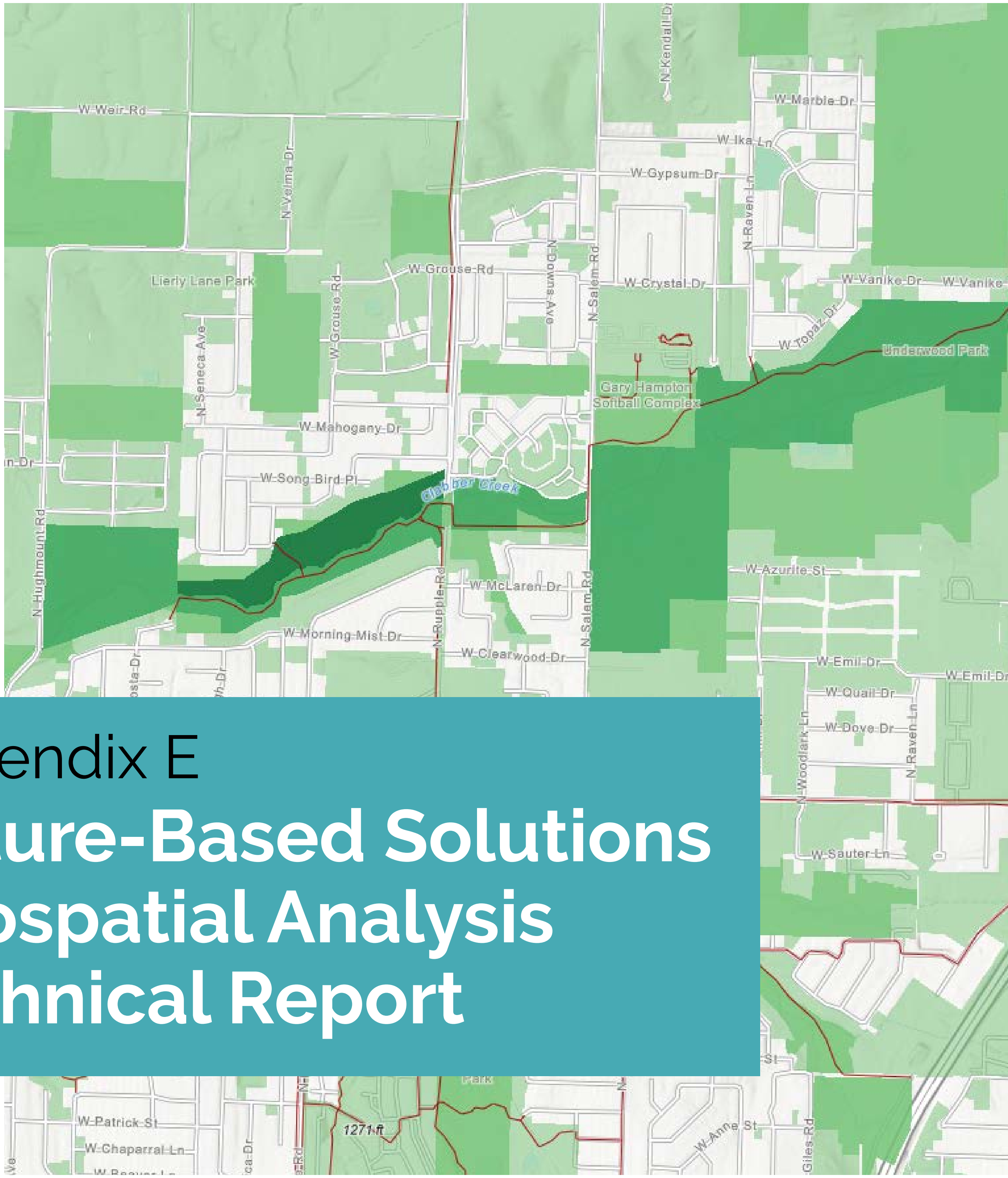
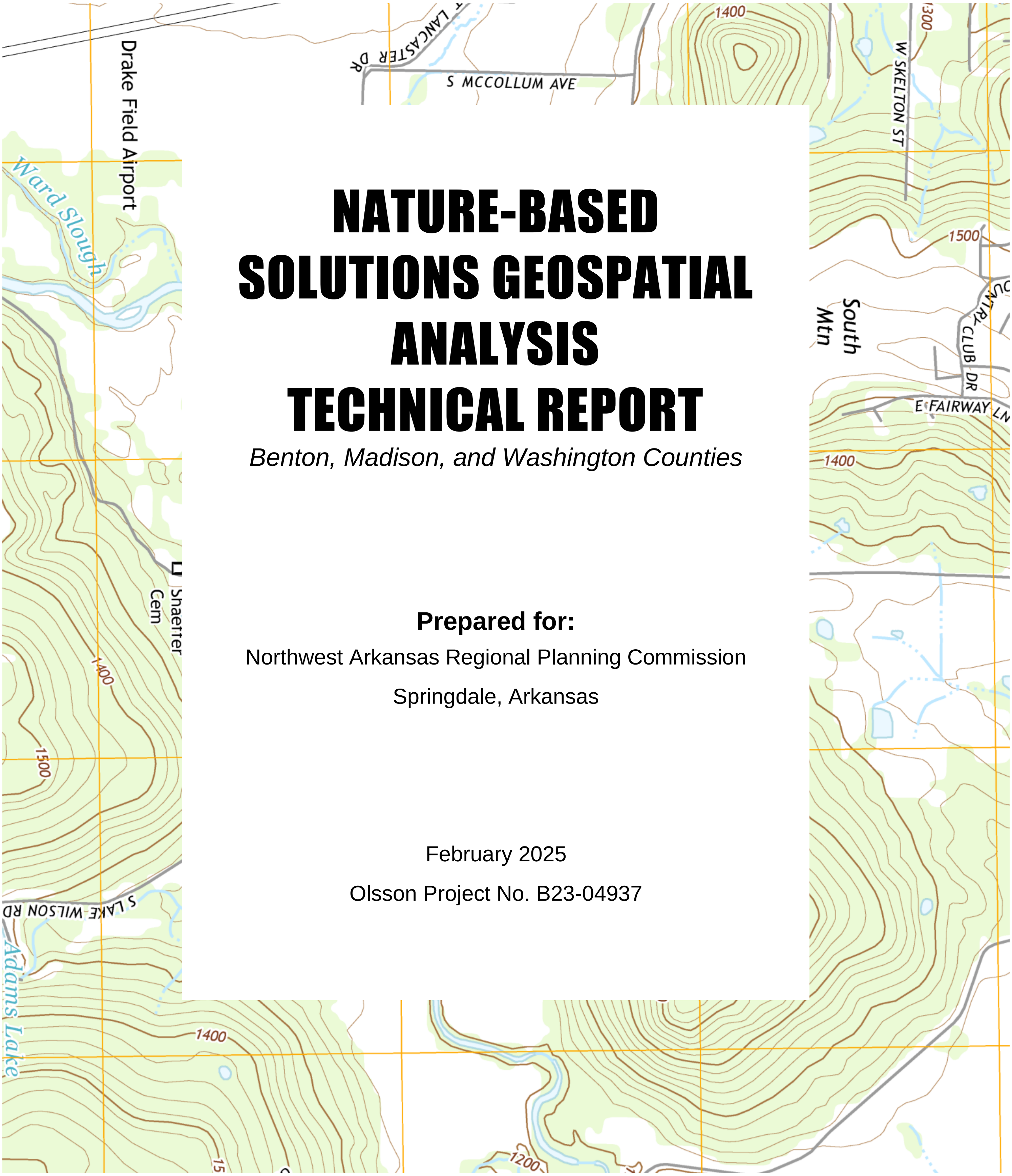


Appendix E

Nature-Based Solutions Geospatial Analysis Technical Report



NATURE-BASED SOLUTIONS GEOSPATIAL ANALYSIS TECHNICAL REPORT

Benton, Madison, and Washington Counties

Prepared for:

Northwest Arkansas Regional Planning Commission

Springdale, Arkansas

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Natural infrastructure, comprising a diverse array of natural features such as wetlands, forests, and riparian areas, plays a vital role in the well-being of Northwest Arkansas. These ecosystems provide a range of critical services, including flood protection, water purification, and urban cooling during the hot summer months. However, the extent and condition of natural infrastructure within the region is increasingly threatened by population growth and urban sprawl.

The Northwest Arkansas Regional Planning Commission (NWARPC) strives to improve environmental quality in the region to ensure a bright future for its residents. As part of this effort NWARPC contracted with Olsson to conduct a geospatial analysis to better understand the distribution, condition, and vulnerability of natural infrastructure across Northwest Arkansas. By mapping and analyzing these crucial assets, we can gain valuable insights into how to best protect, restore, and enhance these invaluable natural resources for the benefit of both people and the environment.

2.0 NATURE-BASED SOLUTIONS

Northwest Arkansas faces a growing number of environmental challenges, including flash flooding, streambank erosion, water pollution, and declining air quality. These stressors not only affect the region's natural ecosystems but also pose significant threats to human well-being and quality of life. Though traditional approaches to environmental management often rely on engineered solutions, this section will explore the potential of nature-based solutions to address these challenges. By harnessing the power of natural processes, such as wetland restoration or reforestation, we can create more resilient and sustainable ecosystems while simultaneously enhancing human well-being. This approach offers a promising pathway for Northwest Arkansas to achieve its environmental and socioeconomic goals.

2.1 Environmental Challenges in Northwest Arkansas

Environmental stressors and extreme weather can have both direct and indirect impacts on the residents and natural resources of Northwest Arkansas; many of the direct impacts to the region’s natural resources will have an indirect impact on residents’ well-being and quality of life.

Heavy Precipitation

When precipitation falls from the sky, it must go somewhere. Under natural conditions, most precipitation infiltrates the soil, where it can be taken up by plants or can recharge groundwater supplies. Different factors contribute to the ability of the soil to absorb stormwater, including soil texture, soil saturation, storm intensity, land cover, and ground slope. Stormwater that is unable to infiltrate the soil must move laterally on the ground surface as runoff.

Impervious surfaces such as roads, buildings, and parking lots are examples of land covers that prevent stormwater from soaking into the ground. As watersheds are urbanized, much of the vegetation is replaced by these impervious surfaces and stormwater runoff increases and arrives at local streams much more quickly, resulting in an increased likelihood of more frequent and severe flooding. The quantity and speed of stormwater runoff is lower in natural areas where more of the stormwater can soak into the soil (Paul and Meyer 2001).

A certain amount of stormwater runoff can be managed by the region's gray infrastructure, which includes curbs, gutters, drains, pipes, and culverts that are designed to move stormwater away from the built environment. However, excessive amounts of stormwater runoff from heavy precipitation events can exceed the capacity of gray infrastructure, resulting in flash flooding and negative impacts to the residents of Northwest Arkansas (Boyett and Lee 2022; Early 2021; Smith 2022).

Impacts from heavy precipitation and stormwater runoff to the natural resources of the region include an increase in stream bank erosion, damage to riparian zones, and landslides (University of Arkansas 2018; Kusler 2006), resulting in a loss of land, habitat, and existing carbon stocks. Lakes, wetlands, and other waterbodies in the region would also see an increase in sedimentation and nutrient loading from runoff originating from agricultural fields and construction sites, which will negatively affect water quality (AGFC 2015; ASWM 2015; Kusler 2006).

Drought

During droughts, the region experiences greater fluctuations in the availability of both surface and groundwater. These droughts could limit access to water for wildlife and livestock and affect the availability and quality of the drinking water supplies in the region (University of Arkansas 2018).

Reduced groundwater recharge during droughts (Kusler 2006) would result in the water table dropping below the beds of intermittent streams for longer periods during the dry season, causing these streams to go dry for longer periods of time. Perennial streams would also likely see lower flow levels during the dry season and may also go completely dry during periods of extreme drought (National Research Council 1995; Mitsch and Gosselink 2015). Aquatic ecosystems would undergo substantial impacts during droughts (Meyer et al. 1999; AGFC 2015).

Wetlands are also expected to be negatively affected by droughts that would result in a reduction of water coverage and changes to surface hydrology (Christie and Kusler 2009). Seasonal wetlands and ephemeral ponds, which rely on hydrological contributions from precipitation during the wet seasons, and herbaceous wetlands would especially be at risk for impacts such as a contraction in their size and hydrological duration and a deterioration of the quality of habitat they provide to wildlife (AGFC 2015; ASWM 2015).

A dryer landscape will also affect terrestrial vegetation, including vegetation found in riparian buffers along the edges of waterbodies. As trees and other vegetation shed their leaves or perish during drought, the risk for wildfires will increase. A reduction in canopy coverage would also exacerbate the urban heat island effect because less shade will be provided (University of Arkansas 2018). Mesic forests would be especially at risk to changes in species composition; many tree species typically associated with these habitats would be expected to decrease (Brandt et al. 2014) and be replaced by more drought-tolerant species (AGFC 2015).

<u>Warmer Temperatures</u>

Warmer temperatures will result in an increase in the evapotranspiration rate of water from the soil, plants, and other surfaces, resulting in dryer conditions (Kunkel et al. 2013; Carter et al. 2014), reduced stream flows, and altered hydrology (Meyer et al. 1999; AGFC 2015; Kusler 2006), further exacerbating the effects of drought and risk of wildfires (University of Arkansas 2018).

Warmer temperatures are also expected to affect residents of Northwest Arkansas by increasing energy costs associated with cooling homes and buildings and increasing the susceptibility of residents to heat-related illnesses (University of Arkansas 2018). Warmer temperatures will increase tick and mosquito populations, which may put residents at greater risk for diseases transmitted by these vectors (University of Arkansas 2018).

