The Refugee Collective Farm
Resilient Farm Plan
—2023—

Prepared by the National Center for Appropriate Technology and Carbon Cycle Institute

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the Refugee Collective — Producing Possibilities Through Food & Fiber

the Refugee Collective Farm

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EXECUTIVE SUMMARY

Nestled in the rapidly developing eastern crescent of Austin, Texas lies a farm on a mission. The Refugee Collective Farm is a 21-acre diversified, specialty crop farm dedicated to training and employing refugee farmers from traditional farming cultures in dignified work that reconnects them to farming in their new communities. The Refugee Collective Farm's Food Access efforts in the refugee community draw a direct connection between regenerative soil health practices and access to culturally desired, nutrient dense produce. This connection supports the health of refugee households as well as preserves their culinary traditions.

As a USDA-certified organic farm with permaculture design elements and abundant community program offerings, the Refugee Collective Farm embodies the One Health principle that the health of soil, plants, animals, people and the Planet are one and indivisible.

This Resilient Farm Plan represents another meaningful step in the Refugee Collective Farm's regenerative and resilient journey. Through a process of exploration and discovery, the Farm Director, Matt Simon, and the Resilient Planning team identified all opportunities to advance the farm goals of increasing production and creating a thriving agroecosystem while simultaneously and naturally boosting the rate of photosynthetically-driven carbon drawdown and storage in healthy soils and fertile fields. The tailored suite of recommended practices herein will result in an estimated 20-year greenhouse gas benefit of 6,905 metric tons of carbon dioxide equivalent (Mg CO_2e). That is the equivalent of taking 1,537 gasoline-powered passenger vehicles off the road for one year.

This Plan is celebrated as the first official Resilient Farm Plan to be adopted in the state of Texas. It is intended to be enduring and adaptive as the Refugee Collective Farm blazes a trail and evolves along the way, as well as continues to adapt to increasingly disruptive climate conditions.

On-farm adoption of conservation practices will require significant time and financial investments. For example, a woodchipper is needed to turn tree pruning byproducts into mulch to keep carbon resources on farm while concurrently providing non-chemical and non-mechanical weed suppression. A compost spreader is another essential tool that will allow for organic soil amendment application and support the Refugee Collective Farm's transition to no-tillage.

This Plan is celebrated as the first official Resilient Farm Plan to be adopted in the state of Texas. It is intended to be enduring and adaptive as the Refugee Collective Farm blazes a trail and evolves along the way, as well as continues to adapt to increasingly disruptive climate conditions. Figure 1 offers a glimpse of what the Refugee Collective Farm could grow into through full implementation of this Plan. The National Center for Appropriate Technology will continue to provide ongoing technical assistance, planning and monitoring support as the Refugee Collective Farm implements recommended conservation practices and continues to move towards a vision of supporting the health of the refugee community in conjunction with a thriving regenerative farming ecosystem.

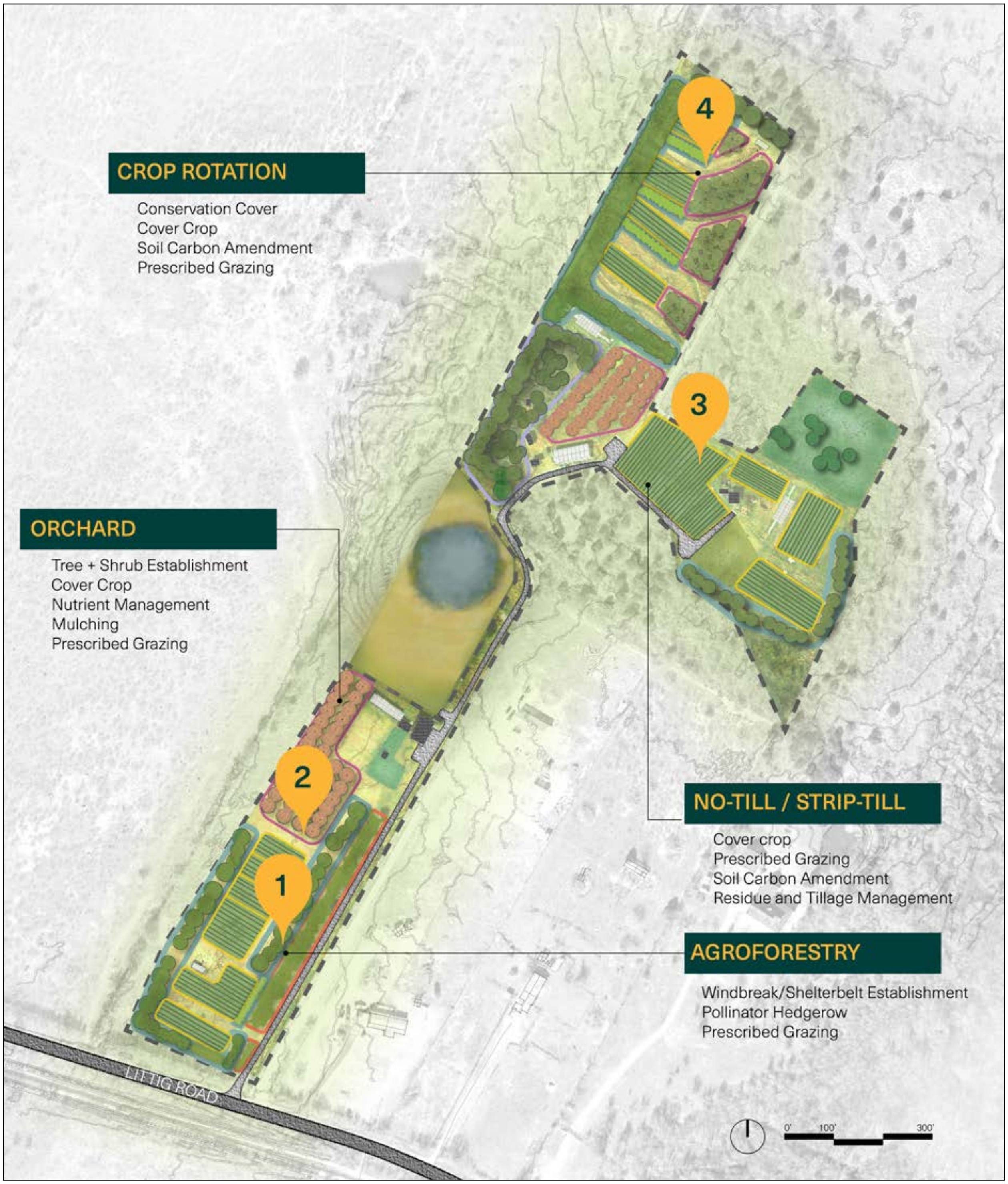


Figure 1. Landscape design map (credit: Lindsay Burnette and Clay Gruber of Rural Futures Collab)

RESILIENT FARM AND RANCH PLANNING

In response to the rapid pace of global climate change, the National Center for Appropriate Technology (NCAT) is engaging agricultural producers in conservation and resilience planning that is rooted in the soil carbon cycle. Through a process known as Resilient Farm and Ranch Planning, NCAT is supporting Texas producers' ability to achieve their goals while simultaneously enhancing interdependent agroecosystem dynamics. We offer tailored planning and implementation technical assistance to boost the carbon cycle as the principle energy pathway driving agricultural productivity, as well as to safeguard critical resources such as water and soil health, increase wildlife habitat and biodiversity, and build resilience to changing climate conditions. With nearly 250,000 farms and ranches covering nearly 130 million acres, Texas agriculture is poised to be a leader in climate forward conservation.

Resilient Farm and Ranch Planning (Resilient Planning) adheres to the Carbon Farm Planning framework developed by the **Carbon Cycle Institute** (CCI). CCI advances the carbon cycle as the fundamental process underlying land management and agricultural conservation in our efforts to mitigate and adapt to the global climate crisis. Greenhouse gas mitigation strategies that lessen the severity of extreme weather paired with adaptation strategies that prepare for anticipated climate changes ultimately give rise to resilience, defined as the ability to rebound from disruptive events.

> While the importance of carbon to soil health and fertility has long been understood, its significance has begun to be increasingly recognized in recent years.

Largely taken for granted, carbon has been absent from the discussion of elements essential to agriculture and the management of working lands; yet carbon is the energy currency of all agricultural production. Carbon enters the farm system from the atmosphere through the process of plant photosynthesis, which harnesses the energy of sunlight to capture carbon dioxide (CO_2) from the air and combine it with water and nutrients from the soil to produce the sugars, cellulose and lignin of harvestable crops. In addition to food, fiber, fuel and flora, carbon can also be beneficially stored long-term (decades to centuries or more) in soils and woody vegetation through a process known as terrestrial carbon sequestration (Figure 2).

While the importance of carbon to soil health and fertility has long been understood, its significance has begun to be increasingly recognized in recent years. Today, managing for increased soil organic matter (SOM), which is about 50% carbon, is the core of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) healthy soils program.

This planning process emphasizes conservation practices that increase the rate of photosynthetically-driven transfer of solar energy and atmospheric CO_2 into plant productivity, perennial cover, woody biomass and/or healthy SOM. Increasing carbon capture and storage on working lands also helps to slow rising levels of carbon dioxide and other atmospheric greenhouse gases (GHGs) that are warming the planet and contributing to climate destabilization and uncertainty. Agroecosystems with enhanced carbon energy pathways are also positively correlated with a variety of ecological benefits, including but not limited to:

- Soil water holding capacity and hydrological function;
- Soil microbial activity and fertility;
- Resilience to environmental stress such as drought and flood;
- Pollinator and wildlife biodiversity; and
- Improved agricultural productivity.

The planning process is based upon the USDA NRCS nine-step conservation planning process and elevates agricultural carbon depletion as the resource concern of overriding importance. The planning team, in collaboration with producers, identifies a tailored suite of NRCS Conservation Practice Standards proven to enhance the rate of carbon accrual in agricultural systems. The conservation practices included in any individual Resilient Farm and Ranch Plan uphold and advance the **five principles of soil health**: keep the soil covered, minimize soil disturbance, maintain continual living root, enhance plant diversity, and integrate animals.

Texas has a vast array of ecosystems from brittle arid western desert to southern great plains and grasslands to eastern timberland and coastal plains. NCAT's national knowledge and database will contribute greatly to being able to create unique Plans for all types of ecoregions.

It is important to note that this framework is not tied to the carbon marketplace and does not result in the issuance or verification of salable carbon credits.

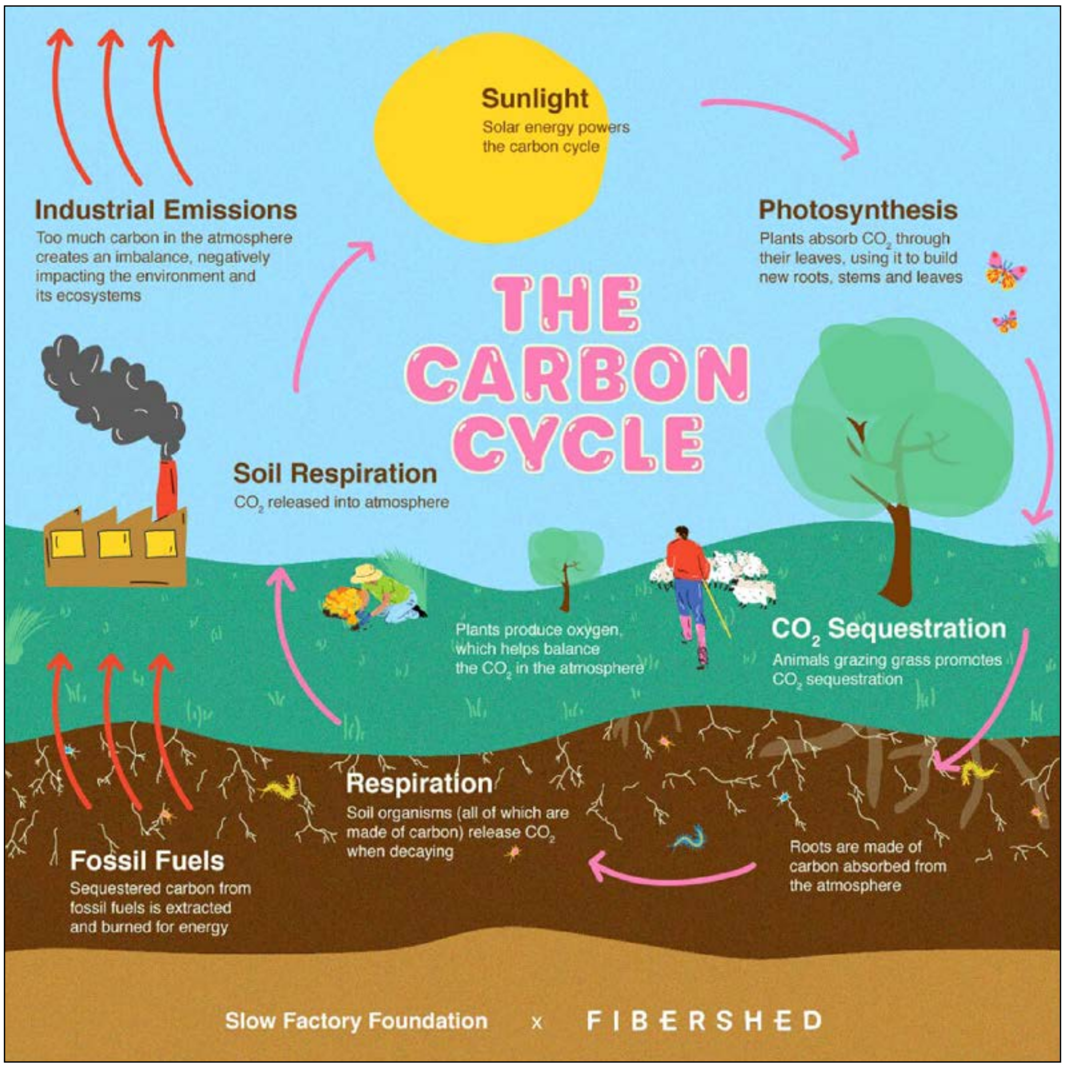


Figure 2. The Carbon Cycle Credit: Fibershed

Carbon as the Keystone

All farming is dependent on carbon because all agricultural production depends on plant photosynthesis to turn solar energy and atmospheric CO_2 into plant material. Carbon entering the farm system from the atmosphere can end up in several locations: the harvested portion of the crop, the SOM through root exudates, grassland vegetation, herbaceous and woody perennials (trees, shrubs, vines, orchards, etc.), and "waste" materials such as compost or manure.

> Carbon in plants and soil organic matter can thus be understood as the embodied solar energy that drives agricultural processes.

On-farm and ranch carbon in all its forms contains energy that originated as the solar energy used by plants to make carbohydrates from atmospheric CO_2, water, and soil nutrients. The carbon in plants and SOM can thus be understood as the embodied solar energy that drives agricultural processes, including the essential ecological processes that predispose soil to greater water holding capacity and nutrient availability for the growing crop. ***Consequently, Resilient Planning places carbon at the center of the planning process and views carbon as the single most important element, upon which all other on-farm processes depend*** *(Figure 3).*

While all farming is completely dependent upon atmospheric CO_2 in order to produce its products, different farming practices, and different farm systems, can lead to very different amounts of on-farm carbon capture and storage. ***The Resilient Planning process differs from other approaches to land use planning by focusing on increasing the capacity of the agricultural land to accrue and store carbon*** *(Figure 4).* While conventional agricultural practices often lead to a gradual loss of carbon from the farm system, Resilient Planning is successful when it leads to a net increase in farm-system carbon.

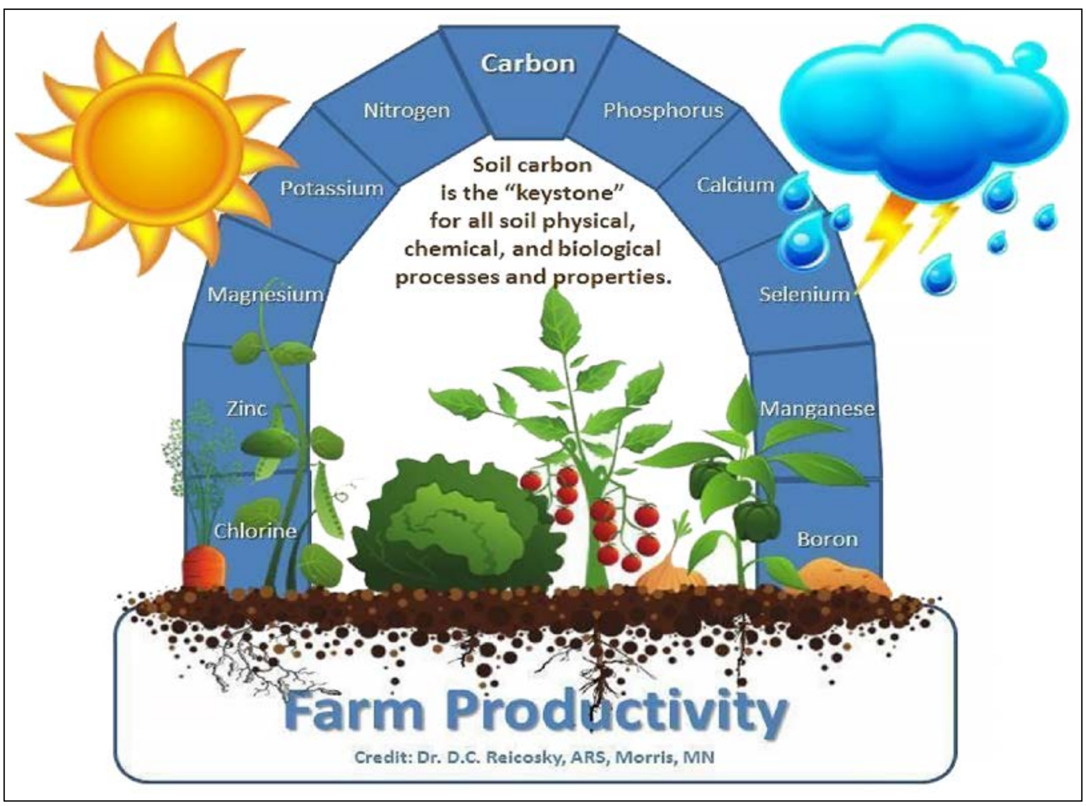


Figure 3. Carbon as the Keystone element to Working Land Productivity and Resilience

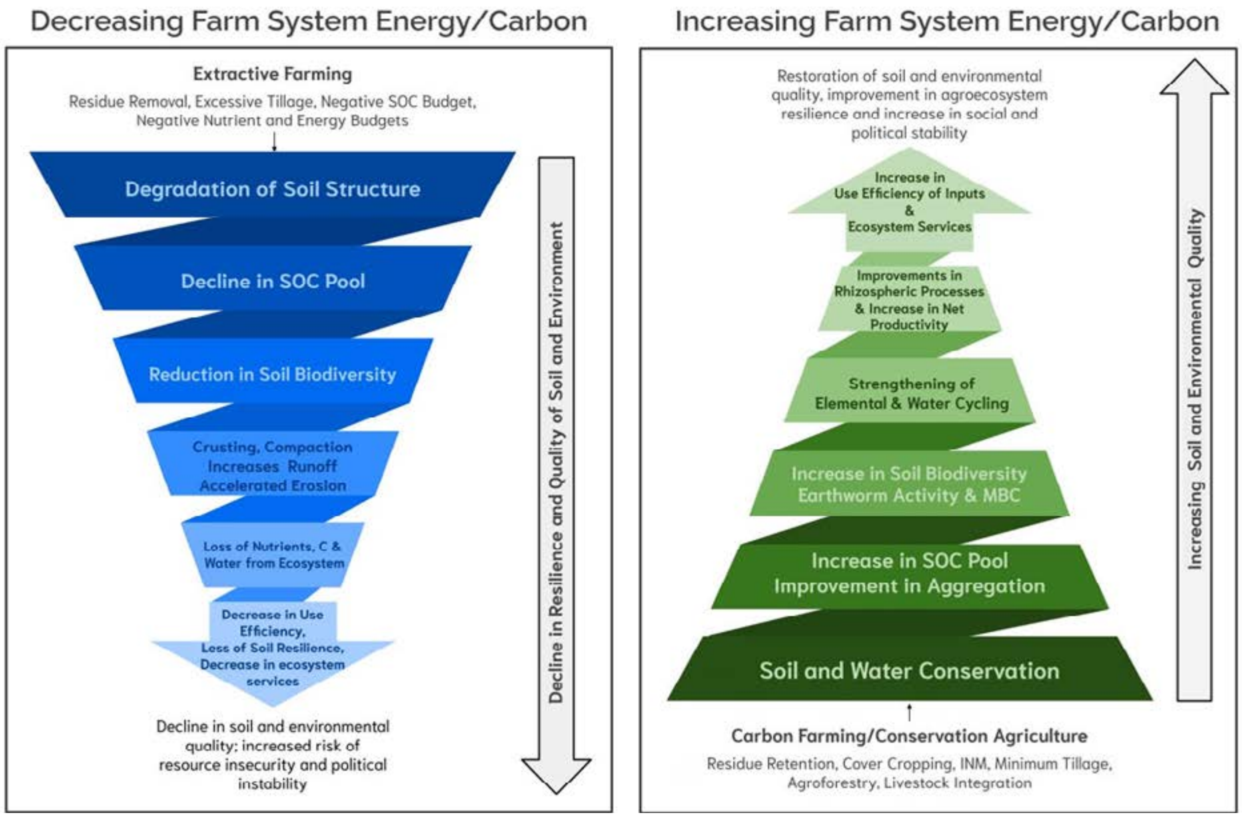


Figure 4. The virtuous carbon cycle. Diagram: CarbonCycleInstitute

The Planning Process

Resilient Planning upholds the conservation planning principles of Carbon Farm Planning, which are similar to the NRCS Conservation Planning process, beginning with producer goals and an overall inventory of natural resource conditions on the farm or ranch. Akin to Carbon Farm Planning, Resilient Planning focuses on identifying opportunities for drawing more atmospheric CO_2 into the farm system and reducing greenhouse gas emissions. This is a creative and collaborative process! It considers the whole farm or ranch property as a tapestry of interdependent systems and considers every square inch of possibility to boost the carbon cycle.

Maps of the property and fields are developed to account for existing infrastructure and natural resources, and to lay out the design of potential conservation practices. The USDA COMET-Planner tool is used to generate an estimated greenhouse gas benefit of each proposed practice in tons of carbon dioxide equivalent (CO_2e) as 1) avoided emissions or 2) atmospheric CO_2 sequestration.

Finally, practices are prioritized based on the needs and goals of the farm or ranch, choosing high carbon-benefit practices wherever possible. Funding mechanisms are identified, such as USDA-NRCS programs, other federal and state programs, and private funding. Projects are implemented as funding, technical assistance and farm scheduling allows. The Plan is a living document that is evaluated and adapted as needed to meet changing farm objectives and environmental conditions, using the fully implemented plan scenario as a goal or point of reference.

Additional information about Carbon Farming can be found online at: **www.marincarbonproject.org** and **www.carboncycle.org**.

Additional information about NCAT's Climate Solutions can be found on line at:
NCAT Climate Solutions and **NCAT Soil for Water**

INTRODUCTION TO THE REFUGEE COLLECTIVE FARM

In the winter of 2021, **The Refugee Collective Farm** (the Farm) approached Carbon Cycle Institute (CCI) for assistance writing a Carbon Farm Plan. Through a technical assistance partnership with the National Center for Appropriate Technology (NCAT) and funding from Southern Sustainable Agriculture Research and Education and The Meadows Foundation, a Resilient Farm Plan has been developed for the 21-acre property leased and operated by the Refugee Collective.

The Farm is a social enterprise of The Refugee Collective, which serves the mission of creating livelihood opportunities for refugees in Austin, Texas through two social enterprises.

1. The Farm, a USDA Organic-certified, diversified, specialty crop farm that trains and employs refugee farmers from traditional farming cultures in dignified work that reconnects them to farming in their new communities.
2. Open Arms Studio, a textile and craft studio that offers fair-wage employment for refugee women seamstresses in Austin, Texas.

The Farm currently grows USDA Organic-certified vegetables on 6 acres of irrigated cropland, growing approximately 60-70 varieties of mixed produce throughout the year. The Farm also rotationally grazes 150 Rhode Island Red laying hens and raises USDA Organic-certified pastured eggs. In addition to growing edible products, the Farm also grows flax for fiber and Mexican mint marigold, indigo, ladies bedstraw, and madder as natural dye plants for use in the Open Arms textile studio.

Permaculture design features are woven into the agroecosystem, such as berms and swales built on the gradually sloping back Fields to slow rainwater runoff and increase water infiltration in the fields. The berms are planted with fruit and nitrogen fixing trees, as well as perennial Mexican mint marigold plants that contribute to the natural dye palette on the farm.

Berm and swale. Photo: Matt Simon

The Farm directly sells their produce through a 150-member Community Supported Agriculture (CSA), the Sunday Mueller Farmers Market in Austin, farm-to-table restaurants in Austin, and wholesale when possible. In Fall-2023, the Farm shifted efforts towards a goal of getting more produce into refugee households and is now distributing 75 weekly CSA shares into refugee households per week at no cost to the refugee households.

Through the Farm's Traditional Provisions program, they offer resources and training for community farmers to manage their own production scale garden beds. The refugee community farmers have autonomy over the crops they grow for their own community, earning a supplemental income in the process. The Farm purchases these culturally desired crops from the community farmers and helps them to distribute it to their communities free of charge.

The Farm employs six refugee farmers with dignified work and provides fair living wages for all farm employees. The front of the property is in transition to become a Traditional Provisions community garden program with 40 community garden plots, a farmer training program, and sales and distribution support to scale impact for the refugee community.

Farm Background

The Farm is located 30 minutes east of Austin, Texas in the small, unincorporated community of Littig in eastern Travis County. The farm is on a larger 300-acre property in the Colorado River Basin Blackland Prairie Ecosystem, prized for its prime farmland soils and threatened by accelerating development in the rapidly growing Central Texas corridor (Figure 5). The Major Land Resource Area is Texas Blackland Prairie, Northern Part (MLRA 086A). This area supports tall and midgrass prairies, although improved pasture, croplands, and urban development account for the majority of the acreage. The property is situated in the Wilbarger Creek Watershed which empties into the Lower Colorado River and eventually into the Gulf of Mexico.

The town of Littig was established in 1883 on land donated by Jackson Morrow, a former slave. Littig was one of the first black freedmen's colonies and an active community for approximately 50 years until it began to decline in the 1930s (Smyrl, 2020). The current landowner purchased a 300-acre property in the 1970s, which had been previously owned by the first black US Postmaster General, Jackson Morrow, in Texas. For nearly half a century, the land where the farm is situated was intermittently and continuously grazed through agricultural leases by the landowner. In 2018, the landowner offered the Refugee Collective a discounted lease on 21-acres to start an agricultural program.

The entire property is now part of 2,000 contiguous acres held in conservation easement by the **Wilbarger Creek Conservation Alliance** (WCCA), a land conservancy founded by the landowner. WCCA is a nonprofit dedicated to the preservation of working farms and ranches, open space, scenic views, water, and wildlife habitat in the Wilbarger Creek Watershed. Riparian tree plantings have been established on areas of the property along Wilbarger Creek through a partnership with Austin-based nonprofit TreeFolks. The remaining roughly 280 acres continue to be intermittently and continuously grazed along with appropriate rest and recovery periods.

Archeological evidence suggests occupation of the landscape for approximately 16,000 years with discoveries at the Gault Site outside of Killeen, Texas. The property is an intact grassland and had been used as grazing pasture prior to the Farm's arrival. The soil had been eroded in some areas and overgrazing had led to dense growth of mesquite, cedar elm, hackberry and ashe juniper, which were cleared for cropland. The landscape of this property was historically a diverse riparian ecosystem, likely including components of riverbed, woodland, temperate grassland and floodplain throughout time.

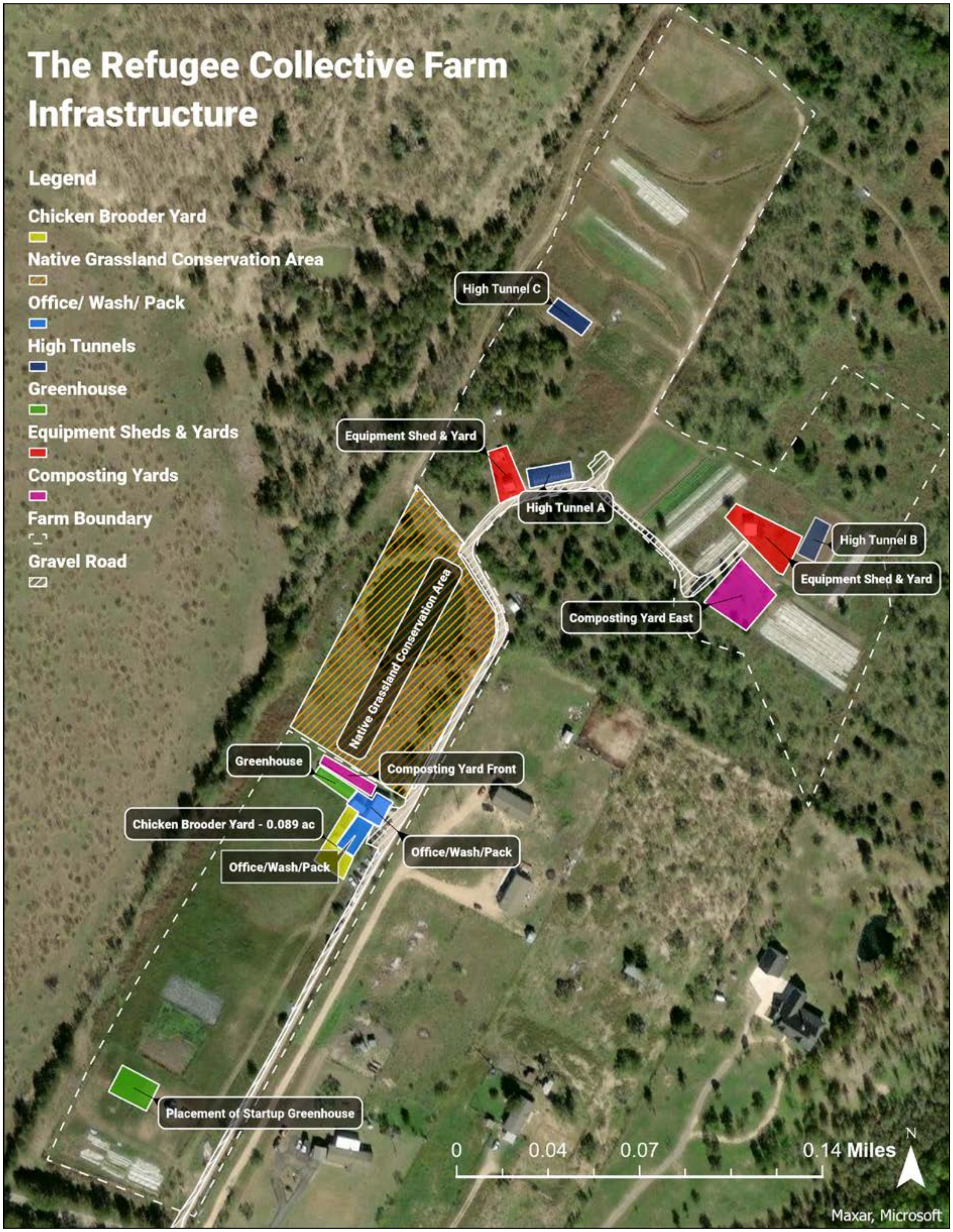


Figure 5. Farm Infrastructure

Farm Goals & Objectives

The Farm Director identified a set of Farm goals and objectives. Through implementation of a grazing plan and practices recommended in the Resilient Farm Plan, many of the goals and objectives will be reached. A monitoring plan has been developed to track progress toward meeting the goals and objectives. The monitoring plan is described later in the document.

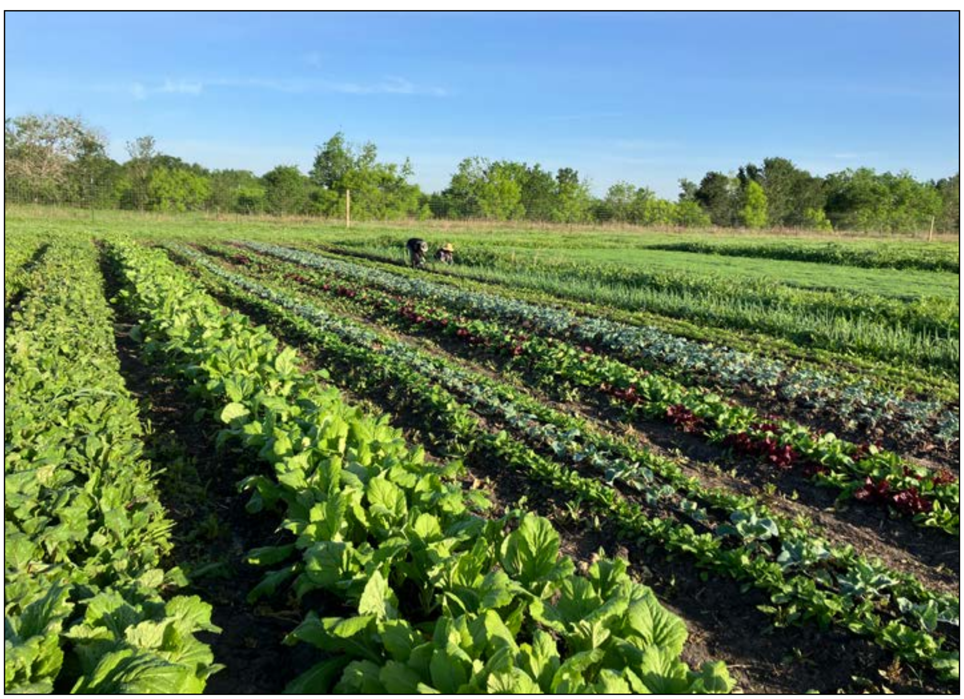
One goal is to increase production to meet growing market demand, to amplify impact for the refugee community and to build a bridge between the farm and textile studio enterprises. Specifically, the producer has identified the following objectives:

- Improve soil profile on 6 acres of annual vegetable production in order to maintain consistent yields in every field.
- Extend the growing season by growing more storage crops
- Install additional orchards.
- Strive for greater produce variety, especially for the CSAs.
- Scale a Traditional Provisions community garden program for the refugee community.
- Grow more fibers and natural dye plants for use in the Open Arms Studio.

The Farm also has a goal of creating a thriving agroecosystem that builds soil health, regenerates ecological functions and has a climate beneficial impact. Specifically, the producer has identified the following objectives:

- Build soil organic carbon and enhance on-farm carbon sequestration.
- Implement a functional no-till cover crop as soon as possible following cash crops.
- Enhance grazing systems by integrating chickens into the entire vegetable cropping system.
- Integrate herbaceous and woody pollinator strips to build pollinator habitat and increase biodiversity.
- Keep resources on the farm by making on-farm compost and mulch.

The Farm goals ultimately advance the Refugee Collective's greater goal of building a Regional Food and Fiber Economy that builds ecosystem health and community wealth and wellbeing.



High spring on the farm. Photo: Matt SImon

Climate

The climate on the Farm is humid subtropical, characterized by hot summers and mild winters. The bulk of rainfall occurs between October and May. The mean average annual precipitation is 35.82 inches. Summers are hot and have been trending hotter and drier than normal. The average annual temperature is 67.1 degrees F. The average high temperature from 1901-2000 is 96.1 degrees F, with 12 of the past 15 years meeting or exceeding that average. The sun shines approximately 75% of the time in summer and 50% of the time in winter. The growing period is between 270 and 299 days. The frost-free period averages 292 days.

By mid-century, Travis County will see changes in climate. Annual and seasonal average temperatures are projected to rise along with more frequent and longer high temperature extremes. Although annual average precipitation is projected to remain fairly consistent, rainfall events will be fewer and more extreme, with high-intensity surges of rain more likely to produce rapid runoff events. The front fields are in the 100-year floodplain (FEMA, 2023). Longer periods of less than average rainfall coupled with higher temperatures will amplify summer heat stress that could negatively affect productivity.

The Farm is already beginning to experience temperate extremes as a result of accelerating climate change. Summers are ushering in excessive heat waves and polar vortexes are causing catastrophic winter freezes. In order to adapt to increasingly unpredictable weather patterns that disrupt growing cycles or lead to crop failure, the Farm would like to pursue avenues to extend the summer and winter seasons.

Wind patterns can get rather gusty on the farm. The prevailing winds are Northerly in fall and winter, and usher in the longest period of strong winds (20+ mph) from December through February. The Farm Director reports extreme winter blasts up to 30-35 mph coming over the hill at the north side of the property. In Spring and summer, the prevailing winds are Southerly and ramp up around hurricane season (Iowa State University, 2023).

Watershed and Hydrology

The Farm is situated in the middle of the Wilbarger Creek Watershed, at the confluence of Cottonwood Creek, Willow Creek, Dry Creek and Wilbarger Creek (Figure 6). All creeks within the watershed eventually converge into Wilbarger Creek, a tributary to the Colorado River Basin. The Wilbarger Creek Watershed extends from northeast Travis County into northwest Bastrop County and encompasses 116,146 drainage acres. Surrounding native vegetation consists of prairie grasses in the upper and middle parts of the watershed and deciduous woods in the lower part of the watershed. The dominant soil type is Houston Black, a dense clay. Predominant land uses are rangeland and cultivated farmland. Wilbarger Creek is a naturally intermittent stream that flows seasonally, although continuous discharge of wastewater effluent from the surrounding municipalities is changing it to a perennial flow (LCRA, 2011).

The watershed is facing increasing development pressure from three rapidly growing communities - Elgin, Manor and Pflugerville. According to the Lost Pines Groundwater Conservation District 2017 Management Plan, the Bastrop County population is expected to increase from 95,487 in 2020 to 382,244 in 2070 (an increase of 302%). Total water demands in Bastrop County are projected to increase from 35,184 acre-feet/year in 2020 to 89,084 acre-feet/year in 2070 (TWDB, 2017).

Surface water resources are little used in Bastrop and Lee counties because of lack of availability and because what is available has already been appropriated. Lake and reservoir surface water is used primarily to cool power plants, with little more than 6% going towards irrigation needs. Local surface water is used for manufacturing, mining and livestock. Groundwater meets virtually all demand for municipal, manufacturing, mining, livestock, and irrigation purposes (TWDB, 2017).

