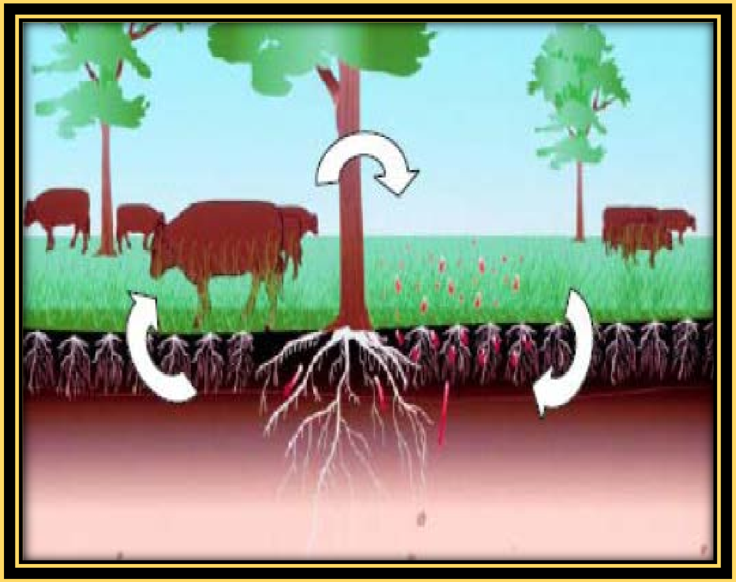
Silvopasture

Agroforestry Workshop October 21-22, 2014

Aurora, OR



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Silvopasture
and
European Dark Ages

Archaeological records indicate that some sites were occupied for 3000 years:

- stable, sedentary society
- diversified economy
- intensive use of the deciduous forest and its resources

Dairy products were particularly important; milking being "an advantageous way of using the rich pasture grasses.

TERMINOLOGY FOR GRAZING LANDS AND GRAZING ANIMALS by The Forage and Grazing Terminology Committee J. of Prod. Agric., vol. 5, no. 1, 1992 pg 191- 201

- As recently as 1992 Forest Grazing was preferred term.

I.6.b.*i*. Agroforestry	Land use system in which woody perennials are grown for wood production with agricultural crops, with or without animal production.

192 J. Prod. Agric., Vol. 5, no. 1, 1992

I.6.b.*ii*. Agro-silvo-pastoral	Land use system in which woody perennials are grown with agricultural crops, *forage crops*, and livestock production.
I.6.b.*iii*. Grazable forestland	*Forestland* that produces, at least periodically, sufficient understory *vegetation* that can be grazed. *Forage* is indigenous or, if introduced, it is managed as though it were indigenous (Syn: grazable woodland, woodland range, forest range).
I.6.b.*iii*.(1). Forest grazing	The combined use of *forestland* or woodland for both wood production and animal production by grazing of the coexisting indigenous *forage*, or *vegetation* that is managed like indigenous *forage*.
I.6.b.*iii*.(2). Silvo-pastoral	Preferred term is *Forest grazing*, I.6.b.*iii*.(1).
I.6.c. Pastureland[5]	Land devoted to the production of indigenous or introduced *forage* for harvest primarily by grazing. Pastureland generally must be managed to arrest successional processes

Secretary Vilsack Highlights First-Ever Report on USDA Efforts to Expand Agroforestry Practices on Farms, Ranches and Woodlands Oct. 28, 2013

- Over the last 5 years, USDA has assisted landowners establish 336,000 acres of agroforestry (windbreaks, riparian forest buffers , alley cropping, **silvopasture,** forest farming).

- < 1% of the potentially suitable land.

- Opportunity to significantly expand agroforestry in the United States.

Agroforestry = Sustainable Land-Use

- Land-use systems that are more complex than either crop or tree monocultures result more efficient capture and utilization of resources (nutrient, light, water).
- Below ground diversity provides more stability and resilience at the site-level
- Above ground diversity provides connectivity with forests and other landscape features at the landscape and watershed levels.

Silvopasture managers must continually work to ensure that sufficient resources – light, water, nutrients – are available in the system to support the whole system.

- Intentional
- Intensive
- Integrated
- Interactive

Draft NRCS Conservation Practice Silvopasture (381)

PURPOSES:

- Provide forage for livestock and the production of wood or other tree products.
- Increase carbon sequestration.
- Improve water quality.
- Reduce erosion.
- Enhance wildlife habitat.
- Provide shade for livestock.
- Improve soil health.
- Increase biological diversity.
- Establish vegetation for beneficial organisms consistent with National Organic Program (NOP) regulations for organic and transition-to-organic agricultural systems.

