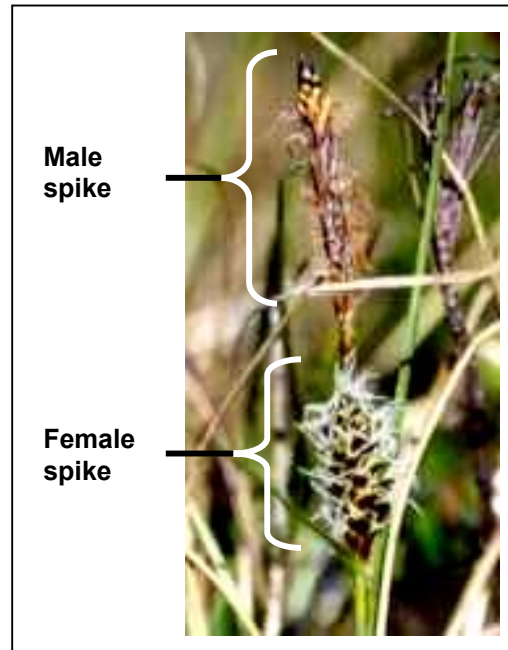
P5: First Seed Shed

Normally, the developing inflorescence will form a cottony, fluffy head. When mature, the seeds will be small, brown sesame seed-shaped seeds attached to part of the white fluff of the head. When released, the seed detaches from the centre of the inflorescence and will be carried by the wind. **Record P5 as soon as you can see a seed pulling away from the centre, or when you can see a gap in the fluff where a seed has already blown away.** Remember to record the second shaft measurement (Q2) for all of the shafts after the first inflorescence on the tussock has reached this stage.



PLOT G: CAREX AQUATILIS

Carex aquatilis is a sedge, like *Eriophorum*, but is quite different in its reproductive structures (flowers) and strategy (it flowers quite late in the season). *Carex* grows from underground rhizomes. Shoots or tillers come out of the ground along the rhizome. Each shoot grows for several years, flowers then dies. Other shoots will come up from other parts of the rhizome. Because a flowering shoot dies within a year, we watch a different flowering shoot every year. The flowering tillers have 1 to 2 terminal male spikes at the top of the flowering stalk and 1 to 3 female spikes (usually one) below the male spikes. The spikes emerge about a week before they begin to flower, so they will give you ample warning on when you should start watching them closely. In general, start watching *Carex* more closely towards the middle of July. You will notice tags on the ground throughout the plot. When a flowering shoot is observed in a 15cm radius (approximately) it is marked and observed for the rest of the season.

**Missing tags**

If you cannot find a tagged plant after checking the map and the plot a few times, a new plant will have to be tagged. Watch for a flowering shoot that is approximately 30 to 50 cm away from any other tagged plant. Mark this shoot with a number in the same series as the other tagged plants. You will miss the snow-free and new leaf dates for this plant but you will be able to record the stages from P3 onwards.

P1: Snow-free

Similar to the Cotton grass plot, snow tends to accumulate (70 to 100 cm) in this plot as a result of its low elevation. It will be snow-covered for a while after others have cleared. As the snow melts, scan the plot for the appearance of the metal ID tags. **Record P1 when a 15cm radius around the tag is free of snow.**

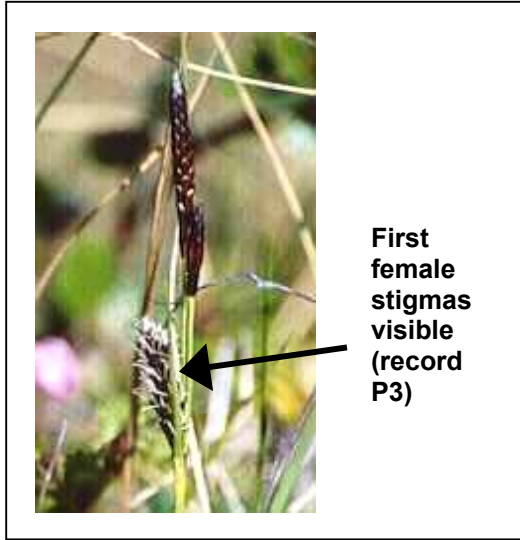
P2: First New Leaf Visible

Old, brown leaves will be evident near the tag. Growth will continue on these leaves so they will be green on the bottom portion and brown at the tips. A new leaf from this season will be entirely green and come up from the centre of a sheath of older leaves. You will have to pull apart the older leaves **slightly** to watch in the centre. **Record P2 when you first see a small, entirely green leaf arising from the centre of a Carex sheath.** Don't tag this plant, just record the date.

P3: First Stigmas Visible

The flowering stalk will come up from the centre of the *Carex* sheath. It usually consists of three parts: a female inflorescence and two male spikes at the end of the stalk. As the stalk emerges you will see the male structures first and the female afterwards. The female inflorescence is oblong, compact and brown. Soon after emergence, the inflorescence will loosen and white stigmas will extend outward. **Record P3 when the white stigmas are protruding out from the inflorescence.** Mark that plant with flagging tape so that all subsequent dates and measurements are taken from the same tiller. If you are not certain if any of the tillers in the 10cm diameter circle are going to flower,

you can mark a tiller that is near by, but record the distance from the tag. If a tiller closer to the tag flowers at a later date, erase the previous data and record the dates of this closer flower.



P4: First Exposed Anthers

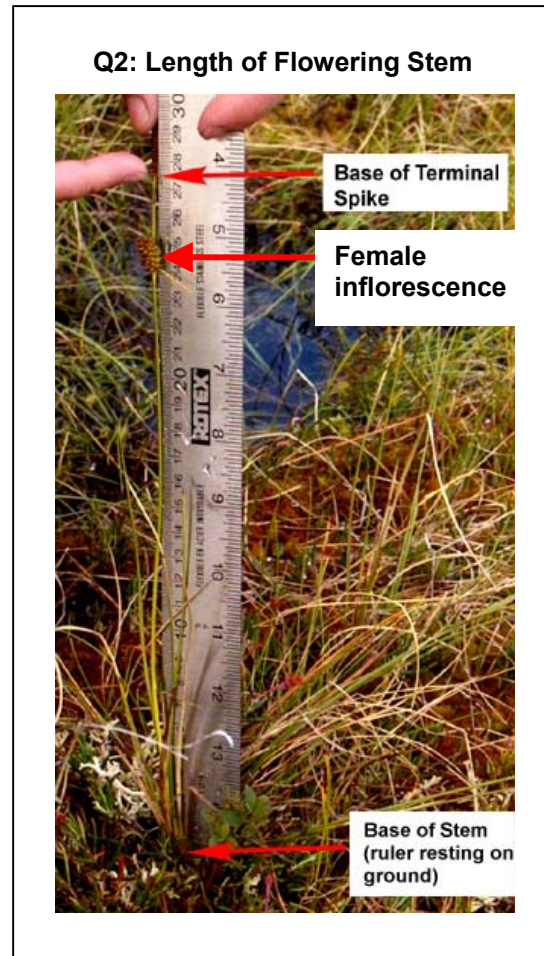
The male spikes are located above the female spikes. The anthers are thin, yellow, fairly long filaments that generally emerge after the female stigmas. The spikes will open slightly and the yellow anthers will extend outwards. **Record P4 when you see yellow anthers protrude from one of the male spikes.**