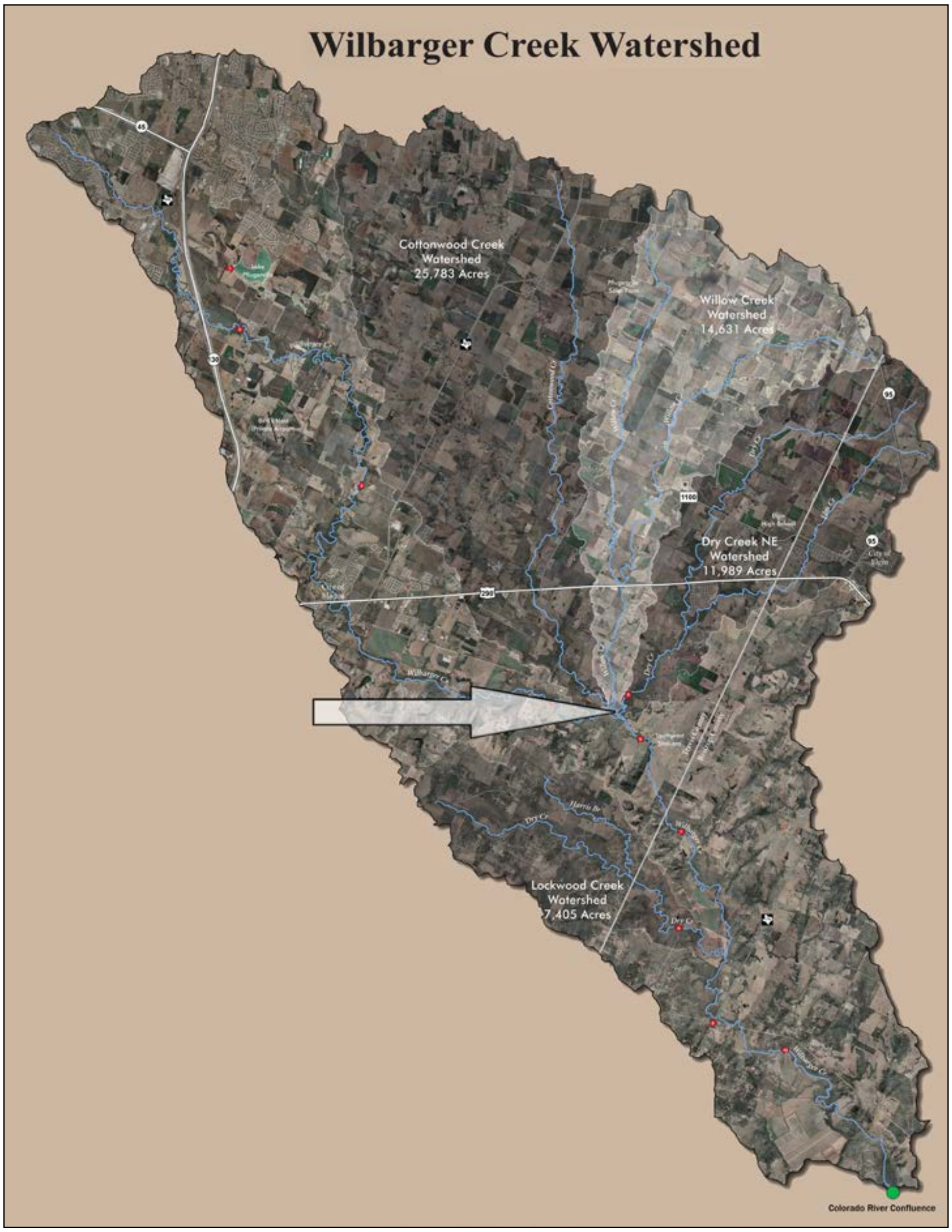


Figure 6. Wilbarger Creek Watershed with the Farm location marked (LCRA, 2011)

The Farm is irrigated with a combination of municipal water and groundwater. The front fields and the wash/pack area operate from municipal water. The back half of the farm is currently irrigated from a ¾ acre runoff collection pond on the Northeast outside corner of the property. The pond irrigates a majority of the farm with rainwater. Drip tape is used for micro-irrigation and K-pod systems are used for irrigation water management. Overhead irrigation is used from time to time for cover crops and to add dissolvable amendments. The groundwater is accessed through a submersible pump and then pumped to central water access points.

Runoff from the front half of the farm travels to bar ditches at the front of the property and eventually flows into Willow Creek. Runoff from the back half of the property goes toward the collection pond. The Farm has already seen lower than historic levels in the runoff collection pond. It will be important to increase soil water holding capacity as the climate continues to warm and rainfall becomes less predictable. Woven throughout this Plan are recommended practices to build soil organic matter, improve soil aggregate stability and keep the soil covered, resulting in reduced evaporation, improved water holding capacity and utilization, and slowing the movement of water out of the farm system.

Vegetation

Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by: big bluestem *(Andropogon gerardii),* Indiangrass *(Sorghastrum nutans),* switchgrass *(Panicum virgatum),* eastern gamagrass *(Tripsacum dactyloides),* and little bluestem *(Schizachyrium scoparium).* Midgrasses such as sideoats grama *(Bouteloua curtipendula)*, Virginia wildrye *(Elymus virginicus)*, Florida paspalum *(Paspalum floridanum)*, Texas wintergrass *(Nassella leucotricha)*, hairy grama *(Bouteloua hirsuta)*, and Dropseeds *(Sporobolus spp.)* are also abundant in the region. Row crop agriculture and urban development have virtually cleared this area of original vegetation. Today, less than one percent of the native tallgrass prairie remains (1. Creswell, 2007).

Prior to being cleared for annual crop production this landscape was also scattered live oak savannah including the following tree species: oaks *(Quercus spp.)*, hackberry *(Celtis spp.)*, cedar elm *(Ulmus crassifolia)*, ash juniper *(Juniperus ashei)* eastern red cedar *(Juniperus virginiana)*, honey locust *(Gleditsia triacanthos)*, pecans *(Carya illinoienses)*, black walnut *(Juglans nigra)*, mulberry *(morus spp.)* mesquite *(Prosopis glandulosa)*, anacua *(Ehretia anacua)*, texas persimmon *(Diospyros texana)*, kidneywood *(Eysenhardtia texana)*, texas ash *(Fraxinus texensis)*, boxelder *(Acer negundo)*, eve's necklace *(Sophora affinis)*, texas mnt. laurel *(Sophora secundiflora)*, huisache *(Acacia farnesiana)*, mexican buckeye *(Ugnadia speciosa)*, yaupon *(Ilex vomitoria)*, retama *(Parkinsonia aculeata)*, sumacs *(Rhus spp.)* and cypress *(Taodium spp.)*.

The native species of shrubs and forbs include, but are not limited to: agarita *(Agarita spp.)*, lantana *(Lantana spp.),* plumbago *(Plumbago auriculata)*, firebush *(Hamelia patens)*, dewberry *(Rubus spp.)*, turks cap *(Malvaviscus arboreus)*, flame acanthus *(Aniscanthus quadrifidus)*, rough-leaf dogwood *(Cornus drummondii)*, texas redbud *(Cercis canadensis var. texensis)*, prickly-pear cactus *(Opuntia spp.)*, texas sage *(Leucophyllum frutescens)*, sunflowers *(Helianthus spp.)*, pink primrose *(Oenothera speciosa)*, horsemint *(Monarda citriodora)*, spiderwart *(Tradescantia gigantea)*, texas thistle *(Girsium texanum)*, purple bindweed *(Ipomoea cordatotriloba)*, wild petunia *(Ruellia nudiflora)*, silverleaf nightshade *(Solanum elaeagnifolium)*, texas bluebonnet *(Lupinus texensis)*, salvias/sages *(Salvia spp.)*, bull nettle *(Cnidoscolus texanus)*, white prickly poppy *(Argemone albiflora)*, frog fruit *(Phyla nodiflora)*, white mistflower *(Ageratina havanesis)*, antelope-horns milkweed *(Asclepias asperula)*, partridge pea *(Chamaecrista fasciculata)*, coreopsis *(Coreopsis tinctoria)*, lindheimer's senna *(Senna lindheimeriana)*, goldenrod *(Solidago spp.)*, zexmenia *(Wedelia texana)*, texas star *(Lindheimera texana)*, mexican hat *(Ratibida columnifera)*, firewheel *(Gaillardia pulchella)*, indian paintbrush *(Castilleja indivisa)*, and standing cypress *(Ipomopsis rubra)* (Arnold, 2018; USDA NRCS PLANTS Database).

The Texas Parks and Wildlife Department (TPWD) has listed the navasota ladies'-tresses *(Spiranthes parksii)* as both threatened and endangered (G3 & S3). Navasota ladies'-tresses occurs primarily in openings of post oak woodlands in sandy loam soils, often over an impermeable clay layer, adjacent to drainages and seasonal streams, in Bastrop, Brazos, Burleson, Fayette, Freestone, Grimes, Jasper, Leon, Limestone, Madison, Milam, Robertson, and Washington counties in eastern Texas.

Wildlife

Major wildlife species in the area include Whitetail deer, fox, rabbit, armadillo, raccoon, Texas Horned Lizard, Box Turtle, rattlesnake and many residential bird species such as wild turkey, bobwhite quail, dove, Burrowing Owl, American Kestrel, various sparrows, and woodpeckers. Migratory bird species include Great Blue heron, duck, cattle egret, painted bunting, and the endangered Golden-cheeked Warbler songbird. Golden-cheeked warbler is a true Texas native and sits on the precarious precipice of extinction due to habitat loss and fragmentation. Golden-cheeked warbler relies on Ashe juniper to build nests and on oak tree dwelling caterpillars and spiders for sustenance. Protecting the habitat of this species has the co-benefits of protecting the Edwards Aquifer recharge zone and improving air quality (Travis Audubon). Golden-cheeked warblers are a Texas icon and it is critical to ensure their survival and protect their legacy.

The farm is in the migratory corridor of the endangered Monarch Butterfly, which relies on native milkweeds to complete their life cycle. The area is also home to up to 1,000 native bee species. The Farm understands the importance of protecting and providing habitat for pollinators. The use of conservation practices that ensure pollinator survival has long been a goal of the farm.

The rare, threatened and endangered species of Travis County include 6 amphibian species, 16 bird species, 13 mammal species and 7 reptile species. They include common household names such as bald eagle *(Haliaeetus leucocephalus)*, brown bat *(Eptesicus fuscus)*, whooping crane *(Grus americana)*, mountain lion *(Puma concolor)*, swallow-tailed kite *(Elanoides forficatus)*, and black-capped vireo *(Vireo atricapilla)*, as well as Austin's very own and beloved Austin blind salamander *(Eurycea waterlooensis)* (TPWD, 2023).

Soils & Ecological Sites

The property is entirely situated in the Northern Texas Blackland Prairie MLRA. Much of this area is considered farmland of statewide importance. Natural vegetation is predominantly tall and midgrass prairies, although improved pasture, croplands, and urban development now account for the majority of acreage.

> The property is entirely situated in the Northern Texas Blackland Prairie MLRA. Much of this area is considered farmland of statewide importance.

Ecological sites are further conceptual divisions of the landscape based on distinct geophysical characteristics such as slope, soil type, and aspect. Individual farms tend to consist of a mosaic of ecological sites that re-occur across the farm landscape. The grouping of a farm into ecological sites allows for the planner and the farmer to see the similarities, differences and limits between areas of the farm to determine potential for carbon capture, practice suitability and management recommendations.

Ecological sites on the Farm have been delineated by soil type and slope classes. Table 1 shows three distinct soil mapping units on the Farm, two of which make up the majority of the farm's acreage: Heiden clay, 3 to 5 percent slopes, eroded, and Wilson clay loam, 1 to 3 percent slopes. Note that these are extremely broad designations, and do not capture the variability actually seen on the landscape. The general upward slope of the front fields is 2.8% going from west to east. The east fields are generally flat with up to 1.4% slope in a few areas. The general upward slope of the back fields is 3.2% going from southwest to northeast.

The **USDA NRCS Web Soil Survey** contains information that helps guide land use and conservation planning decisions. Soil surveys identify soil properties and soil limitations that impact various land uses (Figure 7).

SOIL TYPES

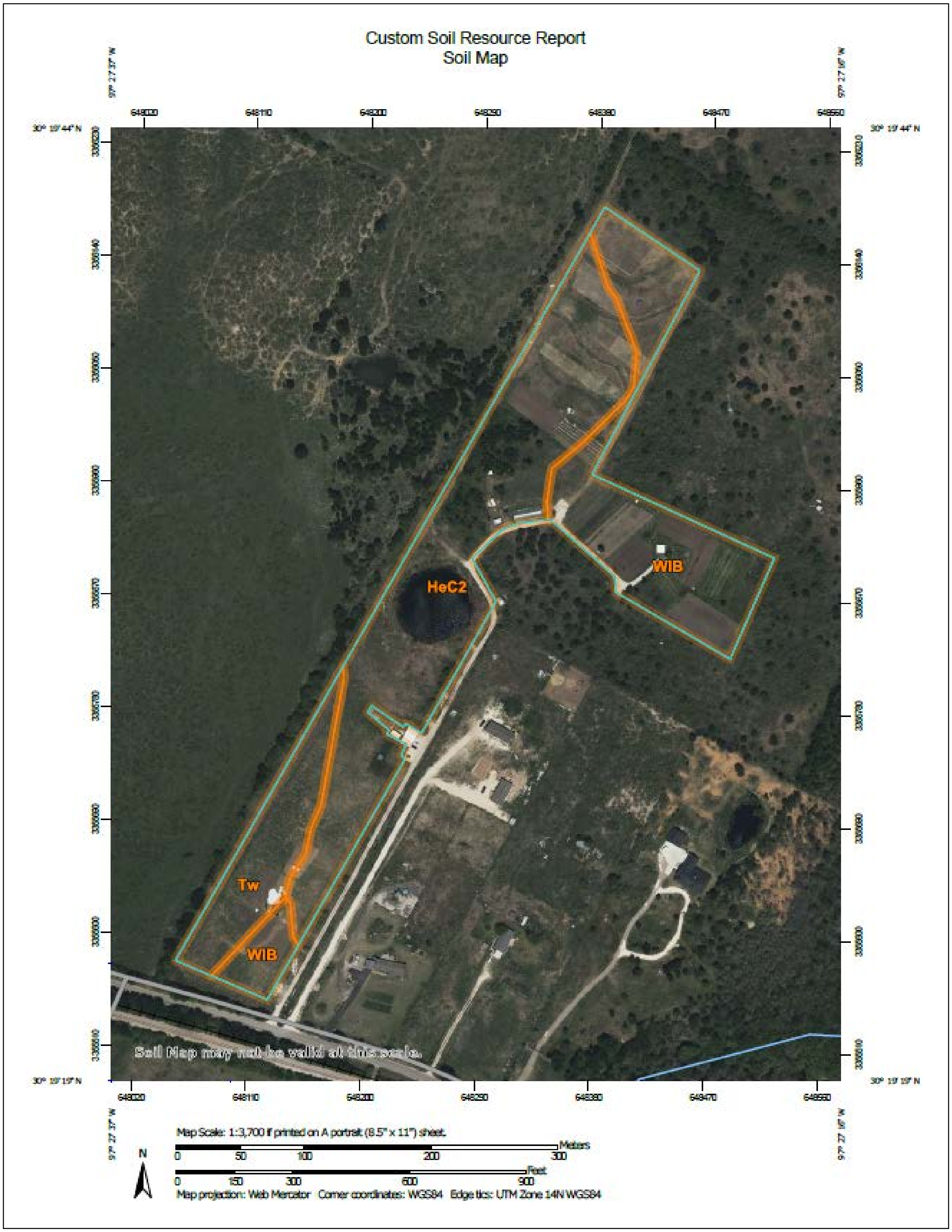


Figure 7. Soil Map (Web Soil Survey, 2022)

Table 1: Soil Table (Web Soil Survey, 2022)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of Aoi
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	8.9	53.3%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	2.3	13.6%
WIB	Wilson clay loam, 1 to 3 percent slopes	5.5	32.9%
Totals for Area of Interest		**16.6**	**100.0%**

HeC2 - Heiden clay, 3 to 5 percent slopes, eroded

Heiden clay is the dominant soil type on the farm, and runs through the middle of the farm from the southeast corner in the front field all the way up to the northwest corner of the back field (Figure 7). This soil class consists of an estimated 85% Heiden moderately eroded and similar soils and 15% minor components Houston black (10%) and Ferris, severely eroded (5%). The setting of this soil is characterized by its landform and parent material.

The ecological site is Southern Eroded Blackland, a tallgrass prairie with intact communities of grasses and pockets of deciduous bottomland woodlands along rivers and creeks. This site consists of well drained soils that are slowly to very slowly permeable (USDA, NRCS). The site consists of gentle slopes ranging from 1 to 20 percent and vulnerability to runoff increases as slope gradient increases. The reference site is highly resistant to erosion, however, conversion to cropland has resulted in extensive erosion that has partially or completely removed the A horizon and reduced biomass productivity (1. Creswell, 2007).

The soil organic matter (SOM) is estimated to be 2.5% for this soil (Web Soil Survey, 2022). Total Organic Carbon (TOC) is 58% of organic matter (Magdoff, 2021) and, thus, an estimated 1.45% based on the conversion of dividing SOM percentage by 1.724 (Web Soil Survey, 2022). SOM can be increased through the formation of stable soil aggregates, the production of plant biomass and the addition of organic amendments.

- **Soil aggregates**. Management practices that minimize soil disturbance can help protect soil aggregates, such as no-till / reduced till. Management practices that armor the soil, such as cover cropping, conservation cover, and mulching can also help protect soil aggregates from erosive disturbance.
- **Plant biomass and residue**. Management practices such as conservation crop rotation, cover cropping, prescribed grazing, mulching and agroforestry can increase plant biomass quantity and diversity.
- **Organic amendments**. Compost application and other organic matter amendments can boost SOM accumulation.

Heiden clay, 3 to 5 percent slope, is well drained with a very high runoff classification meaning that rainfall has a high potential of running off the fields rather than infiltrating into the soil, particularly on steeper slopes. The available water holding capacity of Heiden clay is moderate, rated around 0.16 centimeters per centimeter. Greater runoff potential is also reflected in the high bulk density rating of 1.27 g/cc meaning the soil density may result in restricted water and air movement, reduced available water capacity, restricted root growth and seedling emergence, and, ultimately, reduced productivity. The ideal bulk density for root growth in clayey textured soils is less than 1.10 g/cc. Both runoff potential and bulk density can be improved with management, including increased SOM.

WlB - Wilson clay loam, 1 to 3 percent slopes

Wilson clay loam is the second most predominant soil on the farm. The entire L-shape on the eastern portion of the farm is Wilson clay loam, as well as back field 10 and half of field 9. There is a small section of Wilson clay loam in the southeast corner of the front field (Figure 7).

This soil class consists of an estimated 85% Wilson and similar soils and 15% minor components Burleson (10%) and Crockett (5%). The setting of this soil is characterized by its landform and parent material.

The ecological site is Southern Claypan Prairie, a true tallgrass prairie with intact communities of grasses and pockets of deciduous bottomland woodlands along rivers and creeks. This site consists of moderately well to well drained soils that have slow to very slow permeability. The soils are characterized by a sandy loam surface soil layer underlain by a dense, hard clay that restricts air and water movement, and root penetration. Soils can quickly become saturated due to the impermeable claypan, which slows infiltration and increases the likelihood of runoff. Under the reference conditions of prairie dominated by tallgrasses and forbs, the soil is highly resistant to erosion under normal rainfall conditions. Southern Claypan is often adjacent to Clayey Bottomland ecological site and experiences lower production potential then Clayey Bottomland due to low to moderate soil fertility (2. Creswell, 2007).

The SOM is estimated to be 1.25% for this soil and the TOC is an estimated .73% (Web Soil Survey, 2022). As previously mentioned, SOM can be increased through the formation of stable soil aggregates, the production of plant biomass and the addition of organic amendments. Many of the management practices that build SOM and, by extension, TOC, are captured in this plan.

Wilson clay loam, 1 to 3 percent slope, is moderately well drained with a high runoff classification meaning that rainfall has a high potential of running off the fields rather than infiltrating into the soil, particularly on steeper slopes. The available water holding capacity of this soil is moderate, rated around 0.14 centimeters per centimeter. Runoff potential may be exacerbated by the bulk density rating of 1.40 g/cc; ideal bulk density for root growth in loamy textured soils is less than 1.40 g/cc. Both runoff potential and bulk density can be improved with management, including increased SOM.

Tw - Tinn clay, 0 to 1 percent slopes, frequently flooded

Tinn clay is the minor soil on the farm, and is present on the western side of the front field (Figure 7).

This soil class consists of an estimated 85% Tinn and similar soils and 15% minor components Whitesboro (10%) and Gladewater (5%). The setting of this soil is characterized by its landform and parent material.

The ecological site is Clayey Bottomland, a tallgrass savannah with a hardwood overstory component. The soils are characterized by very deep clays, an intact A horizon, and high shrink-swell properties. The heavy textured soils cause water to drain slowly and are associated with flooding regimes (Creswell, 2008).

The SOM is estimated to be 2.5% for this soil and the TOC is an estimated 1.45% (Web Soil Survey, 2022). As previously mentioned, SOM can be increased through the formation of stable soil aggregates, the production of plant biomass and the addition of organic amendments. Many of the management practices that build SOM and, by extension, TOC, are captured in this plan.

Tinn clay, 0 to 1 percent slopes, is moderately well drained with a high runoff classification meaning that rainfall has a high potential of running off the fields rather than infiltrating into the soil, particularly on steeper slopes. The available water holding capacity of this soil is moderate, rated around 0.14 centimeters per centimeter. Greater runoff potential is also reflected in the high bulk density rating of 1.38 g/cc meaning the soil density may result in restricted water and air movement, reduced available water capacity, restricted root growth and seedling emergence, and, ultimately, reduced productivity. The ideal bulk density for root growth in clayey textured soils is less than 1.10 g/cc. Both runoff potential and bulk density can be improved with management, including increased SOM.

SOIL TESTS

Although soil survey information can be used for general farm planning, onsite investigation can provide a more accurate and thorough assessment of soil health conditions. In March 2022, soil samples were collected at six locations on the farm at a depth of 6 inches and sent to Logan Labs, LLC, for a Standard Soil Analysis and Saturated Paste Analysis. Across the farm, the tests revealed alkaline, calciferous soils with evidence of mild deficiencies of magnesium and potassium. The SOM values (and thus TOC values) were higher than average for each of the soil types (Table 2). Soil organic matter can be improved through the implementation of practices in this plan. While there are few accepted guidelines to determine the right amount of SOM in particular agricultural soils, research has shown that predominantly clayey soils can hold up to 6.1% organic matter (Magdoff, 2021).

Table 2: March 2022 Soil Test Results

	Location	Soil Type	SOM	pH
Sample 1	Field 10	Wilson clay loam	3.60%	7.9
Sample 2	3 blended samples from Fields 6, 7 & 8	Heiden clay	2.83%	8.3
Sample 3	Front Field, northeast section	Heiden clay	3.34%	7.7
Sample 4	Front Field, midwest section	Tinn clay	3.91%	8.2

Soil pH affects the soil's physical, chemical, and biological properties and processes, as well as plant growth. Most crops prefer a soil pH range of 6-7.5. In alkaline soils, nutrients such as phosphorus, iron, copper, zinc, and boron are frequently unavailable to crops. Very alkaline pH levels can slow down microbial activity and, thus, organic matter mineralization. Fungi survive in a pH range of 2-7, with 5 being the optimum value.

In order to decalcify the soils and lower the pH, K-Mag, Potassium Sulfate and Azomite were applied to all fields in late November 2022. The sulfuric process of releasing the calcium and allowing it to eluviate out of the soil takes time.

The soil organic matter values have gone up significantly from the March 2022 values.

In October 2023, eight random soil samples were collected at 6 inches depth from each of the three areas of the farm - Front Fields, East Fields, Back Fields. A total of three samples were sent to Regen Ag Labs, LLC (one blended sample from each of the three fields) for Haney, PLFA, Aggregation, and Soil Water Holding Capacity soil health testing. It is worth noting that the SOM values have gone up significantly from the March 2022 values.

Table 3: October 2023 Soil Test Results

	Location	SOM	TOC	pH	Soil Respiration Rate	Water Holding Capacity (inches H2O per inches of soil)
Sample 1	Front Fields	11.8%	575 ppm	7.9	133.6 ppm	0.32
Sample 2	East Fields	2.7%	243 ppm	7.9	49.8 ppm	0.22
Sample 3	Back Fields	4.9%	288 ppm	8.3	59.5 ppm	0.29
Sample 4	Agroforestry & Other	2.6%	229 ppm	8.0	37.2 ppm	0.26

RESOURCE CONCERNS

Resource concerns are factors that may be limiting the farm's ability to function as a thriving and productive system. A resource concern is when a resource condition has been degraded to the extent that it does not meet minimum acceptable conditions. This can limit the long-term sustainability of soil, water, animals, plants, air, and/or energy resources (SWAPA+E) (USDA, 2019).

The Resilient Farm Plan recognizes on-farm carbon as the principal resource concern and takes into consideration potential SWAPA+E resource concerns that warrant further examination through a formal NRCS CPA-52 resources assessment. Many SWAPA+E resource concerns and associated conservation practices crosslink with opportunities to bring more carbon into the agroecosystem. Thus, the planner is able to identify and construct the plan around potentials for increased carbon capture and storage while also acknowledging potential resource concerns that were inventoried as part of the planning process.

Another important resource concern to keep in mind is the economics of the farm. As all potential opportunities for carbon capture are identified, practices that may not be economically viable today are still worth planning for from both a greenhouse gas perspective and a future economic perspective. Practices in the Plan are progressively implemented over time in accordance with the producer's interest and capacity.

Soil

Soil Erosion: Non-concentrated Water Erosion

- Conversion of the native grassland prairie through improper grazing management (historical use) and cropland (current use) increases the risk for erosion. Once the exposed sandy loam surface soil layer becomes saturated, the underlying claypan layer will restrict water movement. Mimicking the grassland state to at least ensure little bare ground and adequate litter can improve infiltration and reduce the likelihood of runoff.

  See Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Conservation Crop Rotation (328), Cover Crops (340), Conservation Cover (327)

- The 3.2% slope and slow permeability in the back field makes Fields 7-10 vulnerable to erosion during large rainfall events. Left unaddressed, this can cause loss of topsoil and important nutrients, resulting in less productive soils.

  See Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Cover Crops (340), Conservation Cover (327)

Reduced Soil Health & Quality: Organic Matter Depletion

- Currently, organic matter does not meet the farmer's goal of 6% SOM for the predominantly clayey soils found on the farm.

  See Conservation Crop Rotation (CPS 328), Cover Crops (CPS 340), Prescribed Grazing (CPS 528), Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Soil Carbon Amendment (336)

Reduced Soil Health & Quality: Salts and Chemicals in Soil

- High levels of calcium are present in all fields that have been soil tested. All soils tested are alkaline, with pHs ranging from 7.7 to 8.3.

  See Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Soil Carbon Amendment (336)

Reduced Soil Health & Quality: Soil Compaction

- Soil compaction concerns will be present due to all three soil classes on the farm having higher than ideal bulk density for root growth (Web Soil Survey, 2022). It is recommended to conduct ring infiltrometer tests (see Appendix A) to monitor changes in infiltration rates as practices are implemented.

  See Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Cover Crops (CPS 340), Conservation Crop Rotation (CPS 328), Soil Carbon Amendment (CPS 336), Prescribed Grazing (CPS 528)

Reduced Soil Health & Quality: Soil Aggregate Instability

- Soil aggregate instability concerns will be present in standard tillage cropping areas. It is recommended to conduct Slake tests (see Appendix B) to monitor change in aggregate stability as practices are implemented.

  See Cover Crops (CPS 340), Conservation Crop Rotation (CPS 328,) Residue and Tillage Management - No-Till/ Strip-Till (CPS 329), Prescribed Grazing (CPS 528), Mulching (CPS 484), Soil Carbon Amendment (CPS 336)

Water

Insufficient Water: Water Depletion

- Increasing summer temperatures and extended periods of less than average rainfall are resulting in lower levels of groundwater. During these times, irrigation needs for crops are also higher, which leads to excess use of the groundwater supply and further exacerbates groundwater depletion. There is potential to see times where the groundwater supply is too low to pump.

  See Cover Crops (CPS 340), Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Prescribed Grazing (CPS 528), Mulching (CPS 484)

Water Quality Issues: Excess Salts in Water; Excess Nutrients in Water

- The Farm has infrastructure to switch the back half of the farm to municipal water in the event of pond water depletion. Overuse of Central Texas municipal water supplies are high in calcium and contain chloride salts, which can cause pH and salinity issues in the absence of deeply infiltrating rain events.

  See Cover Crops (CPS 340), Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Mulching (CPS 484), Nutrient Management (CPS 590), Prescribed Grazing (CPS 528)
- These high levels of salts can also cause infrastructure and equipment malfunctions when using drip irrigation. Which leads to water use inefficiencies and higher maintenance costs.

Animals

Issues Meeting Basic Livestock Basic Needs: Feed and Forage Imbalance

- Chickens were introduced into the system in 2021. The adequate stocking rate and distribution of grazing through the fields and orchards is still being determined.

  See Prescribed Grazing (CPS 528), Fence (CPS 382)

Issues Meeting Basic Livestock Basic Needs: Inadequate Livestock Shelter

- Excessive heat in the summer threatens the health and wellbeing of the chickens. Although the Farm utilizes portable shade cloth to provide protection from the unrelenting sun, further cooling relief is needed. Silvopasture protection can be provided by rotating chickens through orchard and wooded areas.

  See Windbreak / Shelterbelt Renovation (CPS 650), Tree / Shrub Establishment (CPS 612)

Inadequate Habitat for Fish & Wildlife: Wildlife Habitat on Land

- Pollinator habitat is not abundant on the property. Adequate pollinator habitat will attract pollinators that will help with vegetable production.

  See Conservation Cover (CPS 327), Hedgerow Planting (CPS 422)
- Critical habitat loss and fragmentation is a major concern for the many rare, threatened, and endangered species living in the area. Problems arise when wildlife lack adequate food, water, shelter, space to locate a mate and raise their young, and areas to rest.

  See Conservation Cover (CPS 327), Hedgerow Planting (CPS 422), Windbreak / Shelterbelt Establishment (CPS 380), Tree / Shrub Establishment (CPS 612)

Plants

Issues Causing Plant Damage: Reduced Plant Productivity and Health

- Weather conditions are negatively impacting plant productivity. Plants are exposed to and damaged by uncharacteristic freezes and strong winds.

  See Conservation Crop Rotation (CPS 328), Soil Carbon Amendment (CPS 336), Cover Crops (CPS 340), Residue and Tillage Management - No-Till/Strip-Till (CPS 329), Prescribed Grazing (CPS 528), Herbaceous Wind Barrier (CPS 603), Windbreak / Shelterbelt Establishment (CPS 380)
- Persistent failure to thrive and lower productivity in back Fields 9 and 10 likely due in part to alkaline soil conditions.

  See Herbaceous Wind Barrier (CPS 603), Conservation Crop Rotation (CPS 328), Cover Crops (CPS 340), Prescribed Grazing (CPS 528), Soil Carbon Amendment (CPS 336)

Issues Causing Plant Damage: Plant Pests

- Johnson Grass is the biggest plant pest on the farm. Other undesired plants include henbit, silver leaf nightshade, and amaranth. Crops in the mallow family (okra, roselle hibiscus) are often affected by cotton root rot, cucurbits have been affected by powdery mildew and some tomato plants have been affected by curly leaf virus. Undesired insects include grasshoppers, aphids, cabbage loopers, melon worms, tomato worms, harlequin beetles, Colorado potato beetles, blister beetles, and flea beetles. Deer, racoon, and rabbit have caused significant crop damage.

  See Cover Crops (CPS 340), Mulching (CPS 484), Prescribed Grazing (CPS 528)

Air

Air Quality: Emissions of Greenhouse Gases

- Carbon dioxide emissions from burning fossil fuels in combustion engine-powered equipment and on-farm energy use. Carbon dioxide emissions from soil tillage, which exposes more of the soil to oxygen and enhances the respiration rate of soil microbiology that breathes in oxygen and breathes out carbon dioxide.

  See Residue and Tillage Management - No-Till/Strip-Till (CPS 329)

FARM SYSTEMS MANAGEMENT

Existing Conservation Plans

NRCS-EQIP CONSERVATION INCENTIVE CONTRACT

In July 2022, the Farm entered into a five-year USDA NRCS contract - **Conservation Incentive Contract (CIC)** - in partnership with their Travis County NRCS District Conservationist. A CIC is a new option available through the NRCS Environmental Quality Incentive Program (EQIP) to support rapid adoption of climate-smart agricultural practices. EQIP-CIC is a stepping stone between EQIP and the NRCS Conservation Stewardship Program and is available nationwide. Through a CIC, producers can target priority resource concerns without needing to enroll the entire operation into the program.

> A Conservation Incentive Contract is a new option available through the NRCS Environmental Quality Incentive Program (EQIP) to support rapid adoption of climate-smart agricultural practices.

The Farm pursued this opportunity for the explicit purpose of increasing soil organic matter, establishing pollinator habitat, extending the vegetable growing season, and improving the poultry grazing rotation. They will be reimbursed by NRCS to install the conservation practices listed in Table 4 per NRCS implementation requirements, designs, construction plans and other applicable NRCS technical criteria.

CIC funding enabled the Farm to install two high tunnels in Spring 2023. All other practices funded through this grant were initiated in late-Winter 2023 and Spring 2023. For example, Conservation Cover (CPS 327) was seeded in April 2023 according to NRCS specifications that it must be a 60% grasses and 40% forbs species mix. Seeding dates were followed according to Zone 8 - Middle Claypan requirements. Warm season species are required to be planted 2/15 - 5/15 and 8/15 - 9/30 and cold season species are required to be planted 9/1 - 11/1.

Table 4: Conservation Incentive Contract (CIC) Plan

Conservation Practice	Practice Description	Extent *(each of the 5 years, unless otherwise noted)*	Timeline
Conservation Cover (CPS 327) *Pollinator, Native and Forbs*	Establish and/or maintain permanent vegetation to reduce wind and water erosion, delivery of sediment to surface water, to reduce particulate matter and precursors, and reduce GHGs	1.6 acres total	2023 2024 2025 2026 *month 3
Conservation Crop Rotation (CPS 328) *Specialty Crops, Organic and Non-Organic*	Plan a sequence of crops grown on the same ground over a period of time to maintain or increase soil health, organic matter content, reduce erosion losses and reduce water quality degradation.	5.1 acres total	2023 2024 2025 2026 *month 8
Cover Crop (CPS 340) *Multiple Species, (Organic and Non-Organic)*	Plant grasses, legumes and forbs for seasonal vegetation cover where seasonal cover will protect or improve natural resources.	5.1 acres total	2023 2024 2025 2026 *month 10

High Tunnel System (CPS 325) *High Tunnel, low wind or snow load, intensive sun*	Install one High Tunnel System to cover and protect crops from sun, wind, excessive rainfall, or cold, to extend the growing season in an environmentally safe manner.	NA	2022 *month 10
Nutrient Management (CPS 590) *Basic Nutrient Management (Non-Organic/Organic)*	Implement a Nutrient Management Plan with 4Rs (right source, rate, time, place) to benefit plant productivity based on soil testing and LGU recommendations "within book values."	5.1 acres total	2023 2024 2025 2026 *month 3
Prescribed Grazing (CPS 528) *Standard*	Manage the harvest of vegetation with grazing and/or browsing animals with the intent to achieve specific ecological, economic and management objectives.	5 acres total	2023 2024 2025 2026 *month 9
Residue and Tillage Management, No-Till (CPS 329) *Residue and Tillage management, No-Till / Strip-Till*	Minimize soil disturbance by reducing the number and type of yearly tillage operations to manage the amount, orientation and distribution of crop and plant residues.	5.1 acres total	2023 2024 2025 2026 *month 3

Agricultural Systems

Conservation practice recommendations have been organized by farm system - cropland, agroforestry and grazing. The Figure 1 landscape design map visually illustrates various conservation practices in the Plan and showcases the verdant farm, fields and ecosystem that the Farm is regenerating. Where applicable, Conservation Stewardship Program (CSP) Enhancement Codes have been suggested to facilitate access to Inflation Reduction Act funding. Table 5: Carbon Beneficial Practices and Quantification provides a summary of all recommended practices, including spatial extent and GHG quantification.

CROPLAND

There are several opportunities to implement cropland management practices that improve soil health and quality, strengthen soil aggregate stability, enhance permeability and water holding capacity, boost productivity, and increase carbon capture and storage in the crop system. Below is a set of recommended practices that can potentially sequester more carbon and address resource concerns while the following farm objectives:

- Improve soil quality on 6 acres of annual vegetable production in order to maintain consistent yields in every field.
- Extend the growing season by growing more storage crops.
- Install additional orchards.
- Strive for greater produce variety, especially for the CSAs.
- Build soil organic carbon and enhance on-farm carbon sequestration.
- Implement a functional no-till cover crop as soon as possible following cash crops.
- Keep resources on the farm by making on-farm compost and mulch.
- Grow more fiber and natural dye plants for use in the Open Arms Studio.

