

Trial Results

Created for

2341 Blue Ridge Drive



SOIL FOR
WATER



Report

Bamberger Ranch

Johnson City, Blanco County TX 78636

October 2022

Thank you for allowing your property to be used as a study site, and we hope you find this report helpful in making management decisions, understanding the ecology of your land, and catching and holding more water in your soil.

The report is based on data collected between 2019 and 2021 from stationary 40-meter-long transects at various points on the ranch. During each visit, we took photos and studied ground cover and plant species composition at 10 random one-square-meter plots along each transect. We also took soil samples and analyzed them with various tests, including PLFA and Haney tests, checking soil health indicators such as plant-available water holding capacity, aggregate stability, and certain enzymes.

Please note that various researchers and consultants contributed to this report, and they may not always agree in their interpretations or management recommendations. If you have questions, give us a call or send us an email. We'd love to hear your feedback and would be happy to discuss anything in this report with you.

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This report is based in part on work supported by the Natural Resources Conservation Service, U.S. Department of Agriculture, under number NR203A750001C025. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

CONTENTS:

1. GENERAL INFORMATION

i. Ranch Description

ii. Transect Management Description

iii. Annual Rainfall in General Vicinity

2. PERCENT GROUND COVER, VEGETATIVE HEALTH INDEX, AND SPECIES DIVERSITY

i. Percent Ground Cover Overview

ii. Vegetative Health Index Overview

iii. Vegetative Health Index Summaries— Steve Nelle, Wildlife Biologist

iv. Species Diversity Summaries – Kelly Lyons, PhD, Department of Biology, Trinity University

3. SOIL TEST RESULTS

i. Soil Health Analysis

ii. Soil Health Summaries - Lance Gunderson President & Co-Owner at Regen Ag Lab

4. TRANSECT PHOTOS AND MONITORING REPORTS

5. ANNUAL COMPARISON AND MANAGEMENT SUGGESTIONS

GENERAL INFORMATION

Ranch Description

Bamberger Ranch's original purchase of 3,000 acres in 1969 began a land restoration journey that has been going on for 53 years. Now comprising 5,500 acres in Blanco County, the ranch has been restored to its original habitat and has been one of the largest habitat restoration projects in Texas, winning numerous awards. With the removal of many of the Ashe juniper and replanting of native grasses, long absent springs are now constantly flowing. The major spring produces an average of 3 gallons per minute (4,320 gallons per day) and furnishes all the water used by the ranch and the center, three households, as well as for agricultural use. Overflow from this spring along with other smaller springs and seeps produce the headwaters of Miller Creek which flows into the Pedernales River, which then flows into the Colorado River, the surface supply for the City of Austin 60 miles away.

Today the ranch mission is to teach ethical land stewardship — by example and outreach — offering seminars for landowners and serving as a research lab for botanists, zoologists, and other scientists. Except for a few areas, most of the ranch is currently not grazed by any commercial livestock. However, there is a great deal of wildlife on the land.

At the time of this report, it is unknown if either of the transects have been grazed by livestock. Since we did not receive any management updates, the report does not comment on how grazing management may be affecting the transects.

To view an Ecological Site Description for Bamberger Ranch, SEE APPENDIX.

Learn more about Bamberger Ranch and the Soil for Water program here:

<https://storymaps.arcgis.com/stories/f77025ef60cc43e3ac060f275d18afc6>

Transect Management Description

Bamberger Ranch joined the Soil for Water program in spring 2016. The project currently has two transects established on the Bamberger Ranch in two different areas. Originally transects were set up in locations other than those listed below. However, after determining that the soil in this area was so degraded it would be hard to see changes within the scope of the project, we decided to move the transects. Please also note that data collection methodologies were changed in 2019 for clarity and efficiency. For consistency, the data we are using in this report is from 2019-2021 except for some 2017 soil testing data for the Turkey Hollow transect.

