SKWC
SAW KILL WATERSHED COMMUNITY

sawkillwatershed.wordpress.com

Saw Kill Watershed Source Water Protection Scorecard Recommendations:

Comprehensive Water Resources Protection

Town of Red Hook

February 27, 2019

Introduction

The following recommendations from the Saw Kill Watershed Community are based on information collected to complete Riverkeeper's Source Water Protection Scorecard. We've taken two of our original recommendations and expanded them into more detail at the request of the Town Supervisor and in response to community concerns regarding water quality (drinking water), flood mitigation, and water supply. Each of our recommendations addresses one or more of these concerns, as noted in the table below.

The Town of Red Hook already has some protections in place to address these issues, but as the Scorecard pointed out, it is using less than a third of the resources available for water protection.

To address this gap in resources and protection, we began by reviewing an array of studies (listed at the end of this report) that contain specific information about water issues including contamination, buffers, flood prone areas, climate change projections and peak flood flows, aquifer protection, and storm water runoff management. Some of these studies are specific to Red Hook, others are applicable here because they seek to solve problems shared by many communities.
We consolidated this information and constructed a table of our recommendations. All the recommendations are supported by research, local information and reports, and experiences from other communities. We use a watershed approach to water resources protection because all these waters are connected across the landscape and above and below ground. By using a watershed context, individual code protections or ordinances fit into a larger plan for comprehensive water protection. Instead of treating each water problem separately as it arises, this approach can be used to prevent or reduce problems proactively. It also facilitates more efficient action, for example, buffer protection can address multiple water concerns (water quality, flood mitigation, and water supply).

The watershed approach considers factors such as buffers, water quality, impervious surfaces, forests, wetlands and small streams, floodplains, and water use. To help measure progress in water protection, our recommendations identify some specific thresholds and targets to track water protection progress over time.

Each of the Saw Kill's 15 tributaries in the Town of Red Hook drains a smaller sub-watershed basin, or catchment. We encourage dividing the watershed into its smaller subbasins to make it easier to pinpoint problem areas. Looking at water conditions and measuring protection efforts in each of these smaller areas makes it easier to set goals and track progress. The DEC, for example, divides the watershed into subbasins to identify characteristics including ecological strengths (native fish, streamside woodland, watershed vegetative cover, stream biodiversity, and floodplains) and stressors (runoff, dams, impervious surfaces, and erosion) (Figure 2). Online subbasin maps identify these, and other, characteristics in detail.

Watershed Characteristics Summary

Buffers

Vegetated buffers along the edges of streams, ponds, and wetlands protect water quality and reduce flooding. They are most effective when their size, location, extent, and composition follow well-established parameters. To protect water quality, buffers need to be adequately vegetated and wide enough to process the contaminants in runoff before they reach the water. No single size for buffers will fit all circumstances; the ideal size of a buffer depends on its purpose. Many sources agree that for general water quality protection, a minimum of 100 feet (vegetated buffer on level ground) is recommended. Buffers of 100 feet are generally able to remove up to 48 percent of nitrogen, trap 85 percent of sediments, reduce bank erosion, maintain consistent temperature, and benefit aquatic life.

In 2018, as part of the SKWC's State of the Saw Kill report, an initial review of buffers divided the Saw Kill into 17 segments and evaluated the extent of buffers that are 25 feet or less and buffers that are 100 feet or more. This is one of several studies identifying areas in need of buffer expansion or restoration. To compensate for more rapid runoff, buffers on steep slopes or rocky soils need to be wider. Particular species of wildlife may need specific buffer widths for habitat protection. Formulas for calculating recommended buffer size are described later in this report.

Water quality

Water contamination can affect not only municipal drinking water sources, but also the many individual wells throughout the watershed. Most residents (89 percent) rely on private wells for drinking water. Groundwater contaminants such as septic system effluent, salt, nutrients, algae, pathogens, heavy metals, biocides, and chemicals (pharmaceuticals, antibiotics, etc.)

are all concerns. We can work to keep them out of our water by controlling runoff, improving septic systems, and disposing of waste materials properly.

Water contaminants fall into two broad categories, depending on their source. Point source pollution originates at an identifiable location. Nonpoint source pollution, carried by stormwater runoff, is comprised of contaminants that are washed from land surfaces into the water. Soluble pollutants like chlorides (salts), nitrate, copper, and dissolved solids can migrate into groundwater. Stormwater may also carry chemicals that directly harm aquatic organisms and human health. Hotspots are areas that produce higher concentrations of harmful chemicals such as hydrocarbons and trace metals, which can be carried into water via runoff.

Since 2015, the SKWC has collected water samples from 14 sites along the Saw Kill on a monthly basis. The Bard Water Lab tests them for turbidity, temperature, phosphorus, nitrogen, sewage-indicating bacteria, and conductivity (as an indicator for heavy metals and salt). In some areas, conductivity, nitrogen, phosphorus, and bacterial concentrations indicate potential water quality concerns. DEC's Source Water Evaluation for the Saw Kill watershed contains maps of drinking water systems, septic systems, and phosphorus loading estimates by land use type.

