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Silvopasture In British Columbia Information Series

Unit 2. The Science Behind Silvopasture

Acknowledgment

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Insert local indigenous territorial acknowledgment.

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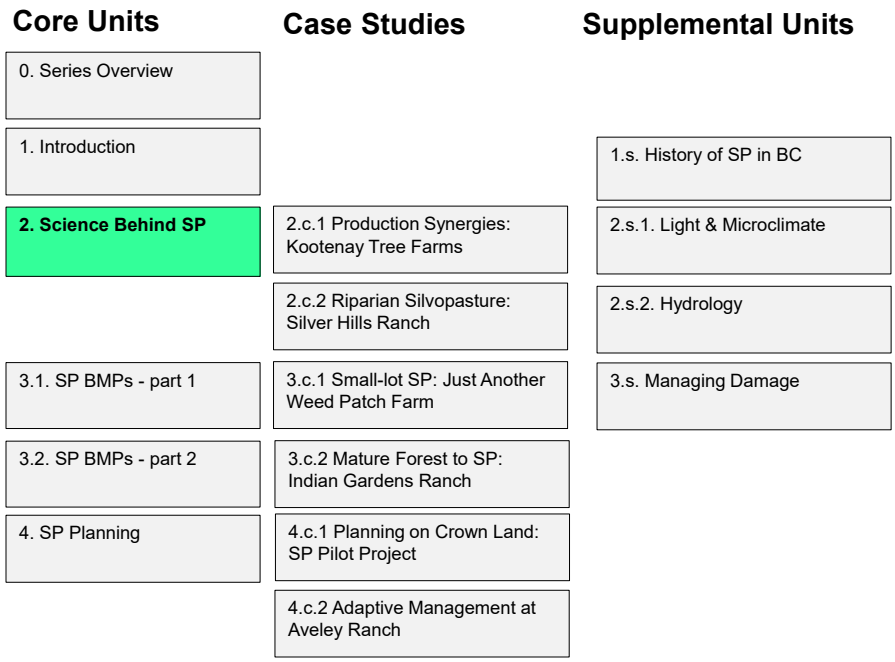
Silvopasture in BC Information Series Content Guide



This second unit in the series focuses on the science behind designing and managing interactions among the forage, livestock and woody components in silvopastures.

This core unit follows on the information presented in the Introduction and is paired with case studies and supplementary units which go into greater details on certain aspects of silvopasture science.

Unit 2. The Science Behind Silvopasture

Goal

Understand the scientific foundations for silvopasture design and management.

Prerequisites

Unit 1 - Introduction.

General understanding of plant, soil and animal sciences

Content

1. Basic Concepts: Resource Sharing, Interactions, Development Phases
2. Above-ground Resource Sharing and Interactions
3. Below-ground Resource Sharing and Interactions
4. Livestock Effects

The goal of this unit is to gain an appreciation for the science behind designing and managing silvopasture systems, with an emphasis on helping you understand, identify and manage the key ecological interactions.

Before completing this unit you should complete unit 1, an Introduction to Silvopasture in BC and have a general understanding of plant, soil and animal sciences.

In this unit we will cover the following:

1. Some basic concepts on how mixtures of trees and forages share resources (water, nutrients, light), highlighting how these can be positive or negative for each others growth and survival, and how they can vary as a silvopasture develops;
2. Detailed look at some specific above-ground processes;
3. Detailed look at some specific below-ground processes; and,
4. How livestock can alter these relationships.

Silvopasture: Agroforestry for Pastures and Range

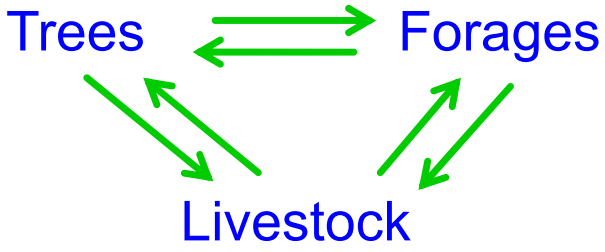
Managed Grazing + Trees and Shrubs + Forages

Silvopasture is the combination of managed grazing in pasture or rangeland settings where trees and shrubs are desired to achieve social, economic, production or conservation goals. In addition to establishing both trees and forages at the same time, silvopastures can be created by introducing or augmenting existing forages in treed systems or by introducing trees into pasture systems. Silvopastures are managed for a blend of forage, livestock and forest products as well as environmental functions.

It is important to understand, that like all agroforestry practices, silvopasture is not defined simply by grazing and forage production in the presence of trees and shrubs. Rather, all the components (the grazers, forages and woody perennials) are integrated through careful planning, implementation and ongoing management.

Silvopasture is a Type of Applied Ecology

- Understanding basic principles will help design and manage your silvopasture.
- Focus: manage resource sharing and interactions among three components.



In silvopasture there are many components that interact and share the growth potential of a given site. For simplification we concentrate on three primary variables: trees / shrubs, forages and livestock / grazing animals.

Resource Sharing

Primary strategy is to separate resource use in space or time:

1. Multiple canopy layers: make full use of sunlight.

2. Multiple rooting layers: utilize different soil zones.

3. Leverage seasonality: blend species with minimal growth cycle overlap.

Sharing resources by separating their use either in space and/or time allows for greater overall production in mixtures than the equivalent combined areas in monocultures of either trees or forage crops.