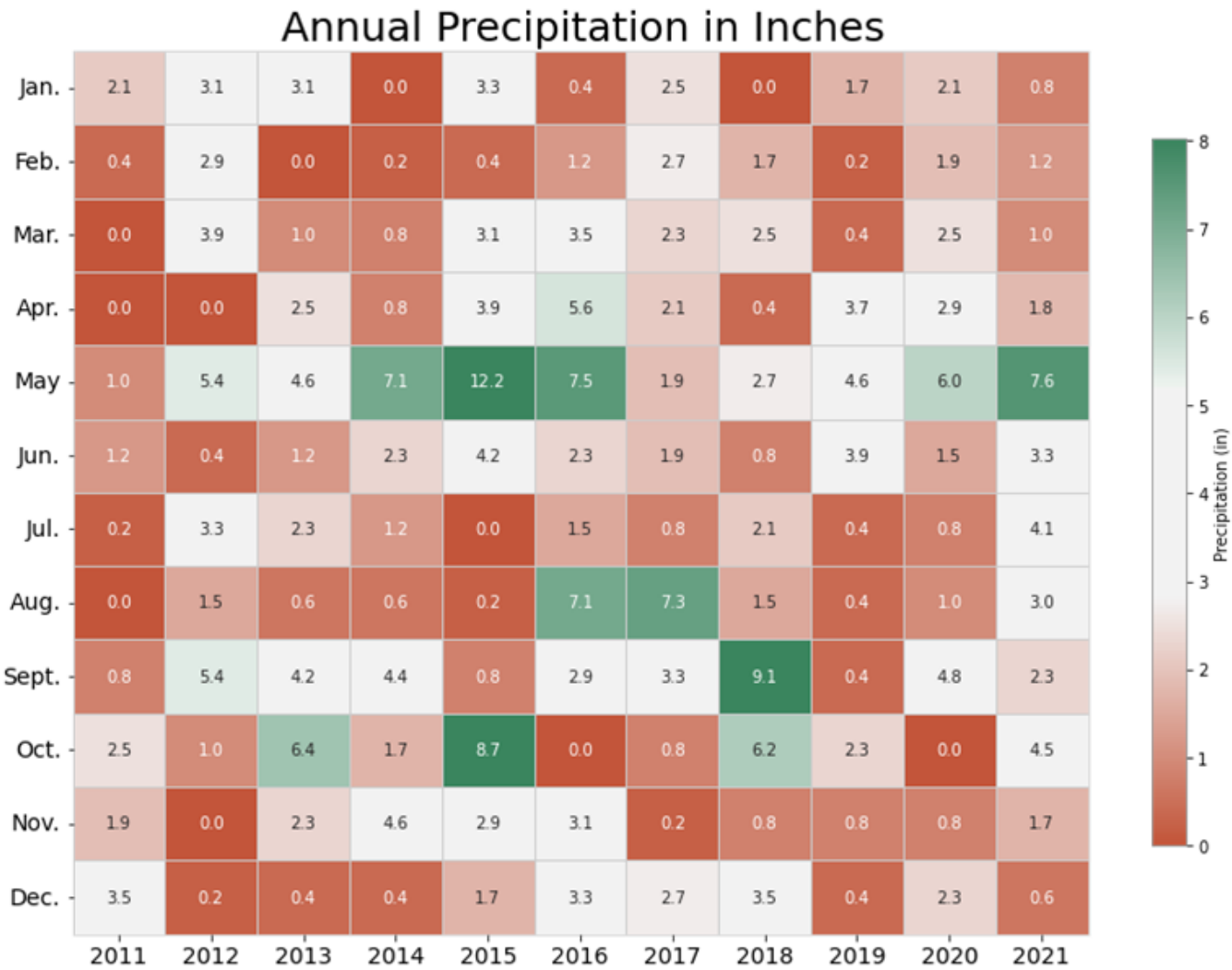
Turkey Hollow

This transect is in a pasture that was void of livestock for many years and set aside for wildlife. The staff decided to graze it periodically and allow for long recoveries after grazing events. During its multi-year rest period, the vegetation became very dense in some places and thin in others. This transect will provide data on changes that occur under short grazing period with long recovery periods. No management information has been shared with us to this date.

Wildlife Preserve

This pasture is set aside for wildlife only. This transect will provide data on changes that take place in the presence of unmanaged wildlife and no livestock grazing for a long period of time. There is no hunting in this area either. Our interest in this site is to learn what changes occur in the soil microbiome without human management and in the presence of a community of wildlife that is now missing key predator species. Without these key species, behavior of existing species changes and some studies indicate that a decrease in overall species diversity may occur under such conditions.

Annual Rainfall in General Vicinity



Precipitation Report (10-Years)
Location: 30.2060, -98.4494
2341 Blue Ridge Dr Johnson City, TX 78636

