EXPLORING A BIOREGIONAL APPROACH TO AGROFORESTRY

Preliminary Site Suitability Analysis in the Connecticut River Valley Watershed
A collaborative project between TK.designlab and Terra-Genesis International

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The Lineage of Ideas

The intention with the BRASA process is to use Geographic Information Systems at a watershed level to consider the appropriate implementation of agroforestry practices. This process considers the geology, hydrology, vegetation patterns, and land-use history of a place, so that we can ask “what is an agriculture of this place?”

Agroforestry is a relatively new word but the practices and knowledge that it refers to are based in traditional ecological knowledge. Therefore, the BRASA process, and the case study shared herein would not exist without the contributions of those indigenous cultures from all continents, past and present, forgotten and remembered who contribute to the continued existence of traditional ecological knowledge. Specifically, in the Connecticut River Valley and surrounding lands discussed in this report, we acknowledge the lineage of the Pocumtuc, Norwottuc, Nipmuc, Elnu Abenaki, Pennacook, and Mahican peoples and nations, as well as their relatives and descendants in diaspora throughout North America today.

The naming of these practices in this document, such as silvopasture or alley cropping, does not imply newness, discovery or ownership of these practices. Rather, in naming these practices we are highlighting them as alternatives to the current dominant practices in U.S. agriculture.

The Hubris of the Status Quo

When we consider that every agricultural system is a piece of an ecosystem and necessarily inseparable from that system’s health, we can see that the predominant agricultural practices in the U.S. are in fact unproven. These practices in their current scale and chemical dependence have existed for under 100 years (less than 1% of agricultural history). In that time they have contributed to the decline of rural communities and livelihoods, drained both the aquifers and the carbon pools of terrestrial ecosystems, concentrated greenhouse gases in earth’s atmosphere and oceans, and contributed to the deterioration of biological processes across millions of acres of ecosystems. To assume that this status quo is permanent is to contradict the processes that have created life on earth.

Teachers and Educators

The experience, ideas, and thinking that have converged to create this process and report emerge from the lives and work of many. Beyond acknowledging the continuous thread of traditional ecological knowledge that birthed these practices, I wish to specifically thank my teachers Dyami and Ethan Soloviev, Connor Stedman, and the many at the Conway School of Landscape Design. This report builds on the work of countless authors whose work has helped shift my understanding of the human integration into landscapes. In particular I’d like to thank M. Kat Anderson, Eric Toensmeier, and J. Russell Smith.

Thank you.

Russell Wallack
On behalf of TK Design Lab and Terra Genesis International
Consensus appears to be emerging around the notion that we are living in a new geologic epoch of our own making. The Anthropocene is described as the era wherein human activity has become the dominant influence on climate and the environment. We are literally a force of nature. It is generally assumed that our collective impacts on the environment are negative, even if inadvertent - think atmospheric carbon dumping or the growth of megacities. In that sense humans are not unlike our fellow passengers aboard Spaceship Earth that, through their very acts of survival, render their ecological niches uninhabitable to them.

However, what distinguishes humans from our fellow passengers is our ability to comprehend the consequences of our actions and learn from the feedback. Fortunately, we have also gained significant insights into and understanding of Nature’s regenerative systems and processes. We are thus poised to become constructive participants in the evolution of our planet. Accepting this responsibility can lead us to the discovery of solutions to some of the major challenges facing humanity as we enter the 21st century. In the words of Buckminster Fuller we can initiate a design science revolution and create a world that works wherein humans prosper and Earth’s overall ecological resilience is enhanced.

The BioRegional Agroforestry Suitability Analysis (BRASA) is a powerful, and timely tool designed to facilitate the integration of responsible stewardship and regional economic development. It helps reveal the synergies that emerge when agroforestry infrastructures designed and realized with stakeholder involvement are established in bioregions.

In 1983 I led an effort by the New Alchemy Institute and the University of Massachusetts Joint Studio in Landscape Architecture and Regional Planning to conduct “The Cape Cod Bioregion Study”. I was introduced to the concept in the Winter 1981 issue of a journal called CoEvolution Quarterly. The 15 townships of the Cape share a sole freshwater source – a single aquifer, consisting of a “lens” of freshwater floating above a denser layer of seawater. I couldn’t imagine a more compelling reason to propose a cooperative regional strategy. Ours too was framed by the bioregion:

A bioregion can provide a foundation for both economic and ecological resilience. The benefits of this approach are many including sustained, annual production; soil quality improvement; improved microclimate; enhanced carbon sequestration and expanded opportunities for local economic development.