Impervious surfaces

Stream health declines when impervious surfaces cover 10 percent or more of the land area in small watersheds. Standard models identify categories of streams along a gradient from "sensitive" to "urban drainage," based on sub-basin percent impervious cover. Using this format, sensitive streams are those with less than 5 percent impervious cover in the sub-watershed. In general, a high quality stream has less than 10 percent impervious cover in its sub-watershed and can continue to function and support good to excellent diversity of aquatic life. "Impacted" streams have 10 to 20 percent impervious cover, and show signs of water contamination and declining health. Land development can exceed 10 percent or more impervious cover fairly easily; for example, residential 1.5-acre zoning approaches this amount.

According to USGS Streamstats data, approximately 12 percent of the entire Saw Kill watershed is developed land; approximately 2.8 percent of the total watershed is impervious surface. This percentage varies within each individual subbasin.

Forests

Wooded areas contribute to overall watershed health by reducing stormwater runoff, flooding, and erosion; improving water quality; and providing habitat. A high percentage of wooded areas in a watershed can lower drinking water treatment costs and improve groundwater recharge. Forest cover is important both within buffers and throughout a watershed; it can be

measured as a percent of total watershed area, or linear riparian buffer. Good stream health has been correlated with a higher percent (45 to 65 percent or more) of the length of a stream in forested buffer (at least 100 feet wide).

The Trust for Public Land and the American Water Works Association have found that the more forest cover in a watershed (at least 60 percent), the lower the cost for clean drinking water. In the Saw Kill watershed, according to USGS Streamstats information, approximately 68 percent of the watershed is covered by forest.

Wetlands and small streams

A network of small wetlands and streams throughout the watershed catch runoff and precipitation and store it or move it downstream. Federal and state regulations protect only a portion of these wetlands and streams; most are unprotected.

The Environmental Protection Agency estimates that 55 percent of the streams that supply drinking water to New York state residents are small intermittent, ephemeral, or headwater streams. This collection system dissipates flooding from heavy rainfall, and more streams are available to catch and transport water. The system of smaller streams reduces flood flows, flashiness, and peak flows in larger perennial streams, like the Saw Kill, especially during storms.

Wetlands of all sizes and types (regardless of regulatory jurisdiction) throughout the watershed collectively serve as sponges that collect and absorb floodwaters and release them slowly. A one-acre wetland, one foot deep, can hold approximately 330,000 gallons of water.

Extensive research indicates streams or rivers in watersheds with less than 10 percent area in wetlands have higher peak stormwater flow. Within the Saw Kill watershed, wetlands and hydric soils cover about 12 percent of the area of the entire watershed (Figure 4).

Floodplains

River and stream floodplains slow and absorb floodwaters and slow surface runoff, allowing water to seep into the soil. Floodplains provide these services best when they are well-vegetated, support minimal structures and impervious surfaces, and are connected to the stream channel (not separated by berms or other barriers to water flow).

Due to the effects of climate change, annual precipitation is expected to increase by 5 to15 percent by the 2080s. To compensate for an increase in the frequency, intensity, and duration of storm events, state guidance calls for using the 500-year flood elevation for planning or adding 2 to 3 feet to the 100-year base flood elevation. The Saw Kill Watershed and Flood Mitigation Assessment identifies 14 sites susceptible to flooding in Red Hook. It states that “many of the study recommendations will have relatively small impacts on flood levels if performed individually, but the combined effects of these recommendations could

significantly reduce existing flooding as well as anticipated increases in flooding as a result of climate change."

Groundwater: supply and quality

Residents in Red Hook obtain their water from the Saw Kill itself (Bard College), from two municipal well systems (Village and Town of Red Hook), and from numerous individual wells throughout the rest of the watershed. These individual wells serve about 89 percent of the town's population. The aquifer that underlies the Village of Red Hook is its main source of drinking water. Municipal well (and stream) water is regularly tested and treated; individual wells are not. All of these water sources are affected by watershed conditions.

Water withdrawal can change the local groundwater-flow system. Pumping from multiple wells can cause cumulative effects on groundwater supply, distribution, and water levels in rivers, streams, and wetlands, especially during periods of low rainfall. Excessive pumping of groundwater may affect a large area through impacts on the interconnections among groundwater and surface streams, wetlands, and lakes. The Dutchess County Aquifer Recharge and Sustainable Rural Density Analysis recommends optimal parcel sizes for Red Hook based on septic system density and soil hydrologic groups.

Conclusion

Comprehensive protection of the town's water resources includes implementation of best management practices, maintenance of areas currently in good condition, changes to the town code and ordinances, and conservation efforts such as purchasing land, strategic acquisition of conservation easements, coordinating buyouts of repeatedly flooded properties, and implementing a Transfer of Development Rights program.

We recognize that the Town of Red Hook already has some of these protections in place. The following recommendations reflect a comprehensive view of water resources protection within a broad watershed context. Presented in table format, they are divided into five sections: Buffers, Contaminants, Water Supply, Flood Mitigation, and Community Outreach. We hope the town will use these recommendations to update and consolidate water protection passages in the existing town code, and add the measures necessary to effectively protect the town's water in the long term and maintain its health in the face of climate change.

Through wise management of natural features, many of these recommendations are expected to save money in the long term and avert expensive repairs and system fixes in the future.