Successful resource sharing in mixtures is achieved by blending crops with differing shapes and sizes, so that we can separate resource use into different layers in the air and different rooting zones below ground.

Separating resource use in time is also possible by selecting species with different growth cycles and peak demands on resources.

For example, silvopastures under a mature canopy of deciduous trees or shrubs can still have near full light available in their understory both before the trees leaf-out in the spring, and after leaf fall in the autumn.

Competition and Facilitation

- Balance competitive (negative) and facilitative (positive) effects.
- Livestock can alter the balance.

Optimal production in species mixtures can be also achieved by encouraging facilitative (positive) rather than competitive (negative) effects, alone or in combination with separating resource use.

The production of mixtures of species of any type ~~are~~ always expres~~sing~~ a mixture of competition and facilitation **effects.**

In Silvopastures:

Competition is the negative effects on plant growth, reproduction or survival caused by the presence of other plants that reduce the availability of resources, including nutrients, light, water, space, pollinators and others. Competition occurs both above- and below-ground.

Facilitation is the opposite process. Positive effects on plant growth, reproduction or survival caused by the presence of other plants via increasing the availability of resources, or modifications to the microclimate. Facilitation also occurs above- and below-ground.

Animal use impacts the balance between competition and facilitation through the removal or destruction of plant material by grazing, browsing, rubbing and trampling, as well as, the redistribution of nutrients deposited in manure and urine.

Balancing Positive and Negative Interactions

Each silvopasture component can modify the growth conditions for the others. Three possible outcomes:

1. Net Competition: overall productivity, resulting in underyielding.
2. Balanced: no significant impact on net productivity.
3. Net Facilitation: mixtures enhance total productivity, resulting in overyielding.

Management goal: promote positive interactions and minimize negative processes.

~~P~~asture or range managers can sometimes focus solely on competitive effects from including trees and shrubs in grazing areas. In reality, mixtures of plants of any type are always expressing a mixture of competition and facilitation, with net effects being any of the following:

1. Net competition (under-yielding) - leading to lower production per unit area;
2. Balanced - expressing no production differences relative to separating production;
3. Net facilitation (over-yielding) - leading to increased production per unit area.

The goal of silvopasture design and management is to promote conditions for over-yielding, through resource use separation and optimizing facilitation, or at a minimum achieve balanced production such that other social or economic outcomes are realized without sacrificing productivity.

Resource Use and Interactions Will Vary

Some interactions can change over time

1. Daily: driven by the angle of the sun and cycle from day to night.
2. Seasonally: driven by the tilt of the earth as it travels around the sun, and biological factors.
3. By Development Stage: as a silvopasture matures through three distinct phases.

The net results that are expressed at any give site are the result of the species that are present, site conditions and microclimate. And they can change seasonally and through the impacts of grazing.

All production systems are constantly in a state of change. For silvopasture management purposes, we consider three important cycles of change:

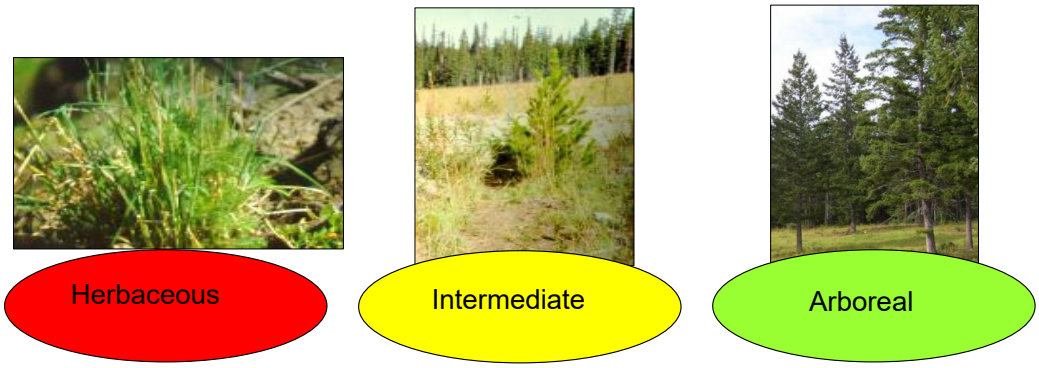
Daily (diurnal): driven by the solar changes from day to night as the earth rotates and the resulting changes in light and temperature;

Seasonal (annual): driven by the movement of the earth around the sun plus biological factors, including overstory type, and the seasonality of livestock use; and,

Developmental: driven by changes brought about by growth in the tree/shrub layer, usually marked by three phases.

Silvopasture Development Phases

1. **Herbaceous Phase**: Trees, shrubs and forages interact symmetrically and all are susceptible to direct livestock impacts.
2. **Intermediate Phase**: Interactions are limited to soil resources; most livestock impacts on trees and shrubs diminished.
3. **Arboreal Phase**: Mature trees/shrubs control availability of most resources and microclimate; livestock have limited impact on trees.



Silvopasture development is driven by the relative size of the tree and shrub components. It is important to note, however, that this is not strictly related to age. They will grow and develop in proportion to the net competition or facilitation they experience.

