SCHOHARIE CREEK WATERSHED CONSERVATION ASSESSMENT

FEBRUARY 2018

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Albany, New York

Prepared for:
NYS Department of Environmental Conservation,
Mohawk River Basin Program
Albany, NY

Recommended Citation:
Shirer, R., C. Zimmerman, J. Hoch. 2018. Schoharie Creek Watershed Conservation Assessment. The Nature Conservancy. Albany, New York.

With gratitude for the contributions of the following organizations:
Catskill Center
Cornell Cooperative Extension
NYS DEC Region 4 Division of Lands and Forests
NYS DEC Division of Water
NYC Department of Environmental Protection
Schoharie County Office of Community Development Services
Schoharie County SWCD
Schoharie River Center

The Nature Conservancy

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WATERSHED OVERVIEW

The Schoharie Watershed is a sub-basin of the Mohawk River Watershed, the largest tributary of the Hudson River. Schoharie Creek originates from Indian Head Mountain in the Catskill Park and travels north 93 miles to drain into the Mohawk River. Schoharie Creek supports numerous recreational, economic, and environmental activities and priorities, ranging from fish habitat to hydroelectric power. The upper portion of the watershed is part of a system that provides drink water to millions of New Yorkers. Downstream of the Gilboa Dam, extensive farmland and forests are important economic resources for communities.

The watershed includes portions of 7 counties: Albany, Delaware, Greene, Montgomery, Otsego, Schenectady, and Schoharie. The upper portion of the watershed is mainly comprised of northern hardwood and conifer forests (85% of land area). The Creek is impounded at the Schoharie Reservoir, where water is diverted to the New York City water supply system, and at the Blenheim-Gilboa Power Project, which is used for hydroelectric generation. Agricultural land uses are more common in the lower watershed, with 9% of land in crops and 27% in pasture (USGS 2014). Cropland in Schoharie and Montgomery counties are mostly planted in corn (58%), alfalfa (17%), and soybeans (7%); 13% of cropland is fallow (USDA 2016).

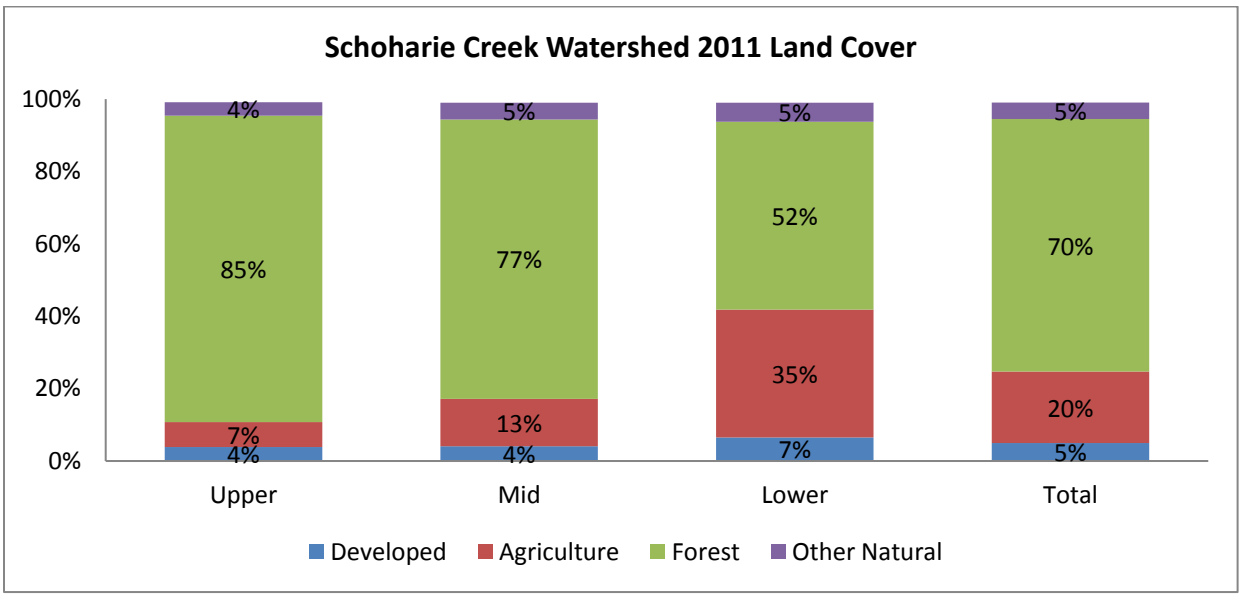

Figure 1. Distribution of land covers within the Schoharie Creek Watershed. NLCD (2011) land cover classes were grouped into general categories and summed by USGS HUC8 sub-watersheds and for the total basin.

There are nearly 150,000 acres of protected lands within the Schoharie Watershed, the majority of which are in the upper half of the watershed within the Catskill Park. NYS DEC owns the largest portion of protected lands (88%), followed by NYC DEP with 9%. Local governments, non-governmental organizations, and other state agencies own most of the remaining protected areas (NYPAD v1.1). NYC DEP also holds conservation easements on approximately 7,500 acres of private land. (NYC DEP, 2017)

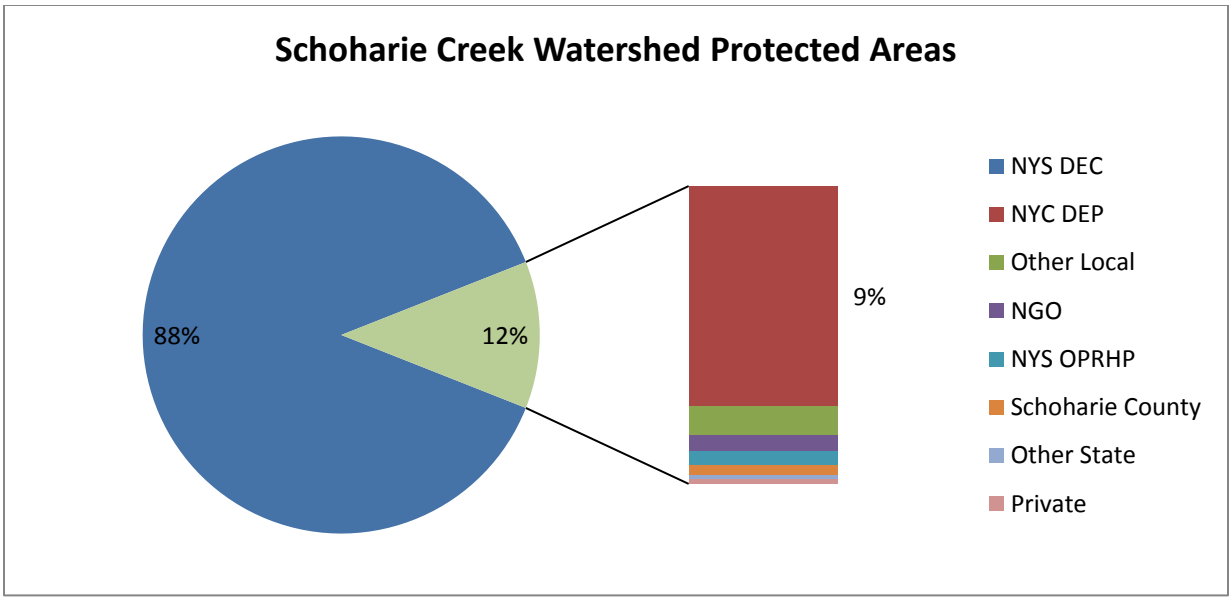

Figure 2. Ownership of protected lands within the Schoharie Creek Watershed. Data are summarized from the NY Protected Areas Database v 1.1 (2014).

The watershed contains a variety of recreational opportunities, largely within the state-owned protected lands. The various state forests in the watershed feature extensive access by road and trail networks. Camping is available at Max V. Shaul State Park and at primitive campsites in the Catskill Park and Eminence State Forest. Public boating and fishing access points are provided on the Schoharie Creek and Reservoir. A significant resource is the Long Path, a regional trail maintained by the NY-NJ Trail Conference, which enters the watershed at the southeast corner from the Catskill Park and winds throughout the watershed, crossing the mainstem twice before exiting to the east toward Thatcher State Park. Many of the priority areas identified in this assessment are linked by the Long Path, creating an opportunity for a connected network of conservation and recreational uses.

Conservation plans for the watershed should consider the changes expected to occur under climate change and incorporate climate adaptation principles. Climate models suggest that the watershed will experience warmer and drier summers, shorter and wetter winters, and an increase in extreme precipitation. Some species are expected to decline in abundance or need to shift northward or upslope to find suitable conditions. At the same time, overall diversity in some areas may increase as southern species move into the watershed; this migration may also expand the range of invasive species and forest pests. Severe storms and flooding, already a historical problem for many of the communities in the watershed, is likely to increase. Conservation and management of the natural resources in the watershed can help both natural and human communities prepare for and adapt to these future changes.

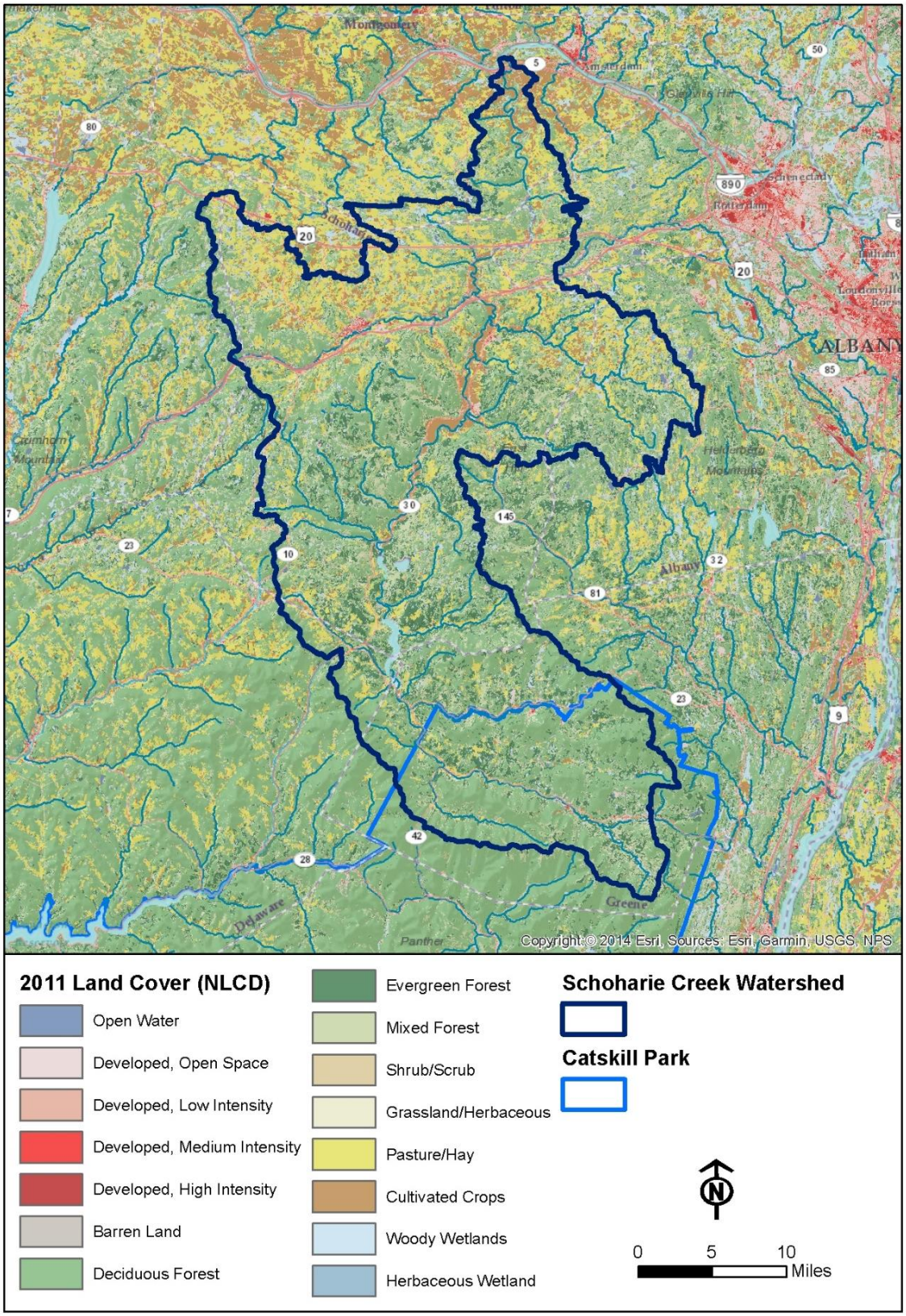

Figure 3. Land cover within the Schoharie Creek Watershed. Data are from 2011 National Land Cover Data.

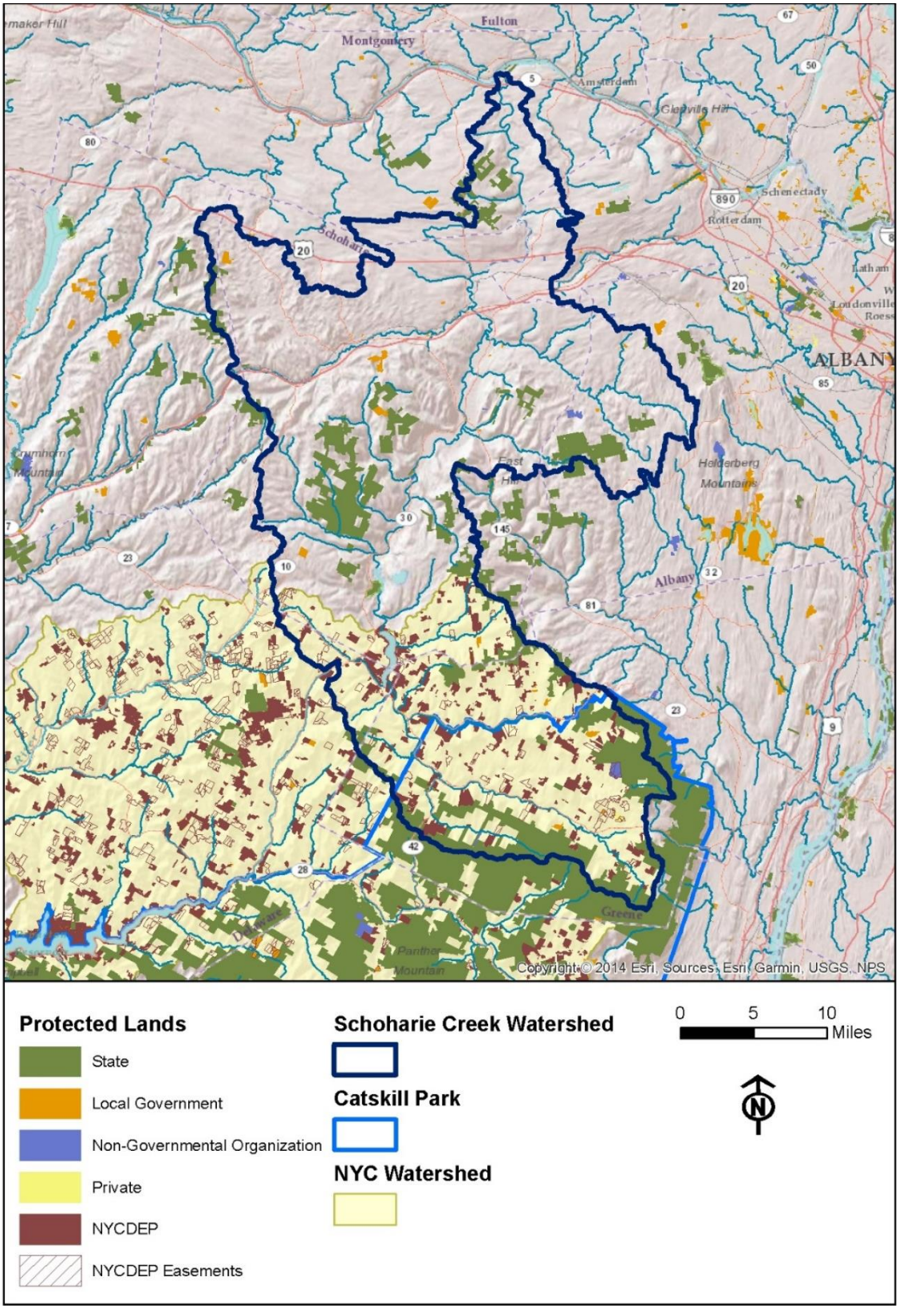

Figure 4. Ownership of protected lands within the Schoharie Creek Watershed. Data are from the NY Protected Areas Database v 1.4 (2017) and NYC DEP (2017).

PROJECT DESCRIPTION

The goal of this assessment was to **provide comprehensive spatial data on priority areas for meeting multiple ecosystem objectives**. This was accomplished by the following steps:

1. Identify priority conservation areas
2. Evaluate intersection of priority areas for multiple benefits
3. Assess needs for protection and restoration

In order to identify locations that maximize return on conservation investments, we mapped a suite of conservation priorities to identify areas recommended for protection to maintain existing services, as well as areas that could be enhanced through habitat restoration.

The geographic scope of this analysis was split into two sections: the Upper Watershed, which includes the headwaters in the Catskill Mountains down to the Gilboa Dam, and the Lower Watershed, from the Gilboa Dam to the confluence of the Schoharie and the Mohawk Rivers. This split was made both because the ecological settings and conservation needs in the two sub-basins were distinctly different.

For much of the spatial analysis we relied on the data contained in the Natural Resource Navigator (NRN), www.naturalresourcenavigator.org, a decision support tool developed by The Nature Conservancy in New York to provide access to an extensive database of ecological data and to help users develop conservation strategies in light of climate change. In addition to providing an extensive collection of spatial data and a climate adaptation planning framework, the Navigator makes the data and analyses publicly accessible.