Date Range: 2011 - 2021

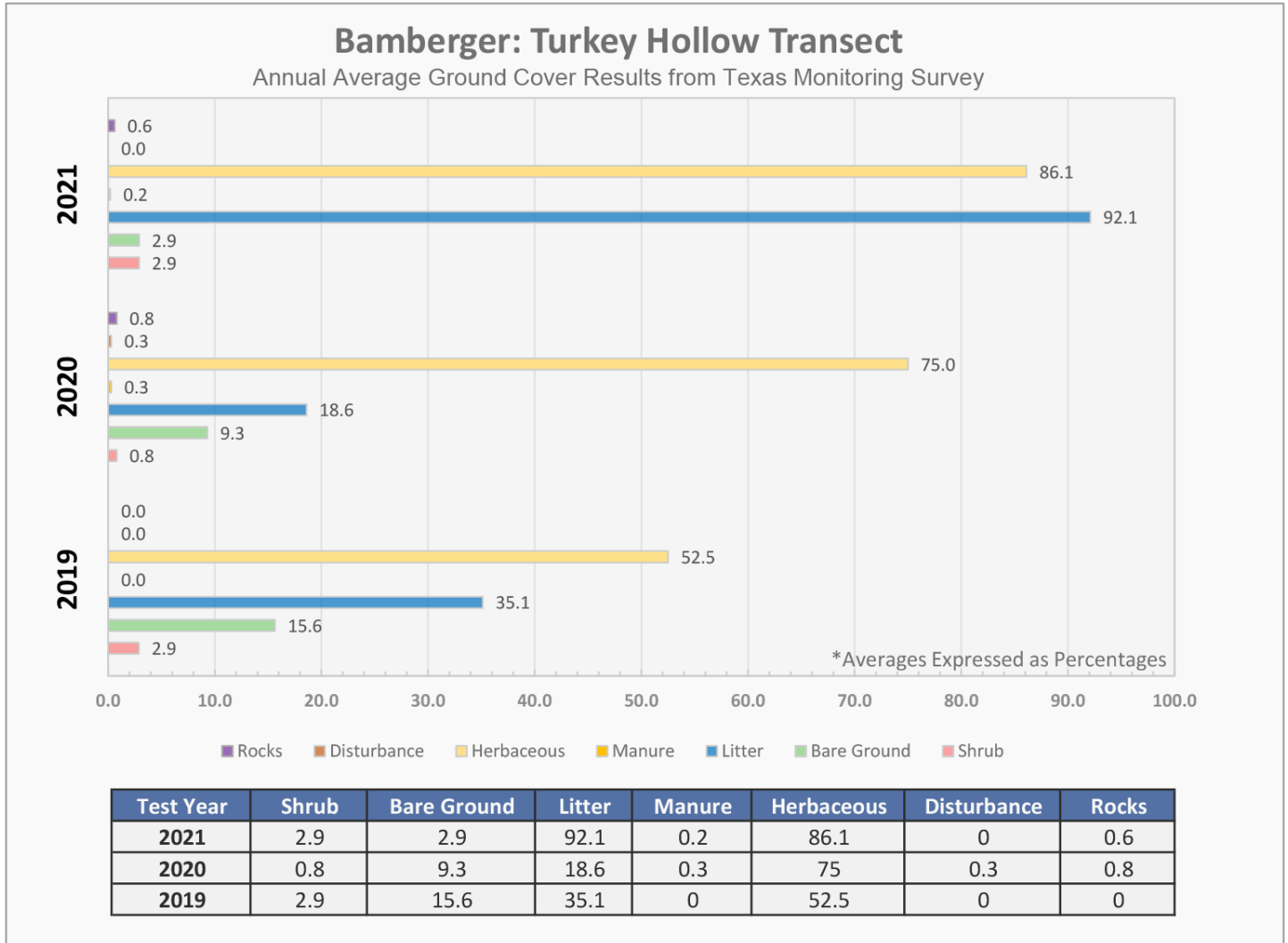
Creation Date: 07 Jul. 2022
Data Derived from:
<https://power.larc.nasa.gov/data-access-viewer/>