Q1: Age Class of Shoot in Flower (number of surrounding dead leaves)

A specific tiller or shoot will grow for several years, producing leaves each year. It will flower and then die the following season. The number of dead leaves surrounding a flowering shoot can be used to estimate how many years the shoot grew before producing a flower. **Count and record the number of dead leaves that surround the flowering spike right after stigmas and anthers have become visible.**

Q2: Length of Flowering Stem at Full Flower

By August the inflorescence will be enlarging and drying out. Measure the length of the flowering stem at full flower which occurs in late July or early August after the stigmas and anthers have emerged. **Measure the length of the flowering stem from the ground to base of tallest male spike, not the tip of this spike.**



Q3: Length of Leaves (all green portions)

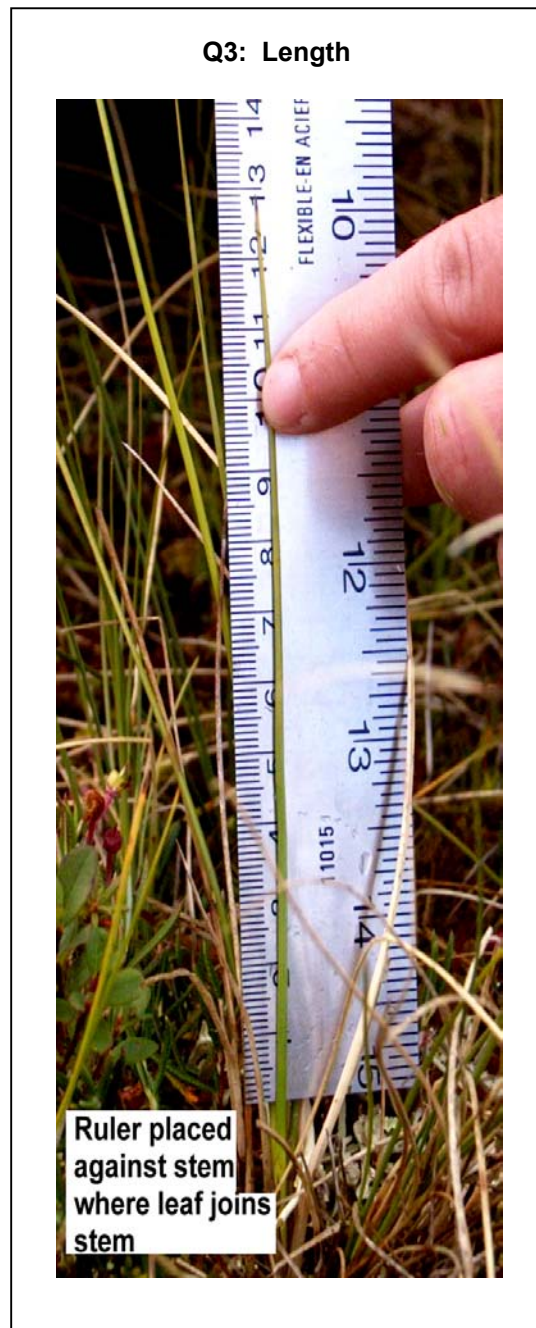
The amount of green leaf production by a single shoot or tiller can provide insight into the growing conditions of the particular season. By measuring and summing the length of all the green leaves surrounding the flowering stalk we can determine the amount of annual leaf production. **Place the ruler in the centre of the tiller where the leaves join the stem and measure to the tip of the green portion of leaf. For leaves that are partially brown, measure and record the length of the green portion only.** Most shoots also have a very short leaf or flower bract located immediately below the flowering spikes. Measure this in a similar manner. Be sure to indicate which measurements are from fully green leaves, partially green leaves and flower bracts. These measurements should be done in the first week of August. Record the exact date on the datasheet.

P5: First Yellowing of Leaves

Carex leaves will start to yellow in early to mid August. Tips of the leaves will yellow first, then slowly the entire leaf. This stage doesn't occur rapidly and can be hard to distinguish. If you have doubts, wait a few days until you can definitely say that ¼ of the leaf is yellow. **Record P5 when approximately 25% of at least one leaf on the marked shoot becomes yellow.**

P6: First Seed Shed

The female inflorescence will slowly enlarge and dry out as it matures. It will have obvious separate seeds that will come loose and blow away. Seeds are usually shed in mid to late August. **Record P6 when you see holes in the inflorescence where seeds have come loose.**



APPENDIX

Julian Days for Non-Leap Years

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Feb	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59			
Mar	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Apr	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
May	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
June	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
July	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
Aug	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
Sept	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	
Oct	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	
Nov	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334
Dec	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365

Julian Days for Leap Years

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Feb	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		
Mar	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
Apr	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	
May	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152
June	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	
July	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213
Aug	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244
Sept	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	
Oct	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	
Nov	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335
Dec	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366

Daring Lake ITEX _____ (YEAR)

Species: *Oxytropis nigrescens*

No.	P1	P2a	P2b	P3	P4	P5	P6	Date		Notes
								Q1	Q2	

P1 – snow-free
 P2a – first green leaf visible
 P2b – first flower bud visible
 P3 – first flower open
 P4 – first petal drop
 P5 – last petals drop
 P6 – first seeds shed

Q1 – number of buds
 Q2 – diameter of plant (mm)

Daring Lake ITEX _____ (YEAR) PLOT _____ OTC _____

Species: *Ledum decumbens*

No.	P1	P2	P3	P4	P5	P6	Date				Notes	
							Q1	Q2	Q3	Q4		

- P1 – snow-free
- P2 – flower buds visible
- P3 – first flower open
- P4 – first flower shed
- P5 – last flower shed
- P6 – first fruit visible

- Q1 – number of flowering stalks
- Q2 – number of flowers per stalk
- Q3 – number of fruit per stalk
- Q4 – growth increment

Daring Lake ITEX _____ (YEAR) **PLOT** _____ **OTC** _____

Species: *Vaccinium vitis-idaea*

No.	P1	P2	P3	P4	P5	P6	Date			Notes
							Q1	Q2	Q3	

P1 – snow-free
 P2 – flower buds visible
 P3 – first flower open
 P4 – first flower shed
 P5 – last flower shed
 P6 – first fruit visible

Q1 – number of flowers
 Q2 – number of fruit
 Q3 – growth increment

Daring Lake ITEX _____ (YEAR)

Species: *Betula grandulosa*

No.	P1	P2	P3a	P3b	P4a	P4b	P5	P6	P7	Date				Notes			
										Q1	Q2	Q3			Q4		

- P1 – snow-free
- P2 – flower buds visible
- P3a – first male catkins visible
- P3b – first female catkins visible
- P4a – first stigmas visible
- P4b – first pollen shed
- P5 – last green leaf turning rusty
- P6 – first abscission of leaves
- P7 – all leaves shed
- Q1 – number of male catkins
- Q2 – number of female catkins
- Q3 – leaf length
- Q4 – growth increment

Daring Lake ITEX _____ (YEAR)

Species: *Salix* sp.