Data layers from the NRN and other public sources were used to identify priority areas for the following conservation objectives:

1. Protect and maintain high quality forest and freshwater habitats
2. Conserve habitat for rare species
3. Secure potential climate refugia and resilient lands and waters
4. Maintain habitat connectivity and potential climate migration corridors
5. Protect and restore floodplains and riparian buffers

Overlapping priority areas were aggregated around broad landmarks such as a named mountain, valley, or stream reaches for the purpose of simplifying the report and map products. In some cases concurrent terrestrial and aquatic priorities were separated for the purposes of mapping and discussion.

Detailed methods for data sourced from the Natural Resource Navigator can be found in the NRN Data Documentation (France et al., 2017) at http://www.naturalresourcenavigator.org/wp-content/uploads/2017/03/NRN-Data-Documentation.pdf. The sources for the spatial data used in the assessment can be found in Appendix 1.

Habitat Condition

The Navigator summarizes a variety of indicators into an aggregate index which represents the general degree of human modification of the ecosystem. Natural systems with high condition are expected to be more diverse and productive, with greater ability to sustain function over time without intervention. For forests, these indicators include patch size, current abundance of invasive plants, large snag density, modeled regeneration, and canopy diversity. For streams, the index includes floodplain land cover, flow alteration from impoundments, impervious cover, road-stream crossings and water quality. Areas in generally high condition that have low future threats and low climate risk will likely be more resilient to climate change. These may require active monitoring and management to detect and reduce the impact of new threats. Areas in lower condition may benefit from restoration to improve specific aspects of condition to realize the full potential of the ecosystem. The individual condition indicators can be viewed in the NRN webmap to identify which conditions are impaired.

Climate Risk

Climate risk is mapped as a combination of climate sensitivity (how much the system is likely to be affected by climate change) and exposure (how much the climate is likely to change). The forest climate sensitivity score is a composite of elevation range, landform variety, forest connectedness, habitat vulnerability and canopy species richness; high values indicate the habitat has low diversity or other limitations on its ability to adapt to changing conditions, making it vulnerable to climate change impacts. The stream climate sensitivity score is based on the relative values of connected network length, size variety, slope variety, and temperature variety. Climate exposure refers to the degree to which the climate is expected to change across multiple climate factors relative to the rest of the state. The forest climate exposure score is the composite of the summer maximum temperature change, change in days below freezing, change in growing degree days, aridity change, total annual precipitation change, total summer precipitation change, and expected decline in canopy species. The stream climate exposure score is the aggregate of change in stream temperature class, change in summer maximum temperature, change in days below freezing, change in growing degree days, aridity change, change in total annual precipitation, change in total summer precipitation, and change in extreme precipitation. High scores for climate risk highlight places that are expected to be more exposed to climate changes than average. Climate data was projected to 2050 based on an ensemble model and the A2 emissions scenario by the North American Regional Climate Change Assessment Program (NARCCAP), and summarized by HUC8 basins. Areas with low scores for both sensitivity and exposure may experience less change in the future than other places and could potentially serve as climate refugia. Refugia are areas that provide more consistent habitat conditions and may help climate-sensitive species persist. Areas with high risk may need to managed with an intent to either reduce their risk or anticipate future conditions.

Geophysical Settings

Geophysical settings are unique places on the landscape with a particular combination of elevation and bedrock geology. A diversity of geophysical settings can help support biological diversity, even as climate conditions change, by providing a wider variety of habitat niches. In considering priorities for climate adaptation, it is important to ensure that the full range of geophysical settings are represented in conservation efforts. (Anderson and Ferree, 2010)

For this assessment we prioritized geophysical settings based on both rarity and representation. Rare settings are those that naturally have low abundance in the landscape, and so are more vulnerable to being lost. For our purposes we defined rare as being those in natural habitats with the lowest 10% for proportion of area in the state and within the ecoregion. Under-represented settings are those that have been disproportionately converted in the past and so do not have good representation in intact natural habitats. This is measured for each setting as the percent of total area in the state that is remaining under natural land cover. The assessment maps display the lowest quartile of representation.

Connectivity

Preserving large, intact areas of forest or stream network is important for migratory species and species that rely on sizable habitat patches. The Matrix Forest Blocks layer defines large contiguous forest areas large enough for the maintenance of ecological processes, which given protection and potential restoration, would serve as critical source areas for all species requiring interior forest conditions. (Anderson, 2008)

Ecological connectivity, which is the ability of organisms to move through landscapes, is equally important for protecting species and maintaining ecological processes. Different species have different habitat and life history requirements, but in general greater connectivity is considered beneficial to support gene flow and allow animals to access sufficient resources. Additionally, connectivity upslope or northward may be needed to allow climate change-induced species range shifts. Linkage Zones, which are modeled least-cost paths between matrix forest blocks, represent areas with the greatest potential to support long-range connections between intact forests. These linkages may contain barriers or land cover that impeded movement, which if restored could greatly enhance connectivity. (Howard and Schlesinger, 2012)

Local connectedness and long-range movement for climate adaptation were also included in the Resilient and Connected Network analysis. Local connectedness, which measures the ability to shift to preferred microclimates, is incorporated into the resilience metric. Long range movement was modeled using Circuitscape, a tool that employs circuit theory to predict movement patterns, and was weighted toward climate-driven upslope and northward movement. The resulting high flow areas were used to identify the Flow Zones (diffuse flow) and Climate Corridors (constrained flow) in the displayed map. (Anderson et al., 2016)

Connectivity is also important for freshwater ecosystems, as dams and other barriers can prevent aquatic species from finding suitable habitat. The Stream Condition Index includes data on stream Connected Network Length, which measures the length of functionally connected stream networks unfragmented by dams. It also incorporates measures of floodplain connectivity, identifying areas of natural cover within the floodplain that are contiguous with the stream and thus support both physical and biological connections between the terrestrial and aquatic systems.

Rare Species Habitat

In order to provide a systematic assessment of biodiversity priorities in the watershed, we chose to use a modeled rare species product developed by the NY Natural Heritage Program. The probability of suitable habitat for each of 379 rare species was modeled and converted to a

presence or absence of suitable habitat; these were then summed across all species to yield the number of species for which suitable habitat was predicted to be present in each cell. Location data input to the model come primarily from NY Natural Heritage element occurrence databases. The full methodology is documented in Howard and Schlesinger (2012). The predicted rare species habitat map was categorized into quartiles and the top two quartiles were used for display. A future habitat analysis is also available, which models predicted rare species habitat locations under climate change, however this was not used in the final watershed assessment due to the high uncertainty of future conditions. Suitable habitat maps for individual species can be viewed within the NRN webmap.

Floodplains

Floodplains in the assessment were mapped using the Active River Area model (Smith et al, 2008). This product maps areas with a potential to flood based on the distance and elevation from the waterbody, regardless of land cover. Riparian wetlands are added to define the 'base zone'. The ARA base zone generally corresponds with the FEMA 100-year floodplain but may exceed it in some cases. No estimates are made of the potential depth or frequency of flooding within the ARA.

The NY Natural Heritage Program has delineated Floodplain Complexes within the ARA which are made up of 'cores' of natural cover greater than 150 acres and the adjacent corridors of undeveloped (natural and agriculture) lands (White et al, 2011). These complexes represent significant examples of functional floodplain habitat.

PRIORITY AREAS

The results of our analysis are reported by broad priority areas of the landscape. Areas may be prioritized based on a single attribute but more likely are elevated in importance by the intersection of multiple attributes which may have conservation value for different reasons. The following sections provide a reference map and summary of conservation features for each priority area, moving generally from the top of the watershed downstream. Results from the upper and lower portion of the watershed are presented separately.

The assessment also provides a set of interactive maps in PDF format that may be used to dynamically view individual map layers that are most pertinent for that area. The interactive maps and instructions on how to use them are provided in Appendix 2.

Upper Schoharie Watershed

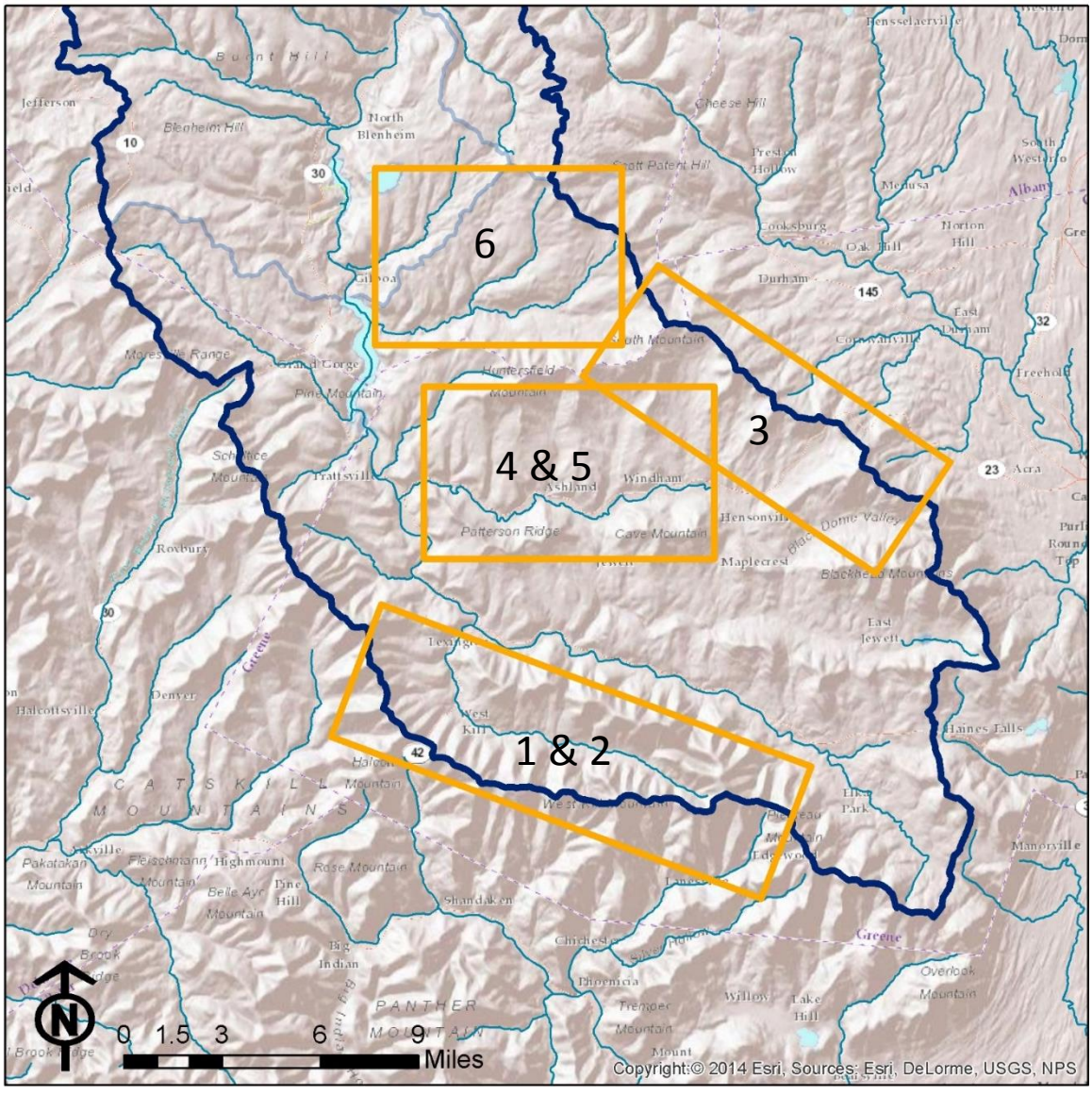

Figure 5. Spatial reference for priority areas, Upper Schoharie watershed

1. West Kill Mountain to Plateau Mountain

This priority area is a high elevation ridge line running east-west from Balsam Mountain to Hunter/Plateau Mountain, on the southern border of the Schoharie Watershed. This area is largely protected by Hunter-West Kill Mountain Wilderness and Indian Head Wilderness within the Catskill Forest Preserve. This area is significant due to its rare geophysical setting and extensive unfragmented forest blocks. Geophysical settings are a combination of elevation and geologic class that represent less than 1% of the area of each terrestrial habitat type within NYS. This high elevation ridge line supports the most extensive patches of Boreal Forest in the Catskill Mountains containing red spruce and balsam fir. The lower elevations are dominated by a mix of Northern Hardwoods, hemlock and white pine. The area is embedded in a forest block that is > 10,000 acres is size. It also contains suitable habitat for several rare bird and reptile species.

The forest condition within this area ranges from moderate to good with high prevalence of invasive plant species. The future threat from forest pests and pathogens and invasive plant species is predicted to be moderate to high. The combination of hemlock woolly adelgid, emerald ash borer, and beech bark disease is predicted to impact >25% of the basal area in some parts of the ridge. Numerous invasive plant species are documented to be present in the surrounding area.

The higher elevation boreal forests in this area are predicted to have high vulnerability to climate change over the next 50 years, with a high proportion of the current forest composition at risk of decline and shifts in forest composition likely. (See table X for a list of the species expected to be vulnerable in this ecoregion) The overall moderate to good condition of the forest, lack of fragmentation and higher canopy tree diversity in this area should mitigate these changes.

The contiguous forest that makes up most of this landscape is expected to be important to allow species to find suitable habitat as they shift ranges in response to a changing climate. Species currently living in this area that need to move northward will have good habitat connectivity along the ridge lines and potential access to a ‘corridor’ of relatively contiguous natural habitat that continues north to the Mohawk River. Any roads fragmenting this forest block could be potentially creating barriers to movement for some species; stream crossings on these roads that need to be upgraded for flood prevention should be designed to also support species habitat and connectivity.

Table 1. Significant features, forest condition, threats and climate risks in the West Kill Mountain to Plateau Mountain priority forest area.

Significant features	Protected lands	Hunter-West Kill Mountain Wilderness Indian Head Wilderness Catskill Forest Preserve
	Habitat fragmentation	Matrix forest block
	Regional connectivity	High flow
	Geophysical diversity	Very high elevation acidic sedimentary
	Potential rare species habitats	Boreal forest community Four-toed Salamander (Hemidactylium scutatum) Marbled Salamander (Ambystoma opacum) Bicknell's Thrush (Catharus bicknelli) Worm-eating Warbler (Helmitheros vermivorum) Eastern/Woodland Box Turtle (Terrapene carolina carolina) Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	Med-high (60-80)	Invasive Plants: High frequency or cover
Threats	Low (10-40)	Invasive Plants: High
		Pests and pathogens: hemlock woolly adelgid, emerald ash borer, beech bark disease
Climate risk	Sensitivity	Med (30-50)
	Exposure	Med (30-50)

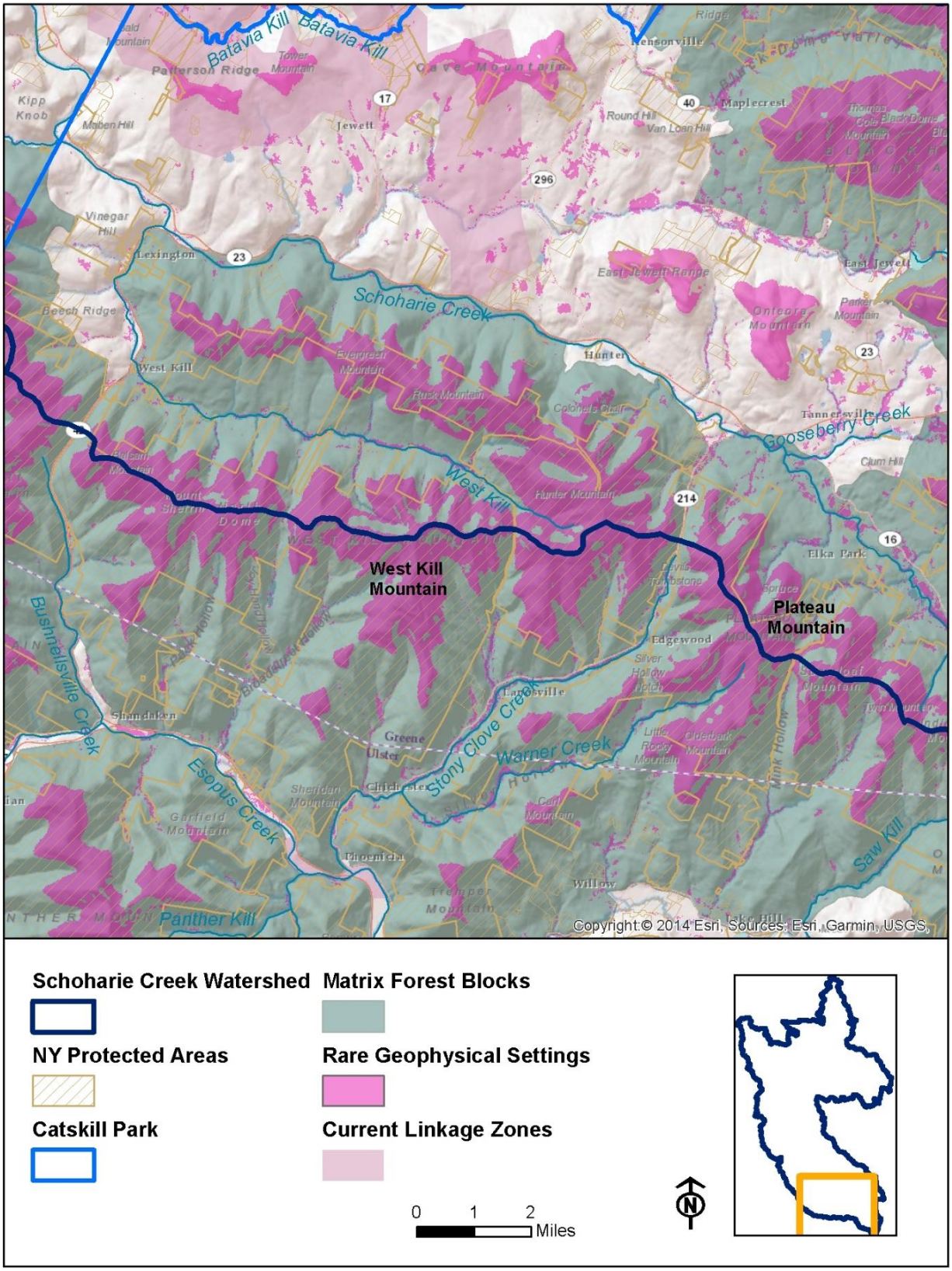

Figure 6. Rare geophysical settings from West Kill Mountain to Plateau Mountain in the Schoharie Creek Watershed.