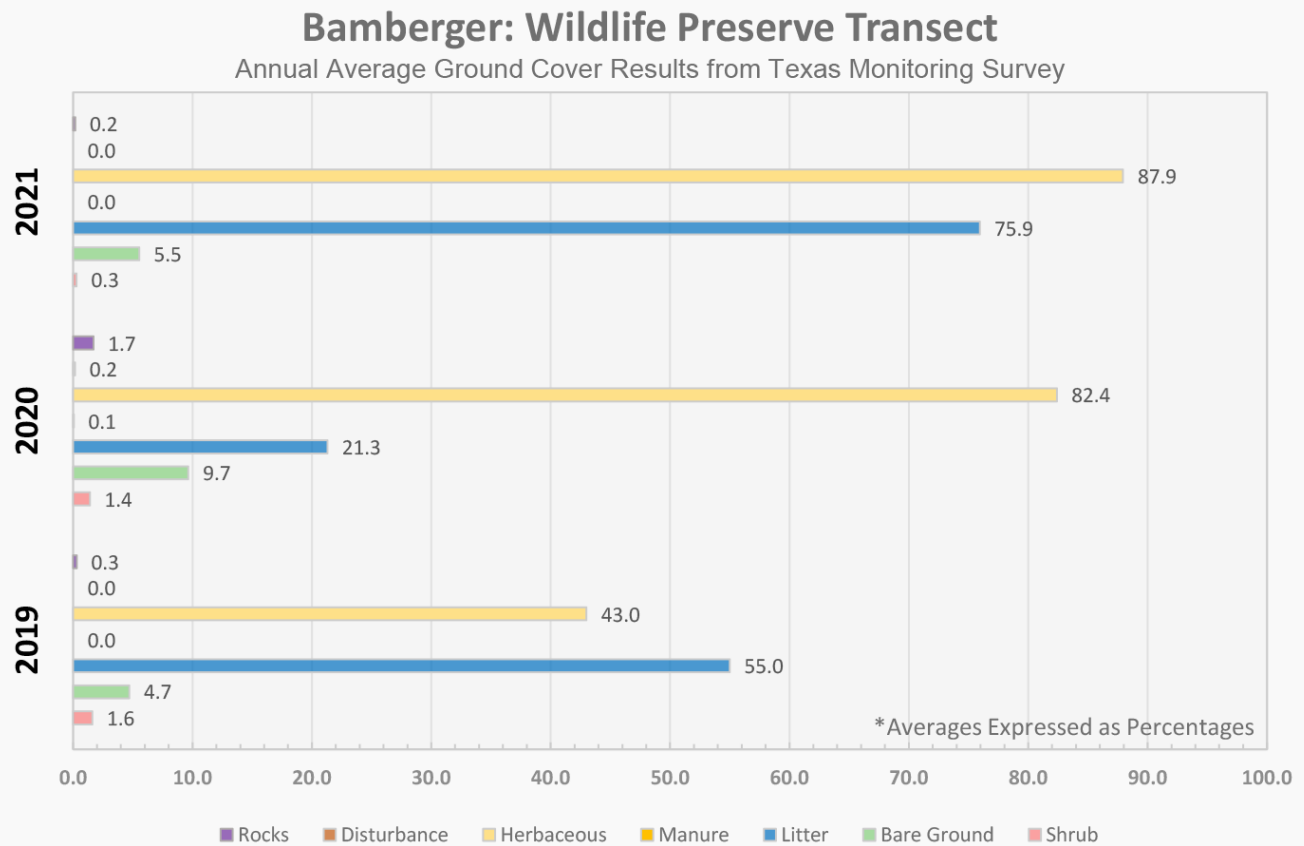
PERCENT GROUND COVER, VEGETATIVE HEALTH INDEX, AND SPECIES DIVERSITY SUMMARIES

Percent Ground Cover Overview

Transect 1: Turkey Hollow



Transect 2: Wildlife Preserve



Test Year	Shrub	Bare Ground	Litter	Manure	Herbaceous	Disturbance	Rocks
2021	0.7	12.0	55.7	0.0	70.7	0.0	0.4
2020	2.8	18.7	8.1	0.1	76.8	0.3	1.7
2019	1.6	4.7	55.0	0.0	43.0	0.0	0.3

Vegetative Health Index Overview

Years	2019		
TRANSECT NAME	Turkey Hollow		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Schizachyrium scoparium	Healthy	Little bluestem	42.14
Bouteloua curtipendula	Healing	Sideoats grama	2.00
Aristida purpurea	Degraded	Purple threeawn	2.00
Bouteloua hirsuta	Degraded	Grama, hairy	1.67
Sporobolus compositus	Healing	Tall dropseed	1.33
Croton monanthogynus	WA	Oneseed croton	1.00
Bothriochloa laguroides	Healing	Silver bluestem	1.00
Polygala alba	Healthy	White milkwort	1.00
Torilis arvensis	WA	Beggar's lice	1.00
Sida abutifolia [=S. filicaulis]	Healing	Spreading sida	1.00
Bouteloua rigidiseta	Degraded	Texas grama	1.00
Plantago rhodosperma	WA	Redseed plantain	1.00
Nassella leucotricha	Healing	Texas wintergrass	1.00
Diaperia verna	WA	Roundhead rabbit tobacco	1.00

Years	2021		
TRANSECT NAME	Turkey Hollow		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Schizachyrium scoparium	Healthy	Little bluestem	41.86
Wedelia hispida	Healing	Orange zexmenia	18.67
Bouteloua curtipendula	Healing	Sideoats grama	8.67
Sporobolus compositus	Healing	Tall dropseed	3.67
Eragrostis intermedia	Healthy	Lovegrass, Plalns	3.00
Aristida purpurea	Degraded	Purple threeawn	2.50
Bouteloua hirsuta	Degraded	Grama, hairy	1.80
Croton monanthogynus	WA	Oneseed croton	1.00
Polygala lindheimeri	Healthy	Lindheimer's milkwort	1.00
Rhynchosia senna var. texana	Healthy	Texas snoutbean	1.00
Evolvulus sericeus	Healing	Evolvulus	1.00
Sida abutifolia [=S. filicaulis]	Healing	Spreading sida	

Years	2019		
TRANSECT NAME	Wildlife Preserve		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Schizachyrium scoparium	Healthy	Little bluestem	27.50
Sporobolus compositus	Healing	Tall dropseed	14.43
Aristida purpurea	Degraded	Purple threeawn	5.20
Bothriochloa ischaemum	NNF	King Ranch bluestem ("K.R.")	3.33
Nassella leucotricha	Healing	Texas wintergrass	3.00
Bothriochloa laguroides	Healing	Silver bluestem	2.80
Bouteloua hirsuta	Degraded	Grama, hairy	2.50
Tridens muticus	Healing	Tridens, slim, rough	1.00
Erioneuron pilosum	Degraded	Hairy tridens	1.00
Sida abutifolia [=S. filicaulis]	Healing	Spreading sida	1.00
Diaperia verna	WA	Roundhead rabbit tobacco	1.00
Torilis arvensis	WA	Beggar's lice	1.00
Plantago rhodosperma	WA	Redseed plantain	1.00
Polygala alba	Healthy	White milkwort	1.00
Panicum hallii var. hallii	Degraded	Hall's panicum	1.00

Years	2021		
TRANSECT NAME	Wildlife Preserve		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Bothriochloa ischaemum	NNF	King Ranch bluestem ("K.R.")	20.43
Nassella leucotricha	Healing	Texas wintergrass	16.00
Wedelia hispida	Healing	Orange zexmenia	15.11
Sporobolus compositus	Healing	Tall dropseed	13.86
Schizachyrium scoparium	Healthy	Little bluestem	10.25
Eragrostis intermedia	Healthy	Lovegrass, Plalns	8.00
Bouteloua curtipendula	Healing	Sideoats grama	6.00
Bouteloua rigidiseta	Degraded	Texas grama	2.00
Bouteloua hirsuta	Degraded	Grama, hairy	2.00
Aristida purpurea	Degraded	Purple threeawn	2.00
Polygala lindheimeri	Healthy	Lindheimer's milkwort	1.29
Tridens muticus	Healing	Tridens, slim, rough	1.00
Sida abutifolia [=S. filicaulis]	Healing	Spreading sida	1.00