Silvopasture Benefits

- Nutrient availability
- Water quality
- Soil quality
- Pollination
- Biological control
- Air quality
- Micro-Climate regulation

Farmers Directly Benefit From:

- Timber production
- Agriculture production

The economic value of ecosystem services is higher than the value of marketable products (i.e. timber and agricultural products).

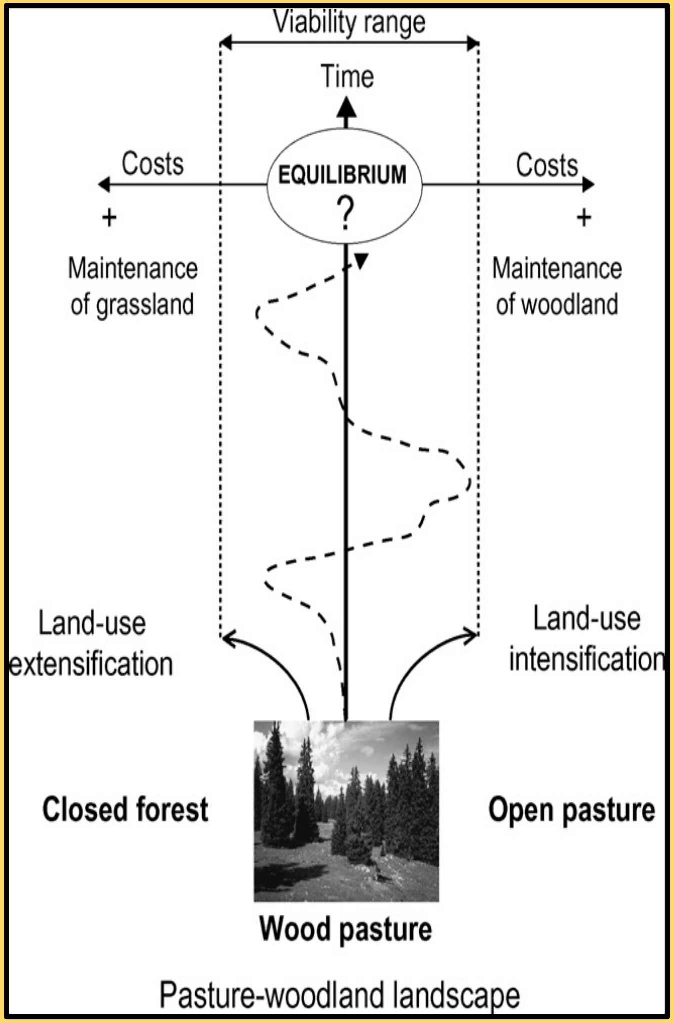
Silvopasture Implementation

- Forest converted
- Pasture converted
- Planted together

Silvopasture – Dynamic Ecosystem

- **Herbaceous Phase**, tree seedlings are subject to competition with the forage crop, and livestock impacts.
- **Intermediate Phase**, trees and forages compete for soil-based resources (water and nutrients). Livestock impacts on trees are diminished (depending on livestock species).
- **Arboreal Phase**, mature trees control the availability of most resources. Livestock have limited impact on trees at this stage.

500 yr model of management weaves Switzerland's wood-pasture plant community back and forth



Gillet (2008) Modelling vegetation dynamics in heterogeneous pasture-woodland landscapes. Ecological Modeling 217: 1-18

Silvopasture Microclimate - Southern pine

Karki and Goodman (2010)

- Solar radiation - 14–58% lower
- Wind speed - 29–58% lower
- Gust speed - 23–58% lower
- Relative humidity, and air and soil temperatures were also lower

Silvopasture Microclimate - Appalachia

- Surface soil temperature remained nearly constant.
- Forages experienced less variation in photosynthetically active radiation (PAR) and temperature, thus reducing the metabolic cost of adaptation to extreme conditions.
- Black locust trees provide near ideal microclimate modification for cool season grasses.
- Leafs out late in the spring, loses leaves early in the autumn, and provides dappled shade during the hottest summer months.