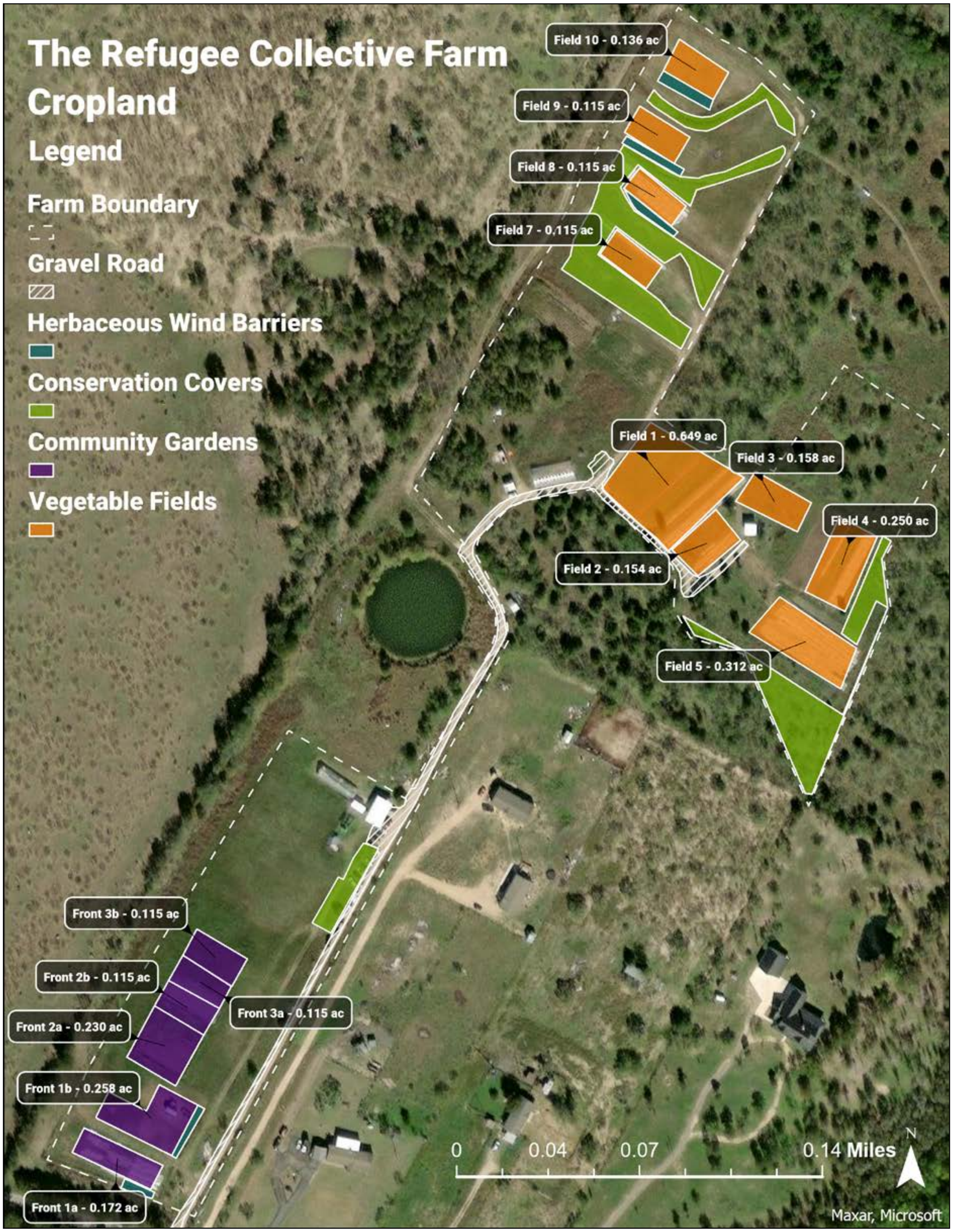


Figure 8. Cropland Fields and Practices

Recommendation: Residue and Tillage Management, No-Till/Strip-Till (CPS 329)

At the beginning of the Resilient Planning process, all fields were tilled with a dual harrow disc six weeks in advance of planting or cover crop seeding. No residue was left on the fields. Depending on weed pressure, the fields might be disced again at 4 weeks and once more right before the beds were prepared. Five-foot beds were prepared using a BCS bed shaper to establish three foot beds with a one foot aisle space on either side (for a total of 2 feet between beds). A BCS walk-behind rototiller went on top of the raised bed and tilled down to one foot depth to fluff the soil and break up chunks, followed by black plastic cover to suppress weed growth.

> Conservation tillage is defined as leaving at least 30% of soil covered with crop residue.

Conservation tillage is defined as leaving at least 30% of soil covered with crop residue with the intentions of reducing the volume of soil disturbed, preserving rather than incorporating plant residue, and protecting soil resources while crops are grown (Claasen et al., 2018). Conservation tillage maintains soil organic matter and soil aggregate stability, improves soil water holding capacity, protects against wind and water erosion, provides escape cover for wildlife, reduces energy use and minimizes carbon dioxide release from soil respiration. Common conservation tillage methods are Reduced Tillage, No-Tillage and Strip-Tillage. No-till and strip-till are defined by the Conservation Tillage Information Center as leaving soil undisturbed from harvest to planting except for strips up to 1/3 of the row width (strips may involve only residue disturbance or may include soil disturbance) (CTIC, 2002). Planting or drilling is accomplished using disc openers, coulter(s), row cleaners, in-row chisels or roto-tillers.

- Recommend converting all Vegetable Fields and Community Gardens from conventional till to no-till/strip-till.
- Consider combining with Soil Carbon Amendment (CPS 336) compost application before cash crops.
- Strip-tilling creates a narrow tilled planting zone for seedbed prep while leaving the area between rows undisturbed. To prep beds, recommend strip-tilling with the BCS walk behind with a Ridger attachment or Rear Tine Tiller attachment to 8-12 inches depth. This method will prevent soil from mounding over into the walkways and leave a cover crop stand in the four-foot paths between rows.
- Recommend applying compost into the trenches (aka “trench composting”) and direct seeding or planting transplants into the compost. Further description in next section.
- At a minimum, recommend no-till in back Fields 9 and 10 until fertility improves. Lightly disc harrow to a depth of 2 inches, then apply compost 4-6 inches deep to plant large seeded crops or transplants into (aka “planting flat”). This includes cash crops and cover crops until fertility improves on the upper slopes of the back Fields.
- Consider moving the whole farm to no-till with direct seeding using a power harrow to a depth of 2 inches.
- Mow cover crops prior to strip tilling to ensure a less competitive environment for the cash crops.
- Consider Enhancement Codes **E329C - No till to increase plant-available moisture** and **E329D - No till system to increase soil health and soil organic matter content**.

Implementation of Residue and Tillage Management, No-Till/Strip-Till (CPS 329) on approximately 3 acres of vegetable production. Sequester an additional 0.48 Mg CO_2e per year.

20-year GHG Benefit

9.6 Mg CO_2e

Recommendation: Soil Carbon Amendment (CPS 336)

Application of carbon-based amendments such as compost nourishes the soil microbial communities, builds soil organic matter, and improves soil aggregate stability.

- Apply compost before every cash crop using the trench composting technique or planting flat method in times that fertility seems to be diminishing.
- Broadcast compost using a compost spreader if the fields need a boost in fertility and plant flat into 3" of compost.
- If there is an 18-month interval between cash crops, then also recommend composting between the summer and winter cover or the winter and spring cover.
- Application rates and compost composition will depend on availability of on-farm compost or off-farm compost. Also dependent on trench composting or planting flat technique is utilized.
- Pulse applications over time versus a single large application to create a virtuous cycle.
- Apply 1-3 inch layers of compost to root zones of orchards, blackberries, and establishing windbreak areas twice a year.
- Apply composted mulch that is generated on-farm to established windbreaks and conservation cover once every two years.

Implementation of Soil Carbon Amendment (CPS 336) on approximately 4.5 acres. Sequester an additional 319.73 Mg CO_2e per year.

20-year GHG Benefit
6394.6 Mg CO2e

Recommendation: Nutrient Management (590)

No synthetic inputs are used on the farm. Agrothrive liquid fertilizer and Simple Grow liquid humates are applied to all fields four times per growing season by a foliar pump sprayer and/or fertigation. According to soil tests, Azomite, Sul-po Mag, and K-Mag are applied to each field once per year. Addition of sulfur should be at least 6 months prior to planting to begin releasing excess calcium, which will begin to lower pH and begin to stimulate biological activity. Organic nutrients that are easily ready for uptake will decrease any water quality concerns for the Wilbarger Creek watershed.

- Apply compost before every cash crop using the trench composting technique or planting flat method in times that fertility seems to be diminishing.
- Consider Enhancement Code **E590A - Improving nutrient uptake efficiency and reducing risk of nutrient loss**.

Implementation of Nutrient Management (CPS 590) on approximately 7.21 acres of vegetable fields and orchards and windbreaks. Sequester an additional 0.22 Mg CO_2e per year.

20-year GHG Benefit
4.3Mg CO2e

Recommendation: Cover Crops (CPS 340)

Cover crops are seeded in two successive plantings between cash crops in all fields when timing allows or at least the season before a cash crop in all fields. Quick covers like buckwheat or sunflower sprouts can be used when there is a less than 6 week window before the next cash crop. Cover crops have traditionally been selected based on region, season, timing, and goals such as nutrient cycling, nitrogen fixation, lasting residue, weed suppression, biodiversity, integrated pest management, pollinator habitat, and quick biomass.

Adding cover crops in all cultivated fields will help protect the soil from wind and water erosion and suppress weed pressure above ground. Below ground, cover crop roots cultivate soil health and nutrient availability, improve soil water holding capacity, aerate dense clayey soils, and add carbon into the soil profile.

- Seed successions of cover crops on all fields between cash crops.
- Shallow disk harrow for good seed to soil contact. Upon funding, use no-till seed drill for all cover crop plantings.
- Soil tests can be used to determine the right cover crop mix and recommended soil amendments for cover crops. See Appendix D for species recommendation list.
- In cash crop fields and orchards, recommend species sunn hemp, sunflower, okra, swiss chard, and tillage radishes to aerate compacted clayey soil, make nutrients available, residue for green manure, and food for chickens.
- Reasonably priced cover crop seed mixes can be ordered from GreenCover, Justin Seeds, Seedway, Douglass King, High Mowing Organic Seeds and Johnny's Selected Seeds.
- K-line pod irrigation system is recommended and requires at least 40 pounds of pressure. Only irrigate as needed hoping for natural rain irrigation. Guidelines are to put on at least one-half inch per day once a week, and adjust more or less depending on how quickly water is evaporating.
- Termination of covers will mostly be done by livestock and solarization. After being mowed once, chickens will graze down cover followed by a period of tarped solarization for termination and to enhance soil nutrients. Solarization should be used carefully during the hottest times of the year as overheating of microbial communities can occur. Seasonally selected covers can also self terminate with weather changes out of season. Upon funding, a roller crimper can be used along with self terminating crops to provide mat layers between rows in the trench composting areas.
- Consider Enhancement Code **E340B - Intensive cover cropping to increase soil health and soil organic matter content**.

Implementation of Cover Crops (CPS 340) on approximately 5.25 acres of vegetable and orchard production. Sequester an additional 6.14 Mg CO_2e per year.

20-year GHG Benefit
122.9 Mg CO2e

Recommendation: Conservation Cover (CPS 327)

Conservation cover is the establishment of perennial herbaceous cover that will not be harvested or used for forage, thus providing permanent cover to protect soil and water resources, enhance wildlife and pollinator habitat, improve soil health, and bring more carbon into the agroecosystem. See Figure 8 green parcels for spatial location.

- Recommend planting a pollinator friendly mix of 60% grasses and 40% forbes, per the NRCS-CIC.
- Select species based on the planting guide for zone 8, Middle Claypan and NRCS Conservationist planting mix with additional considerations for "chicken salad bar" nutritional quality and wildlife biology. See Appendix D for species recommendation list.
- Planting schedule needs to adhere to the NRCS planting schedule.
- Spread conservation cover seed for at least 3 years before it establishes.
- First planting will be based on the mix above, and woody species will be planted along the west edge of Fields 6-10 to create wind barriers and enhance carbon sequestration potential (see Agroforestry subsection).
- Consider Enhancement Code **E327A - Conservation cover for pollinators and beneficial insects**.

Implementation of Conservation Cover (CPS 327) on approximately 2.35 acres of grassland. Sequester an additional 1.86 Mg CO_2e per year.

20-year GHG Benefit
37.1 Mg CO2e

Recommendation: Herbaceous Wind Barrier (CPS 603)

Herbaceous wind barriers in the Back Fields will work in tandem with "Windbreak North" to keep the Northerly winter wind lifted and protect crops against evapotranspiration and wind damage. See Figure 8 blue parcels for spatial location. Herbaceous wind barriers will also serve as a filter strip to slow water and topsoil movement on the sloped Back Fields during large rainfall events. Concurrent benefits also include increasing plant diversity and building soil health, providing pollinator and wildlife habitat, and bringing more carbon into the agroecosystem.

Herbaceous wind barrier is recommended on the north side of berms 2, 3 and 4.

Terminate with a mower to make a 15-foot roadway for the chicken tractor and coop to rotate through, per the grazing plan.

See Appendix D for fast-growing, tall, deep-rooted species recommendations. Most likely will be sorghum sudan, sunflower and okra. Species benefits include hardpan natural tillage and water infiltration. Termination and coop rotations do not differ between species chosen.

Implementation of Herbaceous Wind Barrier(CPS 603) on approximately 0.20 acres of grassland. Sequester an additional 0.16 Mg CO_2e per year.

20-year GHG Benefit
3.2 Mg CO2e

Recommendation: Conservation Crop Rotation (CPS 328)

Conservation crop rotation is the practice of growing different crops on the same land in a sequential rotation over time, to improve soil health and reduce pest pressure.

- Plan a crop rotation that includes diversity among cash crops, cover crops between cash crops, and diverse field borders when able.
- Consider Enhancement Code **E328E - Soil health crop rotation**.

Implementation of Conservation Crop Rotation (CPS 328) on approximately 3 acres of vegetable production. Sequester an additional 0.66 Mg CO_2e per year.

20-year GHG Benefit
13.2 Mg CO2e

AGROFORESTRY

Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits (USDA NAC, 2021). Perennial trees and shrubs generally sequester more carbon than annuals and store it in woody material aboveground while also shuttling carbon into the soil at varying depths through their extensive root systems.

There are several opportunities to implement agroforestry practices that protect fields, humans and livestock from strong winds and increase carbon capture and storage in the agroecosystem with concurrent benefits of providing wildlife and pollinator habitat, building soil health, and enhancing infiltration and water holding

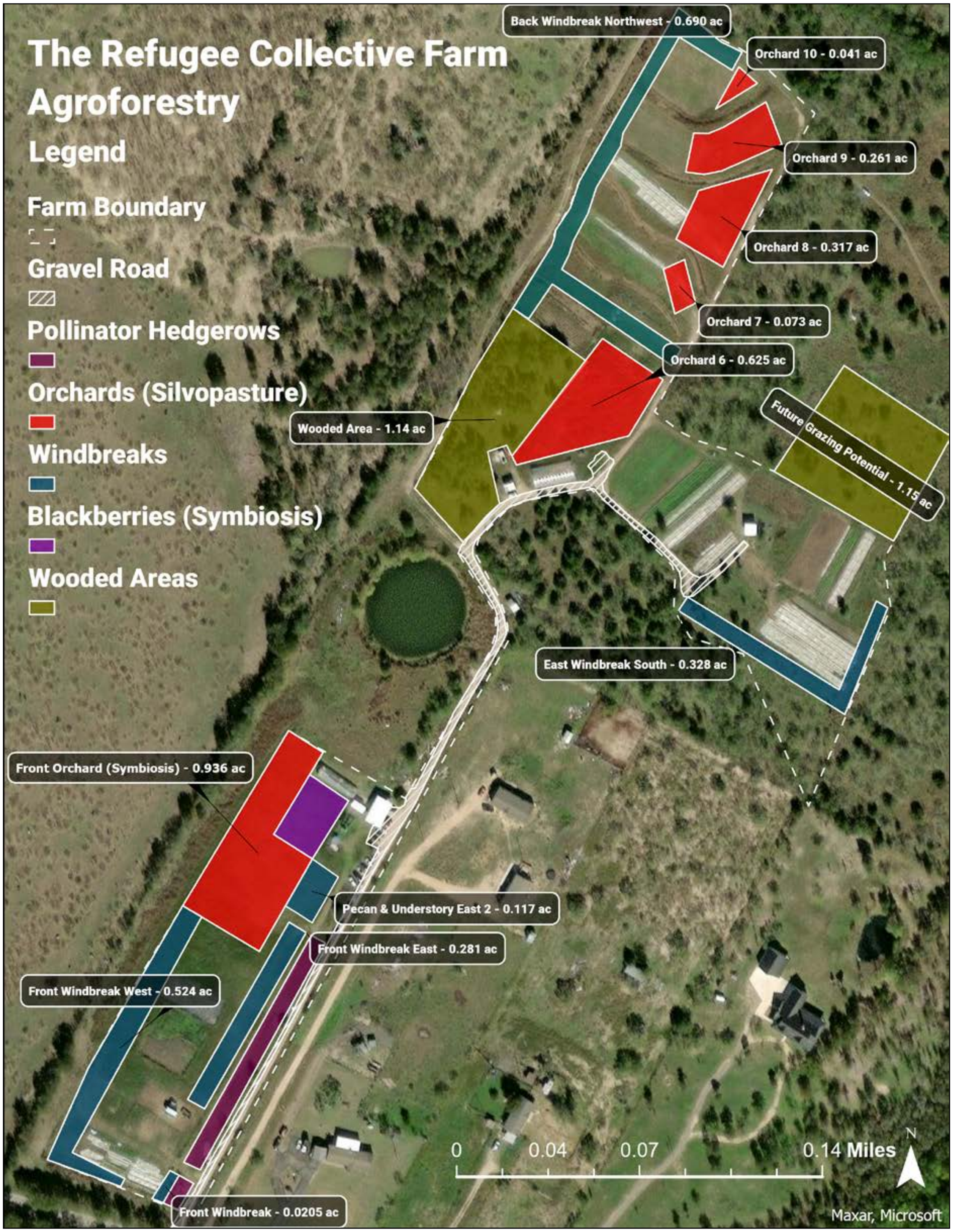


Figure 9. Agroforestry systems

capacity. The set of recommended practices herein can potentially sequester more carbon and address resource concerns while advancing the following farm objectives:

- Integrate herbaceous and woody pollinator strips to build pollinator habitat and increase biodiversity.
- Strive for greater produce variety, especially for the CSAs.
- Build soil organic carbon and enhance on-farm carbon sequestration.
- Keep resources on the farm by making on-farm compost and mulch.

Recommendation: Windbreak/Shelterbelt Establishment and Renovation (CPS 380)

Windbreak establishment is recommended around the perimeter of the property to minimize the force of strong wind gusts (especially in winter), provide shade for livestock, provide pollinator and wildlife habitat, and sequester significant amounts of carbon. The windbreaks can be interplanted with understory crops, such as blackberries and muscadine grapes. All windbreak plantings are proposed inside of the deer fence unless otherwise noted. See Figure 9 blue parcels for spatial location.

- A windbreak along the east side of the Front Fields will consist of a pecan orchard interplanted with mulberry trees, and can also be interplanted with a third row of shrubby butterfly bush or cash crops, such as shrubby herbs like rosemary, blackberries, or muscadine grapes. Muscadine grapes could also be planted on the outside of the fence and mammoth sunflowers or rosemary could be planted inside of the fence between the fence and tree line. Planting three rows of woody species of varying height will create a more protective windbreak. Species selection will depend on the amount of time available for managing and harvesting cash crops. See Appendix D for species recommendation list.
- The “Front Windbreak East” will be planted in two sections to accommodate the entrance gate. The larger of the two sections is 360 feet long and 35 feet wide. The smaller section in the northeast corner running up to the Chicken Brooder Yard is 90 feet long and 55 feet wide.
- A windbreak along the west side of the Front Fields will consist of evergreens to ensure maximum protection from Northerly winter winds. See Appendix D for evergreen species recommendations.
- The “Front Windbreak West” dimensions are 600 linear feet in the shape of an “L” and averaging 45 feet depth.
- A windbreak along the south side of the East Fields will consist of at least three rows of woody species with different height growth to create a solid barrier. See Appendix D for species recommendation list.
- The “East Windbreak South” dimensions are 500 linear feet long by 30 feet wide.
- A windbreak along the northwest side of the Back Fields will consist of evergreens to protect fields 7-10 against Northerly winter wind gusts. See Appendix D for evergreen species recommendations.
- The “Back Windbreak Northwest” dimensions are 1000 linear feet long by 30 feet wide. The southern section of the “u” will also protect against Southerly summer winds.
- Chickens will be rotated through all of the windbreaks. The chicken coop can be pulled up to one end of a windbreak and the portable fencing placed around the perimeter of the windbreak, allowing the chickens to graze the understory. With permanent fencing on one side of all the windbreaks, utilizing the net wire fencing for the other three sides will provide the ability to graze while cycling nutrients and reducing pests. The chicken tractor can be pulled up alongside the windbreak or tucked in a perpendicular position. There is enough space between the windbreaks and the production areas.

Windbreak and shelterbelt renovation is recommended in the two Wooded Areas currently overgrown with hackberry, oak, mesquite, and cedar elm. See Figure 9 light green parcels for spatial location. The existing trees can be pruned or cleared to improve the overall health of the fields and desired species planted to improve biological diversity, enhance wildlife and pollinator habitat, provide shade and shelter for livestock, and increase carbon sequestration and storage. Fungi to bacteria ratios should be high in these wooded areas.

Proper use of livestock or mowing equipment can return oxidizing grasses to a more productive state and return deep rooted drought tolerant native grass and forb species.

Since the chickens will graze through these fields, it is technically considered a "Silvopasture" agroforestry practice. However, silvopasture is not quantified in the COMET-Planner tool for Travis County, so for the purposes of this plan tree plantings in Wooded Areas will be coded as Windbreak/Shelterbelt Renovation to provide an estimated GHG inventory.

- Cleared and pruned trees can be chipped and converted into mulch or compost.
- Desired species can be selected from Appendix D and should be native trees adapted to the soil and the climate, as these fields are not irrigated.
- The chickens can be rotated through these fields as part of a whole-farm grazing plan. The tree canopies in these fields can provide shade protection that shelters livestock from sun exposure in the summer months.

Implementation of Windbreak/Shelterbelt Establishment and Renovation (CPS 380) on approximately 4.25 acres. Sequester an additional 10.57 Mg CO_2e per year.

20-year GHG Benefit
211.4 Mg CO2e

Recommendation: Hedgerow Planting (CPS 422)

Hedgerows are strips of native or naturalized perennial trees, shrubs, and forbs planted on field edges to provide habitat for migratory birds, pollinators and other wildlife, reduce wind impacts, and help store carbon. One strip of pollinator hedgerow is proposed along the entrance road in three rows totaling 525 linear feet long and 30 feet wide. See Figure 9 magenta parcels for spatial location.

- Desired species can be selected from Appendix D and should be woody, native pollinator plants that can survive on rainfall irrigation and require minimal management. A line of wild bushes.

Implementation of Hedgerow Planting (CPS 422) on approximately 0.35 acres of vegetable production. Sequester an additional 0.16 Mg CO_2e per year.

20-year GHG Benefit
3.2 Mg CO2e

Recommendation: Tree/Shrub Establishment (CPS 612)

Trees and shrubs will be established as orchards in the Front Field and in Back Fields 6, 7, 8, 9, and 10. See Figure 9 red parcels for spatial location. Since the chickens will graze through the orchards, it is technically considered an orchard 'Silvopasture" agroforestry practice. However, silvopasture practices are not quantified in the COMET-Planner tool for Travis County, so for the purposes of this plan orchard installation will be coded as Tree/Shrub Establishment to provide an estimated GHG inventory.

- Front Field orchard was planted with pecan, mulberry, blackberry, and stone fruits in March 2023.
- Back Field orchards will be planted, with the help of TreeFolks, per Symbiosis recommendations continuing in Spring 2024.
- Keep a 15-foot roadway for the chicken tractor and multi-use vehicles around vegetable and woody plantings.
- Recommend planting an understory of annuals to keep soil covered and living roots in the ground white allowing for orchard maintenance and eventual harvesting without worry of trampling perennial plants. See Appendix D for recommended mix to meet soil needs.
- To terminate annuals, mow down after going to seed and then graze with the chickens. The animal impact in these areas after going to seed may allow the Farm to not have to replant annual cover crops each season. This will be on a trial basis, and full coverage with seasonal plantings is the goal if the chickens do not succeed as hypothesized.

- After orchard and blackberries are well established and timing of maintenance and harvesting is set, a perennial mix could be planted in lieu of an annual mix at that time. Perennial mix will be as suggested in Appendix D.
- Depending on time of year and soil health, dye and fiber annuals could be considered in this area for multi-story cropping.
- Consider Enhancement Codes **E612C - Establishing tree/shrub species to restore native plant communities** and **E612G - Tree/shrub planting for wildlife habitat**.

Implementation of Tree/Shrub Establishment (CPS 612) on approximately 2.25 acres of vegetable production. Sequester an additional 4.16 Mg CO_2e per year.

20-year GHG Benefit
83.3 Mg CO2e

Recommendation: Tree/Shrub Pruning (CPS 660)

Tree and shrub pruning maintains the health and function of windbreaks and orchards. As trees and shrubs are selectively pruned, woody byproducts can be chipped and turned into mulch or compost to keep energy resources on farm. Tree/Shrub Pruning is a management practice that needs to be done in every agroforestry system.

- Use a small wood chipper for materials smaller than 3 inches in diameter to become composted mulch.
- Use of neighbor tree trimming contacts could be helpful for larger diameter items to become mulch.
- Proper tools and techniques should be used. Always keep tools sharp and disinfect tools between trees or shrubs so as to not spread any diseases or infections.
- Timing and frequency are solely dependent on the species. For example, evergreen species may need very little trimming, while pecan trees will need trimming to support proper weights of nuts. Stone fruit varieties will be trimmed towards the end of their dormancy and during summer months for height control in harvesting needs.
- Making decisions for optimum sunlight capture, breathability (IPM), and harvesting requirements will be important for well established and high yielding windbreak and orchard systems. (**Guide** to help make decisions. TAMU Extension 2008)

Recommendation: Mulching (CPS 484)

Mulching is the application of woody and carbon-rich plant residues, such as wood chips, to the soil surface to prevent erosion, reduce moisture loss and build soil health.

- Mulch windbreaks during establishment until natural mulches occur or trees are well established.
- Mulch orchards at least once a year.
- Put a fresh mulch layer of at least 3" thick above the root zone to the width of the tree canopy. Avoid mulching up against the stem or trunk of the tree.
- When possible, mulch using chips from on-farm Tree/Shrub Pruning.
- Consider Enhancement Code **E484C - Mulching with natural materials in specialty crops for weed control**.

Implementation of Mulching (CPS 484) on approximately 0.83 acres of vegetable production. Sequester an additional 0.27 Mg CO_2e per year.

20-year GHG Benefit
5.4 Mg CO2e

GRAZING

In order to address resource concerns and meet the Farm goals, a prescribed grazing management system has been designed to support achievement of the following objectives:

- Enhance grazing systems by integrating chickens into the entire vegetable cropping system.
- Build soil organic carbon and enhance on-farm carbon sequestration.

The Farm rotationally grazes 150 laying hens for pasture-raised, USDA-certified Organic egg production. The chickens are rotated through the vegetable fields on a monthly basis. Orchard, Conservation Cover, Windbreaks and Wooded Areas will also be utilized for this rotation.

Per the NRCS - CIC, the correct stocking rate is the most important consideration in grazing management. No grazing system will improve grazing lands if the stocking rate is too high. Supplemental feed and/or mineral requirements should be balanced with the forage quality to meet the desired nutritional level for the kind and class of grazing livestock. Forage and/or fecal testing from reputable laboratories are reliable tools to determine these requirements. Schedule livestock movements based on plant physiological stage, available forage, utilization and livestock nutritional needs. Grazing must be excluded for a long enough time during the growing season to adequately meet the objectives. On well established perennial warm and cool season grasses and legumes, deferment periods of 21 to 45 days during the growing season are usually adequate for plants to recover from grazing periods that do not exceed 7 to 10 days in length. The length of rest or deferment periods is governed by the kinds, growth habits, and growth stages of the forage plants concerned and seasonal climatic conditions. The producer has a mobile coop that hens sleep and lay in that is 8 x 24 ft. The hens are kept in a pasture area that is 50x100 ft, and are rotated to new ground once a month. There will be about 43 paddocks that are 5,000sq ft.

Conservation Stewardship Program Enhancement Codes, such as Stockpiling cool season forage to improve structure and composition or plant productivity and health (E528F), Management Intensive Rotational Grazing (E528R), and Soil Health Improvements on Pasture (E528S) could be used to access Inflation Reduction Act funding.

See Appendix E for the entire grazing plan.

Implementation of Prescribed Grazing (CPS 528) on approximately 9.5 acres of vegetable production. Sequester an additional 0.86 Mg CO_2e per year.

20-year GHG Benefit
17.2 Mg CO2e

OTHER - COMPOST OPERATION

The Farm currently passively composts its on-farm organic waste materials, including chicken mortalities, unmarketable eggs, spoiled feed, etc. Improving the compost operation would increase the soil fertility and carbon benefits of this practice. Other practices, like pruning and shelterbelt renovations promote the creation of brown material for mulch, or for co-composting with other materials. By collecting all available organic "waste" resources, the Farm can quickly begin to increase on-farm compost volume to utilize with other practices. As overall farm productivity increases, additional compost feedstocks can be expected to become available, reducing the need for purchased compost. A lack of equipment (loader tractor, compost spreader) limits the ability of the Farm to place compost where and when and at what rate it is needed for best effect.

It is assumed that compost is half carbon (per lab analysis) and that half of that carbon is lost each year after application to oxidation and respiration. However, if reapplied annually, we can quickly build SOM with successive compost applications. On croplands, we generally credit the full amount of CO_2e each *only in the* *year applied* (ie, this is not carried over into subsequent years unless reapplied). Thus the 20 year value assumes annual compost applications throughout that period. See Appendix F for an example calculation.

SOIL WATER HOLDING CAPACITY

This section estimates additional soil water storage capacity (WHC) associated with soil carbon increases on a working landscape as a result of implementing practices proposed in the Plan. NRCS suggests that a 1% increase in SOM results in increased WHC of approximately 1-acre inch, or 27,152 gallons of increased soil water storage capacity per acre. A 1% increase in SOM represents roughly 20,000 pounds (10 short tons) of organic matter or 5 short tons of organic carbon.

By building out a WHC table one can demonstrate to producers the potential for increasing on farm soil water storage capacity through soil carbon enhancement. Figure 10 shows estimated additional WHC associated with practices in Table 5: Carbon Beneficial Practices & Quantification. These estimates are over a 20-year time horizon since it takes time for conservation practices to build SOM and TOC. Total potential WHC increase resulting in Plan implementation are estimated to be 33.67 acre feet. These results reveal the significance of even small increases in soil carbon for overall farm water dynamics.

Carbon Farm Practices (use dropdown)	Mg CO2e 20 yr	Mg TOC	Soil Factor	Mg SOM	Acre Feet (AF)
Conservation Crop Rotation (CPS 328)	13.20	3.60	1.00	7.19	0.07
Herbaceous Wind Barriers (CPS 603)	3.20	0.87	0.50	0.87	0.01
Windbreak/Shelterbelt Establishment (CPS 380)	193.00	52.59	0.50	52.59	0.48
Windbreak/Shelterbelt Renovation (CPS 650)	18.30	4.99	0.50	4.99	0.05
Conventional Tillage to No-Till (CPS 329)	9.60	2.62	1.00	5.23	0.05
Compost Application on Cropland	6394.60	1742.40	1.00	3484.80	31.94
Nutrient Management (CPS 590)	4.30	1.17	1.00	2.34	0.02
Cover Crops (CPS 340)	122.90	33.49	1.00	66.98	0.61
Conservation Cover (CPS 327)	37.10	10.11	1.00	20.22	0.19
Hedgerow Planting (CPS 422)	3.20	0.87	0.50	0.87	0.01
Mulching (CPS 484)	5.40	1.47	1.00	2.94	0.03
Tree/Shrub Establishment (CPS 612)	83.30	22.70	0.50	22.70	0.21
Prescribed Grazing (CPS 528)	17.20	4.69	0.20	1.87	0.02
TOTAL	**6905.30**	**1881.55**		**3673.59**	**33.67**

Figure 10. Water Holding Capacity table

CARBON BENEFICIAL PRACTICES AND QUANTIFICATION

Table 5 contains practices that have been identified by the Resilient Planning team and selected by the Farm as appropriate. The cumulative 20-year benefit of all adopted practices totals a greenhouse gas benefit of 6,905 metric tons of carbon dioxide equivalent (Mg CO_2e) (CSU, 2023). That is the equivalent of 1,537 gasoline-powered passenger vehicles taken off the road for one year.

Table 5: Carbon Beneficial Practices and GHG Quantification

Conservation Practice Standard	Practice Extent	Co-Benefits	Acres	Annual GHG Benefit (Mg CO_2e)	20-year GHG Benefit (Mg CO_2e)
Residue and Tillage Management, No-Till/ Strip-Till (CPS 329)	All vegetable fields	Increased SOM Greater water holding capacity Soil aggregate stability Wildlife habitat Reduced erosion Reduced energy use Reduced CO_2 release from soil respiration	3	0.48	**9.6**
Soil Carbon Amendment (CPS 336)	All vegetable fields All orchards	Increased SOM Soil aggregate stability Plant productivity	4.5	319.73	**6,394.6**
Nutrient Management (CPS 590)	All vegetable fields All orchards All windbreaks	Increased SOM Plant productivity Water quality	7.21	0.22	**4.3**
Cover Crops (CPS 484)	All vegetable fields All orchards	Increased SOM Greater water holding capacity Soil aggregate stability Pollinator and beneficial insect habitat Reduced erosion	5.25	6.14	**122.9**
Conservation Cover (CPS 327)	Front field, NE corner East field Back berms 1, 2, 3 & 4 Back Windbreak NW	Pollinator and beneficial insect habitat Increased SOM Reduced erosion	2.35	1.86	**37.1**

Herbaceous Wind Barrier (CPS 603)	Front field Back berms 2, 3 & 4 (swale-side)	Reduced erosion Plant diversity Improved soil health Wildlife habitat Pollinator and beneficial insect habitat	0.20	0.16	**3.2**
Conservation Crop Rotation (CPS 328)	All vegetable fields	Increased SOM Greater water holding capacity	3	0.66	**13.2**
Windbreak/ Shelterbelt Establishment and Renovation (CPS 380)	Front Windbreak West Front Windbreak East East Windbreak South Back Windbreak Northwest Future Grazing area Wooded area	Wildlife habitat Pollinator and beneficial insect habitat Greater water holding capacity Reduced erosion	4.25	10.57	**211.4**
Hedgerow Planting (CPS 422)	Entrance road	Pollinator and beneficial insect habitat	0.35	0.16	**3.2**
Tree/Shrub Establishment (CPS 612)	All orchards	Plant diversity Increased SOM Water holding capacity Reduced erosion	2.25	4.16	**83.3**
Tree/Shrub Pruning (CPS 660)	All orchards All windbreaks Future Grazing area Wooded Area	Plant productivity Reduced wildfires		NA	**NA**
Mulching (CPS 484)	All windbreaks All orchards	Reduced evaporation Reduced erosion	0.83	0.27	**5.4**
Prescribed Grazing (CPS 528)	All vegetable fields All orchards All windbreaks Future Grazing area Wooded area	Increased SOM Soil aggregate stability Greater water holding capacity Water quality Reduced erosion	9.5	0.86	**17.2**
				345.27	**6,905**

Table 6 is an implementation roadmap, including target dates and practice implementation expenses. Financial assistance will be essential to cover up front costs of practice adoption and in certain instances the Farm may need to raise funds from more than one source to fully cover the true cost of practice implementation.

Table 6: Implementation Roadmap

Conservation Practice Standard	Expenses	Implementation Timeline	Potential Funding Sources
Residue and Tillage Management, No-Till/ Strip Till (CPS 329)	No-till drill-$15,000 one time capital expense Compost spreader-$15,000 one time capital expense	2023, all fields Ongoing annually	Philanthropic Impact Investors
Soil Carbon Amendment (CPS 336)	Compost- $20,000 annually Compost Spreader-$15,000 one time capital expense Labor- $5,000 annually	2023, all fields Annually through 2026	State or local government funding Philanthropic Impact Investors
Nutrient Management (CPS 590)	Soil testing- $400 annually Amendments (compost) - $20,000 annually	6 months prior to crop plantings, Ongoing annually	State or local government funding Philanthropic
Cover Crops (CPS 340)	Seed-$4,000 annually No-till Drill- $15,000 one time capital expense Labor-$1,000 annually	2023, all fields Ongoing annually 2024 & 2025, orchards Ongoing annually	USDA State or local government funding Philanthropic Impact Investors
Conservation Cover (CPS 327)	Seed- $4,000 Annually for 3 years Labor- $400 No-till Drill- $15,000 one time capital expense	2023, back berms and back windbreak Ongoing annually through 2026 2024, east field and front field Ongoing annually through 2026	USDA State or local government funding Philanthropic Impact Investors
Herbaceous Wind Barrier (CPS 603)	Seed-$500 Annually Labor-$100 No-till drill-$15,000 one time capital expense	6-12 weeks prior to crop planting, Ongoing annually	USDA State or local government funding Philanthropic Impact Investors
Conservation Crop Rotation (CPS 328)	Labor- $500 annually	2023	USDA

Windbreak / Shelterbelt Establishment and Renovation (CPS 380)	Establishment: Stock-$30,000 one time expense Labor- $5,000 one time expense Renovation: Labor Wood chipper Pruning tools Chainsaw	Establishment - 2024, 2025, High priority Renovation - Ongoing annually starting in 2026, Low priority	USDA State or local government funding Philanthropic
Hedgerow Planting (CPS 422)	Stock- $10,000 one time expense Labor- $5,000 one time expense	2025, 2026, Medium priority	Philanthropic USDA State or local government funding
Tree / Shrub Establishment (CPS 612)	Stock-$55,000 one time expense Labor-$5,000 one time expense	2024, 2025, High priority	USDA State or local government funding Philanthropic
Tree / Shrub Pruning (CPS 660)	Wood chipper-$15,000 one time capital expense Labor-$5,000 annually Pruning tools-$500 one time capital expense	Ongoing annually starting in 2025, Medium priority	State or local government funding Philanthropic
Mulching (CPS 484)	Wood chipper- $15,000 one time capital expense Labor- $5,000 annually	Ongoing annually starting in 2025, Medium priority	USDA State or local government funding Philanthropic
Prescribed Grazing (CPS 528)	Labor-$15,000 annually Livestock equipment and tools- $15,000 bi-annually	2023 Ongoing annually	USDA State or local government funding Philanthropic
Fence (CPS 382) Facilitating practice for Prescribed Grazing CPS 528	Labor-$15,000 annually Fencing materials- $2,000	As needed, Low priority	USDA State or local government funding Philanthropic

MONITORING

Soil Sampling

Soil sampling will consistently occur in October henceforth. This timing is conducive to ensuring that equal comparisons in ecological timelines occur. October in Texas is more stable than spring or summer because rains and temperatures vary during those times, which can affect microbiology and carbon. Soil sampling protocols are designed differently for cropland areas and all other systems. This is largely because regular cropland harvesting can deplete soil nutrients over time. The overall measurement of progress leans toward soil organic matter and soil organic carbon.