Recommendations Summary Table

Establish Buffers to Protect Streams, Wetlands, and Water Bodies

1. Maintain existing 100-foot buffers along the edges of all streams, wetlands, lakes, and ponds regardless of their size or jurisdictional status; encourage best management practices on all other buffer lands that are currently developed. Buffer maintenance practices include: • Maintaining native vegetation (trees and shrubs on banks for stability; stiff-stemmed plants to slow floodwaters; diverse plants for sustainability) • Limiting impervious surfaces • Prohibiting application of biocides or fertilizers within buffers	Water quality Flood mitigation
2. For new development, require minimum 100-foot buffers along the edges of all streams, wetlands, lakes and ponds regardless of their size or jurisdictional status (see wetland and stream definitions below).	Water quality Flood mitigation
3. Reduce extent of lawns within buffers. Grandfather existing lawn within buffer and encourage landowners to replace lawn with buffer-appropriate vegetation; require new development to keep mowed lawns out of the 100-foot buffer and plant native vegetation in its place.	Water quality Flood mitigation
4. Require larger buffers on slopes, adjacent to high intensity land use or sources of contamination, and in headwaters of all tributaries to the Saw Kill (Figure 1). Calculate buffer size using guidelines from Johnson & Buffler's Riparian Buffer Design Guidelines, USDA, 2008. This resource provides optimal buffer widths adjusted according to slope, surface water features, and other factors.	Water quality Flood mitigation
5. Inventory and map extent of existing buffers protected by conservation easements and land trusts as a baseline for measuring future progress in buffer protection. Use this baseline for establishing a target goal for extent of forest cover along streams within the watershed.	Water quality Flood mitigation
6. Identify and map priority buffer protection and restoration areas, including areas susceptible to flooding and subwatersheds with high stress designation by New York State Riparian Opportunity Assessment, based on Trees for Tribs Statewide Data Explorer's maps (Figure 2).	Water quality Flood mitigation

Keep Contaminants Out of Streams, Ponds, Wetlands, and Groundwater

(Contaminants include heavy metals, biocides, trash, yard waste, salt, fertilizers, nutrients, suspended sediment, harmful bacteria, oil and grease, and emerging contaminants such as pharmaceuticals, personal care and cleaning products, and PFOA/S)

1. Map runoff hotspots (see list following table) as a basis for locating and sizing buffers to protect nearby wetlands, ponds, streams, and aquifer/groundwater. Include maps indicating water quality problem areas, septic system distribution, and SPDES permits.	Water quality Water supply
2. Evaluate hotspots (sources of contamination) for water recycling measures; fate of wastewater discharge; hazardous substances (including quantities), and assurance of flood-proof storage for all contaminant structures and practices.	Water quality
3. Require all new development to comply with Low Impact Development standards, Best Management Practices, and the NY State Stormwater Management Design Manual. Develop local guidelines to address local conditions. Require a local stormwater pollution prevention plan (SWPPP) prepared in accordance with local specifications as per these recommendations regarding water quality, flood mitigation, and water supply before approval of any application for land development activities disturbing 1 or more acres. Require best management practices including: • preserve natural drainage features • allow precipitation to seep into the ground as close as possible to where it falls • locate detention basins at least 100 feet from stream or wetland • Prevent discharge of stormwater directly into streams, natural ponds, and wetlands	Water quality Flood mitigation Water supply
4. Prohibit dumping of trash and yard waste in streams, ponds, wetlands.	Water quality Flood mitigation
5. Develop strategy to reduce the amount of road salt that reaches groundwater or surface waters. Identify waters sensitive to road salt and limit use in these areas (e.g, adjacent to wetlands and streams). • store road salt in areas not prone to flooding or runoff hazard • evaluate appropriate alternative de-icing agents • evaluate and adjust timing of road salt applications to reduce salt load • evaluate mode of application (equipment) to reduce salt load	Water quality

6. Reduce/limit impervious surfaces in watershed with the goal of keeping them at or below 10 percent threshold. This can be used as a baseline for measuring future progress in minimizing impervious cover. Apply this goal to each watershed subbasin. Identify subbasins that support 10 percent or more impervious cover and develop specific measures to prevent its increase (reduce and mitigate impervious surfaces by limiting extent of paved areas and land clearing for new development, maximizing buffer size, maintaining native vegetation, and requiring green infrastructure practices). (Figure 3)	Water quality Water supply Flood mitigation
7. Establish standards for siting new septic systems, water quality testing, and maintenance of existing septic systems. Consider requirements for new development that follow septic criteria and modeling in Dutchess County Aquifer Recharge and Sustainable Rural Density Analysis 2006. This model recommends site-specific housing/septic system densities based on annual recharge rates, hydrologic soil group, impervious surface cover, and target groundwater concentration thresholds.	Water quality
8. In all public areas and in residential areas where lot size is one acre or less, require removal of pet wastes and provide signs, cleanup bags, and trash receptacles throughout the area.	Water quality
9. Require well testing during all real estate transactions. Regularly review all available water quality testing information, including data generated by the Bard Water Lab, Riverkeeper, and the DEC, with special attention to salts, nutrients, fecal bacteria, and heavy metals. Explore testing options (as they may become available) for additional contaminants such as PFOA/PFOS, antibiotics and other pharmaceuticals, biocides, and personal care products.	Water quality
10. Regulate local land clearing and grading to limit disturbance of natural drainage patterns, increased erosion potential, tree loss, and impacts on wetlands and streams and their buffers. Examples of suggested limits can be found in the Town of New Paltz code on grading and clearing, Chapter 140 Zoning, Article XIIIA.	Water quality Flood mitigation Water supply