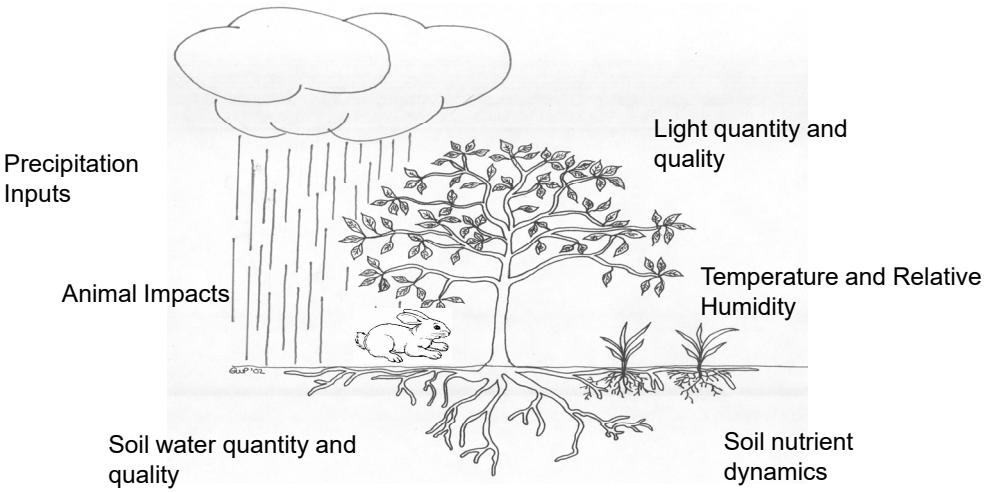
Herbaceous Phase: All interactions are symmetrical, or proportionate to their size, and all are equally susceptible to direct livestock impacts (either positive or negative).

Intermediate Phase: Tree and shrub canopies have grown to the extent that they no longer compete with the forage layer for light. Competition or facilitation for soil resources can be prominent at this phase. Livestock interact with and impact the forage layer, but their impacts on trees and shrubs are usually limited to physical impacts from rubbing or stepping on large surface roots.

Arboreal Phase: Mature trees and shrubs are of sufficient size that they control the availability of both above and below-ground resources. They also now exert a strong influence on the microclimate by controlling temperatures, winds and humidity. Livestock have limited to no impact on the tree and shrub layers, except for woody species that have a high concentration of surface or shallow roots.

Silvopasture Resource Sharing and Interactions

Above- and Below-ground, Consumption, Deposition and Decomposition



We will now look in some detail at resource sharing and the main interactions in silvopastures, including plant-to-plant and livestock-to-plant.

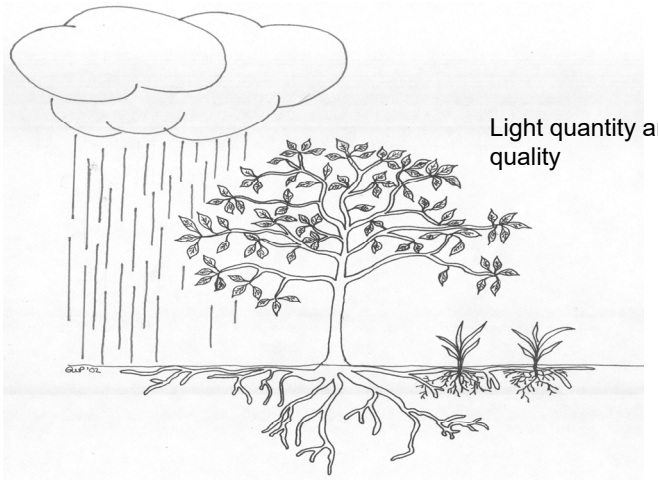
We will explore the scientific basis for these interactions divided into six separate categories. Although in reality, they all can occur at the same time, and resource sharing and interactions at one level can strongly affect how they occur at another level. For example, solar input impacts light levels, and also directly impacts soil water.

The groups of interactions we will cover are:

- Light quantity and quality;
- Precipitation inputs;
- Above-ground temperature and humidity (moisture content of air);
- Herbivory and other animal impacts;
- Soil nutrient dynamics; and,
- Soil water quantity and quality.

Silvopasture Resource Sharing and Interactions

Light Availability and Photosynthesis



Light quantity and quality

- Understory production decreases when canopy above > 30%
- Herbaceous phase: forages can overtop tree and shrub seedlings
- Intermediate/Arboreal phase: trees and shrubs overtop forages

Because light originates from above, competition for light is strongly *asymmetric*: that is, light reaching any given lower canopy layer is dictated by the density of the preceding canopy layers above them.

Light availability is never facilitated. That is, one layer does not increase the availability for another layer. Therefore our design and management goal is to achieve net neutral effects.