2. West Kill

A sub-basin of the Upper Schoharie Watershed, West Kill is located in the southwest portion of the study area. West Kill is a priority due to its intact riparian zone and cold groundwater source. West Kill is known for an abundant and healthy population of wild trout, which is a designated Species of Greatest Conservation Need (SGCN) species. The stream is frequented by many residents and local anglers. West Kill is recognized as a priority place due to its high condition, projected resilience to climate change, and potential as climate refugia given predicted species habitat maps as well as low exposure score values. A significant portion of land in the West Kill sub-basin is protected, either by the NYS DEC, which manages the 19,250-acre Hunter-West Kill Mountain Wilderness or NYC DEP. However, most of the protect lands occurs in the high elevations and not within the stream riparian zone.

The West Kill watershed is heavily forested with forested riparian areas, marsh and northern swamp. The condition of the stream is good (80-90 out of 100) and due to its low-moderate climate exposure (40-50 out of 100) along with its high projected species richness, it could potentially serve as climate refugia for cold-water aquatic species.

West Kill would benefit from continued management due to its current health, cultural significance, and potential for sustained biodiversity. The Stream Management Plan for West Kill includes recommendations such as comprehensive water quality improvement, outreach, and programmatic approaches that are key to continual implementation. Land management efforts will require coordination among government private landowners and across varying levels of governance.

Table 2. Significant features, stream condition, threats and climate risks in the West Kill priority aquatic area.

Significant features	Protected lands	Hunter-West Kill Mountain Wilderness
	Riparian zone	High % vegetated
	Aquatic connectivity	No barriers
	Geophysical diversity	Cold-water stream
	Potential rare species habitats	Northern Cricket Frog (Acris crepitans) Wood Turtle (Glyptemys insculpta)
Condition	High (80-90)	Water quality: Minor Impairments
Threats	Very Low (0-10)	Acid deposition: Marginally sensitive
Climate risk	Low-med (40-50)	

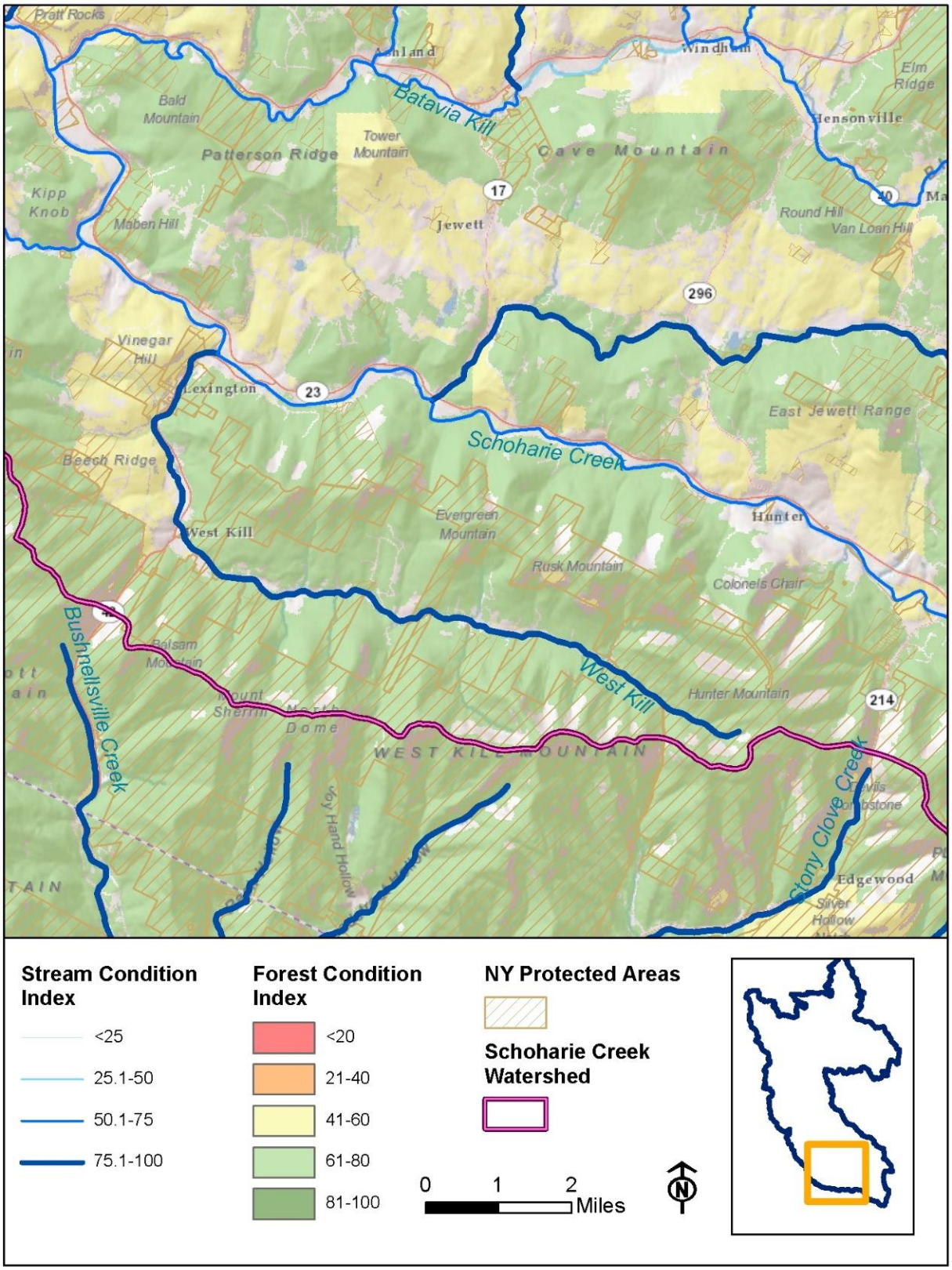

Figure 7. Stream and forest condition of the West Kill in the Schoharie Watershed.

3. Black Dome to South Mountain

This ridge of smaller mountains on the eastern border of the Upper Schoharie Watershed and north border of the Catskill Park that runs north - south is important for its series of protected lands connecting the large forest blocks of the Catskill High Peaks to forests to the north. South Mountain State Forest is the main protected area just north of the Catskill Park. Mount Hayden is situated slightly southeast of South Mountain while Ginseng Mountain is further south and Mount Zoar continues the line to the Windham High Peaks area. The Long Path follows the ridge between the Blackhead and South Mountains.

The forest condition of the area is moderate (50-60 out of a maximum 100), with some potential issues with invasive plant species and forest regeneration. The presence of invasive plant species along road sides and in riparian areas is predicted to be moderate to high. The abundance of forest regeneration is predicted to be fair. Top future threats include forest pests and pathogens and localized forest fragmentation due to development.

Given its future importance in terms of climate adaptation and its current recreational usages, additional conservation in this area is needed. Forests around Mount Zoar should be protected to prevent fragmentation and parcelization in the East Windham area. Additionally, an assessment of potential barriers to wildlife movement across State Route 23 and County Roads 10 and 20 would be beneficial.

Table 3. Significant features, forest condition, threats and climate risks in the Black Dome to South Mountain priority forest area.

Significant features	Protected lands	South Mountain State Forest Long Path
	Habitat fragmentation	Mod-high
	Regional connectivity	Forest block linkage Climate flow zone
	Geophysical diversity	High elevation, Moderately calcareous
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Eastern Small-footed Myotis (Myotis leibii) Eastern Ratsnake (Elaphe obsoleta) Northern Black Racer (Coluber constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	Med (50-60)	Invasive species
		Forest regeneration
Threats	Low-med (10-50)	Pests and pathogens: EAB, maple decline
		Conversion
Climate risk	Sensitivity	Low
	Exposure	Medium (50-60)

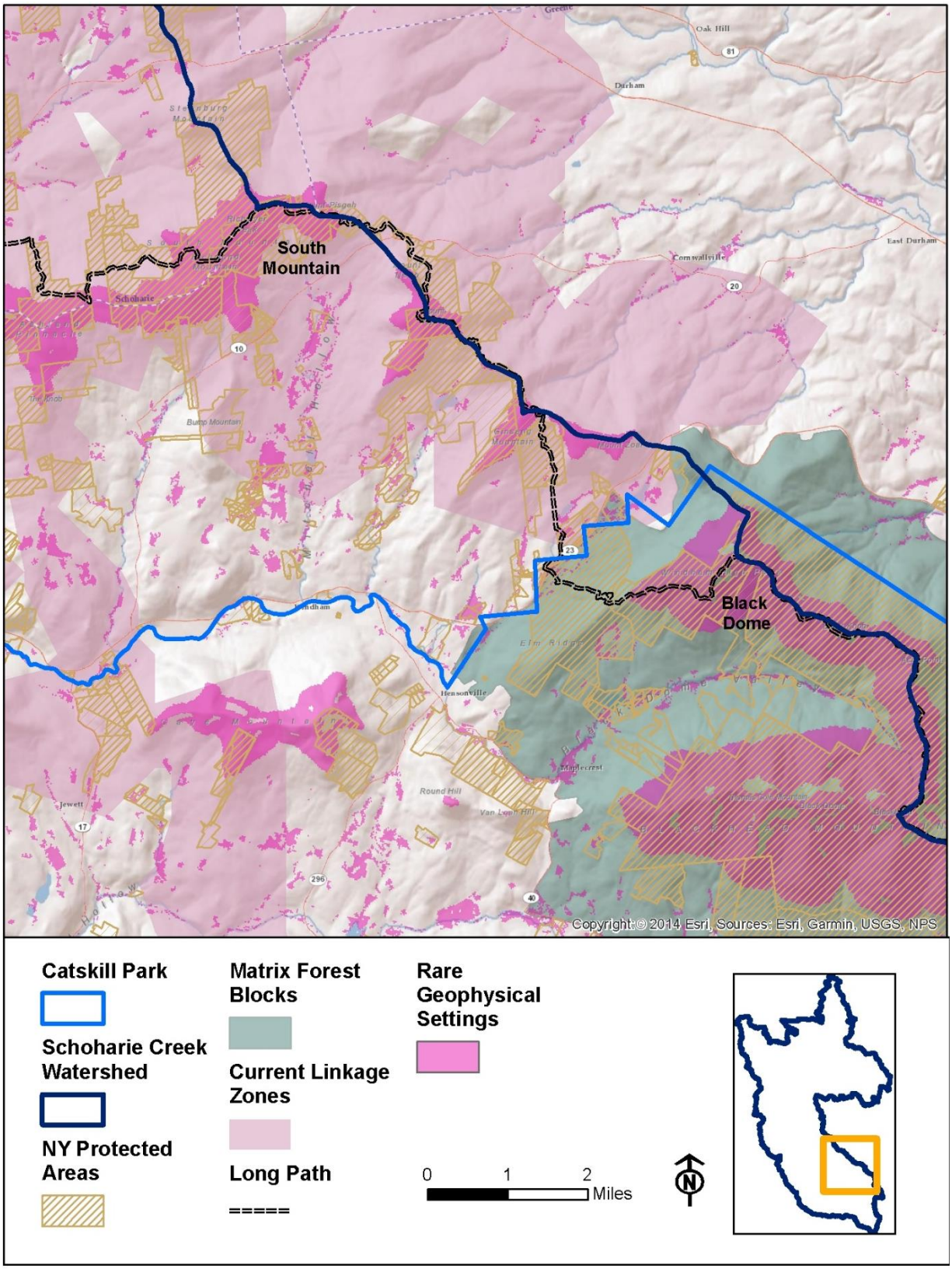

Figure 8. Rare geophysical settings and linkage zone from Black Dome to South Mountain in the Schoharie Creek Watershed.

4. Paterson Ridge to Huntersfield Mountain

Paterson Ridge is situated just north of the Town of Jewett and is connected through a series of conserved parcels (primarily NYC DEP) with Huntersfield and South Mountain State Forests. NYS DEC manages South Mountain, Ashland Pinnacle and Mount Pisgah State Forest where recreational activities include hiking, cross-country skiing, and hunting. This priority area is part of a predicted linkage zone of contiguous forest connecting the Catskill Park to the forest of the Adirondack Park. This area is also predicted to have high future species richness.

The forests in this area have a moderate condition with forest patch size ranging from 100 to 1,000 acres in the more fragmented valley bottoms to large patches of 1,000 to 10,000 on the mountain tops. Invasive plants are predicted to have a high abundance along roads and potential in interior forest areas. Forest pests (HWA and EAB) likely pose a moderate threat to the health of these forest in the future.

Climate sensitivity is moderate to low, with the area having relatively well-connected forest, indicating a potential for high resilience under climate change. Conservation efforts should be made to prevent fragmentation and mitigate any barriers to wildlife movement within and between natural areas.

Table 4. Significant features, forest condition, threats and climate risks in the Paterson Ridge to Huntersfield Mountain priority forest area.

Significant features	Protected lands	Huntersfield State Forest South Mountain State Forest NYC DEP water supply lands
	Habitat fragmentation	Patches >1,000 acres on ridges, <1,000 acres in valley
	Regional connectivity	Forest linkage Climate flow zone
	Geophysical diversity	High elevation: Moderately calcareous High elevation: Acidic sedimentary
	Potential rare species habitats	Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	Med-high (60-70)	Invasive plant species
Threats	Low-med (10-40)	Pests and pathogens: HWA and EAB
		Invasive plant species
Climate risk	Sensitivity	Med (40-50)
	Exposure	Med (50-60)

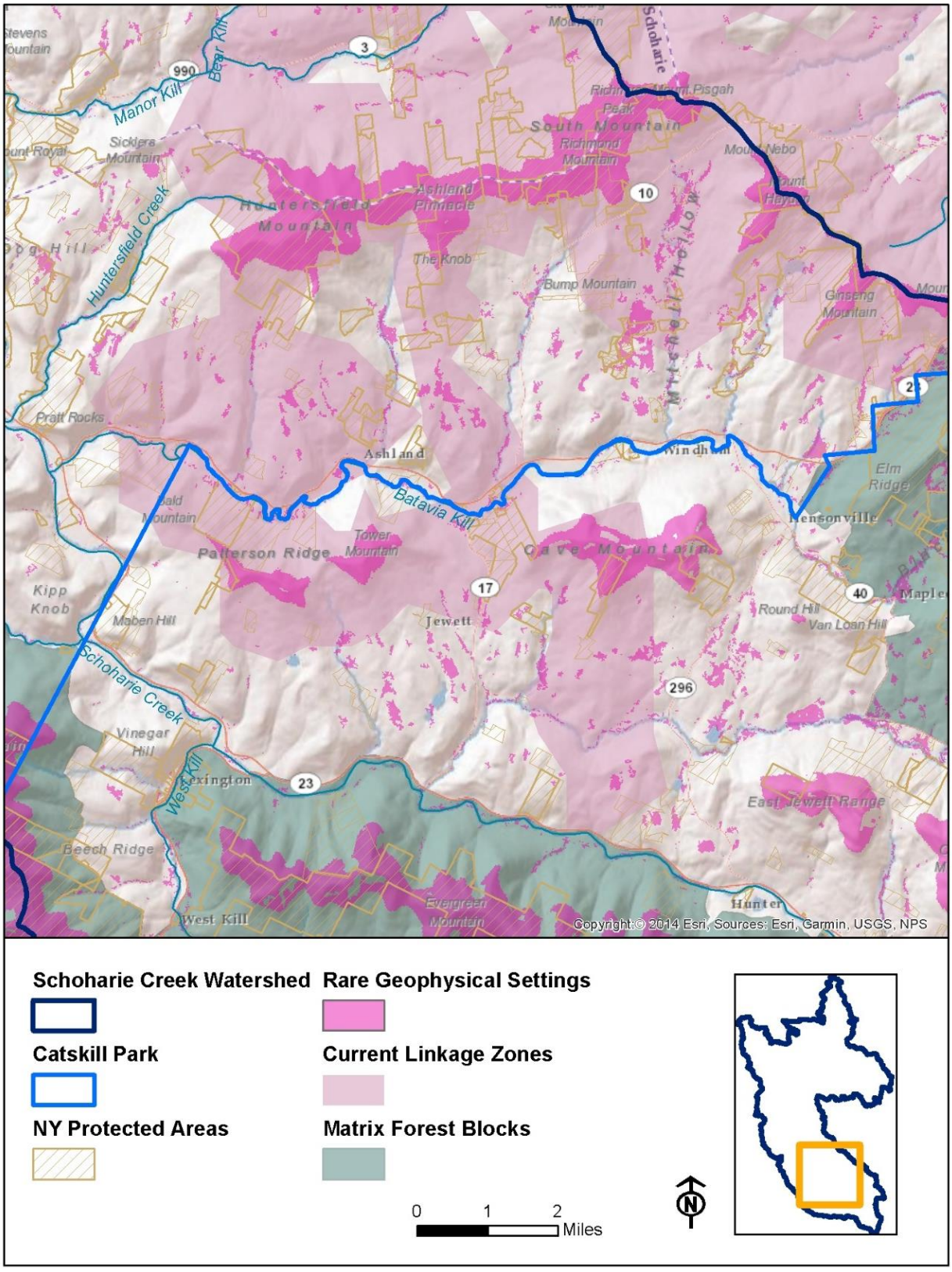

Figure 9. Linkage Zone from Paterson Ridge to Huntersfield Mountain in the Schoharie Creek Watershed.

5. Batavia Kill

Batavia Kill was identified as a priority place due to the presence of a large floodplain complex from just east of Ashland to Prattsville and for the forest linkage zone that crosses the stream in the same area. Floodplain restoration opportunities also exist between Ashland and Windham.