Black locust

Tree Characteristics and Shade

- Tree architecture

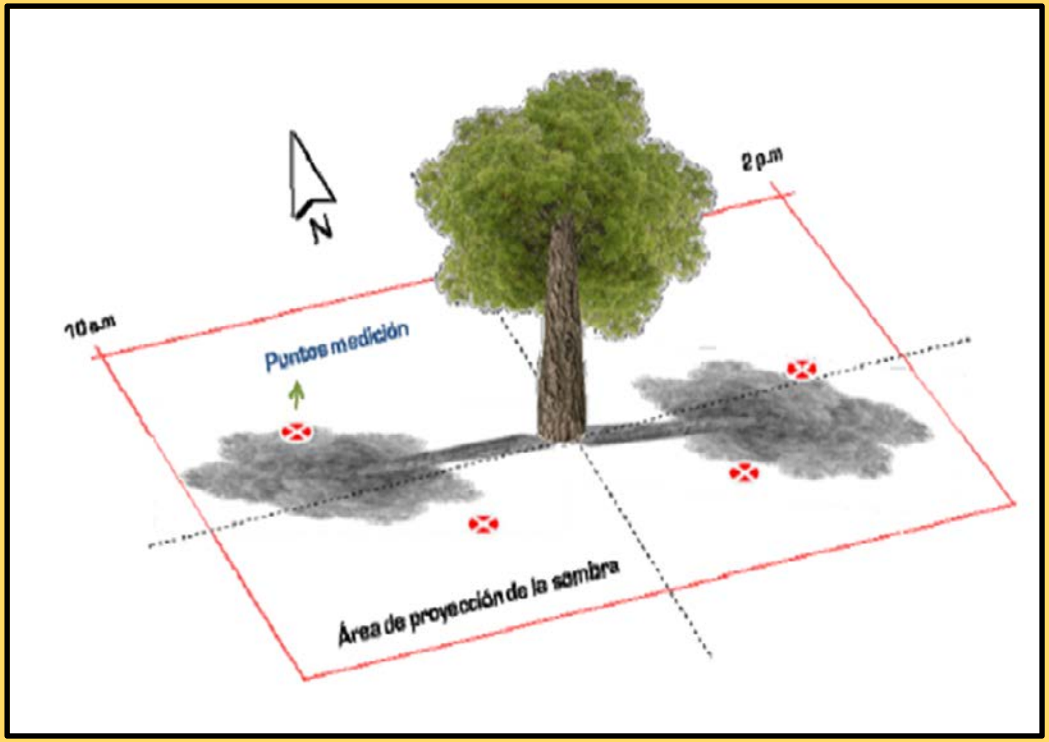
  shape, height, crown type (depth, density and width)

- Lowest branching height

- Leaf phenology

  evergreen

  vs deciduous



Trees and pastures interact and compete for resources.

