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A Historical Examination of Native American and European Agroforestry

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Abstract

According to the United States Department of Agriculture (USDA), “Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits. It has been practiced in the United States and around the world for centuries.” However, for many practitioners in the past, agroforestry was not simply an “integration of trees and shrubs into animal farming systems,” nor was it simply a means to produce foodstuffs. For them, agroforestry defined a way of life where trees were fixtures in the landscape which bore many life-giving gifts: fruits and nuts to eat, sap to drink, wood to stay warm, and shade to keep cool. Especially in temperate biomes, trees defined the

relationships human cultures had with the land itself. The purpose of this paper is to offer a historical perspective on agroforestry by examining the land ethics of southeastern Native American and European cultures.

Part One: Introduction

On August 9th 2021, the Intergovernmental Panel on Climate Change (IPCC) released part one of its Sixth Assessment Report, "Climate Change 2021: The Physical Science Basis." The same day, United Nations Secretary General António Guterres described the results of the report as being a "code red for humanity," stating "greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk." The report's dire implications were recognized by government officials around the world.

Secretary General Guterres was not exaggerating, the findings of the report were alarming. A disastrous 1.5 degree Celsius warming of average temperatures on earth will occur by 2040, a rate "unprecedented in at least the last 2,000 years," and driven by atmospheric concentrations of CO_2 "higher than any time in the last 2 million years." According to the IPCC, this warming will result in a greater "frequency and intensity" of hot temperature extremes, heavy precipitation over land, and agricultural and ecological droughts. Each incremental increase in global temperatures will result in a proportional increase in weather events, meaning simply reducing our emissions will not be enough to stop the positive feedback loop of climate change.

The IPCC suggests that the only way to reduce global temperatures is to achieve not only net zero, but net negative emissions. Anthropogenic CO_2 Removal (CDR) offers the potential to do so. CDR is defined as "Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products." The carbon capture technologies associated with CDR are known for being expensive and experimental. However, the earth already has a natural carbon cycle which has reliably sequestered carbon for millions of years, and an important part of this carbon cycle involves trees.

Afforestation is a simple and effective means of sequestering carbon. The IPCC's FAQ page chapter 4 states "Afforestation (planting new trees) and reforestation (replanting trees where they previously existed) are also considered forms of CDR because they enhance natural CO2 'sinks.'" Pennsylvania State Extension describes trees and forests as "the best carbon capture technology," and for good reason: American forests are estimated to sequester 16% of the United States' emissions yearly (US Forest Service). Woody trunks, branches, and roots are entirely made of carbon, meaning long living trees can keep carbon out of the atmosphere for hundreds of years.

Trees sequester carbon through the process of photosynthesis, where carbon is drawn from the atmosphere and converted into sugars the trees use to grow. Some of these carbon based sugars are stored in the roots, which secrete them into the surrounding soil (rhizosphere.) These released sugars are called "root exudates." Different species of beneficial bacteria colonize the rhizosphere to consume root exudates as a food source, preventing the incursion of harmful microorganisms (Badri, Dayakar V., and Jorge M. Vivanco. "Regulation and Function of Root Exudates"). Bacteria store carbon in their bodies, and sequester carbon in the soil as organic matter when they die. Therefore, trees also sequester carbon by facilitating the life cycle of carbon based organisms in the soil ("Soil Organic Matter - Cornell Cooperative Extension").

The decomposition of leaf litter, branches, roots, tree trunks, and dead organisms acts as also a powerful source of carbon sequestration in forested ecosystems: according to the USDA Office of Sustainability and the Climate, 50% of a forest's total carbon is stored in its soils. In the past, most scientists thought that leaf litter and fallen branches slowly decaying into the soil (Scientific American) built soil carbon. However, a 2014 study by Karina Clemmensen found that an astonishing "50–70% of the carbon stored in humus during the past 100 yr originated from carbon allocated to roots and associated fungi rather than from above-ground plant litter." (Clemmensen, Karina E., et al. "Carbon Sequestration Is Related to Mycorrhizal Fungal Community Shifts during Long-Term Succession in Boreal Forests"). Clemmensen's research reveals that a forest's carbon sequestering potential is not only driven by the growth of trees, but by the complex relationships they have with bacteria, fungi, and other soil dwelling organisms.

