Forests and Society

Forest Management - Past and Present

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Land Use History in Vermont

Indigenous Cultures

Paleo - Indian Period (11,000 B.C. to 7000 B.C.)

- Humans arrived along the Champlain Sea following the retreat of the glaciers
- The landscape looked very different during early settlement, consisting of arctic tundra dotted by small shrubs and stunted spruce trees, and populated by large game
- Hunting pressure and a warming climate drove large game further north and ultimately to extinction

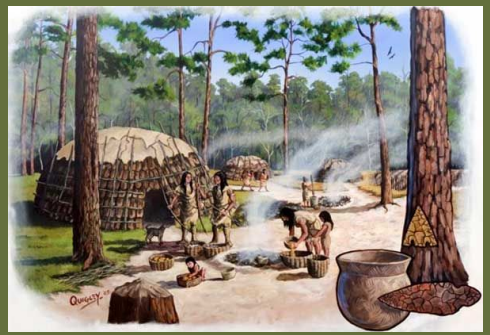
The Archaic Period (7000 B.C. to 1000 B.C.)

- The introduction of trees and shrubs ushered in by a warming climate brought new species such as bear, white-tailed deer, hare, fox, and squirrels
- Food-producing trees, such as beech, chestnut, oak, and elderberry, provided some nourishment, but the hunting of small, furtive game required greater ingenuity and frequency
- A culture of hunting and gathering was developed over generations in response to the landscape

Indigenous Cultures

The Woodland Period (1000 B.C. to 1600 A.D.)

- Larger settlements were established, particularly along the Winooski, Lamoille, Missisquoi, Otter Creek, and Connecticut Rivers
- The climate began to cool following a post-glacial warming period, which favored the forests of maple, beech, and evergreens that we know today
- Three Sisters (corn, beans, and squash) agriculture was established as early as 1100 A.D. in the Connecticut River Valley, and in 1450 along the lower Winooski River
- Agriculture was slower to reach the northern forest, where the growing season is short and it often required more work than hunting and gathering



The Abenaki (1600-present)

- By 1600, the Abenaki were beginning to form villages and stay in one place longer, growing crops and managing forests
- They had less reliance on agriculture than Native populations in southern New England, and therefore relied more on hunting
- Fields for growing crops were cleared by cutting and burning, as were openings in the forest to provide habitat for game and create a more park-like environment for easy navigation
- Hunting, fishing, and gathering on ancestral lands remain an important part of Abenaki culture today, for both subsistence and cultural heritage

European Influence

European settlement (1609-1791)

- Prior to European settlement, there were few clearings and the land was minimally cultivated
- Agriculture was the basis for extensive clearing and plowing, and claiming of the land
- Most of the state was settled between 1760 and 1800, largely by arrivals from southern New England, starting with the valleys to the east and west and slowly moving into the northern mountains
- The long-forested land provided rich, fertile soils during the early years of cropping, but with clearing came the leaching, erosion and drying effects of water and wind

Early agriculture (1791-1860)

- Early agriculture consisted of subsistence farms
- As farmers gained experience on the land, their farms began to yield surpluses which could be bartered or sold, but distance from markets remained a barrier
- The first Merino sheep were imported to Weathersfield from Spain in 1811 by William Jarvis
- The sheep were able to graze on marginal land, including hill farms and rocky soils, and their wool was in high demand
- The industry took off rapidly, and by 1840 there were over 1.6 million sheep in Vermont
- The sheep-farming craze led to a complete alteration of the landscape
- By the 1850s, nearly 75% of Vermont was deforested

Early & Present Day Vermont

Industry (1860-1945)

- With the depletion of soil, especially on the slopes, came the decline of farms
- Competition from the expanding western frontier led to the further abandonment of farms
- Over time, these abandoned farms reverted to second-growth forest
- In contrast to sheep, cows prefer gently rolling pastures and require large amounts of hay and corn silage as supplemental feed; this led to an increase in farmland in the river valleys, while the hills and mountains returned to forest
- Logging was the largest industry in post-Civil War Vermont, fueled by the expansion of railroads and demand for wood products
- By the 1920s, concerns over deforestation led to the creation of municipal forests, many of which had to be replanted
- In the late 1800s, tourism began to take hold in Vermont
- With the completion of the Long Trail in 1930, the Vermont woods became a recreational haven, primarily for the elite
- The Green Mountain National Forest, now occupying more than 400,000 acres in central and southwestern Vermont, was established in 1932

Present day

- Vermont today remains a dairy landscape, with open valley pastures surrounded by forested hills
- Technological innovations and improved food safety standards in the mid- to late-twentieth century led to the consolidation and demise of many small dairy farms that could not afford to upgrade
- Currently, the greatest threat to the landscape is development
- The ski industry, first established in the mid-1930s, helped breathe life back into towns that struggled in the wake of abandoned hill farms, but associated development has further impacted those forests
- Efforts to protect the Vermont landscape from development and fragmentation emerged in the form of conservation easements and regulations