Batavia Kill has been a region of focus in the Schoharie Watershed for decades. The area is prone to flooding, which notably occurred in the 1950s and 1960s and more recently in 2011. In 1997, Batavia Kill was the subject of a pilot stream management project between the GCSWCD and NYC DEP to address stream instability, evaluate erosion rates and flooding, and explore the use of "Natural Channel Design" in stream management. GCSWCD and NYC DEP have since created an SMP for Batavia Kill, representing a coordinated effort among stakeholders involved in conservation efforts in the watershed.

Between Ashland and Windham, Batavia Kill has poor floodplain connectivity and floodplain functionality, due to agriculture and development in the floodplain particularly around Windham. The floodplain connectivity improves from Ashland to Prattsville, with ~50% of the riparian area in natural vegetation. The percent of riparian area protected also ranges, with a greater amount of protected land downstream of Ashland.

Protection and restoration of the floodplain and riparian areas between Windham and Prattsville is likely to improve water quality and improve forest connectivity in the linkage zone between Paterson Ridge and Huntersfield Mountain.

Table 5. Significant features, stream condition, threats and climate risks in the Batavia Kill priority aquatic area.

Significant features	Protected lands	NYC DEP water supply lands
	Floodplain complex	50-60% of ARA
	Aquatic connectivity	No barriers
	Geophysical diversity	Cold-water stream
	Potential rare species habitats	Eastern Pearlshell (Margaritifera margaritifera) Marbled Salamander (Ambystoma opacum) Wood Turtle (Glyptemys insculpta)
Condition	Med-High	Mostly 40-70, 90 in headwaters
Threats	Flood pollution risk	Bulk storage in floodplain downstream of Ashland
Climate risk	Sensitivity	High
	Exposure	Moderate

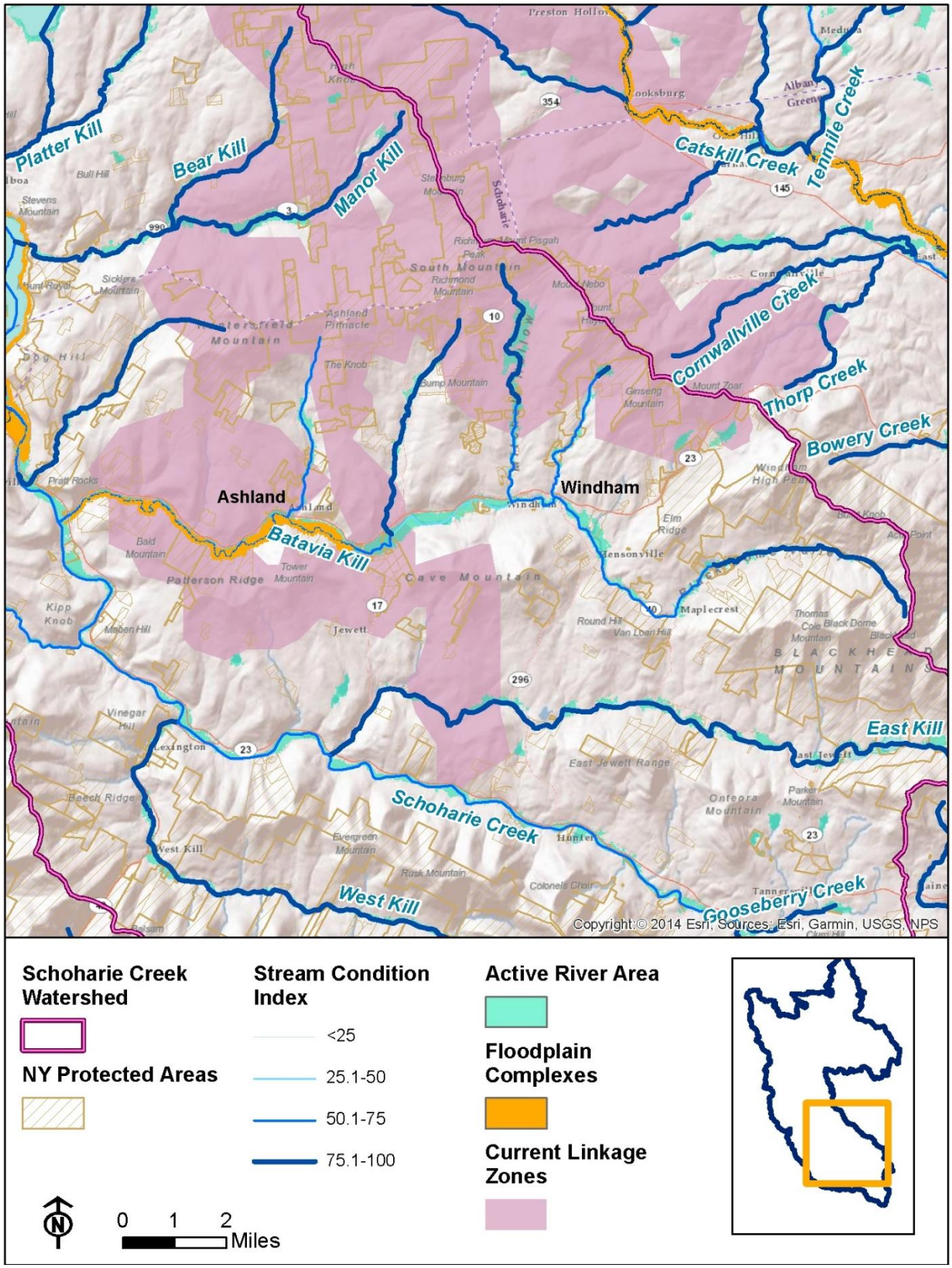

Figure 10. Stream condition, floodplain complexes and linkage zone in the Batavia Kill in the Schoharie Watershed.

6. Manor Kill

Manor Kill is located in the northeast portion of the Upper watershed, draining directly into the Schoharie Reservoir. Manor Kill is recognized as a priority place due to its high condition score (80-90 out of a maximum 100), potential resilience to climate change and a large portion of the watershed falling in the climate migration corridor (linkage zone). Also, stream surveys indicate a potentially sustainable population of Brook Trout in its headwaters and adequately sized Brown Trout for recreational fishing. Underrepresented geophysical settings are also found along the steam.

Manor Kill is in good condition, with few road-stream crossings, no flow alterations and the watershed has low impervious cover, however floodplain connectivity is poor to fair, with <50% of the ARA in natural vegetation. A majority of the ARA is in an agricultural land cover and private ownership.

The Manor Kill SMP recommends both reach-specific strategies as well as broader recommendations for which implementation is encouraged for the entire Upper Schoharie Watershed. In 2015, a stream restoration and public access project resulted in 70 feet of bank restored and created additional trout habitat. Continued protection and restoration of the floodplain and riparian area is likely to improve water quality and substantial improve forest connectivity in the linkage zone.

Table 6. Significant features, stream condition, threats and climate risks in the Manor Kill priority aquatic area.

Significant features	Protected lands	NYC DEP water supply lands
	Water quality	No impairments
	Geophysical diversity	Low elevation Loam
	Potential rare species habitats	Brook Trout and Brown Trout Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Cerulean Warbler (Dendroica cerulea) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
	Forest linkage	Headwaters
Condition	Freshwater	High (80-90)
	Forest	Med-high (50-70)
Threats	Low	
Climate risk	Sensitivity	Med
	Exposure	Med

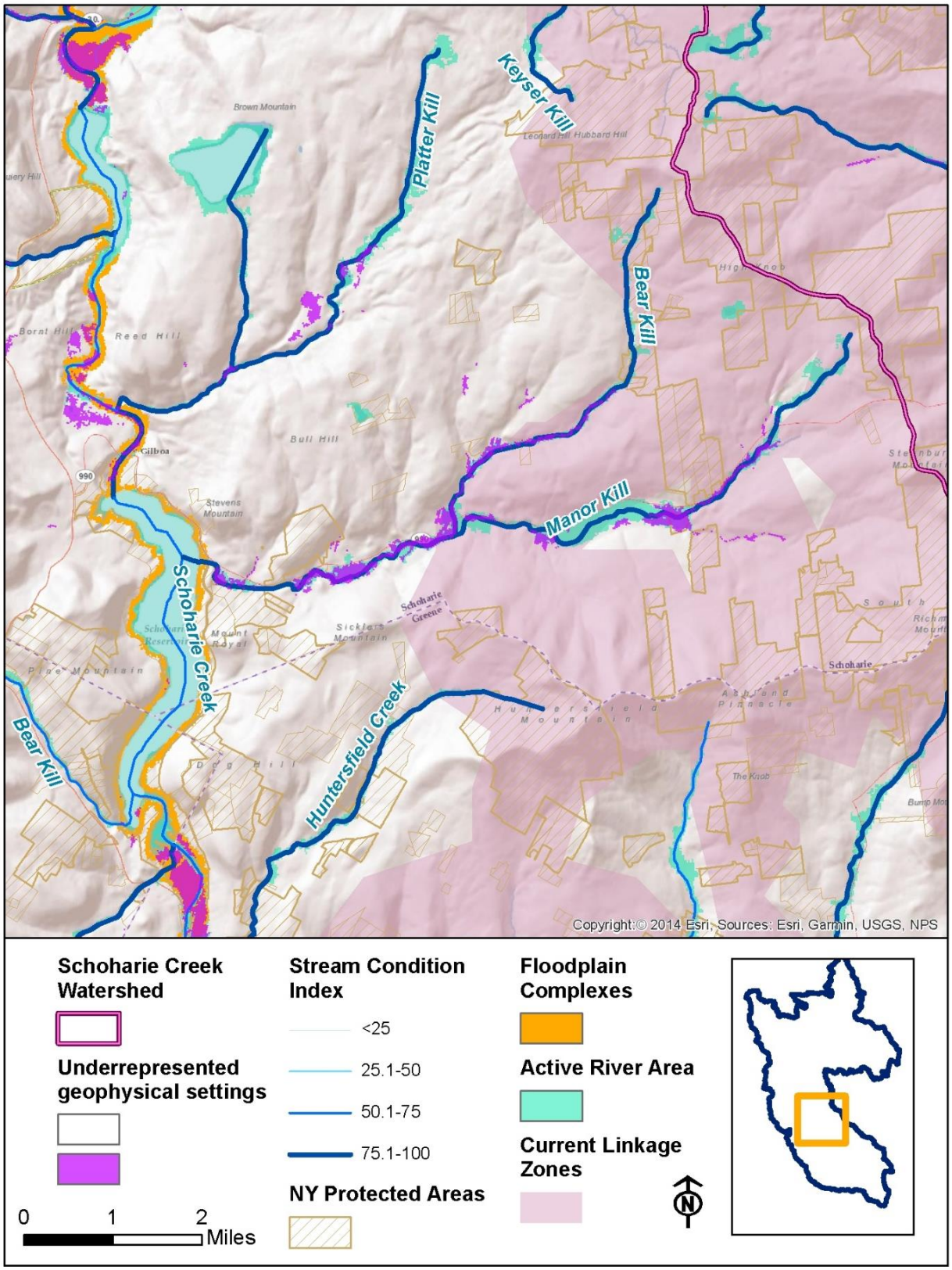

Figure 11. Stream condition, underrepresented geophysical settings and linkage zone in the Manor Kill in the Schoharie Watershed.

Lower Schoharie Watershed

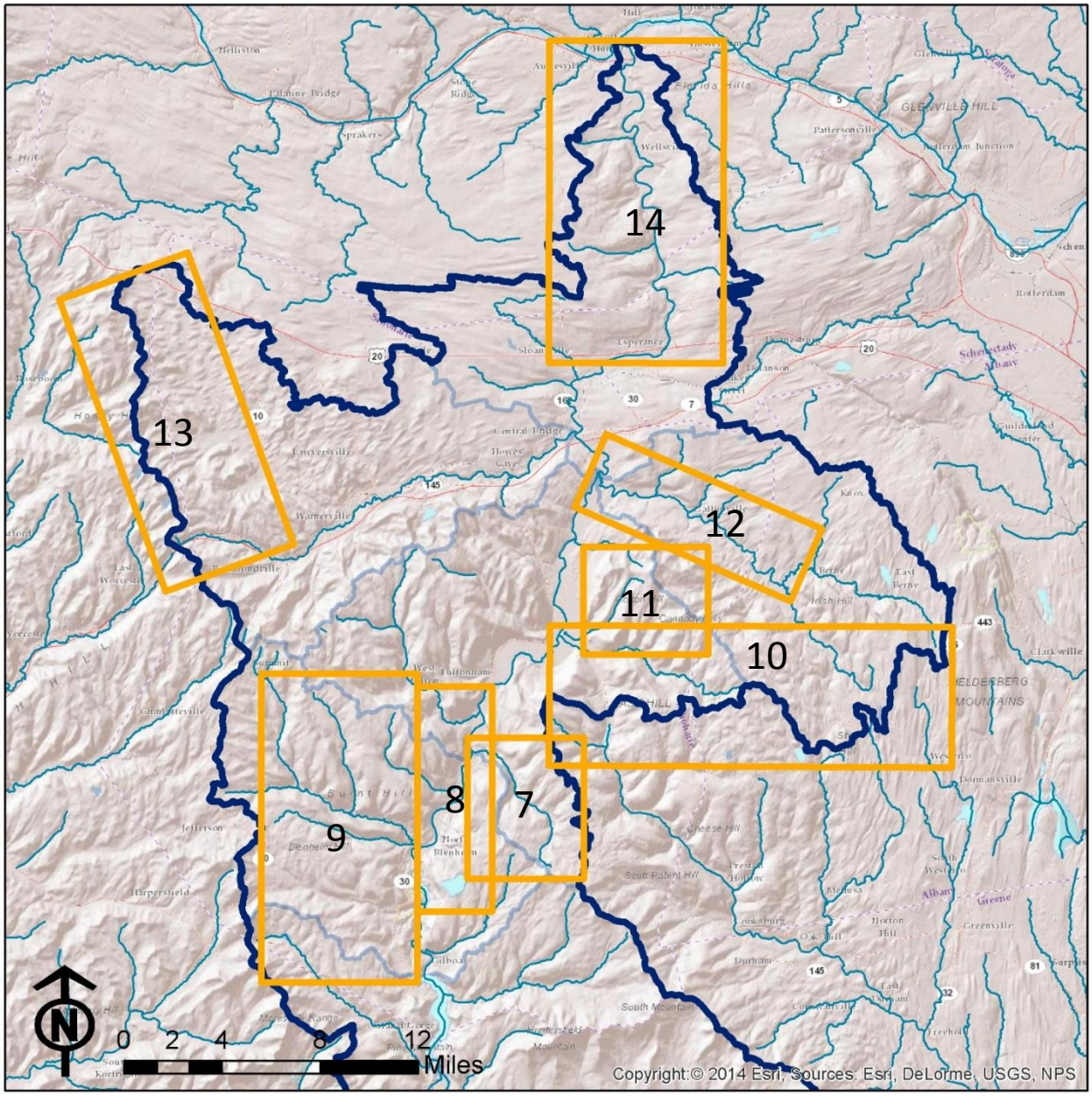

Figure 12. Spatial reference for priority areas, Lower Schoharie Creek watershed

7. Keyser Kill

The Keyser Kill is a small stream on the east side of the watershed which flows into the Schoharie Creek downstream of North Blenheim. This stream and its watershed are priorities due to the very high aquatic condition, potential rare species habitat, and climate resilience.

Much of the watershed is already protected by NYS DEC as part of the Keyserkill and Gates Hill State Forests. The forest lands in the watershed have high climate resilience due to their high connectedness, diversity and physical variety. The headwater areas are part of the forest linkage that runs along the eastern boundary of the watershed. Forest conditions are moderate to good in the watershed and aquatic conditions are very good, scoring above 90 out of a possible 100.

A large number of rare species have potentially suitable habitat modeled within the watershed, mostly within an area of steep hills and narrow valleys near the outlet. These areas of high potential diversity are adjacent to buy not within the current State Forest lands. Expanding these protected areas may be beneficial.

Table 7. Significant features, stream condition, threats and climate risks in the Keyser Kill priority aquatic area.