Historically, the study of ecology in western countries has been reductive. In her bestselling book "Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants," Robin Wall Kimmer recalls how she was taught botany at State University of New York College (SUNY). "My natural inclination was to see relationships, to seek the threads that connect the world, to join instead of divide. But science is rigorous in separating the observer from the observed, and the observed from the observer… following the path of science trained me to separate, to distinguish perception from physical reality, to atomize complexity into its smallest components, to honor the chain of evidence and logic, to discern one thing from another, to savor the pleasure of precision… to walk the science path I had stepped off the path of indigenous knowledge" (Kimmerer 43). Recent scientific research (such as the Clemmensen study) exploring the innumerable relationships between living things has increasingly validated the holistic understanding of nature Kimmerer was led to abandon during her time studying botany. Therefore, when we consider planting trees to combat climate change, we must also move beyond the sterile, mechanical understanding of ecology that is the norm in western science. We should recognize that soil, bacteria, fungi, plants, animals, and humans are all interconnected, interdependent, and equal parts of the whole we call earth.

The practice of agroforestry affirms the holistic understanding of ecology necessary to defend against the danger of climate catastrophe. The integration of trees alone provides a wealth of ecosystem services and economic opportunities to people and the environment. Using trees as the foundation, we can build additional layers of complexity and opportunity into agroforestry systems using annual crops, pollinator belts, shrubs, animals, fungi, and more.

There are limitless combinations of species which could make up an agroforestry system, so it is a massive undertaking for researchers who are trying to quantify and compare the ecosystem services, yields, and biochemical relationships between different schemes. In studying agroforestry, it's easy to become discouraged by the tension between our lack of knowledge and the need to produce food on an economically viable scale. Yet, many people in the past implemented agroforestry systems without any conception of science or scientific research, and certainly without the assistance of machines, chemicals, or fossil fuels. Learning from these people and their cultures can arm us with the courage we need to transform the character of modern agriculture.

Part Two: The Indigenous Tribes of Southern New England

Most modern agroforestry practitioners are concerned with conservation, and much research has been done on how ecologically planned plantings of trees, shrubs, and annual crops increase biodiversity. Some farmers practice syntropic agroforestry, which "helps the farmer replicate and accelerate the natural processes of ecological succession and stratification, giving each plant the ideal… position in space (strata) and in time (succession)" (Andrade, Dayana, and Ernst Götsch. "What Is Syntropic Farming?"). Syntropic agroforestry, which suggests farming follows from natural processes, challenges the idea that simplicity and control should be the designers of our agricultural landscape.

In a sense, the Wampanoag, Nipmuc, Pokanoket, Pequot, and Narragansett indigenous tribes of southern New England were masterful "syntropic agroforestry" practitioners. However, they did not simply replicate natural ecologies within an agricultural context: their agricultural context was ecological. By managing mosaic landscapes, the southern New England Indians created a complex land ethic that benefited both themselves and the ecology they relied upon.

The natives were not simply living off the abundance of the landscape as many European colonists mistakenly observed. In fact, their non-invasive management of the landscape produced the very abundance which European settlers thought they were not properly exploiting. Under the assumption that natives made no "improvements" to the land, they were denied property rights by colonial governments. A baptist minister from Rhode Island sneered, "The Indians in this Part of America appear to have been some of the least improved of the human Species, without any Learning or Knowledge in any of the politer Arts of Life, even without Iron and the Improvements which depend on that. The strange Destruction of this People, now since the Wars ceased, and within Memory, is very remarkable. Their insuperable Aversion to the English industry and Way of Life, the Alteration from the Indian Method of living, their Laziness, and their universal Love of Strong Drink, have swept them away, in a wonderful Manner" (Callender 88). Many British colonists shared the minister's cruel sentiments, and similarly condemned the natives for their ignorance of "the politer arts of life," and importantly, their rejection of intensive European farming practices. Indeed, a land ethic centering upon complexity contrasts strongly with that of the Europeans, naturally evading their understandings. However, the southeastern tribes of New England undoubtedly made improvements to the landscape which can be understood through the cultivation context of agroforestry.

