Water Resources, ChesLen Preserve

Climate Change Vulnerability Assessment for the Natural Lands Climate Adaptation Project

This document represents an evaluation of climate change vulnerability for water resources in the Natural Lands' ChesLen Preserve in Chester County, Pennsylvania. The following information was based on expert input provided in fall 2022 as well as sources from the scientific literature.

Habitat Description

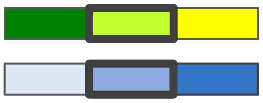
The Natural Lands' ChesLen Preserve is in Chester County, Pennsylvania, and spans 1,282 acres. The preserve's major water resources include West Branch Brandywine Creek and 5.5 miles of unnamed tributaries, wetlands, and a 100-year floodplain located in the preserve's wetland complex. About 1.3 miles of the West Branch Brandywine Creek runs through the preserve's northernmost section, separating the large wetland complex (+/- 241 acres) from the rest of the preserve (*1*). The Brandywine Creek is part of the larger Brandywine-Christina Basin, one of many that makes up the Delaware River Watershed.

Overall, the preserve is comprised primarily of grassland/meadow and row crop agriculture lands (~614 acres), with a smaller portion of riparian afforestation areas (~42 acres) located alongside the Creek and associated tributaries. The soils underlying the tributaries, Creek, and wetland complex are well-drained hydric loam/silt loam soils, which are characteristic of areas regularly saturated with water (*1*). Dominant canopy species in the marsh, wet meadow, floodplain, and wetland complex include red maple (*Acer rubrum*), silver maple (*A. saccharinum*), and sycamore (*Platanus occidentalis*). Common shrubs, vines, and herbaceous species are spicebush (*Lindera benzoin*), silky dogwood (*Cornus amomum*), tussock sedge (*Carex stricta*), soft rush (*Juncus effusus*), sensitive fern (*Onoclea sensibilis*), ironweed (*Vernonia spp.*), wild rye (*Elymus spp.*), cutleaf coneflower (*Rudbeckia laciniata*), stinging nettle (*Urtica dioica*), common cattail (*Typha latifolia*), and bur-reed (*Sparganium americanum*) (*1*).

Vulnerability Ranking

Moderate Vulnerability

Moderate Confidence



Vulnerability is evaluated by considering the habitat's sensitivity and exposure to various climate and non-climate stressors as well as the habitat's adaptive capacity or ability to cope with these stressors with minimal disruption. The overall vulnerability of the habitat is ranked on a scale from low vulnerability (dark green) to high vulnerability (yellow). The confidence in the vulnerability ranking's accuracy is similarly ranked on a scale from low (light blue) to high (dark blue).

Within ChesLen Preserve, water resources (e.g., wetlands, creeks, and streams) are sensitive to fluctuations in hydrologic and thermal regimes, such as changes in stream flow and water temperature. These factors influence water quality and stream channel structure, which, in turn, impacts aquatic and riparian species composition and increases the potential for the introduction of invasive species. Waterways are also vulnerable to extreme flooding and storm disturbances that can facilitate erosion, though these are also important in the establishment and growth of seedlings in wetlands and riparian areas. Non-climate stressors such as pollutants and roads/trails can further alter hydrological regimes, reduce water quality, and fragment or degrade the habitat.

The adaptive capacity of water resources within ChesLen Preserve is supported by the continuity of the creek within the preserve, which is essential for the future dispersal of aquatic species, in addition to the presence of some topographic and physical diversity. Protected segments of the West Branch Brandywine Creek within the preserve may also provide critical refugia for aquatic species located outside of the preserve in stream reaches that are highly influenced by pollutants. Management actions that could help build adaptive capacity under changing climate conditions include maintaining natural hydrologic regimes, promoting native vegetation, enhancing species diversity, and reducing invasive and problematic species that degrade habitat quality. Collaborating with other agencies and organizations to protect water resources at the watershed scale and ensure continued socieal and public support for conservation will also be necessary, particularly as climate change increases the scale of challenges faced across the region.

Sensitivity and Exposure

Moderate Impact

High Confidence

***Sensitivity** is a measure of whether and how a habitat is likely to be affected by a given change in climate and climate-driven factors, changes in disturbance regimes, and non-climate stressors. By contrast, **exposure** is a measure of how much change in these factors a resource is likely to experience. Sensitivity and exposure are combined here for a score representing climate change impact, with high (yellow) impact scores corresponding to increased vulnerability and low (dark green) scores suggesting a habitat is less vulnerable to climate change.*

Sensitivity and future exposure to climate and climate-driven factors

Climate Stressor	Trend	Projected Future Changes[1]
Precipitation	▲	• 5% increase in average annual precipitation (to 48.4 in) in Chester County by 2050; 12% increase (to 5.6 in) by 2100 (*2*) • Most precipitation increases will occur in winter and spring rainfall, with little to no change from historical patterns in the summer and fall (*3*)
Freshwater temperature	▲	• Overall trend toward increased freshwater temperature during the next century (*3*)
Air temperature	▲	• 5.7°F increase in average annual temperature in Chester County by 2050; 9.1°F increase by 2100 (*3*)

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[1] Note that the projections summarized here are based on the RCP 8.5 (high emissions) scenario, which is recommended for planning purposes. Additional details and some projections for the RCP 4.5 (moderate emissions) scenario are provided in the document titled "Overview of Climate Trends and Projections for Natural Lands Preserves", available at https://ecoadapt.org/goto/Natural-Lands.