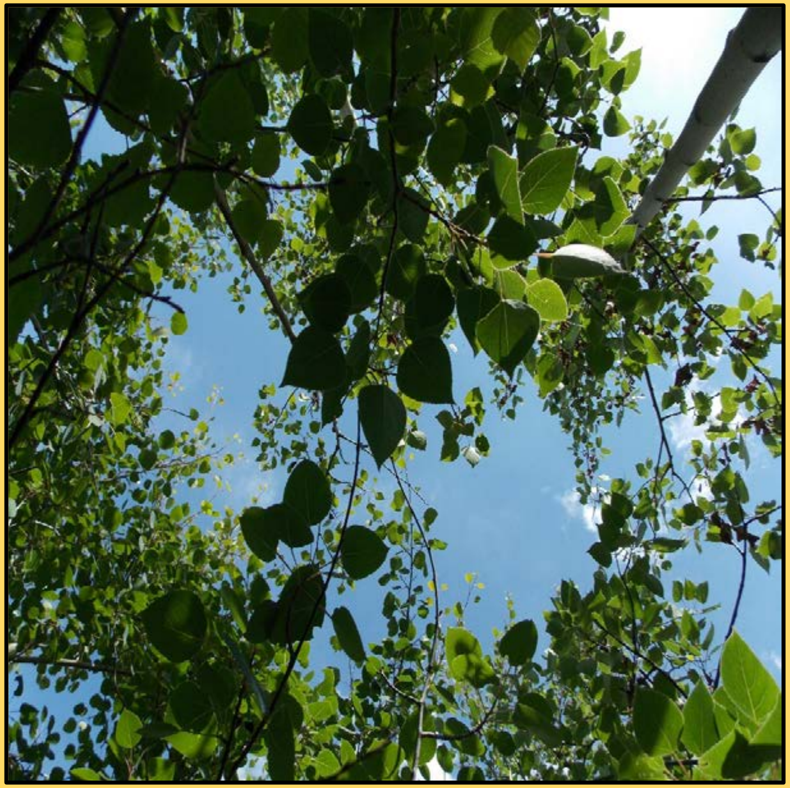
Silvopasture Microclimate

Mature Aspen

% leaf	% wood	% sky
32	32	36

Young Aspen

% leaf	% wood	% sky
70	6	24



Characteristics of the trees over its life span is important to know

Impacts of Shade on Understory

- Aboveground interactions modify microclimatic temperature and water vapor content

- Theoretically, C3 plants (wheat, barley, rye, oats, orchard grass, fescue) planted under shade should perform better than C4 plants (corn, switchgrass) and be better suited for agroforestry practices.

Impacts of Shade on Cool-Season Grass
(Belesky et al 2006)

- Cooler temperatures associated with 45-50% shade may lower cell wall concentrations and slow rate of plant maturity. The outcome is sustained herbage productivity, sward persistence, and somewhat more predictable nutritive value and grazing livestock performance.

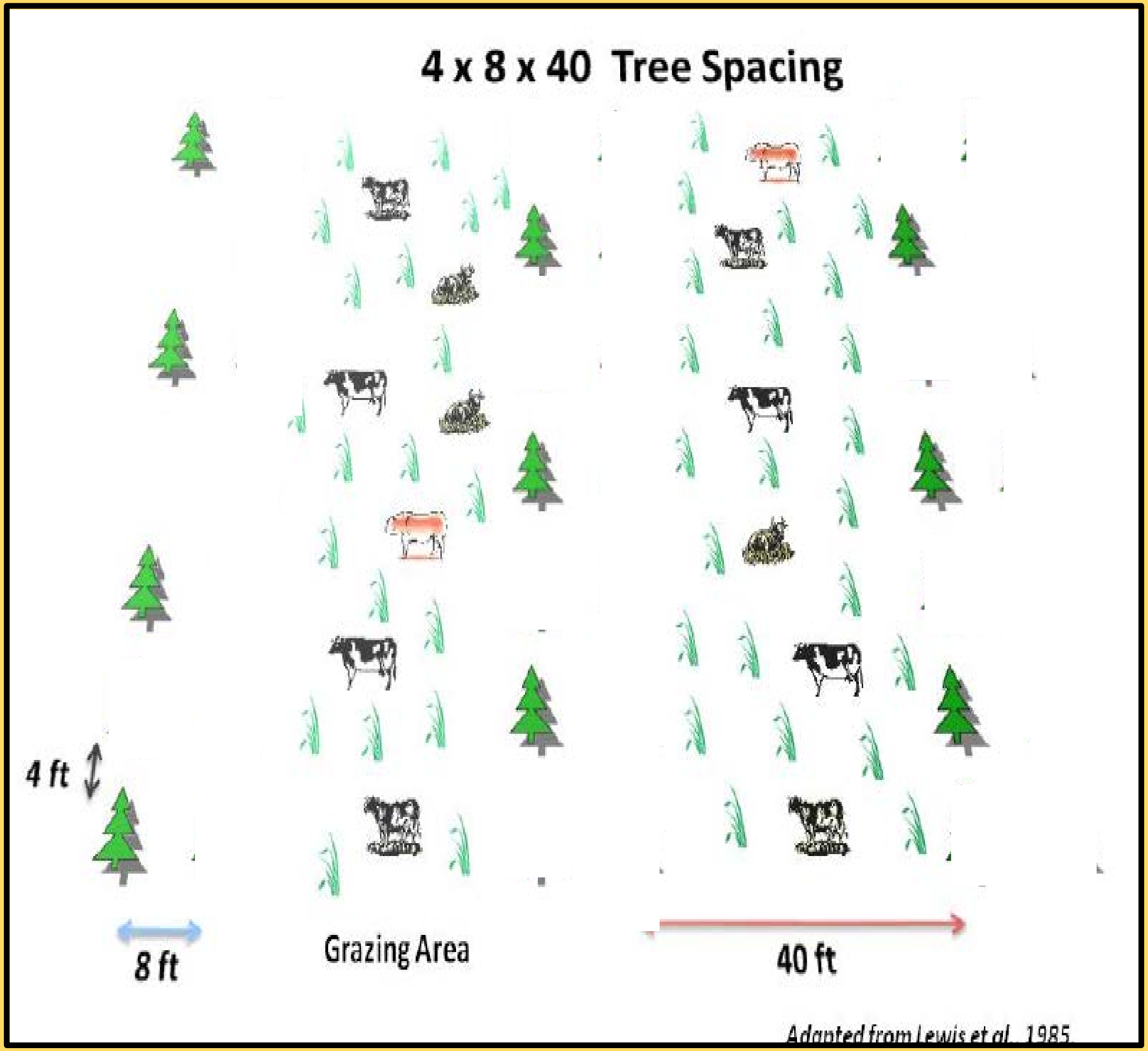
- Orchardgrass (but not tall fescue) persists longer in in shaded sites (Belesky 2011)