We took the liberty of elaborating on this idea:

Because of the varying physical characteristics of bioregions, distinct plant and animal associations have evolved. These differences mean that both the bioregion’s carrying capacity for humans and the ecologically sound ways in which humans can interact or use the bioregion’s resources vary greatly. Bioregions transcend state and national political boundaries and traditionally have had profound effects on human culture, trade, and sources of livelihood.

A bioregionally-informed agroforestry strategy can provide a foundation for both economic and ecological resilience. The benefits of this approach are many including sustained, annual production; soil quality improvement; improved microclimate; enhanced carbon sequestration and expanded opportunities for local economic development.

This timely collaboration between Terra-Genesis International and TK.designlab has developed an inspired holistic planning tool. Ground-truthing and refinements will continue.

I’m anxious to see it put to the test.

Greg Watson
Falmouth, Massachusetts
July 2018
A healthy watershed is composed of a mosaic of perennials, annuals, and animals. Agroforestry production systems add diversity and complexity that contributes to the regeneration of watersheds damaged by industrial agriculture and development. They are production systems that produce conservation benefits like reduced erosion, increased drought and flood resilience, and some of the highest carbon drawdown rates of any farming practices. We know these systems are commercially viable, yet they remain vastly under-implemented in the U.S.

The BioRegional Agroforestry Suitability Analysis (BRASA)—seeks to assess, inventory, and map the appropriate systems and perennial staple crops for the specific conditions of any watershed. Specifically, this report applies to the Connecticut River Watershed in Massachusetts, and maps that landscape for the suitability for productive riparian buffers and commercial hybrid chestnut production.

A rendering of the proposed BRASA interactive map platform enables landowners, conservationists, state and federal agencies to accurately identify conditions for agroforestry practices at the parcel level.
Agroforestry is the intentional integration of trees into agricultural systems. This integration creates environmental, economic, and social benefits. In practice, agroforestry combines trees for timber or non-timber forest products—like nuts or fruit—with traditional agricultural products—like hay or annual vegetables—as a single system.

The USDA recognizes five primary agroforestry practices: alley cropping, forest farming, silvopasture, windbreaks, and riparian buffers systems. These practices are adapted to the complexity of each specific ecological context to foster greater resilience in agricultural landscapes and meet farmer’s production needs.

Though they differ by crop and practice, agroforestry systems provide greater resiliency in agricultural landscapes and meet production objectives of farmers. These combinations provide greater economic return from the land and improve the ecological health of the system.

“\textbf{The widespread adoption of agroforestry practices in the United States could sequester 530 million metric tons of carbon dioxide equivalent each year, thereby transforming agriculture into a carbon sink.}\textsuperscript{1}\”

Unlike widely-practiced industrialized models of agricultural production that contribute to climate change, agroforestry has the potential to provide high-yields of diverse animal, fruit and nut, and grass crops while improving overall soil health and hydrologic function.

The appropriate establishment of agroforestry systems produces ecological benefits such as carbon sequestration in soil and woody biomass, aquifer recharge, flood management, and water purification. Agroforestry plays a key role in creating climate change-resilient agricultural systems while also reducing the concentration of green house gasses in the atmosphere.

In particular, soil regeneration—key to regulating earth’s atmosphere and increasing nutrient and minerals availability—is a critical component and benefit of agroforestry. In supporting healthy soils, agroforestry can reduce soil loss which currently cost farmers and consumers an estimated $400 billion dollars each year.

\textsuperscript{1}Lehner, Peter., and Nathan A. Rosenberg. “Legal Pathways to Carbon-Neutral Agriculture.” Environmental Law Reporter 47. 10 (2017).
Riparian buffers are permanent vegetation strips and/or forest that are established along the edges of rivers. These buffers reduce runoff from adjoining fields, limit bank erosion during flooding events, shade waterways to reduce water temperature, increase habitat and biodiversity, and intercept non-point source pollutants. These systems can include flood-tolerant and high-value crops like silver maples (selected for sugaring) and elderberries.