The land ethic of the southern New England Indian tribes involved the maintenance of mosaic landscapes: a patchwork of forests, meadows, swamps, and crop fields. In "Changes of the Land," William Cronin describes what a hillside may have looked like in pre-colonial New England: "The descent of a single hillside in southern New England, for instance, could easily carry from a sunny dry forest of white and black oaks, white pine, and an occasional huckleberry or lowbush blueberry to a shaded valley buzzing with mosquitoes and containing red oak, tulip poplar, hemlock, and beech. In between might be chestnut and black birch, with the ubiquitous red maple appearing up and down the entire hillside" (Cronin 31). European settlers were amazed by the numbers of wild animals which thrived these mosaic landscapes, as shown by the following poem included in William Wood's "New England's Prospect:"

"The kingly Lyon, and the strong arm'd Beare
The large limbed Mooses, with the tripping Deare,
Quill darting Porcupines, and Rackcoones bee,
Castelld in the hollow of an aged tree;
The skipping Squerrell, Rabbet, purblinde Hare,
Immured in the selfefame Castle are,
Least red-eyed Ferrets, wily Foxes should Them undermine,
if rampird but with mould.
The grim fact Ounce, and ravenous howling Woolfe,
Whose meagrepaunch suckes like a swallowing gulfe.
Blacke glistering Otters, and rich coated Bever,
The Civetsented Musquash smelling ever" (Wood 21).

Contrary to what many settlers thought, this incredible biodiversity was not a naturally occurring feature of the New England landscape. In fact, fires set by the native Americans were responsible for the abundance European colonists often attributed to God.

The settlers first noticed how fires created excellent hunting grounds. Wood spoke of the "…diverse acres being [so] clear that one may ride ahunting in most places of the land if he will venture himself for being lost" (Cronin 25). The controlled burns improved hunting for native Americans by opening up the forest, but settlers also recognized they improved soil productivity: "[The Indians burn the ground] to suppresse the under-wood, which else would grow all over the Countrey, the Snow falling not long after, keepes the ground warme, and with his melting conveighs the ashes into the pores of the earth, which doth fatten it" (Wood 8). By burning woodland, nutrients locked up in woody debris were quickly conveyed back into the soil in plant available forms. This spike in fertility greatly benefited surviving plants and the succeeding ecosystem at large.

Open landscapes with fertile soils made ideal habitat for gather-able food species. William Wood commented on the abundance of these edible plants, noticeably missing from today's forest ecosystems: "There is likewise Strawberries in abundance, very large ones, some being two inches about; one may gather halfe a bushell in a forenoone: In other seasons there bee Gooseberries, Bilberies, Resberies, Trea'ckleberies, Hurtleberries, Currants; which being dryed in the Sunne are little inferiour to those that our Grocers fell in England…" (Wood 15). Burns also cleared crop fields, and the increased soil fertility benefited the annual crops as well. One University of Idaho study found that when amended with wood ash, wheat "grew faster on six different soil types than the control" (L. Etiegni , A. G. Campbell & R. L. Mahler). Another study from the University of Pisa, Italy concluded "wood ash is a rich source of nutrients, and maize plants grown in wood ash amended soil had improved the shoot and root growth, the uptake of important elements, and retarded the inhibition of leaf transpiration under drought conditions" (Romdhane, Leila et al). For the Indians, it was the women's job to clear crop fields. First, they piled wood at the base of trees and set fires. In doing so, the trees died and crops could be planted around them. The standing deadwood eventually toppled, and the logs could be burned as well, adding more wood ash to the crop field (Cronin 48). The gradual toppling and burning of dead trees provided additional fertility that extended the period of usability of a plot of cropland before nutrients were depleted. Thus, without any fertilizer inputs, Indian women could plant the same crop field for 8-10 years before having to choose a new site.

The burns resulted in more readily available game, wild fruits, and agricultural crops for Native Americans, but they also benefited the entire ecosystem. Slow moving, low intensity fires result in an opening of the forest canopy, allowing light infiltration towards the forest floor. The increased levels of light allow light hungry plant species to thrive, and the well drained soil benefits keystone nut bearing tree species like oaks and chestnuts (Cronin 51). In addition, the clearing of woody undergrowth and non-fire adapted plants reduces competition and begets the succession of a greater diversity of plant species (Juli G Pausas and Jon E Keeley). As William Cronin observed, "Selective Indian burning thus promoted the mosaic quality of New England ecosystems, creating forests in many different states of ecological succession. In particular, regular fires promoted what ecologists call the 'edge effect.' By encouraging the growth of extensive regions which resembled the boundary areas between forests and grasslands, Indians created ideal habitats for a host of wildlife species…" With an understanding of modern ecological science, Cronin demonstrated that fires set by natives improved the environments around them. He continued, "because the enlarged areas actually raised the total herbivorous food supply, they did not merely attract game but helped create much larger populations of… elk, deer, beaver, hare, porcupine, turkey, quail, ruffed grouse, and so on. When these populations increased, so did the carnivorous eagles, hawks, lynxes, foxes, and wolves. In short, Indians who hunted game animals were not just taking the "unplanted bounties of nature"; in an important sense, they were harvesting a foodstuff which they had consciously been instrumental in creating" (Cronin 51). In one paragraph, William Cronin efficiently explained how native American improvements to the land created diverse habitats which supported larger populations of wildlife.