Protect Water Supply through Forests and Recharge Areas

1. Maintain existing forest cover throughout watershed, but especially in headwaters, floodplains, and along streams. Limit tree harvesting per watershed subbasin to maintain the existing percentage of forested cover.	Water quality Water supply Flood mitigation

2. Update the "safe yield" formula for calculating impacts of water use and consider average water consumption levels, current water demand, projected demand over time, and maintenance of groundwater/aquifer storage. Factor in effects from drought and climate change. (Examples found in the Town of Red Hook proposed aquifer protection ordinance)	Water supply
3. Evaluate the cumulative effect of additional water consumption by all new development, and its effect on water resources, including stream flow, wetlands, and existing wells.	Water supply
4. Maximize aquifer recharge to reduce flooding severity and provide baseflow reserves for ponds and streams during droughts by maintaining vegetation, limiting impervious surfaces, protecting wetlands, streams and buffers, and encouraging use of pervious surface treatments.	Water quality Water supply Flood mitigation

Flood Mitigation

1. Update flood hazard maps for entire watershed to match most recent FEMA maps and data. Use 500-year flood zone or add 2 to 3 feet elevation to 100-year flood zone to accommodate climate change. Include on the map any additional flood-prone areas identified in the Saw Kill Watershed and Flood Mitigation Assessment report.	Flood mitigation
2. Incorporate climate change projections into all new development and stormwater management infrastructure and practices. Maintain adequately sized culverts and bridges that will accommodate projected increased flood levels (recommended minimum 100 year flood).	Flood mitigation
3. Prohibit new development and additional impervious surfaces in floodplains.	Flood mitigation
4. Prohibit filling of wetlands (regardless of size, location, and jurisdictional status) to reduce peak flood flows in streams and maintain natural flood reduction and water storage infrastructure throughout the watershed. Target goal: Maintain or increase current level of watershed percent coverage by wetlands (See Saw Kill Watershed Community Water Resources map).	Flood mitigation Water quality Water supply
5. Require wetland delineations (according to US Army Corps of Engineers and NYS DEC standards) to identify wetland boundaries prior to new construction. This includes areas labeled hydric soils or poorly drained soils on the SKWC watershed map. Require verification of boundaries for all wetlands mapped by DEC or the National Wetland Inventory (Figure 4).	Flood mitigation Water quality Water supply

6. Maintain connection between stream channel and its floodplain, free of berms or other obstructions.	Flood mitigation
7. Stabilize streambanks with woody vegetation and maintain buffers along the water's edge.	Flood mitigation Water quality
8. Adopt local requirements for stream crossings that apply to all streams in the watershed, based on DEC's stream crossing guidelines.	Flood mitigation
9. Prohibit filling, deepening, damming, or altering course (e.g., straightening) of all small streams (perennial, intermittent, ephemeral) regardless of regulatory jurisdiction status.	Flood mitigation

Community outreach

1. Start a Town-wide buffer maintenance volunteer program.	
2. Develop Best Practices educational materials for landowners that explain how to manage buffers and water's edge areas. Develop a Best Practices brochure or small handbook for landowners (introduced via a workshop) that outlines recommended management practices for streams, wetlands, and ponds.	
3. Sponsor educational events for the community regarding watershed best management and maintenance practices.	
4. Design and install signage for Saw Kill tributaries at road crossings.	

Maps

Definitions

Runoff hotspots
based on DEC Stormwater Design Manual and the Town's draft Aquifer Protection Ordinance:

- Commercial parking lots and fleet storage areas
- Landscaping nurseries and garden centers
- Orchards and crop fields
- Heavy equipment storage areas
- Public works areas (highway maintenance facilities)
- Dry cleaners
- Gas stations
- Petroleum storage facilities
- Wastewater treatment facilities; combined sewer outflows
- Golf courses
- Facilities that store or generate hazardous materials
- Auto repair facilities and truck terminals, including engine repair and machine shops
- Municipal, private, construction and demolition landfills defined in 6 NYCRR Part 360-2 and 6 NYCRR Part 360-7.
- Solid waste management facilities not involving burial, including incinerators, composting facilities, liquid storage, regulated medical waste, transfer stations, recyclables handling and recovery facilities, waste tire storage facilities, used oil, C and D processing facilities, each as defined in 6 NYCRR Part 360.
- Salt storage facilities. Storage of chloride salts for road de-icing is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.
- Residential uses using wells and septic systems where water consumption exceeds natural recharge calculated using water budget methods described below.
- Veterinary hospitals and offices
- Spreading, injection, or storage of agricultural livestock waste
- Funeral parlors engaging in embalming
- Storage or disposal of manure, fertilizers, pesticides/herbicides.
- Disposal, by burial, of any hazardous waste, as defined in 6 NYCRR Part 371

Wetlands
Ecological systems that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Three elements define wetlands:

- Soil (saturated or covered with water at some time during the growing season).
- Water (water table is at or near the surface).
- Plants (indicator plants adapted to live in saturated soil).

Current wetland coverage in the Saw Kill watershed is approximately 10 percent (DEC mapped wetlands, NWI mapped wetlands, additional areas of hydric soil).