Tree Regeneration

- The long term sustainability establishment of new trees to replace mortality and harvest.
    - Lengthen the fire return interval to allow tree seedlings to get above lethal flame heights.

Converted Pasture Tree Regeneration

(Lewis et al 1985)



- 2X row widths on the initial planting.

-15 years - thin rows and plant into open rows.

-30 years harvest initial planting and replant, thin second planting.

Tree Regeneration

Limiting factors:

- Physical damage of the seedlings by livestock
- Lack of suitable sites for seedlings (mineral soil)
- Shade intolerance of seedlings

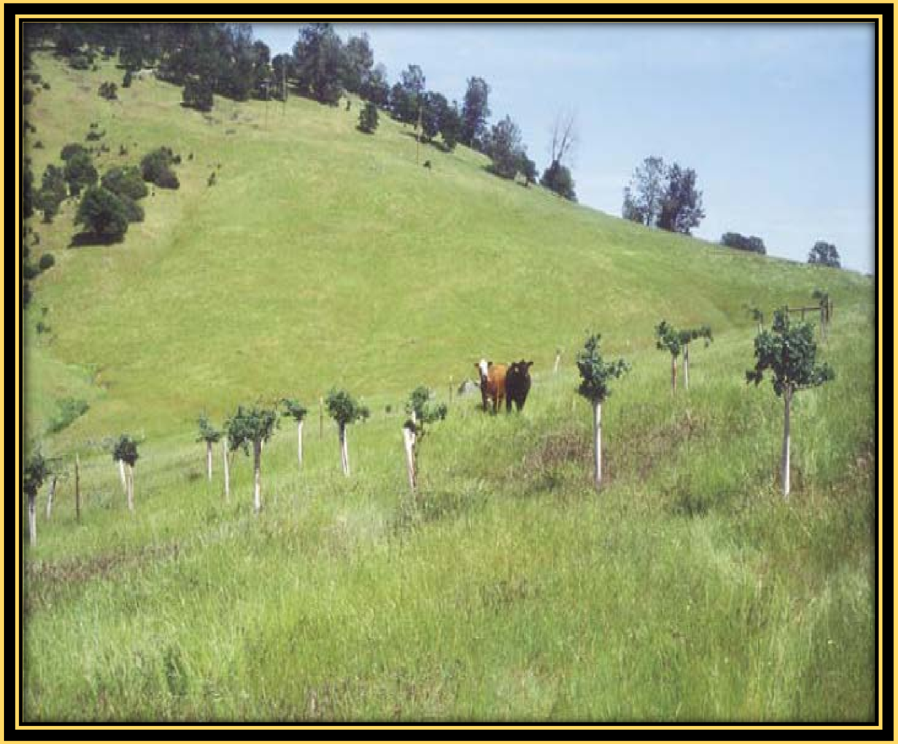
Tree Response to Browsing

Woody plants generally use stem and branches for storage.

Many evergreens do not store nutrients in stems, but leave resources in the last generation of leaves and needles. Nutrients translocate from there to new developing buds.

This make growing points vulnerable to loss to browsers.

Browse Protection



Tree shelters have proved effective in preventing cattle from trampling and grazing oak seedlings. When oaks reach 6.5 feet, they are generally able to withstand cattle damage in little- to moderately grazed pastures.

Browse Protection (Lehmkuhler 2003)

- Both wire or plastic tree shelters reduced deer browse damage of Black walnut and Honey locust and improved tree growth over unprotected trees.