Periodic burns are instrumental to ecological succession in habitats across the United States. In recent years, we have seen the consequences of land management techniques that do not take this reality into account. In 2018, a series of devastating wildfires ravaged the state of California. According to the California Department of Forestry and Fire Protection Services, "The 2018 wildfire season was the deadliest and most destructive wildfire season on record in California, with a total of over 7,500 fires burning an area of over 1,670,000 acres, the largest area of burned acreage recorded in a fire season." The Camp fire alone burned "a total of 153,336 acres, destroyed 18,804 structures and resulted in 85 civilian fatalities and several firefighter injuries" (Cal Fire News Release).

The state of California declared the event a natural disaster and footage of the destruction shocked the nation. Those of us who watched on at the time wondered who such a thing could possibly happen in a state with a 3.36 trillion dollar GDP. Yet, catastrophes like these should be of no surprise to us. By preventing the periodic yearly burns that are natural to places like California in the name of safety, governments are creating the conditions for catastrophic fires fueled by years of built up dry material.

The native peoples of southern New England understood the important ecological impacts of fires. By setting controlled burns yearly, they prevented the accumulation of dry material that results in catastrophes like the 2018 California wildfires. In doing so, they consciously created diverse, fertile mosaic landscapes that mutually befitted them and the ecosystem as a whole. Moreover, the mutually beneficial relationship between people and the ecosystem meant the Indians did not see themselves apart from or hostile to the natural world. Therefore, the controlled burns practiced by the southern New England Indians remained central to the complexity which drove their land ethic.

Part Three: Temperate European Agroforestry

While some modern agroforestry practitioners focus their efforts on maximizing biodiversity, most are faced with the reality of making ends meet. Modern farm economics dictate that an operation must be highly mechanized, highly productive, and highly efficient. As a result, concerns about the environment are greatly overshadowed by economic necessities. In Europe, the ecological goals of agroforestry are often strangled by economic factors such as the price of labor, poor government policy making, economies of scale, and a lack of technical support. Accordingly, the vast majority of European farming is conventionally managed (Eichhorn, M. P., et al. "Silvoarable Systems in Europe – Past, Present and Future Prospects").

Contrary to what we see today, Europe has a long and rich history of temperate agroforestry systems, beginning around 2,500 BCE (Eichhorn, M. P., et al.). According to the "History of Temperate Agroforestry" by Dr. Jo Smith from the Organic Research Center, "The earliest stages of [European] agricultural history were dominated by shifting cultivation, with alternating periods of agriculture and forestry." During this time called the Chalcolithic age, Europeans transitioned from nomadic hunter gatherer societies to permanent settlements where their calories were largely supplied by annual grains (Naugler, Christopher. "Hemochromatosis: A Neolithic Adaptation to Cereal Grain Diets."). To accommodate these settlements, forests had to be cleared, animals domesticated, and crop fields weeded, plowed, and planted. A great deal of effort was exerted to control the landscape so that it would suit human needs.

For the successors of the Chalcolithic age civilizations, the woods remained a place of agricultural production. Forested landscapes provided nuts, fruits, and wild game which amended the diet with the essential nutrients grain lacked. Chalcolithic age Europeans raised domesticated animals in the woods, where they grazed on trees, shrubs, tubers, and nuts. Forests supported the cultivation of annual crops through a transfer of fertility from the woodlands to the fields via manure. Farmers cultivated the forests with silvoarable, silvopastoral, pollard, and coppice systems. Up until the last century, managed forested landscapes were a ubiquitous part of the European landscape (Dr. Jo Smith).

Contrasting with the indigenous land ethic that centered around ecological complexity, the style of farming in Europe aimed to control the ecology demonstrates a reductive drive towards simplicity, the ethos of which is at the heart of modern day conventional farming. However, the European's intensive management of trees under temperate agroforestry regimes reconciled their desire to master the natural world with ecologically resilient landscapes.