No.	P1	P2	P3a	P3b	P4	P5	P6	P7	P8	Sex	Date						Notes		
											Q1	Q2	Q4	Q5	Q6				

- P1 – snow-free
- P2 – first leaf bud burst
- P3a – first stigmas visible
- P3b – first pollen shed
- P4 – first yellowing of leaves
- P5 – last green leaf turning yellow
- P6 – first abscission of leaves
- P7 – all leaves shed

- P8 – onset of seed dispersal
- Q1 – total number of catkins
- Q2 – length of longest leaf (mm)
- Q3 – weight of largest leaf (mg)
- Q4 – total number of mature catkins – not aborted
- Q5 – catkin length (mm)
- Q6 – growth increment

Daring Lake ITEX _____ (YEAR)

Species: *Saxifraga tricuspidata*

No.	P1	P2	P3	P4	P5	Date				Notes
						P6	Q1	Q2		

P1 – snow-free
P2 – first new leaves
P3 – first flower buds visible
P4 – first flower open
P5 – first petal shed
P6 – last petal shed

Q1 – number of flower stalks
Q2 – plant diameter

Daring Lake ITEX _____ (YEAR) **PLOT** _____ **OTC** _____

Species: *Eriophorum vaginatum*

No.	P1	P2	P3	P4	P5	Date	Q1	Q2	Q3							Q4	Notes		

- P1 – snow-free
- P2 – first new leaf visible
- P3 – first inflorescence bud
- P4 – first exposed anthers
- P5 – first seed shed

- Q1 – number of flower stalks (end of season)
- Q2 – inflorescence shaft length (mm)
- Q3 – mean length of 10 longest leaves (mm)
- Q4 – tussock diameter to tips of leaves (cm)

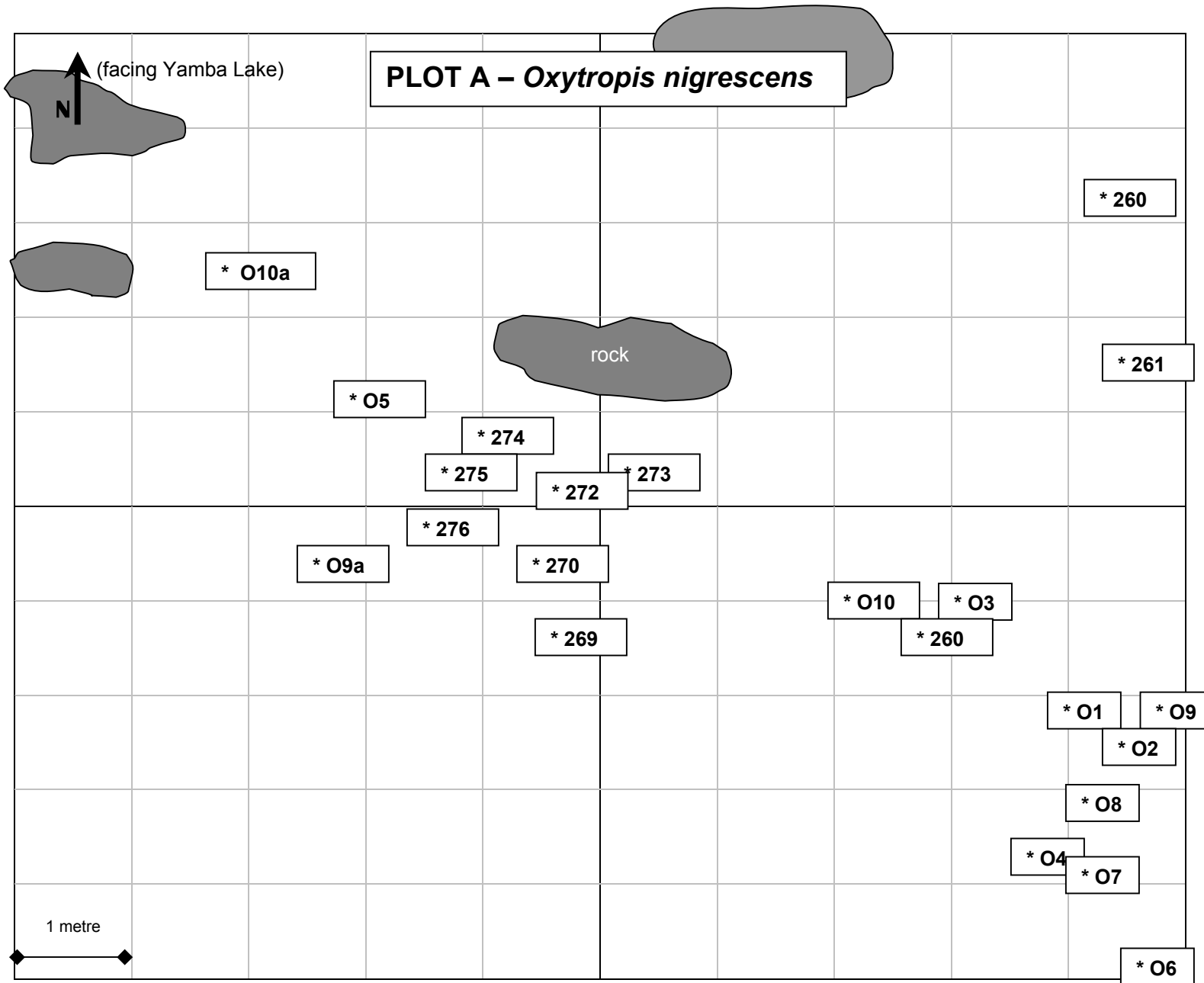
Daring Lake ITEX _____ (YEAR)

