Week 04 Lecture 01
Native American Forestry Management and Agricultural Technology

Weatherford chapter 5
Pages 75—98
Second edition pages 102–127
Native American Forestry Management and Agricultural Technology

The learning objectives for week 04 are:

- to understand the nature of North American Indian agro-forestry
- to appreciate how modern science is making use of Native American farming practices
- to appreciate how modern science is making use of Native American land management practices
- to understand and appreciate some of the most important medical contributions of Native Americans to the world (Week 04 lecture 02)
Native American Forestry Management and Agricultural Technology

Terms you should know for week 04 are:

– back fire
– conuco
– polyculture
– the three sisters
– quinine
– curare
– ipecac
Native American Forestry Management and Agricultural Technology

Week 04 Sources:


Native American Forestry Management and Agricultural Technology

Sources (contd):

Thornton, Russell. 1987. *American Indian Holocaust and Survival: A Population History Since 1492*. Norman: University of Oklahoma Press. Surveys the various estimates of the native population of the New World at the time of European contact. The population figures play an important role in the debate over the extent of Indian forest management described in the Michael Williams book below.


Native Americans Among the World’s Greatest

– Plant breeders
– Biodiversity protectors
– Agricultural technologists
– Environmental managers – including advanced forms of agroforestry and other land management techniques
Modern Scientists Have Discovered That...
- Plants require 18 essential elements to live
- Most from the soil
- Carbon, oxygen and hydrogen from air and water
- Nitrogen most difficult to get from air – ...
Nitrogen thus a crucial “limiting factor” in plant growth

- Modern agriculture gets from oil and natural gas see the Haber-Bosch process described later in this lecture
- Expensive and amount is ultimately limited by fossil fuel availability
- Easy to over-fertilize...excess can run off into local water systems and poison humans - this “reactive nitrogen” a major problem today
Nitrogen thus a crucial “limiting factor” in plant growth

Native Americans solved the problem by planting “nitrogen accumulators” near their food plants

– Black locust, mahogany, bayberry trees
– New Jersey tea shrub
– Peanuts and related plants
– Vetch and bean plants; also most acacias


Other plants used to “accumulate” or “fix”

– Phosphorus – may be facing a world shortage, see later slides
– Potassium
– Calcium
Fertilizers

- Native Americans understood value of animal dung for plants
- Used seaweed and...
- Guano – the giant bird droppings fields in Peru
- Inca had regulated the guano supply
- Peruvian guano helped England overcome soil fertility decline
Vanilla

• Native Americans taught Europeans how to grow
• Also how to cure by aging 4 – 5 months to release flavor
• Fertilized and tended by hand
Other Native American Farming Technology Achievements...
Milpas

- Plant crops on mounds rather than in rows
- Leads to less erosion
- May be a way to preserve soil in modern agriculture
- Peruvian potato mounds shown in *The Columbian Exchange* a sophisticated version of the milpa
Chinampas

• “Floating gardens” of Aztecs
• Did not float
• Artificial islands built up on lakes
• Very rich soil; high output
Week 04 Native American Farming Technology
• Chinampas were food base for the Aztec empire

• Among the most productive farming land ever created
Conuco

- Use root or sprout cuttings to develop genetically desirable traits
- Cassava, sweet potato and pineapple all created this way
Polyculture

• Mix various plants on same field instead of row planting
• Makes natural barrier against pests and diseases
• Preserves long-term biodiversity and soil structure
• See Iroquois three sisters example later in the slides
Mixed Farming and Polyculture: North American Forest Management Before the Europeans
Recent Research Shows Native Americans Practiced Sophisticated Forest Management Techniques Before the Europeans
Native American Agro-forestry

1. Most Europeans saw North America as a wilderness inhabited by uncivilized “savages.”
2. Later researchers – following the anthropologist Alfred Kroeber – estimated the pre-colonial population of North America at about 1 million persons.
3. In the past 20 years an entirely new understanding of the aboriginal conditions of North America has emerged.
4. Two basic points are now widely accepted:

4.2 The pristine forests of NA were actually managed ecosystems.
4.1 The population of NA was at least 9 million and could have been 18 million.
5. The total population of the Western Hemisphere, in fact, may have been greater than that of Western Europe.
6. If point 5 is true, why were such low population estimates made for 500 years?
7. Historical demographer (population studies) Henry Dobyns combed thru hundreds of accounts of diseases and epidemics that struck the Native American population on contact with Europeans after 1491.
8. He found 41 major smallpox epidemics from 1520 to 1899.
9. 15 major measles outbreaks, 10 recorded influenza epidemics, and incidents of bubonic plague, diphtheria, typhus, cholera, scarlet fever, and other diseases not easily identifiable from the account.
9.1 The disease counts and other information only make sense if the native population had been many times larger than 1 million.
10. The relative genetic isolation of Native Americans from the Old World diseases had rendered them uniquely vulnerable to European and African pathogens.
Even Dobyns’ strongest critics now agree that the population of North America was probably around 7 million
11. Epidemics played a major role in the European conquest of Native Americans.
12. The horrible death toll Dobyns retrieved from the historical record has the scientific effect of recasting our estimates of the 1491 population of North America.
13. Higher population estimates lead to many changes in our understanding of Indian life prior to the introduction of Old World diseases.
14. In Eastern North America the native peoples lived in villages surrounded by fields on which they grew a great variety of crops.
15. We discussed these crops in a previous class and they are described in Weatherford’s chapters 4, 5 and 6 and in the video “The Columbian Exchange.”

The video is #2324 Part 6 in Sprague Library

See also the book →

16. To grow these crops the Indians used a “managed ecosystem” approach.
17. Partial clearings were hacked out of the forest and fire would burn off the underbrush.
18. Areas around the village would be in various stages of regrowth – a process ecologists call environmental successions.
18a. **Environmental succession:**

a process by which plant communities move from grassland to forest climax...

...in which they...

– accumulate biomass; and

– soil nutrients move from mineral form to organic matter
19. A European visitor painted the Indian village of Secota, Virginia in 1585
20. Much of the right side of the painting shows corn in various stages of growth.
21. To the left of the corn next to the pathway one can see pumpkins
22. By using fire and other devices to maintain environmental successions, the peoples of the NA Eastern Woodlands maximized output of grains, seeds, nuts, and berries; and attracted deer and other game to the edges of their villages.
23. By NOT opening up large monocrop cleared areas, however, they allowed the forest successions to maintain species diversity (also called “biodiversity”).
24. By not disturbing the forests too much, the Native Americans maintained the root connections among various plants, allowing them to exchange nutrients.
25. Modern plant biologists have recently discovered the importance of *mycorrhizae* (fungus roots) that link forest plants together into a single healthy ecosystem.

26. The fires may also have stimulated the growth of mycorrhiza and the fires also were sometimes used to drive game into traps.
27. Fires also stimulated the growth of berry bushes, an important food source.
28. Native Americans invented the “back fire,” a fire used to burn off the path of an oncoming uncontrolled natural fire. Backfires are still used in modern forest fire fighting today.
29. Recent archaeological and historical research suggests that groups such as the Iroquois moved their villages about once in 20 years to adjust to the various forest successions. Some villages may have been permanent.
30. Most of the meadows and parklike forest areas described by colonists were almost certainly the products of Indian ecological management.
31. It now appears likely that even much of the prairie with its pure grass stands – an unnatural environment – was a product of Indian ecological management thru the use of fire.
32. Far from being a pristine wild and natural environment, it now appears that the North American continent was largely what ecologists would call a “human induced fire based subclimax.”
33. The predominance of pine trees in many NA forests is itself evidence of human eco-management – pine trees are part of an ecological succession.
34. Native American eco-management practices are now influencing the theory and practice of sustainable farming.

Also goes by the name “permaculture”
35. Some Sources:
Permaculture:

consciously designed landscapes which mimic the patterns and relationships in nature while yielding an abundance of food, fiber [and other products?] for human needs.

David Holmgren

Sometimes also called “biomimicry” but actually involves much more than that...
Ecovillage Ithaca: Laboratory for Sustainability?

Much remains to be learned about permaculture’s possibilities, especially the potential of edible landscapes.