Warmer air temperatures would contribute to a rise in water temperatures and reduced levels of dissolved oxygen, affecting aquatic ecosystems (AGFC 2015; ASWM 2015). Temperature increases will cause northerly, and upslope shifts in the ranges for many plant and animal species that have a narrow tolerance for changes in air and water temperatures. Under natural, unfragmented conditions, many species can migrate unhindered with the rising temperatures.

Today, these migrations are often obstructed by dams, traffic, neighborhoods, or other impediments. These restrictions could potentially have a devastating impact on rare and endangered species that are sensitive to small temperature changes if there are no alternative habitats nearby for them to migrate to (Kusler 2006).

Impacts on terrestrial ecosystems from warmer temperatures include a decrease in biodiversity resulting from stress to vegetation and limited food and water resources for wildlife, which is further exacerbated by the fragmentation of natural areas from urban development (University of Arkansas 2018). Extreme heat during the summer months is expected to result in a decrease in basal area and canopy cover of urban trees, creating favorable conditions for the spread of invasive species from subtropical regions and increasing pest outbreaks (AGFC 2015), and further decreasing the biodiversity of native species.

2.2 The Role of Nature-based Solutions

Nature-based solutions are actions that use natural processes and features to address societal, economic, and environmental challenges through the protection, restoration, and sustainable management of natural and modified ecosystems, simultaneously benefiting people and nature (IUCN 2023).

By protecting, restoring, and sustainably managing ecosystems, nature-based solutions offer a win-win approach. They address environmental challenges while simultaneously improving human lives and safeguarding the natural world.

Nature-based solutions also recognize the interconnectedness of humans and the natural world. By integrating nature into urban areas, nature-based solutions can harness the natural functions of ecosystems to provide essential services for people, such as clean air and water, while also conserving biodiversity (FEMA 2025, Chol et al. 2023).

Benefits of nature-based solutions include cleaner air, cooler cities, and healthy ecosystems. Nature-based solutions can be a cost-effective way to protect people and property, reduce vulnerabilities to risks from disasters and environmental stressors, while also improving sustainability and resilience by enhancing human well-being and biodiversity.

A joint report by the International Federation of Red Cross and Red Crescent Societies (IFRC) and the World Wide Fund for Nature (WWF) found that nature-based solutions could reduce the intensity of environmental stressors and weather-related hazards by 26 percent (IFRC and WWF 2022).

Often the following two-pronged approach is recommended for protecting and improving environmental quality with nature-based solutions:

1. **Adaptation**: Adapting to environmental stressors and extreme weather,
2. **Mitigation**: Reducing and stabilizing the levels of greenhouse gases (GHGs) and their co-pollutants in the atmosphere.

Adaptation

Healthy ecosystems provide important ecosystem services that can help society adapt to extreme weather events and environmental challenges. Nature-based solutions for adaptation focus on benefits that humans derive from biodiversity and ecosystem services and how these benefits can be used for managing risk from environmental impacts. Nature-based solutions for adaptation include conservation measures and the restoration of ecosystems to reduce the vulnerability of people and the ecosystem. These measures can be implemented on their own or in combination with gray infrastructure (such as low-impact development principles or ecologically friendly landscaping practices).

Mitigation

Nature-based solutions for mitigation include measures that decrease GHG emissions from deforestation, soil disturbance, and land use and measures that sequester and store carbon dioxide (CO_2) from the atmosphere. These actions include protecting high-value natural areas from degradation, restoring natural areas that have already been degraded, and managing urban and rural natural areas sustainably. Mitigation strategies are essential for rapidly cutting GHG emissions and removing CO_2 from the atmosphere to protect environmental quality in Northwest Arkansas.

2.3 Natural Infrastructure for Nature-based Solutions

Many of the natural resources in Northwest Arkansas provide opportunities for nature-based solutions that can help buffer the impacts to residents from the environmental stressors described above. Though extreme weather can also affect the region’s natural resources, these impacts can be reduced and buffered through the fostering of healthy ecosystems.

In this analysis, the natural resources in Northwest Arkansas were assessed through the lenses of adaptation (ecosystem services and ecosystem resilience) and mitigation (carbon sequestration and storage). Below, the landscape features in the region that comprise the natural infrastructure for nature-based solutions are discussed as they relate to these two categories.

2.3.1 Ecosystem Services

Ecosystem services refer to the benefits that the natural environment provides to humans. The landscape features discussed below provide ecosystem services for adaptation to the impacts from flooding, drought, and extreme heat.

Wetlands, Ponds, and Reservoirs

Wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions (Mitsch and Gosselink 2015). In Northwest Arkansas, wetlands can be found in prairies, in forests, and along the edges of waterbodies such as streams, lakes, and ponds.

Wetlands play an important role in the landscape by acting as natural sponges, capturing and absorbing stormwater runoff. This allows stormwater to remain on the landscape for more time before it is gradually released downstream after peak flows have passed. Wetlands help reduce the frequency and intensity of floods by absorbing and storing significant amounts of stormwater during heavy precipitation events (EPA 1993; National Research Council 1995; Mitsch and Gosselink 2015). The cumulative presence of wetlands, ponds, and reservoirs within a watershed can reduce flood flows during heavy precipitation events (Davies 2016).

Wetland vegetation also helps slow the speed of flood waters and spread it out over the floodplain. This velocity dissipation combined with the capture and storage of stormwater lowers flood heights and reduces erosion (National Research Council 1995; Mitsch and Gosselink 2015). Wetlands located within and downstream of urban areas where impervious surfaces such as pavement and buildings increase the rate and volume of stormwater runoff are particularly valuable in reducing flash flooding (EPA 2002).

Like wetlands, ponds and reservoirs also contribute to the storage of stormwater runoff as surface water. Storing stormwater on the landscape, even temporarily, allows more time for this water to infiltrate the soil and to recharge groundwater supplies and reduce the effects of drought on the landscape (Mitsch and Gosselink 2015). Surface water that is retained on the landscape in wetlands, ponds, and reservoirs also provides locations where people and wildlife can seek relief from extreme heat by submerging themselves to cool off. Groundwater recharge helps to sustain perennial and intermittent stream flows during dry periods and supports subterranean aquatic ecosystems (National Research Council 1995; Mitsch and Gosselink 2015).

These waterbodies provide additional benefits for water quality when stormwater runoff is slowed down or contained, providing more time for the sediment to settle out of the water column, which reduces turbidity levels of downstream aquatic ecosystems. Turbidity levels that are too high can be detrimental to aquatic ecosystems by reducing the amount of sunlight that can penetrate the water column, making it difficult for aquatic plants and algae to carry out photosynthesis and grow. This reduction in photosynthetic activity results in a reduction in dissolved oxygen levels in the water, and when dissolved oxygen levels are too low, it becomes difficult for aquatic organisms to breath. High turbidity can also lead to fine sediment particles lodging in the gills of fish, which can make it difficult for these organisms to breath (EPA 2021).

The water storage provided by wetlands, reservoirs, and ponds also has the beneficial effect of reducing the intensity of stream flows that would normally result from heavy precipitation events, and thus reduces property damage and risks to human life from flooding and streambank erosion and other damage to riparian zones (National Research Council 1995; Mitsch and Gosselink 2015). A reduction in erosion of streambanks helps to reduce turbidity in aquatic ecosystems and reduces the amount of sediment entering local reservoirs, such as Beaver Lake.

Stormwater runoff often carries contaminants that can be harmful to water quality and can affect our drinking water sources. Wetlands act as natural filters by breaking down organic contaminants found in stormwater runoff and improving the water quality of nearby rivers, streams, and reservoirs by eliminating many pollutants before they reach these waterbodies. Through cycles of wetting and drying, combined with the action of bacteria and plants that live in these habitats, wetlands can sequester, alter, and/or assimilate contaminants such as excess nutrients, heavy metals, pesticides, and petroleum products (National Research Council 1995; Mitsch and Gosselink 2015). Wetlands also improve local drinking water sources and reduce the costs of water treatment.

Riparian Buffers

Riparian buffers consist of the natural vegetation found along the edge of a stream, lake, or reservoir. These features reduce the effects of heavy precipitation and flooding by helping to slow down and disperse stormwater runoff, thereby improving soil infiltration and reducing the intensity of stream flows from heavy precipitation events. The roots from riparian vegetation not only helps to facilitate soil infiltration of stormwater, they also provide soil stabilization of streambanks, increasing the streambanks' resistance to erosion (National Research Council 2002; Mayer et al. 2006).

Pervious Surfaces

As discussed above, when stormwater is allowed to infiltrate the soil, less runoff is created. Thus, pervious surfaces are beneficial for reducing the impacts of runoff from heavy precipitation (USGS 2018).

Tree Canopy

Tree canopy also helps reduce impacts from high temperatures by providing shade, which reduces ground surface temperatures. This shade supports local cooling (Shashua-Bar and Hoffman 2000; EPA 2014) and helps to mitigate the effects of extreme heat and reduces energy use (Akbari et al. 1997; Akbari 2002; Donovan and Butry 2009; EPA 2013; Hsieh et al. 2018). In addition, urban trees absorb stormwater, helping to reduce stormwater runoff and flash flooding (Bartens et al. 2009; EPA 2013). Lower ground surface temperatures also reduce the evapotranspiration rate of soil moisture and surface water, buffering the impacts from drought.

2.3.2 Ecosystem Resilience

For natural infrastructure to provide optimal ecosystem services, the ecological integrity of these areas should at a minimum be maintained but also improved where possible to assure that the landscape can support a diversity of native plant and wildlife species. Managing these natural areas to be resilient to environmental stressors and extreme weather will allow residents to reap the greatest benefits of the ecosystem services that these areas provide. The landscape characteristics discussed below provide ecosystem resilience for adaptation to environmental stressors caused by flooding, drought, and extreme heat.

Biodiversity

Ecologically resilient sites are those that can continue to support biological diversity, productivity, and ecological function as they encounter environmental stressors and extreme weather (Anderson et al. 2019). As an ecosystem experiences internal or external stressors, species that may fill a particular niche in that ecosystem can become locally extinct. However, ecosystems that are biologically diverse are more likely to contain species that possess traits that replace the ecological niche provided by the locally extinct species, conferring resilience to that ecosystem and enabling it to adapt to a changing environment. Such species buffer the ecosystem against the loss of other species from environmental stressors and extreme weather (Yachi and Loreau 1999). These species can reduce the recovery time of the ecosystem and allow a species once locally extinct to reappear so its original niche in that ecosystem is restored. Thus, biodiversity and the conservation of biodiverse ecosystems play a critical role in maintaining ecosystem resilience (Vasiliev 2022).

Topographic Diversity

Ecologically resilient sites are those that contain topographic diversity (Beier et al. 2015; Anderson and Ferree 2010). Diverse landscapes can consist of topographic variability, variety in soil types, or a complex network of wetlands and uplands. This diversity creates microclimates and provides a variety of habitat options for resident species (Anderson et al. 2019).

Sites with high microclimate diversity provide temperature and moisture options that can buffer their resident species from the effects of extreme weather and allow plants and animals to persist locally, even while the regional climate becomes unsuitable. Thus, sites with a high diversity in microclimates have the effect of slowing down the rate of change in the species composition of the region (Anderson et al. 2019).

Habitat Connectivity

Wildlife corridors and habitat connectivity are also essential for maintaining regional biodiversity and ecosystem resilience so that plant and animal populations can take advantage of microclimate options without their movements being restricted by human development (Naiman et al. 1993; Anderson et al. 2019).

When habitat connectivity is present, plant and animal populations can move gradually in response to environmental stressors. For example, a population may move upslope toward higher elevations in response to temperature changes or downslope in response to moisture changes (Anderson et al. 2019). Urban development fragments natural infrastructure, making ecosystems less resilient and causing the populations of many local species to struggle, especially in riparian zones.

2.3.3 Carbon Sequestration and Storage

Carbon sequestration refers to the processes by which carbon is removed from the atmosphere and stored in liquid or solid form. As a mitigation measure, it’s estimated that nature-based solutions can account for up to 37 percent of the carbon sequestration needed to keep average global temperatures from increasing 2 degrees Celsius (C) by 2030 (IPBES 2019) and 20 percent of the carbon sequestration needed to keep average global temperatures from increasing 2 degrees C by 2050 (Griscom et al. 2017).

Plants sequester carbon into their biomass through photosynthesis. By absorbing CO_2 from the atmosphere through their leaves, plants use water (H_2O) taken up from the soil through their roots and energy from sunlight to create glucose ($C_6H_{12}O_6$). This glucose is then used by the plant to carry out its physiological processes, resulting in the storage of carbon from the atmosphere in the plant's biomass. Herbaceous biomass such as leaves or nonwoody stems only stores carbon temporarily, typically for one growing season. Woody biomass such as tree trunks, roots, and branches can store carbon for the lifetime of the plant.

Different factors can determine how well a plant can sequester carbon, how much carbon it's able to store, and for how long. Tree species with the following characteristics provide optimal carbon sequestration and storage in their aboveground biomass:

1. Species that are naturally long-lived store carbon for a longer period than short-lived species.
2. Species that produce greater quantities of woody biomass can store a greater amount of carbon than species that produce smaller amounts of woody biomass (Nowak 1993; Nowak and Crane 2000 and 2002; McPherson et al. 2005).
3. Species with a fast growth rate can sequester more carbon in a shorter amount of time than slower-growing species (Enquist 2002).
4. Species with large crowns and large leaf sizes have greater photosynthetic capacity and can remove more carbon from the atmosphere than species with small crowns and small leaf sizes.

Some herbaceous species can sequester and store a significant amount of carbon in their belowground biomass. Species with the following characteristics provide optimal carbon sequestration and storage belowground in their root systems:

1. Long-lived perennial species store carbon for a longer period than annuals, biennials, or short-lived perennials.
2. Species with deep fibrous root systems produce more belowground biomass and store a greater amount of carbon belowground than species with tap root systems.