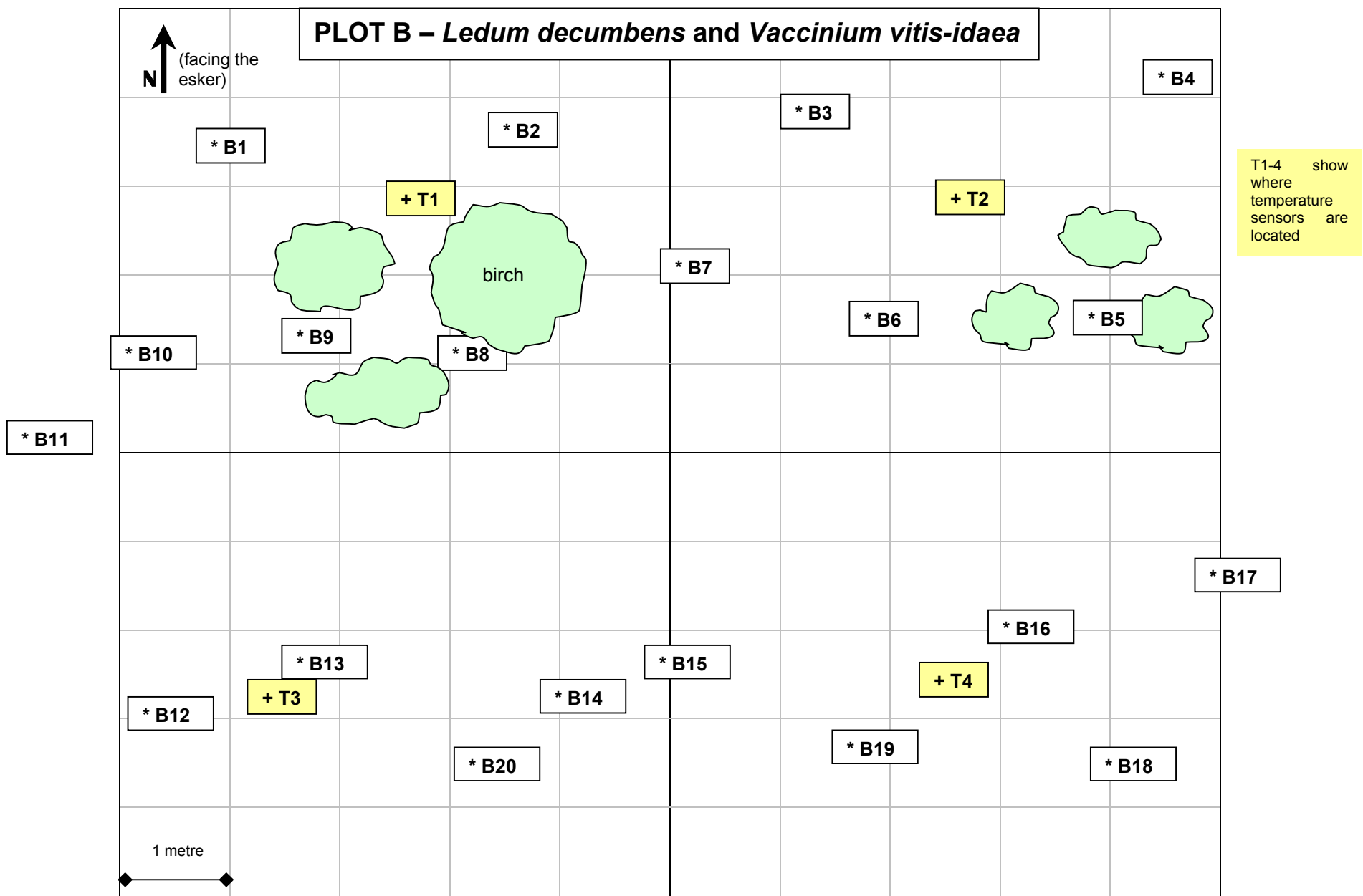
Species: *Carex aquatilis*

No.	P1	P2	P3	P4	P5	P6	Date			Notes
							Q1	Q2	Q3	

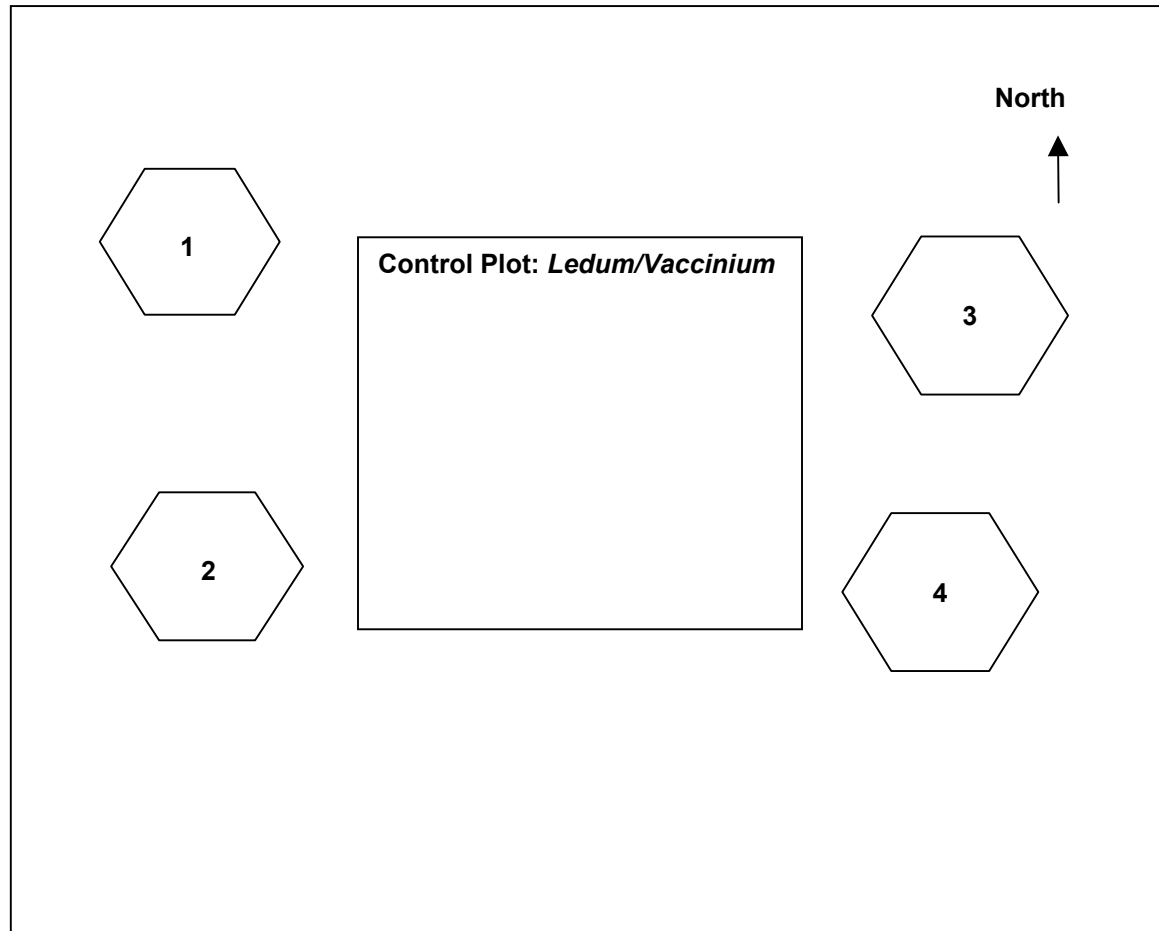
- P1 - snow-free
- P2 - first new leaf visible
- P3 - first stigmas visible
- P4 - first exposed anthers
- P5 - first yellowing of leaves
- P6 - first P6 - seed shed

- Q1 - age class of flowering shoot (no. of surrounding dead leaves)
- Q2 - length of flowering stem at full flower
- Q3 - length of green portions of all leaves