European farming has historically been seen as a burdensome profession. This is demonstrated by the story of Adam and Eve. After God created the earth, he formed man from "the dust in the ground," and placed him in the garden of Eden. In this paradise, "there was not a man to till the ground," and "out of the ground made the Lord God to grow every tree that is pleasant to the sight, and good for food…" Also located within the garden was the tree containing the knowledge of good and evil, from which he instructed Adam not to eat from.

After creating Adam and placing him in the garden of Eden, God "formed every beast of the field, and every fowl of the air," which Adam named. A piece of Adam's flesh formed Eve, and she was convinced to eat from the tree containing the knowledge of good and evil by a serpent. When God found out, he banished the pair from paradise, saying:

> "Because thou hast harkened unto the voice of thy wife, and hast eaten of the tree, of which I commanded thee, saying, Thou shalt not eat of it: cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life; thorns also and thistles shall it bring forth to thee; and thou shalt eat the herb of the field; in the sweat of thy face shalt thou eat bread, till thou return unto the ground; for out of it wast thou taken: for dust thou art, and unto dust shalt thou return."

Banished from paradise, Adam thus had to take up the laborious practice of farming and "till the ground from whence he was taken" and "[by the sweat of his brow] eat bread." Compared to life in paradise, European farming, which was defined by the intensive management of crop fields and domesticated animals, was seen literally as a punishment from God.

In nature, annual plants occupy the earliest stages of ecological succession following a disturbance. These plants rapidly colonize the disturbed soil and die, kick starting the soil biology through the decay of roots and above ground detritus. As the soil quality improves, perennial weeds, shrubs, and eventually trees succeed and form more mature ecosystems. However, the grains which occupied a significant proportion of the European diet were annual plants that could only be grown in disturbed soils. Therefore, Europeans artificially maintained a state of early ecological succession by permanently disturbing the soil. Over time, they manufactured different plows and other technologies to create the right growing conditions for annual crops.

Europeans raised, domesticated, and managed animals like oxen to pull the heavy plows and other equipment necessary to maintain this state of early ecological succession. By preventing succession, farmers also prevented the natural accumulation of fertility and needed to artificially supplement it through animal manures. Ironically, the attempt to simplify and control ecological succession required the use of complicated, labor intensive farming techniques.

A major goal of any agroforestry operation is to establish a perennial system of production where the environmental and economic resilience is greater than that of an annual system of production. Perennial systems increase environmental resilience by preventing erosion, improving soil fertility, by forming micro climates that mitigate extreme weather, and by enhancing biodiversity. When trees and shrubs are planted, their root systems form a fibrous net that holds the soil together and prevents it from being washed away by wind or rain. (Schoeneberger, Michele M, et al. “Agroforestry: Enhancing Resiliency in U.S. Agricultural Landscapes under Changing Conditions”). In addition, these roots create a below ground habitat called the rhizosphere, which is colonized by soil improving bacteria and fungi. The above ground portion of the trees intercept desiccating solar radiation and protect the soil from drying out. By casting shade, trees naturally form a cooler microclimate that protects understory species and provides relief to animals during the hottest days of summer. Trees and shrubs also increase biodiversity by building habitats for many species of insects, amphibians, birds, and mammals. For example, many pollinating insects essential to agricultural production often live in trees or overwinter beneath leaf litter (Dawson, Cathy. “Delay Garden Cleanup to Benefit Overwintering Insects”).

Advocates of agroforestry consider annual agriculture a brittle system of production because it is vulnerable to erosion, soil fertility loss, extreme weather, and a lack of biodiversity. The shallow root systems of annual plants fail to hold the soil together in the event of heavy rains or flooding, and after the crop is harvested the bare field is at the mercy of wind gusts which gradually blow the topsoil away. The annual crops which are removed from the field drain soil fertility and their shallow roots are constantly plowed up, preventing the colonization of beneficial bacteria and fungi. The minimal above ground cover of annual plants are unable to protect the soil from drying out, further killing soil biology and leading to serious water management problems during dry periods of the year. The lack of above ground cover also means that there is minimal habitat available to pollinating insects, and virtually none available to other animals. Unsurprisingly, the brittleness of annual production systems results in significant crop losses for farmers due to soil degradation and extreme weather events.