Cropland soil testing will occur yearly starting in 2023 to monitor additions needed to decalcify and lower pH with sulfur based organic inputs. Specialty crop production depends on ensuring availability of essential nutrients early in the growth cycle. Organic inputs will be added on an as needed basis. Each area, Front Fields, East Fields, and Back Fields, will have its own sample each year. Eight random samples equally distributed across each area will be collected at a depth of six inches, then mixed together in one bucket and at least 4 cups of soil will be sent to Regen Ag Labs for Haney, PLFA, Aggregation, and Soil Water Holding Capacity testing the first year and every third year going forward for all four tests. Three samples will be tested each year from the cropland systems with the Haney test.

All other systems, including agroforestry, windbreaks, conservation cover, and hedgerows will be tested every third year starting in 2023. Eight random samples equally distributed across the entire farm will be collected at a depth of six inches, then mixed together in one bucket and be sent to Regen Ag Labs for Haney, PLFA, Aggregation, and Soil Water Holding Capacity testing.

Sampling instructions for the Farm to continue the above protocol can be found on **Regen Ag Labs website**.

Other Soil Health Indicators

Soil health and structure can be measured through quick on-farm assessments. A **slake test** will determine aggregate stability and soil's ability to hold water and prevent runoff or quick percolation down to the water table. Regularly scheduled **water infiltration tests** will help guide knowledge and success of practices.

Visual aggregation test digging a hole reference video: **https://www.youtube.com/watch?v=iHjlOjq2RkI**

SUMMARY

The suite of practices in The Refugee Collective Farm's Resilient Farm Plan represent a recommended roadmap to reach farm goals and address potential resource concerns while achieving greater farm resilience to changing climate conditions. Carbon Beneficial Practices listed in Table 5 identifies practices and locations/spatial extents that were collaboratively deemed appropriate for the Farm. Farm systems are living, dynamic ecosystems. As such, recommended practices herein are subject to change as the farm business evolves, climate conditions continue to change, and suggested practices are trialed and adapted.

NCAT Agricultural Specialists will continue to provide the Farm with practice implementation and funding technical assistance as the Plan is rolled out across the landscape. The 20-year greenhouse gas benefit of full Plan implementation is an estimated 6,905 metric tons of carbon dioxide equivalent (Mg CO_2e). The GHG benefit of practices adopted on the Farm will be measured as practices are implemented using the COMET tool and SOM will be measured annually through soil testing. Trends will be tracked in a separate reporting tool over the 20-year time horizon of the Plan.

REFERENCES

Smyrl, V. E. (Nov 22, 2020). Littig, TX. Texas State Historical Association. **https://www.tshaonline.org/handbook/entries/littig-tx**

Federal Emergency Management Association. (n.d.). National Flood Hazard Layer FIRMette. FEMA Flood Map Service Center: Welcome! map. Retrieved July 10, 2023, from **https://msc.fema.gov/portal/home**

Iowa State University, Iowa Environmental Mesonet. (n.d.). Windrose Plot for Austin Bergstrom Intl. plot. Retrieved January 10, 2023, from **https://mesonet.agron.iastate.edu/sites/windrose.phtml?station=AUS&network=TX_ASOS**

Lower Colorado River Authority. (2011, January). Wilbarger Creek Watershed. LCRA Interactive Map. map. Retrieved January 10, 2023, from **https://maps.lcra.org/default.aspx?maptype=watershed+posters**

Texas Water Development Board. (2017). Lost Pines Groundwater Conservation District Management Plan Retrieved July 2, 2023, from **https://www.twdb.texas.gov/groundwater/docs/GCD/lpgcd/lpgcd_mgmt_plan2018.pdf**

1. Creswell, L., Ecological site R086AY009TX Southern Eroded Blackland (2007). USDA Natural Resources Conservation Service. Retrieved from **https://edit.jornada.nmsu.edu/catalogs/esd/086A/R086AY009TX**

2. Creswell, L., Ecological site R086AY004TX Southern Claypan Prairie (2007). USDA Natural Resources Conservation Service. Retrieved from **https://edit.jornada.nmsu.edu/catalogs/esd/086A/R086AY004TX**

Creswell, L., Ecological site R086AY013TX Clayey Bottomland (2008). USDA Natural Resources Conservation Service. Retrieved from **https://edit.jornada.nmsu.edu/catalogs/esd/086A/R086AY013TX**

USDA Natural Resources Conservation Service. (n.d.) PLANTS Database. Retrieved July 11, 2023, from **https://plants.usda.gov/home**

Arnold, Michael A. (2018). Landscape Plants for Texas and Environs (3rd ed.). Stipes Publishing Co.

Travis Audubon. (n.d.). Species of concern: The Golden-cheeked Warbler. Retrieved July 11, 2023, from **https://travisaudubon.org/savethegcwa**

Texas Parks and Wildlife Department. (2023). Rare, Threatened, and Endangered Species of Texas by County. Travis County Species Records. Retrieved July 11, 2023, from **https://tpwd.texas.gov/gis/rtest**

USDA Natural Resources Conservation Service. (2017, August). Heiden series. Official Series Description - HEIDEN Series. Retrieved October 20, 2023, from **https://soilseries.sc.egov.usda.gov/OSD_Docs/H/HEIDEN.html**

Web Soil Survey. (2022). Custom Soil Resource Report for Travis County, Texas.

Magdoff, F., & Es, V. H. (2021). Chapter 3: Amount of Organic Matter in Soils. In Building soils for better crops: Ecological management for Healthy Soils. essay, Sustainable Agriculture Research & Education.

USDA Natural Resources Conservation Service. (2019, October). National Resource Concern List and Planning Criteria. Retrieved August 17, 2023, from **https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=44299.wba**

Claassen, R., et al., Tillage Intensity and Conservation Cropping in the United States (2018). USDA Economic Research Service.

Conservation Technology Information Center. (2002, November 11). Tillage Type Definitions. Resource display: Conservation technology information center. **https://www.ctic.org/resource_display/?id=322&title=Tillage%2BType%2BDefinitions**

USDA National Agroforestry Center. (2021, April). Working Trees Info. Retrieved from **www.fs.usda.gov/nac/assets/documents/workingtrees/infosheets/WTInfoSheet-CarbonSequestration.pdf**

Colorado State University. (2023, December). COMET-Planner, version 3.1. **http://comet-planner.com**

APPENDIX A:

RING INFILTROMETER TEST GUIDE

Soil Health - Infiltration

Soil infiltration refers to the ability of the soil to allow water to move into and through the soil profile. Infiltration allows the soil to temporarily store water, making it available for use by plants and soil organisms. The infiltration rate is a measure of how fast water enters the soil, typically expressed in inches per hour.

Steady-State Infiltration Rates*

Soil Type	Steady-State Infiltration Rate (in/hr)
Sand	>0.8
Sandy and Silty Soils	0.4 - 0.8
Loam	0.2 - 0.4
Clayey Soils	0.04 - 0.2
Sodic Clayey Soils	<0.04

*Hillel, 1982

Measuring Infiltration

Materials needed:

3" or 6" Diameter aluminum ring
Wood block
Rubber mallet
Plastic Wrap
Graduated cylinder
Distilled water
Stopwatch or timer

Procedure:

1. Clear all residue from the soil surface. Drive the ring into the soil to a depth of 3" using the mallet and block of wood. Drive the ring down evenly and vertically. Gently tamp down the soil inside the ring to eliminate gaps.

2. Cover the inside of the ring with plastic wrap and drape it over the rim.

3. Pour 107mL (for 3" ring) or 444 mL (for 6" ring) distilled water into the plastic-lined ring.

4. Gently pull the plastic wrap away. Record the time it takes for the water to infiltrate the soil. Stop the timer when the soil "glistens".

5. Repeat Steps 2, 3 and 4 to determine the steady-state infiltration rate. Several measurements may be needed.

6. Record the results.

7. Remove the ring with t he soil intact. This intact soil core may be used indoors for the respiration and bulk density tests.

APPENDIX B:

SLAKE TEST GUIDE

The slake test – a simple way to evaluate soil structure

The slake test demonstrates the stability of soil aggregates in water. When a chunk of topsoil is placed into water, the water is drawn into the soil and displaces air. If the large pores within the soil are stable, water can move into the soil without causing the aggregate to break apart ("slake"). Biological processes such as earthworm activity, root growth and decomposition, networks of root-associated fungal hyphae, and sticky exudates from other soil organisms including fungi and bacteria all contribute to soil aggregation and the stability of macropores. Stable macropores allow better infiltration of water into the soil, reducing water runoff, erosion and surface crusting.

Tillage has a major impact on soil quality, physically disrupting soil and causing decomposition of organic matter. Over time, tillage reduces soil biological activity and thus the ability of soil organisms to stabilize soil aggregates. Comparing soil aggregates from an untilled area such as a fencerow with a regularly tilled production area allows you to evaluate your soil's structural integrity.

To do the slake test, you will need:

- two clear glass or plastic containers

- mesh supports (eg made from hardware cloth) that will fit into the top of the container and hold the soil in the top half of the container

- soil aggregates collected from the surface layer of soil, from a tilled area and from a nearby untilled area such as a fencerow

soilhealth.osu.edu

Steps:

1. Insert the wire meshes into each jar and fill the jars with water to a depth that will submerge the soil aggregate samples.

2. Simultaneously place each soil aggregate sample into the separate jars.

3. Watch to see which soil holds together and which one falls apart. Aggregates from soil with poor structure will break apart in water.

Helpful YouTube videos:

- Soil Aggregation and Water Infiltration https://youtu.be/d1M7EFqqsMM
- How to Conduct the Field Slake Test https://www.youtube.com/watch?v=z8xj5EiNNRo
- Slake and Infiltration Test https://www.youtube.com/watch?v=CEOyC_tGH64
- Slake Test and Capilliary Flow of Soil Quality & Water Movement (kit) with USDA NRCS SD https://www.youtube.com/watch?v=GOos10UyRwY

Prepared by Ruth Genger based on NRCS resources (nrcs.usda.gov).

Contact: ruth.genger@wisc.edu

Department of Horticulture
125 years and growing

APPENDIX C:
SOIL TESTS RESULTS FROM 2022 & 2023

Soil Report

Job Name: **Symbiosis**

Date: 3/25/2022

Company: Symbiosis

Submitted By:

Sample Location			New Leaf	New Leaf	New Leaf	New Leaf	
Sample ID			N1 AA 8.2	2Wt AA 8.2	3Md AA 8.2	4 FD AA 8.2	
Lab Number			306	307	308	309	
Sample Depth in inches			6	6	6	6	
Total Exchange Capacity (M. E.)			13.68	12.32	11.31	16.21	
pH of Soil Sample			7.9	8.3	7.7	8.2	
Organic Matter, Percent			3.60	2.83	3.34	3.91	
ANIONS	**SULFUR:**	p.p.m.	7	9	11	12	
	Mehlich III Phosphorous:	as (P_2O_5) lbs / acre	41	27	69	46	
EXCHANGEABLE CATIONS	**CALCIUM:** lbs / acre	Desired Value	3720	3350	3076	4408	
		Value Found	4572	3923	3597	5178	
		Deficit					
	MAGNESIUM: lbs / acre	Desired Value	393	354	325	466	
		Value Found	318	400	334	408	
		Deficit	-75			-58	
	POTASSIUM: lbs / acre	Desired Value	426	384	352	505	
		Value Found	244	172	298	726	
		Deficit	-182	-212	-54		
	SODIUM:	lbs / acre	60	112	58	52	
BASE SATURATION %	Calcium (60 to 70%)		83.57	79.61	79.50	79.87	
	Magnesium (10 to 20%)		9.69	13.53	12.30	10.49	
	Potassium (2 to 5%)		2.29	1.79	3.38	5.74	
	Sodium (.5 to 3%)		0.95	1.98	1.11	0.70	
	Other Bases (Variable)		3.50	3.10	3.70	3.20	
	Exchangeable Hydrogen (10 to 15%)		0.00	0.00	0.00	0.00	
TRACE ELEMENTS	Boron (p.p.m.)		0.7	0.63	0.67	0.65	
	Iron (p.p.m.)		39	32	44	40	
	Manganese (p.p.m.)		75	36	42	57	
	Copper (p.p.m.)		0.7	0.51	0.68	1.05	
	Zinc (p.p.m.)		0.85	0.55	1.84	1.89	
	Aluminum (p.p.m.)		369	247	245	252	
OTHER							

Logan Labs, LLC

Regen Ag Lab

Account No.:	282	Name:	DARRON GAUS	Grower:	RMING PLANNING PROJEC
Invoice No.:		Company:	NCAT	Field ID:	FRONT FIELDS
Date Recd:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Repd:	10/20/2023	City, State, ZIP:	SAN ANTONIO, TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

HANEY SOIL HEALTH ANALYSIS

Lab #	Nitrogen									Phosphorus					
	H3A Extract			H2O Extract						H3A Extract					
	Nitrate ppm NO3-N	Ammonium ppm NH4-N	Inorg. N ppm N	Total N ppm N	Org. N ppm N	Org. N: Inorg. N	Org. N Rel. ppm N	Org. N Res. ppm N	Avail. N lbs/A	Total P ppm P	Inorg. P ppm PO4-P	Org. P ppm P	Org. P Rel ppm P	Org. P Res. ppm P	Avail. P lbs/A
39794	97.4	2.4	99.8	155.3	55.5	0.56	51.6	4.0	272.4	90.5	76.3	14.2	9.9	4.3	198.2
Rank															

Lab #	Other Soil Measures					Fertility									
						H3A Extract									
	Soil pH 1:1	Buffer pH Mod. WDRF	Soluble Salt mmho/cm	Excess Lime	Soil OM % LOI	Potassium ppm K	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Zinc ppm Zn	Manganese ppm Mn	Iron ppm Fe	Copper ppm Cu	Aluminum ppm Al	Sulfur ppm S
39794	7.9	-	0.53	HIGH	11.8	438	3573	224	108	0.32	3.8	16	0.15	17	59.17
Rank															

Lab #	Soil Health						Nitrogen Comparison				Reviewer Comments
		H2O Extract									
	Soil Resp. ppm CO2-C	Org. C ppm C	MAC %	C:N	SHC	Cover Crop Suggestion	Traditional N lbs/A	Haney N lbs/A	Differ. N lbs/A	Savings N $/A	
39794	133.6	575	23.2	10.36	28.19	10% Legume 90% Grass	175.3	272.4	97.1	100.99	
Rank											

Lab #	Intended		N Credits, lbs/A			Fertility Recommendations, lbs of Required Nutrients per Acre									
	Crop	Yield Goal	Past Crop	Subsoil	Haney	N	P2O5	K2O	S	Zn	Mg	Fe	Mn	Cu	Lime T/A

Reviewed By: Emily Shafto
Date: 10/20/2023

Recommendations Provided by Regen Ag Lab, LLC
Analysis Performed by Regen Ag Lab, LLC

Regen Ag Lab

Account No.:	282	Name:	DARRON GAUS	Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	EAST FIELDS
Date Recd:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Repd:	10/20/2023	City, State, ZIP:	SAN ANTONIO, TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

HANEY SOIL HEALTH ANALYSIS

Lab #	Nitrogen									Phosphorus					
	H3A Extract			H2O Extract						H3A Extract					
	Nitrate ppm NO3-N	Ammonium ppm NH4-N	Inorg. N ppm N	Total N ppm N	Org. N ppm N	Org. N: Inorg. N	Org. N Rel. ppm N	Org. N Res. ppm N	Avail. N lbs/A	Total P ppm P	Inorg. P ppm PO4-P	Org. P ppm P	Org. P Rel ppm P	Org. P Res. ppm P	Avail. P lbs/A
39795	18.6	2.0	20.6	43.8	23.4	1.15	19.2	4.2	71.6	51.2	39.9	11.3	6.9	4.3	107.7
Rank															

Lab #	Other Soil Measures					Fertility									
						H3A Extract									
	Soil pH 1:1	Buffer pH Mod. WDRF	Soluble Salt mmho/cm	Excess Lime	Soil OM % LOI	Potassium ppm K	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Zinc ppm Zn	Manganese ppm Mn	Iron ppm Fe	Copper ppm Cu	Aluminum ppm Al	Sulfur ppm S
39795	7.9	-	0.20	HIGH	2.7	89	1337	132	35	0.77	4.2	30	0.09	76	17.62
Rank															

Lab #	Soil Health						Nitrogen Comparison				Reviewer Comments
		H2O Extract									
	Soil Resp. ppm CO2-C	Org. C ppm C	MAC %	C:N	SHC	Cover Crop Suggestion	Traditional N lbs/A	Haney N lbs/A	Differ. N lbs/A	Savings N $/A	
39795	49.8	243	20.5	10.40	12.19	40% Legume 60% Grass	33.5	71.6	38.1	39.64	
Rank											

Lab #	Intended		N Credits, lbs/A			Fertility Recommendations, lbs of Required Nutrients per Acre									
	Crop	Yield Goal	Past Crop	Subsoil	Haney	N	P2O5	K2O	S	Zn	Mg	Fe	Mn	Cu	Lime T/A

Reviewed By: Emily Shafto
Date: 10/20/2023

Recommendations Provided by Regen Ag Lab, LLC
Analysis Performed by Regen Ag Lab, LLC

Regen Ag Lab

Account No.:	282	Name:	DARRON GAUS	Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	BACK FIELDS
Date Recd:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Repd:	10/20/2023	City, State, ZIP:	SAN ANTONIO, TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

HANEY SOIL HEALTH ANALYSIS

	Nitrogen									Phosphorus					
	H3A Extract			H2O Extract						H3A Extract					
Lab #	Nitrate ppm NO3-N	Ammonium ppm NH4-N	Inorg. N ppm N	Total N ppm N	Org. N ppm N	Org. N: Inorg. N	Org. N Rel. ppm N	Org. N Res. ppm N	Avail. N lbs/A	Total P ppm P	Inorg. P ppm PO4-P	Org. P ppm P	Org. P Rel ppm P	Org. P Res. ppm P	Avail. P lbs/A
39796	12.6	2.0	14.6	33.1	18.9	1.33	15.6	3.3	54.4	34.2	25.4	8.8	5.5	3.4	71.0
Rank															

	Other Soil Measures					Fertility									
						H3A Extract									
Lab #	Soil pH 1:1	Buffer pH Mod. WDRF	Soluble Salt mmho/cm	Excess Lime	Soil OM % LOI	Potassium ppm K	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Zinc ppm Zn	Manganese ppm Mn	Iron ppm Fe	Copper ppm Cu	Aluminum ppm Al	Sulfur ppm S
39796	8.3	-	0.27	HIGH	4.9	132	3144	149	63	0.51	2.8	17	0.09	46	28.34
Rank															

	Soil Health						Nitrogen Comparison				Reviewer Comments
		H2O Extract									
Lab #	Soil Resp. ppm CO2-C	Org. C ppm C	MAC %	C:N	SHC	Cover Crop Suggestion	Traditional N lbs/A	Haney N lbs/A	Differ. N lbs/A	Savings N $/A	
39796	59.5	288	20.7	15.25	13.61	40% Legume 60% Grass	22.7	54.4	31.7	33.01	
Rank											

	Intended		N Credits, lbs/A			Fertility Recommendations, lbs of Required Nutrients per Acre									
Lab #	Crop	Yield Goal	Past Crop	Subsoil	Haney	N	P2O5	K2O	S	Zn	Mg	Fe	Mn	Cu	Lime T/A

Reviewed By: Emily Shafto
Date: 10/20/2023

Recommendations Provided by Regen Ag Lab, LLC
Analysis Performed by Regen Ag Lab, LLC

Regen Ag Lab

Account No.:	282	Name:	DARRON GAUS	Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	AGROFORESTRY & OTHERS
Date Recd:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Repd:	10/20/2023	City, State, ZIP:	SAN ANTONIO, TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

HANEY SOIL HEALTH ANALYSIS

Lab #	Nitrogen									Phosphorus					
	H3A Extract			H2O Extract						H3A Extract					
	Nitrate ppm NO3-N	Ammonium ppm NH4-N	Inorg. N ppm N	Total N ppm N	Org. N ppm N	Org. N: Inorg. N	Org. N Rel. ppm N	Org. N Res. ppm N	Avail. N lbs/A	Total P ppm P	Inorg. P ppm PO4-P	Org. P ppm P	Org. P Rel ppm P	Org. P Res. ppm P	Avail. P lbs/A
39797	8.9	2.0	10.9	23.9	12.8	1.15	8.3	4.5	34.6	3.0	2.3	0.7	0.3	0.4	6.2
Rank															

Lab #	Other Soil Measures					Fertility									
						H3A Extract									
	Soil pH 1:1	Buffer pH Mod. WDRF	Soluble Salt mmho/cm	Excess Lime	Soil OM % LOI	Potassium ppm K	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na	Zinc ppm Zn	Manganese ppm Mn	Iron ppm Fe	Copper ppm Cu	Aluminum ppm Al	Sulfur ppm S
39797	8.0	-	0.13	HIGH	2.6	48	3240	139	20	0.13	1.3	15	0.07	57	6.56
Rank															

Lab #	Soil Health						Nitrogen Comparison				Reviewer Comments
		H2O Extract									
	Soil Resp. ppm CO2-C	Org. C ppm C	MAC %	C:N	SHC	Cover Crop Suggestion	Traditional N lbs/A	Haney N lbs/A	Differ. N lbs/A	Savings N $/A	
39797	37.2	229	16.3	17.93	9.58	50% Legume 50% Grass	16.0	34.6	18.6	19.33	
Rank											

Lab #	Intended		N Credits, lbs/A			Fertility Recommendations, lbs of Required Nutrients per Acre									
	Crop	Yield Goal	Past Crop	Subsoil	Haney	N	P2O5	K2O	S	Zn	Mg	Fe	Mn	Cu	Lime T/A

Reviewed By: Emily Shafto
Date: 10/20/2023

Recommendations Provided by Regen Ag Lab, LLC
Analysis Performed by Regen Ag Lab, LLC

Regen Ag Lab, LLC
31740 Hwy 10, Pleasanton NE 68866

Gain Ground

308-627-0065
regenaglab.com

Regen Ag Lab

Account No.:	282	Name:		Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	FRONT FIELDS
Date Received:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Reported:	10/20/2023	City, State, ZIP:	SAN ANTONIO , TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

PLFA ANALYSIS REPORT

Lab # 39794

	Value	Rank
Total Biomass, PLFA ng/g soil	1042.61	BELOW AVERAGE
Functional Group Diversity Index	1.295	AVERAGE

Overall Rank

BELOW AVERAGE - AVERAGE

Community Breakdown

Functional Group	Value	Units	% of Total Biomass
Total Bacteria	467.80	PLFA ng/g	44.87
Gram +	235.73	PLFA ng/g	22.61
Actinomycetes	63.22	PLFA ng/g	6.06
Gram -	168.85	PLFA ng/g	16.19
Total Fungi	60.78	PLFA ng/g	5.83
Arbuscular Mycorrhizal	16.54	PLFA ng/g	1.59
Saprophytic	44.24	PLFA ng/g	4.24
Protozoa	0.00	PLFA ng/g	0.00
Undifferentiated	514.03	PLFA ng/g	49.30

Ratios

Community	Value	Rank
Fungi:Bacteria	0.1299	BELOW AVERAGE
Protozoa:Bacteria	All Bact	VERY POOR
Gram+:Gram-	1.7706	IDEAL
Stress Indicators		
Sat:Unsat	3.3619	GOOD
Mono:Poly	108.7994	VERY GOOD
Pre 16:Cyclo 17	All Pre16:1	VERY ACTIVE
Pre 18:Cyclo 19	All Pre18:1	VERY ACTIVE

Reviewer Comments

Reviewed By: Emily Shafto
Date: 11/19/2023

Analysis Performed by Regen Ag Lab, LLC

Account No.:	282	Name:		Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	EAST FIELDS
Date Received:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Reported:	10/20/2023	City, State, ZIP:	SAN ANTONIO , TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

PLFA ANALYSIS REPORT

Lab # 39795

	Value	Rank
Total Biomass, PLFA ng/g soil	669.88	POOR
Functional Group Diversity Index	1.211	AVERAGE

Overall Rank

BELOW AVERAGE

Community Breakdown

Functional Group	Value	Units	% of Total Biomass
Total Bacteria	242.70	PLFA ng/g	36.23
Gram +	140.21	PLFA ng/g	20.93
Actinomycetes	54.24	PLFA ng/g	8.10
Gram -	48.24	PLFA ng/g	7.20
Total Fungi	18.72	PLFA ng/g	2.79
Arbuscular Mycorrhizal	9.56	PLFA ng/g	1.43
Saprophytic	9.16	PLFA ng/g	1.37
Protozoa	0.00	PLFA ng/g	0.00
Undifferentiated	408.47	PLFA ng/g	60.98

Ratios

Community	Value	Rank
Fungi:Bacteria	0.0771	POOR
Protozoa:Bacteria	All Bact	VERY POOR
Gram+:Gram-	4.0309	VERY GRAM+ DOM
Stress Indicators		
Sat:Unsat	7.9752	VERY GOOD
Mono:Poly	52.0969	VERY GOOD
Pre 16:Cyclo 17	None Found	N/A
Pre 18:Cyclo 19	All Pre18:1	VERY ACTIVE

Reviewer Comments

Reviewed By: Emily Shafto
Date: 11/19/2023

Analysis Performed by Regen Ag Lab, LLC

Regen Ag Lab, LLC
31740 Hwy 10, Pleasanton NE 68

Gain Ground

308-627-0065
regenaglab.com

Regen Ag Lab

Account No.:	282	Name:		Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	BACK FIELDS
Date Received:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Reported:	10/20/2023	City, State, ZIP:	SAN ANTONIO , TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

PLFA ANALYSIS REPORT

Lab # 39796

	Value	Rank
Total Biomass, PLFA ng/g soil	1124.39	BELOW AVERAGE
Functional Group Diversity Index	1.327	ABOVE AVERAGE

Overall Rank

AVERAGE

Community Breakdown

Functional Group	Value	Units	% of Total Biomass
Total Bacteria	549.73	PLFA ng/g	48.89
Gram +	291.67	PLFA ng/g	25.94
Actinomycetes	95.61	PLFA ng/g	8.50
Gram -	162.44	PLFA ng/g	14.45
Total Fungi	73.91	PLFA ng/g	6.57
Arbuscular Mycorrhizal	30.66	PLFA ng/g	2.73
Saprophytic	43.25	PLFA ng/g	3.85
Protozoa	0.00	PLFA ng/g	0.00
Undifferentiated	500.75	PLFA ng/g	44.54

Ratios

Community	Value	Rank
Fungi:Bacteria	0.1344	BELOW AVERAGE
Protozoa:Bacteria	All Bact	VERY POOR
Gram+:Gram-	2.3842	GOOD
Stress Indicators		
Sat:Unsat	3.4759	GOOD
Mono:Poly	196.0641	VERY GOOD
Pre 16:Cyclo 17	None Found	N/A
Pre 18:Cyclo 19	All Pre18:1	VERY ACTIVE

Reviewer Comments

Reviewed By: Emily Shafto
Date: 11/19/2023

Analysis Performed by Regen Ag Lab, LLC

Account No.:	282	Name:		Grower:	RMING PLANNING PROJECT
Invoice No.:		Company:	NCAT	Field ID:	AGROFORESTRY & OTHERS
Date Received:	10/18/2023	Address:	118 BROADWAY	Sample ID 1:	-
Date Reported:	10/20/2023	City, State, ZIP:	SAN ANTONIO , TX 78205	Sample ID 2:	-
				Sample Depth:	0-6

PLFA ANALYSIS REPORT

Lab # 39797

	Value	Rank
Total Biomass, PLFA ng/g soil	717.36	POOR
Functional Group Diversity Index	1.133	BELOW AVERAGE

Overall Rank

POOR

Community Breakdown

Functional Group	Value	Units	% of Total Biomass
Total Bacteria	210.97	PLFA ng/g	29.41
Gram +	94.62	PLFA ng/g	13.19
Actinomycetes	28.02	PLFA ng/g	3.91
Gram -	88.34	PLFA ng/g	12.31
Total Fungi	10.15	PLFA ng/g	1.42
Arbuscular Mycorrhizal	0.00	PLFA ng/g	0.00
Saprophytic	10.15	PLFA ng/g	1.42
Protozoa	0.00	PLFA ng/g	0.00
Undifferentiated	496.24	PLFA ng/g	69.18

Ratios

Community	Value	Rank
Fungi:Bacteria	0.0481	VERY POOR
Protozoa:Bacteria	All Bact	VERY POOR
Gram+:Gram-	1.3882	IDEAL
Stress Indicators		
Sat:Unsat	6.0217	VERY GOOD
Mono:Poly	All Mono	VERY GOOD
Pre 16:Cyclo 17	None Found	N/A
Pre 18:Cyclo 19	All Pre18:1	VERY ACTIVE

Reviewer Comments

Reviewed By: Emily Shafto
Date: 11/19/2023

Analysis Performed by Regen Ag Lab, LLC

Account No.:	282	
Invoice No.:		
Date Recd:	10/18/2023	
Date Repd:	10/20/2023	
Name:		
Company:	NCAT	
Address:	118 BROADWAY	
City, State, ZIP:	SAN ANTONIO , TX 78205	

MISC. SOIL HEALTH ANALYSIS REPORT

	Sample Information				Respiration ppm	Soil Enzymes µg pNP g^{-1} h^{-1}						POX-C ppm C	Water Holding Capacity			Wet Aggregate Stability %		
Lab #	Grower	Field ID	Sample ID 1	Depth	CO2-C	BG	NAG	PHD	AlkP	AcP	ARS	KMnO4	g H2O g $soil^{-1}$	inch H2O inch $soil^{-1}$	inch H2O depth $soil^{-1}$	Macro	Micro	Total
39794	RMING PLANNING PROJECT	FRONT FIELDS		0-6	-	-	-	-	-	-	-	-	0.24	0.32	1.91	51.9	9.1	61.0
39795	RMING PLANNING PROJECT	EAST FIELDS		0-6	-	-	-	-	-	-	-	-	0.16	0.22	1.30	72.0	1.7	73.7
39796	RMING PLANNING PROJECT	BACK FIELDS		0-6	-	-	-	-	-	-	-	-	0.22	0.29	1.73	65.8	4.9	70.7
39797	RMING PLANNING PROJECT	AGROFORESTRY & OTHERS		0-6	-	-	-	-	-	-	-	-	0.20	0.26	1.57	66.8	5.8	72.6
					-	-	-	-	-	-	-	-	-	-	-	-	-	-
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Reviewer Comments

Reviewed By: Emily Shafto

Date: 11/15/2023

Analysis Performed by Regen Ag Lab, LLC

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Gain Ground

APPENDIX D:

PLANT GLOSSARY

Area	Species	In CIC Plan	NRCS Approved	Dye	ValueAdded	Evergreen	Forage	Notes
Conservation Cover, Windbreak Base Layer, or Animal Grazing Areas								
	Green Sprangletop	Yes	Yes				Yes	Grass, 10%; This is the percentages for the mix Matt is ordering from Justin Seed
	Indiangrass	Yes	Yes				Yes	Grass, 22%
	Canada Wildrye	No	Yes				Yes	Grass, 0%
	Little Bluestem	Yes	Yes				Yes	Grass, 6%
	Eastern Gamagrass	Yes	Yes				Yes	Grass, 6%
	Buffalo Grass	No	Yes				Yes	Grass, 0%
	Hairy Grama	No	Yes				Yes	Grass, 0%
	Side Oats Grama	Yes	Yes				Yes	Grass, 16%
	Bundleflower	Yes	Yes				Yes	Forb, 8%
	Prairie Clover	Yes	Yes				Yes	Forb, 11%
	Ashy Sunflower	Yes	Yes				Yes	Forb, 0%
	Oklahoma Common Alfalfa	No	Yes				Yes	Forb, 0% This variety recommended where cotton root rot is common
	Orange Zexmania	No	Yes				Yes	Forb, 0%
	Maximilian Sunflower	Yes	Yes				Yes	Forb, 12%
	Partridge Pea	Yes	Yes				Yes	Forb, 9%
Windbreak Midlayer or Hedgerow								
	Russian Olive	Yes	Yes	No	No	No	No	
	Grape	Yes	Yes	Yes	Yes	No	No	Especially along fencelines
	Mulberry	Yes	Yes	Yes	No	No	Yes	
	Redbud	Yes	Yes	No	No	No	No	
	Sumac, skunkbrush	Yes	Yes	Yes	No	No	No	
	Yaupon	Yes	Yes	No	Yes	Yes	No	
	Texas Persimmon	Yes	Yes	No	Yes	No	No	
	Rosemary	No	No	No	Yes	Yes	No	
	Butterfly bush	No	No	No	No	Yes	No	Freezes back
	Flame Acanthus	No	No	No	No	Yes	No	Freezes back
	Plumbago	No	No	No	No	Yes	No	Freezes back
	Agarita	No	No	No	Yes	Yes	No	
	Smooth Sumac	No	No	Yes	No	No	No	
	Indigo	No	No	Yes	No	Yes	No	Freezes back
	Milkweed	No	No	Yes	No	Yes	No	Freezes back
	Texas Sage	No	No	No	No	Yes	No	
	Firebush	No	No	No	No	Yes	No	Freezes back
	Fig	No	No	No	Yes	No	Yes	
	Oleander	No	No	No	No	Yes	No	Toxic to livestock if guinea hogs come in
Windbreak Upper Layer								
	Walnut	No	Yes	Yes	Yes	No	No	
	Eastern Cottonwood	No	Yes	Yes	No	No	No	
	Pecan	No	Yes	Yes	Yes	No	Yes	
	Live Oak	No	Yes	No	No	Yes	Yes	Acorns for forage or specialty acorn oil
	Anaqua	No	Yes	No	No	Yes	No	
	Ashe Juniper	No	No	No	No	Yes	No	Has a bad name, most want to remove it, great windbreak value though
	Eastern Red Cedar	No	No	No	No	Yes	No	
	Italian Cypress	No	No	No	No	Yes	No	
	Southern Waxmyrtle	No	No	No	No	Yes	No	
Herbaceous Wind Barrier								
	Castorbean	No	No	No	Yes	No	No	
	Sorghum Sudan	No	Yes	No	No	No	Yes	
	Okra	No	No	No	Yes	No	Yes	
	Mammoth Sunflower	No	No	No	Yes	No	Yes	
	Sweet Corn	No	No	No	No	No	Yes	
	Sesame	No	Yes	No	No	No	Yes	
Cool Cover Crop								
	Oats	Yes	Yes	No	No	No	Yes	NRCS plan 25%
	Winter Pea	Yes	Yes	No	No	No	Yes	NRCS plan 25%
	Triticale	Yes	Yes	No	No	No	Yes	NRCS plan 25%
	Red Clover	Yes	Yes	No	No	No	Yes	NRCS plan 25%
	White Clover	No	Yes	No	No	No	Yes	
	Hubam Clover	No	No	No	No	No	Yes	
	Daikon Radish	No	No	No	Yes	No	Yes	
	Cereal Rye	No	Yes	No	No	No	Yes	
	Wheat	No	Yes	No	No	No	Yes	
	Fava Bean	No	Yes	No	No	No	Yes	
	Flax	No	Yes	No	Yes	No	Yes	Fiber
	Barley	No	Yes	No	No	No	Yes	
	Purpletop Whiteglobe Turnip	No	No	No	Yes	No	Yes	
Warm Cover Crop								
	Sunnhemp	Yes	Yes	No	No	No	Yes	NRCS plan 20%
	Cowpea	Yes	Yes	No	No	No	Yes	NRCS plan 20%
	Sorghum Sudan	Yes	Yes	No	No	No	Yes	NRCS plan 20%
	Fava Bean	Yes	Yes	No	No	No	Yes	NRCS plan 20%; Recommend to replace with Soybean
	Buckwheat	Yes	Yes	No	No	No	Yes	NRCS plan 20%; Recommend something else- either clammy weed or millet
	Guar	No	No	No	No	No	Yes	
	Okra	No	No	No	Yes	No	Yes	
	Swisschard	No	No	No	Yes	No	Yes	
	Browntop Millet	No	Yes	No	No	No	Yes	

Area	**Species**	**In CIC Plan**	**NRCS Approved**	**Dye**	**ValueAdded**	**Evergreen**	**Forage**	**Notes**
	Foxtail Millet	No	No	No	No	No	Yes	
	Japanese Millet	No	Yes	No	No	No	Yes	
	Pearl Millet	No	Yes	No	No	No	Yes	
	Proso Millet	No	Yes	No	No	No	Yes	
	Amaranth	No	No	No	No	No	Yes	Trap crop
	Soybean	No	No	No	No	No	Yes	
	Riogrande Clammy Weed	No	Yes	No	No	No	Yes	
	Florida Broadleaf Mustard	No	No	No	No	No	Yes	
Transition Cover Crop								
	Buckwheat	No	Yes	No	No	No	Yes	
	Chicory	No	No	No	Yes	No	Yes	
	Swiss Chard	No	No	No	Yes	No	Yes	
	Mustards	No	No	No	No	No	Yes	

APPENDIX E:

NRCS PRESCRIBED GRAZING PLAN

Practice Specification
Prescribed Grazing (Code 528)

General Use

Application of this practice will prescribe the rest period, intensity, frequency, duration and season of grazing to promote ecologically and economically stable plant communities that meet both the land manager's objectives and the resource needs. All grazing plans shall be designed with flexibility to reduce risk. Removal of herbage will be in accordance with site production limitations, rate of plant growth and the physiological stage of forage plants and grazing objective.

Manage kind of animal, number of animals, grazing distribution, utilization, and/or timing of use for maintenance or restoration of desired vegetation.

Manage grazing animals to maintain adequate vegetative cover on sensitive areas (i.e. riparian, wetland, habitats of concern, karst areas). Grazing and/or browsing animal numbers will be managed to insure the degree of utilization of key species on the key area does not exceed a prescribed amount (Refer to Appendix 1 & 3).

Refer to Brush Management (314) Attachment III for Biological Management of undesirable woody plants.

For the purposes of this specification, the term "browsing" may be used synonymously for grazing. Forage inventories will be based on the dietary needs of the target species to be managed.

DIFFERENCES BETWEEN RANGE MANAGEMENT AND PASTURE MANAGEMENT

This specification contains criteria for all grazing lands. It is important to understand that the philosophy differs somewhat between the types of grazing land, even though there are overlaps.