Examples of short root systems include those found in species with annual or biannual life cycles and species with rhizomatous or tuberous root systems.

3. Warm-season grasses have higher rates of photosynthesis and use water more efficiently and so can sequester a significantly greater amount of carbon into their belowground biomass than can cool-season grasses. (Fornara and Tilman 2008; Spiesman et al. 2018).
4. Warm-season grasses growing in combination with legumes that sequester atmospheric nitrogen have been shown to increase the rate of capture and storage of carbon into the soil (Yang et al. 2019).

The habitat types discussed below contain species with many of the characteristics discussed above or possess other characteristics that provide optimal carbon sequestration and storage benefits. Because of the variation in these characteristics across the landscape, some habitats can sequester carbon better than others or store more carbon than others. The carbon sequestration processes described for each of the below habitats are illustrated in **Figure 1**.

<u>Upland Forests</u>

Forest communities that contain plants with large amounts of woody biomass, such as trees, are ideal for aboveground carbon sequestration and storage (Nowak 1993; Nowak and Crane 2000 and 2002; McPherson et al. 2005). However, there is a limit to how much carbon upland forests

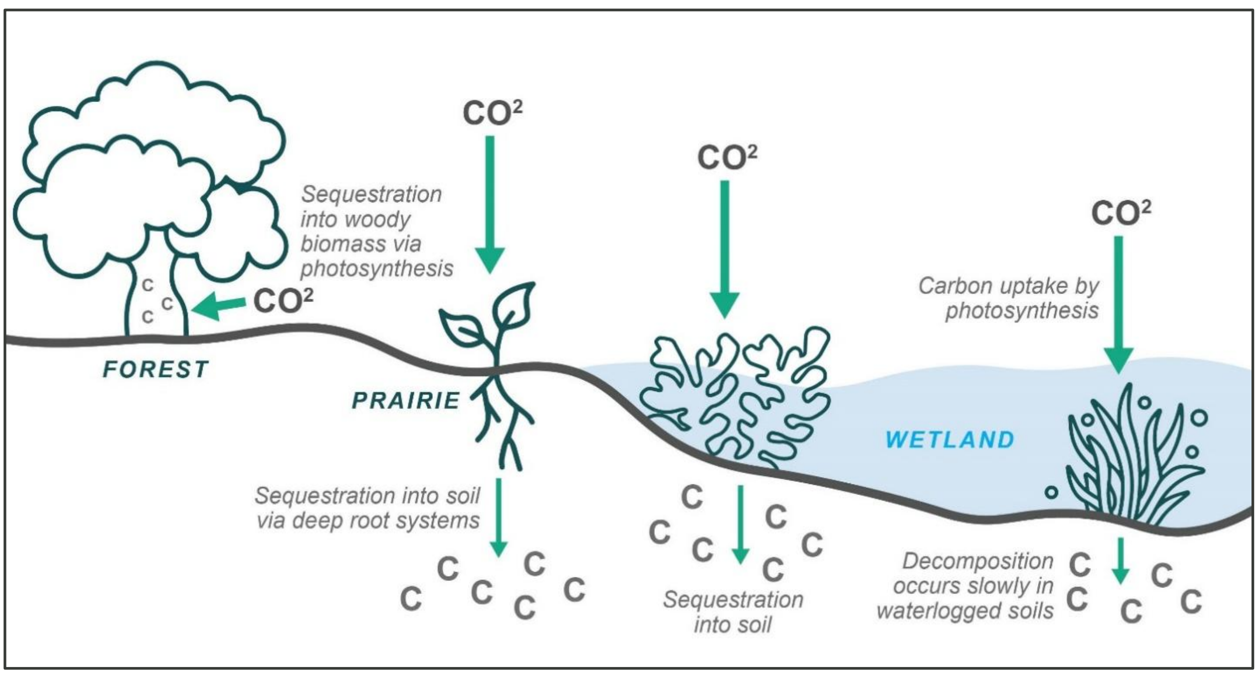

Figure 1. How Carbon is Sequestered and Stored in Different Landscapes.

can store because of the limits to both the lifespan and sizes to which the trees can grow (Zhu et al. 2018; Forrester 2020). Furthermore, because of the space constraints in urban settings, urban trees are better suited to be used as adaptation measures that help urban residents cope with extreme weather, rather than as mitigation measures that aim to remove atmospheric carbon. As a mitigation measure, carbon sequestration and storage in forests is more effective when implemented on large spatial areas where the trees can be maintained for a long period of time (Pataki et al. 2021). Therefore, the protection of existing forests and other high carbon-storing ecosystems is a more effective mitigation measure than planting new trees in small numbers (Forrester 2020).

Upland Prairies

Once covering an estimated seven to ten million acres across the southeastern U.S., prairies have suffered a loss exceeding 99 percent of their original distribution (Southeastern Grasslands Initiative 2023). Dominated by nonwoody herbaceous vegetation such as warm season grasses grasses, prairies contain approximately 12 percent of the world's terrestrial carbon stocks mostly occurring as belowground biomass. The fibrous root systems of most prairie vegetation species can extend several meters below the surface, often making up between 60-80 percent of the biomass carbon in these ecosystems (Ontl and Janowiak 2017). Roots of prairie species contribute carbon to the soil through exudates (Panchal et al. 2022) and through decomposition following root senescence. The turnover rate of carbon in the soil is much slower than in aboveground vegetation. Because of this slow turnover rate and the high quantity of biomass associated with prairie vegetation species, the soils beneath upland prairies can store significantly more carbon than what is found in both the aboveground biomass and belowground soils of upland forests combined (Prentice et al. 2001).

Soil carbon storage in prairie ecosystems appears to be related to plant biodiversity and species richness of these landscapes (Chen et al. 2018; Yang et al. 2019; Pastore et al. 2021) and increases significantly beneath plant communities consisting of C_4 grasses and legumes (Yang et al. 2019). Many nonnative forage and turf grasses have shallow roots and don't sequester or store very much carbon in their belowground biomass or in the soil. Therefore, restoring pastures dominated by these nonnative grasses, especially pastures containing relict nabkha mounds, to prairie ecosystems offers an effective mitigation measure for removing GHGs and co-pollutants from the atmosphere.

Though carbon sequestration in prairie soils occurs more slowly than in the aboveground biomass of forests, the quantity of carbon that can be stored in prairie soils is far greater (Prentice et al. 2001). Therefore, the protection of existing carbon stocks beneath prairie remnants can be an effective mitigation measure. See **Figure 2** for a comparison of carbon stored aboveground in biomass and belowground in the soil of upland prairies and other habitats.

Wetlands

Wetlands act as a carbon sink by first removing carbon from the atmosphere through photosynthesis. During their lifetime, wetland plants sequester and store carbon in aboveground woody biomass and contribute carbon to the soil through exudates the same way plant species in uplands do. However, after the plants complete their life cycle and collapse, they contribute carbon as litterfall to the surface of the soil.

Wetlands that are inundated for most of or the entire year have soils that remain saturated with water. The anoxic conditions created by these saturated and inundated soils in wetlands predominantly support anaerobic bacteria, which decompose organic material at a much slower rate than aerobic bacteria. In fact, the rate at which new organic material is deposited to these soils exceeds the rate at which the anaerobic bacteria can decompose this material. The result is an accumulation of carbon as organic material, creating a carbon sink (Mitsch and Gosselink 2015; Richardson and Vepraskas 2001).

However, when these saturated or inundated soils are disturbed, drained, or otherwise exposed to oxygen, anaerobic bacteria die off and aerobic bacteria communities begin to predominate, and the decomposition of organic matter happens at a much quicker rate than the rate at which new organic material can be accumulated by the processes described above.

Many wetlands are only inundated or saturated during the wet season, or temporarily after a precipitation event. As soon as the soils in these wetlands are no longer saturated, decomposition by aerobic bacteria continues and much of the carbon contained in any organic material present is released back into the atmosphere. Therefore, only wetlands with soils that remain inundated or saturated throughout the year provide significant carbon storage.

Like upland prairie soils, the process of sequestering carbon in wetland soils is much slower than sequestering carbon in aboveground woody biomass. However, the soils of wetlands that remain saturated throughout the growing season can store significantly more carbon than what is found in both upland forests and upland prairies (Prentice et al. 2001). Therefore, the protection of existing carbon stocks in wetlands that are inundated or saturated throughout the year can be an effective mitigation measure. See **Figure 2** for a comparison of carbon stored aboveground in biomass and belowground in the soil of wetlands and other habitats.

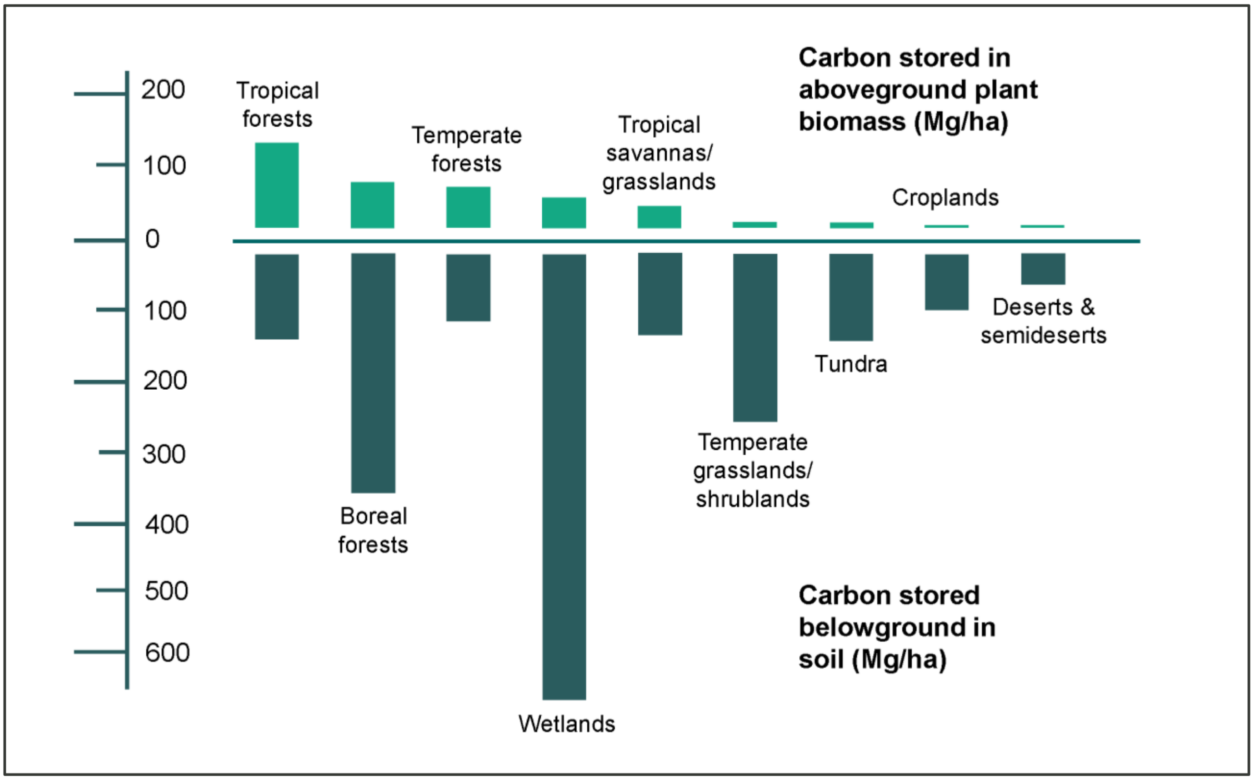

Figure 2. Megagrams per Hectare of Carbon Stored Aboveground and Belowground in Different Landscapes (Prentice et al. 2001).

Lakes and Ponds

The organic carbon burial rate of ponds and small reservoirs has been shown to be significant when compared with other habitats such as forests, prairies, and wetlands. Though they occupy a smaller proportion of the landscape as compared to other carbon-storing habitats, the high burial rates for organic carbon make these features important carbon sinks that are both easy to create and can serve multiple functions on the landscape (Mendonça et al. 2017; Taylor et al. 2019; Holgerson et al. 2023). Carbon typically enters ponds and reservoirs as inflows of organic material or dissolved inorganic carbon in surface water or through atmospheric exchange of CO_2 occurring at the air-water interface. Carbon obtained through photosynthesis can also enter a lake's water column through respiration by aquatic plants and algae. Eutrophic water bodies containing an overabundance of nitrogen and phosphorus have been shown to have a net influx of atmospheric carbon during summer months because of high levels of photosynthetic algae (Balmer and Downing 2011).

2.4 The Importance of Social Equity

Natural disasters and extreme weather do not affect all communities equally. Existing vulnerabilities, historical patterns of inequity, and socioeconomic disparities can result in some communities experiencing disproportionate impacts from these events (EPA 2023). These impacts have increasingly severe social and economic consequences, particularly in low- and lower-middle-income communities that have lower adaptive capacity to the impacts of natural disasters.

Social equity is the idea that all people should have equal access to resources and opportunities (EPA 2023), and natural ecosystems can be used to provide nature-based solutions for social equity. One of the potential impacts from heavy precipitation to underserved and vulnerable populations in Northwest Arkansas is the flooding of properties located within the Federal Emergency Management Agency (FEMA)-mapped flood hazard zones, resulting in displacement of residents, loss of property, injury, and loss of life (University of Arkansas 2018).

Should limited water supplies because of drought lead to increases in the cost of food and drinking water, low-income populations would feel the greatest impact. A rising cost of living attributable to natural disasters and extreme weather would also reduce the spending power of the local population and negatively affect the local economy because people would have less disposable income to spend at local businesses, which could potentially affect employment opportunities in the region.