Years	2020		
TRANSECT NAME	Turkey Hollow		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Schizachyrium scoparium	Healthy	Little bluestem	41.20
Diaperia prolifera	WA	Roundhead rabbit tobacco	11.33
Wedelia hispida	Healing	Orange zexmenia	6.33
Sporobolus compositus	Healing	Tall dropseed	3.50
Tridens muticus	Healing	Tridens, slim, rough	2.00
Bouteloua curtipendula	Healing	Sideoats grama	1.75
Bouteloua hirsuta	Degraded	Grama, hairy	1.60
Polygala lindheimeri	Healthy	Lindheimer's milkwort	1.11
Aristida purpurea	Degraded	Purple threeawn	1.00
Bothriochloa laguroides	Healing	Silver bluestem	1.00
Rhynchosia senna var. texana	Healthy	Texas snoutbean	1.00
Chamaesaracha sordida	Degraded	False nightshade	1.00
Evolvulus sericeus	Healing	Evolvulus	1.00
Croton monanthogynus	WA	Oneseed croton	1.00
Aphanostephus ramosissimus	WA	Lazy daisy	1.00
Desmanthus velutinus	Healthy	Bundleflower, velvet	1.00

Years	2020		
TRANSECT NAME	Wildlife Preserve		
Species	Vegetative health Index	Common Name	Average of Species Percent:
Panicum coloratum	NNF	Kleingrass	30.00
Schizachyrium scoparium	Healthy	Little bluestem	23.67
Sporobolus compositus	Healing	Tall dropseed	12.25
Nassella leucotricha	Healing	Texas wintergrass	11.67
Wedelia hispida	Healing	Orange zexmenia	7.70
Bouteloua curtipendula	Healing	Sideoats grama	7.00
Aristida purpurea	Degraded	Purple threeawn	3.00
Bouteloua hirsuta	Degraded	Grama, hairy	2.33
Tridens muticus	Healing	Tridens, slim, rough	2.00
Bothriochloa ischaemum	NNF	King Ranch bluestem ("K.R.")	1.71
Polygala lindheimeri	Healthy	Lindheimer's milkwort	1.00
Eragrostis intermedia	Healthy	Lovegrass, Plalns	1.00
Diaperia prolifera	WA	Roundhead rabbit tobacco	1.00
Sida abutifolia [=S. filicaulis]	Healing	Spreading sida	1.00
Bothriochloa laguroides	Healing	Silver bluestem	1.00
Bouteloua rigidiseta	Degraded	Texas grama	1.00
Evolvulus sericeus	Healing	Evolvulus	1.00
Erioneuron pilosum	Degraded	Hairy tridens	1.00
Erodium texanum	WA	Filaree, Texas	1.00

Vegetative Health Index Summaries – Steve Nelle, Wildlife Biologist

To keep the extensive amount of data collected understandable, we created a Vegetative Health Index (VHI) for the top 100 most common plants in the region of our Soil for Water research. These plants can be used as indicators of various ecological conditions. In this section, by using the tables above and the All Species Spreadsheet data, we provide feedback on the overall health of your land base using the VHI.

[For a complete list of all the species found on the transects on your ranch each year please see the TX Survey Records or the All Species Spreadsheet in the APPENDIX.](#)

VHI as used in this report is based primarily on the prevalence of native species and their relative indications of ecosystem health. A high percentage of plant cover and plant species described as “Healthy”, or “Healing” would indicate a productive, stable or improving ecological situation. Plant cover dominated by plants described as “Weedy Annual” or “Degraded” would be indicative of an ecologically unhealthy or undesirable situation that has room for improvement.

A high or increasing percentage of “Non-Native Forages” such as KR bluestem or Kleingrass can complicate the interpretation of ecological health since these species often spread and displace natives, reducing plant diversity. Nevertheless, these non-native species do have some ecological function and value and often provide good livestock forage.

VHI Key:

Healthy - These plants are indicative of healthy ecological conditions especially when they are abundant

Healing - When these plants are increasing it often indicates healing from a degraded condition

Degraded - When these species dominate it is indicative of degraded ecological conditions usually caused by long term overgrazing.

Weedy Annuals (WA) -When these species dominate it usually indicates a disturbed and unstable condition

Non-native forage (NNF) – these grasses are often planted for high grazing value but can often be invasive and crowd out higher succession native perennial grasses of high ecological value. We recommend this practice be minimized and native perennial grasses be the focus of management plans.

[More information on the Vegetative Health Index can be found in the APPENDIX.](#)

Turkey Hollow

In this pasture, in all three years, the plant cover is predominantly made up of “Healthy” and “Healing” species. Little bluestem (“Healthy”) is by far the most predominant plant, and this is consistent with its prevalence in the historic plant community prior to European settlement. There is a small proportion of species designated as “Weedy Annuals” and “Degraded” and this is not a concern since these species have ecological function and value and need to be present in small amounts. It should be noted that some species regarded as weedy annuals may still have considerable value to livestock and/or wildlife. Examples include plantago, croton and lazy daisy.

There were no observations of non-native grasses such as K R bluestem or Kleingrass and this is consistent with ranch goals of promoting native plant diversity.

