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Silvopasture In British Columbia Information Series

Unit 2.s.1. Light and Microclimate in Silvopastures

Acknowledgment

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Insert local indigenous territorial acknowledgment.

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Silvopasture in BC Information Series Content Guide

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This supplemental unit is part of the information series on silvopasture in BC.

It builds on information presented in core unit 2, the science behind silvopasture.

Unit 2.s.1. Light and Microclimate in Silvopastures

Goal

Provide a deeper understanding of the science behind silvopasture design and management, specific to light, microclimate and photosynthesis.

Prerequisites

Unit 2: Science Behind Silvopasture.

Content

1. Plant physiology and photosynthesis: Cool vs Warm Season Plants
2. The Physics of Light
3. Microclimate and Photosynthesis

The goal of this unit is to provide a more in depth understanding of the scientific underpinnings to silvopasture, specifically as they relate to the use and modification of light by plants, and the impacts of trees and shrubs on microclimate.

This supplementary unit covers an advanced topic. You should complete core unit 2 in this information series before moving onto this content. Some post-secondary science knowledge will be helpful.

We will explore the following:

1. Plant physiology and photosynthesis: cool vs warm season plants;
2. The physics of light and impacts of canopy layers; and,
3. The impacts of humidity and temperature on understory photosynthesis.

Silvopasture Resource Sharing and Interactions

Photosynthesis

Carbon dioxide (CO_2) turned into carbohydrates (food) and oxygen, powered by sunlight.

Different processes for: cool-season vs. warm-season forages.

Plants capture the energy from the sun to combine carbon dioxide (CO_2) from the atmosphere with water to create carbohydrates (food) and oxygen.

Not all plants use the same physiological set up to accomplish this. There are differences in the leaf anatomies and specific enzymes used to carry out photosynthesis. These differences relate to the environments in which different plants evolved.

Forages grown in BC can be grouped into one of two types based on these variations in the process of photosynthesis they use: they are either cool- or warm-season plants.

Silvopasture Resource Sharing and Interactions

Cool- and Warm-Season Plant Differences

Cool Season Plants

- a.k.a. C3 plants: produce an acid with 3 carbon atoms as first product of photosynthesis.
- Lose water during photosynthesis.
- Includes most common forages grown in BC pasture and range land.

Warm Season Plants

- a.k.a. C4 plants: produce an acid with 4 carbon atoms as first product of photosynthesis.
- Efficient CO_2 and water use but need high temperatures (30-35^o C).
- Only a few C4 crops are grown in warmer areas of BC.

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The main differences in cool and warm season forages are as follows:

Cool-season plants are also called C3 plants because when CO_2 is 'fixed' from the atmosphere, an acid containing 3 carbon atoms is the first product of photosynthesis.

With cool-season plants, water is lost to the atmosphere during photosynthesis when plant openings on the leaves (stomates) are opened to exchange O_2 (out) for CO_2 (in).

C3 plants include most of the common forages grown in pasture and range settings: including orchard grass, fescues, pine grass, clovers, and alfalfa.

Warm season plants are also referred to as C4 plants because when CO_2 is 'fixed' from the atmosphere, an acid containing 4 carbon atoms is first produced before following the same biochemical path of C3 plants.

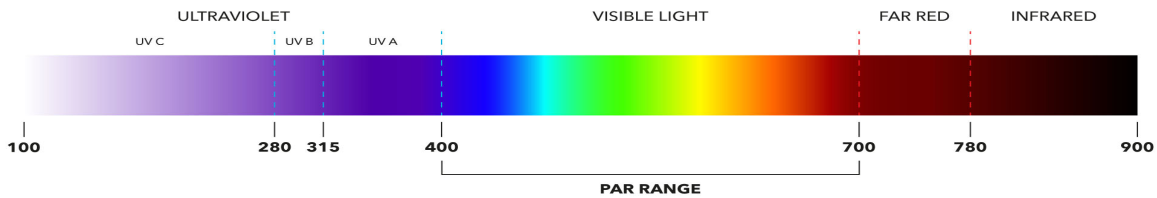
C4 plants are much more efficient in their use of CO_2 because they can recycle some of the output from internal respiration. They also do not need to open their stomates for gas exchange during photosynthesis, and therefore are much better at preventing water loss.

The C4 physiology, however, comes with the trade-off of needing higher temperatures (30-35^{o}C) for optimal growth.

Only a few higher yielding, but temperature sensitive, C4 crops are grown in warmer areas of BC: mostly corn, millet, and sorghum.