The urban heat island effect would be exacerbated by the mortality of heat-sensitive urban tree species, resulting in a reduction of canopy coverage that would put vulnerable populations such as low-income and homeless residents at greater risk of heat-related and insect-borne illnesses. Energy used to cool homes would likely increase as more people remain indoors or choose to use automobiles for transportation instead of walking and biking (University of Arkansas 2018). This increased demand for energy and fuel sources would likely result in an increase in energy and fuel prices, affecting the pocketbooks of low-income populations the most.

3.0 METHODS & MATERIALS

An analysis of each parcel of land within the region was conducted using public and private geospatial datasets. A total of 299,058 land parcels were analyzed in this study, and each parcel was assigned a subscore based on the presence of indicators of nature-based solutions across the following three categories:

1. Ecosystem Services
2. Ecosystem Resilience
3. Carbon Sequestration and Storage

Each land parcel was given a Nature-based Solutions composite score equal to the sum of each of the subscores.

	Ecosystem Services	X
SUBSCORES	Ecosystem Resilience	Y
	Carbon Sequestration and Storage	Z
COMPOSITE SCORE	Nature-based Solutions Score	X + Y + Z

In addition to the Nature-based Solutions score, each parcel was also given a Social Equity score based on factors discussed below.

3.1 Overview of Geographic Information Systems (GIS) Datasets Used

A combination of GIS datasets publicly available online, and private datasets developed by project stakeholders and by Olsson staff were used in the analysis of each land parcel within Northwest Arkansas. **Table 1** below provides an overview of each of the datasets that were used in this study.

Table 1. Overview of Geographic Information Systems (GIS) Datasets.

Dataset	Feature Type	Source	Last Updated	Details
2022 303(d) list in Category 1b (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes streams within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 1b because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 4a (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes streams within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 4a because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 4a Lake (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes lakes within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 4a because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 4b (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes streams within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 4b because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 5 (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes streams within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 5 because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.

Dataset	Feature Type	Source	Last Updated	Details
2022 303(d) list in Category 5 Alt (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes streams within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 5 Alt because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 5 Lake (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes lakes within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 5 because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
2022 303(d) list in Category 5 Alt Lake (Draft)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2022	This dataset includes lakes within Benton, Washington, and Madison counties that have been determined by the Arkansas Department of Energy & Environment to be eligible for inclusion on the state's 2022 draft 303(d) list in Category 5 Alt because of certain contaminants as indicated by Regulation No. 2 adopted by the Arkansas Pollution Control and Ecology Commission.
Biodiversity	Polygon	Arkansas Natural Heritage Commission & Olsson	2024	This dataset contains land parcels that have each been scored based on biodiversity data provided by the Arkansas Natural Heritage Commission.
Ecologically Sensitive Waterbodies (Springs & Seeps)	Polygon	Arkansas Department of Energy & Environment – Division of Environmental Quality	2024	This dataset includes springs and seeps of Arkansas that have been designated as ecologically sensitive springs and seeps as identified by the Arkansas Department of Energy & Environment's Division of Environmental Quality.
Ecologically Sensitive Waterbodies (Streams)	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2024	This dataset includes springs and seeps of Arkansas that have been designated as ecologically sensitive streams as identified by the Arkansas Department of Energy & Environment's Division of Environmental Quality.
Extraordinary Resource Waters	Polyline	Arkansas Department of Energy & Environment – Division of Environmental Quality	2024	This dataset includes springs and seeps of Arkansas that have been designated as Extraordinary Resource Waters as identified by the Arkansas Department of Energy & Environment's Division of Environmental Quality.

Dataset	Feature Type	Source	Last Updated	Details
Landsat Land Surface Temperatures	Raster	U.S. Geological Survey Landsat	2022	This dataset was created using Landsat 9 data downloaded from Climate Engine, and it records locations within Benton, Washington, and Madison counties where the surface temperature during the summer months exceeds the mean temperature during that period. This dataset further records how many degrees in Celsius each location exceeds the mean temperature for that location.
Hydric Soils	Polygon	Natural Resources Conservation Service's Web Soil Survey	2024	This dataset records the location of soils with hydric components as defined by the National Technical Committee for Hydric Soils (NTCHS).
Low-moderate Income	Polygon	U.S. Census Bureau	2020	This dataset was created from 2020 U.S. Census data and contains polygon features recording the locations of residential areas containing greater than 50 percent of households with low-moderate income.
National Flood Hazard Layer Floodway	Polygon	Federal Emergency Management Agency (FEMA)	2024	This dataset records the locations of areas mapped by FEMA as being within the FEMA-mapped flood hazard zones.
National Hydrography Dataset (NHD)	Polyline	U.S. Geological Survey NHDPlus High Resolution layer	2019	This dataset records the water drainage network of the U.S, with features such as rivers, streams, lakes, and ponds.
National Land Cover Dataset	Polygon	Multiresolution Land Characteristics (MRLC) Consortium	2021	This dataset records the location and boundaries of a wide variety of land cover categories.
National Wetlands Inventory	Polygon	U.S. Fish & Wildlife Service National Wetlands Inventory	2024	This dataset records the locations of U.S. wetlands, classifying them based on the Cowardin classification system.
Natural Area Boundaries	Polygon	Arkansas Natural Heritage Commission	2024	This dataset records the locations of natural areas in Benton, Madison, and Washington counties that are managed by the Arkansas Natural Heritage Commission or the Nature Conservancy.
Northwest Arkansas Land Trust (NWALT) Preserves	Polygon	Northwest Arkansas Land Trust	2024	This dataset records the locations of parcels in Benton, Washington, and Madison counties that are owned by the Northwest Arkansas Land Trust.

Dataset	Feature Type	Source	Last Updated	Details
Public Land Boundary	Polygon	Arkansas GIS Office, Arkansas Natural Heritage Commission	2024	This dataset records the locations of publicly accessible open space in Benton, Washington, and Madison counties such as city parks, county parks, state parks, natural areas, wildlife management areas, national forests, private parks, and private preserves.
Prairie Mounds	Polygon	Arkansas Natural Heritage Commission	2024	This dataset records the location of relict nabkha mounds in Benton, Madison, and Washington counties.
Resilient and Connective Network	Polygon	The Nature Conservancy Resilient and Connected Landscapes	2016	This dataset records the locations mapped by The Nature Conservancy as the Resilient and Connected Network, which is a connected network of sites that maximize site resilience, biodiversity, connectivity, and climate flow.
Resilient Site	Polygon	The Nature Conservancy Resilient and Connected Landscapes	2016	This dataset records Resilience Sites mapped by The Nature Conservancy. A site's Resilience Score estimates its capacity to maintain species diversity and ecological function as the climate changes and was determined by evaluating and quantifying physical characteristics that foster resilience, including topography, slope, elevation range, geology, and soil.
Special or Unique Habitat	Polygon	Arkansas Natural Heritage Commission, U.S. Geological Survey, Fayetteville Natural Heritage Association	2024	This dataset contains land parcels that have each been scored based on special or unique habitat data such as clifflines, canebrakes, glades, prairie remnants, shale barrens, springs, and wet savannas within Benton, Madison, and Washington counties provided by the Arkansas Natural Heritage Commission.
Springs	Point	Arkansas Natural Heritage Commission	2024	This dataset records the locations of springs identified by the Arkansas Natural Heritage Commission.
Trails	Polyline	University of Arkansas & NWA Trail Blazers	2024	This dataset records the locations of both paved off-street trails and soft-surface trails within Benton, Madison, and Washington counties.

3.2 Indicators of Ecosystem Services

A scoring matrix was developed to assign an Ecosystem Services subscore to each of the land parcels located within Northwest Arkansas. This subscore was based on the presence of indicators of ecosystem services that would provide opportunities for nature-based solutions for adaptation to the following:

- Heavy precipitation
- Drought
- Extreme heat

The ecosystem services indicators and their corresponding GIS datasets are listed in **Table 2**. Each land parcel was assigned an Ecosystem Services subscore based on the sum of the indicators identified on that parcel during the analysis.

Table 2. Ecosystem Services Scoring Matrix.

Indicator	Dataset(s) Used	Score	Logic Query
Ephemeral Drainage	National Hydrography Dataset	1	Does the land parcel have a natural drainage that only conveys stormwater?
Floodway	National Flood Hazard Dataset	1	Does the land parcel intersect a Federal Emergency Management Agency (FEMA) flood zones A, AE, or AO?
Reservoir	National Wetlands Inventory	1	Does the land parcel intersect a pond or lake mapped by the National Wetlands Inventory?
Riparian Buffer	National Hydrography Dataset & National Land Cover Dataset	1	Does the land parcel intersect a forested riparian buffer?
Stormwater Infiltration	National Land Cover Dataset	1	Is the land parcel covered by 20 percent or less impervious surface?
Tree Canopy	National Land Cover Dataset	1	Is the land parcel covered by greater than 50 percent tree canopy?
Wetland	National Wetlands Inventory	2	Does the land parcel intersect a wetland mapped by the National Wetlands Inventory?

<u>Ephemeral Drainages</u>

Ephemeral drainages are prime locations for the construction of ponds that collect stormwater. Ponds provide stormwater control during heavy precipitation and surface water storage during droughts. Ponds are also a source of groundwater recharge, which helps sustain creek flows during dry periods. Because of their potential for opportunities for nature-based solutions to improve adaptation to both heavy precipitation and drought, the presence of one or more ephemeral drainages on a land parcel contributes one point toward its Ecosystem Services subscore.

Floodways

Parcels of land within FEMA-mapped flood hazard zones are prime locations for the consideration of stormwater and flood mitigation projects that can help slow down and disperse stormwater during the heavy precipitation events, improving the infiltration of stormwater into the soil. Because of their ability to provide opportunities for nature-based solutions for adaptation to heavy precipitation, the presence of a FEMA-mapped flood hazard zone on a land parcel contributes one point toward its Ecosystem Services subscore.

Reservoirs

Parcels of land containing lakes and ponds provide stormwater control during heavy precipitation events and surface water storage during droughts. Lakes and ponds are also a source of groundwater recharge, which helps sustain creek flows during dry periods. Because of their ability to provide opportunities for nature-based solutions for adaptation to heavy precipitation and drought, the presence of one or more lakes or ponds on a land parcel contributes one point toward its Ecosystem Services subscore.

Riparian Buffers

Parcels of land with riparian buffers help improve water quality, control flooding and erosion, and increase the infiltration of stormwater into the soil. Because of their ability to provide opportunities for nature-based solutions for adaptation to heavy precipitation, the presence of a riparian buffer on a land parcel contributes one point toward its Ecosystem Services subscore.

Stormwater Infiltration

Parcels of land with little to no impervious surfaces allow stormwater to soak into the soil, reducing runoff while recharging groundwater and helping to sustain creek flows during dry periods. Because of their ability to provide opportunities for nature-based solutions for adaptation to heavy precipitation and drought, pervious surfaces that cover greater than 90 percent of a land parcel contribute.one point toward its Ecosystem Services subscore.

Tree Canopy

Parcels of land containing tree canopy are valuable for the shade they provide, which helps reduce ground surface temperatures and surface water temperatures, helps reduce energy usage for cooling homes and buildings, and provides relief from heat for both humans and wildlife.

Because of its ability to provide opportunities for nature-based solutions for adaptation to extreme heat, tree canopy that covers greater than 50 percent of a land parcel contributes one point toward its Ecosystem Services subscore.

Wetlands

Parcels of land containing wetlands contribute to stormwater and flood control during heavy precipitation events, provide surface water storage during droughts, are a source of groundwater recharge, and help sustain creek flows during dry periods. Because of their unique ability to provide a wide range of ecosystem services and opportunities for nature-based solutions for adaptation to both heavy precipitation and drought, the presence of one or more wetlands on a land parcel contributes two points toward its Ecosystem Services subscore.

3.3 Indicators of Ecosystem Resilience

A scoring matrix was developed to assign an Ecosystem Resilience subscore to each of the land parcels located within Northwest Arkansas. This subscore was based on the presence of indicators of ecosystem resilience that would provide opportunities for nature-based solutions for adaptation, including the following:

- Biodiversity
- Topographic diversity
- Wildlife habitat
- Habitat connectivity

The ecosystem resilience indicators and their corresponding GIS datasets are listed in **Table 3**. Each land parcel was assigned an Ecosystem Resilience subscore based on the sum of the indicators identified on that parcel during the analysis.

Table 3. Ecosystem Resilience Scoring Matrix.

Indicator	Dataset(s) Used	Score	Logic Query
Biodiversity	Biodiversity	1+	Have any species of conservation concern ever been recorded on the land parcel?
Ecologically Resilient Site	Resilient Site & Resilient and Connective Network	2	Does the land parcel contain an ecologically “resilient site” or part of the “resilient and connective network “as identified by The Nature Conservancy's Resilient and Connected Landscapes project?

Indicator	Dataset(s) Used	Score	Logic Query
Ecologically Sensitive Waterbody	Ecologically Sensitive Waterbodies (Streams) & Ecologically Sensitive Waterbodies (Springs & Seeps), Extraordinary Resource Waters, Springs	1	Does the land parcel intersect an ecologically sensitive waterbody?
Habitat Connectivity	National Land Cover Dataset	1	Does the land parcel intersect land that isn't classified by the National Land Cover Dataset as Developed?
Impaired Waterbody	2022 Impaired Streams 303(d) list in Category 1b (Draft), 2022 Impaired Streams 303(d) list in Category 4a (Draft), 2022 Impaired Streams 303(d) list in Category 4b (Draft), 2022 Impaired Streams 303(d) list in Category 5 (Draft), 2022 Impaired Streams 303(d) list in Category 5 Alt (Draft), 2022 Impaired Streams 303(d) list in Category 4a Lake (Draft), 2022 Impaired Streams 303(d) list in Category 5 Lake (Draft), & 2022 Impaired Streams 303(d) list in Category 5 Alt Lake (Draft)	1	Is the parcel adjacent to an impaired stream or waterbody?
Proximity to Natural Waterway	National Hydrography Dataset	1	Does an intermittent or perennial stream flow through the parcel or within 25 feet of the parcel's boundaries?
Unique or Special Habitat	Unique or Special Habitat	1+	Does the land parcel contain unique or special habitat?
Wetland Habitat	National Wetlands Inventory	1	Does the land parcel intersect a wetland mapped by the National Wetlands Inventory?