Vermont Forestry Rules and Regulations:
Use Value Appraisal Law

- Vermont today is 76% forested, the majority of which is privately owned
- The Use Value Appraisal Law (also known as current use), which is available to forest- and farmland owners, was passed in 1978 in response to increasing development pressure
- **The program appraises land based on the value of timber or food production rather than the development potential, thereby reducing the tax burden**
- Enrolled forestland must be at least 25 acres and have an approved Forest Management Plan
- Forest Management Plans can include recommendations for timber and firewood production, wildlife habitat, invasive species management, watershed protection, aesthetics, and recreation, depending on the goals of the landowner
- As of January 2022, more than 16,000 parcels were enrolled for a total of nearly 2 million acres of forest (more than half of Vermont's privately-owned forest)

Vermont Forestry Rules and Regulations:
Act 250

- Act 250 went into effect in 1970 to **address the environmental and societal impacts of development projects of a certain size**
- The law requires a review of potential projects for impacts to the following standards:
  - Air and water quality
  - Water supply
  - Waste disposal
  - Flood hazards
  - Soil stability
  - Habitat
  - Transportation
  - Local schools and services
  - Municipal expenses
  - Historic resources
  - Aesthetics
  - Primary agricultural soils
  - Forest fragmentation
  - Energy conservation
  - Growth
  - Consistency with local and regional plans

Vermont Forestry Rules and Regulations:
Vermont's Acceptable Management Practices (AMPs)

- Adopted under Vermont's water quality statutes in 1987 and revised in August of 2018, AMPs are **intended to prevent discharges of sediment, pollutants, and woody debris from entering State waters**
- Any discharges without a permit or proper application of AMPs represent a violation enforceable by law
- It includes methods for the control and dispersal of water on logging roads, skid trails, and log landings before, during, and after logging operations to reduce erosion and sediment in streams

Methods include:

- Recommended culvert size for stream crossings
- Establishing skid trails across the slope rather than straight up
- Keeping slash and other debris out of surface waters
- Maintaining a protective buffer of 25 feet or greater along streambanks, except at stream crossings
- Using skidder (temporary) bridges to protect stream crossings from erosion
- Locating log landings on level or gently sloping land
- Filling in ruts and establishing properly spaced water bars at close-out
- Seeding and mulching of logging roads, log landings, and skid trails

Forest Products and Economics

- With 76% of Vermont forested, the wood products industry has an important role in Vermont's economy
- 79% of Vermont's forestland is privately owned, and the wood products industry provides incentive for keeping the land forested
- The forest economy as a whole contributes over $3.4 billion annually to Vermont's economy, including forestry and logging; wood products manufacturing; furniture making; paper manufacturing; wood energy; Christmas trees and maple syrup; and forest-based recreation

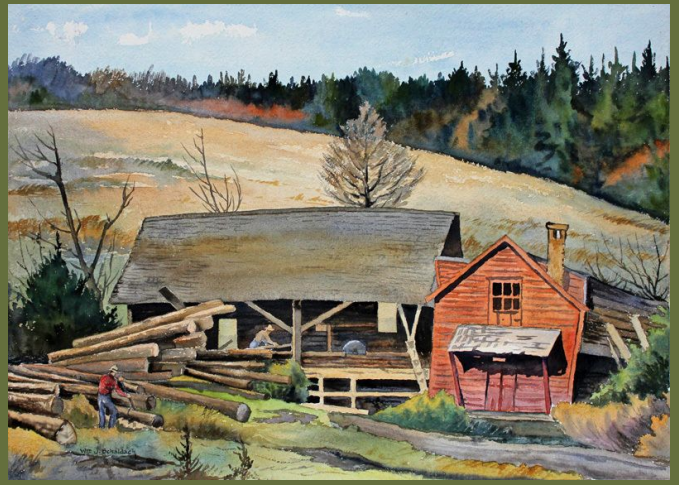
Timber and Wood Products

The forest and wood products industry provides $1.3 billion in direct contributions to the state's economy

- Local sawmills, from small, portable mills to large corporations, process slightly less than half of the timber harvested in-state
- Pulpwood is shipped out of state to mills in Maine, New York, and Quebec
- Global market forces have led to the closure of many local sawmills since the turn of the century
- Logs are often trucked to Canada, where they are milled and then shipped back to Vermont, adding to costs
- Local specialty products and diversification can add value to the market

Industry outputs include:

- ➔ Forestry
- ➔ Logging
- ➔ Primary solid wood products (wood-based power generation, sawmills, wood preservation, veneer and plywood)
- ➔ Secondary solid wood products (wood windows and doors, millwork, flooring, pallets, manufactured buildings)
- ➔ Wood furniture
- ➔ Pulp, paper, and paperboard mills
- ➔ Secondary paperboard and other paper products (paperboard, paper bags, stationary, sanitary paper)



Fuelwood

Cordwood and pellets provide a market for low-grade material

38% of Vermont households use cordwood as a heating source, and many in the commercial and institutional sectors rely on wood chips

Approximately 21% of the state's thermal energy is generated by wood

Two wood-fired electrical stations account for nearly one-fifth of in-state electrical generation

78 cents of every dollar spent on heating fuel stays in the region when heating with locally sourced wood.