Grazed Range, Grazed Forest, and Native Pasture are generally managed for many species of plants for multiple benefits. Grazed Pasture and Cropland are generally the management of a few species for specific objectives.

Grazed Range, Grazed Forest, CRP, and Native or Naturalized Pasture are managed through the use of tools such as prescribed fire, chemicals, mechanical methods, and biological agents. The same principles are applied to pastureland and to cropland to an extent, but are generally more intensive.

Pasture and Cropland tend to be agronomically dependent monocultures, a limited variety of exotic plants, or managed native single species. Agronomic practices such as fertilizer, pest management, irrigation, routine seeding and renovation are needed to maintain pasture and cropland communities.

Improve or Maintain Riparian and Watershed Function.

Minimize concentrated livestock areas through grazing management, fencing, alternate water sources, hardened water points, controlled access, supplemental feed placement, and/or shade or cover manipulation. This is to enhance nutrient distribution and ground cover.

Grazing management strategies must also consider the sensitivity of different riparian areas to disturbance and their resiliency or ability to recover.

Additional Criteria to Improve or Maintain the Quantity and Quality of Food And/or Cover Available For Wildlife

Refer to Texas NRCS EFOTG State supplements, as available for specific species habitat management criteria. If no supplement is available, request assistance from the State Biologist or State Rangeland Management Specialist. When T&E species occur on the management unit, grazing should be planned to not cause harm to a population or the habitat of federally listed or state listed endangered or threatened plants or animals.

Manage duration, frequency, kind of animal, or intensity of grazing to produce diverse plant communities with appropriate plant height, structure, diversity, and density for the desired wildlife habitat.

Utilize the kind of animal whose dietary and behavioral traits are compatible with the desired wildlife species of concern.

Identify the species of concern and the habitat component(s) to be managed in the goals and objectives of the grazing plan.

Use short-term heavy grazing to create areas of low-successional plant species that are need for habitat of upland species. These spots are to be well distributed within the grazing unit and are not to compose the majority of the unit, nor create any resource concerns. In subsequent years, manage grazing so that these heavily grazed areas recover.

Refer to Upland Wildlife Habitat Management (645) and Wetland Wildlife Habitat Management (644) standards for guidance on habitat management.

VARIANCES

Any requests for variances are to be submitted to the State Rangeland Management Specialist.

PRESCRIBED GRAZING PLAN

The Prescribed Grazing Plan will include:

1. **Goals and Objectives** clearly stated.
2. **Resource Inventory** that identifies:
   a. Soils and ecological site map
   b. Water distribution map
   c. Topography map
   d. Kind and class of animal
   e. Forage inventory documentation (i.e. Rangeland Similarity Index Worksheet, Step Rank Transect, Rangeland Health Assessment, Forage Inventory 809d, 809e, etc.)
   f. Grazable acre determination
      i. Determining grazable acres will be included in the grazing management plan. Non Grazable acres would include acres effected by brush canopy, surface rock cover, slope, (surface rock cover of about 30% and/or slopes exceeding 8% can reduce cattle accessibility), surface roads, oil and gas development, surface water, etc. When Grazed Forest has a canopy exceeding 40%, no appreciable amount of grazing can be expected. Managed thinning will extend forage production and improve tree growth.
   g. Location and condition of structural improvements such as fences, water developments, etc, including seasonal availability and quality of watering sites.
3. At least one **key grazing area** with one or more key forage species will be established for each management unit or for a group of management units with similar topography, soils, grazing duration, and seasons(s) of use. (Refer to Appendix 1)
4. **Forage-Animal Balance** developed for the grazing plan, which ensures forage produced or available meets forage demand of livestock and/or wildlife.
   a. The correct stocking rate is the most important consideration in grazing management. No grazing system will improve grazing lands if the stocking rate is too high.
   b. Supplemental feed and/or mineral requirements should be balanced with the forage quality to meet the desired nutritional level for the kind and class of grazing livestock. Forage and/or fecal testing from reputable laboratories are reliable tools to determine these requirements.
5. **Grazing Plan** developed for livestock that identifies periods of grazing and/or browsing, deferment, rest, and other treatment activities for each management unit.
   a. Schedule livestock movements based on plant physiological stage, available forage, utilization and livestock nutritional needs.
   b. Design grazing systems to minimize livestock losses from storm surges, flooding, and other

potential natural disasters

c. Grazing during different seasons favors diverse plant communities on grazed range and native grazing land.
d. Herding can be used as a tool to avoid sensitive areas or to meet specific landowner goals and objectives.

6. **Contingency plan** developed that details potential problems (i.e., severe drought, flooding, insects) and serves as a guide for adjusting the grazing prescription to ensure resource management and economic feasibility without resource degradation.
   a. Evaluation dates and action plan identified
7. **Monitoring plan** developed with appropriate records to assess in determining whether the grazing strategy is resulting in a positive or upward trend and is meeting objectives. Identify the key areas and key plants that the manager should evaluate in making grazing management decisions.
   a. Utilization or stubble height target levels are tools to use in conjunction with monitoring.
   b. Grazing exclosures and/or photo points are tools that can be used to document changes in trend.

The following appendices will be used for:

- Appendix 1- acceptable degrees of use on grazed range, native pasture, grazed forestland and wildlife land. Table 1 of Appendix 1 lists acceptable use heights on pastureland.
- Appendix 2- Appropriate deferment periods.
- Appendix 3- Grazed Cropland

Appendix 1

1. **Acceptable Grazing Use (Utilization) On Grazed Range, Native Pasture, Grazed Forestland, and Wildlife land and Pastureland.**
   a. Key grazing areas shall be selected using the following criteria:
      - Will be selected for each management unit or group of management units that have similar topography, soils, grazing duration, and season(s) of use. The key grazing area is usually located within a dominant soil type or an ecological/range site.
      - Provide a significant amount, but not necessarily the greatest amount of the available forage in the grazing unit and is readily accessible. Small areas immediately adjacent to water troughs, salt, or shade, are not key grazing areas, nor are areas remote from water or with limited accessibility. A management unit may have more than one key grazing area.
      - May be sensitive areas such as riparian areas, bottomlands, wetlands, dunes, or other areas where close attention to grazing management is needed for site integrity.
      - Will be areas that are preferred by livestock or wildlife and may become overused before other areas in a management unit are grazed properly.
      - Key grazing areas will be located and specified for each kind of grazing or browsing animal where their key grazing area is different.
      - Areas in a management unit where seeding, brush management, prescribed burning, mowing, etc., have been completed, will become a key grazing area.

      Key areas can be Ecological Sites (Range Sites) or a specific location, whichever is more useful. Identify the key areas on the plan map, overlay or NRCS-414.

   b. Key grazing plants shall be selected using the following criteria:
      - Select the highest successional preferred perennial plant(s) comprising approximately 15

percent or more of the composition by weight as the key plant(s).

- If management objectives are to maintain a lower rangeland similarity index for a specific purpose, then the key plant will be the major perennial plant being managed for that purpose.
- Normally, only one plant will be selected as the key plant. However, occasionally it may be desirable to designate different key plants for summer and winter use. More than one key species may be designated for a management unit when different kinds of livestock and wildlife are present.
- On areas where reseeding is to be carried out, the key plant will be selected after stand establishment and at the start of the first grazing season's use.
- The designated key plants upon which degree of use is based will need to be reevaluated as the plant composition changes.
- For monoculture pastureland, there will only be one key species. If the pastureland is managed as a polyculture, especially if warm and cool season plants are utilized, then there may be multiple key species.

c. Degree of use will be based on the key species on the key area using the following guidance:

- Degree of use of herbaceous plants should be no more than 50 percent by weight of the current year's growth by the beginning of the next growing season.

  Minimum residual herbage (air-dry pounds per acre) during non-growing season to protect the soil from erosion:

Type	Pounds/Ac	Inches Stubble Height (approximately)
Tallgrass	1200 – 1500	12-14
Midgrass	750 – 1100	6-8
Shortgrass	300 – 500	2-3

- Browse use during the growing season should not exceed 50 percent by weight of the current year's growth of twigs and leaves within reach of the animal. Use of key species during the dormant season should not exceed 65 percent by weight of the current year's growth of available twigs of deciduous species, or twigs and leaves of evergreen species.
- Less than 50 percent use by livestock should be stipulated to promote vegetative cover on eroding or critical sites, on riparian areas or wetlands, or where rapid range recovery is needed. Protection by means of permanent or temporary fencing may be needed.
- Areas of excessive grazing use or concentrated livestock shall not exceed 10 percent of the management unit as long as these areas are not sensitive areas.

d. Animal Unit Equivalents

Refer to Table 6-5, National Range and Pasture Handbook for Animal Unit Equivalents.

Additional 1.00 AU equivalents:

5 Axis, Aoudad, Fallow, Mouflon

9 Blackbuck antelope

7 Sika

2.5 Red Deer

1 Eland

For calculating carrying capacity and Forage/Animal Balance, use 26 lbs. oven-dry weight or 30 lbs. air-dry weight of forage demand for a 1,000 lb. animal unit (AU).

2. **Degree of Use on Pastureland**
   - **a. See Table I for Grazing Use Heights and Growth Cycles for Pastureland.**
     - Use the “Minimum Heights for Rotational Use” listed in Table 1 to determine grazing use heights when warm season species are grazed during plant dormancy.
   - **b. When cool season legumes or small grains are over-seeded in a permanent sod, use the following guidance.**
     - To allow germination of the cool season species from mechanical seeding or natural reseeding, graze competition to a height of 3 inches at least 4 to 6 weeks prior to the first frost date.
     - To decrease competition with the permanent sod, graze cool season annuals intensively as they begin to approach maturity and the permanent species begin to grow.

APPENDIX 2 - RESTING OR DEFERRING GRAZING LAND FOR A PRESCRIBED PERIOD

1. **General**

   Rest implies non-grazing for a full year or longer while deferment implies non-grazing for less than a year.

   All domestic livestock must be excluded when a management unit is being rested or deferred. All exotic animals must be excluded when management of such can be accomplished. In large grazing units where spacing between water points exceed 2.5 miles, deferment requirements can be met by manipulating accessibility to these water points.

   Grazing must be excluded for a long enough time during the growing season to adequately meet the objectives. On well established perennial warm and cool season grasses and legumes, deferment periods of 21 to 45 days during the growing season are usually adequate for plants to recover from grazing periods that do not exceed 7 to 10 days in length. The length of rest or deferment periods is governed by the kinds, growth habits, and growth stages of the forage plants concerned and seasonal climatic conditions.

   Perennial Warm Season Plants

   - To improve vigor and produce seed: From spring green-up until first killing frost.
   - To promote short and mid-grass seed production, defer from spring green-up until seed maturity. For tall-grasses, defer for 90 days prior to average killing frost.

   Perennial Cool Season Plants

   - To improve vigor and produce seed: From fall green-up until seed maturity.
   - For seed production only where vigor is good: From spring growth until seed maturity.
   - To improve vigor: Either from fall green-up until December 1 or from spring growth until seed maturity.

2. **Deferring Grazing On Grazed Range to Improve Similarity Index and on Grazed Forest and Native Pasture to Improve Forage Value Rating.**
   - a. Where the rangeland Similarity Index is 25 percent or less, or the forage value rating is low, use a full growing season deferment initially. Defer during a spring or fall period every 2 years thereafter until the rangeland similarity index is greater than 25 percent or the forage value

rating is moderate. Successive deferment periods are needed when the vigor of the plants is very low and the climax plants on rangeland comprise less than 20 percent of the total composition.

b. Rangeland Similarity Indexes of 26 to 60 percent or a forage value rating of moderate will receive a minimum of 90 consecutive days of deferment during the growing season every 3 years.

c. Rangeland similarity indexes of above 61 or a forage value rating of high will receive a minimum of 90 consecutive days of deferment during the growing season once every 4 years.

d. A prescribed grazing sequence that provides adequate deferment periods each growing season may be used to accomplish A, B, and C above.

3. **Deferred Grazing Following Brush Management (314) without seeding**

All livestock will be removed from the management unit at the beginning of treatment. Deferment period will begin when treatment(s) are completed.

a. The treatment area will receive a minimum of 90 days deferment during the growing season. If control is done less than 90 days before first killing frost, the area will be deferred the remainder of the growing season and the area will also receive a 90 day deferment the next year following spring green-up. A deferment period during the second growing season will be based on the recovery needs of the plant community.

- When **slow acting**, **soil applied herbicides** are used, the area will be deferred from the time of the first visual signs of chemical activity through the remainder of the first growing season.
- Shorter deferment periods may be allowed based on a **documented technical determination** that key plants are fully recovered.
- For Chemical broadcast or individual plant treatment, deferment may be waived based on a **documented technical determination**. If using chemical application follow label grazing restrictions.
- A short duration type of grazing system may be used to manage the released species for improved vigor and upward trend.
- Deferment periods may be longer than 90 days if deemed necessary in order to improve rangeland similarity index, plant vigor or rangeland health.

4. **Deferred Grazing Following Range Planting (550) or Forage and Biomass Planting (512)**

All Grazed Range seeded areas will be deferred the first growing season following seeding and if necessary the second growing season. Further deferment periods during succeeding growing seasons may be necessary to establish or increase the stand. Light grazing may be possible during the first dormant season if plants are sufficiently established (well rooted and numerous mature seedheads) so that they will not be damaged.

On Pastureland, defer until plants reach minimum grazing heights as listed in Table 1 in the "Minimum Heights Prior to Grazing Inches" and are well established.

Flash grazing by livestock may be used to control competing annual grasses and forbs at a time when they are vulnerable but not to exceed a two week period. Flash grazing will not be used past July 15, when soils are wet, nor when hoof action will compact the soil or damage seedlings. If there is damage to seedling plants, flash grazing shall cease immediately.

5. **Wildlife Benefit**

Livestock grazing can be used as a tool to manipulate habitat to benefit wildlife. When the primary goal is to benefit wildlife through grazing, refer to the Upland Wildlife Habitat Management (645) and applicable Zone supplement(s) for habitat requirements for the species of interest. Grazing and deferment periods shall be designed to result in the desired structure and plant composition for the targeted wildlife.

6. **Weed Impaired Grazing Land**
   If herbaceous weeds are a resource concern controlled, concentrated grazing/browsing by the appropriate kind and class of animals can be used for short periods during the time that the weeds are the most vulnerable. These use periods should be followed by a deferment period for recovery of the desired plant community.

7. **To Manage Fine Fuel Loads**
   Defer for 90 consecutive days in the spring or fall to accumulate fuel. In semi-arid and arid climates, rest for a full year to accumulate fuel, and maintain continuity. The Prescribed Burning Standard and Specification (338) has criteria on fuel loads.

   To remove excessive or hazardous fuel loads, one-time use of grazing can be done if minimum ground cover (surface litter) is maintained, refer to Appendix 1C. (Refer to Firebreak (394).

8. **Following Wildfires, Insect Damage, Severe Drought or Similar Damage**
   Rest or defer until the vegetation has made adequate recovery.

9. **Following a Prescribed Burn**
   Defer a minimum of 90 days following spring green-up after the burn. An exception is where livestock are used as a tool to manipulate plant communities.

10. **Grazed Forestland**
    Exclude livestock from all areas of desirable hardwood reproduction until trees have reached a size that cannot be significantly damaged by browsing animals.

    Livestock must be excluded from pine and hardwood plantings for at least three years after planting or seeding or until the apical meristem is above the grazing height of the livestock species. Exclude goats and sheep from pine reproduction until trees are 8 feet tall.

11. **Annual Cool Season Legumes**
    To allow clovers the best chance to provide seed for next year, they must be deferred for 2 to 4 weeks toward the end of their production period. General deferral dates for some commonly planted clovers are as follows:

Arrowleaf clover	5/1 - 6/15
Crimson clover	4/1 – 5/15
Ball clover	4/15 – 5/15
Subterranean clover	4/1 – 5/15
Rose clover	5/1 – 6/15
Vetch	5/1 – 6/15
Singletary peas	5/1 –6/15

12. **Types of Prescribed Grazing**
    There are several general types of grazing management methods or strategies. Refer to the National Range and Pasture Handbook, Chapter 5, for examples.

Appendix 3 - CRITERIA FOR GRAZED CROPLAND

General

Grazing of cropland comprises two types of situations.

One is using a growing crop, and the other is grazing crop stubble or residue.

Grazing of all crops must be managed so that adequate crop residues remain to meet the soil loss tolerance values using current NRCS measurement criteria.

Cover Crops

No grazing should occur until plants are well established. Adequate residue should be left and maintained in order to meet cover crop objectives. High stock density grazing is the preferred grazing system, to allow uniform utilization, adequate incorporation of organic matter, and reduced soil compaction.

Forage sorghums

Rotational grazing will provide more grazing days per acre than continuous grazing. Most uniform grazing and least waste are achieved when the plant reaches 20 to 28 inches in height. Best regrowth is obtained if grazing is suspended when 6 to 8 inches in height remain with some succulent plant parts with buds left. A thin culmed sorghum or pearl millet recovers more rapidly and can tolerate closer grazing than do those with thicker culms.

The young plants and leaves of sorghum, sudangrass and Johnsongrass contain the highest concentration of a glycoside called dhurrin, which releases a poisonous substance known as prussic acid or hydrocyanic acid (HCN) upon breakdown. Growth after dry, hot or cold (frost) weather, trampling or other stress results in toxic levels of cyanide or prussic acid. Losses of cattle, horses, sheep and goats can occur when grazing plants in this condition.

Reduce risk from prussic acid poisoning using these management practices:

1. Do not put hungry animals on stressed plants.
2. Delay grazing of sorghum or sorghum-cross plants until at least 15 inches tall.
3. Do not graze below 6-8 inches to maintain vigor.
4. Do not graze when plants are drought stressed and growth is severely reduced.
5. Do not graze wilted plants or plants with young tillers.
6. Do not graze for two weeks after a non-killing frost.
7. Do not graze after a killing frost until plants are dry. (The toxin is usually dissipated within 48 hours).
8. Do not graze at night when frost is likely.
9. Poisoning is less likely to occur if the animals eat some ground grain before being turned in on susceptible pasture.
10. Test forages to remove doubt.
11. Graze in the afternoon when HCN levels are reduced.

    Nitrate poisoning can also occur on heavily fertilized sorghums. Nitrate accumulation in plants is worse during cloudy weather or other conditions where nitrate assimilation by the plant slows down. Rations high in carbohydrates will reduce and sometimes prevent losses from nitrate poisoning. The forage should be tested if problems are suspected.

Small grains (wheat, triticale, barley, rye)

Initiate grazing on small grains when the plants are about 8 inches in height, fully tillered, and have a well developed coronal root system. This generally occurs 6 to 8 weeks after germination with adequate fertility and moisture conditions.

If the objective of the client is to have fall grazing of small grains, it is essential to plant during the last week in August or the first week in September. October planting dates offer unreliable fall grazing.

Grazing management strategies of winter small grains pasture occur in two different phases: a “fall & winter phase” and a “spring phase”. The fall and winter phase is characterized by using accumulated forage, while the spring phase is dependent upon growth that can be described as very rapid over a short period with decreasing forage quality at the end of the grazing period. During the spring phase, the stocking rate and individual animal performance can be greater than in the fall and winter phase.

“Fall and Winter Phase”

The fall and winter phase of grazing generally occurs from November 1 through March 1. This phase of grazing relies on stockpiled forage. Stocking rates should be calculated by determining the amount of forage available at the time grazing is initiated, estimating any additional growth, account for residual ground cover, determine the number of days the forage is to be grazed, and calculate the animal demand.

During the fall and winter phase, rotational grazing with 4 - 6 grazing units will increase forage production over continuous grazing. Strive to remove only 25 to 30 percent of the available forage during any one grazing period. This allows the grazing unit time to recover from animal impact and leaves adequate ground cover to maintain warmer soil temperature and trap moisture.

“Spring Phase”

This phase generally occurs from March 1 through May 15. During this phase, manage for regrowth potential rather than stockpiled forage. Stocking rates should be calculated by determining the amount of forage available, estimating the growth anticipated from residual nitrogen plus the growth expected from a spring topdressing of nitrogen, determine the number of days the forage is to be grazed and calculate the animal demand.

For grazing management on small grains, multiple grazing units are desired over single grazing units.

Considerations for grain production of grazed small grains

If grain harvest is desired, grazing should be terminated when the stems begin to elongate (the first hollow stem can be identified above the crown in larger ungrazed shoots). This is the earliest portion of the jointing stage. For each day the wheat is grazed after the appearance of the first hollow stem, grain yields are significantly reduced.

'ABLE 1 – GRAZING USE HEIGHTS AND GROWTH CYCLES – for Pastureland

Species	Minimum Heights Prior To Grazing Inches	Minimum Use Heights For Season Long Grazing Inches	Minimum Use Heights For Rotational Grazing Inches	Growth Cycles for Forage Recovery[1] Days	
				Fast Growth	Slow Growth
Sod-forming				April-June	July-Sept.
Bermudagrass: Common	6	4	3	14-28	28-42
Bermudagrass: Hybrid	6	4	3	14-28	28-42
Bahiagrass	6	4	3	14-28	28-42
Dallisgrass	6	4	3	14-28	28-42
Mid Height – Native Warm Season				April-June	July-Sept.
Sideoats grama	6	5	4	21-28	28-60
Mid Height – Native Cool Season				Mar.-June	Nov.-Mar
Wheatgrass, Western	6	5	4	21-28	28-60
Mid Height – Introduced Warm Season				April-June	July-Sept.
Bluestems: Caucasian, Plains, Ganada, K.R., Old World T-587, B. Dahl	8	6	4	21-28	28-60
Kleingrass	8	6	4	21-28	28-60
Lovegrass: Weeping, Common, Morpa, Ermelo, Wilman	8	6	4	21-28	28-60
Mid Height – Cool Season				Mar.-June	Nov.-Mar.
Tall Fescue	6	6	4	21-28	28-60
Wheatgrass, Tall	8	6	4	21-28	28-60
Texas Wintergrass	6	6	4	21-28	28-60
Wildrye, Virginia and Canada	8	8	6	21-28	28-60

Species	Minimum Heights Prior To Grazing Inches	Minimum Use Heights For Season Long Grazing Inches	Minimum Use Heights For Rotational Grazing Inches	Growth Cycles for Forage Recovery[1] Days	
				Fast Growth	Slow Growth
Tall Height				April-June	July-Sept.
Bluestems: Sand & Big, Little	12	8	6	21-28	28-60
Indiangrass: Cheyenne & Lometa	12	8	6	21-28	28-60
Switchgrass: Blackwell & Alamo	12	8	6	21-28	28-60
Eastern gamagrass	12	8	6	21-28	28-60
Johnsongrass	12	8	6	21-28	28-60
Sacaton: Alkali, Common, Saltalk	12	8	6	21-28	28-60
Legumes – Warm Season				April-June	July-Sept.
Alyceclover	12	8	6	21-28	28-60
Lespedeza	8	6	4	21-28	28-60
Bundleflower	6	6	4	21-28	28-60
Sweet Clover	8	6	4	21-28	28-60
Legumes – Cool Season				Mar.-May	Dec.-Feb
Clover: Ball, White, Berseem, Bur, Crimson, and Arrowleaf	6	4	3	14-21	21-42
Vetch	6	4	3	14-21	21-42

ength of recovery period is influenced by the severity of grazing use, growing conditions (moisture and temperature), and growth habit of the forage species.

APPROVAL AND CERTIFICATION

Prescribed Grazing

(AC)

CODE 528

PRACTICE SPECIFICATIONS APPROVED:

s/ Jeff Goodwin 10/1/2015

State Rangeland Management Specialist Date

/s/ Kristy Oates 10/1/2015

State Resource Conservationist Date

Reviewed By:
Zone Rangeland Management Specialists
State Office Specialists

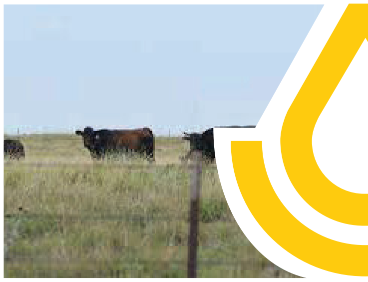
Specific Site Requirements

USDA United States Department of Agriculture

TX-528 IR-1

Practice Implementation Requirement Sheet

Prescribed Grazing (Acre) Code 528



Client Name: Multicultural Refuge Coalition County: Travis

Plan Name: EQIP-CIC Farm/Tract: Tract 8569 Field(s): 2

Contract: 747442226ES CIN(s): 6, 12, 18, 24, and 30

PURPOSE(s): check all that apply

☐ Improve or maintain desired species composition, structure and/or vigor of plant communities.
☐ Improve or maintain quantity and/or quality of forage for grazing and browsing animals' health and productivity.
☐ Improve or maintain surface and/or subsurface water quality and/or quantity.
☐ Improve or maintain riparian and/or watershed function.
☑ Reduce soil erosion and maintain or improve soil health.
☐ Improve or maintain the quantity, quality, or connectivity of food and/or cover available for wildlife.
☐ Manage fine fuel loads to achieve desired conditions.

Job Class	Number of Vegetation Types[2] / Number of Pastures / Scope (Number of Herds)
Job Class I	1 Vegetation Type / ≤ 4 Pastures / 1 Herd
Job Class II	≤ 2 Vegetation Types / ≤ 7 Pastures / ≤ 3 Herds
Job Class III	≤ 4 Vegetation Types / ≤ 12 Pastures / ≤ 5 Herds/ Wetland or wet meadow
Job Class IV	≤ 6 Vegetation Types / ≤ 15 Pastures / ≤ 6 Herds
Job Class V	Unlimited/ Noxious Invasive Species/ Annuals

[2]Refer to ESJAA fact sheet for vegetation types

NRCS will:

☑ Assist producers with a current forage inventory that will result in forage animal balance.
☑ Assist in the design of a planned grazing system.
☑ Provide technical guidance based on the prescribed grazing standard.
☑ Provide the producer a copy of the planned area where prescribed grazing is to be applied on a location map.
☑ Provide producer an assessment of their current management system and guidance regarding needed changes.
☑ Assist the producer in determining where to locate monitoring points.
☑ Provide support documentation and technical assistance with respect to the associated management practice implementation, (i.e. CPS-645 Upland Wildlife Habitat Management).
☑ Certify the installation of the practice upon notification of completion and receipt of documentation, if required, and ensure installed practice meets NRCS practice standard and specifications.

PARTICIPANT will:

☑ Apply practice in accordance with TX-528 IR provided by NRCS.
☑ Balance livestock with available forage based on a current forage inventory.
☑ Develop and implement, when necessary, a drought contingency plan.
☑ Monitor key grazing sites for plant recovery or utilization.

☑ Notify NRCS upon completion of practice implementation.
☑ Provide any documentation (written records or documentation on number of animal units, dates when herd(s) were moved, and pastures which were grazed or deferred) required for NRCS to certify the conservation practice.
☑ Certification will be at the beginning of the next growing season unless other certification options are warranted.

NRCS Review Only

Designed by: CHIANA PALMER Digitally signed by CHIANA PALMER Date: 2022.08.19 13:28:47 -05'00' **ESJAA:** ______ **Date:** 8/19/22

Reviewed by: ______ **ESJAA:** ______ **Date:** ______

Approved by: MATTHEW MACHACEK Digitally signed by MATTHEW MACHACEK Date: 2023.02.16 06:30:22 -06'00' **ESJAA:** V **Date:** 2/16/23

Refer to plan map for treatment area(s): ☑ **See Attached** **Project job class:** I

Is this DEFERMENT only? ☐ **Yes** ☑ **No**

[1]Planned deferment: **total days:** ______ **Dates - from:** ______ **to:** ______

[1]Applied deferment: **total days:** ______ **Dates - from:** ______ **to:** ______

Description of required deferment:

Is this a treatment for another practice? ☐ **Yes** ☐ **No**

☐ CPS-314 Brush Management
☐ CPS-315 Herbaceous Weed Treatment
☐ CPS-645 Upland Wildlife Habitat Management
☐ Other: ______

Description of work:

CIN/Field Number	Planned Acres	*Applied Acres	Meets Prescription[1]
			--
			--
			--
			--

***for practice certification**

Prescribed Grazing Plan: (attach/include the following) ☑ **Yes** ☐ **No**

☑ Ecological sites identified.

☑ Forage inventory of the expected forage quality, quantity, and species in each field.

☑ Forage-animal balance developed for the grazing plan that ensures forage produced or available meets forage demand of livestock and/or wildlife.

☑ Animal inventory:

Type: Chickens

Number: 175

Animal Unit Equivalent (AUE): 0.01/head

Total AUs: 1.75

☑ Planned number of grazing cycles: 1 Actual: ____________

☑ Planned days of rest/recovery for each field: 15 Actual: ____________

☑ Monitoring plan attached

☑ Contingency plan(s) attached

***Add additional sheets, if needed**

Additional notes to properly apply this practice:

The correct stocking rate is the most important consideration in grazing management. No grazing system will improve grazing lands if the stocking rate is too high.
Supplemental feed and/or mineral requirements should be balanced with the forage quality to meet the desired nutritional level for the kind and class of grazing livestock. Forage and/or fecal testing from reputable laboratories are reliable tools to determine these requirements. Schedule livestock movements based on plant physiological stage, available forage, utilization and livestock nutritional needs. Grazing must be excluded for a long enough time during the growing season to adequately meet the objectives. On well established perennial warm and cool season grasses and legumes, deferment periods of 21 to 45 days during the growing season are usually adequate for plants to recover from grazing periods that do not exceed 7 to 10 days in length. The length of rest or deferment periods is governed by the kinds, growth habits, and growth stages of the forage plants concerned and seasonal climatic conditions. The producer has a mobile coop that they sleep and lay in that is 8x24 ft. The hens are kept in an area that is 50x100 ft. we rotate them to new ground once a month. There will be about 43 paddocks that are 5,000sq ft.

CERTIFICATION

I certify the implementation of this conservation practice is complete and meets NRCS conservation practice standard and specifications. This practice will meet the intended purpose and should last the expected lifespan.

Planner: ________________________ **ESJAA:**____________ **Date:** ____________

	Acres				**Planned** % or residual height of key species at end of grazing season	**Actual** % or residual height remaining				
Unit	Planned	Applied	Location of key site	Key species		20	20	20	20	20
2	5		field 2	Native grasses	4 inches					

Monitoring and drought:
April 1:

- Residue left in pastures should average between 4____ and 6_____ inches in height equaling roughly 9,360 lbs. of forage per acre. (Adequate residue is needed to assure proper soil protection, improve infiltration from precipitation events, and provide the ability to conduct a prescribed burn. More residue may be required to fuel some prescribed burns.)
- Precipitation received since November 1 typically averages 3____ inches (roughly _____% of total).
- If either condition is not met, adjustments to animal numbers may need to be adjusted at this time.

DECISION(S):

June 15:

- About 80_____% of the total annual forage production has occurred. (Determining forage production on this date allows an opportunity to adjust animal numbers based on actual current year's growth instead of estimates or averages.)
- Precipitation received since November 1 typically averages 4______ inches (roughly _____% of total).
- Animal numbers may need to be adjusted up or down depending on soil moisture, precipitation forecasts, and available forage. (Example: If average annual production is 4000 lbs./ac and on June 15 we determine that 1500 lbs. of forage has been produced, we can predict that annual production will be 3000 lbs./ac and pasture is overstocked if based on average conditions.)

DECISION(S):

July 15:

- About 90____% of the total annual forage production has occurred. Begin estimating end of season residue amounts.
- Precipitation received since November 1 typically averages 2____ inches (roughly ______% of total).

- Limited precipitation or heavy grazing past this date may reduce recovery of desirable grasses and may affect next year's stocking plan.

DECISION(S):

August 15:

- 100 % or more of the total annual forage production (leaf area) has occurred. (Warm season grasses are preparing for next year's growing season and rest from now until frost will greatly benefit their vigor.)
- Precipitation received since November 1 typically averages 2 inches (roughly _____% of total). Below average precipitation in the months of July and August will result in slow recovery.
- Available forage measurements should be calculated, and grazing herd days estimated to allow for end of season residue levels. Adjustments to animal numbers should be implemented to attain grazing prescription objectives.

DECISION(S):

November 1:

- End of growing season (no significant forage growth occurs after this date). Remember April 1st residue goal if winter grazing will occur.
- Less than 80% of the average annual precipitation indicates the beginning of a drought for next season unless the winter is exceptionally wet.
- Measure available forage and calculate winter grazing herd days. Evaluate grazing prescription objectives for next year.

DECISION(S):

Proper Stocking Rate Estimate Using Rangeland Analysis Platform (RAP) Rangeland Production Data

Client: Multicultural Refuge Coaliton-Chicken Rotation
Land unit:

The following responses were provided to generate this stocking rate report:

What is the number of acres of the land unit?
5 acres

What is the animal type that will be grazing the land unit?
10 pounds (lbs)

What is the average intake (% of body weight) that the animal consumes each day?
3% of live body weight

How many days will the livestock be grazing this land unit?
30 days

What is the expected harvest efficiency (%) for the grazing system planned?
25% harvest efficiency

What is the adjustment factor for influence of topographic slope and distance to water?
100%

Table 2: Annual summary data

Year	Herbaceous production (lbs/acre)	Percent perennial production	Percent annual production	Estimated total animals for proper stocking	Estimated acres per animal
2021	5135	87%	13%	713	0.01

NOTE: The vegetation biomass data and maps from RAP are intended to be used alongside local knowledge and on-the-ground data to inform management actions that improve rangelands and wildlife habitat. They should not be used in isolation to quantify rangeland resources, determine or define thresholds, or evaluate the efficacy of management practices or treatments. Data can be used to evaluate resources in concert with site-specific information about the area under investigation, such as past land management practices, vegetation treatments, conservation efforts, or natural disturbances.

NOTE: Summary statistics reported in Table 1 and Figure 1 calculated for long-term average period of 2021-2021

Table 1: Summary statistics

	Average	Lowest value	Highest value	Range
Production (lbs/acre)	5,135	5,135	5,135	0
Stocking rate (animals)	713	713	713	0

Land unit map

Figure 1: Herbaceous Biomass Production (lbs/ac) from RAP

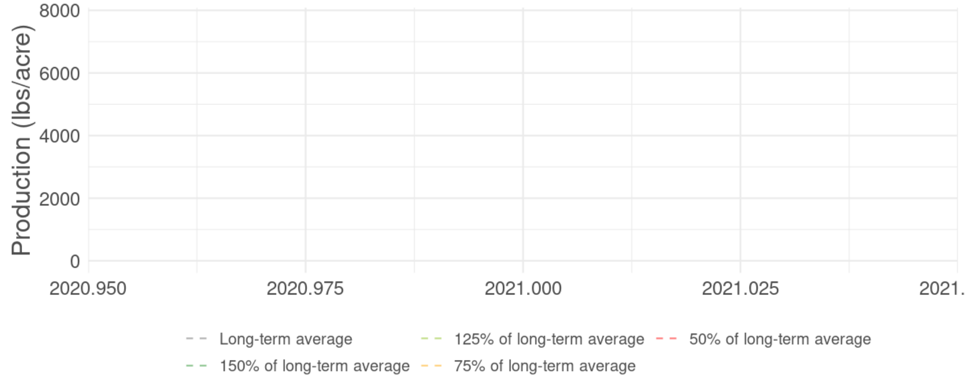
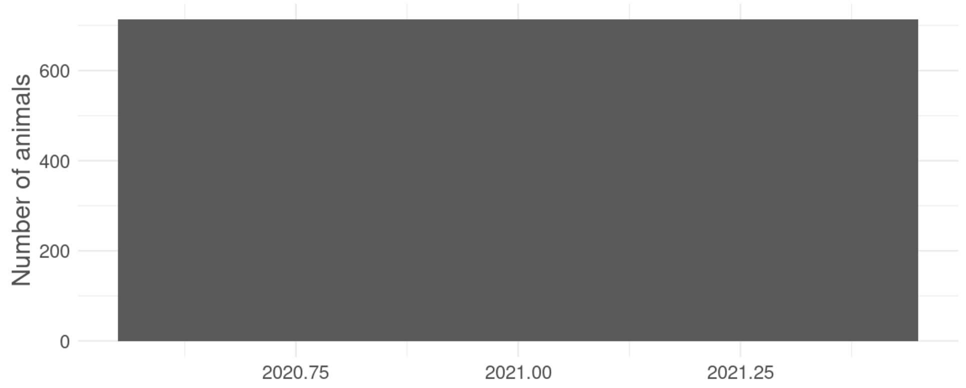


Figure 2: Estimated number 10 lb animals grazing 30 days and consuming 3% of body weight daily



Details of the Stocking Rate Calculations Using Average (2021-2021) Biomass Production

Land Unit:

1) Determine the Forage Available in the Fields

Acres in Field(s)		Forage Dry Matter Production (Lbs per Acre)		Total Lbs of Forage Dry Matter in Field(s)		Harvest Efficiency (%)		Available Lbs of Forage Dry Matter in Field(s)
5	X	5,135	=	25,676	X	25%	=	6,418

2) Determine the Individual Animal's Forage Demand for Grazing Event

Average Live Weight of each Grazing Animal (lbs)		Forage intake Rate (% of body weight per day)		Forage Dry Matter Demand per Head per Day (lbs)		Number of Planned Grazing Days		Forage Dry Matter Demand per Head per Grazing Event (lbs)
10	X	3%	=	0.2999999999999999888978	X	30	=	9

3) Determine the Suggested Number of Head

Available Lbs of Forage Dry Matter in Field(s)		Forage Dry Matter Demand per Head per Grazing Event (lbs)		Adjustment factor for water availability and slope		Suggested Number of Head		Suggested Acres per Head
6,418	/	9	x	100%	=	713	OR	0.01

Proper Stocking Rate Estimate Using Rangeland Analysis Platform (RAP) Rangeland Production Data

Client:
Land unit: Chicken Grazing Area

The following responses were provided to generate this stocking rate report:

What is the number of acres of the land unit?

9.31 acres

What is the animal type that will be grazing the land unit?

10 pounds (lbs)

What is the average intake (% of body weight) that the animal consumes each day?

3% of live body weight

How many days will the livestock be grazing this land unit?

30 days

What is the expected harvest efficiency (%) for the grazing system planned?

25% harvest efficiency

What is the adjustment factor for influence of topographic slope and distance to water?