Find out more about permaculture at:

https://fingerlakespermaculture.org/what-is-permaculture/
The Three Sisters

Native American Agriculture:
Iroquois “Three Sisters” Farming
The Three Sisters

The best known example of Native American agricultural sophistication comes from the three sisters system of the Iroquois.
The Iroquois are Mostly Famous in U.S. History for the League of the Iroquois

- Founded by Hiawatha and Deganwidah between AD 1000 and AD 1450, under a constitution called the "Great Law of Peace"
- The League of the Iroquois united 5 Indian nations:
League of the Iroquois

– Mohawk: People Possessors of the Flint
– Onondaga: People on the Hills
– Seneca: Great Hill People
– Oneida: Granite People
– Cayuga: People at the Mucky Land
League of the Iroquois

The Three Sisters

37. Early European explorers were astounded at the large amounts of corn stored up in Iroquois villages.
The Three Sisters

In 1535 Jacques Cartier, and later Henry Hudson, noted large granaries filled with corn.
The Three Sisters

In 1779 Continental Army general John Sullivan reported destroying 6,000 bushels in the village of Genesee New York and 160,000 bushels along the East Side of Seneca Lake and surrounding areas.

Lewandowski 1987:78
The Three Sisters

Iroquois agriculture was based on the “three sisters:” corn, beans, and squash.
The Three Sisters

The three sisters are also part of the origin stories of the Iroquois and other Northeast North American groups.
The Three Sisters

The Iroquois farmed without the plow and without commercial fertilizers – such as today’s petroleum based ammonia to fix nitrogen.
The Three Sisters

Instead the women planted a few corn seeds at a time in holes set about 3 ft apart.

Modern agricultural scientists now recommend 5 ft between the corn plantings.
The Three Sisters

When the corn sprouted they weeded and mounded up the soil around the stalks.
The Three Sisters

The mounds exposed the soil to the air, helping it warm up in the spring; and helped drain the soil.
Two weeks later the women planted beans next to the corn and then squash between the mounds.
The Three Sisters

The “3 sisters” were now ready to help each other:

- The corn provides a pole for the beans to climb on.
The Three Sisters

The big squash leaves reduce weeds and help retain soil moisture.

They are thus a natural self-generating mulch.
The Three Sisters

The beans change atmospheric nitrogen into a form it can be absorbed ("fixed") in the soil – an important nutrient for the corn. They function as a substitute for the high-tech Haber-Bosch system to be described soon.
The Three Sisters

The mounds prevent soil erosion and help recycle the nutrients, especially when the plant residues at harvest time are thrown back on the mounds.

Weeding is made easier by moving from mound to mound.

Wolkomir 1995; Hart 2008:87-88
The Three Sisters

The Seneca, one of the Iroquois nations, are known to have used at least one organic-biological pest control: seeds were soaked in Hellebore (Veratum album or “false Hellebore”) extract. This made the plant repellent to birds and other pests.

Lewandowski 1987:82
The Three Sisters

It is not clear whether Native American biological pest control devices have been tested by modern scientists.
The Three Sisters

The Three Sisters system in the Finger Lakes region of New York state where many of the Iroquois lived is at least 650 years old.


The Three Sisters

The Three Sisters system, however, could be 6,000 years old, based on findings in Mexico that corn and beans were being planted together in the same fields at that time.

Lewandowski 1987:78
The Three Sisters

The system may have thus migrated up through North America before being adopted by most of the Northeast woodlands groups from modern Ohio to New England.

Hart 2008
The Three Sisters

The unique contribution of the Native Americans in the Finger Lakes area then would have been to adapt and adjust the system to the area by choosing and/or selecting appropriate varieties of each crop.
The Three Sisters

The Iroquois are known from the research of the famous American ethnologist Lewis Henry Morgan in 1850 to have cultivated at least 3 types of corn. More recent studies show they knew of at least 5 types: soft, flint, sweet, pop and pod.

Lewandowski 1987:89
The Three Sisters

As well as at least 60 varieties of beans.

Lewandowski1987:89
The Three Sisters

And many types of squash including bottle gourds used for containers, utensils and rattles as well as several types of pumpkins.

The Three Sisters

The 3 sisters together provide a fairly balanced diet of vitamins, minerals, carbohydrates, and the full complement of amino acids for proteins.