In the past, perennial systems of cultivation were common in central Europe. Silvoarable agriculture, which involved widely spaced plantings of trees intercropped with annuals or perennials, provided not only environmental, but economic resilience through the reliable production of fruits, nuts, animal fodder, fuel, and timber (Eichhorn, M. P., et al.). One example of a silvoarable system that was once common in central Europe was the Streuobst, in which 'tall trees of different types and varieties of fruit, belonging to different age groups, which are dispersed on croplands, meadows and pastures in a rather irregular association' (translated from Lucke et al. 1992). According to Eichhorn, M. P., et al., streuobst "generally consisted of paired rows of fruit trees, intercropped close to the tree trunks, with relatively low branches to facilitate fruit harvest. The most common fruit trees were apple, pear, plum (Prunus domestica L.) and mazzard cherry (P. avium L.)"

In France, another silvoarable system exists where walnuts and other fruit trees, particularly pear and apple, were planted in annual crop fields. In the early years of tree growth, the plantations were intercropped with "maize and other cereals, sorghum, soybean, oil-seed rape, sunflower, tobacco, alfalfa, lavender and bush fruits (Ribes spp.)." Farmers harvested the trees for timber at the end of their productive lives. 19th century writers who saw these plantations were amazed by their beauty and utility. The French writer Marie-Henri Beyle, also known as Stendahl, wrote "I cannot imagine a greater impact than these fields covered with spaced, strong and vigorous trees; and underneath there is wheat and hemp (Cannabis sativa), the most beautiful of crops." John Evelyn, an English writer and gardener said "walnut delights in a dry sound and rich land; …in cornfields. …Burgundy abounds with them, where they stand in the midst of goodly wheat lands, at sixty and an hundred feet distance; and it is far from hurting the crop, that they look on them as a great preserver, by keeping the grounds warm, nor do the roots hinder the plough" (Dupraz, C., et al. "Temperate Agroforestry: The European Way"). Through silvoarable agroforestry systems, Europeans buttressed their annual crop fields with rows of fruit, nut, and timber trees.

The benefits of forested landscapes in Europe also extended to domesticated animals. Planted or natural forests managed for livestock grazing are referred to as silvopastoral. One silvopastoral practice common dating back to Roman times was pannage, wherein domesticated pigs were "released into beech and oak woodlands to feed on the acorn and beech mast, and into fruit orchards to eat fallen fruit" (Dr. Jo Smith). Graziers found pannage so advantageous that pigs were moved across long distances to access forested pasture, in one case up to 50 kilometers (Bruun, Hans Henrik, and Bo Fritzbøger. "The Past Impact of Livestock Husbandry on Dispersal of Plant Seeds in the Landscape of Denmark"). The pannage season lasted from September to November, and the abundant oak and beach nuts fattened the hogs for winter. Today, pannage is most widely practiced in Spain and Portugal, which produce an internationally famous acorn finished pork known for its deep marbling and "nutty, evocative flavor" (Crawley, Tash. "What Makes Iberico Pork so Special?").

Aside from the fruits and nuts of trees, animal husbandry in Europe was also strengthened by the use of branches and leaves as fodder. In times where cold or drought reduced the amount of herbaceous forages available to grazing livestock, farmers harvested branches from tree species including poplars, oaks, ashes, and elms to feed their animals (Emanuelsson et al., "The Rural Landscapes of Europe: How Man Has Shaped European Nature"). Tree fodder for animals could be obtained through another tree management practice called pollarding, where branches were cut 2-3 meters above the ground, leaving the trunk intact (Dr. Jo Smith). Some trees have adapted to severe disturbances like animal browsing or fires. Following the disturbance, these resilient species rapidly sprout numerous suckers, which grow in a bushlike form. For these hardy survivors, coppicing is another viable method of management. Coppicing is another historically common practice in Europe that involved cutting trees very close to the ground, removing most of the above ground growth. As with pollarding, the harvested material was fed to livestock or used as firewood. Some species, such as the hazelnut, benefit from regular coppices because the heavy pruning removes old growth, thereby maintaining the health and vigor of the bush. In Europe, some coppices possibly date back over a thousand years (Unrau, Alicia. "Coppice Forests in Europe").