Maple Syrup

Maple sugar was first discovered by Indigenous peoples and taught to early settlers

Vermont has been the leading U.S. producer of maple syrup every year since 1916, except two (1918 and 1926)

Roughly 50% of the syrup produced in the United States (more than 3 million gallons in 2025) comes from Vermont, making it an important regional crop

Revenue in 2024 totaled $95 million

Sugarmakers are natural stewards of the forest, as their livelihoods depend upon healthy forests, and off-season work typically consists of forest road improvement, thinning, and management of invasive species

Fruit, Nuts & Fungi

Edible species can be grown or foraged beneath a dappled canopy or along the forest edge, including:

Pawpaw
Currant
Elderberry
Serviceberry
Raspberry
Hazelnut
Black walnut
Hickory nut
Ramps
Morel Mushrooms

Forest Medicinals

The practice of forest farming involves growing or foraging medicinal species beneath a managed forest canopy

Forest farming can complement timber management and provide additional income

Medicinal species of northern hardwood forests include:
Ginseng
Black cohosh
Goldenseal
Bloodroot
Wild ginger
Solomon's seal

Regulations exist for the harvest and sale of ginseng and goldenseal, due to their status as endangered species

Local markets for such products have not been widely established

Craft Products

Craft products, such as willow and dogwood stems, evergreen branches, pinecones, mosses, and plant dyes can be grown or foraged from the forest

The Christmas tree industry accounted for $2.8 million in sales in 2012

Hunting

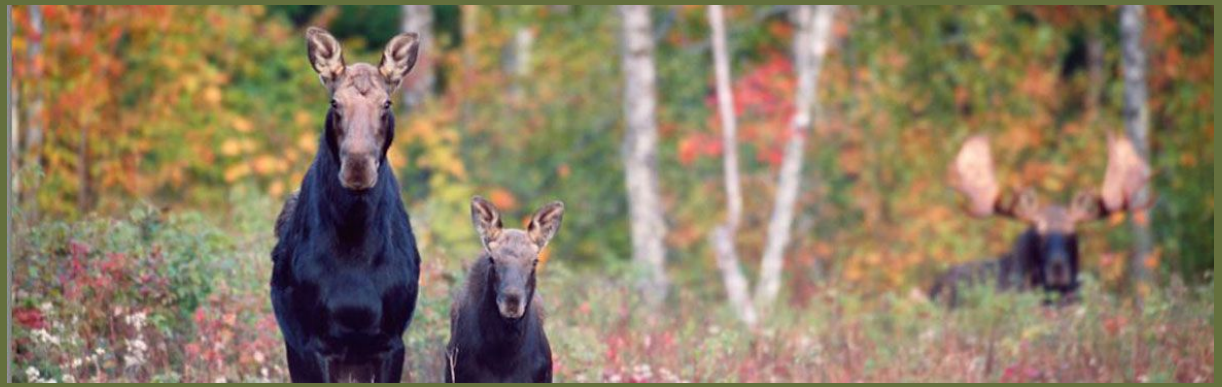
- Commercial fishing, hunting, and trapping contribute over $500,000 annually to the state's economy
- In 2021, there were 170,000 licensed hunters, anglers, and trappers in Vermont
- According to 2011 survey results from the U.S. Fish & Wildlife Service, resident and nonresident expenditures on hunting, fishing, and wildlife viewing in Vermont totaled $704 million, including food, lodging, and gear
- This spending typically comes at a time of year when other tourism-related spending (hiking, biking, skiing) is lagging

Recreation & Tourism

Forest-based recreation and tourism are estimated to contribute $1.9 billion annually to Vermont's economy

Fall foliage viewing accounts for 48% of tourism-related sales, followed by downhill skiing, hunting, wildlife watching, camping, snowmobiling, hiking, and cross-country skiing

72% of Vermonters report participating in outdoor recreation each year



Ecosystem Services

Forests provide a broad range of benefits to human health, livelihoods, and the environment, including the following:

- **Wildlife habitat and biodiversity** to support resilience and healthy ecosystems
- **Nutrient cycling** to support healthy plant growth and prevent runoff
- **Water storage and filtration** to reduce flooding and pollution downstream
- **Climate regulation** through the storage and sequestration of carbon, provision of shade, and transpiration
- **Reduced erosion** through living root systems, downed trees, and debris on the forest floor
- **Food, fuel, fiber and building materials** to support human habitat and rural economies
- **Recreation and tourism** to benefit human well-being and rural economies
- **Cultural heritage** through opportunities to interact with the forest in traditional ways

Silvicultural Practices and Land Management

Silviculture vs. Forestry

Silviculture:

the **art and science of cultivating trees and managing a forest**. Includes the establishment, growth, composition, and health of forest stands to meet a specific objective.

Forestry:

the **broader field of science that is forest management**. Encompasses silviculture, but also includes areas of study like ecology, economics, and policy.

Management Objectives:

the goal or intent behind managing a particular forest.

Common objectives include:

- ➔ Timber Production
- ➔ Wildlife Habitat
- ➔ Wildfire Resilience
- ➔ Forest Health
- ➔ Recreation
- ➔ Preservation

Forest owners and stewards often have multiple objectives in mind
when planning and implementing management activities.