Silvopasture Resource Sharing and Interactions

Light Availability and Photosynthesis



- Only a portion of solar input used = Photosynthetically Active Radiation (PAR).
- Light compensation point = minimum PAR needed to survive (~10% full sun).
- Light saturation point = maximum PAR that can be used:
  - Cool-season plants ~ 50% of full sun
  - Warm-season plants ~ 85% of full sun

All plants transform sunlight into biological energy by photosynthesis. But only a portion of the solar input can used by plants. This range of wavelengths is referred to as Photosynthetically Active Radiation (PAR).

For any given species, plant growth has both upper and lower thresholds in response to PAR; that is, photosynthesis responds to a range of light levels, above and below which there is no change.

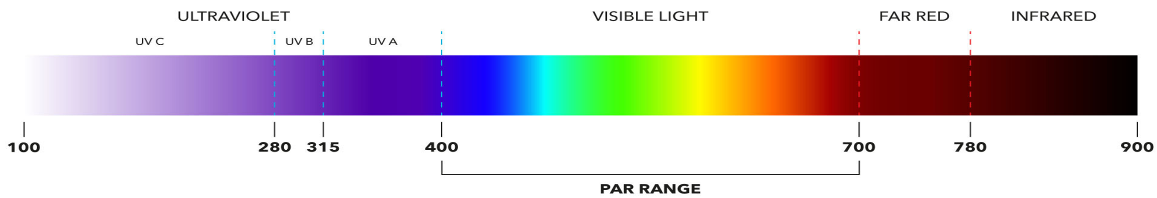
At the light compensation point (LCP), light levels are insufficient to generate enough energy in excess of the base amount consumed in order for plants to survive. Whereas, at the light saturation (LSP), additional units of PAR do not increase the rate of photosynthesis.

LCP for most plants is about 10% of full sunlight. LSP ranges from approximately 50 to 80% of full sun and is dependent on air temperature (net photosynthesis over respiration) and the plant physiology. Cool season forages have much lower light requirements than warm season forages.

This is an important consideration in silvopasture design. For example, in the Central Interior on a clear day, solar input can exceed 2600 umol/m/s PAR. Alfalfa, a widely cultivated forage, can only make use of up to 1450 umol/m/s PAR (it's LSP). Meaning overstory canopies can block 45% of incoming PAR and have no impact on alfalfa photosynthesis.

Silvopasture Resource Sharing and Interactions

Light Quality and Forage Growth



- As light passes through the uppermost canopy layer, the spectral quality changes.
- Important ratio: Red to Far-Red wavelengths (R:FR).
- Low R:FR ratio triggers growth change: elongated stems, less tissue density, less roots.

In addition to reducing the total amount of light reaching the lower layers, overstory canopies also change the quality of the light.

Because the upper canopy is absorbing light in the range for photosynthesis, its foliage selectively filters more red than far-red wavelengths. This results in a decreased R:FR ratio.

And this is an important ratio for plant growth because of its influence on plant growth hormones. Plants have light quality detection chemicals called phytochromes. They respond to the balance of red light in proportion to the amount far-red light reaching their leaves.

When low amounts of R:FR are detected, the plant growth form changes as a survival mechanism. Plants will start ‘reaching for the light'. This makes the shaded plant taller with less tissue density (aka ‘spindly'). Deeply shaded plants also devote more growth to the shoot than the root. This makes heavily shaded plants more susceptible to soil moisture and nutrient shortages.

Silvopasture Resource Sharing and Interactions

Light and Delayed Development

- Small reductions in PAR and a shift in light quality with other understory effects can be beneficial.
- Delays the maturation of forage crop to later in the season.
- Supports lush forage, at peak quality, later in the growing season.

Sometimes, small reductions in the PAR reaching the understory coupled with other understory effects (temperature reductions) can be beneficial to the management goals.

This occurs when the modifications caused by the overstory delay development and maturation of the understory forages.

Pushing back the development of the silvopasture forages creates the opportunity to support more lush foliage, at or close to peak quality, later in the growing season than open-grown forages that have already matured.

A silvopasture strategically used for summer or early autumn grazing, therefore, extends the overall period of high-quality grazing resources available to the operation.

Silvopasture Resource Sharing and Interactions

Temperature and Relative Humidity

At the herbaceous and intermediate phases in silvopastures, the above-ground climatic conditions, including temperature and humidity, will mirror open pasture conditions.

At the mature/arboreal phase, however, tall trees and shrubs have strong effects on the microclimate in their understory.

Silvopasture Resource Sharing and Interactions

Temperature Effects on Plant Physiology

Positive

Moderate extreme temperatures that can impact cool-season crop production.

Negative

Cooler temperatures in understory work against the base requirements of warm-season crops.

Large woody plants can both depress high temperatures and counter-act low temperatures, and therefore act as a moderating factor for forage growth.

As a consequence of blocking sunlight, they will reduce the amount of short and long-wave radiation reaching the ground. This can account for a 5 to 10% drop in peak temperatures. This can improve the production of cool season grasses, however the temperature reductions in the understory can have negative implications for the growth of warm-season crops, that only grow optimally at higher air temperatures (30 to 35^{o}C).

