2.0 Discuss the terms of plant (tree) autecology typical of the Boreal forest.

2.1 Define some processes common to most boreal forest plants.

A process that all plants, animals or anything biotic must have is respiration. This is the changing of energy from one form to another form so that the organism can use it for a variety of purposes. The most common form of respiration requires oxygen – without oxygen the organism may not capture the energy that would be available through the process of respiration. A lot of people associate breathing with respiration, but oxygen is required in the process of breathing and that does change some stored energy to a form that an organism may use for a variety of reasons. Sometimes flooded areas can kill certain plants because of the lack of oxygen required at the plant's roots for the process of respiration.

The manufacture of food in the presence of light, carbon dioxide and water is known as photosynthesis. This food, which is mainly sugars, is actually energy. This energy is released through the process of respiration. Plant scientists say that respiration is more important than photosynthesis because if we can't change stored energy to a form we can use, then that energy is of no use to us. For example, if you had 20L of gas and your car is broken down and won't start, then that 20L of gas (stored energy) is no good to you because you can't use it.

Another process that all organisms try to undertake is that of reproduction – producing offspring, seeds, or clones to keep the species alive (sometimes referred to as propagation of the species). Reproduction requires a lot of resources and energy in order for it to occur. Most animals require a healthy system during their gestation period, or the offspring could be aborted through natural means. A tree will reproduce seeds under two conditions:

a) when the tree is very healthy
b) when the tree is stressed to the point of death.

A lot of forest trees will reproduce when they are very healthy, are mature enough, and have a large enough crown; sometimes associated with a high nutritional status. Trees from stands that are mechanically thinned out or fertilized will reproduce at a younger age, as well as trees from a rich site. Trees that are grown very close together, have a small crown and have much competition for nutrients and sunlight will not reproduce in this arrangement. It will give up its competitiveness for sunlight and nutrients. If a tree gets severely scarred or undergoes a lot of damage (stressed to death), that tree will produce a lot of seeds to try to propagate the species. These seeds may not be the best quality seeds, with lots unable to germinate – but nevertheless, there will be some good seeds available for that purpose.

There are other processes that organisms undertake, such as assimilation, which is the taking up of food from photosynthesis and using it within the plant for further growth and development. A couple of comments on these processes are that some plants are more efficient than others in certain processes – sometimes either genetically or the way the plants are structured, or because of the site on which the plant is growing. For example, balsam fir is wasteful of its water use

because this tree species usually grows on a rich site where water is normally plentiful. Also noteworthy is that plants are very good recyclers for nutrients within themselves. For example, when leaves are shed in the fall, the tree usually sends out its waste products to the leaves prior to shedding. The chloroplasts of the leaves are retained by the tree for future use. Trees also move other recycled products throughout the plant by means of the tree's plumbing system.

2.2 Discuss terms of longevity and growth rates.

Longevity means how long something is normally able to live. Some organisms may live for 1 day, 1 month or 300 years. Most animals do not live beyond 100 years, with the majority being much shorter. Trees and shrubs have become described as short-lived and long-lived and they are usually compared to each other within a region. For example, pin cherry is short-lived in the Boreal forest, at 20-30 years, but would be long-lived when compared to the eucalyptus plantation at 5-8 years maturity. The oldest known biotic organism on Earth is the bristlecone pine (Pinus longaeva) at over 4600 years of age. Longevity is important for outlasting short-lived plants in the same forest. Some forests turn into a forest of the longest-lived species. Some species of great longevity reproduce later than other species, while some species that are short-lived reproduce at a very young age. Recall that it is the goal of every organism to reproduce, and short-lived plants have some disadvantages if they have to reproduce in an environment that is competitive.

Rate of growth is very important within a competitive environment. No two species grows at exactly the same rate. Two different species growing side by side on the same site might experience different growth rates because of different niches and their differences in ability to use the site for growth purposes. Actually, two of the same species growing side by side on the same site may experience different growth rates, but this would be more related to genetics. A lot of trees that are short-lived have fast growth rates, such as trembling aspen.

2.3 Describe different means of reproduction by most plants.

Almost all plants reproduce by seeds with a few exceptions, and all plants' main goal in life is to propagate the species. Recall that reproduction takes a lot of effort from a plant's point of view; production of flowers, pollination, fertilization, growth, health status, etc. Once the seeds are produced they are then dispersed by various means such as wind, gravity, animals, birds, etc. After dispersal, there is no guarantee that the seed will land on a good seed bed or that it will germinate, or is able to germinate - a lot of effort on a plant's part without the certainty of an offspring. Some trees can produce a lot of seeds, sometimes over a million seeds in a good year. One good thing about a seedling (a tree originating from a seed and that is usually less than 1.3m in height) is that it is diverse in genetics; having male and female parents. The timeline for seed production after the first appearance of flowers (cones) can range from weeks (willow, trembling aspen) up to 3 years (some species of pine and spruce).

An alternative to reproduction by seed for some plants is the production of clones – a genetic duplicate of the parent that may grow from a certain plant part. The clones are given certain

names depending upon what part of the tree they originate such as:

Sprouts – new growth arising from a cut stump, e.g. White birch, balsam poplar

Suckers – new growth arising from roots, e.g. Trembling aspen

Layering – new growth arising from a branch going underground and coming back up to form a tree, e.g. common to black spruce on bogs.

Sometimes, a whole forest may grow this way, and this would be called a coppice forest – meaning that all the trees have the same parent - all clones. Other ways that plants have been known to reproduce vegetatively is when some leaves have been separated from the parent plant, and then these leaves could produce another plant, still is a clone. When some twigs break off from the parent and fall to the ground, these twigs could produce a clone if that twig had buds on it before it fell. Also, some pieces of trembling aspen that have been cut into stove-lengths for firewood have grown twigs on their bark.

There are lots of advantages to a tree species for coppicing. Where a tree grows on a poor site, this can help immensely. Some disturbances, such as a fire, will burn the above ground material and not the roots and this could provide for suckers – this is very common for trembling aspen. These suckers help the aspen to take over this fire-killed site very quickly and usually don't allow other species to grow on the site. Some other advantages of vegetative reproduction from a tree's point of view are:

- Sharing an existing root system with the parent tree
- Guarantee of growing space for the new clone
- Genetics are already proven on the site (it can survive)
- Can occur very quickly
- Less energy from the parent
- Head start on anything coming from seed origin

The biggest disadvantage of a coppice forest is that they're all clones that have the same genetic make-up. These clones may be well-adapted to the site, but if something goes wrong, then it can be disastrous. Having the same genetics can be bad in times of infection, infestation outbreak, or some disaster that the clone's particular genetic makeup can't overcome. If one clone plant can't recover and dies, then all plants in that clone will likely die. This is the biggest disadvantage of clones or a coppice forest. Some foresters call "coppice forests" similar to putting all your eggs in one basket.

The best alternative to a coppice forest is when we have the forests being produced by seeds which will have genetic diversity. When we have seeds of different genetics, then we have the ability to respond to more disturbances or catastrophic events. This is the biggest advantage of many seeds of different genetics –the potential to adapt. The potential to adapt has contributed to the survival of most species on earth today.

2.4 Define terms of self-pruning and self-thinning

Another term for self-pruning is natural pruning and both terms mean that a tree will get rid of its lower branches by natural means. Trembling aspen and Jack pine are great self-pruners, meaning that these trees will have a long trunk free of branches. A branch-free stem will have fewer knots in lumber manufactured from that stem, usually making it more commercially valuable. The lower branches are dropped off by the tree because the tree has no more use for those branches (and possible leaves) in that location. Usually shading of the branches is the main cause of self-pruning but an injury may cause this as well. For a tree to be termed a good self-pruner, that species will drop its branches a lot younger in life than another species. Tree species are considered good self pruners when branches will not grow back on the tree trunk where there were once branches even if something allowed more sunlight to penetrate through the crown. Trees that are good self-pruners normally can't stand any amount of shade to any parts of their live crown.

This knowledge is important for mechanical pruning for telephone poles and Christmas tree growers. Species that are known as poor self-pruners can have new branches grow back on the site where the pruned branches were if sunlight is able to hit the tree stem.

Species that are considered good self-thinners are much like the self-pruners in growth habitat. Good self-thinners are trees that will reduce their stem numbers very quickly when young due to competition and shading concerns. Species characterized as self-thinners will usually have low numbers at maturity and are very competitive in nature. Good self-thinners will have a lot of mortality on the site, which are generally the smaller trees that fell out of the race. Good self-thinners will occasionally kill their own clones due to competitiveness. Trees that are poor self-thinners will have high stem numbers, be very crowded on occasion and are generally longer-lived than the good self-thinners. Trembling aspen, balsam poplar, jack pine, pin cherry are good self-thinners, while balsam fir and white spruce are poor self-thinners.

2.5 Describe the term "tolerant" and "intolerant" with respect to shade and other site factors.

The term tolerant means "able to put up with" and is usually followed by a condition such as shade or moisture. Plants that are shade tolerant are able to withstand and may live for a long time in the shade. Some plants can tolerate shade, but if these trees are given full sunlight, then lots of these species will respond positively to the new light. Some other plants can only live in the shade, and are not adapted to lots of sunlight – so there wouldn't be much point in providing these plants with lots of sunlight. Plants that are shade intolerant cannot live in the shade and would shortly die if they became fully shaded. If one was to put numbers from 1 – 10 alongside the tolerance levels and an example of a tree species, it would look like this:

Numerical Value	Rating	Species
1-2	very shade intolerant	trembling aspen, willow, pin cherry
3-4	shade intolerant	Jack pine, tamarack larch

5-6	intolerant/tolerant	balsam poplar, white birch
7-8	shade tolerant	white spruce, black spruce
9-10	very shade tolerant	balsam fir

Note: these numbers are not exact and is used here as a comparable illustration

The term tolerant is sometimes used in forest ecology for terms of moisture tolerance – meaning some plants can tolerate moisture-rich sites; some species will even flourish on these sites. Moisture intolerant means that a species will grow on a dry site, such as Jack pine growing on dry, sandy soils. Some species can grow on poor wet sites; tolerate these sites while some won't grow there at all. For example, tamarack larch will grow on poorer sites, and can tolerate wetter soils, but tamarack larch doesn't do as well on rich forest sites. Some species will only grow on rich sites, and are sometimes used as an indicator of site richness. Tall ferns in a forest are an indicator of site richness. Sites that are growing balsam fir and white birch are generally considered rich sites.

Bear in mind that some species can tolerate certain conditions and can live quite well on these sites. Lots of plant species would want to be on a richer site but this may not be possible for one of two reasons;

a) the plant's genetic processes may not be best suited to this site
b) the plant may not be as competitive on this site as other plant species which are more suited to this site.

2.6 Discuss some features of growth that are different from shade intolerants to shade intolerants.

We have discussed already that shade intolerants are great self-pruners and self-thinners, but there are many other features that are also common. Let's look at shade intolerants a little closer. Shade intolerants don't like shade, they like full sunlight. There is not much sunlight on a full-canopied forest floor, so you wouldn't find any shade intolerants here. Shade intolerants will want full sunlight and this is usually achieved after some disturbance in a forest – such as a clearcut, fire, blowdown, insect outbreak, etc., - something that will get rid of the existing overhead vegetation. Shade intolerants can now overtake this site very readily. Shade intolerants have some physiological features that enable them to move in on this new clearing. Most shade intolerants will:

a) produce a lot of seeds
b) produce these seeds rapidly
c) produce very small seeds to be distributed easily
d) produce these seeds younger in the tree's life

Shade intolerants are generally short-lived but very fast growers. Shade intolerants put a lot of energy into reproduction. When shade intolerants are mature trees, they won't have their own seedlings grow under the crown of the parent trees. The only way that this can happen is if there

is lots of light in the understory – because the seedlings need lots of light as well as do the parent trees.

Shade tolerants generally have lower seed numbers and are usually producing seeds later in life. Shade tolerants don't put as much effort into reproduction as shade intolerants. Shade tolerants are usually more long-lived and slower growing than shade intolerants. Shade tolerants can have their own seedlings living in the understory of themselves (because they tolerate shade). For this reason, shade tolerants can usually replicate itself in a natural environment.

If we clearcut a forest stand that was white spruce and trembling aspen, and planted white spruce within a year of harvest, we would not normally have a monoculture white spruce plantation. The trembling aspen would sucker in very vigorously on this site, where trembling aspen is very shade intolerant and grows fast. The trembling aspen would soon overtake the white spruce in height, size and number. The white spruce will tolerate the shade of the trembling aspen for a long time, growing in height each year, but not as much as the trembling aspen. As the trees reach 60 – 70 years of age, the trembling aspen will start to die out (not as long-lived as tolerant white spruce) and the white spruce will eventually take over the site. If the forest floor is heavily shaded, then there might not be any trembling aspen in the understory, but there may be white spruce seedlings in the understory if the right conditions existed for them to be there. If there are lots of white spruce in the understory, then that is what the future forest will look like after the original crops of mature white spruce die. In forestry circles, this is known as a climax forest, meaning that species (white spruce) will occupy this site for generations unless something occurs, such as a disturbance of fire, clearcut, etc.