Different management objectives often aren't mutually exclusive: Opening up small clearings in a forest can **improve timber quality** for remaining trees (less competition for light and resources), **improve forest health** (removing diseased or poor quality trees), and **create wildlife habitat**

Passive and Active Forest Management

Passive Management:

allowing natural disturbance and forest development to restore old growth conditions to a forest stand without human intervention. This hands-off approach may take a century or more to reach desired conditions, which makes it compatible with many easement programs.

Active Management:

involves the creation of human-caused disturbance, through patch cuts, prescribed burning, or thinning, in order to restore forest health and production at an accelerated rate. The intensity of management depends on the objectives and the current condition of the stand.

When to use passive vs. active management

It's complex! Often **depends on management goals** (timber, carbon storage, wildlife habitat) **and the current health and condition** of the stand

Sensitive Areas:

existing stands of old growth forest and ecologically sensitive areas, such as ridgetops and wetlands, are likely best protected through **passive management** and conservation easements.

Healthy Forests:

diverse and consisting of a mix of old growth, young growth, wetlands, streams and newly disturbed areas, which can be maintained through **active or passive approaches** depending on management objectives

Heavily Managed/ Impacted Forests:

In areas that have been significantly disturbed or altered by past human activities, and where invasive species, pests, and diseases are present, **active management** may be necessary in order to restore forest health.

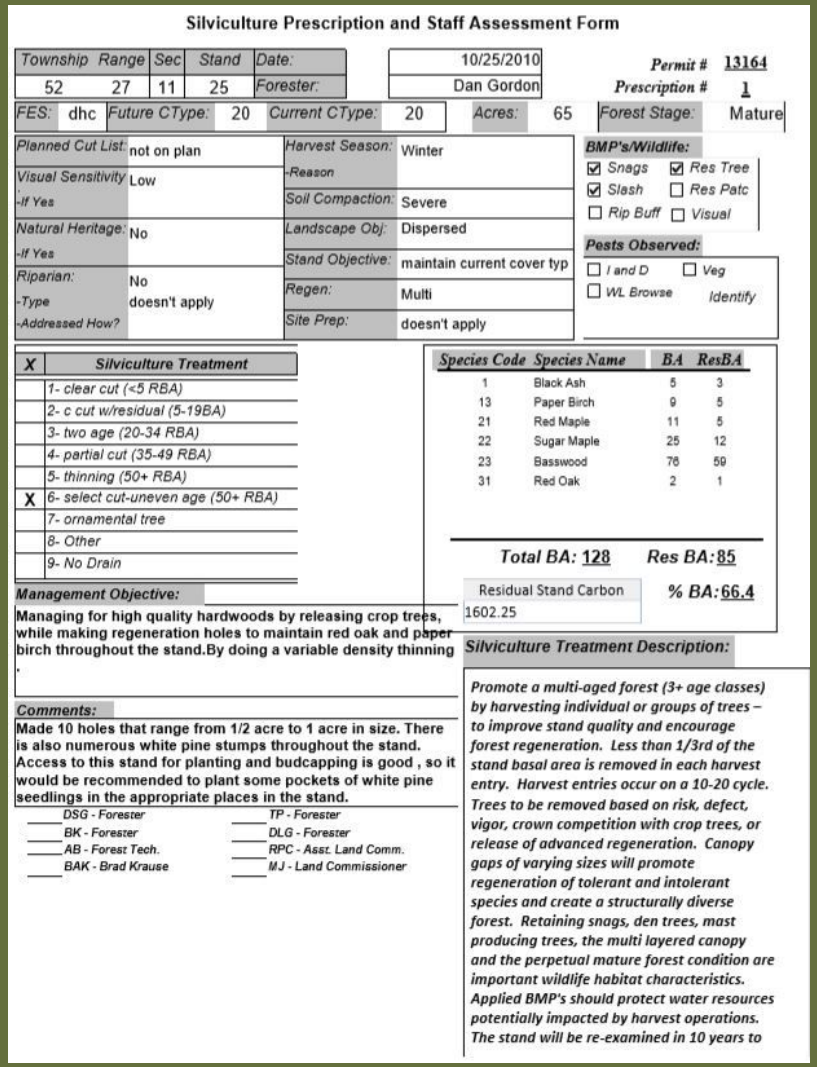
Vermont's Forests:

mainly young, even-aged stands that sprouted following the vast clearing of the nineteenth century for agricultural use. Many areas lack in the biodiversity needed to sustain many species of plants and animals.

Silvicultural Prescriptions

A document that includes a planned series of treatments or practices that are designed to change the current forest structure and composition to better meet specific management objectives.

Silvicultural Treatments include:
Thinning and clearing trees, prescribed burning, planting, pruning.