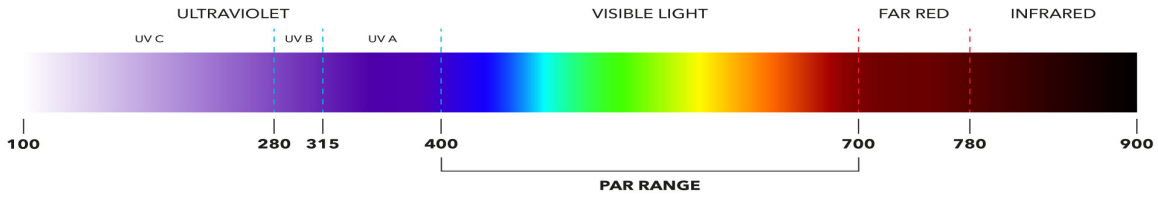
Many experiments have shown a negative relationship between forage production and increasing tree cover, leaf area or crown volume.

As a rule of thumb, understory production starts to decrease after overstory closure is greater than 30 to 40% of open sky.

The dominant canopy layer changes as a silvopasture develops: in the herbaceous phase, forages can overtop tree and shrub seedlings, reducing their light availability. In the intermediate and arboreal phases however, trees and shrubs overtop forages.

Silvopasture Resource Sharing and Interactions

Light Availability and Photosynthesis



More information on this topic is available in supplementary module 2.s.1.

A more detailed description of the science of light availability and crop growth is provided in the supplementary module 2.s.1.

Silvopasture Resource Sharing and Interactions

Light and Delayed Crop Development

Small light reductions can be beneficial:

- Delay crop maturation.
- Support lush forage at peak quality later in season.

Sometimes, small reductions in light reaching the understory coupled with other understory effects, such as temperature reductions, can be beneficial to achieving your management goals.

This occurs when the overstory causes a delay in the development and maturation of the forage crop.

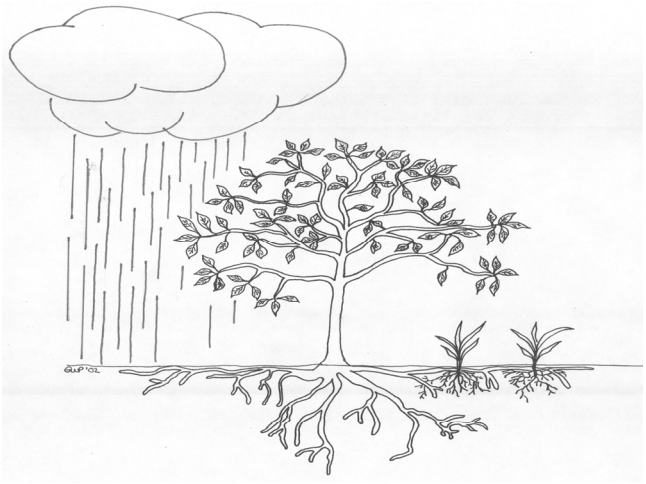
Setting back the development of silvopasture forages creates the opportunity to support more lush foliage, at or close to peak quality, later in the growing season than for open-grown forages.

A silvopasture strategically used for summer or early autumn grazing, can therefore extends the overall availability of high-quality grazing resources.

Silvopasture Resource Sharing and Interactions

Precipitation Inputs

Precipitation Inputs



At the herbaceous and intermediate phases of silvopastures, precipitation will mirror open pasture conditions.

At the arboreal phase, however, tall trees and shrubs impact the total amount of precipitation reaching the understory.

Silvopasture Resource Sharing and Interactions

Precipitation Inputs

Positive

- Mature trees and shrubs block air flow, and trap snow.
- Trees and shrubs are a barrier to overland flow of water; roots improve infiltration rates.

Exposed tree roots, Wikimedia Commons

Negative

- Small rainfalls are intercepted. Some never reach the ground: rain shadow around the canopy.
- Large trees channel rainfall down their stem, reducing the amount reaching the forage crop.

From a positive perspective, mature trees and shrubs block air flow. In the winter months, this causes wind driven snow to drop into the understory, and thus acts as a type of precipitation trap.

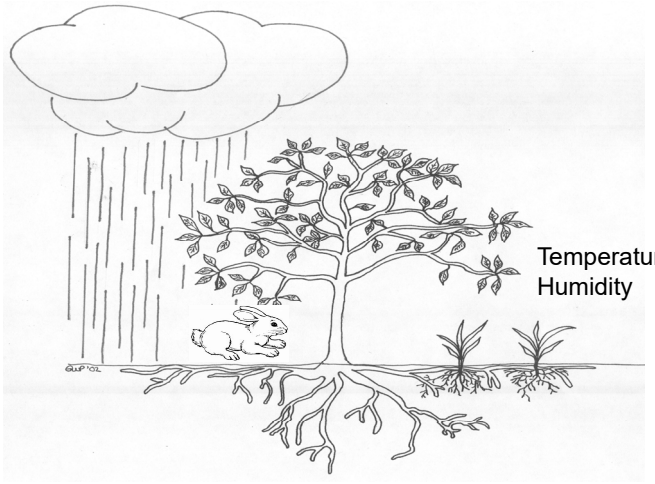
The large root systems of trees and shrubs also provide a significant barrier to overland flow of surface water. By slowing water down, a greater fraction soaks into the ground, where the decompacting effects of their roots will also create additional pathways for water movement. Together, this can greatly improve total infiltration rates, with a higher percentage of precipitation captured on site.