Wildlife Preserve

In this pasture, in all three years, the plant cover has a strong component of “Healthy” and “Healing” species giving good indication of desirable ecological condition. However, little bluestem (“Healthy”) showed a decline from 27% to 10% during the sample period while KR bluestem showed an increase from 3% to 20% during the same period. It is too early to say whether this is a real long-term trend or just part of the normal flux in species abundance. It will be something to watch in the years ahead.

The one-time jump of Kleingrass shown for 2020 may be an anomaly in the sampling. The plot locations randomly selected for sampling each year are not the same from year to year. It is possible that in 2020, a few of the plots happen to fall in dense areas of Kleingrass which would skew the average. This is also something to keep an eye on. Both KR bluestem and Kleingrass are deep rooted, stable species with certain ecological value and function even though they are not native. However, an increasing amount of these non-natives at the expense of natives would **not** be regarded as a positive ecological trend as they have the tendency to crowd out higher succession native grasses that are ideal for creating optimal soil health conditions and thus ideal community dynamics.

There is a small proportion of species designated as “Weedy Annuals” and “Degraded” and this is not a concern since these species have ecological function and value and need to be present in small amounts. If their prevalence increases, it will mean that adjustments in management would be needed

Species Diversity Summaries – Kelly Lyons, PhD, Department of Biology, Trinity University

Biological diversity, or biodiversity, is important to the regenerative agriculture process for primarily two reasons. First, where plant biodiversity is higher, especially where it is composed of native species, we can generally assume that there are more resources for resident species other than humans and that the food web will be healthier. The second reason is that plant diversity is demonstrated time and again to be associated with higher productivity, or biomass. This means more forage!

Biodiversity is measured by scientists in many ways, some of which are more informative than others. The most basic metric of biodiversity is “**richness**.” This is simply a count of the total number of species in a designated area. However, having just a list (or count) of the species that are present can be unsatisfying as not all species exist in the same amounts (e.g., number of individuals or mass). For example, species that are valuable forage (e.g., Indian grass) may be present but in very low abundance. In contrast, species that are invasive or less valuable as forage may increase in abundance (e.g., KR bluestem, Mexican hat). Due to this limitation, ecologists have developed more advanced diversity metrics.

Here we provide the **Shannon Equitability Index** for your transects as well as comparisons across other ranches included in the Soil for Water project. For simplicity we have not included the equation, but you can easily search it on the internet. This is a powerful metric because it considers not only species presence but also their abundances, which allows us to assess diversity AND “evenness.” A value of 0 means that just one species is present. The higher the value of the index the higher the number of species AND the more evenly distributed they are. For each transect and across all ranches, we provide tables for the **Average Raw Diversity Index** as well as an **Average Standardized Diversity Index**. The latter divides the Diversity Index by the natural log of the number of species, forcing the range between 0 and 1 to make comparisons across time and between areas easier.

Biodiversity Averages Across All Ranches Surveyed through Time

Year	Average Raw Diveristy Index ("Shannon")	Average Standardized Diversity Index
2019	1.025	0.595
2020	0.976	0.555
2021	1.067	0.564

Diversity at Bamberger through Time

Site	Year	Ave Num. Species	Average Raw Diveristy Index ("Shannon")	Average Standardized Diversity Index
Turkey Hollow	2019	5	0.611	0.266
	2020	8.7	1.191	0.505
	2021	5	1.232	0.540
Average			1.011	0.437
Wildlife Preserve	2019	7.1	1.321	0.671
	2020	9.7	1.469	0.648
	2021	8.8	1.704	0.792
Average			1.498	0.704

Both Turkey Hollow and the Wildlife Preserve are relatively “Healthy,” and the diversity indices suggest that evenness across species has increased over time. This could be due to the management practice but the increase in rainfall 2019-2021 (see above) cannot be discounted. **Continued monitoring over time will help separate the non-biotic controls on grassland health.** Turkey Hollow is clearly in excellent condition with little bluestem as a dominant species. Hopefully, through time, other native grasses will establish in higher abundance.

The one concern is the dominance of Kleingrass in Wildlife Preserve in 2020, although little bluestem, tall dropseed and Texas wintergrass are in relatively high abundance at this site. This keeps the diversity relatively high, even in the presence of this invasive species. While Kleingrass is considered good forage, we recommend that future management plans include monitoring the species through time and targeting it for control or eradication, if possible.

Soil metrics for Turkey Hollow are in line with what we might expect from increases in diversity that result in better soil nutrient usage (uptake) and soil microbial development. Indeed, nitrogen levels dropped between 2019 and 2021. In addition, the Total Living Biomass and Arbuscular Mycorrhizal Fungi % increased from 2017 showing an improvement in soil microbiology health. While more years of measurements are needed, these trends, combined with the species composition and diversity trends, suggest that these grasslands are on the mend.

The soil metrics for Wildlife Preserve are harder to discern but the presence of the invasive Kleingrass may explain the less positive trends for soil health metrics in this site.