Buffers
Vegetated areas along the edges of streams, lakes and wetlands that protect these water resources from adjacent land uses.

Green infrastructure
Defined in the NYS Environmental Quality Review Act as practices that manage storm water through infiltration, evapo-transpiration and reuse including: the use of permeable pavement; bio-retention; green roofs and green walls; tree pits and urban forestry; stormwater planters; rain gardens; vegetated swales; downspout disconnection; stormwater harvesting and reuse.

References

American Rivers. Pharmaceuticals in the Water Supply. [https://www.americanrivers.org/threats-solutions/clean-water/pharmaceuticals-personal-care/]

Chae, E. (2018) Saw Kill Source Water Evaluation. NYSDEC, NYS Water Resources Institurte.

Conley, Amy K., Erin L. White, and Timothy G. Howard (2018). New York State Riparian Opportunity Assessment. New York Natural Heritage Program, State University of New York College of Environmental Science and Forestry, Albany, NY.

Developing community-focused, climate-change informed flooding decision support tools for New York State. Workshop, ABT Study, Town of Red Hook. October 13, 2017.

Dutchess County Government, Dutchess County Communities, Urban-Mead, R. (2010). Town of Red Hook Aquifer Protection Ordinance (draft).

Environmental Law Institute (2003). Conservation Thresholds for Land Use Planners,Washington DC.

Fuss and O'Neill, Inc. (2018). Saw Kill Watershed and Flood Mitigation Assessment- Final Report. NYSDEC Hudson River Estuary Program, NEIWPCC.

Johnson, C.W., & Buffler, S. (2008). Riparian Buffer Design Guidelines For Water Quality and Wildlife Habitat Functions on Agricultural Landscapes in the Intermountain West. General Technical Report RMRS-GTR-203. USDA, Forest Service, Rocky Mountain Research Station. (**Message providing details for determining size of buffers based on slope, soils, and other site conditions**)

Klein, R. D. (1979). Urbanization and stream quality impairment. Water Resources Bulletin 15:948–963.

Kwon, H.Y. et al. (2019). Eight Tools of Watershed Protection in Developing Areas. Center for Watershed Protection, EPA. [https://cfpub.epa.gov/watertrain/pdf/modules/new_eighttools.pdf]

National Menu of Best Management Practices for Stormwater. NPDES, EPA. [https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu]

Pringle, C. M. (2001). Hydrologic connectivity and the management of biological reserves: a global perspective. Ecological Applications 11:981–998.

Riverkeeper (2017). How's The Water? 2017 Technical Report [https://www.riverkeeper.org/wp-content/uploads/2017/11/Riverkeeper_WQReport_2017_final-1.pdf]

Saw Kill Watershed Community (2018). Water Quality Data. [https://drive.google.com/drive/folders/1p6-iIA78md61LZbYfnZeMsplSCmTb0xp]

State of the Saw Kill (2018). Saw Kill Watershed Community [sawkillwatershed.wordpress.com]

Sweeney, B.W. & Newbold, D. (2014). Streamside Forest Buffer Width Needed to Protect Stream Water Quality, Habitat, and Organisms: A Literature Review. *Journal of the American Water Resources Association, Vol 50. No.3,* 560-584.

Thomas Schueler et al., (2009). Is Impervious Cover Still Important? Review of Recent Research. *Journal of Hydrologic Engineering, Vol 14, No 4*

Town of New Paltz, Ulster County. Town Code. [https://ecode360.com/NE1058]

Urban-Mead, R. (2006). Dutchess County Aquifer Recharge and Sustainable Rural Density Analysis. Chazen Companies, NY.

Walter et al., (2014). Determining Peak Flow Under Different Scenarios and Identifiying Undersized Culverts, Technical Report. Collaboration between Cornell University, NYSDEC Hudson River Estuary Program, NYS Water Resources Institute.