From a competitive lens however, the large canopies of trees and shrubs intercept rainfall before it reaches the ground. Indeed, small rainfall events can be completely captured in their canopies and evaporated from the leaves back into the atmosphere, creating an understory rain shadow effect.

Large trees will also channel some rainfall from their branch network, and down the main stem (bole). This concentrates water around the tree root mass to the competitive exclusion of the understory forage crop.

Silvopasture Resource Sharing and Interactions

Temperature and Relative Humidity



Temperature and Relative Humidity

Similar to the effects of trees and shrubs on precipitation, other above-ground climatic conditions (temperature and humidity) at the herbaceous and intermediate phases in silvopastures will mirror that of open pasture conditions.

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

Silvopasture Resource Sharing and Interactions

Temperature

Positive

- Mature trees and shrubs moderate extreme temperatures.
- Radiated heat warms the understory at night and prevents frosts.

Negative

- Understory retains snow cover longer and soils take longer to warm in the spring.

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

As a consequence of blocking sunlight, they also reduce the amount of heat producing solar radiation reaching the ground. This can account for a 5 to 10% drop in peak temperatures.

Living trees and shrubs are composed of about 50% water. Water is very effective at absorbing heat coming from the sun. And this captured heat reservoir is radiated out into its surroundings. In doing so, it counteracts heat losses at night or during cooler days.

From the negative side however, the cooling effect of the large canopies of trees and shrubs can be problematic when they prevent soils from warming rapidly in the spring. It can mean a 2 to 3 week lag in early pasture or range readiness as the forage growth is delayed by cold soils.

Silvopasture Resource Sharing and Interactions

Temperature

Benefits

1. Animal production and welfare.
2. Forages protected from heat damage
3. Forages have longer frost-free growing period

The overall benefits to temperature modifications in silvopastures usually outweigh the potential negative outcomes:

1. Animal welfare is promoted through the relief from heat stress in the summer or shelter from the cold (thermal cover) in the winter.
2. Forages in the understory are protected from heat damage relative to open pastures. This is particularly notable during ‘heat dome’ events where damage to plant tissue will start when temperatures rise above 40^{o}C.
3. Forage crops can also benefit from a longer growing season. In some instances the heat emitted from trees and shrubs can completely counteract radiative frosts (i.e. heat loss from the ground to the atmosphere). This can be an important factor in extending the length of the growing season in both the spring and autumn when these types of frost events are common in northern latitudes or higher elevations.

Silvopasture Resource Sharing and Interactions

Relative Humidity (RH)

- Some forages need higher humidity for the biological processes of growth.
- When the air is too dry they stop growing
- Mature trees and shrubs elevate RH, allowing understory forages to continue to grow.

More information on this topic is available in supplementary module 2.s.1.

Trees and shrub canopies also benefit the understory production of some forages through their impact on raising the relative humidity.

Cool-season plants are the most common cultivated and native forage species grown in BC. And cool-season plants need higher humidity for photosynthesis to proceed (the chemical process of converting sunlight into plant energy).

When the air is too dry, cool-season plant growth shuts down. This means that under otherwise optimal conditions in the open for light, water and nutrients, forage growth and development will cease due to low humidity.

Trees and shrubs increase the relative humidity in their understory, to the benefit of cool-season plants under hot, dry conditions.

A more detailed description of this process is available in the supplementary module 2.s.1.

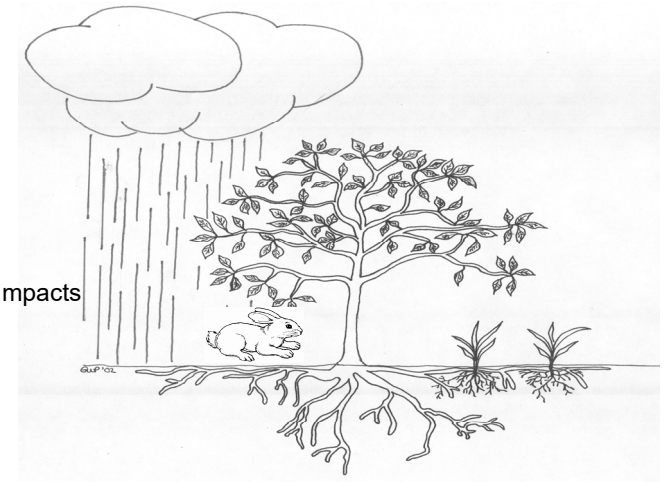
Break for Questions

Break for questions on above-ground processes.

Silvopasture Resource Sharing and Interactions

Herbivory and Animal Impacts

Animal Impacts



Silvopastures, by definition, always include a grazing component.

In traditional Indigenous practices and other ecological restoration applications of silvopasture, that grazing may be from wildlife.

For the most part though, we are incorporating domestic livestock grazing, coupled with wildlife.

It is very important to understand that herbivory and other animal impacts can completely alter the balance of some plant-to-plant interactions, either positively or negatively. Grazing animals also strongly influence the form and availability of soil resources, but usually only have minimal impacts on site microclimate.