By intensively managing trees, Europeans provided their animals with an important source of food during times of scarcity. However, modern scientific research has revealed that chemical compounds in tree fodder may assist animals in reducing parasite loads. In nature, plants produce chemicals called secondary metabolites that are not required for growth, but confer other selective advantages (Monfil, Vianey Olmedo, and Sergio Casas-Flores. "Molecular Mechanisms of Biocontrol in Trichoderma Spp. and Their Applications in Agriculture"). When consumed by animals, secondary metabolites interfere with digestion or damage the nervous system, which protects the plant from browsing. Tannins are a secondary metabolite commonly found in tree leaves which, when consumed in moderation, are actually beneficial to the health of grazing animals. One 2009 study found that lambs infected with parasites seek out foods with tannins, even if the source (grape pomace) was of poor nutritional quality (Larry D. Lisonbee et al. "Tannins and self-medication: Implications for sustainable parasite control in herbivores"). The researchers observed that when compared with the control, the grape pomace containing tannins were associated with a lower fecal egg count (the count of parasite eggs found in the feces of infected lambs.) This research importantly suggests that livestock self medicate for parasites by consuming tannin rich sources of food. Thus, the ancient practice of feeding tree fodder to livestock provided not only nutritional benefits, but medicinal benefits as well.

Labor intensive systems of cultivation that aimed to simplify and control natural ecologies characterized European agriculture. Annual crop cultivation was especially reliant upon burdensome external inputs of resources and labor and detrimental to the environment because it resulted in erosion, habitat loss, and declining soil fertility. However, silvoarable contexts where annual crops and trees grew together provided Europeans with a sustainable source of annual crops in addition to fruits, nuts, and timber. Silvopastoral contexts extended the benefits of trees to domesticated livestock through the practice of pannage and the harvesting of tree fodder through pollarding or coppicing. The prevalence of these intensively managed systems demonstrate that the European land ethic was defined by control, which produced environmental degradation in annual agricultural contexts. However, intensively managed agroforestry contexts produced environmental resiliency. Accordingly, brittle and resilient systems of cultivation both exist within the European farming tradition. Today, we see the tension between these systems borne out in discussions of sustainability, climate change, politics, and our planetary future at large.

Part Four: Discussion and Conclusion

On October 13th, 2021 Star Trek actor William Shatner boarded billionaire Jeff Bezos' "Blue Origin" space shuttle and at 90 years of age became the oldest man to travel into space. Contrary to the sentiment his Star Trek character Captain Kirk expressed when he resolved "to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before," Shatner reflected "when I looked in the opposite direction, into space, there was no mystery, no majestic awe to behold . . . all I saw was death. I saw a cold, dark, black emptiness. It was unlike any blackness you can see or feel on Earth. It was deep, enveloping, all-encompassing. I turned back toward the light of home. I could see the curvature of Earth, the beige of the desert, the white of the clouds and the blue of the sky. It was life. Nurturing, sustaining, life. Mother Earth. Gaia. And I was leaving her. Everything I had thought was wrong. Everything I had expected to see was wrong… I discovered that the beauty isn't out there, it's down here, with all of us." Nobody expected to hear something like existential dread from Captain Kirk.

Instead of being swept away by the egotistical notion that humankind's destiny is to leave earth and colonize space, Shatner grieved for our planet. He continued, "It was among the strongest feelings of grief I have ever encountered. The contrast between the vicious coldness of space and the warm nurturing of Earth below filled me with overwhelming sadness. Every day, we are confronted with the knowledge of further destruction of Earth at our hands: the extinction of animal species, of flora and fauna . . . things that took five billion years to evolve, and suddenly we will never see them again because of the interference of mankind. It filled me with dread. My trip to space was supposed to be a celebration; instead, it felt like a funeral." Unfortunately, Shatner's sadness is scientifically validated: rather than seeking new life, human civilization has instead annihilated it.

The 20th and 21st centuries have been disastrous for non-human life on earth. According to the World Wildlife Fund's living planet report, 70% of all individuals of vertebrate species have disappeared since 1970. In the last 100 years, we know of 400 species that went extinct, and many more function as "ecological zombies," where populations exist but have no significant impact on the ecosystem. A prominent example of this are the American Bison, who once numbered in the tens of millions and played a keystone role in the nutrient cycling of American ecosystems (Knapp, Alan K., et al. "The Keystone Role of Bison in North American Tallgrass Prairie: Bison Increase Habitat Heterogeneity and Alter a Broad Array of Plant, Community, and Ecosystem Processes"). William T. Hornady, a Superintendent of the National Zoological Park, described their original range. "Between the Rocky Mountains and the States lying along the Mississippi River on the west, from Minnesota to Louisiana, the whole country was one vast buffalo range, inhabited by millions of buffaloes… They lived and moved as no other quadrupeds ever have, in great multitudes, like grand armies in review, covering scores of square miles at once. They were so numerous they frequently stopped boats in the rivers, threatened to overwhelm travelers on the plains, and in later years derailed locomotives and cars" (Hornady 388-389). Once American settlers identified Bison as an impediment to colonization, they exterminated them. Columbus Delano, who served as the Secretary of the Interior during the 1870s, identified the buffalo with the livelihoods of native Americans. He wrote, "The rapid disappearance of game from the former hunting-grounds must operate largely in favor of our efforts to confine the Indians to smaller areas and compel them to abandon their nomadic customs" (Delano, Columbus. "Report of the Secretary of the Interior/1872."). Significant efforts have since been made to save the bison, but modern populations are frequently culled to prevent the bison from entering private property.