Altered stream flow	▲ ▼	• Higher winter stream flows due to shifts towards a greater proportion of winter precipitation occurring as rain (*4*) • Decreased stream volume during warm months and ~18% increase in the length of the low-flow season in the Mid-Atlantic region by 2050 (*5*) 6/9/2023 11:34:00 PM

- **Changes in precipitation amount/timing** and associated **alterations in stream flow** can decrease water quality and impact the growth, composition, and survival of aquatic plants, invertebrates, and fish (*6*, *7*). Lower streamflow in conjunction with warmer air temperatures could contribute to an increase in water temperature and impact the timing, movement, and success of spawning for native trout species in the West Branch of the Brandywine Creek (*8*–*11*). By contrast, increases in precipitation that lead to higher flow volumes, particularly in the winter and spring, are likely to contribute to erosion and transport of sediments and contaminants in the West Branch Brandywine Creek and associated tributaries. Water quality is likely to decline where runoff contains herbicides or other pollutants from agricultural fields, and water quality issues such as these have been linked to tree mortality and overall plant community degradation within the riparian areas that buffer tributaries from agricultural lands (*12*, *13*).
- **Warmer air temperatures** can impact soil moisture, water quality, and species productivity and survival (*14*, *15*). Warmer annual temperatures are likely to increase water loss within the ecosystem, particularly in the summer and fall, which then leads to drier soils and reduced plant establishment, growth/productivity, and survival in communities associated with the preserve's water resources (*3*, *15*, *16*). Warmer temperatures are ultimately likely to impact species composition within the preserve over time, as some species decline and ranges shift northward which has the potential to alter ecosystem diversity and structure and may increase the risk of invasion (*15*, *17*–*21*). Additionally, a change in vegetation could impact water availability and flow via changes in groundwater movement and evaporation and transpiration rates typical within the watershed. Warmer air temperatures have also been connected to changes in the ecosystem hydrology (e.g., stream volume and flow) (*14*, *22*).
- **Warmer freshwater temperatures** could have an impact on habitat species composition and survival and water quality (*14*). Increased water temperatures may provide a means for invasive/problematic species introductions and increased competition from more thermal-tolerant species. These impacts could reduce the ability of some to survive and could be exacerbated by altered flow regimes (*23*). Reproduction and growth of many aquatic invertebrate species are also sensitive to water temperature (*6*, *14*). Increased water temperatures have been connected to decreases in water quality as it leads to a reduction in dissolved oxygen, which can impact aquatic organism respiration rates and, ultimately, species growth and survival (*3*, *24*–*26*).

Sensitivity and exposure to climate-driven changes in disturbances

Disturbance Regimes	Trend	Projected Future Changes
Extreme flooding & storms	▲	• Increase in magnitude, frequency, and intensity of extreme precipitation events and associated flooding (*3*) • Increase from 0.8 to 1.2 days per year with >2" precipitation (+50%) in Chester County by 2100 (*2*)

- **Increases in extreme flooding and storm events** could lead to reduced water quality and damage to ecosystem structure and function (*17*, *27*). Earlier snowmelt, changes in precipitation, and increased temperature are likely to disrupt hydrologic regimes by increasing the duration and amount of flooding during the winter and spring months (*3*). Within the water resources of the preserve, seasonal flooding is common and riparian and wetland plants tolerate short periods of submergence and shallow flooding. Larger flood events and/or prolonged flooding, however, could reduce woody plant seedling establishment by delaying or inhibiting germination, or limiting growth and survival (*28*). Over time, these factors can impact the species composition of the habitat, favoring those that can adapt to longer periods of inundation. Flooding may have the potential to reduce water quality where increased runoff and pollutants enter the wetland from nearby roads as well as agricultural, residential, and industrial areas. Extreme flooding and storm events could also be destructive to trails within the preserve, making them inaccessible and bringing debris and other hazards into the stream (*9*).

  Wetland and riparian stream habitats could provide an important service during flooding events by capturing and storing floodwaters, which are then released back into the watershed gradually over time. Additionally, plant cover helps slow the water flow speed, which may minimize or moderate extreme flooding impacts on the watershed (*29*, *30*).