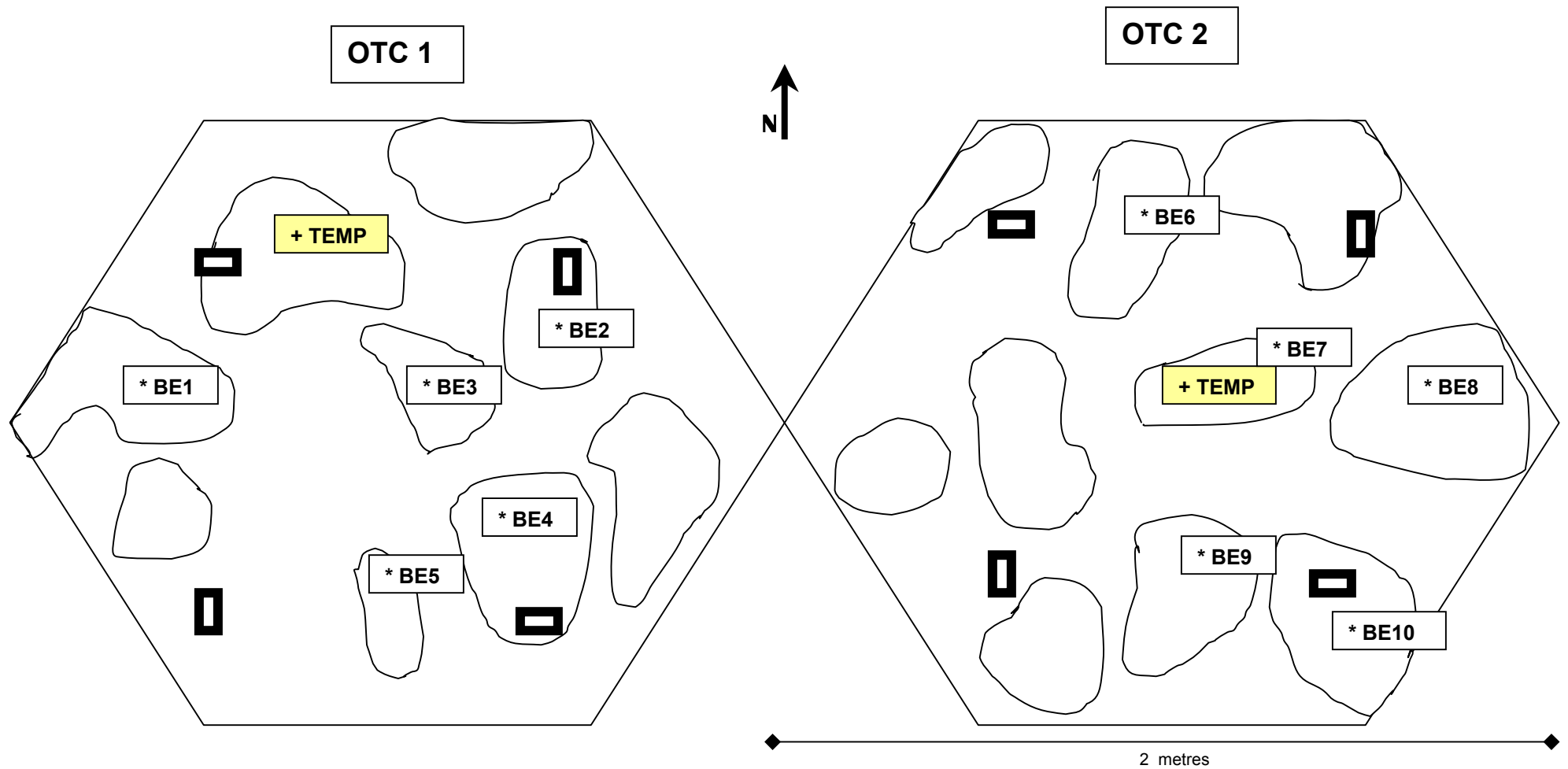




Layout of OTC's - Plot B: *Ledum/Vaccinium*



OTC's – *Ledum decumbens* and *Vaccinium vitis-idaea*

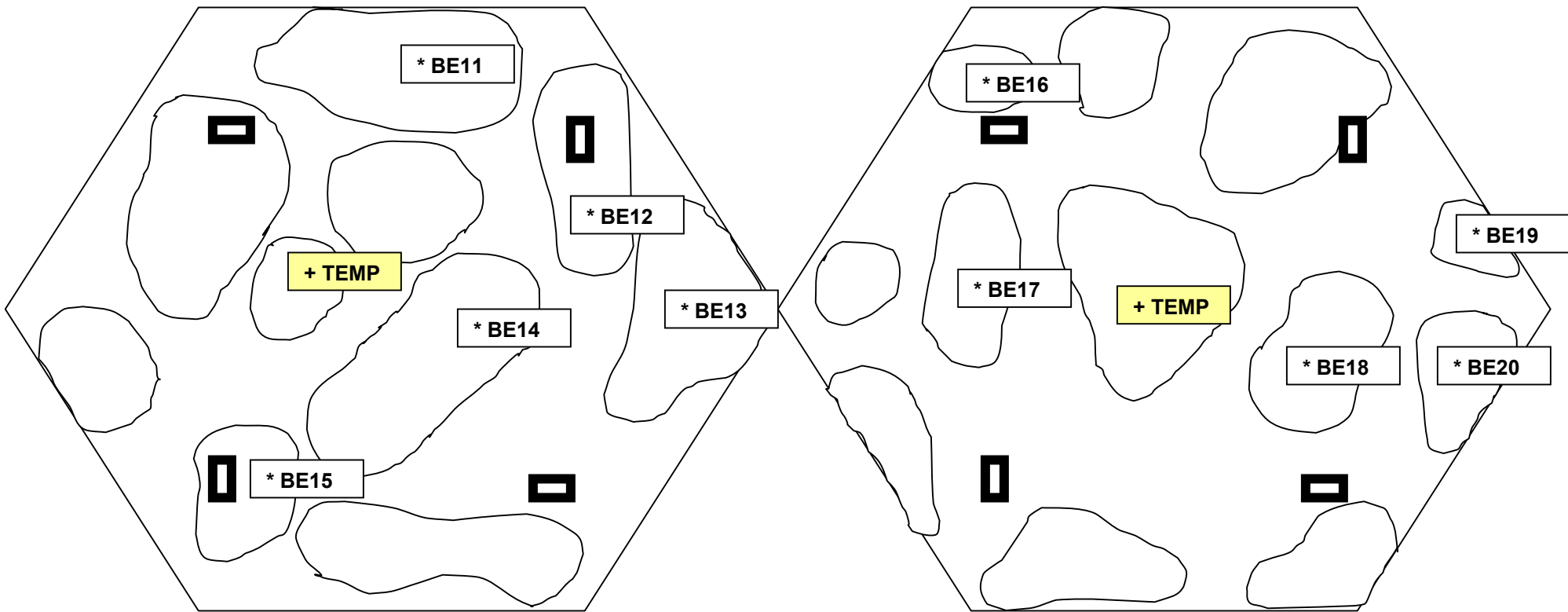


* irregular shapes in chambers indicate “hummocks” or mounds of vegetation