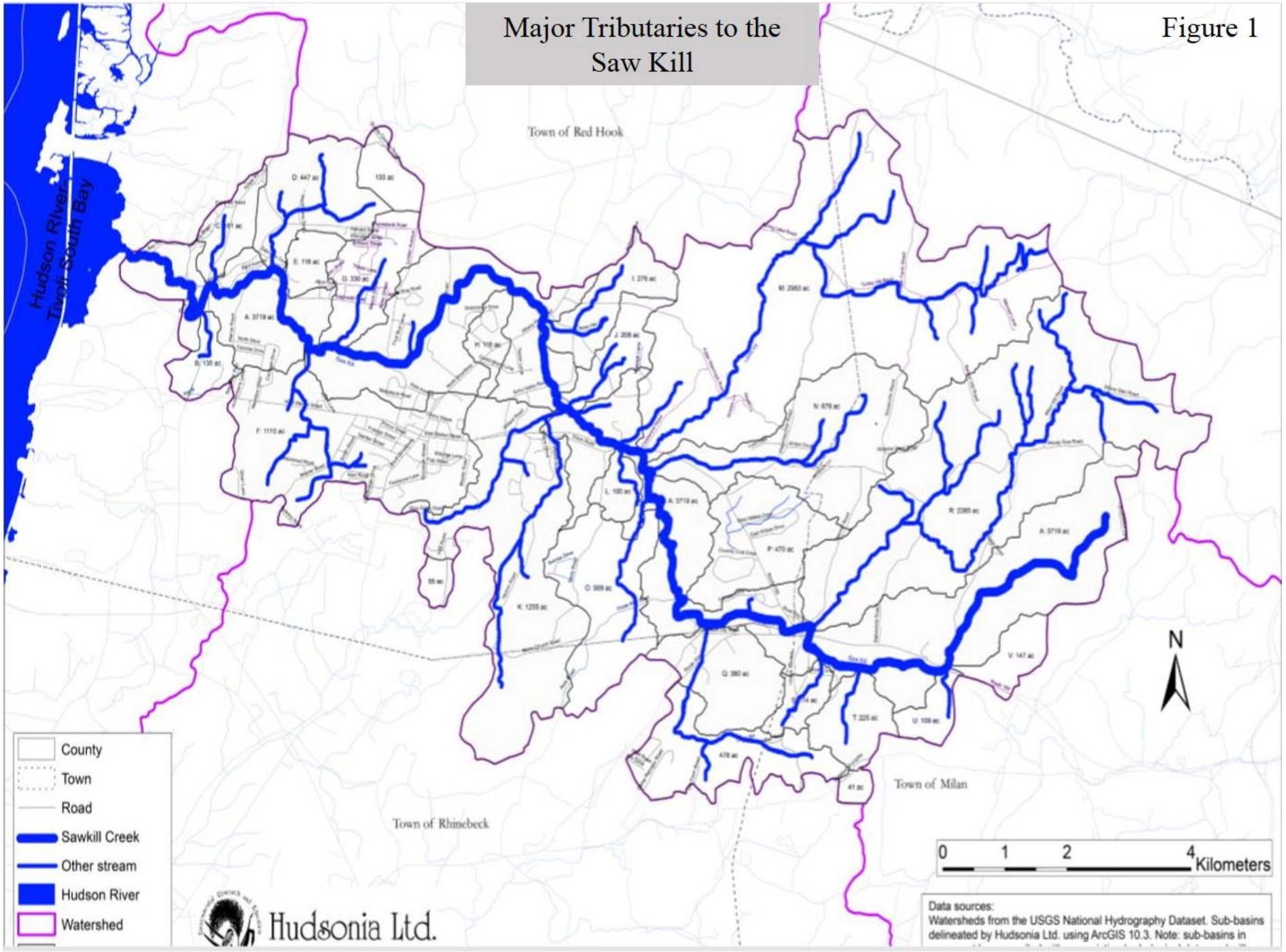
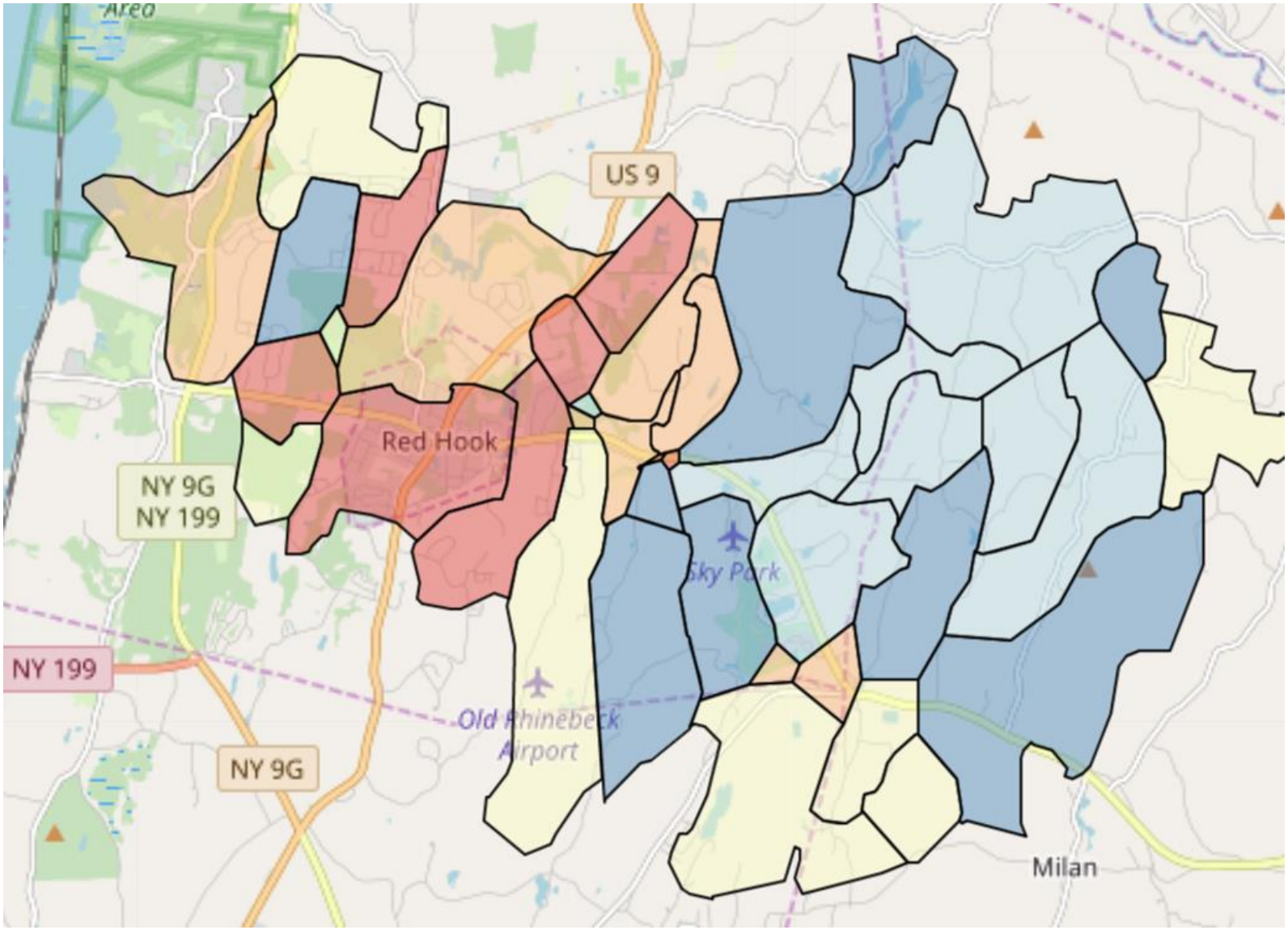