Alley Cropping is the interplanting of rows of trees within other agricultural systems. This strategy allows producers to cultivate a mix of tree crops and annuals or shrubs, increasing overall yields per acre, and diversifying the revenue streams, while drawing down more carbon than purely annual-based systems. The yields of this type of system are highly dependent on the companion crops used. For example, trees may be intermixed with forage crops like grasses to allow for wider tree spacing to increase nut or fruit production.

Silvopasture systems are the appropriately introduction of trees into existing pasture. This provides shelter for livestock like cattle or sheep, reducing heat stress and improving their health, the rate of weight gain, and milk production, while adding an additional long-term yield to the system such as timber, fruit, or nuts.

Forest Farming involves the cultivation of high-value specialty crops under protection of a forest canopy providing adequate shade. Some examples of forest crops are ginseng, ramps, mushrooms, ferns and other medicinal herb, all of which provide income in addition to high-quality timber.

Windbreaks are linear plantings of trees and shrubs designed to enhance crop production and protect people and livestock. Windbreaks exist to support specific crops, activities, or conservation efforts. For example, field windbreaks protect wind-sensitive crops and limit soil erosion. Crops such as winter wheat, barley, strawberries, and raspberries have all demonstrated greater than 20% increases in yields on average when planted with windbreaks.

Left to right: alley cropping system consisting of chestnuts and raspberries; chestnuts and winter wheat; and pine trees and cotton. These systems enable multi-layered production within a single system, and increase its resiliency.
This suitability study explores the process of identifying, assessing, and inventorying parcels based on their suitability for two different practices. The first analysis indicates the suitability for establishing productive riparian buffers in response to erosion risk, and the second illustrates the suitability for intercropping hybrid chestnut trees on existing farmland. GIS is the core data processing tool for the BRASA project.

The initial analyses were conducted within the Connecticut River Watershed in Massachusetts. This study extent was selected for its proximity to active and proposed production systems for hybrid chestnuts, and because of the availability of GIS data layers provided by the Commonwealth GIS office MassGIS.

The BRASA analytical process is comprised of two distinct phases: elimination and classification. Elimination began with an assessment of the 2005 land use data in the study area and eliminated land uses unsuitable for production. This five-step elimination process reduced the study area extent from 1.7 million acres to 115,816 acres, or approximately 7% of the original study area. The classification phase then bifurcated to explore independent class schemes for productive riparian buffers and hybrid chestnuts.

BRASA Process Model
The BRASA model was developed using state and federal data layers.

A Geographic Information System (GIS) is a framework for gathering, managing, and analyzing data. Integrating location-based information with other relevant data layers enables researchers to reveal patterns, relationships, and insights that lead to better decision-making. These patterns, relationships, and insights can be communicated in the form of visualizations like maps, infographics, animations, interactive mapping platforms, or 3D models.
The study area covers approximately 1.7 million acres in Western Massachusetts and includes all of Franklin, Hampden and Hampshire counties and part of Berkshire and Worcester counties. This also covers the Springfield metropolitan area and includes towns and urban centers like Amherst, Northampton, Chicopee, Gardner, and Greenfield.

The valley is defined by the Connecticut River as it winds southwards past the most productive agricultural lands in the region and is flanked by rugged hardscape of the Worcester plateau to the east, and the foothills of the Berkshires to the west.
HYDROGEOGRAPHY IN THE STUDY AREA

Hydrologic Conditions

This analysis includes the Connecticut River watershed and its six sub-watersheds and tributaries including the Chicopee, Deerfield, and Westfield Rivers. It also included the Quabbin Reservoir, which supplies water for the City of Boston, lakes, ponds, and hundreds of wetlands. In total, the study analyzed 2,005 miles of tributaries.
PARCEL SELECTION BY SUITABILITY CRITERIA

Identifying Parcels for Practice or Crop

Parcels in yellow are identified as meeting the criteria for supporting agroforestry. That criteria requires parcels greater than 5 acres in area and not classified as developed. Additional considerations included eliminating parcels that were classified as parkland, or owned by state or federal entities. Parcels that did not meet these classifications were eliminated.

At the conclusion of the elimination phase, approximately 115,000 acres—or 6.7% of the study area—remain. This includes approximately 26,500 individual parcels. This selection of parcels would be analyzed for supporting either riparian buffers or hybrid chestnut production.