Silvopasture Resource Sharing and Interactions

Relative Humidity

- Cool-season forages need stomates open for photosynthesis.
- When the air is too dry, these plants close leaf openings to conserve moisture.
- Mature trees and shrubs elevate humidity allowing crops to continue to grow.

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Large trees and shrubs also benefit understory production of cool-season forages through their impact on humidity.

Recall that cool-season plants must actively exchange oxygen for carbon dioxide for photosynthesis to proceed. They do this through microscopic openings on their leaves called stomates.

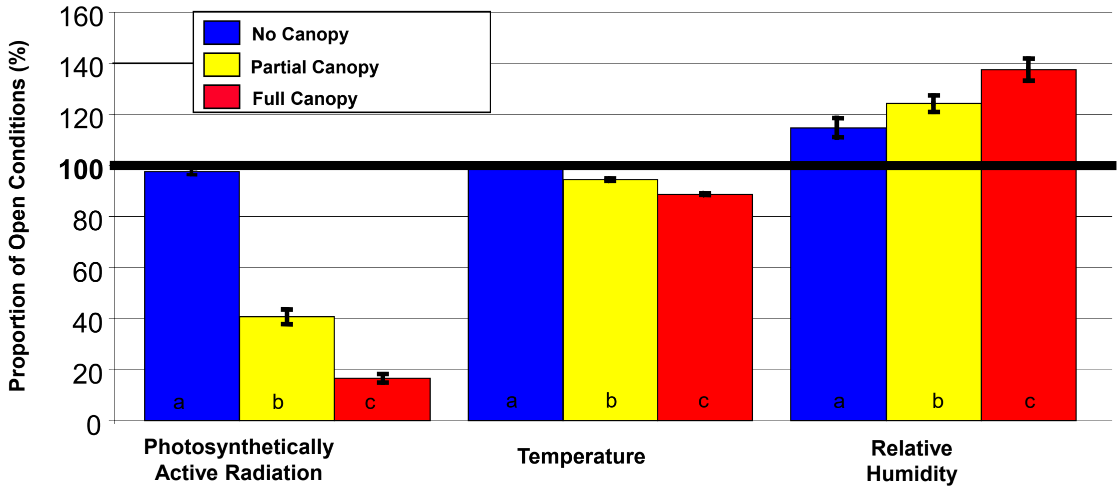
When leaf stomates are open for photosynthesis, they also allow moisture to escape from the plant. If the surrounding air is warm and dry, the water vapour losses from the plant are potentially lethal, leading to desiccation. So as survival mechanism, when the leaf-to-atmosphere vapour pressure differences are large, the forage leaf will close its stomates.

When the stomates are closed, photosynthesis also shuts down. This means that under otherwise optimal conditions in the open for light, soil moisture and nutrients, growth and development of the cool-season forages will cease due to low humidity.

An overstory can elevate the humidity below, allowing crops to continue to grow.

Silvopasture Resource Sharing and Interactions

Average climatic conditions in a silvopasture in the Lower Boreal ecoregion of central Alberta



Powell 2003 PhD Dissertation

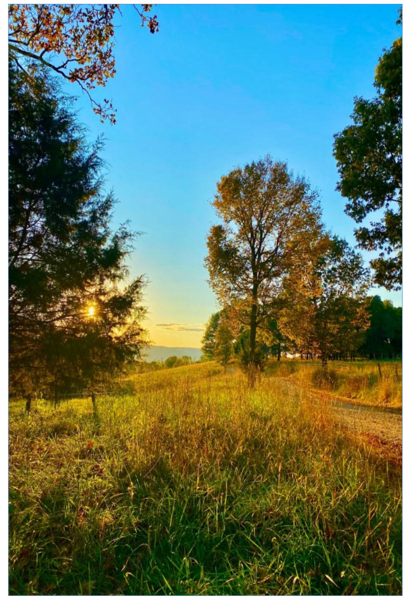
Growth chamber and field studies have confirmed that these overstory impacts on temperature and humidity are always occurring, though they are often masked by reductions in the amount light reaching the forage crops and competition for water.

In times of prolonged drought or elevated temperature, however, net positive production can be expressed in the understory relative to open conditions, and is a strong argument for including some silvopasture units in your operation as a production diversification strategy.

This figure shows the average climatic conditions over four years in a silvopasture in the Lower Boreal ecoregion of central Alberta (similar conditions to the Sub-boreal spruce biogeoclimatic zone in BC).

The partial canopy of the silvopasture configuration, while reducing light, also depressed air temperatures and elevated relative humidity. These changes resulted in better forage production during a drought than in adjacent open pastures.

Questions and Discussion



Question and answer break.