Major Tributaries to the Saw Kill
Figure 1
Town of Red Hook
Hudson River
Tivoli South Bay
Town of Rhinebeck
Town of Milan
N
0 1 2 4 Kilometers
County
Town
Road
Sawkill Creek
Other stream
Hudson River
Watershed
Hudsonia Ltd.
Data sources:
Watersheds from the USGS National Hydrography Dataset. Sub-basins delineated by Hudsonia Ltd. using ArcGIS 10.3. Note: sub-basins in

Figure 2: Catchment Areas From NYS Trees for Tribs
Statewide Data Explorer

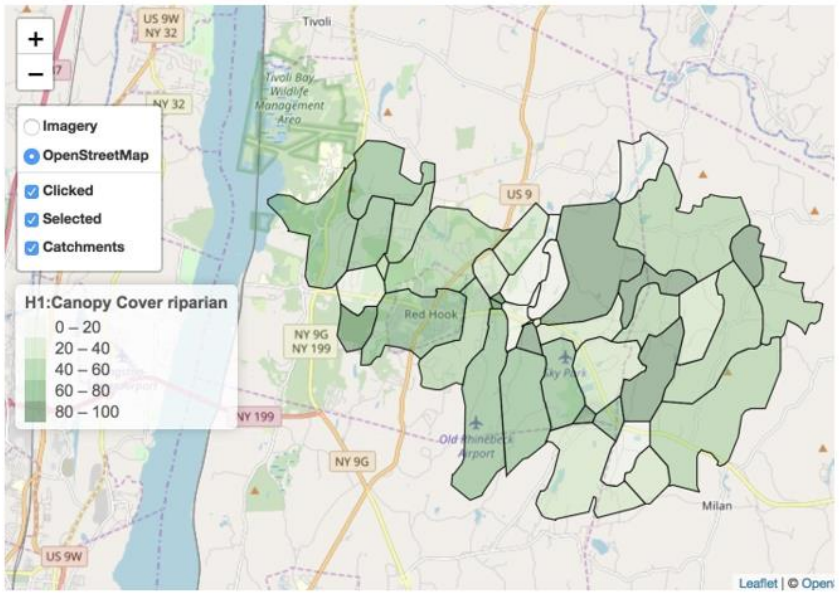


Description- The dark red areas are the highest ecologically stressed catchment areas, the darkest blue areas have the least ecological stress. The ecological stress is caused by runoff, dams, impervious surfaces, and erosion.

Figure 3: Canopy Cover vs. Impervious Surfaces in Riparian Zones

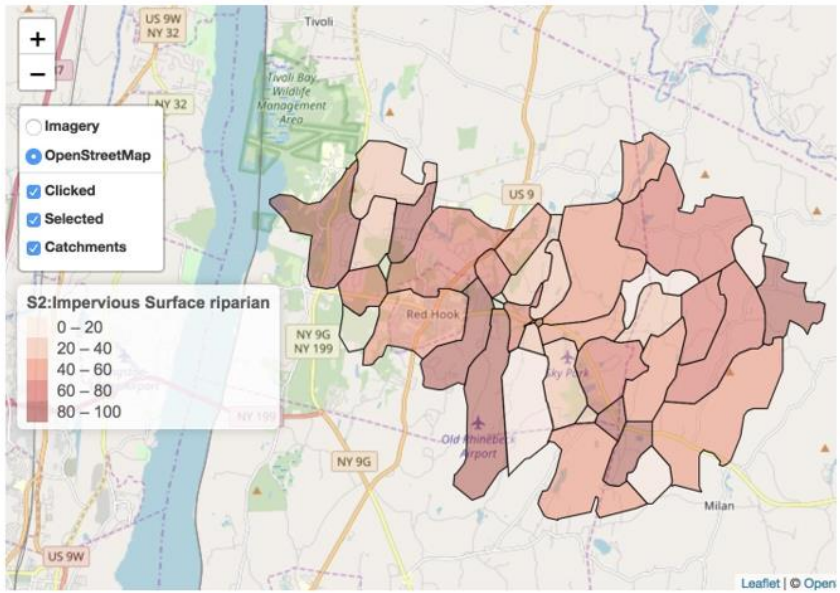
NYS Trees for Tribs Statewide Data Explorer