- Electric fencing on both sides of tree rows improved survival for Virginia pine

- Leave sapling shelters in place for at least 2 years after the seedlings have grown up and out of the tops

Convert Forest to Silvopasture - Missouri
(Staley 2008)

- Mixed hardwood natural succession of cut-over timberland or abandoned pasture
- Dominated by White oak (Quercus alba L.), with minor amounts of Sugar maple (Acer saccharum L.) and Tulip poplar (Lirodendron tulipifera L.).
- Understory plants completely absent
- Thinned to allow 50% full sunlight, followed by sheep trampling to reduce the forest litter and prepare a seedbed for Orchardgrass, perennial ryegrass, and white clover.

Convert Forest to Silvopasture - Missouri
(Staley 2008)

- Organic-C and organic-N concentrations were reduced in silvopasture by 17 and 9%, respectively, indicative of substantial litter decomposition.

- Conversion to Silvopasture resulted in a rapid and significant change in the soil C and P cycles.

- Soil tests before conversion do not reflect management needs after conversion .

Convert Forest to Silvopasture - Appalachia
(Feldhake et al 2010)

- Thinned mature White oak (Quercus alba L.)
- Establishing two orchardgrass-perennial ryegrass-white clover silvopasture replications for comparison with two nearby open pasture replications.
- Total forage yields in silvopastures were only 60% of those from open pasture

However, Silvopasture provided environmental services such as, improved wildlife habitat, carbon sequestration, and capture and recycling of nutrients leached below the forage root zone.

Conversion Establishment Seeding Mix
(Kyriazopoulos 2012)

- Production and nutritive value of forage in silvopastoral systems can be improved by introducing shade tolerant grass and legume species in appropriate mixtures

- A 25:75 mixture of Orchardgrass:Sub clover suggested as the most suitable under moderate shade (60%), to perpetuate the stand and avoid the frequent re-sowing.

Convert Pasture to Silvopasture
(Houx et al 2013)

- Black walnut height growth was greatest in 3’ or larger vegetation-free zones.

- Diameter growth was greatest in 4’ vegetation-free zones and larger.

- The results suggest that a minimum of a 4’ vegetation-free zone in tall fescue pastures should be used to maximize black walnut height and diameter growth in the critical first years of tree establishment.

Convert Pasture to Silvopasture – Georgia
(Karki et al 2013)

- Diversity of understory species in Silvopasture was greater than open-pasture during the early growing season (April–May) but was lower during late season (Aug.–Nov.).

- Pine needles accounted for about 10 % of the total ground cover after 7 years.

- Overstory coverage by the pine canopy was about 11 % after 7 years.

- Plant community began to vary after 7 years.

Grazing Behavior (Rusch et al 2010)

- Grazing livestock cattle can change the structure and composition of the silvopasture. Knowledge about grazing behavior is important to silvopasture management.
- Livestock make decisions about where to graze at three scales, landscape, forage patch, and parts of plants.
- Animals make the following four decisions:
  1) which patch type to visit
  2) how long to stay in each patch
  3) which food types to eat in the patch
  4) which foraging path to employ in the patch.

Grazing Behavior (Karki and Goodman 2010)

- Shade in silvopasture appeared to reduce heat stress for cattle grazing during warm weather portions of the year.

- Cattle grazed the landscape more evenly in the Silvopasture versus the open-pasture due to reduced solar radiation recorded in the Silvopasture.

- Grazing was the dominant behavior in the Silvopasture while loafing was dominant in the open-pasture.

Grazing Behavior

- Temperature reductions can help reduce heat stress of crops and/or animals.
- Shade can reduce the energy expended for thermoregulation, which in turn can lead to higher feed conversion and weight gain.
- Cattle provided with shade reached their target body weight 20 days earlier than those not afforded shade.

Grazing and Soil compaction:

- Increases resistance of soil to root penetration
- Lowers water infiltration rates
- Reduces soil aeration by loss of air-filled macropore space
- Shallow compaction can recover. Compaction by livestock hooves is limited to the top 5–10 cm of soil.
- Deeper soil layers are generally slower to recover. Logging equipment can compact soil at depths exceeding 50 cm

Grazing – Soil Impacts (Sharrow 2007)

- Douglas-fir forest, Douglas-fir/subclover pasture/sheep silvopasture, and subclover/sheep pasture

- Pastures and silvopastures were grazed each spring, sampled over an 11 year period of grazing, and again following 2 years without grazing.