Hart 2008:88; Mt Pleasant 2001 and 2006
The Three Sisters

Corn is low in the amino acids lysine and tryptophan, but beans, it turns out, have ample amounts of those two essential protein builders.

Lewandowski 1987:84

Corn has a 9.2% overall protein content, compared with 8% for brown rice and 7% for white rice.
The Three Sisters

The Seneca made corn into hominy by soaking it in wood ash – this made it easier for humans to absorb the niacin and some other nutrients – in other words, it made the corn healthier to eat – corn is the grain weakest in niacin.

Lewandowski 1987:84
The Three Sisters

The manufacture of hominy is probably an ancient Native American craft, known from Mexico (as nixtamal) and throughout much of North America.
The Three Sisters

The Huron, whose diet was probably similar to the Iroquois, and whose diet was studied in some detail, ate 65% corn, 15% beans-squash-pumpkins 10–15% fish and 5% meat.

They ate 1.3 pounds of corn per person per day.
The Three Sisters

The Seneca ate in addition: succotash*, cornbread with fruit or beans, hominy soups and stews, maple syrup, and berries.

Lewandowski 1987:84

*Succotash comes from the Narragansett language, an Algonquian language like that spoken by the Iroquois. It means “boiled corn kernels.”
The Three Sisters

The rising cost of petroleum and natural gas-based nitrogen fertilizer makes the Iroquois approach appealing – and the threat of a worldwide phosphorous shortage adds to the comparative advantage of the three sisters approach.

Source on the looming phosphorous shortage:
The Three Sisters

Using the natural fertilizers in the soil and returning them at harvest time makes the farming more “sustainable,” a goal now widely accepted in environmental and policy circles.
The Three Sisters

Sustainable farming may be even more crucial than the slide above suggests – because other problems also loom in the near future
In 1909 German chemists Fritz Haber and Carl Bosch invented a way to turn atmospheric nitrogen into a form that could be applied as liquid or pellets on agricultural fields.

Many scientists consider the Haber-Bosch process to be among the most important discoveries of the 20th Century.
One-half of all nitrogen fertilizer used today is made from the Haber-Bosch process— the other half consists of natural crop and animal wastes.

Haber-Bosch today generates more than 500 million tons of nitrogen fertilizer while utilizing 1% of the world’s total energy budget— mostly natural gas burned in the chemical alteration process.

Some observers claim that up to 40% of all humans alive today exist only because of Haber-Bosch.

https://www.idsia.ch/~juergen/haberbosch.html

https://www.wisegeek.com/what-is-the-haber-bosch-process.htm
The Earth’s atmosphere near the surface (up to about 18 km or 11 mi) has lots of nitrogen: 78% and 21% oxygen.
But Haber-Bosch has two limiting factors:

If energy descent theory is correct, Haber-Bosch will be difficult to sustain—and along with it the food production that depends on it.

It requires tremendous amounts of heat and that currently means burning large amounts of fossil fuels, mainly petroleum and/or natural gas.
2013 Update: Haber-Bosch Today

The October 21, 2013 *New Yorker* Magazine contains a book review essay by Elizabeth Kolbert that includes an interesting discussion of some of the current debates on population growth and world environmental problems that she connects with the Haber-Bosch discoveries.

To access the article, click [here](#).
The Three Sisters

A second problem with Haber-Bosch results from its very success: we now have too much nitrogen in the soils and fresh waterways of earth. When nitrogen is a gas in the atmosphere, it is considered “non-reactive.” In soil, rivers and lakes, however, the nitrogen reacts with other chemicals – too much nitrogen causes all kinds of harmful side effects.
The Three Sisters

The 2005 Millennium Ecological Assessment considered reactive nitrogen one of the most serious environmental threats to the entire earth’s life support system.