SOIL TEST RESULTS

Transect 1: Turkey Hollow

Turkey Hollow Transect Soil Health Analysis

Soil pH	7.9	8.3	8.2
Soil Organic Matter	4	3.4	5.8
Soil Respiration	-	49.6	49
Water Extractable Organic Carbon	-	393	79
Water Extractable Organic Nitrogen	-	16.5	5.31
Microbially Active Carbon	-	12.6	61.7
Organic C to Organic N Ratio	-	23.8	14.8
Organic N to Inorganic N Ratio	-	1.2	1.88
Organic Nitrogen Release	-	-	5.31
Organic Nitrogen Reserve	-	8.3	0
Organic Phosphorus	-	2.2	0.5
Organic Phosphorus Release	-	0.8	0.5
Organic Phosphorus Reserve	-	-	0
Soil Health Score	-	14.46	7
Total Living Biomass	2118.74	3880.34	4024.43
Functional Group Diversity	1.428	1.584	1.533
Arbuscular Mycorrhizal Fungi %	1.98	8.9	4.77
Fungi: Bacteria	0.1661	0.523	0.3294
Protozoa: Bacteria	All Prey	0.0038	0.0079
Microaggregate	-	-	17.7
Macroaggregates	-	-	39.3
β -glucosidase enzyme - carbon enzyme	-	-	81.6
Permanganate Oxidizable Carbon - labile carbon	-	-	500
Water Holding Capacity, inch H ₂ O inch soil ⁻¹	-	-	0.22
	Nov-2017	May-2019	Oct-2021

Test Dates

Soil Health Summary Turkey Hollow – Lance Gunderson, Regen Ag Lab

When reviewing the soil health numbers given in this report it is important to keep in mind that any soil test should be perceived as a moment in time. These tests are heavily influenced by soil type, temperature, moisture, and management. It is also important to note that the soil test results shown above were taken at different times of the year, which will have a significant influence on the results, making it hard to compare the two to one another. To see trends, it is best to take a soil test every two years at the same time of the year and have at least three to four years of data to review. Moving forward, the Soil for Water project will only be taking soil samples in the fall.

Several measurements indicate a positive trend in the microbial community as well as other soil measures. For example, soil organic matter has shown a significant increase. This could partly be due to sampling bias and variability across the transect, but other values support at least a modest increase in SOM. The dramatic reduction in water soluble carbon and the soil health score on the Haney Test is likely due to the difference in sampling timing between the 2 years.

The transect was sampled in 2019 during May, which is when the system is receiving the most rainfall and should have moderate soil temperatures. The % Microbially Active Carbon value is low in 2019 due to the abundance of water-soluble carbon, and this tells us that carbon is not the limiting factor in this system for microbial respiration. Low respiration is likely a constraint of soil pH.

The sample taken in October 2020 would have likely had similar soil temperatures, but this was following several months of excessive heat and much lower rainfall. The % Microbially Active Carbon here is in the desirable range, but this is due to the dramatic downward trend in available organic C rather than an increase in soil respiration. This again lends support to the notion that pH may be limiting for respiration overall. The soil aggregation is on the right track as we like to see total aggregation above 50% with a majority of that being made up of macroaggregates as these are more stable and indicate a more advanced degree of aggregate formation compared to microaggregates.

Overall, it looks like the Fungi: Bacteria ratio is increasing which is positive since most thriving rangeland environments tend to be fungal dominant. The Increase in Arbuscular Mycorrhizal Fungi % can help increase soil water holding capacity and lengthen the growing season by improving the supply of water and nutrients, such as phosphate and nitrogen, to the host plant.

Wildlife Preserve Transect Soil Health Analysis

<i>Soil pH</i>	7.9	8.2	8.3
<i>Soil Organic Matter</i>	4.3	4.1	3.1
<i>Soil Respiration</i>	-	26	19
<i>Water Extractable Organic Carbon</i>	-	313	89
<i>Water Extractable Organic Nitrogen</i>	-	8.3	6.39
<i>Microbially Active Carbon</i>	-	16.7	21.7
<i>Organic C to Organic N Ratio</i>	-	18.7	14
<i>Organic N to Inorganic N Ratio</i>	-	1.2	1.81
<i>Organic Nitrogen Release</i>	-	-	5.54
<i>Organic Nitrogen Reserve</i>	-	5.6	0.9
<i>Organic Phosphorus</i>	-	1.7	0.5
<i>Organic Phosphorus Release</i>	-	0.4	0.4
<i>Organic Phosphorus Reserve</i>	-	-	0.2
<i>Soil Health Score</i>	-	10.54	4.4
<i>Total Living Biomass</i>	2000.01	3319.47	2126.31
<i>Functional Group Diversity</i>	1.404	1.51	1.466
<i>Arbuscular Mycorrhizal Fungi %</i>	2.81	7.6	4.46
<i>Fungi: Bacteria</i>	0.1511	0.418	0.2151
<i>Protozoa: Bacteria</i>	All Prey	All Prey	All Bact
<i>Microaggregate</i>	-	-	16.7
<i>Macroaggregates</i>	-	-	31.6
<i>β-glucosidase enzyme - carbon enzyme</i>	-	-	36.4
<i>Permanganate Oxidizable Carbon - labile carbon</i>	-	-	361
<i>Water Holding Capacity, inch H₂O inch soil⁻¹</i>	-	-	0.19
	Nov-2017	May-2019	Oct-2021