Significant features	Protected lands	Keyserkill and Gates Hill State Forests
	Water quality	No impairments
	Riparian zone	Mostly 80-90% vegetated
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Longtail/Long-tailed Salamander (Eurycea longicauda) Cerulean Warbler (Dendroica cerulea) Arrowhead Spiketail (Cordulegaster obliqua) Gray Petaltail (Tachopteryx thoreyi) Eastern Ratsnake (Elaphe obsoleta) Five-lined Skink (Eumeces fasciatus) Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta
	Wildlife movement	Headwaters in forest linkage High connectivity
Condition	Freshwater	High (90-100)
	Forest	Med-high (50-70)
Threats	Low	
Climate risk	Sensitivity	Med-low
	Exposure	Med

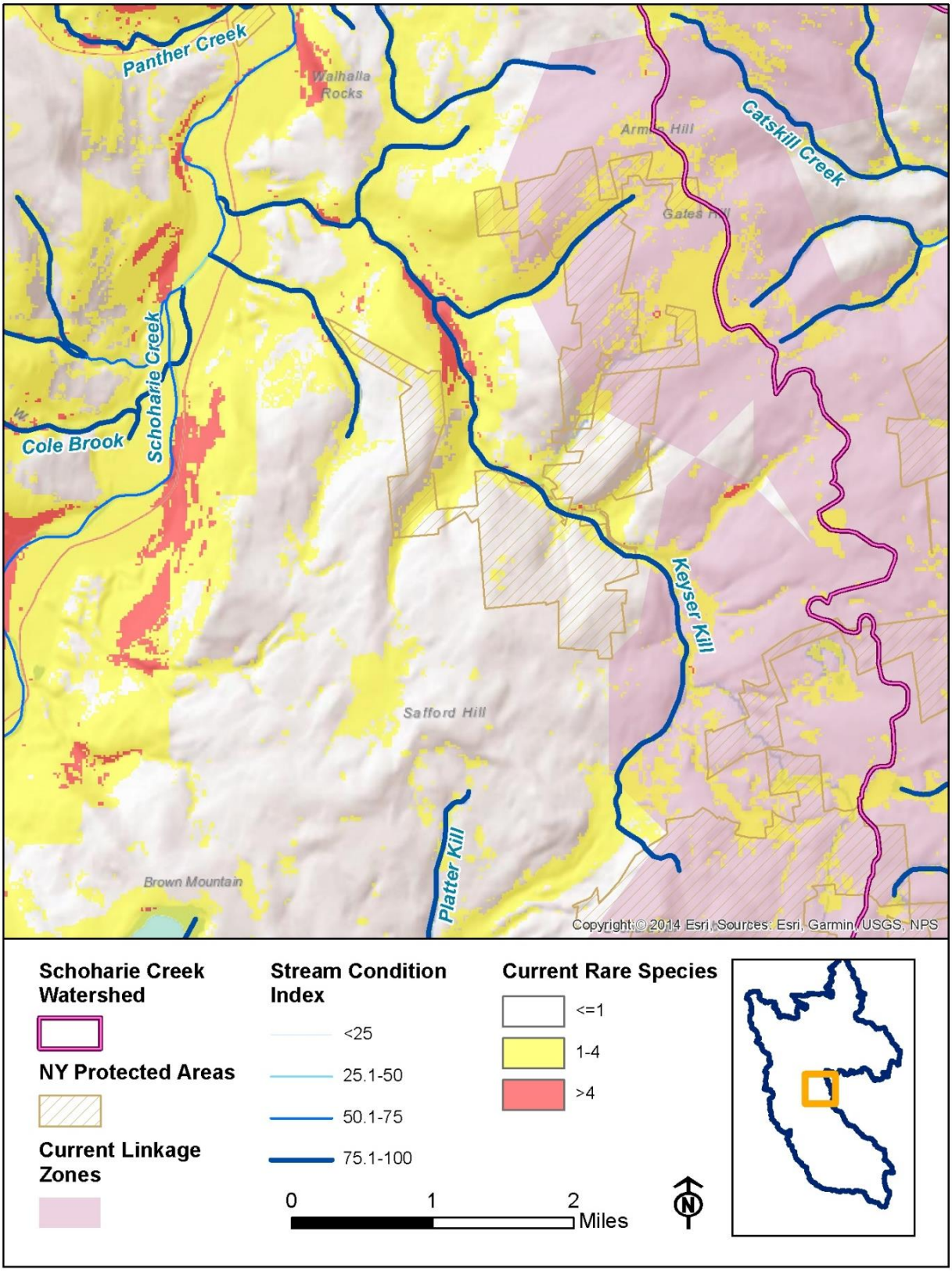

Figure 13. Stream condition, predicted number of rare species and linkage zone in the Keyser Kill in the Schoharie Watershed.

8. Schoharie Mainstem – Blenheim to Fultonham

The stretch of the mainstem of the Schoharie Creek between Blenheim and Fultonham is identified as a priority for its two floodplain complexes and the opportunity for additional floodplain restoration to connect them. This area is also potential suitable habitat for rare species, climate resilient, and in relatively high condition compared to other parts of the mainstem.

The Active River Area is a about ¾ of a km wide for stretch of over 13 km in this area, with two delineated floodplain complexes – a smaller one directly below the Blenheim Dam and a larger spanning an area around Fultonham from Max V. Shaul State Park to Vromans Nose. The area between these complexes is a mix of agricultural and forest lands that fall short of the 150 acre patches to qualify as a complex but that have the potential for restoration to expand and connect existing patches.

The potential biodiversity in this is area is very high, due to the concurrence of habitat in the Creek and floodplain directly and habitat for more terrestrial species in the cliffs and steep hills on either side. This elevation range also provides the area with some resilience under climate change, as species should be able to shift to higher elevations as needed in search of suitable conditions.

There is very little protected land in this area, although the county has purchased lands in the floodplain as buyouts and flood mitigation. These lands could represent good opportunities for additional restoration of natural floodplains.

Table 8. Significant features, stream condition, threats and climate risks in the Schoharie Mainstem (Blenheim to Fultonham) priority aquatic area.

Significant features	Protected lands	Max V. Shaul State Park
	Recreation	
	Floodplain complex	
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale Longtail/Long-tailed Salamander (Eurycea longicauda) Marbled Salamander (Ambystoma opacum) Appalachian Tiger Beetle (Cicindela ancocisconensis) Cerulean Warbler (Dendroica cerulea) Eastern Pearlshell (Margaritifera margaritifera) Green Floater (Lasmigona subviridis Yellow Lampmussel (Lampsilis cariosa) Gray Petaltail (Tachopteryx thoreyi) Copperhead (Agkistrodon contortri Eastern Ratsnake (Elaphe obsoleta) Eastern/Woodland Box Turtle (Terrapene carolina carolina) Five-lined Skink (Eumeces fasciatus Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus Wood Turtle (Glyptemys insculpta) Rock-cress (Draba arabisans) Smooth Cliff Brake (Pellaea glabella ssp. glabella) Yellow Mountain-saxifrage (Saxifraga aizoides) Back's Sedge (Carex backii) Bird's-eye Primrose (Primula mistassinica) Drummond's Rock-cress (Boechera stricta) Golden-seal (Hydrastis canadensis
Condition	Med-high (50-70)	Flow alteration
		Riparian and floodplain condition
		Impaired water quality: Minor impacts in two reaches
Threats	Low	Flood pollution risk: Bulk storage in floodplain
Climate risk	Sensitivity	Medium
	Exposure	Medium

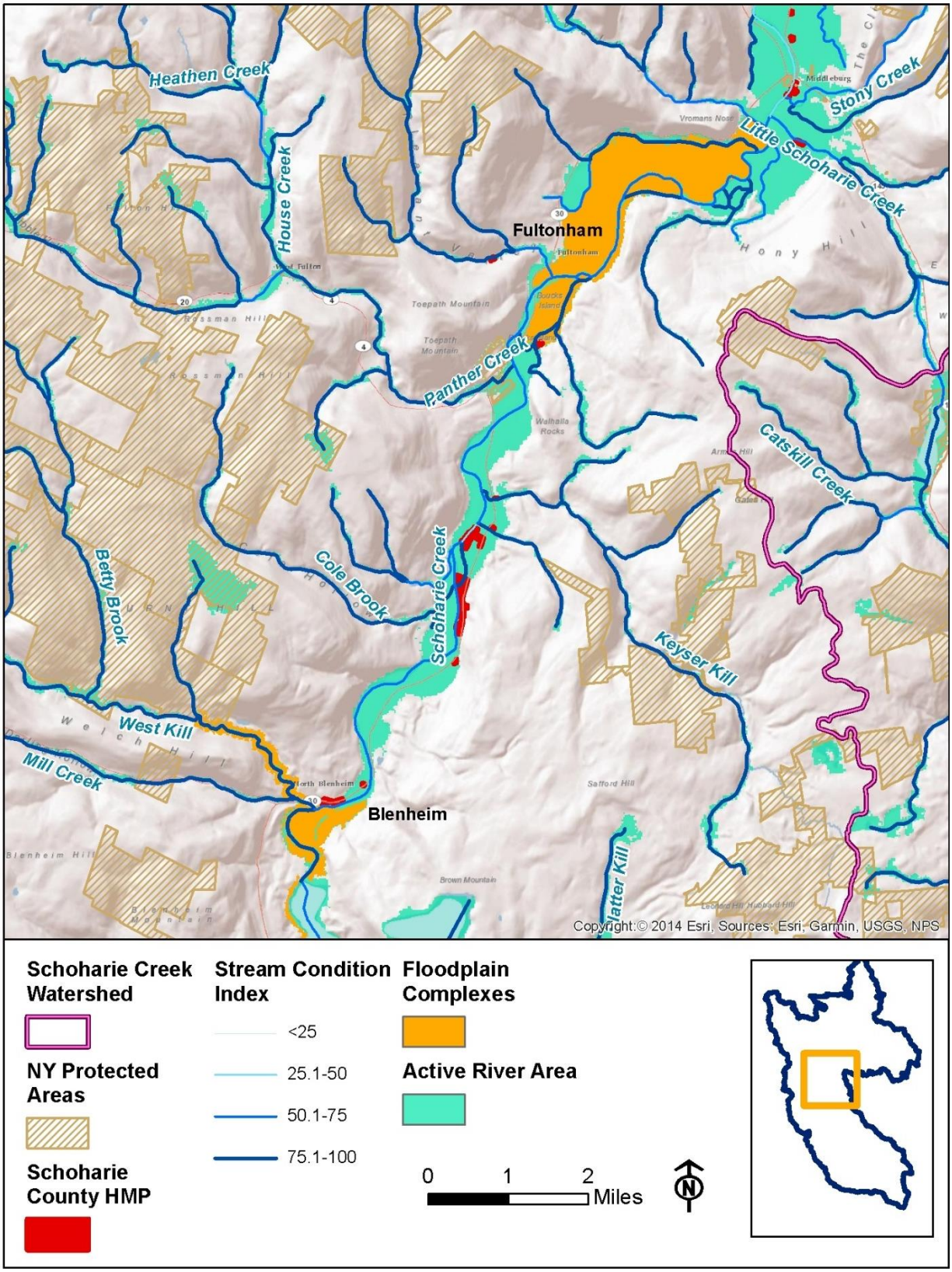

Figure 14. Stream condition, floodplain complexes and active river areas along the Schoharie Creek mainstem between Blenheim and Fultonham.

9. Eminence State Forest

The collection of forested hills to the west of the central Schoharie between Blenheim and Middleburgh are broadly included in the area referred to as the Eminence Management Unit. This area includes a number of different state forests and is a result is largely unfragmented, making it important for connectivity and wildlife movement on the west side of the watershed. A number of high-quality streams, including the Mine Kill, West Kill, Cole Brook, and Panther Creek flow out of these forests. This area is expected to be resilient under climate change and may support increasing numbers of rare species, especially in the stream valleys.

Forest conditions are generally good, although slightly lower in the northern part of this area. Management to address any problems with regeneration or forest structure may help the habitat support wildlife into the future.

Table 9. Significant features, forest condition, threats and climate risks in the Eminence State Forest priority forest area.

Significant features	Protected lands	Blenheim Hill State Forest Burnt-Rossman Hills State Forest Mallet Pond State Forest Patria State Forest Schoharie County Lands
	Habitat fragmentation	Med – 100-10,000 acre patches
	Regional connectivity	High flow area
	Geophysical diversity	Mid elevation: Moderately calcareous
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Longtail/Long-tailed Salamander (Eurycea longicauda) Cerulean Warbler (Dendroica cerulea) Arrowhead Spiketail (Cordulegaster obliqua) Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	Med-high (40-70)	Regeneration: Low north of Panther Creek
Threats	Low	
Climate risk	Sensitivity	Low
	Exposure	High

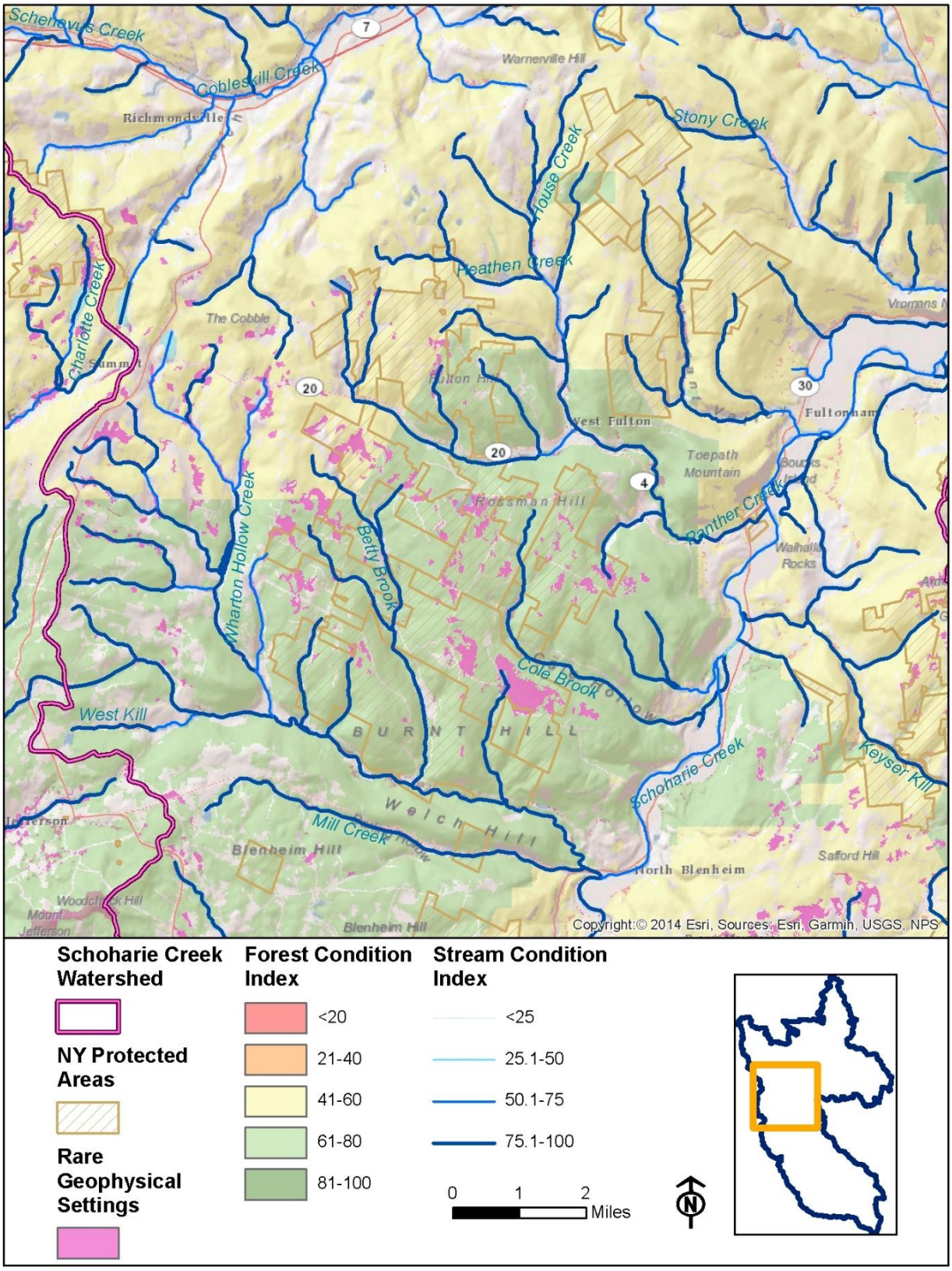

Figure 15. Forest and stream condition in Eminence State Forest in the Schoharie Creek Watershed.

10. East Hill to Helderberg

The forest linkage that was identified as a priority area in the upper watershed continues north along the eastern boundary of the watershed until it shifts east toward the Helderberg Escarpment. The headwaters of Fox Creek, Switz Kill and the Little Schoharie Creek are included in this linkage. The linkage is partially protected within the Cole Hill State Forest and the Partridge Run WMA. Some large patches of forest remain while in other areas there is considerable fragmentation from roads and agricultural areas. Land use models indicate further risk of fragmentation north of the towns of Westerlo and Rensselaerville, and around east Berne.

Invasive plant species and regeneration may be problems for forest condition in this area. Climate risk is generally moderate with some smaller areas with higher risk expected on Irish Hill. Species diversity is expected to increase in the higher elevations with climate change. Management of these forest should avoid further fragmentation and work to support climate adaptation.

Table 10. Significant features, forest condition, threats and climate risks in the East Hill to Helderberg Forest priority forest area.

Significant features	Protected lands	Partridge Run WMA Cole Hill State Forest
	Habitat fragmentation	10-10,000 acre patches
	Regional connectivity	Forest linkage
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Cerulean Warbler (Dendroica cerulea) Eastern Ratsnake (Elaphe obsoleta) Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	Med (40-60)	Invasive plant species
Threats	Low-High (20-70)	Fragmentation: Westerlo, Rensselaerville, East Berne
Climate risk	Sensitivity	Low-Med
	Exposure	Med

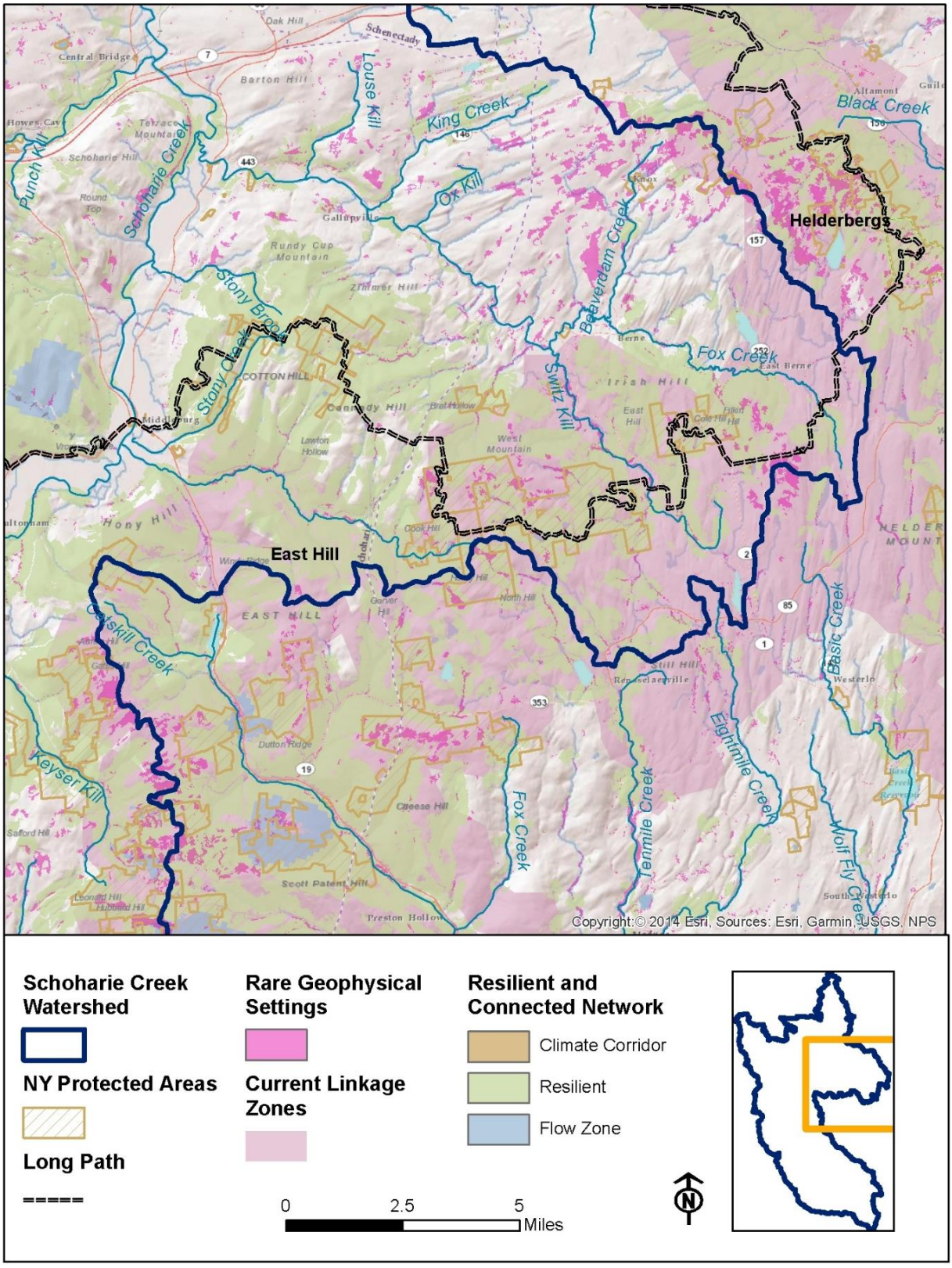

Figure 16. Linkage zone from East Hill to the Helderbergs in the Schoharie Creek Watershed.