Sensitivity and current exposure to non-climate stressors

Non-climate stressors may interact with climate stressors and disturbance regimes:

- **Invasive and problematic species** can alter the abundance and diversity of native plants through competition for resources, increased predation risk, and/or disease spread (*31*). Increasing temperatures leading to drier soils could promote the spread of invasive species more adapted to low soil moisture and warmer environments (*18*). Invasive species already present in the wetland, riparian, and floodplain areas of the preserve include multiflora rose (*Rosa multiflora*), reed canary grass (*Phalaris arundinacea*), garlic mustard (*Alliaria petiolata*), autumn olive (*Elaeagnus umbellate*), and common reed (*Phragmites australis*) (*32*).
- **Pollution and poisons** such as pesticides, excess nutrient input, and heavy metals can degrade water resource quality (*33*). The preserve has recreation spaces (e.g., boat launch) and crop row agriculture and is surrounded by residential areas, agricultural easements, and industrial zones, all of which could be potential sources of pollutants that could travel into the preserve during periods of heavy rain or flood conditions (*1*, *9*, *14*, *15*). Excess phosphorous that enters waterways in runoff from agricultural areas can cause accelerated growth in aquatic plant

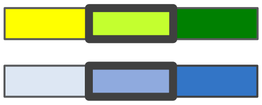
species, which can result in reduced dissolved oxygen, possibly impacting the growth and survival of fish and other aquatic species (*24*, *25*).

- The presence of **roadways** in natural areas has been connected to changes in species composition, ecosystem function, and altered hydrologic processes (*34*, *35*). Roadways can contribute to increased stormwater runoff, dispersal of contaminants (e.g., road salt, brake dust, fuel runoff), and the spread of invasive species (*9*, *33*, *34*). They can also limit hydrological connection within the watershed (i.e., by restricting flow) and act as barriers to dispersal for species seeking refuge from climate impacts.

Adaptive Capacity

Moderate Adaptive Capacity

Moderate Confidence



Adaptive capacity *is the ability of a habitat to accommodate or cope with climate change impacts with minimal disruption. High adaptive capacity (dark green) corresponds to lower overall climate change vulnerability, while low adaptive capacity (yellow) means that the habitat will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the habitat.*

Habitat extent, integrity, continuity, and barriers to dispersal

The creek and tributaries are relatively continuous within the preserve, but the landscape buffering the habitats is a matrix of forest, meadow, agricultural fields, and development. The preserve itself is segmented by roads and trails and is surrounded by land easements, municipal, open/recreation space, roads, and residential and agricultural areas (*9*). These factors not only impact dispersal but may affect the habitat's integrity through the spread of contaminants and pollutants from upstream in the watershed. The continuity of the water resources allows aquatic species (e.g., fish and invertebrates), and the water itself within the creek and tributaries, to move freely within the preserve. However, dispersal of riparian species may be limited by barriers within the surrounding forest, grassland, and agricultural spaces.

Habitat diversity

Within the northern part of the preserve, waterways are located at slightly steeper elevations than the agricultural lands, providing some topographical diversity among riparian, forested, and grassland areas. The wetland complex has a relatively flat topography at the lowest elevation of the preserve. The plant communities located in and around the water resources in ChesLen Preserve include floodplain-wet meadows and marshes dominated by shrub, vine, and herbaceous species, including numerous invasives such as autumn-olive, reed canary-grass, and common reed (*1*). Increasing species diversity (i.e., by diversifying species chosen for planting in afforestation riparian stream habitats) could help to increase the adaptive capacity of the habitats surrounding water resources, helping to preserve water quality.

Resistance and recovery

Like most small streams, the West Branch Brandywine Creek floods regularly and is well-adapted to the impacts of these events. However, some stream bank erosion is already present and climate-driven increases in severe flood events could exacerbate these issues. Invasive species are already present in/near the preserve's water resources, which could further stress or weaken species already under duress from climate impact – influencing their ability to resist and recover. While segments of the creek outside of the preserve are currently under stress from pollutants, protected segments within the preserve could provide refuge for some species if they are not detrimentally influenced by pollutants in the future as a result of increased flooding and precipitation that could transport contaminants downstream (*9*).

Management potential

Overall, the ChesLen Preserve is highly valued by the public because of its recreational opportunities (e.g., fishing and non-motorized boats) as well as its role in protecting water resources and preserving water quality for local drinking water and the Delaware River Watershed (*9*). These positive impacts on the community and regional water system have increased opportunities for financial and legislative support to ensure the protection and preservation of the water resources within the preserve.

Natural Lands is implementing conservation strategies to address climate change impacts, such as creating riparian afforestation areas to reduce streambank erosion, expanding the width of existing riparian buffers to 100 feet, and increasing the distance between riparian buffer areas and nearby the forest edge to 600 feet (*1*). Managers also have the opportunity to diversify the species selected for planting in afforestation riparian stream habitats to increase species diversity and improve the preserve's adaptive capacity.

In the future, it may become more challenging to implement strategies designed to address and alleviate the impacts of climate change on the preserve as conditions necessitate increasing levels of financial and technical support that may go beyond the capacity of preserve managers and Natural Lands' staff. The future management potential will also be impacted by the conditions of the watershed not located within the preserve.

Recommended Citation

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Further information on the Natural Lands Climate Adaptation Project is available on the project page (https://ecoadapt.org/goto/Natural-Lands).

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