Silvopasture Resource Sharing and Interactions

Herbivory and Animal Impacts

- **Grazing and browsing** removes above-ground biomass.
- **Trampling** breaks or wounds stems.
- **Chewing** of bark on pole sized or larger trees.
- **Rubbing** on pole or larger sized trees for scratching or cleaning horns.
- **Shearing** of large surface roots by hoof action.

Grazing and browsing can either selectively or non-selectively remove above-ground biomass. This can strongly alter the competitive balance for light in the herbaceous phase by removing forages around small tree or shrub seedlings.

In the intermediate phase, some livestock species will also elevate themselves by standing on hind legs or climbing into the canopy in order to remove leaves and branches on trees and shrubs. At the arboreal phase, feeding on trees and shrubs generally has minimal impacts on the canopy volume.

In addition to grazing, animals can also have physical impacts on vegetation through:

- **Trampling:** This can have profound impacts in the herbaceous phase on tree and shrub stems;
- **Chewing:** Some livestock will bite the bark of trees out of boredom or habituation;
- **Rubbing**: Animal scratching or rubbing horns against tree stems; and,
- **Shearing**: Hoof action that can break or scar on large surface roots.

Silvopasture Resource Sharing and Interactions

Herbivory and Animal Impacts

Positive

- Controlled grazing releases competition.

Negative

- Browsing can damage or kill young trees and shrubs;
- Rubbing can damage pole sized trees;
- Damage that breaks the bark can deform growth or provide disease entry; and,
- Hoof action can damage or deform roots.

Silvopastures, when designed and managed with care, leverage grazing and browsing to reduce plant-to-plant competition.

Otherwise, uncontrolled animal impacts are generally detrimental to the overall productivity and system health, and need to be managed to minimize damage.

For example:

- Young trees and shrubs can be directly killed or severely damaged through browsing.
- Rubbing and biting damage that breaks through the outer bark can deform trees or provide an entry point for diseases to enter the woody vegetation, which in turn can result in more damage or mortality.
- Hoof action that breaks through the outer layers of tree and shrub roots can reduce growth and vigour of the woody plants, because they then have a smaller volume of roots to gather water and nutrients. As with the above-ground canopy, roots fan out into a branch network away from the main stem. And, the larger the root that is damaged, the bigger the impact will be on overall tree and shrub health and growth.

Silvopasture Resource Sharing and Interactions

Tree and Shrub Browsing

e.g. Cattle and pine

- Browsing minimal (< 2% of seedlings) and mostly accidental.
- High levels occur when forage is scarce or the tree/shrub species is a preferred source of food.

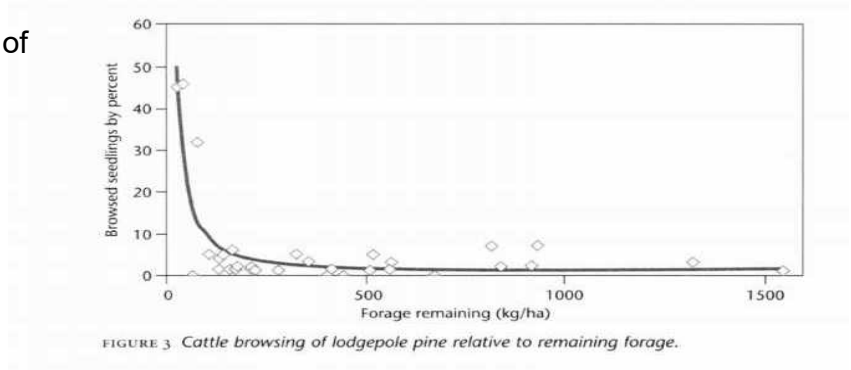


FIGURE 3 *Cattle browsing of lodgepole pine relative to remaining forage.*

Newman and Powell, 1997

Long-term, BC-based research has been conducted to look at livestock impacts on regenerating trees, and the relationships for cattle and sheep with major timber species are well established. e.g. cattle-forage-livestock interactions in mid-elevation forests of the Southern Interior have been the focus of multiple studies over the last 40 years, highlighting that minimal browsing occurs on lodgepole pine unless other forage is scarce.

Less information is available however, for other livestock species (e.g. goats, swine, poultry) or for other trees and shrubs (nut and fruit trees). But the basic principles hold the same.

Management options will be discussed in detail in the next unit of this information series.

Silvopasture Resource Sharing and Interactions

Tree and Shrub Trampling

- Common in first 2 years: a function of livestock density and tree size.
- Obstacle planting or tree guards can greatly reduce trampling.

Many studies have shown that trampling damage is simply a random occurrence. Animals do not step on small trees and shrubs on purpose. It is a function of animal density relative to the density of the woody plants.

For tree and shrub seedlings, trampling damage to the main stem falls off rapidly after the plants attain a size where they become visual and physical obstacle to animal movement.

Preventing large root trampling, however, can be more problematic. This is particularly true where animals are seeking the shelter of large trees or shrubs.

Silvopasture Resource Sharing and Interactions

Other Considerations

Positive

- Birds and predatory insects supported that feed on crop and livestock pests.
- Livestock benefit from tree/shrub component in their diet.
- Some livestock species may be calmer/happier with access to treed environments.

Negative

- Some livestock may experience stress when their line of sight is blocked.
- Predators may find cover in canopies.
- Soil compaction can have secondary effects.