11. Cotton/Cannady Hill

Cotton and Cannady Hills, just east of the town of Middleburgh, are prioritized for their large patches of very high condition forests. Two State Forests, Cotton Hill and Dutch Settlement, protect much of this priority area but could be expanded and connected. Expected to be resilient to climate change, this area should continue to be protected and managed to provide high quality refugia for rare species.

Table 11. Significant features, forest condition, threats and climate risks in the Cotton Hill Forest priority forest area.

Significant features	Protected lands	Cotton Hill and Dutch Settlement State Forests
	Unfragmented forest	>1,000 acre patches
	Potential rare species habitats	Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Cerulean Warbler (Dendroica cerulea) Henslow's Sparrow (Ammodramus henslowii) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
Condition	High (70-80)	Regeneration: High
		Invasive plant species: Low
Threats	Low (0-30)	
Climate risk	Sensitivity	Low
	Exposure	Med

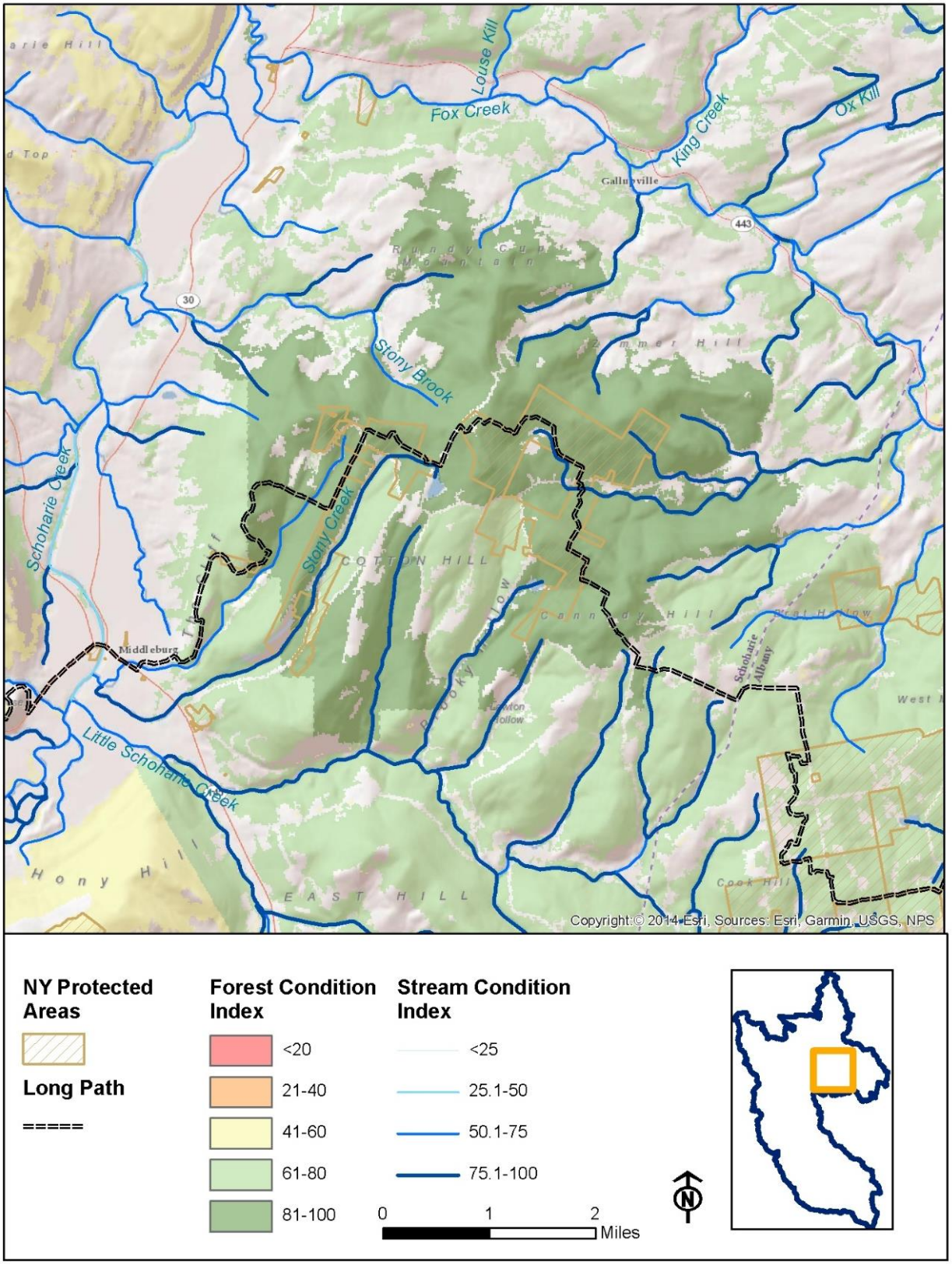

Figure 17. Forest condition at Cotton Hill in the Schoharie Creek Watershed.

12. Fox Creek

Lower Fox Creek, downstream of the junction with Switz Kill, is prioritized for its good freshwater habitat conditions, high biodiversity, and potential for floodplain restoration. Land protection is very limited in the stream corridor, with just a small acreage owned by the Village of Schoharie near the mouth. Water quality is unimpaired and the stream valley provides potentially suitable habitat for a large number of rare species. A floodplain complex at the convergence of Fox Creek and Switz Kill could be expanded by restoration in the remaining floodplain areas, further enhancing the habitat conditions. Climate risk is low in the lower reaches but greater in the upper half of this area, and should be planned for as part of any restoration activities.

Table 12. Significant features, stream condition, threats and climate risks in the Fox Creek priority aquatic area.

Significant features	Protected lands	Village of Schoharie
	Floodplain complex	Convergence of Fox Creek and Switz Kill
	Water quality	No impairments
	Geophysical diversity	Low elevation: Acidic sedimentary
	Potential rare species habitats	Four-toed Salamander (Hemidactylium scutatum) Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Cerulean Warbler (Dendroica cerulea) Henslow's Sparrow (Ammodramus henslowii) Yellow Lampmussel (Lampsilis cariosa) Copperhead (Agkistrodon contortrix) Eastern Ratsnake (Elaphe obsoleta) Eastern/Woodland Box Turtle (Terrapene carolina carolina) Five-lined Skink (Eumeces fasciatus) Northern Black Racer (Coluber constrictor constrictor) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta) Back's Sedge (Carex backii) Golden-seal (Hydrastis canadensis)
Condition	Med-High (60-80)	Floodplain Condition: Low, opportunity for restoration in lower reaches
Threats	Low	
Climate risk	Sensitivity	Med
	Exposure	Med

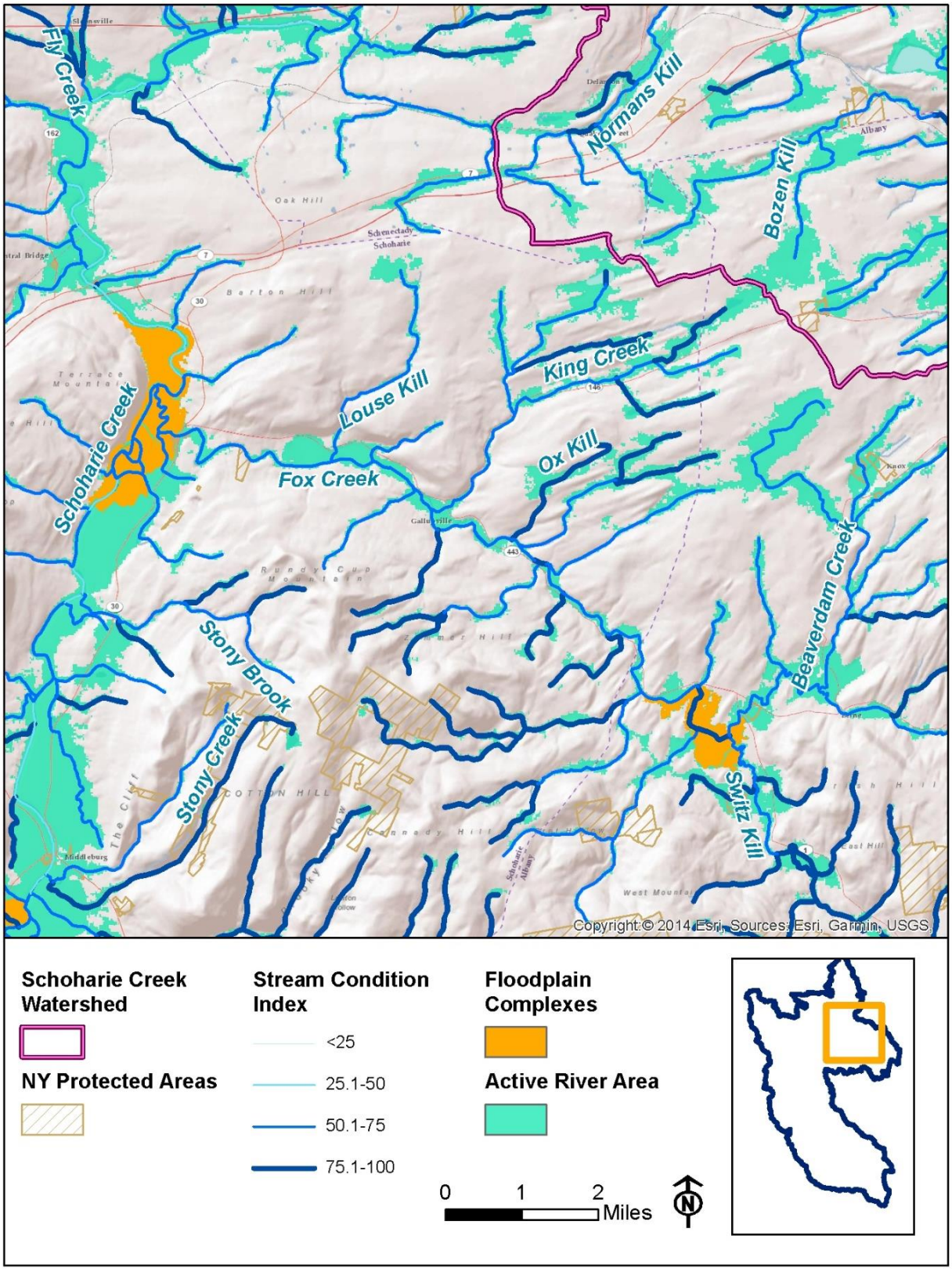

Figure 18. Stream condition and floodplain complexes in Fox Creek in the Schoharie Creek Watershed.

13. West Creek Ridge

This priority area contains the ridge defining the western boundary of the Cobleskill Creek watershed. It includes Honey Hill and Bear Swamp State Forests, and a number of large forest patches along the length of the ridge. This area is identified as a potential climate corridor, an area of potentially high wildlife movement constrained by surrounding land uses. The condition of these forests is modeled to be moderate to low with possibly simplified structure and composition. In addition, forest pests and invasive plant species may become more prevalent in the future. These threats should be monitored and managed in order to increase climate resilience of the forest.

Table 13. Significant featured, forest condition, threats and climate risks in the West Creek Ridge priority forest area.

Significant features	Protected lands	Honey Hill and Bear Swamp State Forests
	Unfragmented forest	100-10000 acre patches
	Wildlife movement	Climate corridor
	Potential rare species habitats	Four-toed Salamander (Hemidactylium scutatum) Jefferson Salamander Complex (Ambystoma jeffersonianum x laterale) Cerulean Warbler (Dendroica cerulea) Henslow's Sparrow (Ammodramus henslowii) Eastern/Woodland Box Turtle (Terrapene carolina carolina) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta)
	Geophysical diversity	Low elevation: Moderately calcareous
Condition	Med-Low (30-60)	Canopy structure and diversity: Possibly low based on models
Threats	Low (0-30)	Invasive plant species
		Pests and pathogens
Climate risk	Sensitivity	Med (40-60)
	Exposure	Med-high (50-80)

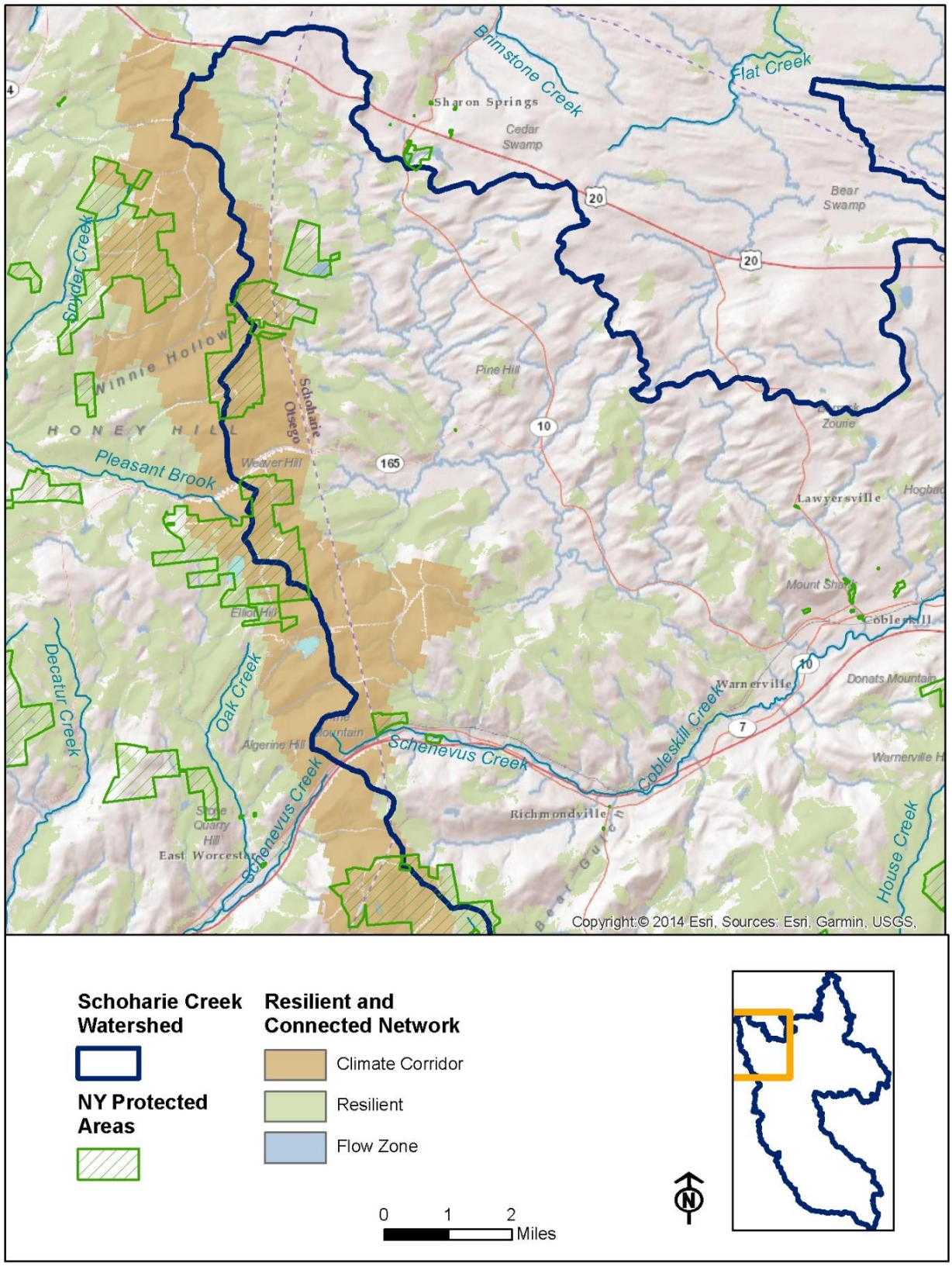

Figure 19. Modeled climate corridor on the western edge of the Schoharie Creek Watershed.