OTC's (cont.) – *Ledum decumbens* and *Vaccinium vitis-idaea*

OTC 3

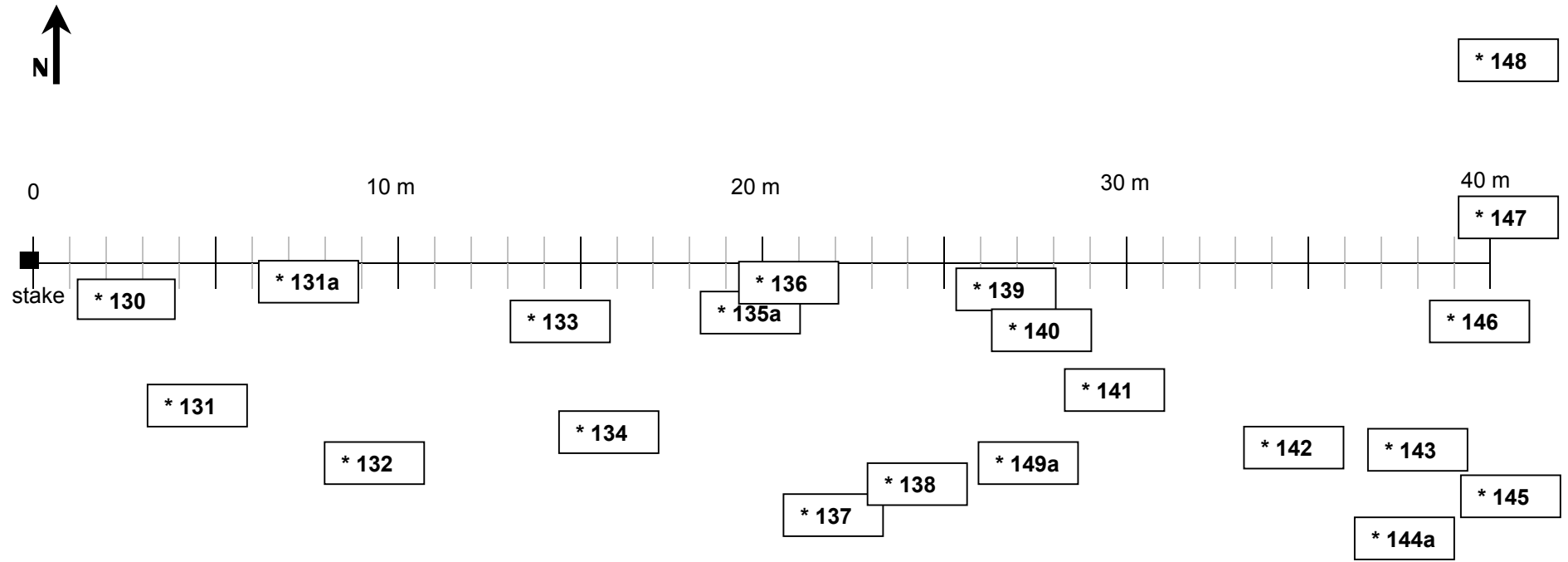
OTC 4



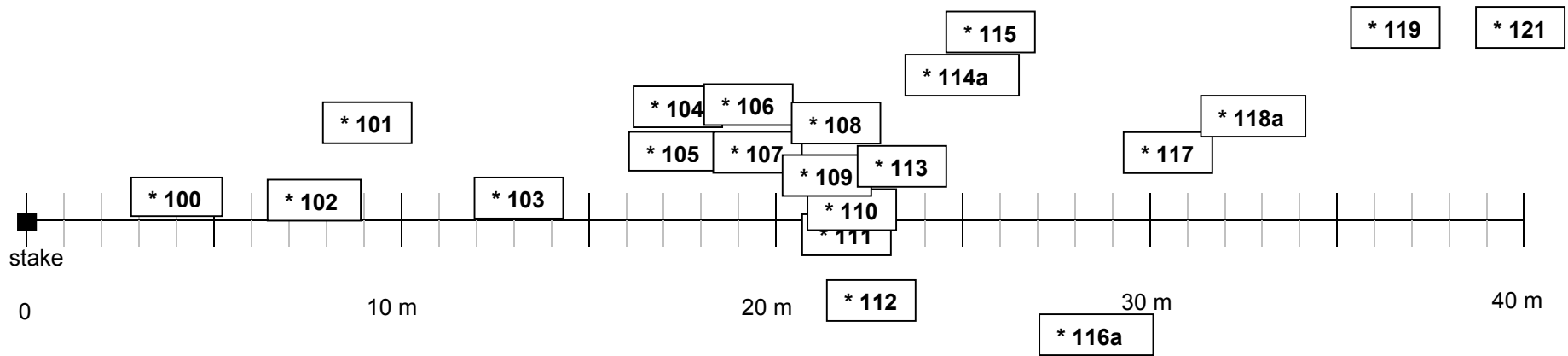
* irregular shapes in chambers indicate "hummocks" or mounds of vegetation