Data Sources: NOAA, MassGIS, ESRI, NRCS-USDA, USGS
Classifying Extent of Riparian Buffer

The parcels remaining from the elimination process were then classified according to their proximity to water features including rivers, streams, lakes, ponds, and wetlands. This classification system relied on the 2005 study *Riparian Buffer Zones: Functions and Recommended Widths* prepared by the Yale School of Forestry and Environmental Studies called.

Approximately 56,800 acres (3.3%) of the study area were identified as riparian buffer zones.

Buffers overlap where multiple riparian corridors exist, especially at the confluences of tributaries.
RIPARIAN BUFFER ZONE INTERVENTION

Once riparian buffer zones were identified, the next step was to classify them according to the level of concern for excessive erosion and runoff, which leads to habitat degradation. This classification was based on the soil type, slope, erosion risk, and proximity to water bodies. Future analysis may include the proximity and extent of tree cover, priority habitat, and agriculture use to riparian corridors.

Approximately 16,200 acres (1%) of the study area were identified as buffer zones of high concern and 76,400 (4.4%) acres of low concern. 31,000 acres (1.8%) of riparian buffers were determined not of concern based on process criteria.
In addition to classifying riparian buffers, the BRASA process was applied to assess the suitability of eligible parcels for commercial hybrid chestnut orchards. Factors considered in this classification include soil type, flood frequency, slope, and pH.

Approximately 104,000 acres (5.9% of the watershed) were identified as potentially suitable for hybrid chestnut production. Only 19,700 (1.1%) of the study area was determined not ideal for production based on process criteria.
We, the authors, consider this to be a brief demonstration of what questions the BRASA process can answer. Beyond this case study we are exploring partnerships and projects that will apply this lens to a diversity of questions applied to some of the largest watersheds in the United States. As we proceed into a more comprehensive study of agroforestry nationwide, we expect to evolve this process through three major developments:

1. Improved processing capacity through hardware investment to increase speed, efficiency, and breadth of operations
2. Identification and acquisition of more detailed and current data to reduce the margin of error
3. Enhanced and expanded criteria to improve the information products and insights resulting from the process

This refinement process will be facilitated through an ongoing process with philanthropic institutions, project partners, and clients. Here is a list of organizations and initiatives whose important work we intend to support through the expansion and development of this tool.

**Chesapeake Bay Foundation**  
*Chesapeake Bay Watershed (MA, PA, DE, VA, WV)*  
Acts as watchdog, we fight for effective, science-based solutions to the pollution degrading the Chesapeake Bay and its rivers and streams.

**Ecotrust**  
*(OR, WA, CA, UT, ID, NV)*  
Develops and applies strategic approaches that improve habitat for native fish and wildlife, create local jobs and recreational opportunities, increase public awareness of the value of nature’s services like water, and ensure a more reliable access to clean water for all members of communities.

**Project Drawdown**  
*Worldwide*  
Geared towards assembling the best available information on climate solutions in order to describe their beneficial financial, social and environmental impact over the next thirty years. Of 80 core approaches, silvopasture, intercropping regenerative agriculture, temperate forests, afforestation, and conservation agriculture rank in the top 20.

**Prairie Rivers Network**  
*Mississippi River Watershed (IL)*  
Identifies conservation practices including drainage water management, wetlands, and riparian buffer strips, and builds public-private partnerships with agriculture, industry, conservation, and the government agencies to identify and enact best solutions.

**Santa Barbara County Conservation Blueprint**  
*Santa Barbara County (CA)*  
The Blueprint provides a common language and platform for publicly available data to support in depth conversations and informed decisions about the Santa Barbara County landscape.

If you or your organization are interested in the value of agroforestry in your watershed, please contact our team at design@terragenesis.com
For the initial phase of development we have focused on producing meaningful analysis at the watershed level. However, with each process, and as our database grows we plan to create a web-based interface that allows all users to explore the BRASA results on a parcel by parcel basis. Here we used Google Earth Pro and the results of the BRASA Chestnut Analysis to produce a 3D rendering in the area around the towns of Amherst and Hadley in Massachusetts.

Contact us at design@terra-genesis.com to learn more!