14. Schoharie Mainstem - Esperance to Mohawk River

The mainstem of the Schoharie Creek north of Esperance and the associated tributaries of Bowman Creek and Wilsey Creek are combined in this priority area. The lower Schoharie supports an extensive connected floodplain complex with few gaps, which provides suitable habitat for a large number of species. The floodplain also includes very low elevation geophysical types that are underrepresented in NY protected lands. Water quality is relatively good for a large river, and climate risk is low. The floodplain area contains limited protected lands and may be a good condition for additional land protection as well as restoration to fill the existing gaps.

While forests in this part of the watershed are mostly highly fragmented, the Wilsey and Bowman Creek watersheds entering the mainstem around the middle of the priority area contain larger well-connected patches of forest. Those on the west side are about half protected within the Charleston and Lost Valley State Forests, but those on the east in Bowman Creek are unprotected. Conservation of these remaining unfragmented forests would serve to support regional connectivity as well as the aquatic habitats in the associated tributaries.

Table 14. Significant features, stream condition, threats and climate risks in the Schoharie Creek lower mainstem aquatic area.

Significant features	Protected lands	Charleston and Lost Valley State Forests
	Floodplain complex	Large
	Water quality	No impacts or minor impairments
	Geophysical diversity	Very Low elevation: Moderately calcareous and Acidic sedimentary
	Potential rare species habitats	Cerulean Warbler (Dendroica cerulea) Henslow's Sparrow (Ammodramus henslowii) Yellow Lampmussel (Lampsilis cariosa) Arrowhead Spiketail (Cordulegaster obliqua) Extra-striped Snaketail (Ophiogomphus anomalus) Gray Petaltail (Tachopteryx thoreyi) Tiger Spiketail (Cordulegaster erronea) Copperhead (Agkistrodon contortrix) Eastern Ratsnake (Elaphe obsoleta) Eastern/Woodland Box Turtle (Terrapene carolina carolina) Five-lined Skink (Eumeces fasciatus) Northern Black Racer (Coluber constrictor) Spotted Turtle (Clemmys guttata) Timber Rattlesnake (Crotalus horridus) Wood Turtle (Glyptemys insculpta) Bird's-eye Primrose (Primula mistassinica) Golden-seal (Hydrastis canadensis) Smooth Cliff Brake (Pellaea glabella ssp. glabella)
	Forest fragmentation	High connectivity in the Bowman and Wilsey Creek basins, otherwise very low
Condition	Forest	High (60-90)
	Freshwater	Med-high (50-80)
Threats		Low
Climate risk: Forest	Sensitivity	Med high (50-70)
	Exposure	Med low (20-60)
Climate risk: Freshwater	Sensitivity	Med low (30-50)
	Exposure	Med (40-60)

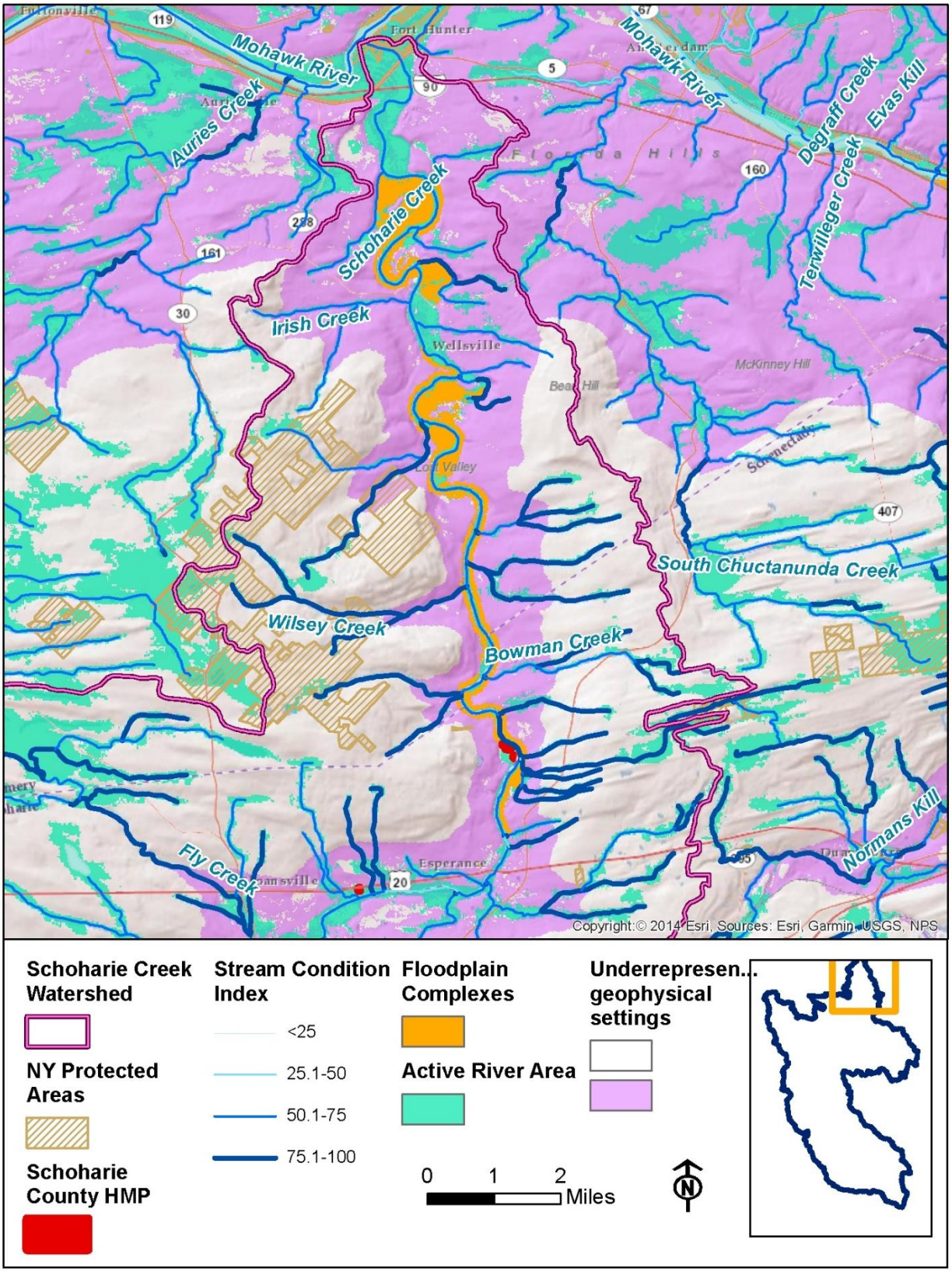

Figure 20. Floodplain complexes and stream condition on the lower portion of the Schoharie Creek.

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Appendix 1: GIS Data Sources

The following data layers were employed to identify and assess priority places in the Schoharie Creek Watershed. Detailed methods for data sourced from the Natural Resource Navigator can be found at http://www.naturalresourcenavigator.org/wp-content/uploads/2017/03/NRN-Data-Documentation.pdf. Other data sources are cited in the table below.

Subject	Dataset	Source
Protected Areas	New York Protected Areas Database	New York State Department of Conservation. 2016. New York Protected Areas Database (NYPAD) version 1.4. http://nypad.org/Download
	DEP Water Supply Lands	New York City Dept. of Environmental Protection. December 31, 2017
	Schoharie County HGMP	Schoharie County Office of Community Development Services
Recreation	Long Path	NY-NJ Trail Conference. 2017. https://maphub.net/tcmaps/long-path-2017
Forest Condition	Patch size Invasive plant frequency and abundance Large snag density Regeneration Canopy diversity	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/0spxz6tu4hhr5tf9at7slnazoixwsl11
Stream Condition	Flow alteration Floodplain condition Impervious cover Road-stream crossings Water quality impairments	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/lwa7g2lmfaaqca99qhh43wirgein1csa
Forest Sensitivity	Landform Variety Elevation Range Connectedness Canopy Species Richness Habitat Vulnerability	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/mzj4e90szqz1jgl7yu09ax4lkp1alvga
Forest Exposure	Change In: Annual Aridity Summer Max Temperature Num. Days Below Freezing Growing Degree Days Annual Total Precipitation	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/3mm4zr8uts45fhdc2o2phvtynumwb11x

Stream Sensitivity	Connected Network Length Size Variety Slope Variety Stream Temperature Class Variety	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/lwa7g2lmfaaqca99qhh43wirgein1csa
Stream Exposure	Change In: Stream Temperature Class Extreme Precipitation Annual Aridity Summer Max Temperature Num. Days Below Freezing Growing Degree Days Total Annual Precipitation Summer Precipitation	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/lwa7g2lmfaaqca99qhh43wirgein1csa
Geophysical Diversity	Rare geophysical settings Under-represented geophysical settings	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/po8iob41p21bbxe1daffban6niivalyg
Wildlife movement and climate adaptation	Matrix forest blocks Linkage zones	The Nature Conservancy. 2016. Natural Resource Navigator Map Tool. www.naturalresourcenavigator.org. Albany, NY. https://tnc.box.com/s/po8iob41p21bbxe1daffban6niivalyg
	Resilient and Connected Network	http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/default.aspx
Rare Species Habitat	Suitable habitat models Current richness Predicted change in richness	New York Natural Heritage Program. 2014. http://nynhp.org/data#stackedEDMs
Floodplains	Active River Area Floodplain Complexes Riparian vegetation	https://tnc.box.com/s/51c242axw78h0tq5kuy2hfcqlupbwlpg
Threats	Pests and pathogens Invasive plant species Habitat loss and fragmentation Flood pollution risk	https://tnc.box.com/s/9lf6wmqmmyu2wxp722aozno4y8onpkyi

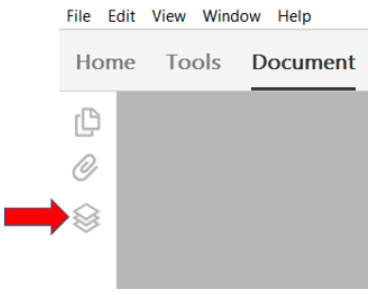
Appendix 2: Interactive PDF Maps

Interactive PDFs (Portable Document Format) support vector and raster graphics and allow limited customization of map documents. A package of 6 interactive maps are included with this assessment, displaying the primary datasets and covering the full extent of the watershed. These maps may be used to explore the data for a particular priority area, refine the maps to identify conservation project locations, or create custom maps for reports and presentations.

Adobe Acrobat is the most common software used to view PDFs. It is available for download here: https://get.adobe.com/reader/. Listed below are instructions regarding use of the Interactive PDFs.

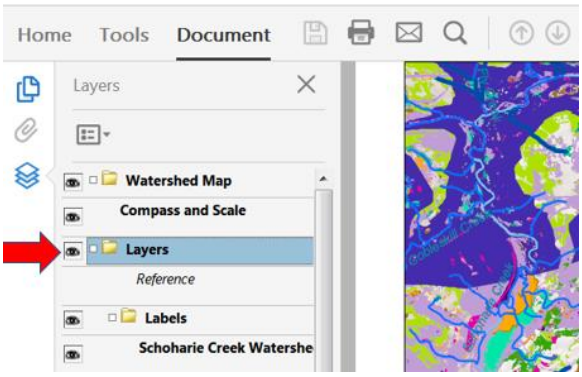
1. Open the Interactive PDF using Adobe Acrobat/Adobe Reader.

2. Find the map that includes the area of interest.

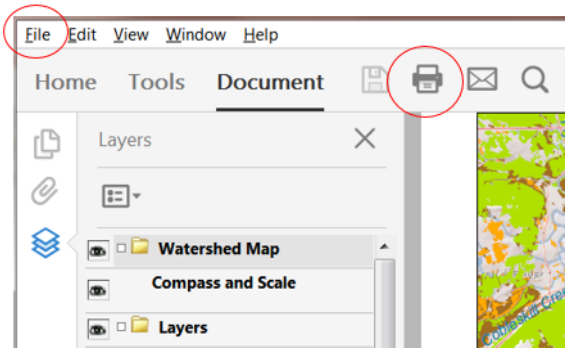


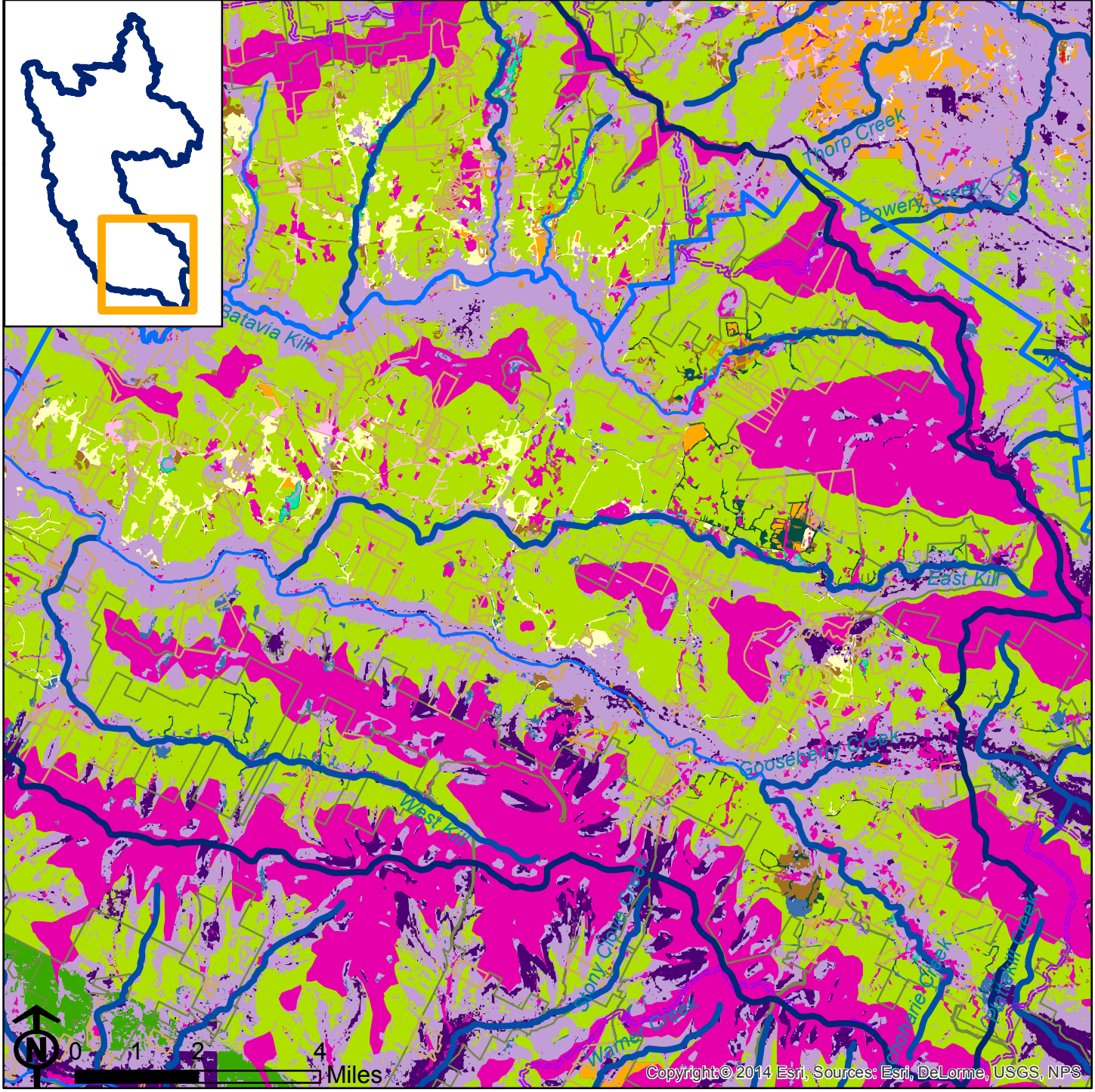
3. Click the "Layers" button on the left side of the page. This will display a list of the layers available to view in the map document. Folders may be expanded by clicking the checkbox next to them.

4. Click the eye button to the left of the layer that you would like to turn on/off. A visible eye indicates that the layer is turned on and an empty box indicates that the layer is turned off. Use the legend in the bottom right of the screen to interpret the map contents.



5. It is recommended to only display a few layers at a time. It is not possible to change layer order or symbology. Customized maps may be printed or saved as a new PDF document.