100%

Table 2: Annual summary data

Year	Herbaceous production (lbs/acre)	Percent perennial production	Percent annual production	Estimated total animals for proper stocking	Estimated acres per animal
2019	3318	88%	12%	858	0.01
2020	4243	78%	22%	1097	0.01
2021	4503	86.7%	13.3%	1165	0.01

NOTE: The vegetation biomass data and maps from RAP are intended to be used alongside local knowledge and on-the-ground data to inform management actions that improve rangelands and wildlife habitat. They should not be used in isolation to quantify rangeland resources, determine or define thresholds, or evaluate the efficacy of management practices or treatments. Data can be used to evaluate resources in concert with site-specific information about the area under investigation, such as past land management practices, vegetation treatments, conservation efforts, or natural disturbances.

NOTE: Summary statistics reported in Table 1 and Figure 1 calculated for long-term average period of 2019-2021

Table 1: Summary statistics

	Average	Lowest value	Highest value	Range
Production (lbs/acre)	4,021	3,318	4,503	1,185
Stocking rate (animals)	1,040	858	1,165	307

Land unit map

Figure 1: Herbaceous Biomass Production (lbs/ac) from RAP

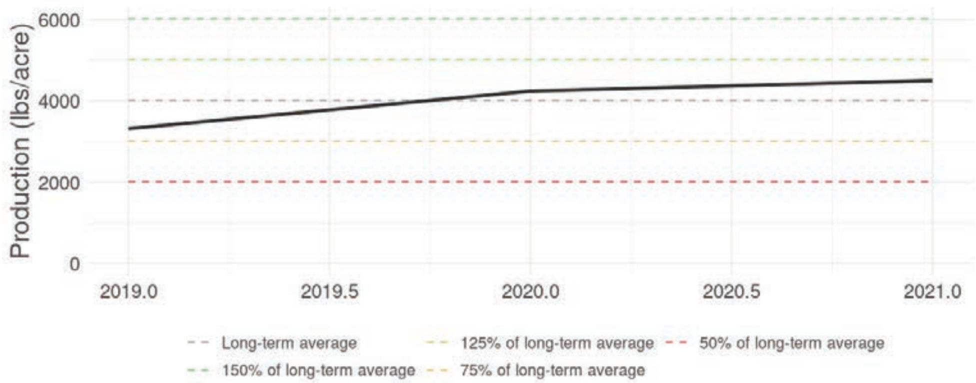
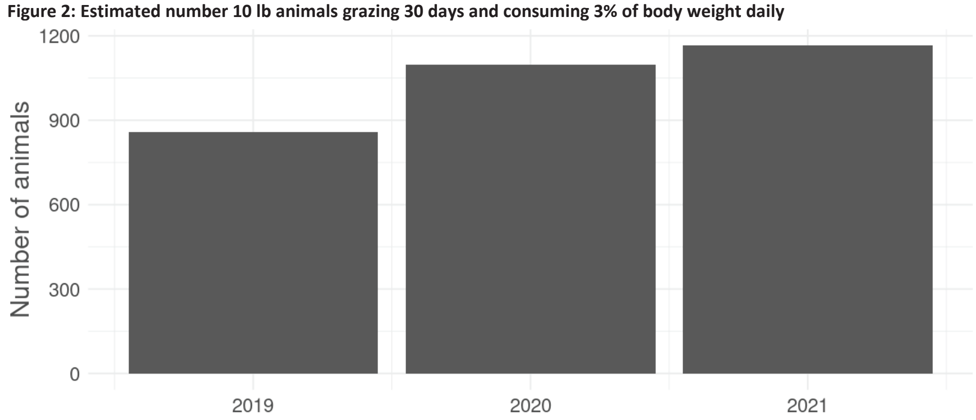


Figure 2: Estimated number 10 lb animals grazing 30 days and consuming 3% of body weight daily



Details of the Stocking Rate Calculations Using Average (2019-2021) Biomass Production

Land Unit: Chicken Grazing Area

1) Determine the Forage Available in the Fields

Acres in Field(s)		Forage Dry Matter Production (Lbs per Acre)		Total Lbs of Forage Dry Matter in Field(s)		Harvest Efficiency (%)		Available Lbs of Forage Dry Matter in Field(s)
9.31	X	4,021	=	37,438	X	25%	=	9,360

2) Determine the Individual Animal's Forage Demand for Grazing Event

Average Live Weight of each Grazing Animal (lbs)		Forage intake Rate (% of body weight per day)		Forage Dry Matter Demand per Head per Day (lbs)		Number of Planned Grazing Days		Forage Dry Matter Demand per Head per Grazing Event (lbs)
10	X	3%	=	0.2999999999999999888978	X	30	=	9

3) Determine the Suggested Number of Head

Available Lbs of Forage Dry Matter in Field(s)		Forage Dry Matter Demand per Head per Grazing Event (lbs)		Adjustment factor for water availability and slope		Suggested Number of Head		Suggested Acres per Head
9,360	/	9	x	100%	=	1,040	OR	0.01

Historical (2020-2021) Production Report using Rangeland Analysis Platform (RAP) data

Land unit name: Multicultural Refuge Coalitionn
Date of report: August 19 2022
Long-term period: 2020-2021

Land unit map

Long-term averages

Average annual production	5042 lbs/acre
150% of average annual production	7563 lbs/acre
125% of average annual production	6302 lbs/acre
75% of average annual production	3782 lbs/acre
50% of average annual production	2521 lbs/acre

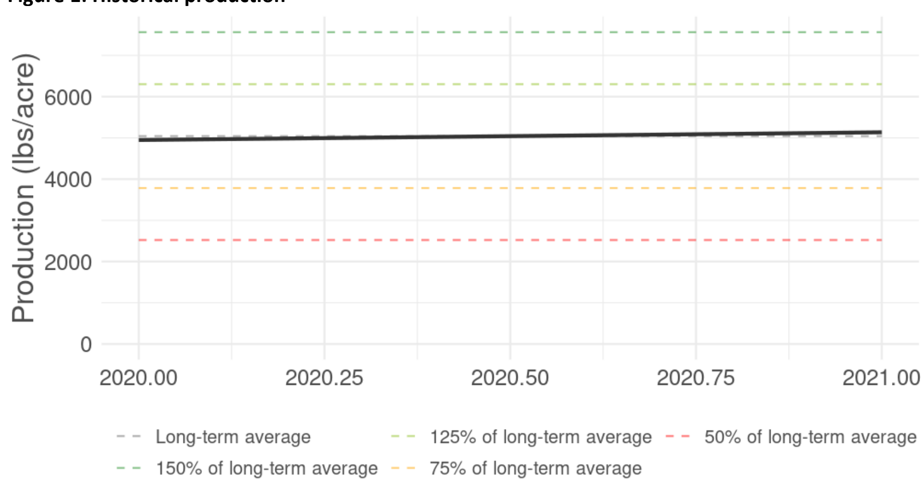
gSSURGO production estimates

Normal	5966 lbs/acre
Favorable	7017 lbs/acre
Unfavorable	3810 lbs/acre

Table 1: Historical data

Year	Annual production (lbs/acre)	Percent of average
2020	4948	98.1%
2021	5135	101.9%

Figure 1: Historical production



Current Year (2022) Production Report using Rangeland Analysis Platform (RAP) data

Land unit name: Multicultural Refuge Coalitionn
Date of report: August 19 2022
Long-term period: 2020-2021

Land unit map

Current year

Production through Jul 27 of 2022:	2343lbs/acre

Long-term averages

Average production through Jul 27:	3249lbs/acre
150% of average production through Jul 27:	4874lbs/acre
125% of average production through Jul 27:	4061lbs/acre
75% of average production through Jul 27:	2437lbs/acre
50% of average production through Jul 27:	1624lbs/acre

Table 1: Current year data

Date	16-day production (lbs/acre)	Cumulative production (lbs/acre)	Percent of average
01/01/2022	0	0	NA%
01/16/2022	55	55	74.32%
02/01/2022	61	116	63.74%
02/17/2022	68	184	62.37%
03/05/2022	90	274	58.17%
03/21/2022	152	426	59.92%
04/06/2022	253	679	69.07%
04/22/2022	228	907	70.58%
05/08/2022	247	1154	72.53%
05/24/2022	254	1408	75.42%
06/09/2022	266	1674	75.64%
06/25/2022	223	1897	73.16%
07/11/2022	225	2122	72.65%
07/27/2022	221	2343	72.11%
08/12/2022			
08/28/2022			
09/13/2022			
09/29/2022			
10/15/2022			
10/31/2022			
11/16/2022			
12/02/2022			
12/18/2022			
12/31/2022			

Figure 1: 16-day production plot

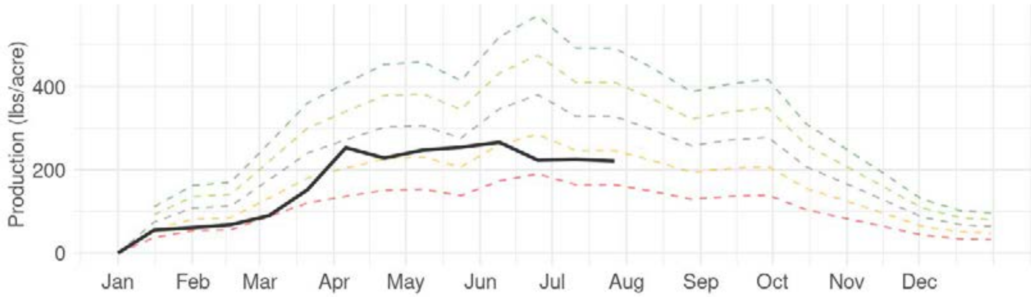
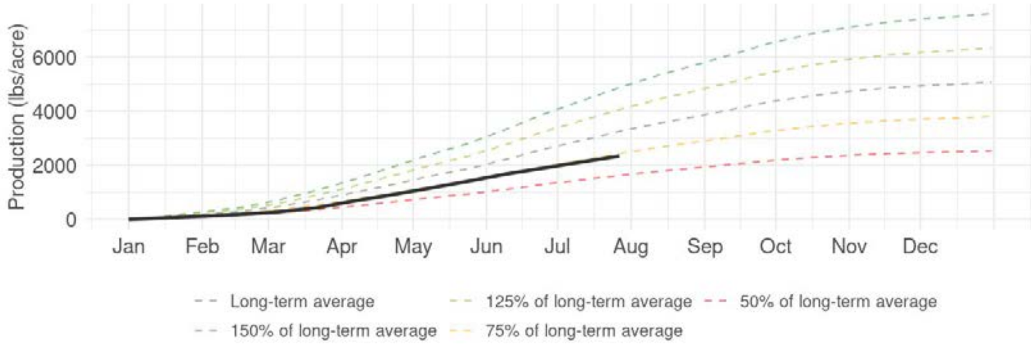


Figure 2: Cumulative production plot



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Pastured Poultry Nutrition and Forages

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This publication explores the important role that forages play in pastured poultry production for either meat or egg production. Research on the effects of raising poultry on pasture has increased greatly in recent times, with an ever-growing body of scientific work. This publication pays special attention to the nutritional benefits of poultry foraging on pasture: regarding both the birds' health and the impact that forages have on the nutritional and flavor qualities of the meat and eggs.

Laying hens, both commercial and heritage breeds, are enthusiastic foragers on pasture. Photo: NCAT

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Introduction: Forage's Historical Role in Poultry Rations

Raising poultry on pasture is a time-established method of farming quality chickens, turkeys, waterfowl, and other poultry. Historically, before the maturation of poultry nutritional science and the widespread availability of balanced rations, forages were an important component of poultry diets. Access to vegetation was a way of providing a multitude of critical vitamins and minerals, many unknown until the middle of the 20th century, to meet a flock's nutritional needs. The importance of the vegetation that poultry consumed while on pasture can be seen in the following excerpt from a 1930 poultry-production textbook:

> "At all times of the year, an abundance of green feed is necessary. A lack of it is often a cause of ill health and low production. It acts as a tonic in functioning properly, securing for the bird a larger utilization of the feed consumed. The principal value, therefore, is in maintenance of health. The importance of abundance, as well as a variety, of green feed is seldom fully realized." (Rice and Botsford, 1930)

For hundreds of years, small farm flocks were allowed to roam and scavenge most of their diet from a farm's pastures, barnyards, orchards, and fields, with occasional supplementation from scratch grains and table and garden scraps. The leaves and seeds the birds ingested, as well as the insects that were quickly gobbled up (often full of freshly consumed plant matter), helped balance out any of the unknown deficiencies in the feed ration. Indeed, before the middle of the 20th century, forages were the only reliable source for necessary nutrients like vitamin A, critical in preventing devastating diseases.

As poultry farms grew larger as the 20th century progressed, the ways that farmers incorporated greens into the diets of their birds were as varied as the farmers themselves. Many farmers would let their flocks freely graze around the colony houses/coops where the hens lived and laid their eggs. Where climate, space, and economics allowed, other farmers would plant grains such as barley, oats, or winter wheat for the birds to graze while the grains were young and still appetizing. This practice was especially helpful in the winter, when few other forages were present. Similarly, some farmers managed poultry-friendly pastures—filled with ryegrass, clovers, or other highly palatable forages—for laying flocks. By midsummer, when the flocks had consumed most of the available forages and the invertebrate populations become scarce, greens or fodder crops would be supplied from a truck patch or even garden pickings. On many farms, greens—primarily kale —were grown specifically to harvest as poultry food. Reviewing old poultry accounts, one variety of kale is frequently referenced: 1,000-headed kale. This kale was prized by many poultry farmers over other greens due to its prolific and hardy nature. Plants could easily approach six feet tall, and the large leaves were harvested as needed in a "cut and come again" fashion.

Lavelle Donovan, who grew up on a poultry farm in California in the 1920s, recalls:

> "Chicken greens were kale or a low vine called rape which was cut with a scythe. I can still see my father in the kale patch. He'd pick a kale leaf and tuck it under his arm until he collected a bunch. Then he'd put the bunch in a burlap bag he dragged along tied to his waist. Then he chopped up the leaves with the kale cutter in the barn." (Lowry, 1993)

The larger and more confinement-based the farm, the more greens were needed. The largest farms grew at least a couple of acres of kale and other greens, usually transplanted by hand, for their poultry rations.

Other farmers used different strategies to get greens into their flocks when forages became scarce. Supplementing rations with green additions like alfalfa or grass meal (a strategy still well-advised today) was considered essential to provide sources of unidentified nutrients (Blair, 2008). Sprouted grains such as oats or wheat (see Appendix 1 – Oat Sprouter), or vegetables like kale and cabbage, were also fed to the flock at regular intervals. Feeding rootstocks like mangels (a type of large beet for livestock) or carrots during the winter, along with winter-hardy greens, was a routine practice, providing a nutritional boost and also helping to reduce excessive pecking in flocks during the winter by keeping the hens preoccupied.

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- Pastured Poultry Budgets: Slow Growing Broiler and Organic Comparisons
- Pastured-Raised Poultry Nutrition
- Range Poultry Housing

Advantages of Forage Consumption by Poultry

Feed Savings

Forages can provide a significant amount of poultry nutrition, reducing the amount of feed that a poultry farmer feeds a flock. Although poultry are NOT ruminants (they're omnivores), a good pasture is still a valuable resource for the flock. Jeff Mattocks, a livestock nutritionist with decades of experience in pasture-based and sustainable/organic farming, estimates that after "gathering data from year to year and producer to producer, I have come to the conclusion that pastured poultry eat 5-20% (of their diet) from pasture, depending on type and age of poultry, and the quality of forage growth" (2002).

In many areas, feed savings are typically greatest in the late spring and early fall, when lush pasture provides plenty of high-quality forages to offset a significant amount of the cost of feeding poultry. Additionally, insect and other invertebrate populations (poultry favorites) in the pasture are booming at the same time. The amount of plant forages consumed by the flock, or even an individual bird, depends on a variety of factors that will be further explored below.

Nutrition Source

The primary benefit of forage consumption is that plant matter is typically high in both vitamins and minerals. Besides the vitamins and minerals,

Turkeys are excellent foragers and will eagerly hunt for insects and palatable plants to consume on pasture. Photo: NCAT

forages also contain components such as fiber, protein, energy (calories), and other compounds like carentoids and Omega-3 fatty acids that are important for metabolic functions in all animals, especially humans. The specific benefits that poultry gain from forages are explored below for each nutritional group.

Vitamins

Vitamins are complex organic compounds required by animals for normal growth. Many of the vitamins added to modern-day poultry rations can lose their potency over time because they are not as shelf-stable as other components of the poultry ration. Pasture intake by poultry acts as a form of nutritional insurance, as the living forages provide a back-up "bank" of nutrition to prevent any vitamin deficiencies of the feed from affecting the birds.

Vitamins are classified as either water soluble or fat soluble. Fat-soluble vitamins dissolve in body fat and when excess vitamins are consumed, they are able to be stored in the liver and fatty tissues. The fat-soluble vitamins are vitamins A, D, E, and K. Forages are high in all the fat-soluble vitamins except D and are an important natural source of these nutrients for poultry. In confinement production, vitamin D must be added to the poultry ration to prevent the nutritional disease rickets. For pastured poultry production, however, vitamin D deficiency is not a problem because pastured poultry are exposed to ample amounts of sunshine and readily synthesize vitamin D in their skin. With access to plenty of forage and sunlight, poultry on pasture should not have problems with fat-soluble vitamin deficiencies.

With access to plenty of forage and sunlight, poultry on pasture should not have problems with fat-soluble vitamin deficiencies.

Water-soluble vitamins are not able to be stored in the body and need to be consumed regularly. The water-soluble vitamins include several important vitamins grouped together and collectively called the vitamin B complex, as well as vitamin C. Poultry can synthesize vitamin C in their own bodies, and generally don't need to supplement with dietary intake. The B vitamins consist of vitamins like riboflavin, folic acid, and B6, which are found in ample amounts in pasture vegetation. Vitamins such as niacin, thiamine, and B12 are found in animals (think insects) that poultry eagerly hunt on pasture. Some of the water-soluble vitamins are also produced by bacteria in a healthy poultry gut. Forage consumption plays a significant role in poultry gut health, as will be discussed in the "Fiber" section on page 5.

Poultry feed can often be deficient in vitamins A, D, riboflavin, and B12 due to the perishable nature of these vitamin sources in the feed. As mentioned above, pasturing poultry and giving them access to high-quality forages will help in balancing out any deficiencies. Forages are rich in vitamin A and riboflavin; when exposed to sunshine, a bird's body manufactures all the vitamin D the bird needs; and vitamin B12 can be supplemented by grasshoppers, crickets, worms, and other invertebrates (and the occasional vertebrate) that are commonplace in healthy pastures.

Minerals

Minerals are inorganic compounds, typically found as salts, that are critical for bone and eggshell formation in poultry, as well as important in many biochemical processes like hormone production and fluid balance in the bird's body. Many of the minerals needed by poultry can be supplemented by forages.

By far, the most common mineral deficiency is calcium, especially for laying hens. Calcium plays a critical role in poultry health, comprising approximately 70% of the mineral content in a bird. Calcium works hand-in-hand with phosphorous inside of the bird to build strong bones and eggshells. The calcium content of grains is very low, and typically sources like oyster shells, limestone, or calcium salts are added to feed. Forages can provide supplemental minerals, and the calcium found in plants like alfalfa is highly bioavailable. A bird's digestive system is able to utilize calcium from forages as efficiently as calcium from more common sources like limestone or oyster shell (Blair, 2008). Although pasture can supply around 25% (Horsted, 2006) of the calcium required by layers, it cannot serve as the long-term sole source of calcium. Good pasture with access to supplemental limestone or oyster shell, however, will provide all the calcium the flock needs.

Proteins

Proteins are used by animals to build muscles, organs, and all other tissues. Crude protein is a basic measure of what percentage of a particular feed item is protein. Proteins are comprised of amino acids, of which there are over a dozen types. An easy way to understand protein nutrition is to imagine crude protein as a completed wall made up of individual amino-acid bricks. Each type of amino acid is like a different type of brick, and each animal requires a completed wall (crude protein) with a certain pattern of amino acid bricks (i.e., particular types and numbers of amino acids). When looking at the crude protein of a food, it is important to understand that not all proteins are the same, and that different animals have different levels of amino acid requirements.

Of particular importance in raising poultry, there is one amino acid that can often be limiting: methionine.

Of particular importance in raising poultry, there is one amino acid that can often be limiting: methionine. In grains, methionine is found only in relatively low levels, and the best natural source for methionine is animal proteins – typically fish (fed as a meal), or insects and other animals found while ranging. In the modern poultry industry (including organic), most methionine is supplied in poultry diets by synthetically produced protein powders (the only way that so-called vegetarian poultry diets are possible).

Chickens and turkeys especially crave methionine. One sign of methionine deficiency is an increase in feather pecking or even cannibalism in the flock. One of the major advantages of allowing poultry to forage on pasture is that it allows the birds to hunt and eat insects and other invertebrates that they find while ranging, thus satisfying the bird's craving for animal protein. Indeed, research has demonstrated that even commercial Cornish Cross broilers are able to make up for some methionine deficiencies by consuming vegetation and insects on pasture (Mortiz et al., 2005; Horsted, 2006).

For decades, poultry farmers have noted that hens given access to pastures full of alfalfa and clover need less protein than hens raised in confinement. Experience has shown that hens purposefully fed protein-deficient diets increased their consumption of pasture forages compared to flocks fed a ration with adequate protein levels (Horsted, 2006). The same behavior was exhibited by broilers fed a protein-deficient diet (Eriksson, 2010). Horsted (2006) reported a 50% increase in forage consumption in hens fed a restricted diet of wheat and oyster shell compared to hens with access to a balanced layer ration. Similarly, poultry scientists have found that consumption of forages is inversely tied to protein levels – i.e., a higher protein content (methionine) in the feed ration can result in a lower amount of plant matter consumed on pasture (Heuser, 1955; Mortiz et al., 2005). A study in 2007 demonstrated that poultry are able to utilize the majority of the amino acids that they consume in forages, finding that the amount of methionine and lysine digested was 88% and 79% of the respective amount consumed (Buchanan et al., 2007;). Rivera-Ferre et al. found that broilers on pasture were able to meet around 7% of their protein needs from foraging (2007). For more information about methionine in poultry, consult the ATTRA publication *Organic Poultry Production: Providing Adequate Methionine*.

Among plants, the legume family is the king of protein production. Legumes are unique in the plant world because they house a group of bacteria called *Rhizobia* in their roots that are able to pull atmospheric nitrogen (which composes roughly 70% of the air we breathe) and are able to convert it as a nitrogen fertilizer source for the legumes. In return, the *Rhizobia* are able to get shelter, water, and sugars from the cells in the legumes' roots. The abundant nitrogen production of legumes leads to elevated levels of valuable nitrogen-rich protein in these plants. Legumes important in poultry production are soybeans and various field peas, as well as pasture forages like alfalfa, lespedeza, clovers, and vetches.

Energy

As mentioned previously, forages are poor sources of energy, but they still contribute some calories to fuel the bird's need for energy. Buchanan et al. (2007) reported that a chicken gains anywhere from 129 to 246 calories for each pound of forages consumed (or 285 to 542 kcal/kg) and Rivera-Ferre et al. reported that broilers raised on pasture got only 3% of their energy need from forages (2007). Yellow dent corn, the main supplier of energy in poultry rations, by comparison, supplies around 1,632 calories per pound (3,596 kcal/kg). While grains are obviously one of the most important sources of energy in poultry rations (along with oils), even the small amounts of energy supplied by forages are important when feed prices soar. Forages can play a small but key role in reducing the feed bill in a pastured poultry operation.

Fiber

Although fiber is often overlooked, research is increasingly showing that it is an important component of poultry diets. Fiber generally falls into two categories: digestible and indigestible. Both types have roles in maintaining a healthy poultry digestive system.

Digestible fiber is fiber that gets broken down by the bacteria in the bird's digestive tract. Digestible fiber is an excellent food source for beneficial bacteria like *Lactobacillus sp* and *Bifidobacteria*. Additionally, lactic acid and other beneficial compounds are produced as these beneficial bacteria ferment digestible fiber, stimulating gut health. The competitive presence of populations of these beneficial bacteria, as well as the lower pH resulting from the fermentation of the fiber, creates a difficult environment for the establishment of *Salmonella* and other pathogenic populations (Nurmi and Ratala, 1973; Esmail, 2012).

Indigestible fiber does not get broken down as it moves through the bird's gut. This type of fiber does, however, slow things down considerably by bulking up the food and helping the gut "grip" the feed. Indigestible fiber typically is very water-absorbent, and allows water more time to be absorbed by the digestive system, especially in the large intestines.

When evaluating the nutrition of a particular feed item, it is helpful to understand a few terms that involve fiber:

Crude Fiber (CF) – CF expresses the percentage of the feed item that is made of fiber, both digestible and indigestible.

Total Digestible Nutrients (TDN) – this term refers to the sum of all the digestible parts of a feed item, including fiber, fats, proteins, and carbohydrates. Expressed as a percentage, it represents

Table 1. Changes in Alfalfa Quality Due to Maturity

Alfalfa Stage of Maturity	% Total Digestible Nutrients	% Crude Protein	% Acid Detergent Fiber
Pre-Bud	65	21.7	28
Bud	62	19.9	31
Half Bloom	56	16	38
Full Bloom	54	15	40
Mature	52	13.6	42

Source: Nutrient Requirements of Dairy Cattle, 3rd edition. National Research Council. 1966.

Appropriate grass height encourages foraging and vegetation consumption by the flock. Photo: NCAT

what can be digested by the animal; the remainder is indigestible.

Acid Detergent Fiber (ADF) – refers to the indigestible plant parts, including cellulose and lignin, that make up the outer walls of individual plant cells and, on a larger scale, the walls of leaves and stalks.

When building poultry rations, the greatest concern associated with fiber is having too much in the diet, which can cause a drastic drop in poultry performance and health. It is advisable to stick with a ration recipe formulated by a poultry nutritionist, especially in confinement situations. Poultry have the ability to at least partially regulate fiber intake, as birds in confinement have been observed supplementing their fiber intake by eating wood shavings from the litter when fed a fiber-limited diet. With access to pasture, poultry are able to round out any fiber deficiencies on their own, especially if given a wide variety of forages to choose from. Grasses are more fibrous than legumes, and grasses often have two or three times the fiber concentration of legumes in similar growth stages (Buxton and Redfearn, 1997).

Forage Impacts on Poultry Meat and Egg Quality

One of the main marketing points that pastured poultry farmers use to sell their products is that their meat and eggs are different from those produced by confinement-based poultry. While some critics dismiss these claims, a multitude of customer experiences reinforces the claim that pastured poultry is indeed different.

As pastured poultry production fills an ever-larger niche, research is beginning to explore claims of different nutritive profiles for pastured eggs and meat. In the case of eggs, evidence is emerging that the poultry products from grass-fed flocks tend to have less cholesterol, more vitamins A and E, multiplied Omega-3 content, and a healthier ratio of Omega-3s to Omega-6s.

Rybina and Reshetova found that egg cholesterol decreased as alfalfa and grass meal increased in a hen's diet (1981). A steady increase in egg vitamin A and carotene content was observed as the amount of grassmeal increased in the diet of a flock (Davtyan and Manukyan, 1987). A study at Penn State demonstrated that hens with access to good pasture had eggs with at least twice as much vitamin E and Omega-3s, as well as more vitamin A, as eggs from hens with no access to pasture (Karsten et al., 2010). Another study, with funding from the Sustainable Agriculture Research and Education (SARE) program of the USDA, examined eggs from pastured laying flocks in Pennsylvania. The pastured eggs tested had one-third less cholesterol, one-third more vitamin A, and nearly triple the amount of

Omega-3s (Gorski, 2000). Lopez-Bote et al. also found increased Omega-3 content in eggs laid by free-ranging hens (1998). These studies bolster an independent study that tested eggs from 14 pasture-based farms across the country. Vitamins A and E, Omega-3, beta carotene, saturated fat, and cholesterol were all tested and compared to the nutrient qualities of a standard production egg. The vitamin E, Omega-3, and beta carotene contents were all significantly higher—in fact more than twice as high—as those in eggs produced by chickens in confinement with no access to vegetation. The vitamin A content was higher as well (Long and Alterman, 2007).

It's worth noting that there are conflicting studies and industry claims that free-range eggs have little or no difference from eggs produced in confinement. The problem, though, is that "free-range" simply means having outdoor access, without stipulations on the amount of time, pasture condition, minimum space requirements, or even whether the birds have access to the ground.

The results of poultry meat production on pasture are similar. Studies have shown elevated Omega-3 levels in meat from pasture-raised broilers as well as higher levels of vitamin E (although no difference in cholesterol) (Ponte et al., 2008a) and other nutritive factors (Gorski, 2000). Pastured poultry meat may possibly have a longer fresh-product shelf life (Sun et al., 2012a), as well as a discernible difference in taste according to a 30-person untrained tasting panel (Ponte et al., 2008b), although there was no significant difference among the meat qualities affecting taste as measured by the researchers in the laboratory. Sun et al. (2012a) also reported higher vitamin E and iron content in thighs and breast meat from broilers reared in grasshopper-rich alpine pastures, as well as lower cholesterol and a higher Omega-3 content (Sun et al., 2012b).

Factors Affecting Forage Consumption

Common experience among pastured poultry producers is that the birds will readily consume large amounts of forages, even if they have good rations available: poultry crave greens and eat them readily even if a balanced ration is provided (Blair, 2008). Just because poultry have access to pasture, though, does not necessarily mean that the birds will consume the available forages. There are several factors that determine how appealing a plant is to a bird (called the plant's palatability), including the plant type/species; the nutritional content, height, and stage of growth of the plant; as well as the nutritional needs of the bird, how hungry it is, and its foraging instincts. These factors are explored below.

Poultry Foraging Behavior

One of the main factors that determines the amount of plant matter that chickens and other poultry consume while foraging is the actual behavior of birds. Several factors affect a bird's ability to forage, including:

- ***Species/Type*** – Different breeds of poultry have different foraging habits and consumption rates. On two separate ends of the spectrum, geese are able to meet nearly all their nutritional needs with the vegetation they graze on, whereas modern broilers like the Cornish Cross can only make modest (though still economically and nutritionally important) supplements to their diet from pasture. Turkeys are voracious foragers, and will forage as a flock, forming a line and cleaning a pasture of insects, tasty forages, and seeds with almost military precision. Among chickens, laying hens forage much more than their meaty broiler cousins. Many pastured poultry farmers who have experience with both modern layer hybrids and heritage breeds of hens see little general difference between the two in terms of foraging, but quite a difference in feed conversion and production from the more modern breeds. Additionally, producers notice variability in grazing ability from hatchery to hatchery, flock to flock, and even among individuals within the same breed (Salatin, 2001). Pousga et al. point to research that suggests genetics also play a role in chickens' ability and efficiency in balancing their nutritional deficiencies, at least in free-choice feeding systems (2005). They report that brown-egg layers seem to be able to adapt more readily to free-choice feeding systems than white- or tinted-egg layers. Within a flock, individuals show a range in their capability to select for their own needs, along the same lines as the experiences mentioned above.

Poultry crave greens and eat them readily even if a balanced ration is provided

- *Time of day* – Poultry are most active during the morning and evening hours. Of the two times, poultry are most active right before sunset (Dawkins et al., 2003). Danish research has found that laying hens with constant access to forages consumed the most vegetation prior to sunset (Horsted et al., 2007). The birds really prefer to fill up before they head off to the roost for a good night's sleep. Filling up their crops enables them to digest the seeds, feed, insects, plants, and other food items overnight. Likewise, the birds will be out foraging first thing in the morning, looking to get food into their empty stomachs, but not to the same extent as they do at night.

  Long-time pastured poultry producer and innovator Joel Salatin, with decades of pastured poultry experience under his belt, advised in the 1990s of the importance of providing chickens fresh pasture early in the morning, noting that "the birds' most aggressive grazing period is two hours pre-daylight, which occurs long before the sun rises. Every quarter hour we wait to move pens after daylight reduces the grazing time period. As the dew comes off and the day gets warmer, the birds begin lounging not because they have grazed their fill, but because physiologically they demand a rest period" (Salatin, 2001). The results of research and experience are clear: give access to forages in the morning and evening if you want to maximize forage utilization.

- *Experience* – It takes time for a flock of birds to adapt to new types of feed (Jones, 1986). Novel food types require time for the birds to figure things out. Some producers give their birds a head

Sericea Lespedeza – Poor Man's Alfalfa for Poor Southern Soils

Sericea Lespedeza is an adaptable, high-protein, heat-loving legume that was introduced into the United States in the 1930s for erosion control. Known for its toughness, sericea was once called poor man's alfalfa in the South, a reference to this tough legume's ability to grow in poor-quality soils. Other uses for the plant, which include restoring surface mine spoils or roadbank cuts, testify to sericea's ability to grow in low-fertility, acidic soils. The author of this publication has successfully grazed layers and turkeys on naturalized, pure stands of sericea for researchers (Moyle et al., 2012). The poultry like serecia best when it is still immature and soft and will readily graze the whole plant. Once the plant starts to mature, getting around eight to 10 inches high, the stems become too woody for the birds, but they will continue to strip the leaves off and, later, the seeds, throughout the growing season. The plant is not the most preferred poultry forage, but often it can be the only one available, as sericea will grow and thrive on ground so poor that other forages cannot get started. In record-breaking drought and high heat, sericea will remain green and grazable, even when other forages have withered away. Additionally, the high tannin content of the plant has been proven to be an effective, natural de-wormer in sheep and goats (Coffey et al., 2007) and may have similar properties in poultry (Moyle et al., 2012; Todd and McSpadden, 1947).

A stand of nearly pure sericea lespedeza on a clay and shale bench that has been used as poultry pasture for turkeys and layers at Across the Creek Farm in West Fork, Arkansas. Photo: NCAT

start by placing a tray of chopped forages daily in the brooder (lawn clippings work well). Others dig a chuck of sod and place it in the brooder for the chicks to investigate and pick through. Broiler intake is positively correlated with age (de Almeida et al., 2012). When broilers are first put on pasture, they may pick half-heartedly at forages or totally ignore them. This will change over time, but with the short lifespan of broiler chickens (as short as seven weeks), the sooner they get on pasture, the faster they learn that forages are food. Poultry raised in pens tend to learn faster than those in day-range-style systems because the birds feel a competitive drive to eat fresh forages before their flockmates gobble them up first. Laying hens seem to learn to eat forages faster than their broiler kin, but it must be remembered that meatbirds grow much faster than layers, and although their body size is large, they are still essentially chicks in terms of instincts and habits that they are developing.

- *Shade* – Shade/protective cover encourages foraging (Dawkins et al., 2003), most likely from the protective effect of shelters (Rivera-Ferre et al., 2007). Shade, whether from trees or shelters, especially encourages layers to roam. Chickens originated in the jungles of Southeast Asia, and turkeys in the hardwood forests of Eastern America. Staying hidden under tree or plant cover seems to afford the flock an instinctive sense of protection from predators (a false sense when it comes to hawks!). Brightly lit, open areas are one of the least desirable habitats for most poultry, and for centuries farmers have noticed that poultry will often overgraze the areas immediately surrounding their housing even if undergrazed forages are available just a little further away.

- *Height of forage* – Poultry like their forages relatively short. Virginia producer Joel Salatin prefers forages under four inches (Salatin, 2001) but ideally around two inches. Before his birds get to the pastures, he grazes ruminants until the pastures are the preferred height for the birds (Salatin, 1996). Meanwhile, Oregon producer Aaron Silverman prefers a sward height of six to eight inches for his chickens (Silverman, 2000). Producer and research observation have noted that chickens go for shorter forages over longer plants when given the choice (Horsted, 2006). Turkeys do not seem to be nearly as picky, eagerly ingesting long strands of grass either in pieces or whole, like slurping noodles. It is worth considering, though, that forage height usually correlates with palatability, as younger, more succulent plants tend to be shorter.

Palatability

The term "palatability" refers to how "tasty" a bird finds a particular plant to eat at a particular time. Whether or not a plant is palatable is one of the most critical factors for birds on pasture: if the bird won't eat a plant, the benefits of the plant—no matter how nutritious—are worthless. Several things directly affect palatability:

Whether or not a plant is palatable is one of the most critical factors for birds on pasture: if the bird won't eat a plant, the benefits of the plant—no matter how nutritious—are worthless.

Plant Species/Variety – Like people, poultry find some plants highly palatable, while others are completely unappealing and will not be eaten. Some plants have strong flavorings that poultry love, like the tart taste of yellow wood sorrel or clover seed pods, or despise, like the bitter fluid from milkweed. Generally, legumes and young, soft grasses are appreciated, while forbs and shrubs can be hit or miss. Clovers and alfalfa have long been considered among the best forages for a variety of reasons: high protein content (legumes), lush leaves, perennial growth, and, importantly, because these legumes mature slower and stay palatable much longer than grasses. Grass leaves on average contain twice the fiber of legume leaves. Fiber content in alfalfa and crimson clover leaves at the mid-blooming stage is around 25%, compared to fescue and orchardgrass leaves that have fiber contents near 50% and up to 70% in big bluestem and bermudagrass as the plants go to seed. Given their structural purpose of supporting seeds, it comes as no surprise that stems are typically much higher in fiber than leaves (Buxton and Redfearn, 1997).

The specific variety of a plant can affect the amount of grazing a bird does on pasture. For instance, alfalfa varieties high in bitter tannins or saponins are less palatable than varieties with little of these compounds. The tannins can also depress protein digestibility and reduce overall feed intake, which can reduce feed conversion. Therefore, in the case of alfalfa, variety can play a significant role in the amount of vegetation consumed.

Feeding Poultry, a poultry nutritional text from 1955, makes the following suggestion on desirable species for poultry production:

> "For poultry pastures, plants capable of forming a dense, hard-wearing, and lawn-like turf are desirable. Wild white clover and ladino clover are suitable legumes. Grasses suitable for poultry turf are perennial rye grass, meadow grasses, the fescues, creeping bent, and crested dog's tail. However, poultry does not like the plants after they have become aged and woody and will then only eat them as a last resort. Turkeys prefer ladino clover, but other grasses can be satisfactorily used for grazing." (Heuser, 1955)

Insects provide around four times more usable protein and energy for chickens and other poultry by weight, compared to poultry feed rations.

Aaron Silverman from Oregon has settled on a complementing blend of highly palatable clovers and more persistent grasses, "a balanced mixture of orchardgrass, perennial ryegrass, tall fescue, annual ryegrass, subclover, and New Zealand white clover" (Silverman, 2001).