Some additional considerations regarding animal impacts in silvopastures:

From a positive perspective,

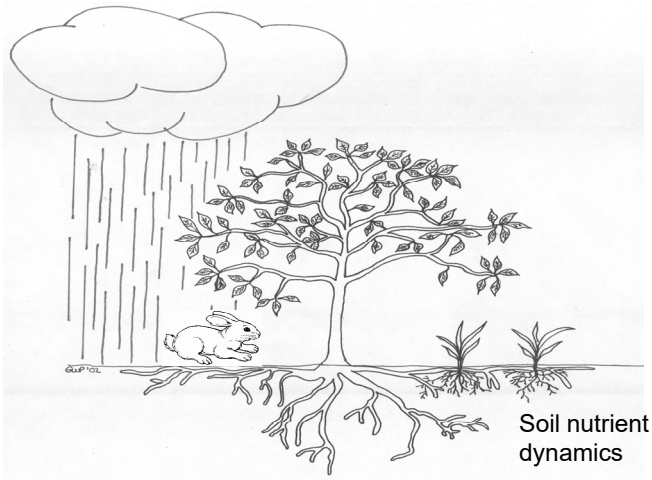
- Trees and shrubs support habitat for birds and predatory insects, both of which can provide a measure of natural control of crop and livestock pests;
- Some studies have shown that livestock benefit from tree and shrub material in their diets. For example, tannen-rich tree material can reduce parasite loads in sheep, or improve digestive health in cattle; and,
- Some livestock species were bred from wild ancestors that evolved in forested or partially forested habitats (e.g. European cattle breeds). These species can be more at ease or “happier” when they have access to trees and forested environments.

Conversely,

- Some livestock species may experience additional stress in a silvopasture when their line of sight is interrupted by trees. For example, sheep may have an evolutionary preference for open spaces or edge habitat with long lines of sight.
- Certain predators, including cougars, raptors and members of the weasel family, may take advantage of the additional tree cover in a silvopasture to harass and kill livestock; and,
- Improper livestock distribution at any phase of development can lead to soil compaction, with secondary effects on below-ground resource sharing and interactions.

Silvopasture Resource Sharing and Interactions

Soil Nutrient Dynamics



Soil nutrient dynamics

Silvopastoral production, as with any type of pasture or rangeland, is dependent on healthy nutrient flows from deposition, decomposition and uptake by the crop plants.

Resource sharing among the trees, shrubs and forage species is strongly controlled by site conditions (e.g. soil parent materials, topography, texture, types of soil organisms present and level of organic matter) as well as climate and management inputs.

Silvopasture Resource Sharing and Interactions

Soil Nutrient Dynamics

Positive

- Nutrient pumping.
- Shade reduces soil temperatures and increases nitrogen release.
- Livestock cycle nutrients faster than natural decomposition.

Negative

- Where rooting zones overlap, competition occurs.

Sharing of nutrients can be prominent in the late intermediate phase, through to the arboreal phase of development. During these later phases the much larger root networks of trees and shrubs allow them to exploit deeper soil layers than most forage species, increasing the overall productivity per unit area.

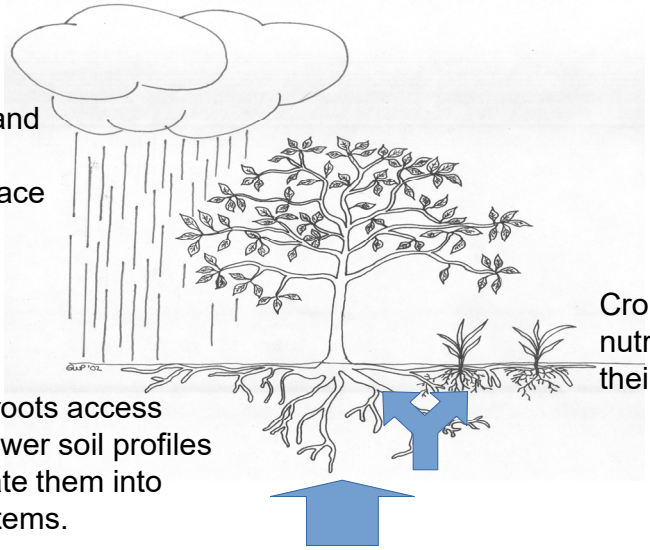
Mature trees and shrubs can improve understory growth by increasing nutrient availability by:

- Nutrient pumping; and,
- Through cooling the soil and restricting evaporation, they allow for greater release of nutrients from decomposing organic matter (mineralization); this can be particularly important for nitrogen release during dry, hot conditions.
- The presence of livestock in silvopastures is also a positive for plant growth because they cycle nutrients faster than natural decomposition.
- In any phase however, when rooting zones overlap between the forages and woody crops, competition for soil nutrients will occur.
- Soil-based competition in silvopastures is symmetric, meaning it is relative to the size of the individual root systems, therefore:
- At the herbaceous phase, the relatively larger forage layer can express dominance in scavenging nutrients;
- In the intermediate phase, competition for nutrients may persist or become more balanced; and,
- In the arboreal phase, mature trees and shrubs are advantaged in gathering nutrients.