2 metres

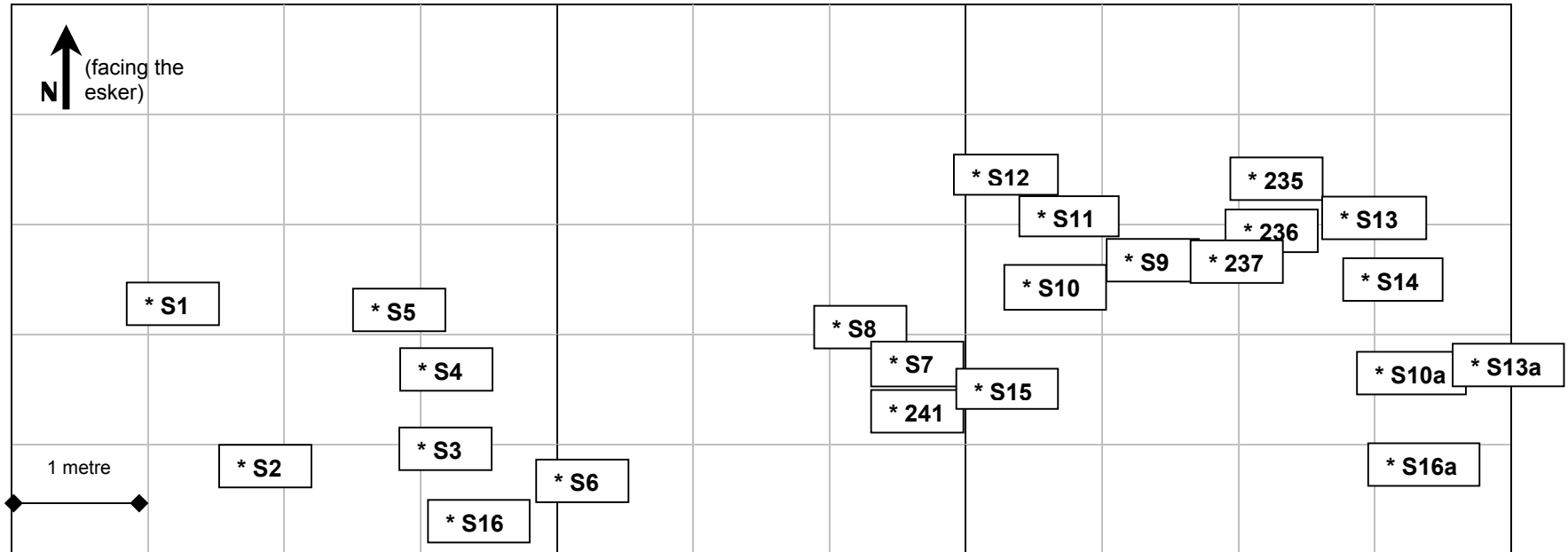
Plot C – *Betula glandulosa*

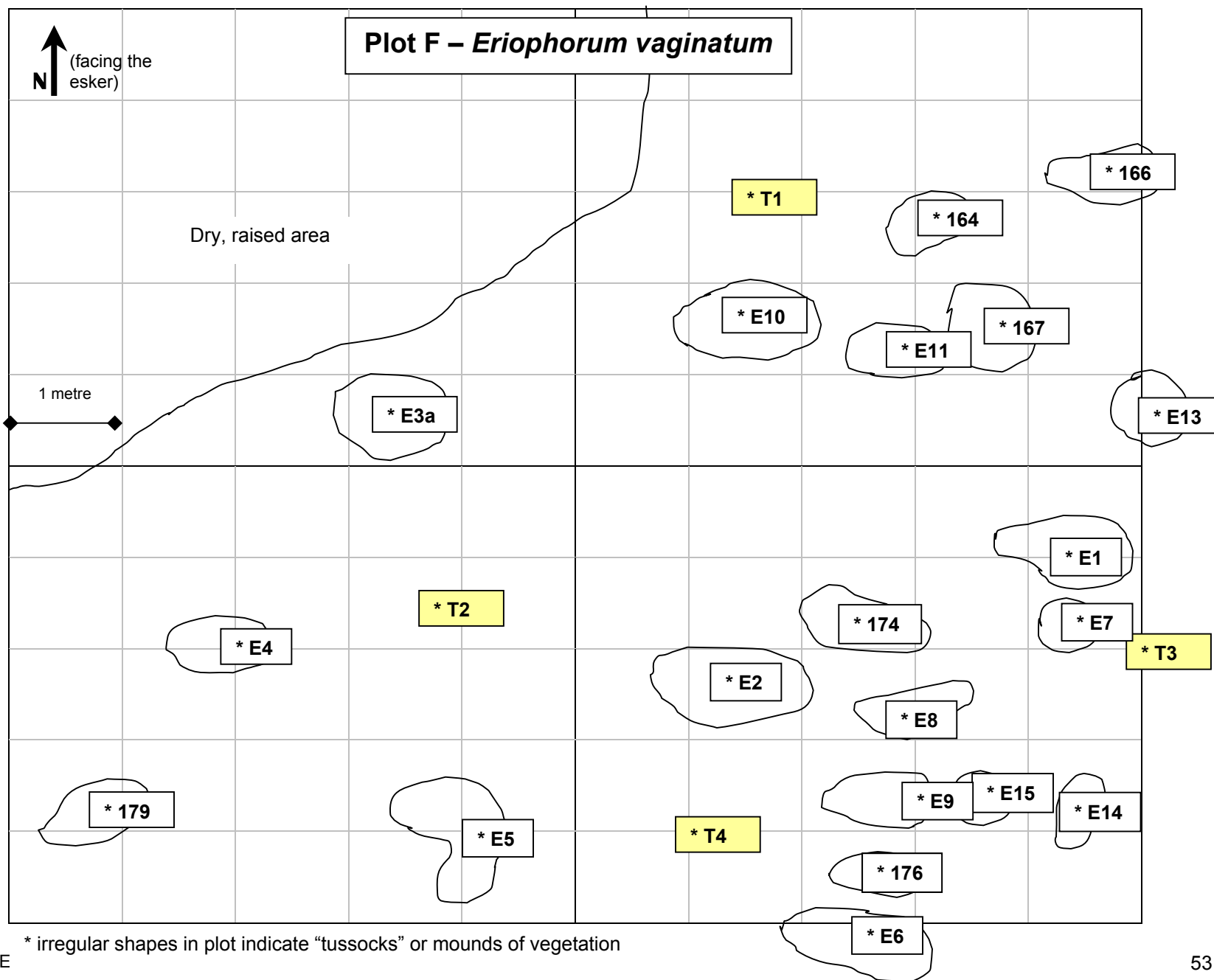


Plot D – *Salix* sp.