Silviculture Prescription and Staff Assessment Form

Township	Range	Sec	Stand	Date:	10/25/2010	Permit #	13164
52	27	11	25	Forester:	Dan Gordon	Prescription #	1

FES: dhc | Future CType: 20 | Current CType: 20 | Acres: 65 | Forest Stage: Mature

Planned Cut List:	not on plan	Harvest Season:	Winter
Visual Sensitivity -If Yes	Low	-Reason	
Natural Heritage: -If Yes	No	Soil Compaction:	Severe
Riparian: -Type -Addressed How?	No doesn't apply	Landscape Obj:	Dispersed
		Stand Objective:	maintain current cover typ
		Regen:	Multi
		Site Prep:	doesn't apply

BMP's/Wildlife:
☑ Snags ☑ Res Tree
☑ Slash ☐ Res Patc
☐ Rip Buff ☐ Visual

Pests Observed:
☐ I and D ☐ Veg
☐ WL Browse Identify

X	Silviculture Treatment
	1- clear cut (<5 RBA)
	2- c cut w/residual (5-19BA)
	3- two age (20-34 RBA)
	4- partial cut (35-49 RBA)
	5- thinning (50+ RBA)
X	6- select cut-uneven age (50+ RBA)
	7- ornamental tree
	8- Other
	9- No Drain

Species Code	Species Name	BA	ResBA
1	Black Ash	5	3
13	Paper Birch	9	5
21	Red Maple	11	5
22	Sugar Maple	25	12
23	Basswood	76	59
31	Red Oak	2	1

Total BA: 128 Res BA: 85

Residual Stand Carbon 1602.25 % BA: 66.4

Management Objective:
Managing for high quality hardwoods by releasing crop trees, while making regeneration holes to maintain red oak and paper birch throughout the stand.By doing a variable density thinning .

Comments:
Made 10 holes that range from 1/2 acre to 1 acre in size. There is also numerous white pine stumps throughout the stand. Access to this stand for planting and budcapping is good , so it would be recommended to plant some pockets of white pine seedlings in the appropriate places in the stand.

____ DSG - Forester
____ BK - Forester
____ AB - Forest Tech.
____ BAK - Brad Krause
____ TP - Forester
____ DLG - Forester
____ RPC - Asst. Land Comm.
____ MJ - Land Commissioner

Silviculture Treatment Description:
Promote a multi-aged forest (3+ age classes) by harvesting individual or groups of trees – to improve stand quality and encourage forest regeneration. Less than 1/3rd of the stand basal area is removed in each harvest entry. Harvest entries occur on a 10-20 cycle. Trees to be removed based on risk, defect, vigor, crown competition with crop trees, or release of advanced regeneration. Canopy gaps of varying sizes will promote regeneration of tolerant and intolerant species and create a structurally diverse forest. Retaining snags, den trees, mast producing trees, the multi layered canopy and the perpetual mature forest condition are important wildlife habitat characteristics. Applied BMP's should protect water resources potentially impacted by harvest operations. The stand will be re-examined in 10 years to

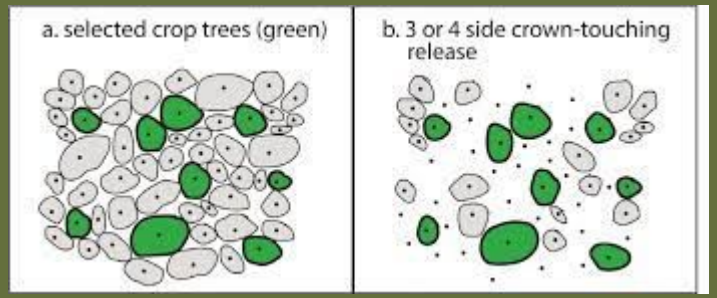
Silvicultural Practices: Thinning

Crop Tree Release involves **selecting desirable trees and removing surrounding, competing trees** to allow better access to sunlight and other resources

- ➔ Desirable trees are selected for mast (fruit or nut) production, wildlife habitat, timber production, or other landowner goals

Thinning is **the removal of selected trees within a stand**, often diseased or with little timber value, to create better tree density, species and age distribution within a given stand, and to reduce competition among the remaining trees.

- ➔ Selected trees are removed through felling (cutting) or girdling (cutting through the cambium layer to create standing deadwood). Felled trees can be used for firewood, lumber, or pulp, or left on the forest floor to provide habitat and nutrient cycling.



Silvicultural Practices: Shelterwood Harvest

Shelterwood harvest is a management technique that uses multiple cuts to obtain an even-aged forest:

- ➔ Preparatory cut: thins the stand, removing undesirable tree species so they will not contribute seed source to the establishment cut
- ➔ Establishment cut: most trees within the stand are removed except for a portion of healthy, mature trees that function as a seed source for the natural regeneration
- ➔ Removal cut: most or all of the remaining mature trees are removed after natural regeneration becomes established

Silvicultural Practices: Patch Cuts

Patch cuts involve **the removal of trees in a small area (typically 5 acres or less) to mimic natural disturbance and promote regeneration**.

- ➔ These cuts can be beneficial for wildlife that find food and shelter among the species and structural diversity that respond to increased sunlight.
- ➔ It is most beneficial when done in a mosaic pattern within a larger tract, and near areas that already provide habitat and food for wildlife.

Silvicultural Practices: Clear Cutting

Clear Cutting is **the removal of all or most of the trees in a given area**, typically larger than a patch cut.