- Infiltration rate and total pore space decreased, and , bulk density increased compared to the ungrazed forest but the water holding capacity of the top 4 inches were equal on all sites.

- All changes were reversed with 2 years of no grazing. Lack of a vegetation response to treatment differences observed in soil properties reflects a general adequacy of soil structure to support vegetation, regardless of management system

Grazing Management

- **Variables:**
  - Species of livestock grazed (cattle, sheep, goats, horses or a combination)
  - The animals' previous grazing experience (can affect their preferences for certain plants)
  - Time of year as it relates to plant physiology (animal consumption is directed by the seasonal nutrient content)
  - Animal concentration or stocking density
  - Grazing duration
  - Animal physiological state

Grazing Management - Deciduous Trees
(Fedelhake et al 2010)

- Deciduous trees shed their leaves allowing greater light penetration during winter and early spring – many variables.

- Schedule the first grazing rotation about 20 days later in silvopastures than in open pastures..

- Stubble heights post grazing also need to be higher.

Grazing Management - CA Oak Silvopasture

(McCreary and George 2005)

- Rest pastures to minimize damage to seedlings in the summer when dry grass is less attactive.
- Grazing intensity to prevent thatch buildup (rodent damage to seedlings).
- Stock densities of less than one cow per acre are preferable.
- Plant more than 0.5 mile from stock water and on slopes greater than 20%.
- Place salt, supplements, rubbing posts and water far away from planted areas to reduce the time livestock spend near seedlings.
- Cattle follow a predictable daily path of grazing and rest. Avoid planting in those areas.

Soil Management

- Belowground interactions
- Competition for water and/or nutrients
- Allelopathy -Juglone – black walnut
- N2-fixation and sharing – 650 woody species are capable of fixing N.

Carbon Sequestration (Nair et al 2009)

- The wood of slower-growing, higher specific gravity species may accumulate more C in the long-term than faster growing species.

- High-specific-gravity wood also constitutes a longer-term sink for fixed C (e.g., construction timber, furniture, wood crafts) than low-specific-gravity wood used for short-lived purposes such as packaging cases and poles.

Carbon Sequestration (Sharrow and Ismail 2004)

- Estimates of undisturbed Pacific Northwest coniferous forests contain approximately 60% of their stored carbon in aboveground biomass.
- Grasslands store approximately 90% of their carbon in soil organic matter.
- **11 year-old silvopastures, which have greater total biomass productivity than pastures or plantations, and which have both pasture below-ground and tree above-ground carbon cycles active, accrete more carbon.**

Nitrogen fixing plants

- Leguminous Trees/shrubs
  - Black locust (Robinia pseudoacacia)
  - Leucaena (Leucaena leucocephala)
  - Mesquite (Prosopis glandulosa)
  - Silk tree (Albizia julibrissin)
- Leguminous Herbaceous species
  - Alfalfa (Medicago sativa)
  - Clover (Trifolium spp.)
  - Hairy vetch (Vicia villosa)
- Non-leguminous trees and shrubs
  - Alder (Alnus spp.)
  - Autumn olive (Elaeagnus umbellata)
  - Snowbrush (Ceanothus velutinus)

Silvopasture trees

- Douglas fir (Pseudotsuga menziesii)
- Ponderosa pine (Pinus ponderosa)
- Oregon White Oak (Quercus garryana)
- Red alder (Alnus rubra)
- KMX hybrid pine (Pinus radiata × P. attenuata)
- Black locust (Robinia pseudoacacia)
- Honey locust (Gleditsia triacanthos)
- Tulip poplar (Lirodendron tulipifera)
- Black walnut (Juglans nigra)

Silvopasture herbaceous

- Perennial ryegrass (Lolium perenne)
- Tall fescue (Schedonorus arundinaceus)
- Orchardgrass (Dactylis glomerata)
- Big bluestem (Andropogon gerardii)
- Roemer’s fescue (Festuca roemeri)
- Colonial bentgrass (Agrostis capillaris)
- Smooth bromegrass (Bromus inermis)
- Subterranean clover (Trifolium subterraneum)
- Crimson clover (Trifolium incarnatum)
- White clover (Trifolium repens)

Summary: Silvopasture is a system characterized by integrating trees or shrubs with forage and livestock production in the same acreage to utilize space, growing season, and growth factors more intentionally. The goal of a silvopastoral system is to optimize, rather than maximize, production of all three components.