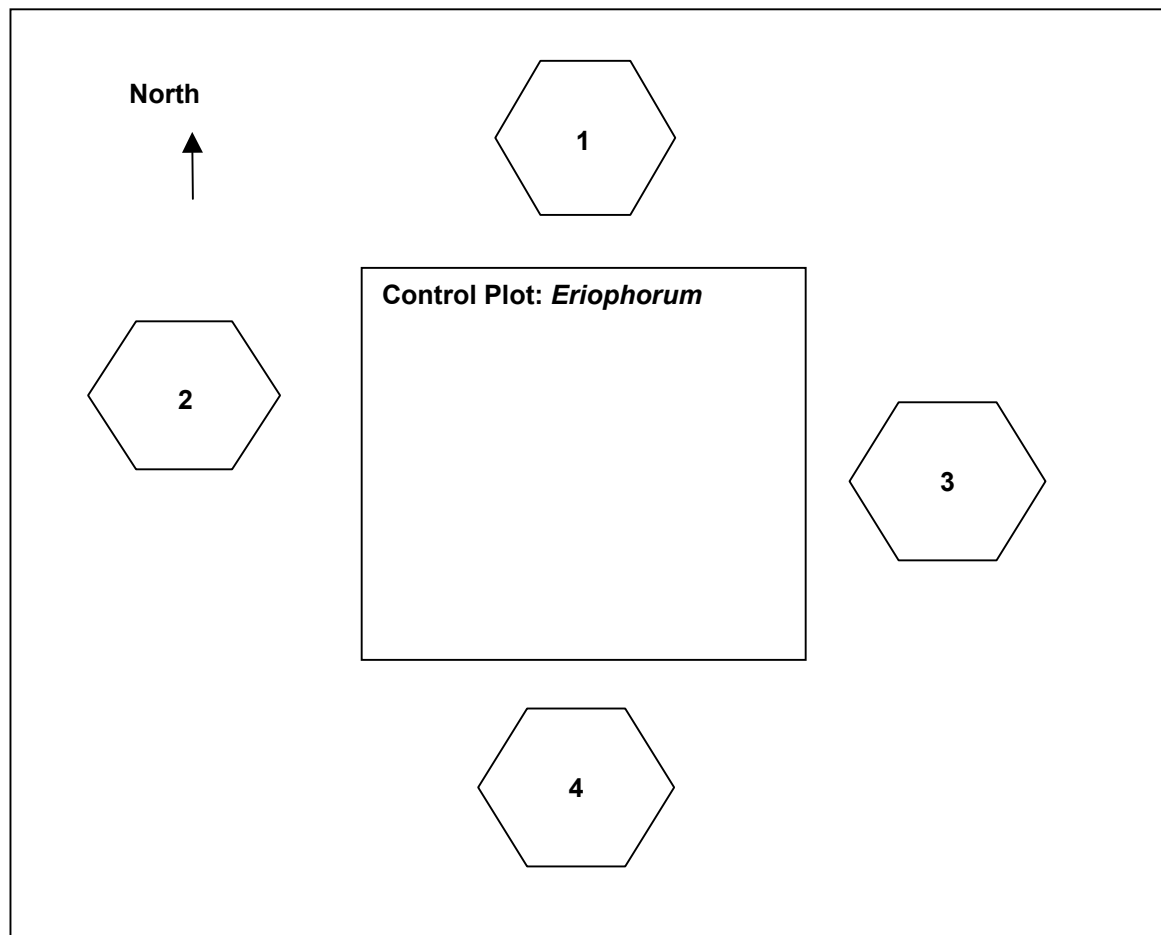


Plot E – *Saxifraga tricuspidata*

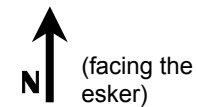




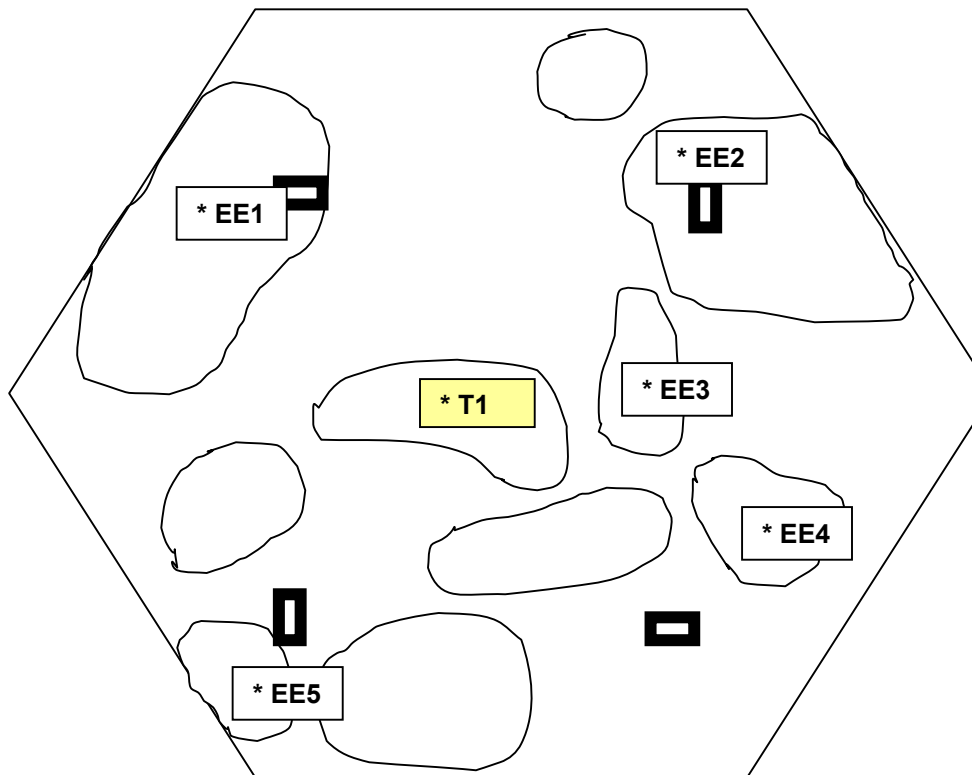
Layout of OTC's - Plot F: *Eriophorum*



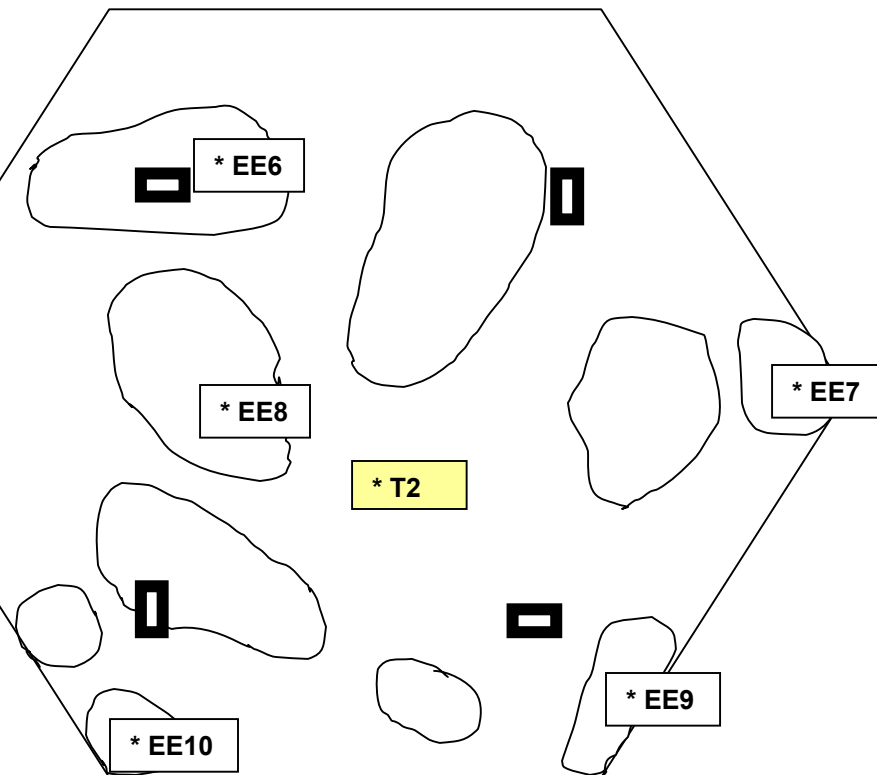
OTC's – *Eriophorum vaginatum*



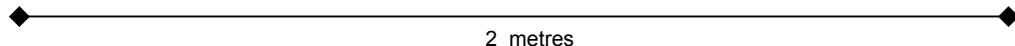
OTC 1



OTC 2

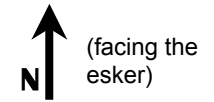


* irregular shapes in chamber indicate "tussocks" or mounds of vegetation



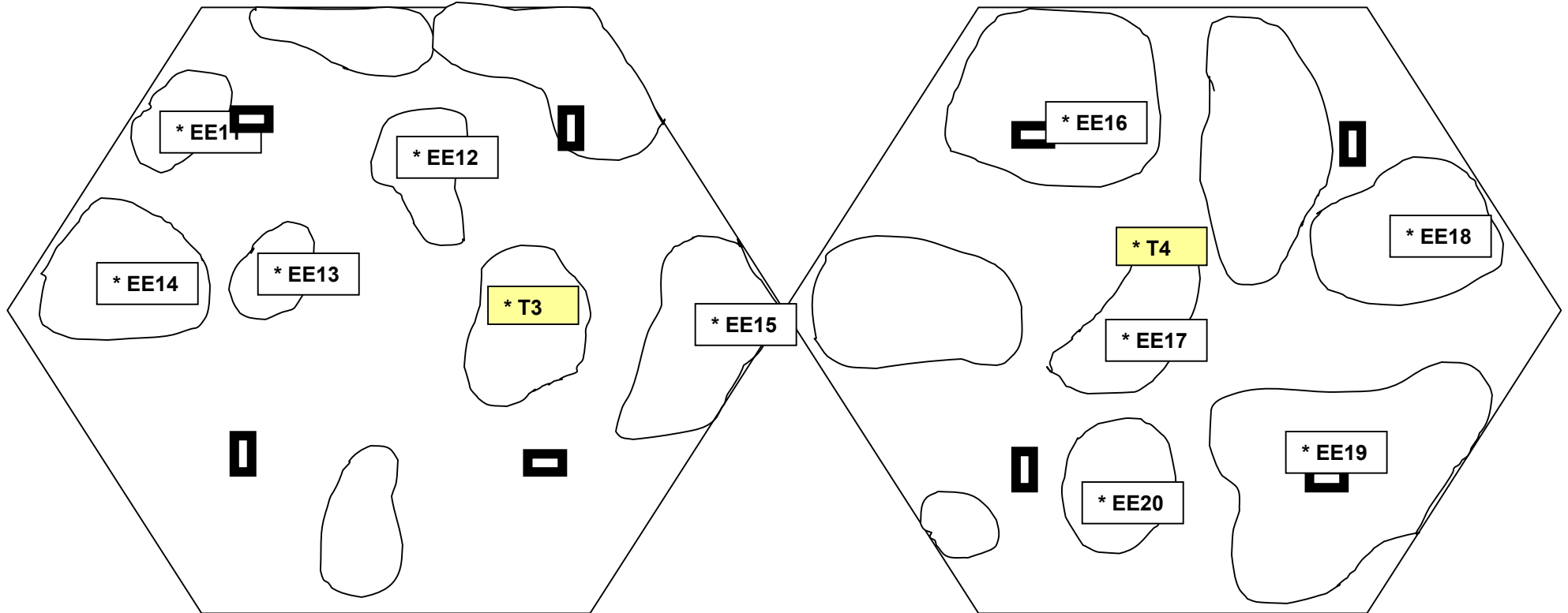
2 metres

OTC's (cont.) – *Eriophorum vaginatum*



OTC 3

OTC 4



* irregular shapes in chamber indicate "tussocks" or mounds of vegetation