➔ While efficient for timber harvest and the regeneration of trees of a uniform size, it can lead to soil erosion, loss of biodiversity, and long-term degradation of ecosystems.

Silvicultural Practices: Prescribed Burning

Practiced by Indigenous peoples for centuries, **prescribed burning** is the **intentional low-intensity burning of forests to maintain forest health and habitat** through the removal of diseased trees and promotion of native, fire-resistant species.

- ➔ Prescribed burns help prevent accumulation of debris on the forest floor, which can lead to hotter, more uncontrollable forest fires.
- ➔ It should only be practiced under certain conditions and by qualified professionals.

Silvicultural Practices: Tree Establishment - Natural Regeneration

Natural Regeneration is **the process by which a forest or field re-grows from roots, seeds, and seedlings present on site and without human intervention**.

- ➔ This ensures the genetic continuity of species that are adapted to a particular site.
- ➔ While this is a low-cost, low-input way of reestablishing forests, it may be less successful in areas where invasive species are present or the land and existing seed bank have been diminished.

Silvicultural Practices: Tree Establishment - Reforestation

Reforestation involves **direct seeding or transplanting trees in disturbed areas to facilitate the reestablishment of forest**.

- ➔ This requires more labor and cost than natural regeneration, but may be more successful in areas where genetic diversity and vigor are lacking.
- ➔ Species are selected for wildlife habitat, water quality, erosion control and/or timber value, and may range from low to high in biodiversity.

Silvicultural Practices: Tree Establishment - Afforestation

Afforestation is **the establishment of trees in areas where they have not been for quite some time, such as agricultural or urban lands**.

- ➔ Trees can be planted for crops or timber; for the protection of livestock or cropland; or to provide wildlife habitat, streambank stabilization, water quality protection, recreation, and beauty.

Silvicultural Practices: Pruning

Pruning involves **the removal of tree limbs for multiple purposes**, including the development of knot-free, high value lumber; increasing airflow, sunlight, and productive wood within fruit- and nut-producing species; or removing dead and diseased wood to promote tree health.

Silvicultural Practices: Coppicing and Pollarding

Coppicing (cutting a tree at the base) and **pollarding** (cutting a tree above browse height) are **methods to encourage sprouting, which provides habitat for wildlife and wood products** such as firewood, fence posts, and craft material.

- ➔ Managing this way in rotation within a larger stand (copse) eliminates the need for replanting, prevents soil erosion, and keeps trees young and vigorous indefinitely.
- ➔ Species such as ash, maple, oak, willow, elderberry, and hazelnut can be managed in this way.

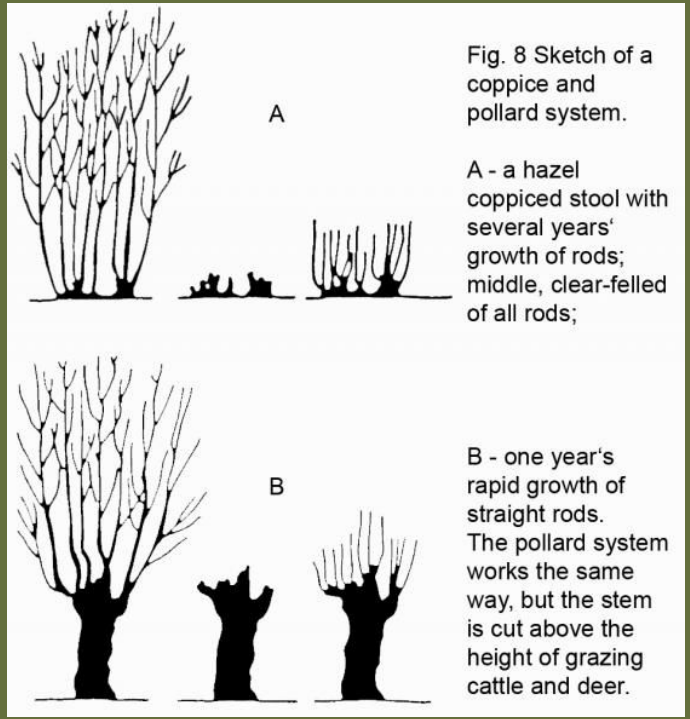


Fig. 8 Sketch of a coppice and pollard system.

A - a hazel coppiced stool with several years' growth of rods; middle, clear-felled of all rods;

B - one year's rapid growth of straight rods. The pollard system works the same way, but the stem is cut above the height of grazing cattle and deer.

Other Management Considerations: Invasives

Invasive species, pests and diseases pose threats to forest health and biodiversity.

- ➔ Invasive species often proliferate in disturbed areas, and pests and diseases are becoming increasingly common in northern woodlands due to climate change.
- ➔ Managing these threats to native ecosystems through mechanical, biological, or chemical means are an important part of maintaining forest health. Once established, however, they can be difficult to remove so prevention is the best strategy.