Consider a few of their findings as described in the next few slides...taken from their report - all basically a consequence of Haber-Bosch
Millennium Ecosystem Assessment Findings

Slides taken from the Millennium Assessment Report
Largest assessment of the health of Earth’s ecosystems

Experts and Review Process
- Prepared by 1360 experts from 95 countries
- 80-person independent board of review editors
- Review comments from 850 experts and governments
- Includes information from 33 sub-global assessments

Governance
- Called for by UN Secretary General in 2000
- Authorized by governments through 4 conventions
- Partnership of UN agencies, conventions, business, non-governmental organizations with a multi-stakeholder board of directors
Changes in direct drivers: Nutrient loading

- Humans have already doubled the flow of reactive nitrogen on the continents, and some projections suggest that this may increase by roughly a further two thirds by 2050.

Estimated Total Reactive Nitrogen Deposition from the Atmosphere

Accounts for 12% of the reactive nitrogen entering ecosystems, although it is higher in some regions (e.g., 33% in the United States).
Changes in direct drivers
Impacts of Excessive Nitrogen Flows

Environmental effects:
- eutrophication of freshwater and coastal ecosystems
- contribution to acid rain
- loss of biodiversity

Contribution to:
- creation of ground-level ozone
- destruction of ozone in the stratosphere
- contribution to global warming

Resulting health effects:
- consequences of ozone pollution on asthma and respiratory function
- increased allergies and asthma due to increased pollen production
- risk of blue-baby syndrome
- increased risk of cancer and other chronic diseases from nitrate in drinking water,
- increased risk of a variety of pulmonary and cardiac diseases from production of fine particles in the atmosphere
Teragrams of Nitrogen per Year

- **Fossil Fuels**
- **Agroecosystems**
- **Fertilizer**
- **Total Human Additions**

Source: Millennium Ecosystem Assessment
The Three Sisters

Here are the notes from the previous slide:

From: MA Synthesis Figure 14. Global Trends in the Creation of Reactive Nitrogen on Earth by Human Activity, with Projection to 2050 (R9 Fig 9.1)

Most of the reactive nitrogen produced by humans comes from manufacturing nitrogen for synthetic fertilizer and industrial use. Reactive nitrogen is also created as a by-product of fossil fuel combustion and by some (nitrogen-fixing) crops and trees in agroecosystems. The range of the natural rate of bacterial nitrogen fixation in natural terrestrial ecosystems (excluding fixation in agroecosystems) is shown for comparison.
Human activity now produces approximately as much reactive nitrogen as natural processes do on the continents. (Note: The 2050 projection is included in the original study and is not based on MA Scenarios.)

MA Synthesis SDM: “Since 1960, flows of reactive (biologically available) nitrogen in terrestrial ecosystems have doubled, and flows of phosphorus have tripled. More than half of all the synthetic nitrogen fertilizer, which was first manufactured in 1913, ever used on the planet has been used since 1985.”
Percent Increase in Nitrogen Flows in Rivers

Source: Millennium Ecosystem Assessment
Some results of excessive reactive nitrogen: eutrophication
Gulf of Mexico Dead Zone

Source: NOAA
The World’s 405 Dead Zones as of 2008; up from 49 in the 1960s

This is no small economic matter. A single low-oxygen event (known scientifically as hypoxia) off the coasts of New York State and New Jersey in 1976 covering a mere 385 square miles (1,000 square kilometers) of seabed ended up costing commercial and recreational fisheries in the region more than $500 million. As it stands, roughly 83,000 tons (75,000 metric tons) of fish and other ocean life are lost to the Chesapeake Bay dead zone each year—enough to feed half the commercial crab catch for a year.

The Three Sisters

57. The 3 sisters are thus part of a new farming movement called “permaculture” that began in Australia in the 1970s and is now taught at many major US agriculture schools.
The Three Sisters

58. A key element of permaculture is that food production fields should “mimic” natural environments to the greatest extent possible.
The Three Sisters

59. Iroquois 3 sister intercropping is not like big US corporate farms where a single crop is grown over a large area.
The Three Sisters

Large monocrop farms offer short term labor efficiency advantages but in the long run are more vulnerable to disease, infestation, soil erosion and loss of soil fertility.
The Three Sisters

By contrast, the 3 sisters system promotes biodiversity – now recognized as a key element in both organic pest resistance and in long term sustainability.
The Three Sisters

Sources on The Three Sisters:


The Three Sisters

Sources on The Three Sisters:
End of Slides on Native American Agricultural Technology

Weatherford chapter 5