Biodiversity

The presence of species of conservation concern indicates that a land parcel has unique attributes and habitat that supports ecosystem resilience. A land parcel's biodiversity score is based on the total number of different species of conservation concern that have been confirmed on that parcel.

Ecologically Resilient Sites

The Nature Conservancy's Resilient and Connected Landscapes project has previously mapped resilient lands and significant habitat corridors across the U.S. These are areas that have high ecological resilience to environmental stressors and extreme weather because of their exceptional biodiversity and topographic diversity, both of which help species adapt to environmental stressors and extreme weather. Land parcels that have been mapped by The

Nature Conservancy's Resilient and Connected Landscapes project received two points because of their exceptional value for ecological resilience to environmental stressors and extreme weather.

Ecologically Sensitive Waterbodies

The presence of an Ecologically Sensitive Waterbody, as identified by the ADEE's Division of Environmental Quality, indicates that a land parcel has unique habitat that supports ecosystem resilience. The presence of an Ecologically Sensitive Waterbody within or adjacent to a land parcel contributes one point toward its Ecosystem Resilience subscore.

Habitat Connectivity

Parcels of land that provide habitat connectivity support ecosystem resilience. Wildlife corridors connect the various habitats in the different parts of the region and provide ways for species to migrate while minimizing interactions with humans. The presence of part of the Enduring Green Network within a land parcel contributes one point toward its Ecosystem Resilience subscore.

Impaired Streams

Parcels of land that contain or are adjacent to streams that are impaired because of one or more contaminants are prime locations for the consideration of water quality improvement projects to restore these aquatic habitats. Restoration of these aquatic habitats can improve biodiversity so that these streams can function as habitat and wildlife corridors and be more ecologically resilient. Because of its potential to improve ecosystem resilience, the presence of an impaired stream within or adjacent to a land parcel contributes one point toward its Ecosystem Resilience subscore.

Proximity to Natural Waterways

Natural waterways such as streams and rivers provide important habitat to species that are uniquely adapted to aquatic environments. Natural waterways also connect terrestrial habitats, providing corridors for wildlife to travel along as they adapt to environmental stressors and human pressures from growth and development in the region. As both habitats and wildlife corridors, natural waterways help support ecosystem resilience. Therefore, the presence of a natural waterway within or adjacent to a land parcel contributes one point toward its Ecosystem Resilience subscore.

Unique or Special Habitat

The presence of Unique or Special Habitat indicates that a land parcel improves biodiversity within the region and supports ecosystem resilience. A land parcel received one point for each type of unique or special habitat that exists on the parcel.

Wetland Habitat

Typically valued for their biodiversity and multiple ecological functions, wetlands provide important habitat to species that are uniquely adapted to these environments, helping to improve biodiversity within the region and support ecosystem resilience. The presence of a wetland within a land parcel contributes one point toward its Ecosystem Resilience subscore.

3.4 Indicators of Carbon Sequestration and Storage

A scoring matrix was developed to assign a Carbon Sequestration and Storage subscore to each of the land parcels located within Northwest Arkansas. This subscore was based on the presence of indicators of carbon sequestration and storage that would provide opportunities for nature-based solutions for mitigation through the following:

- Aboveground woody biomass
- Belowground soil carbon

The carbon sequestration and storage indicators and their corresponding GIS datasets are listed in **Table 4**. Each land parcel was assigned a Carbon Sequestration and Storage subscore based on the sum of the indicators identified on that parcel during the analysis.

Table 4. Carbon Sequestration and Storage Scoring Matrix.

Indicator	Dataset(s) Used	Score	Logic Query
Carbon-storing Forested Wetland	National Wetlands Inventory & Hydric Soils	5	Does the land parcel intersect a wetland mapped by the NWI that has a Cowardin classification of palustrine forested (PFO), is greater than 1 acre in size, and intersects a mapped soil unit that has a hydric rating greater than or equal to 60 percent?
Carbon-storing Shrub Wetland	National Wetlands Inventory & Hydric Soils	4	Does the land parcel intersect a wetland mapped by the NWI that has a Cowardin classification of palustrine scrub-shrub (PSS), is greater than 1 acre in size, and intersects a mapped soil unit that has a hydric rating greater than or equal to 60 percent?
Carbon-storing Herbaceous Wetland	National Wetlands Inventory & Hydric Soils	3	Does the land parcel intersect a wetland mapped by the NWI that has a Coward classification of palustrine emergent (PEM), is greater than 1 acre in size, and intersects a mapped soil unit that has a hydric rating greater than or equal to 60 percent?

Indicator	Dataset(s) Used	Score	Logic Query
Carbon-storing Reservoir	National Wetlands Inventory	2	Does parcel intersect a wetland mapped by the National Wetlands Inventory that categorized as “Freshwater Pond” or “Lake”, and is greater than 1 acre in size?
Carbon-storing Upland Prairie	National Land Cover Dataset & Prairie Mounds	2	Does the parcel intersect an area mapped as either a “Grassland” or as “Herbaceous” by the National Land Cover Dataset, or has the parcel otherwise been determined by knowledgeable local experts to contain predominantly prairie vegetation?
Carbon-storing Upland Forest	National Land Cover Dataset	1	Does the parcel have greater than 50% tree canopy, excluding carbon storing forested wetlands?

Carbon-storing Wetlands

As discussed above, wetlands with soils that remain saturated or inundated for most of the growing season can sequester and store significantly more carbon in their soils than any other type of terrestrial landscape. Therefore, carbon-storing wetlands are much more valuable than upland ecosystems when it comes to providing better carbon sequestration and storage.

Wetland ecosystems are also much less common on the landscape than upland ecosystems, and most have already been filled or drained by development and agriculture over the past few hundred years. For these reasons, the few carbon-storing wetlands that remain in Northwest Arkansas were ranked the highest as carbon-storing ecosystems in this analysis.

Forested wetlands have the added benefit of being able to sequester and store significant amounts of carbon in their aboveground woody biomass and are therefore the most valuable type of carbon-storing wetland ecosystem. Therefore, the presence of one or more carbon-storing forested wetlands on a land parcel contributes five points toward its Carbon Sequestration and Storage subscore.

Scrub-shrub wetlands also sequester and store additional carbon in their aboveground woody biomass. Though these wetland types store more carbon than a wetland dominated by nonwoody herbaceous vegetation, they store less carbon compared to forested wetlands because of the smaller size of the aboveground woody biomass found in the shrubby vegetation. Therefore, the presence of one or more carbon-storing scrub-shrub wetlands on a land parcel contributes four points toward its Carbon Sequestration and Storage subscore. This is fewer than the number of points that a carbon-storing forested wetland contributes to a land parcel's Carbon Sequestration and Storage subscore, but greater than what carbon-storing herbaceous wetlands contribute.

Wetlands dominated by nonwoody herbaceous species store little to no carbon in their aboveground biomass. Though these wetland types store more carbon overall than an upland ecosystem when the belowground soil carbon is considered, they store less carbon compared to forested and scrub-shrub wetlands because of their lack of woody aboveground biomass. Therefore, the presence of one or more carbon-storing herbaceous wetlands on a land parcel contributes three points toward its Carbon Sequestration and Storage subscore. This is fewer than the number of points that carbon-storing wetlands containing woody species contribute to a land parcel's overall Carbon Sequestration and Storage subscore but greater than what non-wetland carbon-storing ecosystems contribute.

Carbon-storing Reservoirs

Ponds and lakes can store carbon in their soils in quantities that are similar to wetlands, but the rate at which ponds sequester carbon from the atmosphere is much lower than wetlands because they have a limnetic zone with little to no vegetation that contributes litterfall to the pond's benthic zone. Therefore, the presence of one or more ponds on a land parcel contributes two points toward its Carbon Sequestration and Storage subscore. This is fewer than the number of points that carbon-storing wetlands contribute but greater than what upland forests with little to no soil carbon contribute.

Carbon-storing Upland Prairies

With little to no aboveground carbon stored in woody biomass and less belowground carbon stored in the soil than carbon-storing wetlands, upland prairies can still store more carbon in their soils than any other type of upland ecosystem, including upland forests. Therefore, the presence of one or more upland prairies on a land parcel contributes two points toward its Carbon Sequestration and Storage subscore. This is fewer than the number of points that carbon-storing wetlands contribute but higher than what upland forests contribute.

Carbon-storing Forests

Upland forests sequester and store carbon in their woody biomass, mostly aboveground. Although these habitats don't store as much belowground carbon in their roots and soils as carbon-storing wetlands or upland prairies do, upland forests can still provide more carbon sequestration and storage than most other types of terrestrial landscapes, especially when compared to nonnative forage and turf grasses. However, because trees are limited in how tall they can grow and how long they can live, forested ecosystems are much more limited in the quantity and longevity of the carbon storage they provide when compared to carbon-storing wetlands and upland prairies.

Despite providing less carbon storage, forested areas can sequester carbon into their woody biomass at a much quicker rate than wetlands and prairies can sequester carbon into their soil. Therefore, the presence of one or more upland forests on a land parcel contributes one point toward its Carbon Sequestration and Storage subscore. This is fewer than the number of points that carbon-storing wetlands, ponds, and upland prairies contribute to a land parcel's Carbon Sequestration & Storage subscore but greater than parcels that provide little to no carbon sequestration and storage.

3.5 Social Equity Factors

A scoring matrix was developed to assign a Social Equity score to each of the land parcels located within Northwest Arkansas. This score was based on factors that should be taken into consideration to assure an equitable distribution of benefits from nature-based solutions. These factors include the following:

- Socioeconomics
- Access to community resources
- Urban heat

A land parcel’s Social Equity score is not included in the Nature-based Solutions composite score because these factors do not reveal the presence of natural infrastructure that provides nature-based solutions on the parcel, but rather are factors that reveal potential benefits provided by the natural infrastructure of a parcel, or whether there are any deficiencies in natural infrastructure that could be addressed through the implementation of nature-based solutions. The social equity indicators and their corresponding GIS datasets are listed in **Table 5**. Each land parcel was assigned a Social Equity score based on the sum of the indicators identified on that parcel during the analysis.

Table 5. Social Equity Scoring Matrix.

Factor	Dataset(s) Used	Score	Logic Query
Heat Island	Landsat Land Surface Temperatures	1	Does the land parcel intersect a heat island?
Low-moderate Income	Low-moderate Income	1	Is the land parcel located within a census block that has greater than 50 percent low-moderate income households?
Proximity to Active Transportation Network	Trails	1	Is the land parcel within 1 mile of a trail?
Proximity to Open Space	Public Land Boundary, Natural Area Boundaries, and Northwest Arkansas Land Trust Preserves	1	Is the land parcel more than 1 mile away from a park or open space that is accessible to the public?

Heat Islands

Heat islands are urbanized areas that experience higher temperatures than outlying areas. Structures such as roads and buildings absorb and reemit the sun's heat; temperatures near these structures differ from outlying areas, mostly at night. These heat islands lead to increased energy costs for the buildings in these areas and can disproportionately affect those with low or limited income. Heat islands are prime locations for the consideration of tree plantings to reduce temperatures in these areas. Therefore, the presence of a mapped heat island on a land parcel contributes one point toward its Social Equity score.

Low-moderate Income

Socioeconomic disparities can result in some communities, such as those with low or limited income, experiencing disproportionate impacts from natural disasters and extreme weather. Therefore, land parcels that were within a census block consisting of households with low to moderate levels of income were given one point toward their Social Equity score.

Proximity to Active Transportation Network

A land parcel that is near the Active Transportation Network may be an ideal location for a new park or open space that provides ecosystem services that benefit disadvantaged communities. Therefore, land parcels that were within 1 mile of the active transportation network were given one point toward their Social Equity score.

Proximity to Open Space

A land parcel that is greater than a 1 mile from existing parks and open space may be an ideal location for the dedication of a new park or open space that provides ecosystem services that benefit disadvantaged communities. Therefore, land parcels that were greater than 1 mile from existing parks or open space were given one point toward their Social Equity score.

4.0 RESULTS

In total, 299,058 land parcels comprising approximately 1,709,171 acres were analyzed for the presence of indicators that would provide opportunities for nature-based solutions for adaptation and mitigation strategies to environmental stressors and for social equity factors.

These land parcels were categorized into four size classes based on their acreage to differentiate between benefits provided by larger parcels from those provided by smaller parcels. The size classes and number of land parcels within each class are listed below in **Table 6**.

Table 6. Number of Land Parcels per Size Class.

Size	Number of Land Parcels
<1 acre	211,837
1-5 acres	37,118
5-40 acres	38,146
>40 acres	11,957
Total	**299,058**

Land parcel subscores and the composite score were ranked into categories ranging from Lower through Very High based on natural breaks in the distribution of the sub- and composite scores. Parcels of land that scored a zero were not included in the ranking system. The results of the geospatial analysis for each of the three subscores are discussed below, followed by a discussion of the results of the Nature-based Solutions composite score and the Social Equity score.

4.1 Ecosystem Services Subscore Results

A total of 149,304 land parcels were assigned an Ecosystem Services subscore based on indicators identified on each parcel during this analysis. The higher the subscore a land parcel received, the greater number of indicators of ecosystem services the parcel was found to have.

Figure 3 below shows the distribution of the land parcels throughout the region that received an Ecosystem Services subscore.