- *Stage of growth* – As pasture forage plants near maturity, they will direct energy and nutrients away from producing nutrient-dense leaf mass and into producing the next generation of seeds. Funneling nutrients into the seeds, which includes pulling nutrients from existing leaf mass, greatly decreases the livestock feed value of the forage. Additionally, the lignin content (roughly, the "woodiness") of the plant increases as the plant gets closer to producing fruit or seeds, especially in the stems (resulting in higher fiber content). As an example, alfalfa's nutritive qualities plummet after the blooming stage (see Table 1 on page 5). It makes sense that the younger the forage, the more tender and palatable it will be. Plant stems become lignified faster than leaves, and rapidly become indigestible and unattractive to poultry.

Although grasses can be higher in several nutritive qualities, other plants may be preferred as forages because they stay palatable for a longer time during the growing season. It was noted in the 1950s that "clover and alfalfa ranges are preferred [for poultry], primarily because the green stuff is available over a longer period of the year. They do not grow up and become tough and unavailable, as grass does. Frequent mowing of grass, either with ruminants or machinery, however, will help keep it tender" (Heuser, 1955).

Insects and Other Animals as Forages

Insects are an important source of nutrition for birds worldwide. Insects and other invertebrates provide around four times more usable protein and energy for chickens and other poultry by weight, compared to poultry feed rations (Bassler, 2005). Chickens, turkeys, ducks, and other species of fowl will greedily consume every insect on pasture, as these are excellent sources of protein and energy (see Table 2).

Poultry consumption of insects not only promotes the health of the flock while saving on feed costs, but also helps the pasture, as many insects feed on and negatively impact high-value forage species. Crickets and grasshoppers especially can be problematic. Pastured poultry turns this pest problem into a valuable asset in much the same way that brush and weeds despised by

To Seed or Not to Seed

A common question from new pastured poultry farmers is "What should I plant?" While this is an understandable question, an even better question would be "Should I plant?" In most areas, if the soil provided the right environment, then highly desirable forages would already be growing. Spending money on high-dollar seeds and sowing them into infertile ground is essentially throwing hard-earned (and probably limited) money away. Many producers are surprised by how quickly their pastures benefit from pastured poultry production—especially broilers, which lay down a lot of manure. Over a couple of seasons, as the soil environment changes (pH, nutrients, organic matter, etc.) from the manure inputs of the birds, farmers typically see some sort of ecological transition that includes new, often desirable, plant species like clovers, chicories, and vetches appearing in their fields. If you do decide to seed forages into new or existing pasture, make sure that you take a soil test and that your soil environment is favorable to establishing the forages that you are sowing.

Table 2. Protein and Energy Value of Common Pasture Invertebrates

Invertebrae Type	% Protein	% Fat%
Cricket	6.7%	5.5%
Grasshopper	14.3%	3.3%
Large Spider	63%	10%

Source: National Research Council. 1996.

cattle ranchers are valued by goat farmers. On the author's farm (Across the Creek Farm), the summer of 2012 was one of the most brutal on record for our county in Northwest Arkansas. The second record-breaking drought in a row, with barely a drop of rain over a period of months, left pastures in the county in a poor state. Then the grasshopper population exploded. It was all over the news: stories of hay fields, gardens, and lawns being plagued by the hoppers. Our layers and broilers gorged themselves on the pests. We noticed our feed consumption dropped quite a bit, without a drop in production from the birds. As a bonus, the birds were getting forages that they did not normally touch, like barnyardgrass, into them because the grasshoppers were eating these undesirable plants and then getting gobbled up by the hens and broilers. It didn't take long before grasshoppers became pretty scarce in our pastures. At least we know now that there's an upside to droughts.

The best way to increase the population of insects in your pastures is to improve the quality of the forages in your fields. The denser and more diverse the pasture sward, the greater the quantity and diversity of insects the birds have for foraging. It's worth noting that insects are not the only animals that poultry relish. Other invertebrates such as worms, spiders, and ticks and even vertebrates like snakes, lizards, amphibians, and mice are fair game if the birds can catch them.

Utilizing Native Pastures

The most profitable strategy for utilizing forages often means using those that are already established. With the host of challenges that face a pastured poultry operation, especially new operations, spending money on planting forages may not make economic sense. Seed costs can be significant, especially for smaller farms, and a farmer would do well to assess current pasture resources before expending cash.

An existing pasture often has a large community of plants that are already established and have survived on your farm at no cost and with minimal attention. With an investment of a little bit of management, such as the addition of the nutrients from pastured poultry manure, existing forages will likely pay dividends by offsetting feed cost. Additionally, the soil more than likely has a diverse seedbank that was decades in the making, full of new species that will appear and thrive when conditions become favorable. Rotational grazers of all animals are very familiar with the phenomenon of reaping what they do not sow when pasture management takes priority. Joel Salatin, the modern-day grandfather of pastured poultry, has this to say about native pastures:

> "Every geographic region has its native forage species. I have not found any forages that the chickens dislike. Whether it is fescue or lovegrass, the height and density seem far more important. In areas where grass grows sparsely, it may be necessary to move the pen more frequently to ensure that the birds get enough to eat… The critical factor is that it be fresh, short, and preferably composed of many different species so that the birds have a great variety." (Salatin, 1996)

Mob Grazing with Chickens

Poultry are one of the smallest sizes of livestock. It should be fairly obvious that they will struggle trying to forage through chest-high grasses. Poultry prefer to forage through relatively short vegetation. They do well in pastures where clump grasses are present, as they'll move in between the clumps searching for insects and forages. Over time, poultry will trample down tall grasses. Pasture systems that use mobile floorless pens, such as Salatin-style pens, will help lay tall grasses down, essentially mulching the ground with grass stems and leaves as the pen is moved in high grass. If seeds are formed, the poultry will eagerly consume them, and the manure that they lay down in the knocked-down grass will form a protective mat of fertility that shields the ground, similar to the results of high density mob-grazing in rotational grazing systems using ruminants. Old lignified grasses are high in carbon and, when trampled into the ground and covered with manure rich in nitrogen, decompose readily, essentially composting in place and feeding soil biota while creating an excellent seedbed for future forages.

A diverse pasture, containing a mix of cool- and warm-season grasses, legumes, and broadleaves of different heights and stages of maturity, gives the poultry a constantly changing "saladbar" (a term coined by Joel Salatin) of forages to choose from. "I hesitate to rank the species in order of preference because someone may then try to provide only the most desirable thing," writes Salatin. "Actually in their first few minutes of grazing, some birds eat fescue and others eat seeds and others eat clover leaves, just as people would pick over a salad bar that would contain 'favorites' and 'I need to eat this because it's good for me' items" (Salatin, 1996).

One of the greatest things about utilizing existing pasture, besides the fact that it is essentially free, is that it requires little maintenance—there's no liming or fertilizing needed. The existing plant community is hardy and well-adapted to the current environment. The pasture should only respond positively to the manure and activity of a well-managed pastured poultry operation.

Establishing Poultry Pastures

Despite the economic sense of utilizing existing pasture resources for pasturing poultry, there are situations where establishing pastures for poultry makes sense. Perhaps land is being converted from cropland or forest to pasture, or the current pastures are filled with weeds and brush without any real value for poultry. In this case, the following advice for establishing a poultry-friendly pasture may be of help:

> [O]ats and peas sown together very thinly with a liberal seeding of red clover and a very little rape make a good combination. The oats and peas furnish a rapid growth of green feed. Much of it will get tramped down and some go to seed, but will serve to protect the clover and the rape, which will make good feed late in summer and fall. Three pecks of oats, two of peas, a pound of rape and 5 quarts of red clover seed make a good proportion for sowing an acre. The oats and peas should be first harrowed in deeply, then the clover and rape sown mixed and lightly scratched in. (Kains, 1920)

Protecting Pasture from Poultry

While the benefits of poultry on pasture have been discussed at length, it is worth ending with a caution to the producer about the damage that poultry can do to pasture. Poultry production can be seen as a neutral tool for pasture management: the birds can either improve or destroy pasture health. The keys to maintaining healthy pastures are to move the birds often and to watch the condition of the pasture. If possible, avoid grazing pastures when they are wet and the soils are at their weakest. Laying hens, with their constant scratching, and heavy birds, such as mature turkeys, are hardest on pasture. Additionally, if broilers are left too long in one spot, they can put so much manure on the ground that the soil becomes too rich and "burns" plants trying to grow there. Many pastured poultry farms use designated areas as "sacrifice paddocks" during the winter months, wet season, or other periods when the forages are dormant and vulnerable. Observation and common sense go a long way in keeping pastures healthy and making sure that your pastures will be providing forages for your flocks for years to come.

References

Bassler, A. 2005. Organic broilers in floorless pens on pasture. PhD Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden. http://pub.epsilon.slu.se/859

Blair, R. 2008. Nutrition and Feeding of Organic Poultry. CAB International Publishing, Oxfordshire, UK.

Buchanan, N., J. Hott, L. Kimbler, and J. Moritz. 2007. Nutrient composition and digestibility of organic broiler diets and pasture forages. The Journal of Applied Poultry Research. Vol. 16, No. 1. p. 13-21.

Buxton, D., and D. Redfearn. 1997. Plant limitations to fiber digestion and limitation. Journal of Nutrition. Vol. 127, No. 5. p. 814S-818S.

Coffey, L., M. Hale , T. Terrill, J. Mosjidis, J. Miller, and J. Burke. 2007. Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza. National Center for Appropriate Technology: ATTRA Publication IP316. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=217

Davtyan, A., and V. Manukyan. 1987. Effect of grass meal on fertility of hens. Ptitsevodstvo. Vol. 6. p.28-29.

Dawkins, M., P. Cook, M. Whittingham, K. Mansell, and A. Harper. 2003. What makes free-range chickens range? In situ measurement of habitat preference. Animal Behaviour. Vol. 66. p.151-160.

de Almeida, G., L. Hinrichsen, K. Horsted, S. Thamsborg, and J. Hermansen. 2012. Feed intake and activity level of two broiler genotypes foraging different types of vegetation in the finishing period. Poultry Science. Vol. 91, No. 9. p. 2105-2113.

Eriksson, M. 2010. Protein supply in organic broiler production using fast-growing hybrids. PhD Dissertation. Uppsala, Sweden. http://pub.epsilon.slu.se/2362/1/eriksson_m_101008.pdf

Esmail, S. 2012. Fibre plays a supporting role in poultry nutrition. World Poultry Magazine. February. www.worldpoultry.net/Breeders/Nutrition/2012/2/Fibre-plays-a-supporting-role-in-poultry-nutrition-WP009965W

Gorksi, B. 2000. Nutritional Analysis of Pastured Poultry Products. APPPA GRIT! American Pastured Poultry Producers Association. Vol. 11. p. 1-3.

Heuser, G. 1955. Feeding Poultry: The Classic Guide to Poultry Nutrition for Chickens, Turkeys, Ducks, Geese, Gamebirds, and Pigeons. Norton Creek Press, Blodgett, OR. Reprinted 2003.

Horsted, K. 2006. Increased Foraging in Organic Layers. PhD Thesis. Department of Agroecology, University of Aarhus. Faculty of Agricultural Sciences. http://orgprints.org/10463/1/10463.pdf

Horsted, K., J. Hermansen, and H. Ranvig. 2007. Crop content in nutrient-restricted versus non-restricted organic laying hens with access to different forage vegetations. British Poultry Science. Vol. 48. p.177-184.

Jones, R. 1986. Responses of domestic chicks to novel food as a function of sex, strain and previous Experience. Behaviour Processes. Vol. 12. p. 261-271.

Kains, M. 1920. Profitable Poultry Production. James A McCann Publishing, New York, NY.

Karsten, H., P. Patterson, R. Stout, and G. Crews. 2010. Vitamins A, E, and fatty acid composition of the eggs of caged hens and pastured hens. Renewable Agriculture and Food Systems. Vol. 25, No. 1. p. 45-54.

Long, C., and T. Alterman. 2007. Meet real free-range eggs. Mother Earth News. October/November. p. 4. www.motherearthnews.com/Real-Food/2007-10-01/Tests-Reveal-Healthier-Eggs.aspx

Lopez-Bote, J.,A. Sans , A. Rey, A. Castano, B. Isabel, and J. Thos. 1998. Effect of free range feeding on n-3 fatty acid and a-tocopherol content and oxidative stability of eggs. Animal Feed Science Technology. Vol. 72. p.33-40.

Lowry, T. 1993. Petaluma's Poultry Pioneers. Manifold Press, Ross, CA.

Mattocks, J. 2002. Pasture-Raised Poultry Nutrition. National Center for Appropriate Technology: ATTRA Publication IP 227. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=333

Mortiz, J., A. Parsons, N. Buchanan, N. Baker, J. Jaczynski, O. Gekara, and W. Bryan. 2005. Synthetic methionine and feed restriction effects on performance and meat quality of organically reared broiler chickens. Journal of Applied Poultry Research. Vol. 14. p.521–535.

Moyle, J., J. Burke, A. Fanantico, J. Mosjidis, T. Spencer, K. Arsi, I. Reyes-Herrera, A. Woo-Ming, D. Donoghue, and A. Donoghue. 2012. Palatability of tannin-rich sericea lespedeza fed to broilers. Journal of Applied Poultry Research. Vol. 21. p. 891-896.

National Research Council. 1966. Nutrient requirements of dairy cattle, 3rd edition. National Academy of Sciences, Washington, DC.

Nurmi, E. and M. Ratala. 1973. New aspects of Salmonella infection in broiler production. Nature. Vol. 241. p. 210-211.

Ponte, P., J. Prates, J. Crespo, D. Crespo, J. Mourão, S. Alves, R. Bessa, M. Chaveiro-Soares, L. Ferreira, and C. Fontes. 2008a. Improving the Lipid Nutritive Value of Poultry Meat Through the Incorporation of a Dehydrated Leguminous-Based Forage in the Diet for Broiler Chicks. Poultry Science. Vol. 87. p.1587-1594.

Ponte, P., J. Prates, J. Crespo, D. Crespo, J. Mourão, S. Alves, R. Bessa, M. Chaveiro-Soares, L. Ferreira, and C. Fontes. 2008b. Restricting the Intake of a Cereal-Based Feed in Free-Range-Pastured Poultry: Effects on Performance and Meat Quality. Poultry Science. Vol. 87. p. 2032-2042.

Pousga, S., H. Boly, and B. Ogle. 2005. Choice feeding of poultry: a review. Livestock Research for Rural Development. Vol. 17. p.45.

Rice, J. and H. Botsford. 1930. Practical Poultry Management. Braunworth & Co, Brooklyn, NY.

Rivera-Ferre, M., M. Guadalupe, E. Lantinga, and R. Kwakkel. 2007. Herbage intake and use of outdoor area by organic broilers: effects of vegetation type and shelter addition. NJAS-Wageningen Journal of Life Sciences. Vol. 54. p. 279-291.

Rybina, E. and T. Reshetova. 1981. Digestibility of nutrients and biochemical values of eggs in relation to the amount of Lucerne and grass meal and the quality of supplementary fat in the diet of laying hens. Zhivotnovodstva. Vol. 35. p. 148-152.

Salatin, J. 1996. Pastured Poultry Profit$. Polyface Inc., Swoope, VA.

Salatin, J. 2001. Grass Conversion Rates by Poultry. APPPA GRIT! American Pastured Poultry Producers Association. Vol. 15. p. 3-4.

Silverman, A. 2000. The 'Pasture' in Pastured Poultry: An Oregon View. APPPA GRIT! American Pastured Poultry Producers Association. Vol. 12. p. 9.

Silverman, A. 2001. The 'Pasture' in Pasture Poultry, Continued. APPPA GRIT! American Pastured Poultry Producers Association. Vol. 18. p. 14-15.

Sun, T., Z. Liu, L. Qin, and R. Long. 2012a. Aspects of lipid oxidation of meat from free-range broilers consuming a diet containing grasshoppers on alpine steppe of the Tibetan Plateau. Poultry Science. Vol. 91. p. 224-231.

Sun, T., Z. Liu, L. Qin, and R. Long. 2012b. Meat fatty acid and cholesterol level of free-range broilers fed on grasshoppers on alpine rangeland in the Tibetan Plateau. Journal of the Science of Food and Agriculture. Vol. 92. p. 2239–2243.

Todd, A. C. and B. J. McSpadden. 1947. Pastures for chickens and their relation to the parasitic fauna. Poultry Science. Vol. 26 p. 576-581.

Appendix 1: Sprouted Oats

Source: Practical Poultry Management, by J. Rice and H. Botsford. 1930.

Sprouted oats.—Sprouted oats furnish one of the most desirable winter succulents. They also provide the most satisfactory means of using oats, since the absorption of water, while not increasing the nutriment, makes the grain more palatable and digestible. One hundred pounds of oats in sprouting will absorb enough water to make about 350 pounds of the sprouted grain.

The sprouter.—Anyone handy with a hammer and saw can make a good sprouter out of wood. A very satisfactory device consists of a rack holding seven trays, one above the other (Fig. 63). For the corners 2 × 2-inch posts 6 feet long should be used. Brace them with 1 × 2-inch strips each 2 feet long, and 9 inches apart, on which the trays slide. The trays may be made 2 feet square and about 2 inches deep. (Use 1 × 2-inch lumber.) An advantage of square trays is that they can be given one-quarter turns, thus exposing all sides to the light. The bottom boards, made of ½-inch lumber, should be set ⅛ inch apart to allow excess water to drain off.

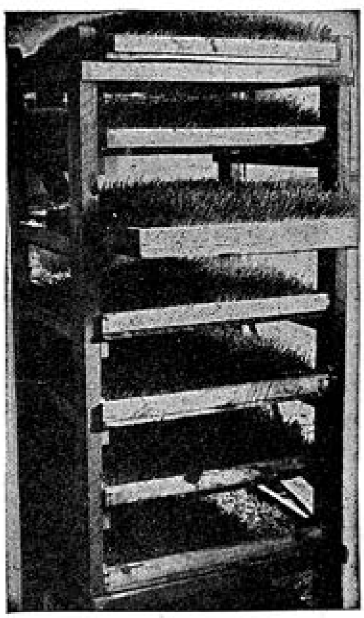

Fig. 63.— Homemade Oat Sprouting Rack.

Sprouting.—The sprouting can be done best in a well-lighted room where a temperature of 60° to 70° F. can be maintained. The grains will not sprout well in a temperature below 60° F., and mold will usually result. The room should also have provision for ventilation. The grain, before it is put into the sprouter, should be soaked and treated with formalin to prevent the development of molds. For each tray (2 × 2 feet), place in a pail 6 quarts of oats and 6 quarts of lukewarm water to which has been added one teaspoonful of formalin. Cover with an old bag or burlap and allow to soak for 36 to 48 hours. Then spread out on the trays from about ¾ to 1 inch deep.

Sprinkle thoroughly each day so as to keep the oats always moistened. Cover the tray with building paper to prevent too rapid evaporation, thus hastening the sprouting. Stir the oats daily until the sprouts are about ¼ inch long. The trays should be reversed occasionally so that all sides will

[1] West Virginia Bulletin No. 178.

have exposure to the light. The oats should be started on the bottom tray and the trays moved upward each day, the feeding being done from the top trays. This gives the growing oats at the top the most light, which is necessary.

Under favorable conditions, the oats should be ready to feed in about a week or ten days. When the trays have been emptied, they should be disinfected with a 5 per cent solution of formalin to prevent the development of mold in the wet trays.

The oats usually are fed when the sprouts are from 1 to 3 inches high. The sod is removed, broken into chunks, and fed in troughs or on clean litter. From 1 to 2 square inches for each hen should be fed regularly each noon.

Germinated oats.—Many poultrymen prefer to feed the oats after germinating, or when in the racks but four or five days.

These are similar to sprouted oats except that they are fed when the grain has just sprouted and has not yet turned green. Many of the best feeders use germinated oats in preference to sprouted oats. When fed thus the formalin treatment is not necessary.

Roots and tubers.—In this group, yellow carrots are the most desirable. "They are satisfactory substitutes for field-grown greens." [1] Mangels are next in importance. Mangels should not be wilted or tough when fed. They are probably one of the cheapest and most easily handled succulents. Mangels are low in vitamine content.[2] From 10 to 12 tons may be raised to the acre; this should be enough to feed from 1400 to 1600 hens. Mangels can be stored in a root cellar or pit. The birds should be given all they will eat from noon until night; and 100 fowls can be expected to eat from 8 to 10 pounds a day during the winter. The golden tankard variety is one of the best.

Turnips, rutabagas, and other roots may be used where there are no beets. They usually yield less, however, do not keep so well, and are not so well liked by the fowls.

Cabbage.—Cabbage is less expensive to raise but more difficult to store than mangels. It is an excellent succulent, especially for fall and early winter. Fowls prefer cabbage to most other vegetable feeds. The small, unmarketable heads may be used to advantage for poultry.

Any vegetable, such as lettuce, onions, spinach, kale, and the like, may be used as green food. The dandelion is especially desirable for chicks. Fowls relish a variety of greens.

[1] Bulletin 384. University of California.

[2] Two per cent of cod liver oil in the mash, will, in all probability, prevent any loss due to vitamine A deficiency. Yellow corn is also effective. Bul. 384, University of California.

Notes

Notes

Notes

Pastured Poultry Nutrition and Forages
By Terrell Spencer
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APPENDIX F:
COMPOST ESTIMATES

Assumptions underlying GHG benefits of Compost

Example compost is 16.48% C by dry weight (per lab analysis)

The Farm is applying 3” per acre, or 403.34 cubic yards. per acre

This compost is 1,068 lbs /yard to convert yards to tons; (typical)

Short tons applied/acre at 3” is 215.38 (assumes a full acre at 3”)

Carbon applied at this rate is 35.49 tons (at 16.48% C)

Metric tons of C is therefore 32.27 tonnes

Metric tons of CO_2e is therefore 118.42 tonnes/acre

x 4.5 acres =532.89 tonnes

60% of each cropland acre (beds minus pathways) = 319.73

Half of compost carbon is lost each year, after application, to oxidation and respiration, but if reapplied annually, we can quickly build SOM, at least in the particulate organic matter category, and some of that will become mineral associated over time.

On croplands, We generally credit the full amount of CO_2e, but only in the year applied (ie, this is not carried over into subsequent years unless reapplied);

Rangelands and no-till systems may reasonably carry credit for additional years, though for how long will vary with site specific considerations.

Compost Analysis Report

LOGAN LABS
SOIL TESTING SERVICES

Job Name	Central Texas Food Bank	**Company**	Central Texas Food Bank
Contact		**Sample ID**	Compost
Rep		**Lab Number**	18944
Submitted by		**Run Date**	11/12/2021

Sample Location	Compost	**Notes**	
Sample Name			

	% Dry Basis	% Wet Basis	lbs/Ton
Moisture		18.28	365.60
Mineral Matter	65.38	53.43	1068.6
Lost By Ign (Org M+)	34.62	28.29	565.80
Total Nitrogen	1.34	1.099	21.98
Phosphorus	0.22	0.176	3.52
Phos. as (P205)	0.49	0.403	8.06
Potassium	0.76	0.621	12.42
Potassium as K20	0.92	0.748	14.96
Calcium	5.74	4.694	93.88
Magnesium	0.63	0.511	10.22
Sodium	0.12	0.100	2.00
Sulfur	0.18	0.145	2.90
Carbon	20.17	16.48	329.60

	ppm Dry Basis	ppm Wet Basis	lbs/Tons
Boron	44.15	36.08	0.072
Iron	8406.75	6870.00	13.740
Manganese	252.08	206.00	0.412
Copper	22.15	18.10	0.036
Zinc	96.55	78.90	0.158

pH	8.34
C/N Ratio	15.00

Logan Labs, LLC

APPENDIX G:

WEB SOIL SURVEY

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Travis County, Texas

October 2, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

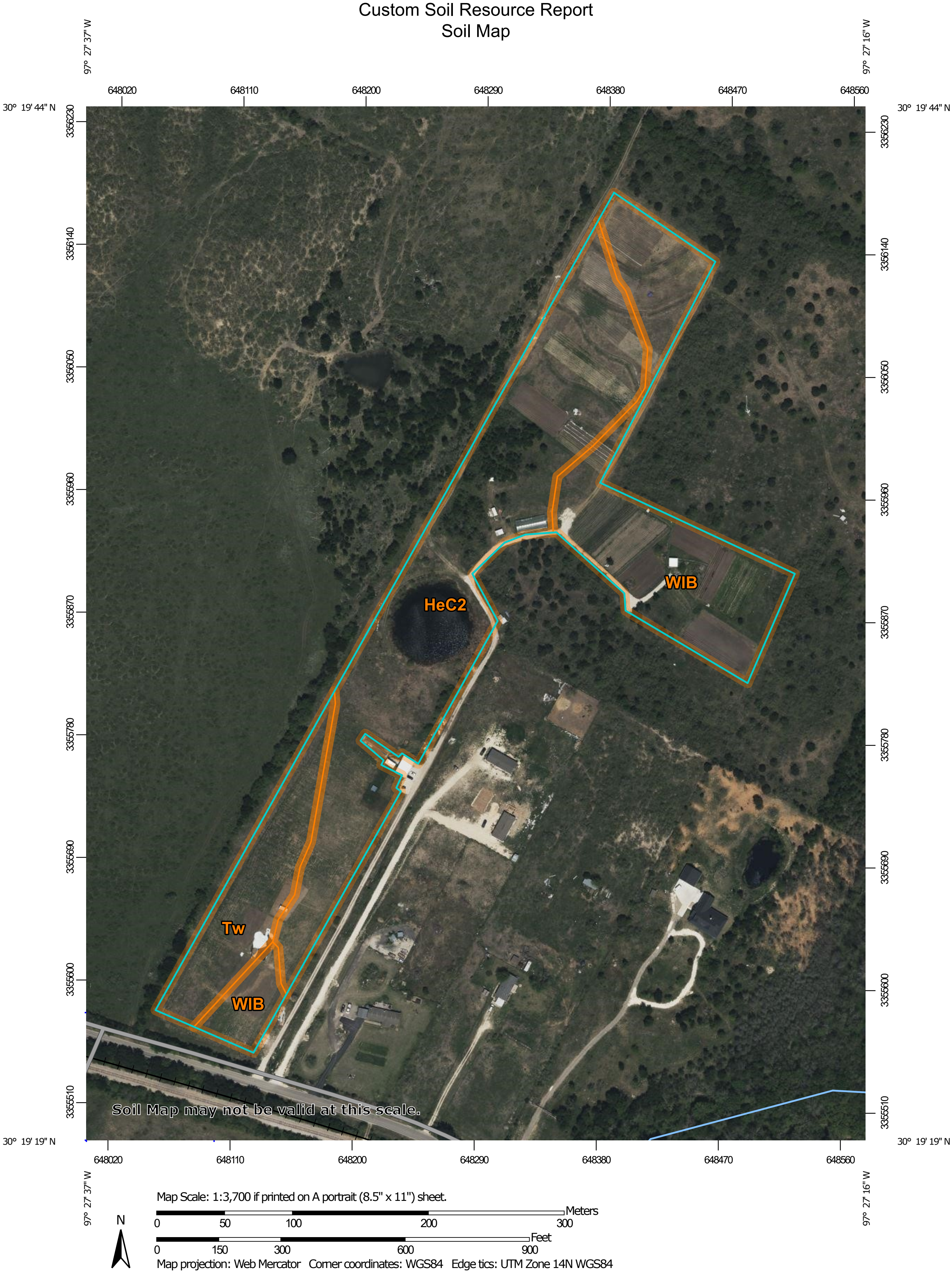
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


97° 27' 37" W
97° 27' 16" W
648020
648110
648200
648290
648380
648470
648560
30° 19' 44" N
30° 19' 19" N
3356230
3356140
3356050
3355960
3355870
3355780
3355690
3355600
3355510
HeC2
WlB
Tw
WlB
Soil Map may not be valid at this scale.
Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.
Meters
0 50 100 200 300
Feet
0 150 300 600 900
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	5.5	32.9%
Totals for Area of Interest		**16.6**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Travis County, Texas

HeC2—Heiden clay, 3 to 5 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2v1vb
Elevation: 300 to 1,390 feet
Mean annual precipitation: 33 to 48 inches
Mean annual air temperature: 64 to 68 degrees F
Frost-free period: 233 to 278 days
Farmland classification: Not prime farmland

Map Unit Composition

Heiden, moderately eroded, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Heiden, Moderately Eroded

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Microfeatures of landform position: Linear gilgai
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Clayey residuum weathered from mudstone

Typical profile

A - 0 to 13 inches: clay
Bss - 13 to 22 inches: clay
Bkss - 22 to 58 inches: clay
CBdk - 58 to 80 inches: clay

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: 40 to 65 inches to densic material
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 12.0
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: R086AY009TX - Southern Eroded Blackland

Hydric soil rating: No

Minor Components

Houston black

Percent of map unit: 10 percent
Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Microfeatures of landform position: Circular gilgai
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R086AY011TX - Southern Blackland
Hydric soil rating: No

Ferris, severely eroded

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Microfeatures of landform position: Linear gilgai
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: R086AY009TX - Southern Eroded Blackland
Hydric soil rating: No

Tw—Tinn clay, 0 to 1 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2vtgr
Elevation: 330 to 750 feet
Mean annual precipitation: 35 to 47 inches
Mean annual air temperature: 63 to 68 degrees F
Frost-free period: 226 to 263 days
Farmland classification: Not prime farmland

Map Unit Composition

Tinn and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tinn

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Microfeatures of landform position: Circular gilgai
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Calcareous clayey alluvium

Typical profile

A - 0 to 17 inches: clay
Bss - 17 to 57 inches: clay
Bkssy - 57 to 80 inches: clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: D
Ecological site: R086AY013TX - Clayey Bottomland
Hydric soil rating: No

Minor Components

Whitesboro

Percent of map unit: 10 percent
Landform: Flood plains
Microfeatures of landform position: Circular gilgai
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Gladewater

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R086AY013TX - Clayey Bottomland
Hydric soil rating: Yes

WIB—Wilson clay loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2wg9f
Elevation: 200 to 770 feet
Mean annual precipitation: 34 to 48 inches
Mean annual air temperature: 64 to 67 degrees F
Frost-free period: 243 to 262 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Wilson and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wilson

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loamy and/or clayey alluvium derived from mudstone

Typical profile

Ap - 0 to 7 inches: clay loam
Btss - 7 to 31 inches: clay
Btkss - 31 to 36 inches: clay
Btkssyg - 36 to 42 inches: clay
Btkyg - 42 to 80 inches: clay loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 15 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w

Hydrologic Soil Group: D
Ecological site: R086AY004TX - Southern Claypan Prairie
Hydric soil rating: No

Minor Components

Burleson

Percent of map unit: 10 percent
Landform: Stream terraces, stream terraces
Landform position (three-dimensional): Tread
Microfeatures of landform position: Circular gilgai, circular gilgai
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R086AY011TX - Southern Blackland
Hydric soil rating: No

Crockett

Percent of map unit: 5 percent
Landform: Ridges, stream terraces
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, tread
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: R086AY004TX - Southern Claypan Prairie
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Land Management

Land management interpretations are tools designed to guide the user in evaluating existing conditions in planning and predicting the soil response to various land management practices, for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture, and rangeland. Example interpretations include suitability for a variety of irrigation practices, log landings, haul roads and major skid trails, equipment operability, site preparation, suitability for hand and mechanical planting, potential erosion hazard associated with various practices, and ratings for fencing and waterline installation.

Drought Vulnerable Soils

Drought Vulnerable Soils

Even in a year, having normal precipitation or slightly less than normal, some soils are prone to having drought stress occur in the plants growing on them. Several conditions can allow this to happen. Most influential may be a relative lack of effective precipitation, as is estimated by subtracting the mean annual precipitation from an estimate of the annual evapotranspiration. Soils west of the 100th meridian frequently fall into this situation, especially at low elevations. Also, a soil may have an inherently low ability to store water. This is typical of sandy or shallow soils or soils having a high content of rock fragments. In this case, even though there may be significant rainfall, the soil matrix does not retain sufficient water for crop growth.

Topographic and climatic characteristics can be present to mitigate a soil's droughty tendacies. Some soils exist on water-gathering portions of the landscape and can thus support more plant growth than their similar neighbors because of run on. Some soils have a water table present within the rooting zone during the growing season to supply plant water needs. Finally, some soils exist in a climate where precipitation is much higher than evapotranspiration and the soil is nearly always moist. This can occur in cool climates at high elevations.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are vulnerable to drought. Numerical ratings indicate the degree of vulnerability associated with each soil or site feature. The ratings are shown in decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature imparts the greatest degree of vulnerability (1.00) and the point at which the soil feature helps to mitigate drought vulnerability (0.00).

Verbal ratings are defined as follows:

Severely drought vulnerable (rating index equals 1.0). — The soil and site properties present are such that the plants growing on the soil must be very drought tolerant even in years with normal amounts of rainfall. The soil may have very low water storage capacity (below 5 cm) or may be in an area of low annual precipitation or high annual temperature or both.

Drought vulnerable (rating index is greater than 0.67 but less than 1.0). — The soil and site properties are such that drought conditions generally occur every year. The soil may have low water storage capacity (5 to 15 cm) and the site may have low annual precipitation or high annual temperature or both.

Moderately drought vulnerable (rating index is greater than 0.33 but less than 0.67). — The soil and site proerties are such that in an average year, some water stress may occur, but in a good year, plant available water is generally adequate. Water storage is in the range of 15 to 25 cm. Rainfall and estimated potential evapotranspiration are nearly equal.

Somewhat drought vulnerable (rating index is greater than 0 but less than 0.33). — These soils have greater than 25 cm of water storage and annual precipitation is generally adequate for plant growth. In dry years some water stress may occur.

Slightly drought vulnerable (rating index equals 0). — These soils are either in lowlying parts of the landscape where plant roots may exploit near-surface ground water or are in areas where precipitation is much higher than potential evapotranspitration. In an extremely dry year plants may be water stressed on these soils.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is provided to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Drought Vulnerable Soils

Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 150, 300, 600, 900

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Severely drought vulnerable

Drought vulnerable

Moderately drought vulnerable

Somewhat drought vulnerable

Slightly drought vulnerable

Not rated or not available

Soil Rating Lines

Severely drought vulnerable

Drought vulnerable

Moderately drought vulnerable

Somewhat drought vulnerable

Slightly drought vulnerable

Not rated or not available

Soil Rating Points

Severely drought vulnerable

Drought vulnerable

Moderately drought vulnerable

Somewhat drought vulnerable

Slightly drought vulnerable

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Drought Vulnerable Soils

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	Drought vulnerable	Heiden, moderately eroded (85%)	Not subirrigated (1.00)	8.9	53.5%
				Not perudic (1.00)		
				Somewhat dry climate (0.92)		
				Moderately high water storage (0.07)		
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	Drought vulnerable	Tinn (85%)	Not subirrigated (1.00)	2.3	13.6%
				Not perudic (1.00)		
				Somewhat dry climate (0.70)		
				Moderately high water storage (0.20)		
				Somewhat water gathering (0.13)		
WIB	Wilson clay loam, 1 to 3 percent slopes	Drought vulnerable	Wilson (85%)	Not subirrigated (1.00)	5.5	32.9%
				Not perudic (1.00)		
				Somewhat dry climate (0.74)		
				Somewhat water gathering (0.40)		
				Moderately high water storage (0.30)		
Totals for Area of Interest					**16.6**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Drought vulnerable	16.6	100.0%
Totals for Area of Interest	**16.6**	**100.0%**

Rating Options—Drought Vulnerable Soils

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Erosion Factors

Soil Erosion Factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

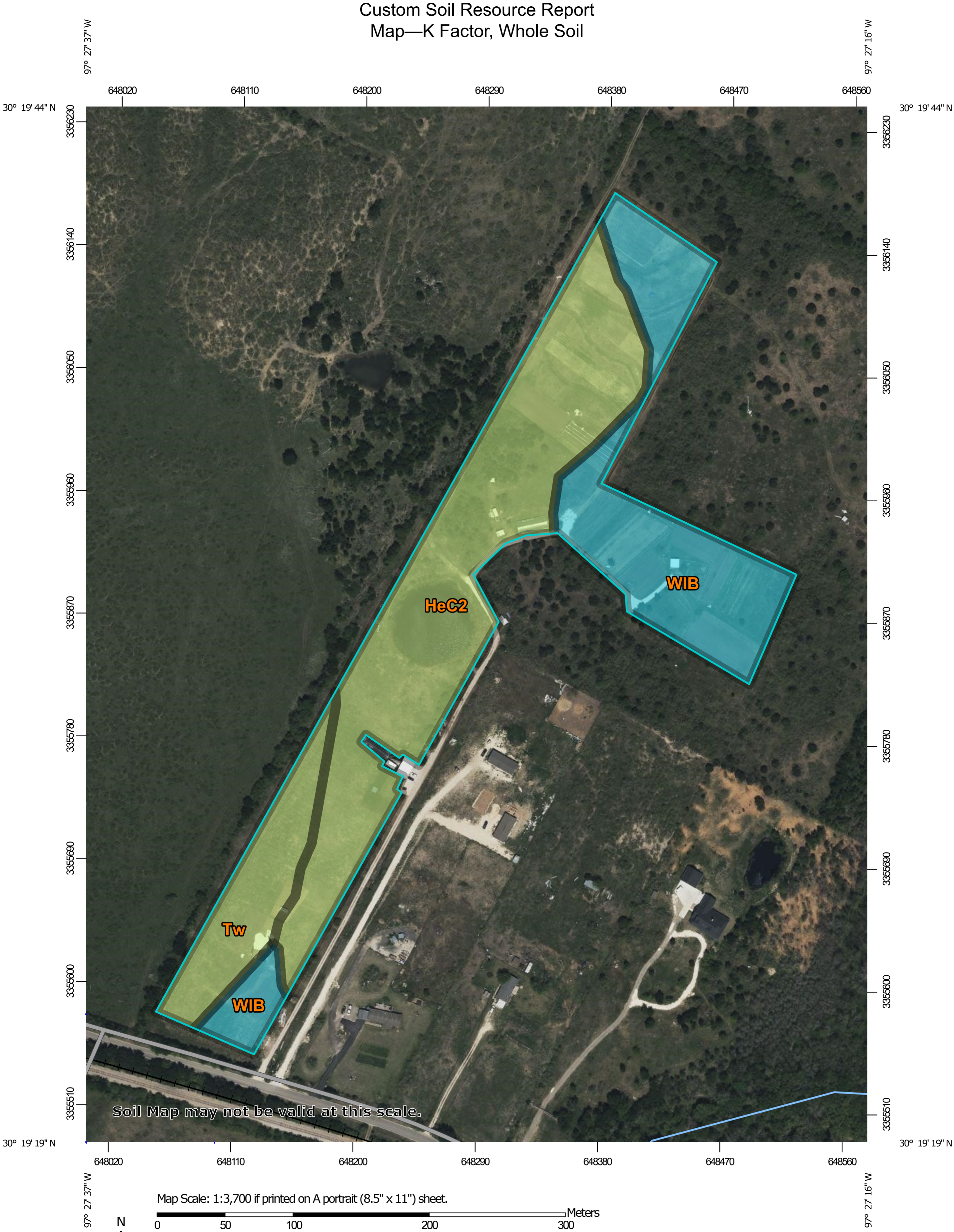
K Factor, Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Factor K does not apply to organic horizons and is not reported for those layers.