Silvopasture Resource Sharing and Interactions

Nutrient Pumping

Deep-rooted trees and shrubs relocate nutrients to the surface soil layers.



Crops benefit from extra nutrients turned-over into their root zone.

Tree / shrub roots access nutrients in lower soil profiles and translocate them into their root systems.

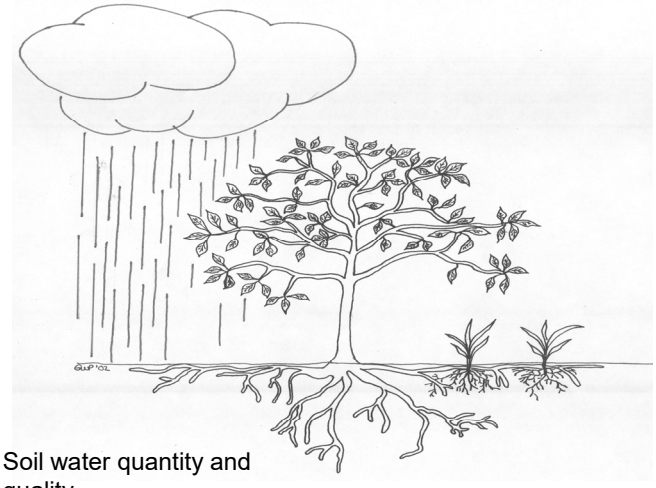
Nutrient pumping is a process by which large, deep-rooted plants access nutrients in lower or distant soil horizons and draw them into their root system.

These nutrients get redistributed throughout the tree or shrub for its own growth and development needs, including into fine root hairs in the shallow soil layers.

As these root hairs are shed from the woody plants and decompose, they release the deep-sourced nutrients into the root zone of the forage crop, which can then be drawn up for forage growth and development.

Silvopasture Resource Sharing and Interactions

Soil Water Quantity and Quality



Soil water quantity and quality

Mirroring the resource sharing and interactions for nutrients, the quantity and quality of soil water available in silvopastoral production, is also strongly controlled by site conditions as well as climate and management inputs.

Soil water follows the same general pattern of resource sharing and interactions as was outlined for the nutrient dynamics, and also changes through the various silvopasture development phases.

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Soil Water Quantity and Quality

Positive

- Hydraulic lift.
- Reduced evaporation.
- Improved water quality.

Negative

- Where rooting zones overlap, competition occurs.
- On heavy soils, or those prone to flooding, longer periods of saturation.

Mature trees and shrubs can also aid understory growth by increasing the availability of water by two means:

- Through hydraulic lift, they pull deep profile water to the surface layers; and,
- Through cooling the soil and restricting evaporation, they reduce evaporative losses from the shallow soil layers.

Tree and shrub root networks also add to the silvopastures ability to filter and clean suspended solids and excess nutrients from water, resulting in improved water quality.

At all phases however, when rooting zones overlap between the forages and woody vegetation, competition for soil water will occur.

Just as with soil nutrient dynamics, the balance of competition for water is also relative to the size of each root system.

- At the herbaceous phase, the relatively larger forage layer can express dominance in scavenging water.
- In the intermediate phase, competition for water may persist or become more balanced.
- In the arboreal phase, mature trees and shrubs are advantaged in gathering water through both a larger root network and the stronger ‘pull’ caused by transpiration.

In addition to competition, on heavy soils however, or those with recurring saturation or flooding, the reduced evaporation potential in the understory can sometimes be considered a negative. This happens if it prolongs soil saturation, starving the shallow rooting zones of oxygen.

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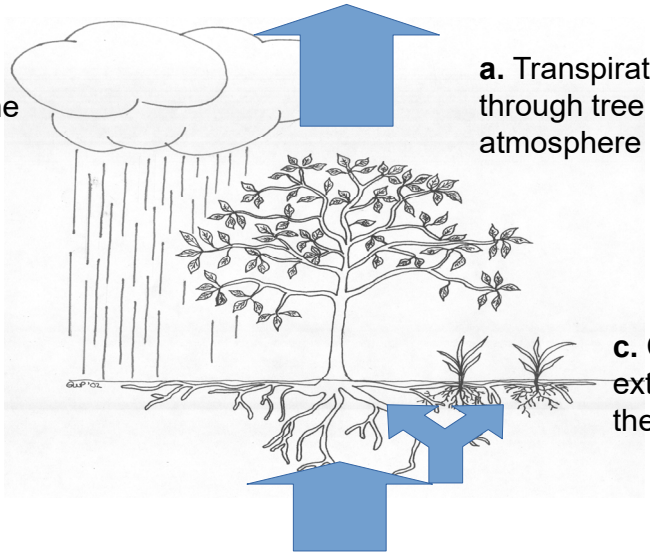
Hydraulic Lift

Deep-rooted trees and shrubs 'pull' water to the surface soil layers



a. Transpirational 'pull' through tree into the atmosphere

c. Crops benefit from extra water pulled into their root zone

b. Tree roots create a 'vacuum' that draws deep water upward

Hydraulic lift, the process by which trees and shrubs pull deep ground water to the surface, is described in greater detail in the supplementary unit 2.s.2, on silvopasture hydrology.

Questions and Discussion

Final question and answer break.