Approximately 50 percent of the total number of land parcels within Northwest Arkansas did not receive a subscore for any indicators of ecosystem resilience. Of the land parcels that did receive an Ecosystem Services subscore, a total of 75,995 land parcels ranked as having a Lower value (score of 1); another 42,872 ranked as having a Medium value (score of 2). A total of 25,083 land parcels, totaling approximately 681,790 acres, ranked as having a Higher value (scores of 3 or 4) for Ecosystem Services; another 5,354 parcels, totaling approximately 357,631 acres, ranked as having a Very High value (scores of 5 to 8). The number of land parcels for each Ecosystem Services subscore are shown in **Table 7** below. The number of land parcels that received a score for each indicator of ecosystem services are shown in **Table 8**.

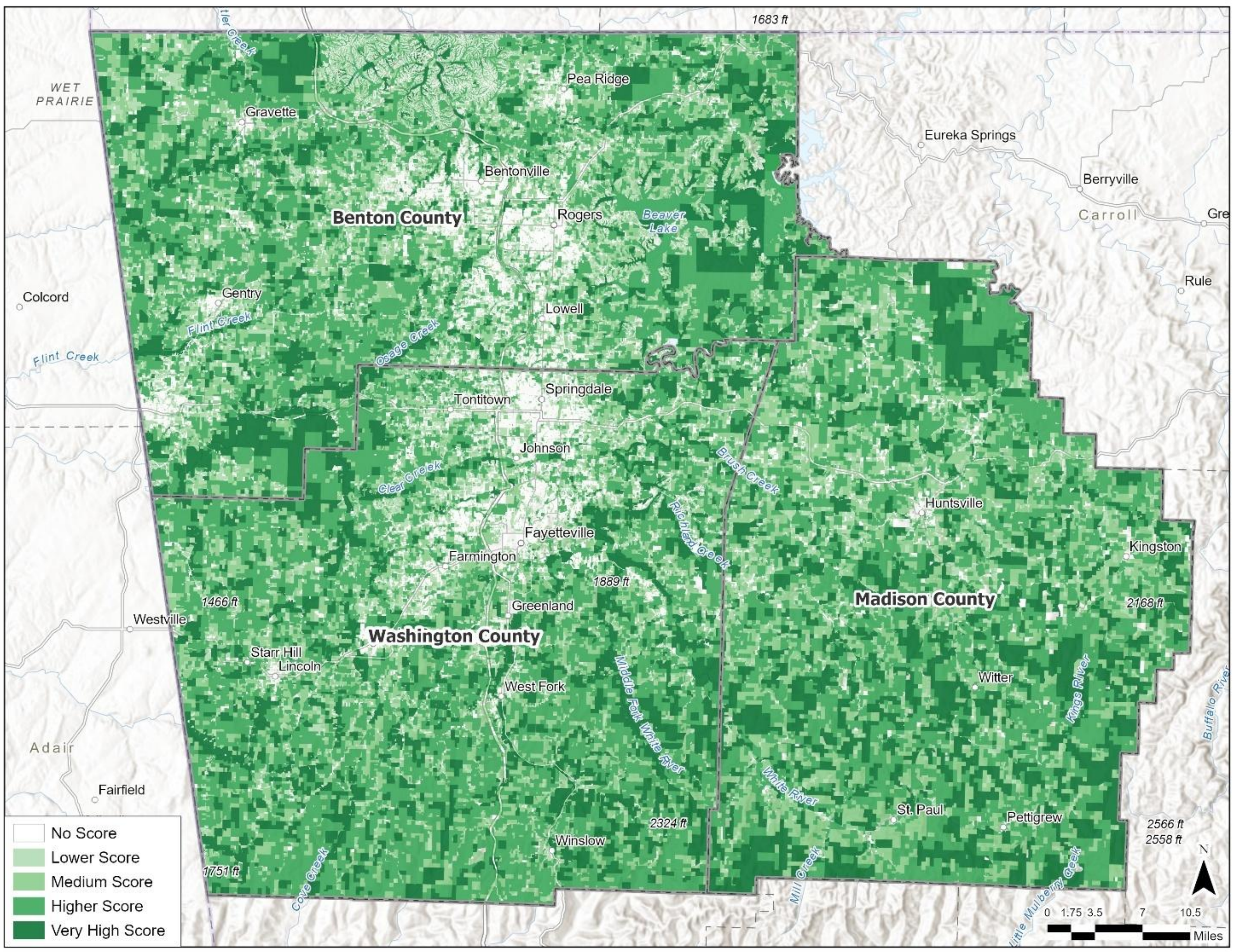

Figure 3. Distribution of Ranked Ecosystem Services Subscores.

Table 7. Number of Land Parcels per Ecosystem Services Subscore.

Rank	Subscore	Number of Land Parcels: Size Class < 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	Total	Percentage of Ranked Land Parcels	Percentile of Ranked Land Parcels
UNRANKED	0	134,027	12,412	3,253	62	**149,754**	-	-
LOWER	1	54,029	12,778	8,647	541	**75,995**	50.9	0
MEDIUM	2	19,873	8,160	12,389	2,450	**42,872**	28.7	14
HIGHER	3	2,830	2,763	8,830	3,765	**18,188**	12.2	29
	4	736	748	3,123	2,288	**6,895**	4.6	43
VERY HIGH	5	198	197	1,381	1,661	**3,437**	2.3	57
	6	94	50	412	801	**1,357**	0.9	72
	7	43	9	97	331	**480**	0.3	86
	8	7	1	14	58	**80**	0.1	100

Table 8. Number of Land Parcels per Ecosystem Services Indicator.

Indicator	Number of Land Parcels: Size Class < 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	Total
Ephemeral Streams	8,273	4,527	10,933	6,126	**29,859**
Floodway	9,924	3,673	4,707	1,876	**20,180**
Lake/Pond	5,072	2,748	10,357	5,672	**23,849**
Riparian Buffer	3,220	3,064	8,915	5,803	**21,002**
Stormwater Infiltration	39,905	13,167	24,773	10,817	**88,662**
Streambank Erosion Risk	39,508	13,490	18,496	7,163	**78,657**
Tree Canopy	609	533	2,197	2,162	**5,501**
Wetland	8,273	4,527	10,933	6,126	**29,859**

Overall, approximately 50 percent of land parcels in Northwest Arkansas, totaling 1,566,626 acres, currently provide some form of ecosystem services that will help the region adapt to extreme weather (see **Figure 4**), primarily in the form of tree canopy and soil infiltration of stormwater. The percentage of land parcels scoring for each indicator of ecosystem services is shown in **Table 9** below.

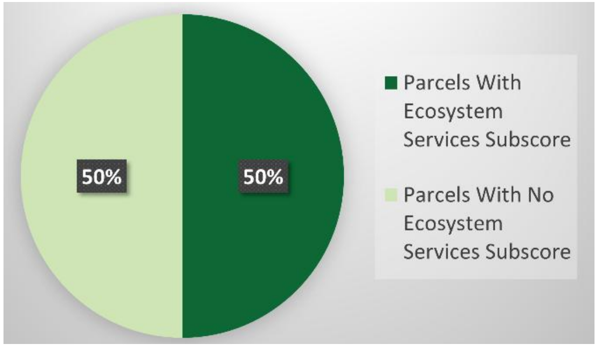

Figure 4. Percentage of Total Land Parcels with Ecosystems Services Indicators.

Table 9. Percentage of Total Land Parcels per Ecosystem Services Indicator.

Indicator	Percentage
Ephemeral Streams	11
Floodway	8
Lake/Pond	9
Riparian Buffer	8
Stormwater Infiltration	33
Wetland	2
Tree Canopy	20

4.2 Ecosystem Resilience Subscore Results

A total of 196,707 land parcels were assigned an Ecosystem Resilience subscore based on indicators identified on that parcel during this analysis. The higher the subscore a land parcel received, the greater number of indicators of ecosystem resilience the parcel was found to have. **Figure 5** below shows the distribution of the land parcels throughout the region that received an Ecosystem Resilience subscore.

Approximately 34 percent of the total number of land parcels within Northwest Arkansas did not receive a subscore for any indicators of ecosystem resilience. Of the land parcels that did receive an Ecosystem Resilience subscore, a total of 101,387 parcels ranked as having a Lower value for Ecosystem Resilience (scores of 1 or 2); another 88,503 ranked as having a Medium value (scores of 3 or 4). A total of 6,623 land parcels, totaling approximately 351,653 acres, ranked as having a Higher value for Ecosystem Resilience (scores of 5 to 8); 194 other parcels of approximately 17,487 acres ranked as having a Very High value (scores of 9 to 25). The number of land parcels for each Ecosystem Resilience subscore are shown in **Table 10** below. The number of land parcels that received a score for each indicator of ecosystem resilience are shown in **Table 11**.

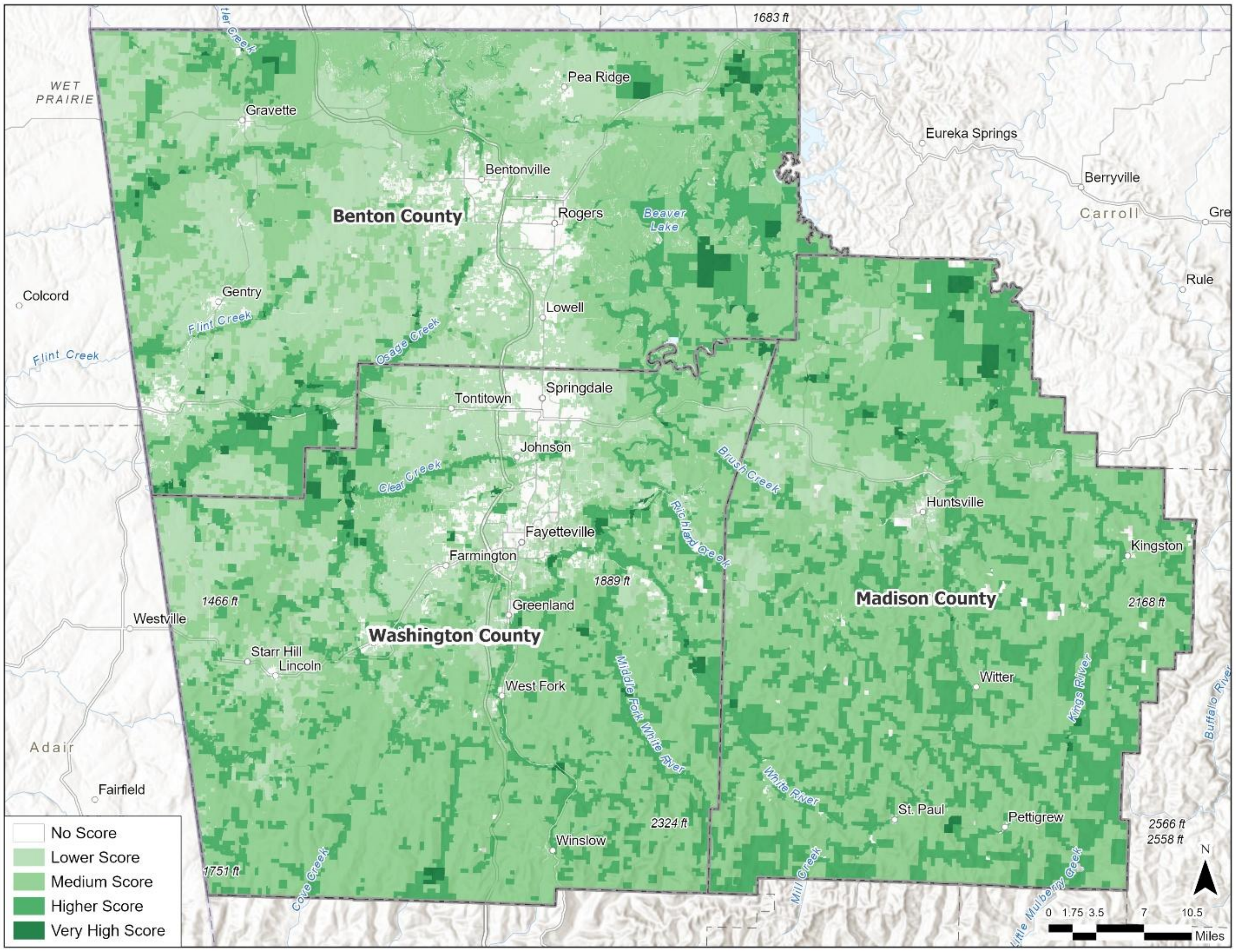

Figure 5. Distribution of Ranked Ecosystem Resilience Subscores.

Table 10. Number of Land Parcels per Ecosystem Resilience Subscore.

Rank	Sub-score	Number of Land Parcels					Percentage of Ranked Land Parcels	Percentile of Ranked Land Parcels
		Size Class				Total		
		< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres			
UNRANKED	**0**	99,311	2,656	377	7	**102,351**	-	-
LOWER	**1**	58,505	15,656	9,371	768	**84,300**	42.856	0
	2	7,388	3,548	5,092	1,059	**17,087**	8.687	4
MEDIUM	**3**	42,788	12,402	14,560	4,008	**73,758**	37.496	8
	4	3,165	2,192	6,025	3,363	**14,745**	7.496	13
HIGHER	**5**	434	489	1,882	1,842	**4,647**	2.362	17
	6	149	113	535	515	**1,312**	0.667	21
	7	57	34	181	209	**481**	0.2	25
	8	21	16	63	83	**183**	0.09	29
VERY HIGH	**9**	9	9	24	36	**78**	0.04	33
	10	2	2	18	19	**41**	0.02	38
	11	1	1	8	23	**33**	0.02	42

Rank	Sub-score	Number of Land Parcels					Percentage of Ranked Land Parcels	Percentile of Ranked Land Parcels
		Size Class						
		< 1 acre	1-5 acres	5 - 40 acres	> 40 acres	Total		
	12	2	-	5	11	**18**	0.01	46
	13	1	-	1	6	**8**	0.004	50
	14	2	-	1	2	**5**	0.003	54
	15	-	-	2	3	**5**	0.003	58
	16	1	-	1	1	**3**	0.002	63
	17	-	-	-	-	**-**	0	63
	18	-	-	-	-	**-**	0	63
	19	-	-	-	-	**-**	0	63
	20	1	-	-	-	**1**	0.001	79
	21	-	-	-	1	**1**	0.001	83
	22	-	-	-	-	**-**	0	83
	23	-	-	-	-	**-**	0	83
	24	-	-	-	-	**-**	0	83
	25	-	-	-	1	**1**	0.0005	100

Table 11. Number of Land Parcels per Ecosystem Resilience Indicator.