Test Dates

Soil Health Summary Wildlife Preserve – Lance Gunderson, Regen Ag Lab

The Wildlife Preserve is trending downward regarding many of the soil health measurements. Based on the vegetative health index, we also see a decline in desirable native species and those are being replaced by non-native species. While non-native species can still provide beneficial support to the microbial community, there will likely be a shift in the community during this transition process. We also see an increase in bare ground when comparing 2021 to 2019. A third factor, much like transect 2, is that these samples were not all taken during the same season. If we compare the few numbers from November of 2017 to November of 2021, we see more of a steady trend with even a slight increase in some. Therefore, it is difficult to say that all differences we see between 2019 and 2021 can all be attributed to changes in vegetation or ground cover. The total aggregation is lower than we would like to see, but it is unknown if this is trending down as well with only one year's worth of data. The good news is that the macroaggregates are still almost double the microaggregates.

Again here, it looks like Fungi: Bacteria ratio is increasing which is positive since most thriving rangeland environments tend to be fungal dominant. The increase in Arbuscular Mycorrhizal Fungi % can help increase soil water holding capacity and lengthen the growing season by improving the supply of water and nutrients, such as phosphate and nitrogen, to the host plant.

TRANSECT PHOTOS AND MONITORING REPORTS

The following photos are the transect overview photos taken at the starting T Post at each monitoring event. To view the full monitoring reports as well as photos for all 10 plots along the transect the [APPENDIX](#) for the file labeled TX Survey Records.



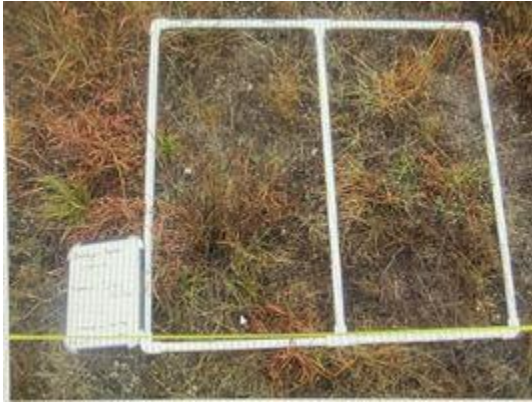
Wildlife Preserve Survey Date: October 29, 2019, 1:37 PM



Wildlife Preserve Survey Date: November 19, 2020, 12:47 PM



Wildlife Preserve Survey Date: October 20, 2021, 11:32 AM



Turkey Hollow Survey Date: October 29, 2019, 12:46 PM



Turkey Hollow Survey Date: November 19, 2020, 2:21 PM





Turkey Hollow Survey Date: October 20, 2021, 1:23 PM

ANNUAL COMPARISON AND MANAGEMENT CONSIDERATIONS

Turkey Hollow

Measurements and trends in key indicators for the 2019 – 2021 period are encouraging and positive.

- Herbaceous cover increased from 52% to 86%
- Litter cover increased from 35% to 92%
- Bare ground decreased from 16% to 3%
- The combination of herbaceous cover and litter increased from 87% to 178%
- The number of species documented in the sampled plots was relatively stable for the three years, ranging from 22 to 27. This is a good level of diversity considering the overall small amount of land area that was sampled.
- Together, these indicators appear to show that the management is resulting in a positive direction for a healthy landscape. However, three years of monitoring is not long enough to establish a clear and certain trend, but it seems that good things are happening as a result of management.

This pasture is under active management, primarily periodic grazing which is intended to maintain or enhance ecological function and value. If the goal were to hasten further improvement with more aggressive management, these are a few things for consideration:

- Indiangrass and big bluestem are primary tall grasses that are missing from the area. These can be seeded in niche pockets if desired or in any pig rooting areas.
- High successional and high value perennial forbs which are currently missing in this area can be added by seeding in combination with the grasses – Engelmann daisy, bush sunflower, Maximilian sunflower.
- High intensity but brief grazing periods can help open the vegetation cover for seeding. The use of range cubes or protein blocks at select locations can create some disturbance and bare soil from animal impact in which to seed some of the species listed above.

Management considerations:

- Graze this area more frequently
- Consider using high stocking densities when grazing that allow for high dung and urine deposits in the area. These deposits help keep carbon and nitrogen inputs in the area and can continue to foster the upward movement of fungal dominance and particularly AMF.

Wildlife Preserve

Measurements and trends in key indicators for the 2019 – 2021 period are encouraging and positive.

- Herbaceous cover increased from 43% to 71%

- Litter cover declined and then rebounded from 55% to 8% and back to 56%
- Bare ground showed an increase from 5% to 12% but is not a cause for alarm at this time
- The combination of herbaceous cover and litter showed a modest and probably non-significant increase from 98% to 127%
- The number of species documented in the sampled plots was relatively stable for the three years ranging from 26 to 31 species. This is a good level of diversity considering the overall small amount of land area that was sampled
- Together, these indicators appear to show a relatively healthy and stable overall condition but with some things to watch. However, three years of monitoring is not long enough to establish a clear and certain trend so a continuation of monitoring will be needed to better determine real trends.

Management considerations:

- Since this pasture is somewhat of a control or “hands off” area, no additional management is warranted other than continued monitoring and watching for any changes.
- Watch Kleingrass and KR bluestem encroachment and consider a plan for when to act.