Canopy Cover

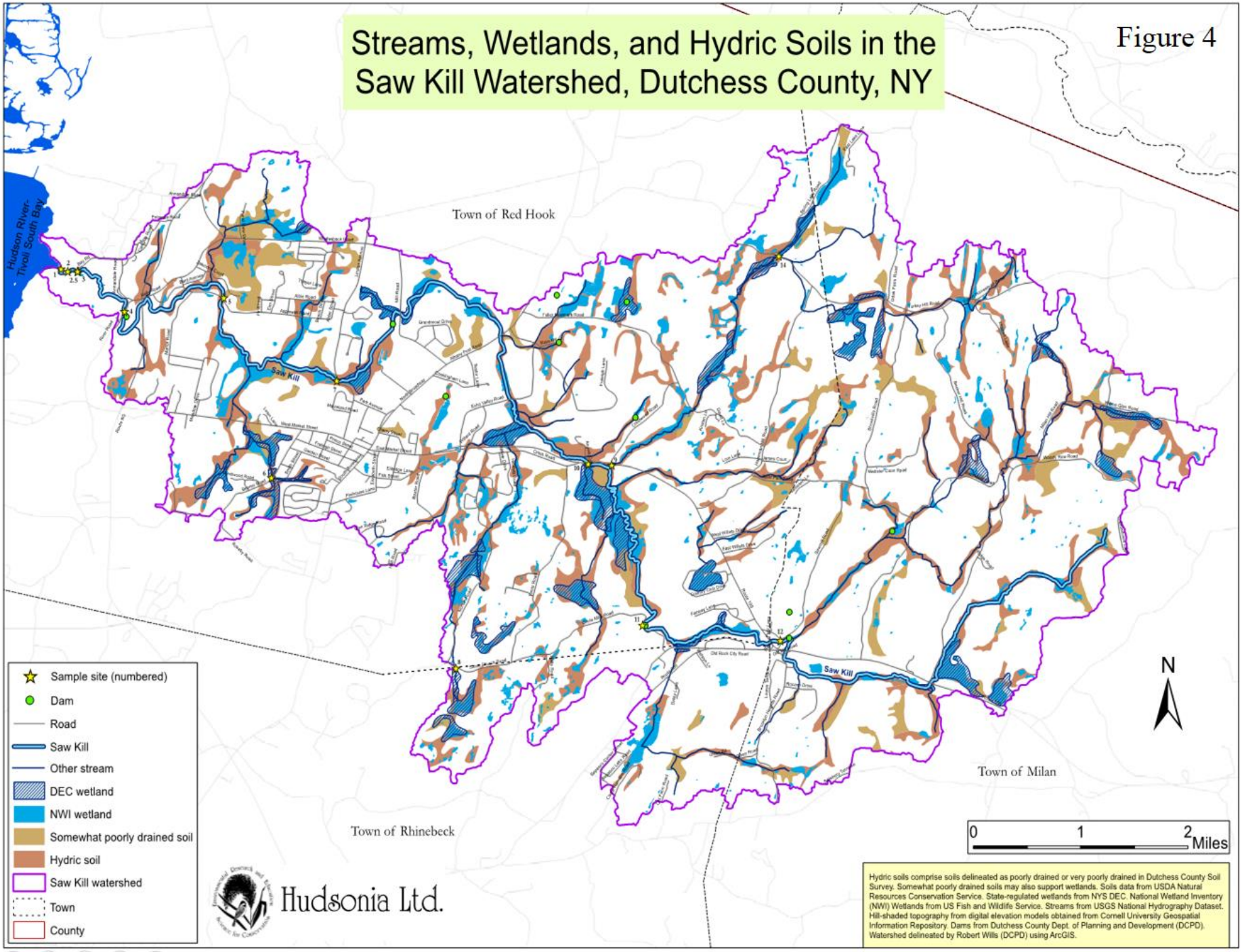


Dark areas have more canopy coverage, light areas have less canopy coverage

Impervious Surface



Dark areas have more impervious surfaces, light areas have less impervious surfaces


Streams, Wetlands, and Hydric Soils in the Saw Kill Watershed, Dutchess County, NY
Figure 4
Town of Red Hook
Hudson River-Tivoli South Bay
Saw Kill
Saw Kill
Town of Milan
Town of Rhinebeck
Sample site (numbered)
Dam
Road
Saw Kill
Other stream
DEC wetland
NWI wetland
Somewhat poorly drained soil
Hydric soil
Saw Kill watershed
Town
County
N
0
1
2 Miles
Hudsonia Ltd.
Hydric soils comprise soils delineated as poorly drained or very poorly drained in Dutchess County Soil Survey. Somewhat poorly drained soils may also support wetlands. Soils data from USDA Natural Resources Conservation Service. State-regulated wetlands from NYS DEC. National Wetland Inventory (NWI) Wetlands from US Fish and Wildlife Service. Streams from USGS National Hydrography Dataset. Hill-shaded topography from digital elevation models obtained from Cornell University Geospatial Information Repository. Dams from Dutchess County Dept. of Planning and Development (DCPD). Watershed delineated by Robert Wills (DCPD) using ArcGIS.