Indicator	Number of Land Parcels				
	Size Class				Total
	< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	
Biodiversity	469	314	798	553	**2,134**
Ecologically Resilient Site	48,636	14,930	22,225	9,582	**95,373**
Unique or Special Habitat	916	1,199	3,292	1,979	**7,386**
Ecologically Sensitive Waterbodies	1,697	732	1,022	453	**3,904**
Wetland Habitat	609	533	2,197	2,162	**5,501**
Habitat Connectivity	105,779	34,046	37,628	11,891	**189,344**
Proximity to Natural Waterway	10,727	5,406	11,767	6,646	**34,546**
Impaired Stream	498	273	750	443	**1,964**

Overall, approximately 66 percent of land parcels within Northwest Arkansas, totaling 1,626,554 acres, currently provide some form of ecosystem resilience that will help the region adapt to environmental stressors (see **Figure 6**), primarily in the form of habitat connectivity. The percentage of land parcels scoring for each indicator of ecosystem resilience are shown in **Table 12** below.

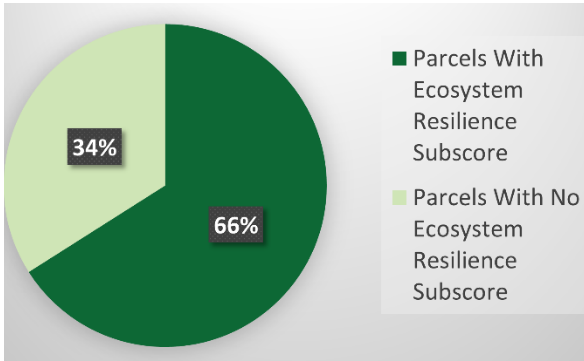

Figure 6. Percentage of Total Land Parcels with Ecosystem Resilience Indicators.

Table 12. Percentage of Total Land Parcels per Ecosystem Resilience Indicator.

Indicator	Percentage
Biodiversity	0.7
Ecologically Resilient Site	31.9
Unique or Special Habitat	2.5
Ecologically Sensitive Waterbodies	1.3
Wetland Habitat	1.8
Habitat Connectivity	63.3
Proximity to Natural Waterway	11.6
Impaired Stream*	0.7

* Impaired streams are not in themselves an indicator of ecosystem resilience but are prime locations for the consideration of water quality improvement projects to restore these aquatic habitats and improve biodiversity so that these streams can become more ecologically resilient.

4.3 Carbon Sequestration and Storage Subscore Results

A total of 87,098 land parcels were assigned a Carbon Sequestration and Storage subscore based on indicators identified on that parcel during this analysis. The higher the subscore a land parcel received, the greater number of indicators of sequestration and storage the parcel was found to have. **Figure 7** below shows the distribution of the land parcels throughout the region that received a Carbon Sequestration and Storage subscore.

Approximately 71 percent of the total number of land parcels within Northwest Arkansas did not receive a subscore for any indicators of carbon sequestration and storage. Of the land parcels that did receive a Carbon Sequestration and Storage subscore, a total of 77,426 land parcels ranked as having a Lower value for Carbon Sequestration and Storage (score of 1); another 9,229 ranked as having a Medium value (scores of 2 or 3). A total of 282 land parcels, totaling approximately 10,346 acres ranked, as having a Higher value for Carbon Sequestration and Storage (scores of 4 or 5), and another 161 parcels, totaling approximately 6,194 acres, ranked as having a Very High value (scores of 6 to 9). The number of land parcels for each Carbon Sequestration and Storage subscore is shown in **Table 13** below. The number of land parcels that received a score for each indicator of carbon sequestration and storage is shown in **Table 14**.

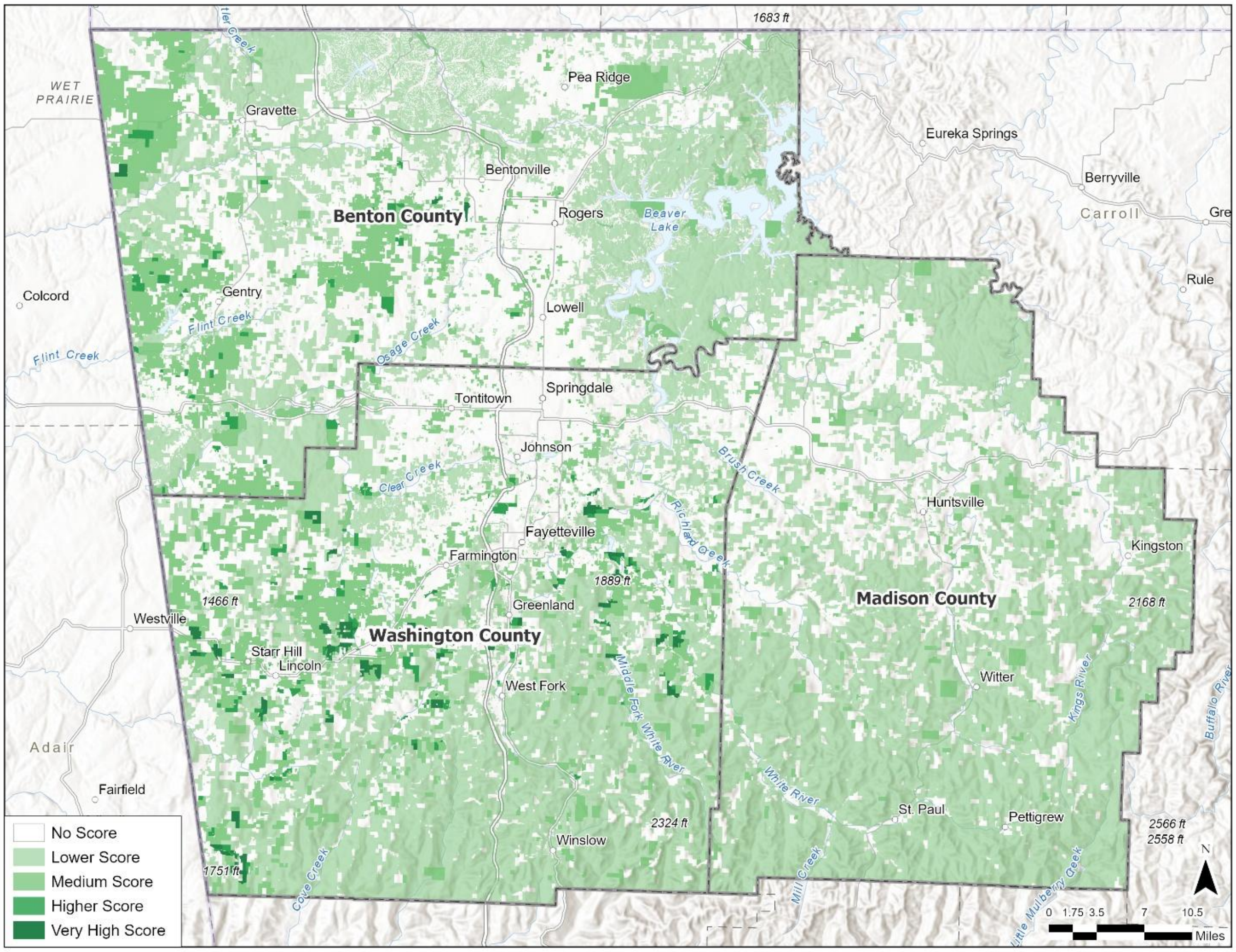

Figure 7. Distribution of Ranked Carbon Sequestration and Storage Subscores.

Table 13. Number of Land Parcels per Carbon Sequestration and Storage Subscore.

Rank	Sub-Score	Number of Land Parcels: Size Class < 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	Total	Percentage of Ranked Land Parcels	Percentile of Ranked Land Parcels
UNRANKED	0	169,157	22,540	16,765	3,498	**211,960**	-	-
LOWER	1	39,248	13,309	18,015	6,854	**77,426**	88.895	0.0
MEDIUM	2	3,112	1,057	2,745	1,163	**8,077**	9.273	12.5
	3	240	175	449	288	**1,152**	1.323	25.0
HIGHER	4	11	8	60	65	**144**	0.165	37.5
	5	42	21	50	25	**138**	0.158	50.0
VERY HIGH	6	16	7	35	21	**79**	0.091	62.5
	7	8	1	27	36	**72**	0.083	75.0
	8	2	-	-	6	**8**	0.009	87.5
	9	1	-	-	1	**2**	0.002	100.0

Table 14. Number of Land Parcels per Carbon Sequestration and Storage Indicator.

Indicator	Number of Land Parcels				
	Size Class				Total
	< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	
Carbon-storing Forest	39,506	13,490	18,496	7,162	**78,654**
Carbon-storing Pond	198	79	339	310	**926**
Carbon-storing Prairie	3,182	1,167	2,998	1,327	**8,674**
Carbon-storing Wetland: Herbaceous	2	-	7	7	**16**
Carbon-storing Wetland: Shrub	4	3	20	13	**40**
Carbon-storing Wetland: Forested	67	28	94	71	**260**

Overall, approximately 29 percent of land parcels, totaling 1,062,813 acres, currently provide some form of carbon sequestration and storage (see **Figure 8**), primarily upland forests. Land parcels with carbon-storing herbaceous and shrub wetlands make up the smallest number of carbon-storing landscapes in Northwest Arkansas. The percentage of land parcels scoring for each indicator of carbon sequestration and storage is shown in **Table 15** below.

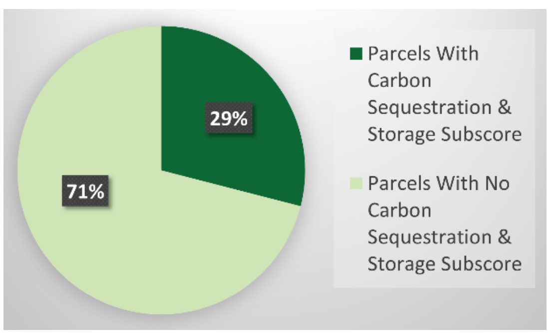

Figure 8. Percentage of Total Land Parcels with Carbon Sequestration and Storage Indicators.

Table 15. Percentage of Total Land Parcels per Carbon Sequestration and Storage Indicator.

Indicator	Percentage
Carbon-storing Forest	26.30
Carbon-storing Pond	0.31
Carbon-storing Prairie	2.90
Carbon-storing Wetland: Herbaceous	0.01
Carbon-storing Wetland: Shrub	0.01
Carbon-storing Wetland: Forested	0.09

4.4 Nature-based Solutions Composite Score Results

A total of 294,895 land parcels were given a Nature-based Solutions composite score equal to the sum of each of the three subscores. The higher the Nature-based Solutions composite score a land parcel received, the greater the number of features for adapting to and mitigating environmental stressors and extreme weather the parcel was found to have, and the more valuable the parcel is for the implementation of nature-based solutions. **Figure 9** below shows the distribution of the land parcels throughout Northwest Arkansas that received a Nature-based Solutions composite score.

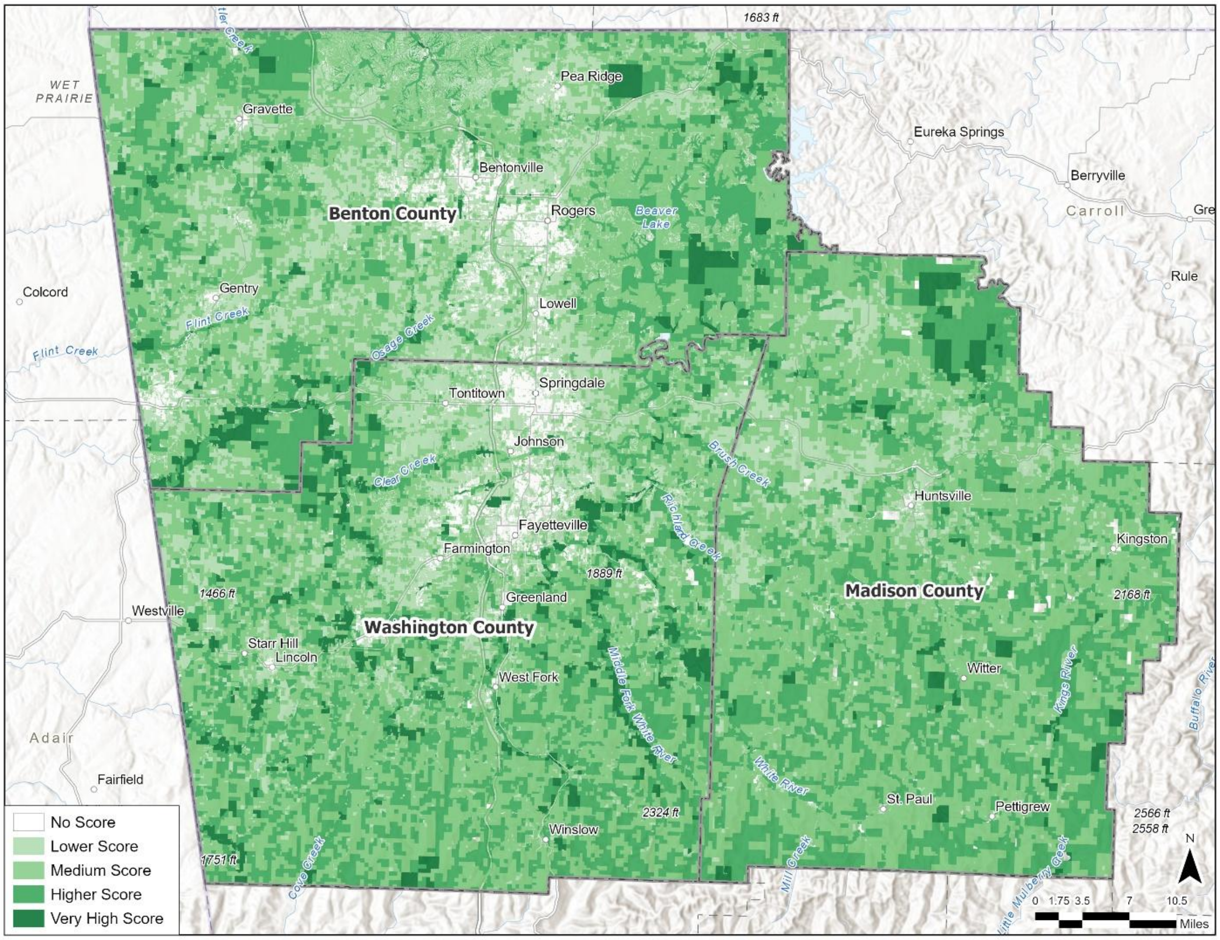

Figure 9. Distribution of Ranked Nature-based Solution Scores.