Buckthorn


Bush Honeysuckle


Burning Bush


Japanese Barberry

Other Management Considerations: Wildlife

- Standing dead and woody debris leftover from logging can improve wildlife habitat, soil health, and water retention.
    - Downed trees and limbs left on the forest floor slowly release nutrients as they break down.
    - Snags (standing dead trees) provide habitat for birds, small mammals, insects and amphibians.
    - Debris helps to slow the movement of water across the landscape.
- Multiple layers of vertical growth, including ground cover, understory, midstory, and canopy species, and temporal growth, including stands of young and old trees, create more diverse habitat.
- Maintaining large tracts of contiguous forest provides habitat for wider-ranging species.
- Maintaining healthy stands of mast species provides a food source for many species of wildlife.

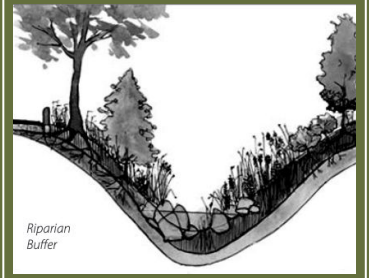
Agroforestry

Agroforestry is the **intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits**. It combines centuries-old Indigenous practices with modern research in order to benefit food production, wildlife habitat, soil health and water quality, and provide resilience to climate change

- ➔ **Alley Cropping** is the planting of crops such as small fruits, vegetables, and grains in between rows of trees that provide shade, erosion control, and/or longer-term economic value
- ➔ **Forest Farming** is the growing of high value non-timber forest products, such as fruits, nuts, mushrooms, medicinal crops, floral and craft products beneath a managed forest canopy
- ➔ **Riparian Buffers** is the planting of native edible and non-edible species along rivers and streambanks to reduce erosion and runoff and provide wildlife habitat
- ➔ **Silvopasture** is the integration of trees and shrubs into pasture to provide shade, forage, erosion control, and other benefits to livestock and grazing land
- ➔ **Windbreaks** are planted perpendicular to the prevailing winds in order to protect livestock, fields, and infrastructure from temperature extremes and wind erosion

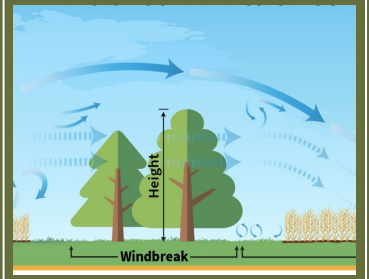
Alley Cropping

Forest Farming



Riparian Buffers

Silvopasture



Windbreaks

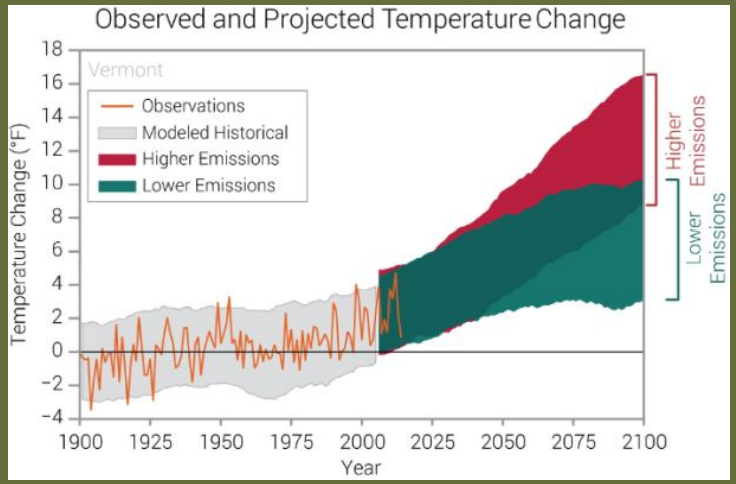
Urban Forestry

- **Urban trees and forests can provide habitat for wildlife, reduce energy costs, mitigate stormwater runoff and pollution, provide temperature regulation, improve air quality, and increase property and community value.**
- Trees in urban settings require different management than those in a forest setting:
  - They have been cut off from the complex ecosystems in which they evolved, and experience many additional stressors like air pollution, elevated temperatures, compacted soils, road salts, and invasive pests and diseases
  - Tree species should be selected that can withstand urban stressors and grow in confined environments without causing damage to infrastructure
  - Trees may require more regular watering, mulching, and pruning to maintain soil and tree health
- Vermont's Urban & Community Forestry Program was founded in 1991 as a collaboration between the Department of Forest, Parks & Recreation, University of Vermont Extension, and the USDA Forest Service; its mission is to help communities plan, plant, and care for their community trees through technical, educational, and financial assistance

Forests and Climate Change

Extreme Weather Patterns

- Vermont's average annual temperature has increased by almost 2 degrees Fahrenheit since 1900, and is expected to warm by 5 to 9 degrees Fahrenheit by 2100
- Winter temperatures have increased 2.5 times faster than annual temperatures in the past 60 years
- Average annual precipitation has increased by 21% since 1900, and heavy precipitation events (more than one inch per day) have increased by 0.5 days per decade since the 1960s, occurring mostly in the summer but expected to increase in the winter and spring
- Both drought and flooding events are becoming more common
- The number of freeze-free (greater than 28 degrees Fahrenheit) days has increased by 9 days per decade since 1991, with the greatest increase occurring in southeastern Vermont