Schoharie Creek Watershed Boundary

Blueline - Catskill Park

Long Path

Stream Condition Index

<25

25.1-50

50.1-75

75.1-100

NYC DEP

Protected Lands NYPAD

State

Local Government

Non-Govern... Organization

Private

Rare Geophysical Settings

Under-represented Settings

Current Rare Species

1-4 species

>4 speices

Floodplain Complexes

Active River Area

Forest Condition Index

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75.1-100

Resilient Connected Network

Resilient

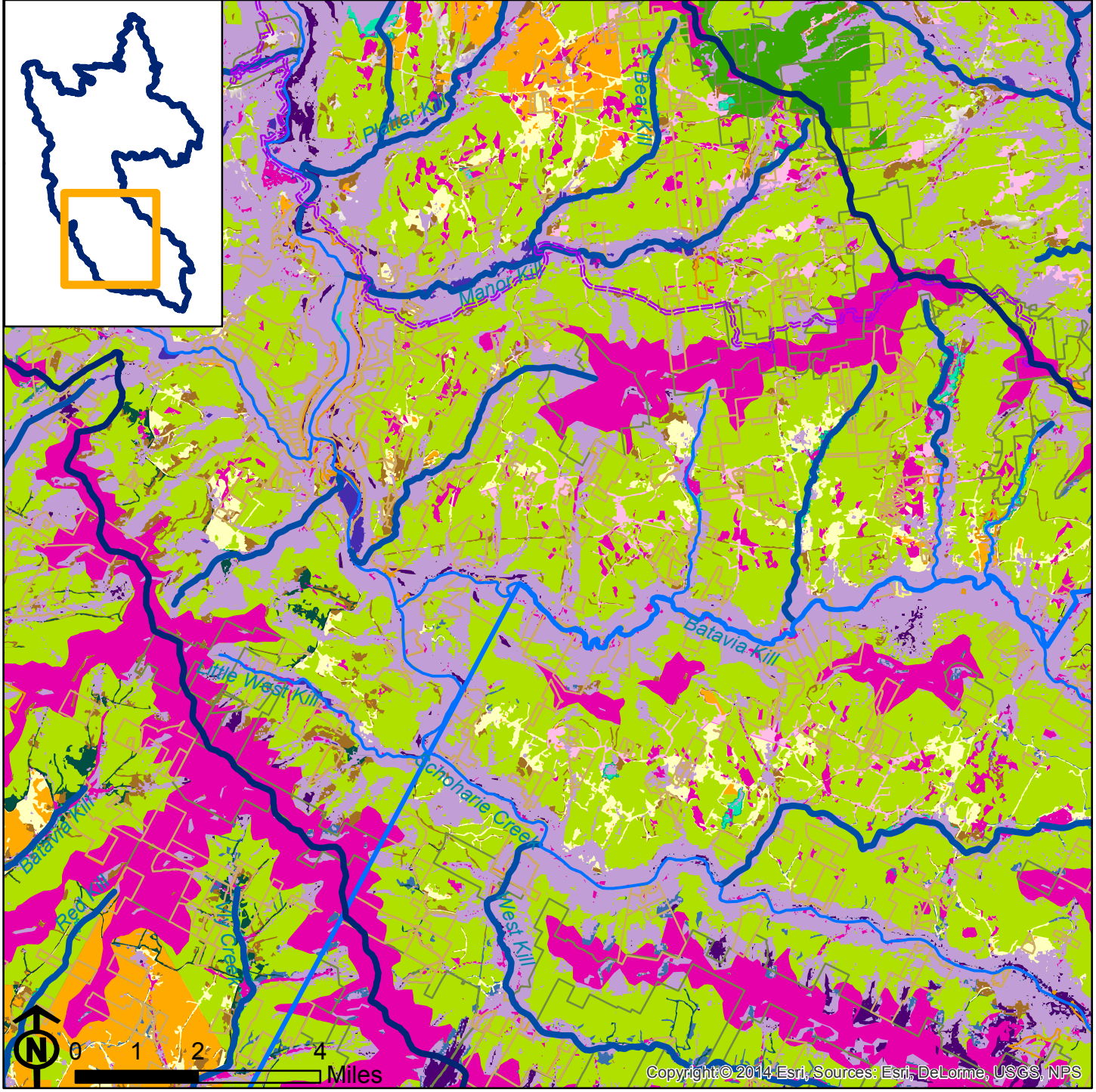
Climate Corridor

Flow Zone

Matrix Forest Blocks

Current Linkage Zones

NYC Watershed



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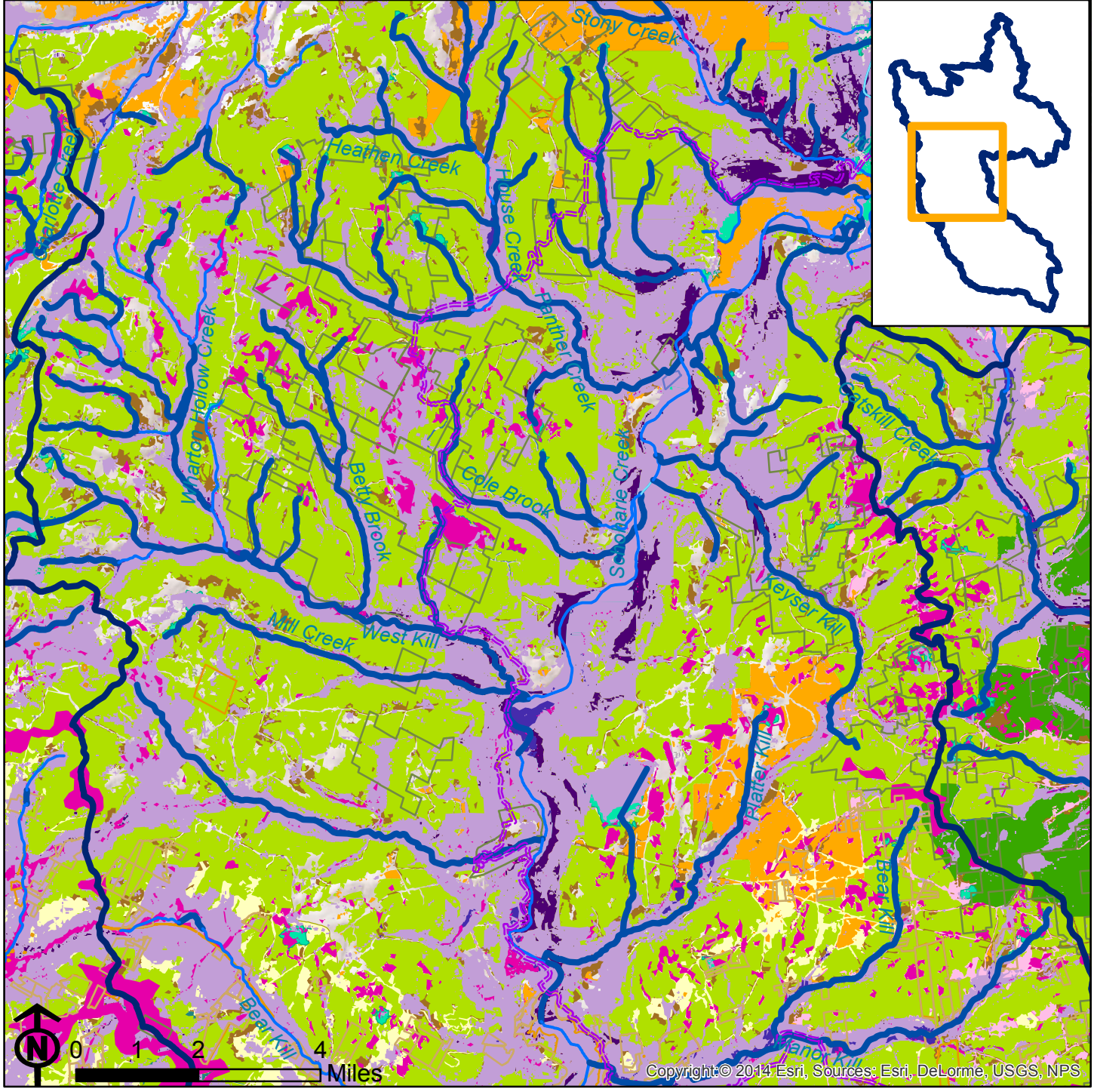

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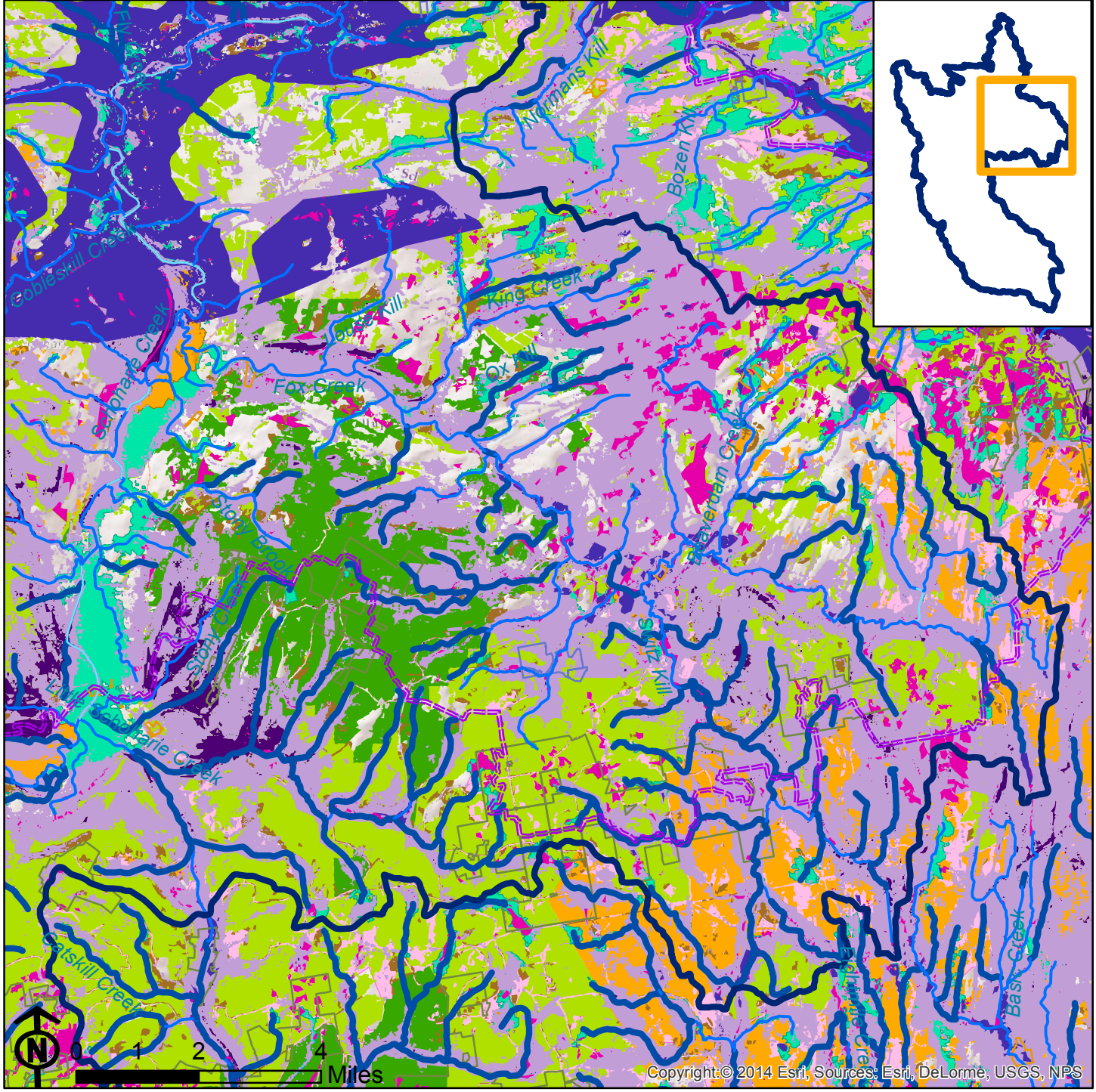

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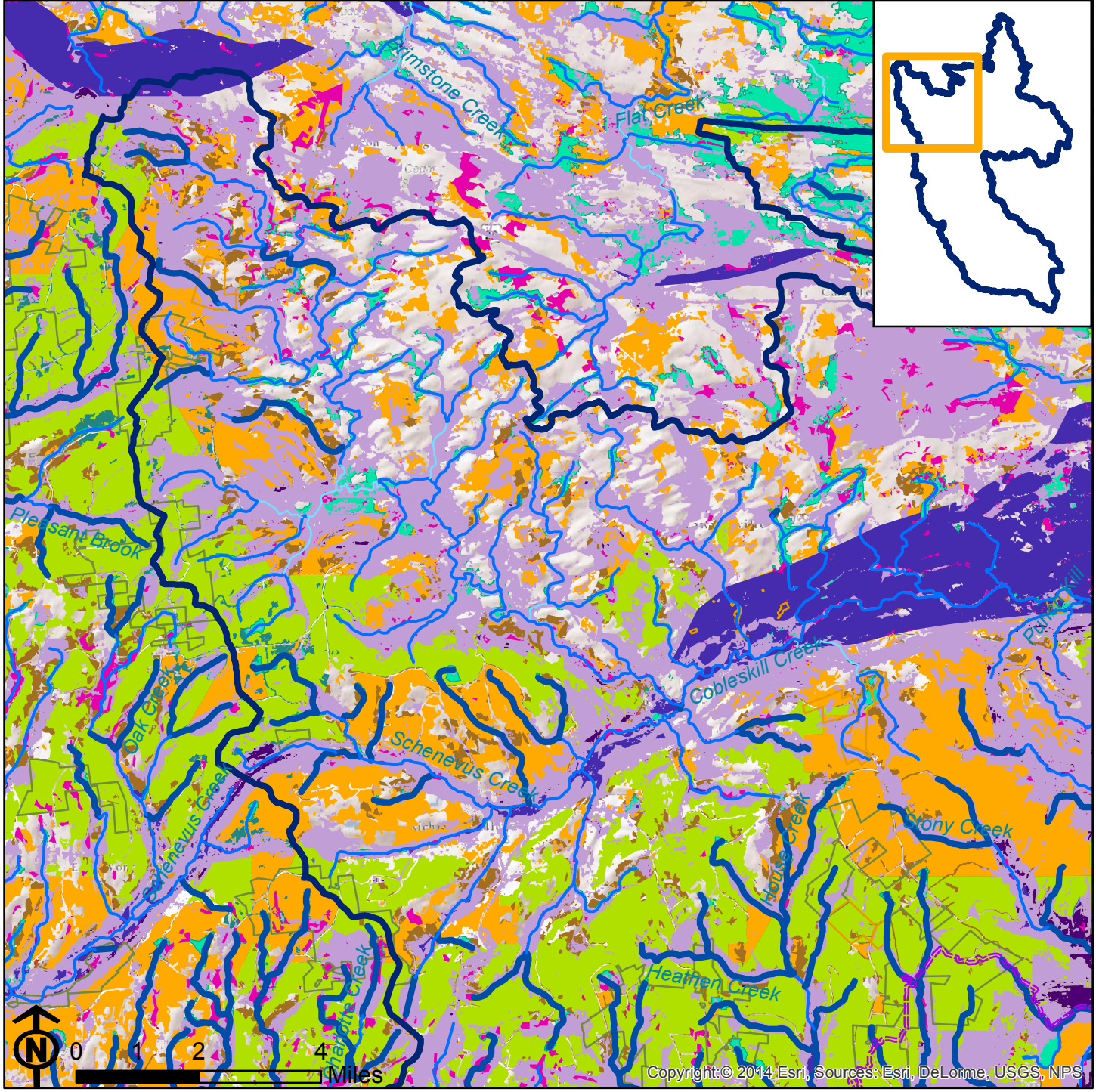

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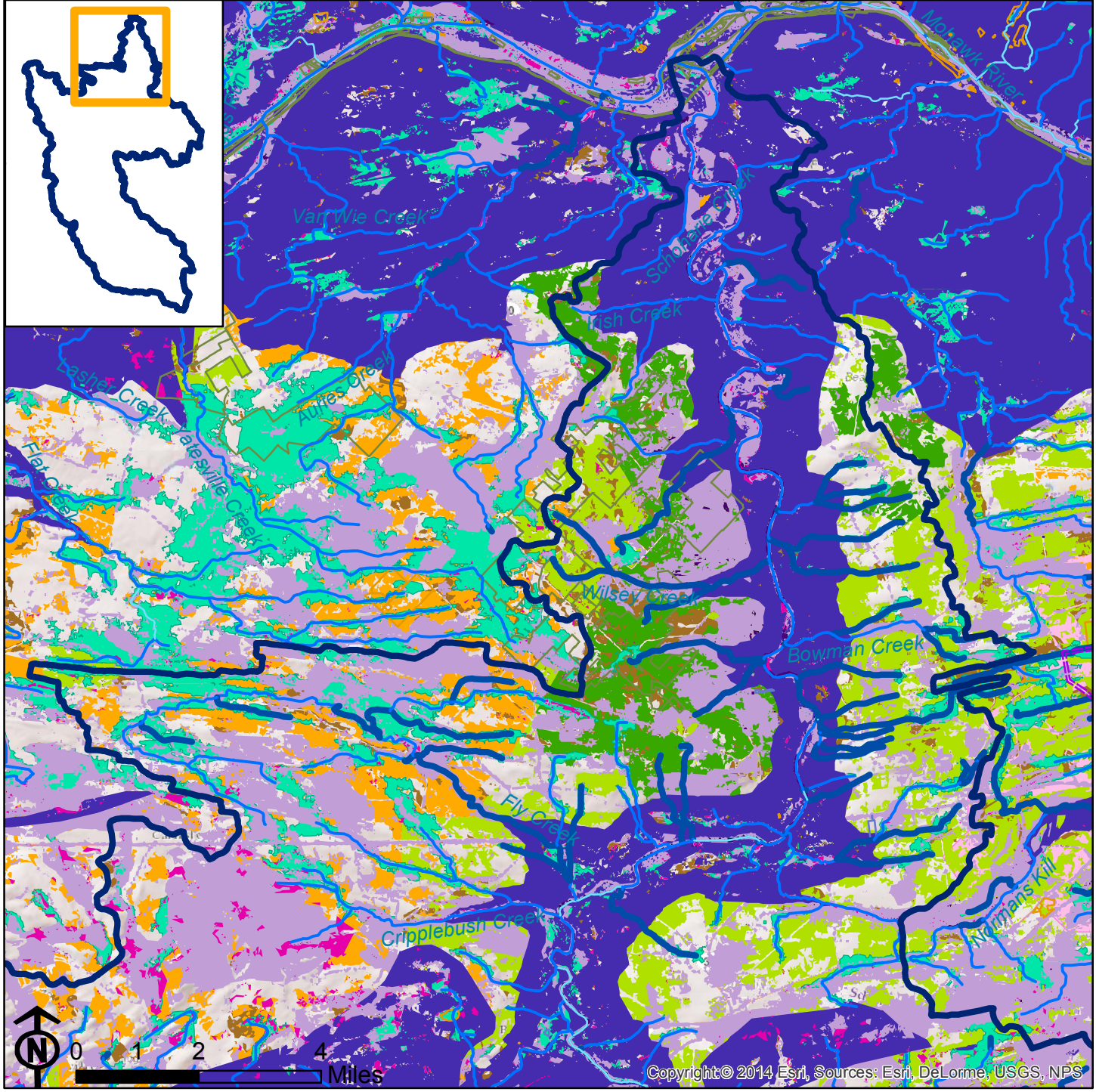

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