Map—K Factor, Whole Soil



Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 150, 300, 600, 900

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Lines

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Points

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	.24	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	.24	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	.37	5.5	32.9%
Totals for Area of Interest			**16.6**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Health Properties

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This folder contains information on soil properties that are important indicators of soil health.

Soil Health - Bulk Density, One-Third Bar

Bulk density, one-third bar is the oven-dry weight of the soil material less than 2 millimeters in size per unit volume of soil at a water tension of 1/3 bar (33 kPa). It indicates the density of the soil and is expressed in grams per cubic centimeter (g/cc) of soil material.

Significance:

Bulk density is one of several soil properties frequently used as a measure of soil health (Volchko et al., 2014) and as an indicator of soil compaction and root restriction. It reflects the soil's capacity to provide structural support, water and solute movement, and soil aeration (Arshad et al., 1996). Even though bulk density varies with soil texture, it is a dynamic soil property that also varies depending on the structural condition of the soil. It can be altered by cultivation, trampling by animals, compaction by agricultural machinery, and raindrop impact (Arshad et al., 1996). Any soil management that alters the soil cover, the amount of organic matter, soil structure, or porosity will affect soil bulk density (USDA-NRCS, 2008). A dense soil will restrict root growth and seedling emergence, reduce the available water capacity, restrict water and air movement, and ultimately reduce productivity. Management that improves soil bulk density includes reducing soil disturbance when the soil is wet, applying conservation practices that increase or maintain soil organic matter contents, and maintaining soil surface protection (such as a cover crop, especially a multi-species cover that can provide a wide range of root penetration).

Measurement of bulk density is essential for weight to volume or area conversions of other properties, such as soil carbon stocks and nutrient pools. It is also used in the calculation of pore space.

Factors Affecting Bulk Density:

Inherent factors.—Bulk density is dependent on soil texture and the densities of soil mineral particles (sand, silt, and clay) and organic matter particles, as well as their packing arrangement. Generally, loose, porous soils and those rich in organic matter have lower bulk densities. Sandy soils have relatively high bulk densities since total pore space in sands is less than that of silty or clayey soils. Finer-textured soils that have good structure, such as silt loams and clay loams, have higher pore space and lower bulk density compared to sandy soils.

There is a general relationship of soil bulk density to root growth based on soil texture. Bulk densities ideal for root growth are less than 1.60 g/cc for sandy textures, less than 1.40 g/cc for loamy textures, and less than 1.10 g/cc for clayey textures. Bulk densities that restrict root growth are greater than 1.80 g/cc for sandy textures, 1.65 g/cc for loamy textures, and 1.47 g/cc for clayey textures.

Dynamic factors.—Bulk density is changed by crop and land management practices that affect soil cover, organic matter, soil structure, and/or porosity. Cultivation can result in compacted soil layers with increased bulk density. Livestock as well as the use of agricultural and construction equipment can compact the soil and reduce porosity, especially on wet soils. Freeze-thaw action in the soil can lead to lowered bulk density.

Measurement:

In general, there are two broad groupings of bulk density methods. One group is for soil materials that are cohesive enough that a field sample can be removed, and the other group is for soils that are too fragile for field sampling and require an excavation operation. In methods for the former group, a clod sample is coated with a plastic film and the volume determined by submergence. There are also various core methods for the former group in which a cylinder of known volume is used to obtain a sample. The detailed procedures are outlined in the Kellogg Soil Survey Laboratory Methods Manual (Soil Survey Staff, 2014).

References:

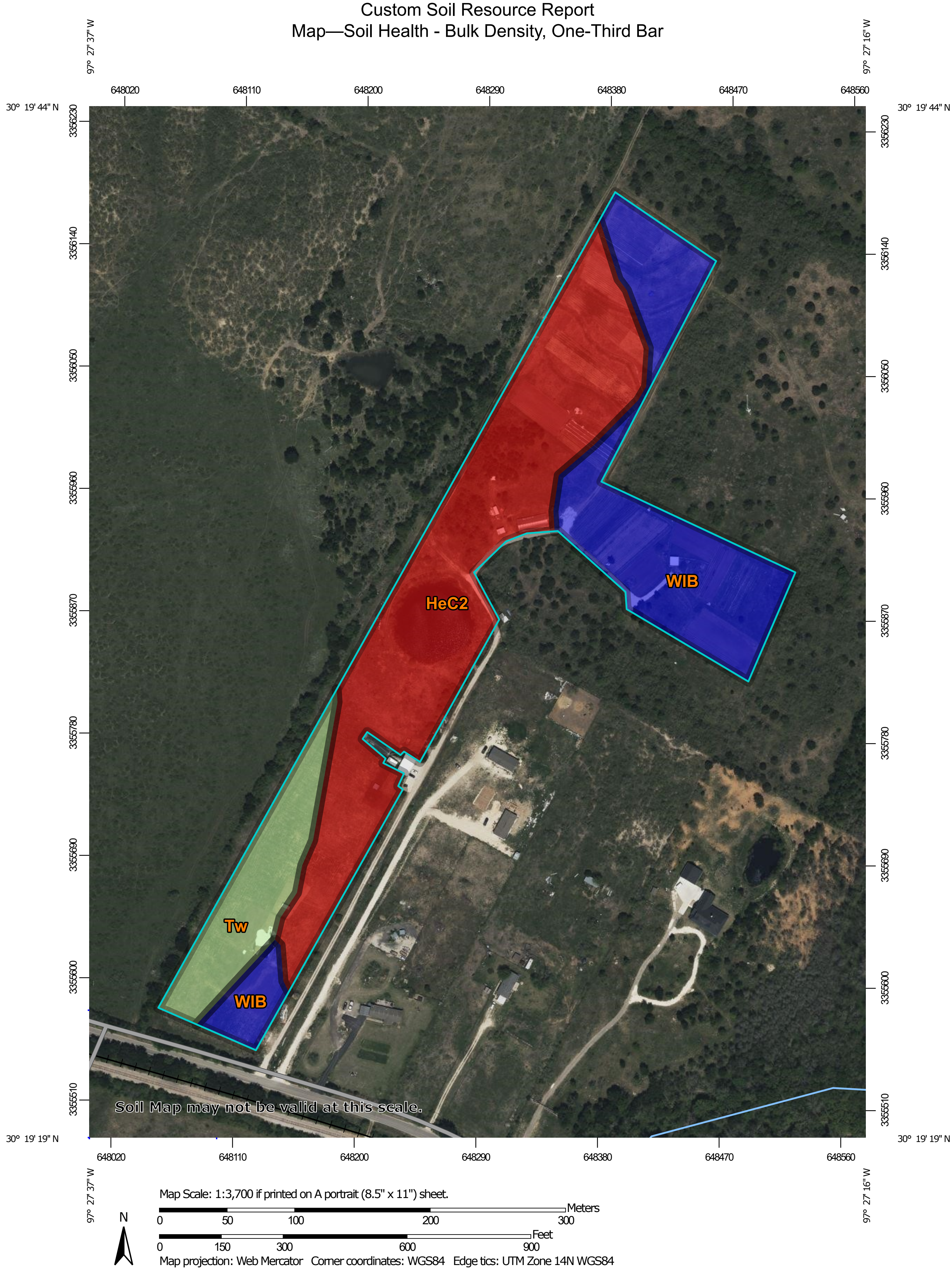
Arshad, M.A., B. Lowery, and R. Grossman. 1996. Physical tests for monitoring soil quality. In: J.W. Doran and A.J. Jones (eds.) Methods for Assessing Soil Quality. Soil Science Society of America Special Publication 49:123-142.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (eds.). U.S. Department of Agriculture, Natural Resources Conservation Service.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. Soil quality indicators—Bulk density.

Volchko, Y., J. Norrman, L. Rosèn, and T. Norberg. 2014. A minimum data set for evaluating the ecological soil functions in remediation projects. Journal of Soils and Sediments 14:1850-1860.

Map—Soil Health - Bulk Density, One-Third Bar



Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 150, 300, 600, 900

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 1.27
- > 1.27 and <= 1.38
- > 1.38 and <= 1.40
- Not rated or not available

Soil Rating Lines
- <= 1.27
- > 1.27 and <= 1.38
- > 1.38 and <= 1.40
- Not rated or not available

Soil Rating Points
- <= 1.27
- > 1.27 and <= 1.38
- > 1.38 and <= 1.40
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Soil Health - Bulk Density, One-Third Bar

Map unit symbol	Map unit name	Rating (grams per cubic centimeter)	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	1.27	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	1.38	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	1.40	5.5	32.9%
Totals for Area of Interest			**16.6**	**100.0%**

Rating Options—Soil Health - Bulk Density, One-Third Bar

Units of Measure: grams per cubic centimeter

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Health - Soil Reaction (pH)

Soil reaction (pH) is a measure of acidity or alkalinity. Chemically, it is a measurement of the hydrogen ion activity [H+] in the soil solution. The pH scale ranges from 0 to 14; a pH of 7 is considered neutral. If pH values are greater than 7, the solution is considered basic or alkaline; if they are below 7, the solution is acidic.

Significance:

The acidity or alkalinity of a soil affects the availability of plant nutrients, the activity of microorganisms, and the solubility of soil minerals (Brady, 1990). In general, pH values between 6 and 7.5 are optimum for general crop growth. Site-specific interpretations for soil health will depend on specific land uses and crop tolerances. In acid soils, calcium and magnesium, nitrate-nitrogen, phosphorus, boron, and molybdenum are deficient but aluminum and manganese are abundant, in some cases at levels toxic to some plants (USDA-NRCS, 2008). Phosphorus, iron, copper, zinc, and boron are frequently deficient in very alkaline soils. Bacterial populations and activity decline at low pH levels, whereas fungi adapt to a large range of pH (acidic and alkaline). Nitrification and nitrogen fixation are also inhibited by low pH (USDA-NRCS, 2008). To increase pH, liming, adding organic residues rich in basic cations, and rotating crops to interrupt the acidifying effect of leguminous crops are effective. Applying ammonium-based fertilizers, urea, sulfur, or ferrous sulfate; irrigating with acidifying fertilizers; or using acidifying residues (acid moss, pine needles, sawdust) decrease soil pH (USDA-NRCS, 2008).

Factors Affecting Soil Reaction:

Inherent factors.—The natural soil pH reflects the combined effects of climate, vegetation, topography, parent material, and time. Temperature and rainfall are two major factors that control the intensity of leaching and soil mineral weathering. Acidity is generally associated with leached soils, and alkalinity is generally associated with soils in drier regions. In arid climates, soil weathering and leaching are less intense, cations accumulate, and the soil becomes neutral or alkaline. In soils where the pH is less than 5, aluminum becomes soluble and reacts with water to produce hydrogen ions. Sandy soils may acidify more easily compared to clay soils because they have a low buffering capacity and tend to leach more readily. Vegetation has an effect on soil pH through the type of organic matter that is added; certain types of vegetation are soil acidifying (USDA-NRCS, 2008).

Dynamic factors.—The conversion of uncultivated land into cropland can result in drastic pH changes after a few years. These changes are caused by the removal of cations by crops, the acceleration of leaching, the effect of fertilizers and amendments, and the variations in organic matter content and soil buffering capacity (USDA-NRCS, 2008). Inorganic amendments (lime and gypsum) and organic amendments rich in cations increase soil pH. Ammonium from organic matter mineralization (nitrification), ammonium-based fertilizers, and sulfur compounds lower the pH. High rates of water percolation and infiltration can increase the leaching of cations and accelerate soil acidification.

Measurement:

The pH reported here is measured using the 1:1 soil to water ratio method (Soil Survey Staff, 2014). A crushed soil sample is mixed with an equal amount of water, and the pH of the suspension is measured.

References:

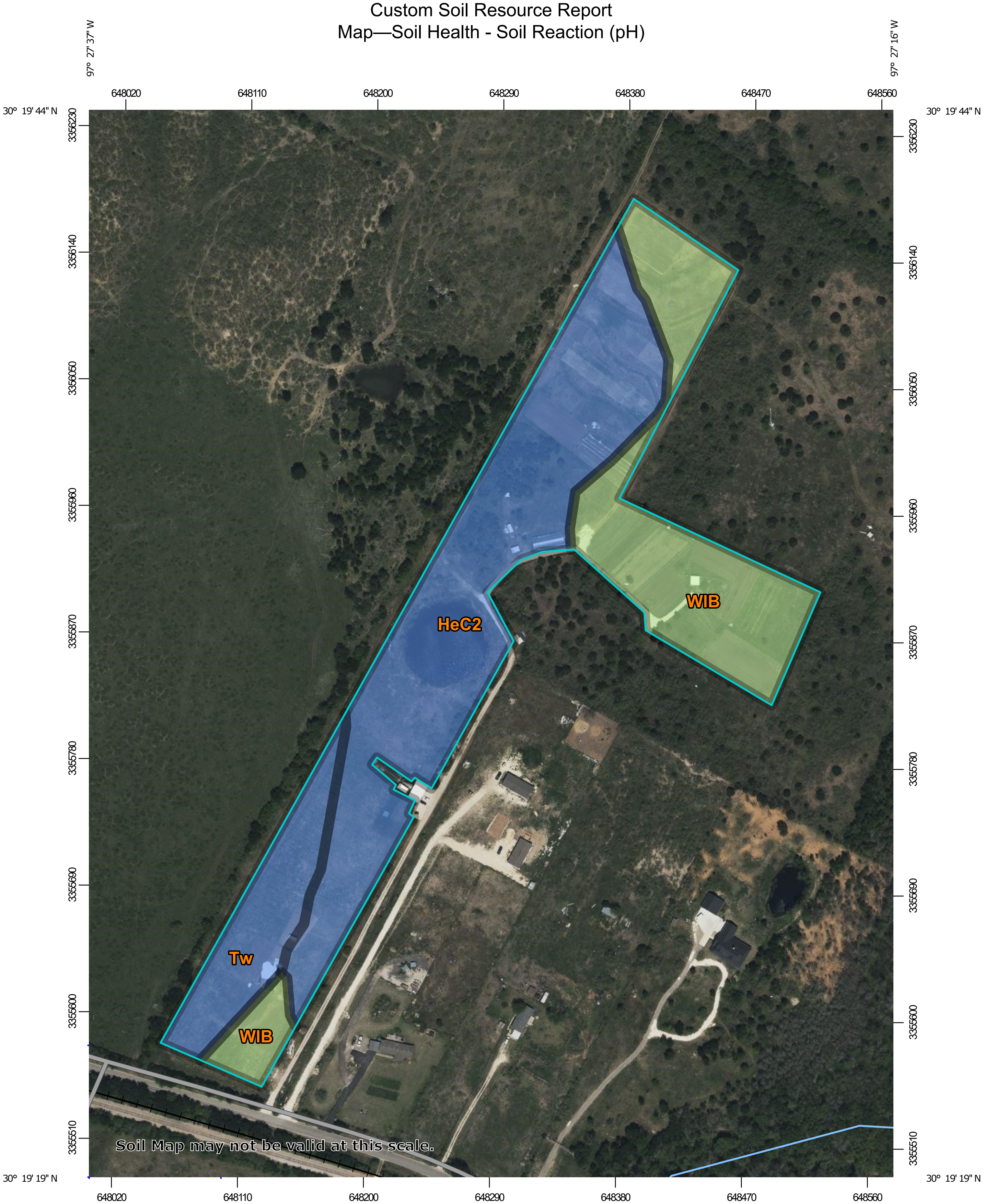
Brady, N.C. 1990. The nature and properties of soils. 10th ed. Macmillan Publishers, NY.

Smith, J.L., and J.W. Doran. 1996. Measurement and use of pH and electrical conductivity for soil quality analysis. In: J.W. Doran and A.J. Jones (eds.) Methods for Assessing Soil Quality. Soil Science Society of America Special Publication 49:169-185.

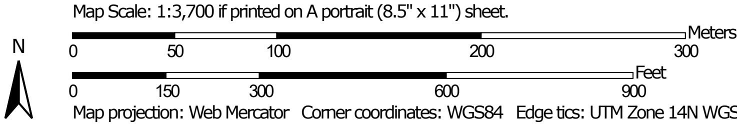
Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (eds.). U.S. Department of Agriculture, Natural Resources Conservation Service.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. Soil quality indicators—Soil pH.

Map—Soil Health - Soil Reaction (pH)



Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Ultra acid (pH < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

Soil Rating Lines

- Ultra acid (pH < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

Soil Rating Points

- Ultra acid (pH < 3.5)
- Extremely acid (pH 3.5 - 4.4)
- Very strongly acid (pH 4.5 - 5.0)
- Strongly acid (pH 5.1 - 5.5)
- Moderately acid (pH 5.6 - 6.0)
- Slightly acid (pH 6.1 - 6.5)
- Neutral (pH 6.6 - 7.3)
- Slightly alkaline (pH 7.4 - 7.8)
- Moderately alkaline (pH 7.9 - 8.4)
- Strongly alkaline (pH 8.5 - 9.0)
- Very strongly alkaline (pH > 9.0)
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

> Warning: Soil Map may not be valid at this scale.
>
> Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Soil Health - Soil Reaction (pH)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	8.2	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	7.9	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	6.5	5.5	32.9%
Totals for Area of Interest			**16.6**	**100.0%**

Rating Options—Soil Health - Soil Reaction (pH)

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Health - Available Water Capacity

Available water capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. It is expressed in centimeters of water per centimeter of soil for each soil layer.

Significance:

Available water capacity is an indicator of a soil's ability to retain water and make it sufficiently available for plant use. In areas where daily rainfall is insufficient to meet plant needs, the capacity of soil to store water is very important (USDA-NRCS, 2008). Water held in the soil is needed to sustain plants between rainfall or irrigation events and provide a buffer against periods of water deficit. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity determinations are used to develop water budgets, predict droughtiness, design and operate irrigation systems, design drainage systems, protect water resources, and predict yields (Lowery et al., 1996). They also are an important factor in the choice of plants or crops to be grown. The available water capacity can be increased by applying soil management that maximizes the soil's inherent capacity to store water. Improving soil structure and ameliorating compacted zones can improve both the storage capacity of the soil itself and increase the depth to which plant roots can penetrate.

Factors Affecting Available Water Capacity:

Inherent factors.—Available water capacity is affected by soil texture, amount of rock fragments, and a soil's depth and layers. It is primarily controlled by soil texture and structure. Soils with higher silt contents generally have higher available water capacities, while sandy soils have the lowest available water capacities. Rock fragments reduce a soil's available water capacity proportionate to their volume, unless the rocks are porous. Soil depth and root-restricting layers affect the total available water capacity since they can limit the volume of soil available for root growth.

Dynamic factors.—Available water capacity is affected by soil organic matter, compaction, and salt concentrations. Organic matter can increase a soil's capacity to store water, on average, equivalent to its weight in available water (Libohova et al., 2018). Indirectly, organic matter improves soil structure and aggregate stability, resulting in increased pore size and volume. These soil improvements result in increased infiltration and movement of water through the soil. Greater amounts of water entering the soil can then be used by plant roots. Compaction reduces the available water capacity by reducing the total pore volume. Soils with high salt concentrations have a reduced available water capacity. Solutes in soil water attract water (osmotic potential), making it difficult for plant roots to extract or uptake the water.

Measurement:

Available water capacity is determined in the lab by measuring the water content at field capacity (33 kPa) and wilting point (1500 kPa) and calculating the difference (Soil Survey Staff, 2014). Pressure plates or membranes are used to bring the soil sample to a desired matric potential (33 kPa or 1500 kPa). When at equilibrium, the soil sample is removed and dried to determine its water content.

References:

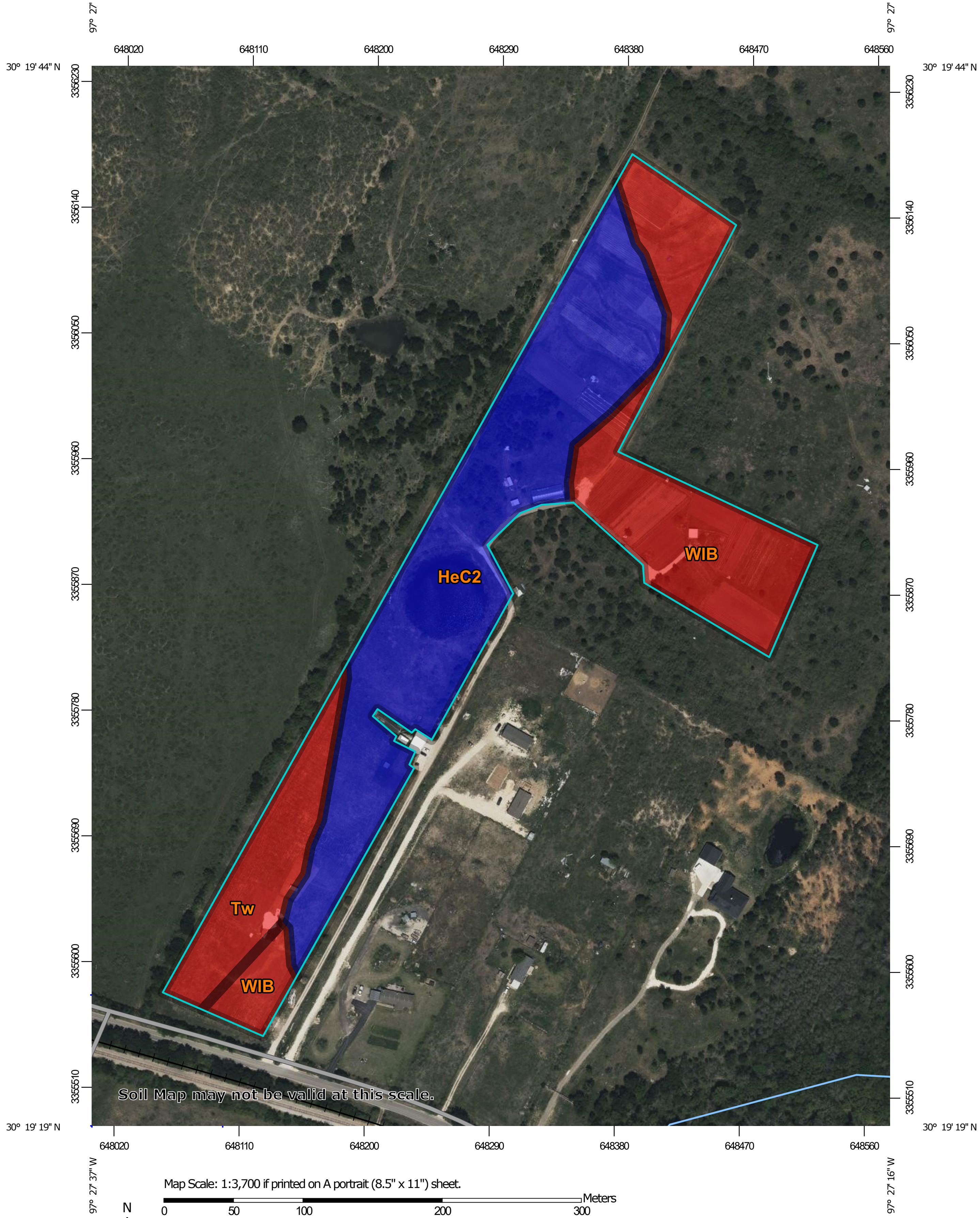
Libohova, Z., C. Seybold, D. Wysocki, S. Wills, P. Schoeneberger, C. Williams, D. Lindbo, D. Stott, and P.R. Owens. 2018. Reevaluating the effects of soil organic matter and other properties on available water-holding capacity using the National Cooperative Soil Survey Characterization Database. Journal of Soil and Water Conservation 73(4):411-421.

Lowery, B., M.A. Arshad, R. Lal, and W.J. Hickey. 1996. Soil water parameters and soil quality. In: J.W. Doran and A.J. Jones (eds.) Methods for assessing soil quality. Soil Science Society of America Special Publication 49:143-157.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (eds.). U.S. Department of Agriculture, Natural Resources Conservation Service.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. Soil quality indicators—Available water capacity.

Custom Soil Resource Report
Map—Soil Health - Available Water Capacity



Map Scale: 1:3,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

Feet: 0 150 300 600 900

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

<= 0.14

> 0.14 and <= 0.16

Not rated or not available

Soil Rating Lines

<= 0.14

> 0.14 and <= 0.16

Not rated or not available

Soil Rating Points

<= 0.14

> 0.14 and <= 0.16

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Soil Health - Available Water Capacity

Map unit symbol	Map unit name	Rating (centimeters per centimeter)	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	0.16	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	0.14	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	0.14	5.5	32.9%
Totals for Area of Interest			**16.6**	**100.0%**

Rating Options—Soil Health - Available Water Capacity

Units of Measure: centimeters per centimeter

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Health - Organic Matter

Organic matter percent is the weight of decomposed plant, animal, and microbial residues exclusive of non-decomposed plant and animal residues. It is expressed as a percentage, by weight, of the soil material that is less than 2 mm in diameter.

Significance:

Soil organic matter (SOM) influences the physical, chemical, and biological properties of soils far more than suggested by its relatively small proportion in most soils. The organic fraction influences plant growth through its influence on these soil properties. It encourages soil aggregation, especially macroaggregation, increases porosity, and lowers bulk density. Because the soil structure is improved, water infiltration rates increase. SOM has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to microorganisms in the soil. As SOM is decomposed by soil microbes, it releases nitrogen, phosphorous, sulfur, and many micronutrients, which become available for plant growth. SOM is a heterogeneous, dynamic substance that varies in particle size, carbon content, decomposition rate, and turnover time. In general, the content of SOM is highest at the surface—where plant, animal, and microbial residue inputs are greatest—and decreases with depth.

Total organic carbon (TOC) is the carbon (C) stored in SOM. Total organic carbon is also referred to as soil organic carbon (SOC) in the scientific literature. Organic carbon enters the soil through the decomposition of plant and animal residues, root exudates, and living and dead microorganisms. Inorganic carbon is common in calcareous soils in the form of calcium and magnesium carbonates. In calcareous soils, the content of inorganic carbon can exceed TOC.

Factors Affecting Content of SOM and SOC:

Inherent factors - Soil texture, parent material, drainage, climate, and time affect accumulation of SOM. Soils that are rich in clay have greater capacity to protect SOM from decomposition by stabilizing substances that bind to clay surfaces. The formation of soil aggregates—enabled by the presence of clay, aluminum and iron oxides, fungal hyphae, bacterial exudates (carbohydrates), and fine roots—protects SOM from microbial decomposition. Extractable aluminum and allophanes, which are present in volcanic soils, can react with SOM to form compounds that are stable and resist microbial decomposition. Warm temperatures increase decomposition rates of SOM. High mean annual precipitation increases accumulation rates of SOM by stimulating the production of plant biomass.

Loss of SOM through erosion results in SOM variations along slope gradients. Areas of level topography tend to have much more SOM than areas with other slope classes. Both elevation and topographic gradients affect local climate, vegetation distribution, and soil properties. They also affect associated biogeochemical processes, including SOM dynamics. Analysis of factors affecting C in the conterminous United States indicates that the effects of land use, topography (elevation and slope), and mean annual precipitation on SOM are more obvious than the effects of mean annual temperature. However, when other variables are highly restricted, SOM content clearly declines with increasing temperature.

Dynamic factors - Dynamic gains and losses in SOM are due primarily to management decisions in combination with climate and microbial influences. Accumulation of SOM is controlled by the rate of C mineralization, the amount and stage of decomposition of plant residues, and the addition of organic amendments to soil.

Soil organic carbon comprises approximately 52 to 58% of the SOM and is the main source of energy for soil microorganisms. The C within plant residues, particulate organic matter, and soil microbial biomass is generally considered to be within the active pool of SOM. The emergent view of SOM focuses on microbial access to SOM and includes an emphasis on the need to manage C flows rather than discrete C pools. During decomposition of SOM, energy and nutrients are released and utilized by plant roots and soil biota. Recognizing that SOM is a continuum of decomposition products is a first step in designing management strategies for renewing SOM sources throughout the year.

Soil aggregates of various sizes and stabilities can act as sites at which SOM is physically protected from decomposition and C mineralization. Soil disturbance and aggregate destruction increase biodegradation of SOM. Aggregates are readily broken apart by tillage operations.

Crop residues incorporated into or left on the soil surface reduce erosion and the losses of SOM associated with sediment. In acidic soils, applications of lime increase plant productivity, microbial activity, organic matter decomposition, and CO2 release.

The diversity of the soil microbial population affects SOM. For example, while soil bacteria and some fungi participate in SOM loss by mineralizing C compounds, other fungi, such as mycorrhizae, facilitate stabilization and physical protection by aggregating SOM with clay and minerals. SOM is better protected from degradation within aggregates than in free-form.

Relationship to Soil Function:

SOM is one of the most important soil constituents. It affects plant growth by improving aggregate stability, soil structure, water availability, and nutrient cycling. SOM fractions in the active pool, described above, are the main source of energy and nutrients for soil microorganisms, which mediate nutrient cycling in the soil. Biochemically stable SOM participates in aggregate stability and in holding capacity for nutrients and water.

Microaggregates are formed by mineral interactions with iron and aluminum oxides and are generally considered an inherent soil characteristic. They are, however, impacted by current and past management. Fine roots, fungal hyphae, and organic carbon compounds, such as complex sugars (carbohydrates) and proteins (also referred to as glues), bind mineral particles and microaggregates together to form macroaggregates that are still porous enough to allow air, water, and plant roots to move through the soil.

An increase in SOM leads to greater biological diversity and activity in the soil, thus increasing biological control of plant diseases and pests.

Problems Associated with Low Organic Matter Levels:

Low levels of SOM result in energy-source shortages and thereby lowered levels of microbial biomass, activity, and nutrient mineralization. In noncalcareous soils, aggregate stability, infiltration, drainage, and airflow are also reduced. Scarcity of SOM results in less diversity in soil biota and a risk of disruption to the food chain equilibrium. This disruption can cause disturbance in the soil environment (e.g., increased plant pests and diseases and accumulation of toxic substances).

Improving SOM Levels:

An estimated 4.4x10 to the 9th power tons of C have been lost from soils of the United States due to traditional farming practices. Most of this carbon was SOC. Nearly half of the SOM has been lost from many agricultural soils. Other farming practices, such as no-till and cover cropping (especially when used together), can stop losses of SOM and even lead to increases. Continuous application of manure and compost can increase SOM. Burning, harvesting, or otherwise removing plant residues decreases SOM.

Measurement:

SOM is measured in the laboratory by determining total carbon (TC) content using either dry or wet-dry combustion. Current analytical methods do not distinguish between decomposed and nondecomposed residues, so soil is first sieved to 2 mm to remove as much of the recognizable plant material as possible. If no carbonates are present, TC is considered to be the same as TOC (or SOC). For calcareous soils, soil inorganic carbon in the form carbonates must also be measured and then subtracted from the TC to determine TOC content. Results are given as the percent TOC in dry soil. To convert percent TOC to percent SOM, multiply the TOC percentage by 1.724. To convert percent SOM to percent TOC, divide the SOM percentage by 1.724. Note that this value continues to be debated by researchers with possible values ranging from 1.4 to 2.5 (Pribyl, 2010). A conversion factor of 2 has been suggested for this database but has not yet been adopted. Detailed procedures for measurement of SOM are outlined in 'Soil Survey Investigations Report No. 42, Kellogg Soil Survey Laboratory Methods Manual, Version 5.0,' (Soil Survey Staff, 2014).

Many soil testing laboratories use a 'loss on ignition' method to estimate soil organic matter. The estimate produced by this method must be correlated to analytical TOC measurements for each area to improve accuracy. The loss on ignition method can provide a good indication of the trend in SOM content within a field. It is important to note that temperature and timing used for the loss on ignition approach vary across labs and can influence results. Thus, comparisons should be made using only results from within a given lab.

Currently, no standard method exists to measure TOC in the field. Attempts have been made to develop charts that match color to TOC content, but the correlation is better within soil landscapes and only for limited soils. Near-infrared spectroscopy has been tested for measuring C directly in the field, but it is expensive and sensitive to moisture content.

Estimates:

Color and feel are soil characteristics that can be used to estimate SOM content. Color comparisons in areas of similar parent materials and textures can be correlated with laboratory data and thereby enable a soil scientist to make field estimates. In general, darker colors or black indicate the presence of higher amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator. Sandy soils tend to look darker with a lower content of SOM. In general, lower numbers for hue, value, and chroma (in the Munsell soil color system) tend to be associated with darker soil colors that are attributed to higher content of SOM, soil moisture, or both.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A 'representative' value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

References:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Edwards, J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1999. Tillage and crop rotation effects on fertility status of a Hapludalf soil. Soil Science Society of America Journal 56:1577–1582.

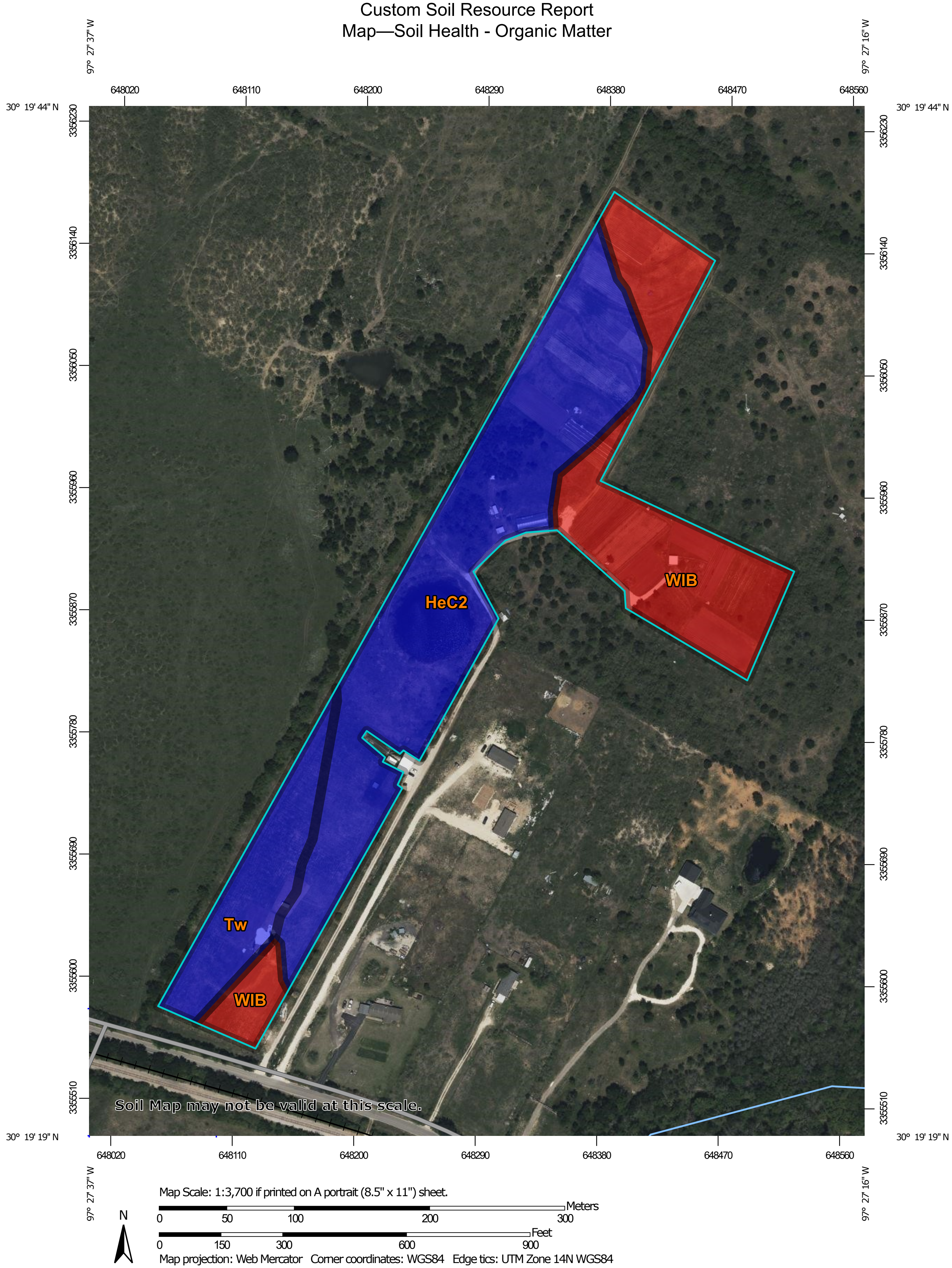
Pribyl, D.W. 2010. A critical review of the conventional SOC to SOM conversion factor. Geoderma 156:75–83.

Sikora, L.J., and D.E. Stott. 1996. Soil organic carbon and nitrogen. In: J.W. Doran and A.J. Jones, editors, Methods for assessing soil quality. Madison, WI. p. 157–167.

Schulze, D.G., J.L. Nagel, G.E. Van Scoyoc, T.L. Henderson, M.F. Baumgardner, and D.E. Stott. 1993. Significance of organic matter in determining soil colors. In: J.M. Bigham and E.J. Ciolkosz, editors, Soil color. Soil Science Society of America, Madison, WI. p. 71–90.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Custom Soil Resource Report
Map—Soil Health - Organic Matter



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 1.25
- > 1.25 and <= 2.50
- Not rated or not available

Soil Rating Lines

- <= 1.25
- > 1.25 and <= 2.50
- Not rated or not available

Soil Rating Points

- <= 1.25
- > 1.25 and <= 2.50
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Travis County, Texas
Survey Area Data: Version 24, Aug 24, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 2, 2022—May 17, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Soil Health - Organic Matter

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	2.50	8.9	53.5%
Tw	Tinn clay, 0 to 1 percent slopes, frequently flooded	2.50	2.3	13.6%
WlB	Wilson clay loam, 1 to 3 percent slopes	1.25	5.5	32.9%
Totals for Area of Interest			**16.6**	**100.0%**

Rating Options—Soil Health - Organic Matter

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf