SUSTAINABLE FOREST MANAGEMENT NETWORK
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Competition and light in boreal mixedwoods: implications for spruce regeneration

Highlights

- Since light is a limiting factor for growth of understory trees in mixedwood forests, it is often used as a measure of plant competition.
- Under conifer-dominated canopies, juvenile white spruce need about 40% of above-canopy light for maximum height growth. Virtually no understory spruce survive when light levels drop below 8%.
- Leafless aspen canopies transmit a large amount of light to the understory in spring and fall; this may be why juvenile spruce can survive in dense aspen stands that have less than 8% light levels in summer.
- Mature balsam fir, spruce and birch have long, dense crowns and therefore capture more light than pine, aspen or balsam poplar.
- In both juvenile and mature stands, aspen have little impact on spruce mortality. In mature stands, canopy-sized spruce are more likely to die if there are spruce nearby.
- Simple measures of competition, such as basal area of adjacent trees or % cover of understory vegetation, are as good at predicting growth as complex indices that use exact measures of tree size and distance, or models of light transmission.
- Recent work indicates that the size of the tree at year 14 is a much better predictor of its future growth than assessments of the immediately surrounding neighbours.

Neighbouring trees, shrubs and other vegetation often have a negative effect on growth of conifer seedlings. Various studies have measured the impact of neighbouring trees by measuring or modeling the light availability or by measuring the size and proximity of neighbours through competition indices. These competition indices have been used in growth and yield models and in regeneration standards such free-to-grow assessments.

This note summarizes the research findings from several studies partially supported by the Sustainable Forest Management Network and other agencies.

Why measure light in boreal mixedwoods?

In mesic and nutrient-rich sites, light is thought to be the most limiting resource for understory tree growth. Light availability is linked to the height of surrounding vegetation and the amount of light it intercepts.

Light can be measured in several ways:

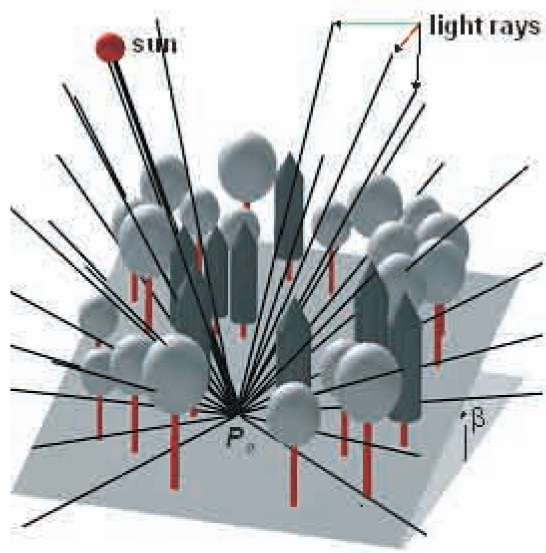
1. Radiometers measure light directly, but several measurements are needed for an estimate of seasonal light.

Photo courtesy of Victor Lieffers.

2. Seasonal light can be estimated using a hemispherical photograph of the canopy and computer software which tracks the sun. This technique is not precise at low light levels.

Photo courtesy of Ken Stadt.

3. Light can also be modeled from the spatial distribution of trees, size of tree crowns, and their density. The MIXLIGHT model estimates the light transmission over the season to a particular point in the understory. If the spatial coordinates of trees are not known and the canopy is closed, a simpler sub-model estimates the average understory light. MIXLIGHT was calibrated and tested in mixedwood forests of various composition, size and density in Alberta and Quebec.



Not all competitors are created equal

Figure 1 (next page) shows how tree species can influence the amount of light that reaches the understory. Light transmittance is lowest in balsam fir due to high foliage density, and this can limit the growth of understory spruce (Alberta data). Aspen and poplar have the lowest foliage density, allowing more light to reach understory spruce.

Competition varies between tree species:

- Spruce and balsam fir stands have the lowest understory light levels, due to their high density of foliage and long crowns. Conversely, hardwoods have the most understory light, due to their lower density of foliage and shorter crowns.
- Mature balsam fir, spruce and paper birch have the greatest negative effects on growth of other trees.
- Mature aspen have a smaller suppressive effect on growth of neighbouring trees of similar size, than most other tree species.
- In some circumstances, the presence of balsam poplar relates to increased growth of spruce.
- In juvenile stands, the number or size of juvenile aspen does not affect the mortality of planted spruce when the aspen are located within 1.78 m of the spruce. In mature stands, the mortality of mature spruce is also unaffected by the presence of neighbouring aspen within 1.78 m. However, mortality increased if other mature spruce neighbours were within the 1.78 m zone ($10m^2$).
- Herbs and grasses that have persistent litter that remains upright after death (such as *Calamagrostis canadensis*) have very negative effects on small conifer seedlings because it shades spruce seedlings during the fall and early spring. *Calamagrostis* also competes for soil moisture and nutrients. Under a load of snow it will collapse and press spruce seedlings flat to the ground.

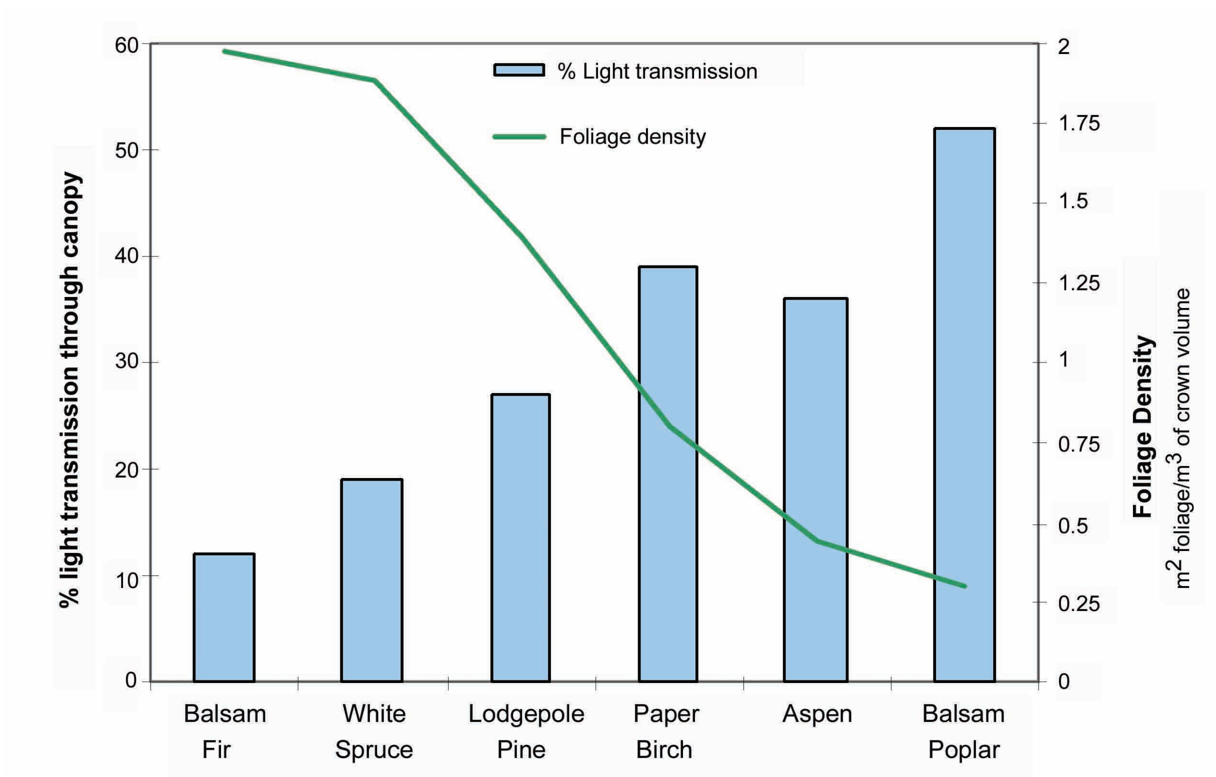


Figure 1. Influence of tree species on light reaching understory.

Implications for spruce regeneration

Aspen lets the spruce grow in its off-seasons

In early spring and late fall, aspen are leafless. As spruce are able to photosynthesize at this time, the aspen has little negative effect on the spruce. Note the blue-sky conditions through the aspen canopy in the fall photo to the right. In contrast to the aspen, a taller spruce tree will strongly shade its neighbours year-round.

Photo courtesy of Victor Lieffers.

How much light is needed to grow spruce in boreal forests?

If a spruce or fir canopy is above the spruce sapling, 40% light is needed to attain maximum height growth, while less than 8% light can cause mortality. If light levels are measured in mid-summer, understory spruce can withstand lower light levels under aspen or balsam poplar canopies. This is because there are spring and fall 'shoulder-seasons' where additional light is available for spruce growth that would not be available if the spruce sapling was in the understory of a conifer stand.

Measuring plant competition

Often research on the measurement of competition or light used complex methods for assessment of plant competition. Given the practical constraints of operationally-collected data, however, simple techniques were often found to be just as good.

1) The basal area (or sum of diameters) of adjacent trees predicts the growth of mature trees almost as well as more complex competition indices measuring distance to and size of adjacent trees.
2) A simple measure of the basal area of neighbouring trees surrounding a spruce sapling generally predicts its growth just as well as modeled-estimates of light transmission.
3) Simple estimates of the percent cover of shrubs and herbs were better at predicting light transmission than complex light models using difficult measures of leaf area and leaf angles. Many pre-harvest survey efforts already measure percent cover of shrubs and herbs.

Implications for regeneration standards

Free-to-grow standards (FTG) are a widely-applied standard for assessing competition in juvenile stands. In 14-year old Alberta plantations, a conifer crop tree must not have taller hardwood trees or shrubs within a 1.78 m radius in order to pass the FTG assessment. If a tree passes the FTG assessment it is thought that the tree will survive to maturity and no further silviculture intervention is required for regeneration.

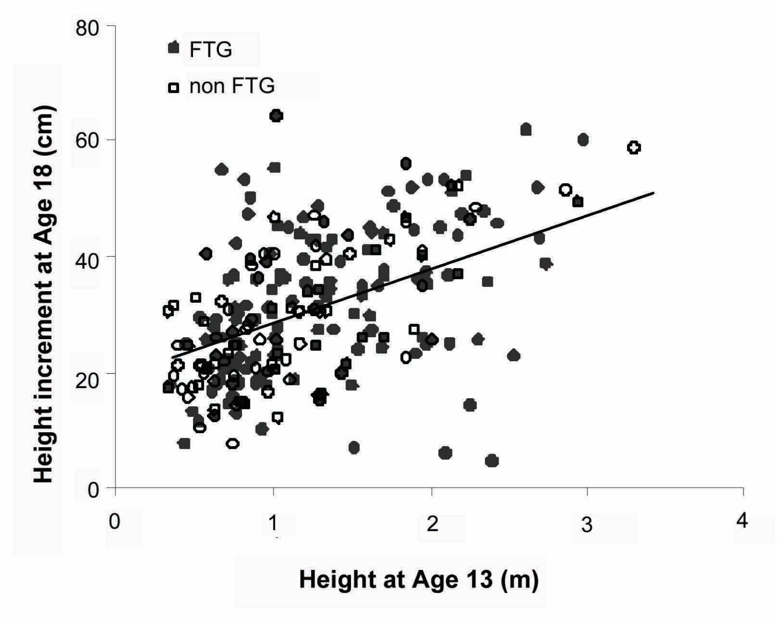


Figure 2. FTG vs. non-FTG assessment.

Recent work indicates that the size of the tree at year 14 is a much better predictor of its future growth rate than this FTG assessment. As figure 2 shows, the annual height increment of a white spruce at age 18 years is not well-predicted by the FTG status of the tree at age 13 years.

The reason for poor prediction based upon FTG status is likely related to the fact that a plot of 1.78 m radius (10m^2) is too small an area for assessment of competition at this stage of stand development.

Further reading

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Management Implications

- Balsam fir, spruce and paper birch are more important competitors on growth of both juvenile and maturing spruce than are overstory and neighbouring aspen.
- In partial-harvesting regimes, leaving aspen or balsam poplar as residual trees will have less impact on the growth of regenerating trees than leaving spruce or balsam fir as residual trees or variable retention.
- Free-to-grow assessments at year 14, using plots 1.78 m in radius were ineffective at predicting future growth of spruce saplings. Either very large plots (5 m radius) or stand-level averages of competition from other trees are needed to assess competition from other trees at this stage.
- Competition from grasses and forbs may be problematic for growth and survival of spruce seedlings in the first few years after establishment. In boreal mixedwoods, control of this competing vegetation is often necessary for the early establishment phase of spruce.

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