Source: UVM and VTDigger
https://vtdigger.org/2021/11/09/local-impacts-of-global-change-vermont-climate-assessment-shows-climate-change-has-arrived/

Development and Disturbance

- A warming climate and other weather-related stressors and disturbances are providing increased pathways for many invasive species, pests, and diseases
- Climate refugees and summer visitors are expected to increase as other parts of the country experience more extreme heat, which could lead to an increase in development and forest fragmentation
- Warmer winters and wetter summers are limiting the timeframe in which forest management activities can take place, which could have a greater impact on forest health and rural economies in the future

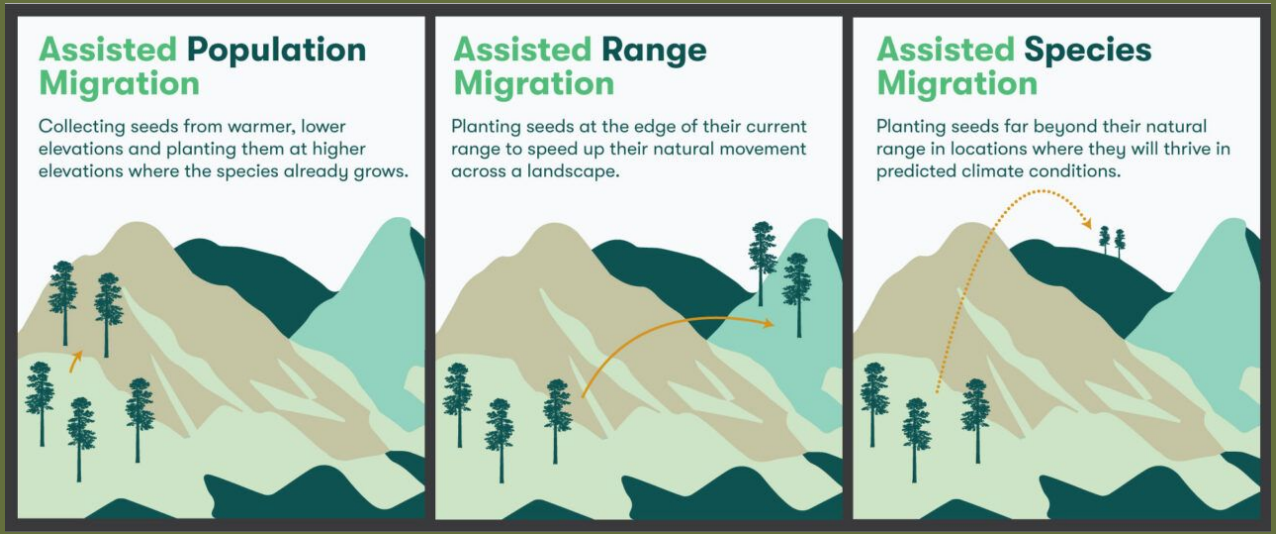
Species Migration

- The white-tailed deer population is expected to increase as the climate warms, which could have long-term impacts on forest composition
- Low adaptive species are those that are adapted to colder climates and may be forced beyond their native range as the climate warms

  Examples include:
  - ➔ Balsam fir
  - ➔ Paper birch
  - ➔ Quaking aspen
  - ➔ Northern white cedar
  - ➔ White spruce
  - ➔ Black ash
  - ➔ Tamarack
- Sugar maple, Vermont's state tree, is facing stress caused by warming temperatures, drought, and an increase in pests; in addition, warming springtime temperatures and changes in the freeze-thaw cycle are expected to impact the maple sugaring industry in Vermont
- Increasing diversity of species, including red maple, may help to offset some of these impacts

Impacts on Tree Species

- Vermont's climate is becoming more habitable to southern-adapted species such as northern red oak, shagbark and bitternut hickory, and black cherry
- Changes in forest composition may occur more slowly than climate change projections due to forest fragmentation, the reproductive cycle of trees, and limitations of natural dispersal methods (wind, water, wildlife)
- Assisted migration involves planting specific tree species in areas beyond their range in anticipation of future climate, and can be used to speed up the process of natural tree migration; the closer a tree species is planted to its range, the more likely it is to be successful



Developing a Land-Use Ethic

- All species, past and present, interact with and alter their environment through the daily tasks of living: acquiring and maintaining food; water; shelter; safety; and in the case of humans, cultures and economies.
- **Keystone species** are those that have an outsized effect on the ecosystem relative to population size; they include ecosystem engineers, mutualists, and predators. While ecosystems often adapt over time, the removal of keystone species can significantly alter species composition in a given ecosystem.
    - Beavers are an example of an ecosystem engineer that create new wetland habitat through the damming of streams, and provide openings in the forest for early successional species
    - Bees are mutualists, who benefit flowers through pollination while collecting nectar and pollen for their own sustenance
    - Historically, predator species such as wolves and mountain lions kept deer populations in check, allowing forests to regenerate

- **Do humans fit the definition of a keystone species? If so, in what ways are we altering the environment around us? Looking to the past and future projections, how might we develop a land-use ethic that protects ecosystems and sustains diverse life?**

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