A total of 128,992 land parcels ranked as having Lower value for Nature-based Solutions (scores of 1 to 4); another 71,357 ranked as having Medium value (scores of 5 to 8). A total of 9,225 land parcels ranked as having Higher value for Nature-based Solutions (scores of 9 to 13); another 845 parcels ranked as having Very High value (scores of 14 to 32). Land parcels ranked as Higher total approximately 482,839 acres, or 28.25 percent of the acreage of the region. Land parcels that ranked Very High total approximately 71,269 acres, or 4.17 percent of the acreage of the region. The number of land parcels for each Nature-based Solutions composite score is shown in **Table 16** below.

Table 16. Number of Land Parcels per Nature-based Solutions Composite Score.

Rank	Composite Score	Number of Land Parcels					Percentage of Ranked Land Parcels	Percentile of Ranked Land Parcels
		Size Class						
		< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	Total		
UNRANKED	0	86,515	1,895	223	6	**88,639**	-	-
LOWER	1	41,605	7,351	1,575	20	**50,551**	24.0240	0.0
	2	18,919	5,037	2,881	106	**26,943**	12.8045	3.2
	3	22,661	5,635	3,854	302	**32,452**	15.4226	6.4
	4	9,598	4,216	4,657	575	**19,046**	9.0515	9.6
MEDIUM	5	16,607	5,201	5,536	780	**28,124**	13.3657	12.9
	6	12,371	4,549	7,317	1,886	**26,123**	12.4148	16.1
	7	1,960	1,729	5,007	2,027	**10,723**	5.0960	19.3
	8	808	794	3,034	1,751	**6,387**	3.0354	22.5
HIGHER	9	318	330	1,672	1,291	**3,611**	1.7161	25.8
	10	154	151	885	928	**2,118**	1.0066	29.0
	11	103	115	700	851	**1,769**	0.8407	32.2
	12	86	55	404	602	**1,147**	0.5451	35.4
	13	37	27	166	350	**580**	0.2756	38.7
VERY HIGH	14	18	18	95	156	**287**	0.1364	41.9
	15	22	6	59	119	**206**	0.0979	45.1
	16	15	4	33	68	**120**	0.0570	48.3
	17	12	4	17	46	**79**	0.0375	51.6
	18	9	1	12	29	**51**	0.0242	54.8
	19	8	-	11	29	**48**	0.0228	58.0
	20	3	-	4	16	**23**	0.0109	61.2
	21	4	-	1	10	**15**	0.0071	64.5
	22	2	-	2	4	**8**	0.0038	67.7
	23	-	-	1	3	**4**	0.0019	70.9
	24	1	-	-	-	**1**	0.0005	74.1
	25	-	-	-	-	**-**	-	74.1
	26	-	-	-	-	**-**	-	74.1
	27	-	-	-	-	**-**	-	74.1
	28	-	-	-	-	**-**	-	74.1
	29	1	-	-	1	**2**	0.0010	90.3
	30	-	-	-	-	**-**	-	90.3
	31	-	-	-	-	**-**	-	90.3
	32	-	-	-	1	**1**	0.0005	100.0

Overall, approximately 70 percent of land parcels, totaling 1,631,757 acres, currently have the ability to provide nature-based solutions for adapting to and mitigating environmental stressors and extreme weather in one form or another (see **Figure 10**); most of these parcels are less than 1 acre in size. The percentage of land parcels scoring for Nature-based Solutions in each size class is shown in **Table 17** below.

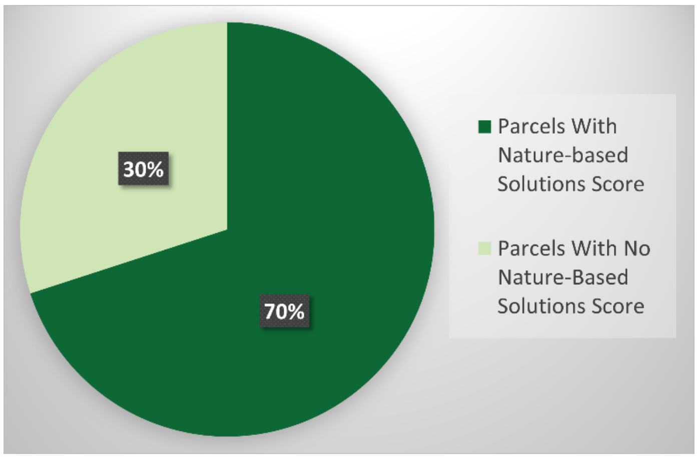

Figure 10. Percentage of Total Land Parcels with Nature-based Solutions Score.

Table 17. Percentage of Total Land Parcels Scoring for Nature-based Solutions per Size Class.

Size Class	Percentage
<1 acre	71
1-5 acres	12
5-40 acres	13
>40 acres	4

4.5 Social Equity Score Results

A total of 257,085 land parcels were assigned a Social Equity score based on factors discussed above that were identified on that parcel during this analysis. The higher the score a land parcel received, the more factors are present on that parcel for consideration of social equity when nature-based solutions are implemented. **Figure 11** below shows the distribution of the land parcels throughout Northwest Arkansas that received a Social Equity score.

Approximately 16 percent of land parcels within Northwest Arkansas are located in a mapped heat island, and 12 percent are in communities with low-moderate income households. Approximately 28 percent of land parcels are currently located more than a 1.0-mile walk from a public park or open space. The number of land parcels for each Social Equity score are shown in **Table 18** below. The number of land parcels that received a score for each Social Equity factor are shown in **Table 19**.

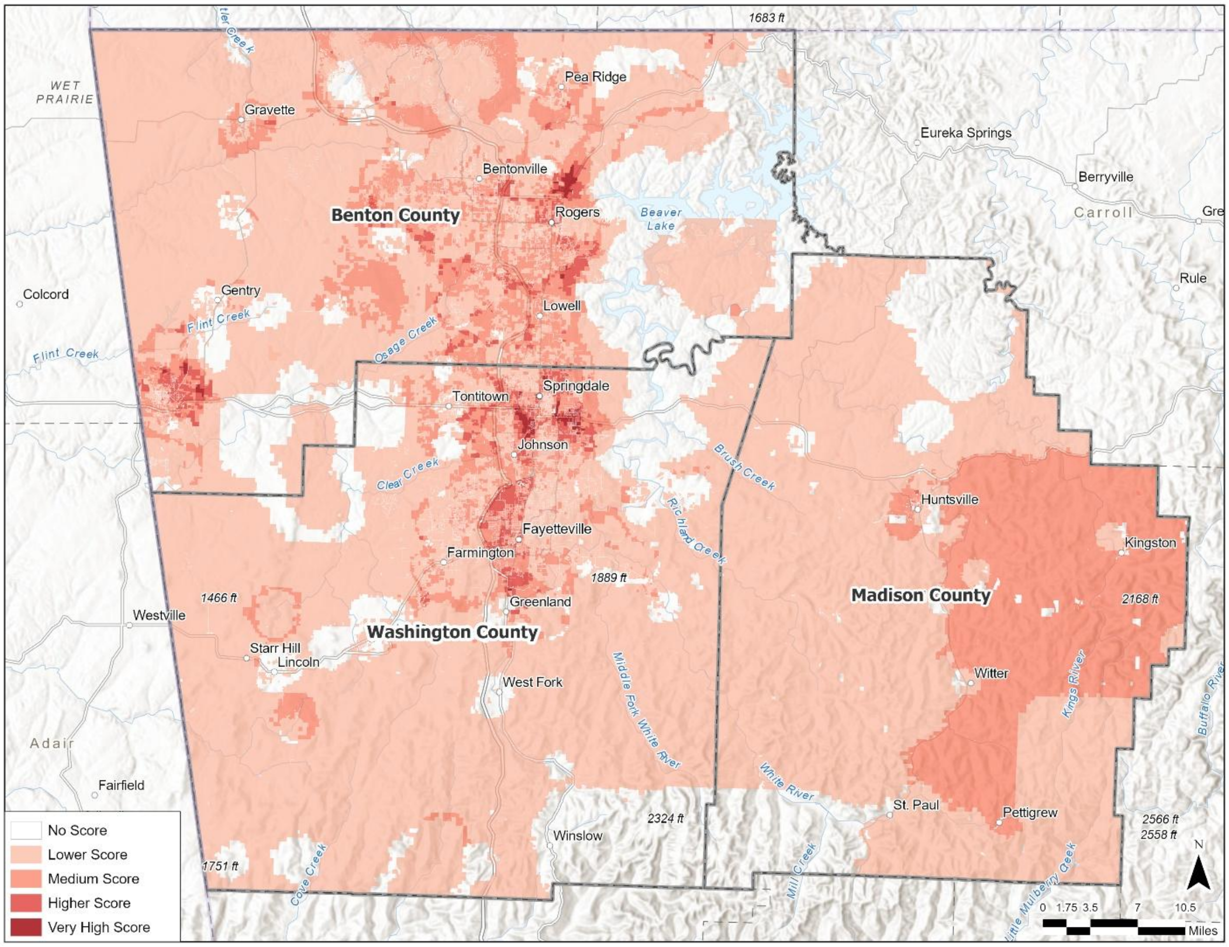

Figure 11. Distribution of Ranked Social Equity Scores.

Table 18. Number of Land Parcels per Social Equity Score.

Score	Number of Land Parcels				
	Size Class				Total
	< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	
0	24,988	7,975	7,197	1,813	**41,973**
1	116,542	21,988	24,685	8,111	**171,326**
2	60,626	6,177	5,653	1,945	**74,401**
3	8,784	911	549	80	**10,324**
4	897	67	62	8	**1,034**

Table 19. Number of Parcels per Social Equity Indicator.

Factor	Number of Land Parcels					Percentage of Total Land Parcels
	Size Class					
	< 1 acre	1 - 5 acres	5 - 40 acres	> 40 acres	Total	
Lack of Proximity to Open Space	35,536	15,262	23,457	8,725	**82,980**	**28**
Low-moderate Income	26,515	2,984	3,707	2,141	**35,347**	**12**
Proximity to Active Transportation Network*	164,777	15,431	8,142	1,060	**189,410**	**63**
Heat Island	40,906	3,666	2,580	347	**47,499**	**16**

* Land parcels near the active transportation network are prime locations for the consideration of establishing new open space that could provide refuge during the day from extreme temperatures for those who may lack indoor air conditioning.

5.0 CONCLUSION

To support sustainability and resilience in Northwest Arkansas, it is important to understand the characteristics of the natural landscape within the region that provides natural infrastructure for the implementation of nature-based solutions for protecting and improving environmental quality. Identifying lands of ecological value can better inform future policies, programs, and actions undertaken within the region to assure the continuance of a high quality of life for its residents.

This study has identified land parcels that provide valuable ecosystem services, ecosystem resilience, and carbon sequestration and storage; it has also identified parcels where special considerations should be made regarding social equity as the region implements the measures included in the NW Arkansas Energy & Environment Innovation Plan to improve the overall sustainability and resilience of the region.

With the wealth of natural resources in the region, Northwest Arkansas is in a strong position to take proactive steps to implement nature-based solutions to protect environmental quality and preserve quality of life in the region.

Parcels of land that ranked High or Very High for providing opportunities for nature-based solutions should be considered for preservation or conservation efforts to protect and improve these areas so they can continue to contribute to the region's resilience to environmental stressors. Some of these areas serve as biodiversity hotspots that help to buffer the ecological stressors placed on other natural areas within the region, providing habitat for wildlife while simultaneously providing carbon sequestration and storage and ecosystem services that buffer the impacts from extreme weather. An effort to conserve a diversity of landscapes in the region, from uplands to wetlands and hilltops to valleys, would provide further improvement to the ecological resilience to environmental stressors. These and other natural areas could continue to provide the ecosystem services that benefit both humans and wildlife.

Parcels of land that connect High or Very High ranked natural areas should also be considered for preservation or conservation, because these habitat linkages allow species to migrate in response to environmental stressors while simultaneously providing carbon sequestration and ecosystem services. Allowing wildlife populations to use these habitat linkages improves their ability to meet their biological needs in the face of environmental stressors and human pressures, will keep the ecosystems within the region healthy, and will thus optimize the ecosystem services provided to residents.

Addressing social equity in Northwest Arkansas can include considering the implementation of nature-based solutions in areas occupied by disadvantaged communities that are located in flood-prone areas or that are in mapped heat islands.

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