Bison and other large mammals are believed to be responsible for the deep, fertile soils that are the breadbasket of the United States (Knapp, Alan K., et al.). By destroying the prairie in order to make way for farms, Americans have eliminated the ecosystem services that created the corn belt's soils. Without the soil building powers of the prairie ecosystem, the corn belt's topsoil is being lost to erosion. According to a 2021 study, over a third of the region's topsoils have already been eroded (Thaler, Evan A., et al. "The Extent of Soil Loss across the US Corn Belt"), and the UN Food and Agriculture organization found that "A full 90 per cent of the Earth's precious topsoil is likely to be at risk by 2050." The anti-ecological land ethic of modern societies has not only led to the annihilation of other species, but also the means of our own subsistence.

There are many more cases where entire species vanish from the earth due to human driven habitat destruction and degradation, over exploitation, invasive species, climate change, and pollution. The widespread loss of life results in a global destabilization of earth's ecosystems, which are responsible for the proper function of the carbon, oxygen, and water cycles. When these cycles are out of balance, the planet experiences extreme climate change, the impacts of which are expected to be catastrophic for human civilizations (McElwee, Pamela. "Climate Change and Biodiversity Loss"). The severity of the threat towards our home planet demands an immediate transition towards ecologically minded development. Agriculture, which occupies 38% of the global land surface (Food and Agriculture Organization), should be a central theater of transition. The adoption of agroforestry practices would be a significant move towards an ecological mode of production.

The societies of the southern New England natives and the Europeans contrasted in many ways, but sustainable agroforestry models remained important to both. The former employed controlled burns which created mosaic landscapes with incredible ecological abundance. The latter implemented silvoarable and silvopastoral systems of agricultural production which, with intensive management, sustainably produced grains, vegetables, fruits, nuts, timber, and animal products. Using modern technology, traditional management techniques like controlled burns, coppicing, and pollarding can be safely and efficiently implemented on large scales. For example, 11 states in the southeastern region of the United States train and certify technicians to carry out controlled burns. In 1998, Florida strengthened a law that encourages prescribed burns following a series of firestorms which burned 500,000 acres of land. Instead of fearing property damage, Director of fire research at Tall Timbers research station Morgan Varner said local communities "love [their] green space[s] and they associate [them] with the burning that takes place." According to Varner, private landowners also employ technicians to carry out controlled burns, and these technicians can secure a permit quickly and easily: often over a 15 minute phone call. Additionally, technicians are protected from any liability in the rare case where property damage occurs (Sommer, Lauren. "Why the South Is Decades Ahead of the West in Wildfire Prevention"). In this case, the southeastern United States is a perfect example of how ecologically and scientifically minded laws and government policies can breathe new life into ancient land management techniques.

The modern implementation of agroforestry, informed by historical practices and supported by scientifically informed legislation will create landscapes of abundant agricultural production and ecological diversity. The adoption of an regenerative land ethic based on stewardship would equip societies with the ability to combat existential threats like climate change, biodiversity loss, and the erosion of topsoils. However, practicing agroforestry is not simply about "saving the planet," a notion comedian George Carlin called "the greatest arrogance of all." As Carlin asserted, nature is resilient: "[it's] been through volcanoes, plate tectonics, continental drift, solar flares, sun spots, magnetic storms, the magnetic reversal of the poles… hundreds of thousands of years of bombardment by comets and asteroids and meteors, worldwide floods, tidal waves, worldwide fires, erosion, cosmic rays, [and] recurring ice ages… the planet is going anywhere, WE are." Implementing agroforestry as an alternative land use model to conventional farming is not about saving the planet, but instead choosing what kind of planet WE want to inhabit. It is the choice to create vibrant landscapes that offer the gifts of life to all species, from humans to soil bacteria and fungi. By understanding historical agroforestry practices and the land ethics of the past, we can make the informed choice to create landscapes that will nourish us and future generations.

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