Conservation Easements as a Strategy for Drinking Water Protection, Lewisburg, West Virginia

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WEST VIRGINIA LANDTRUST

Downstream Strategies

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ACKNOWLEDGEMENTS

We would like to thank the dedicated group of stakeholders who attended multiple meetings and provided insight beneficial to the success of this study. We would also like to thank the Peyton Family Foundation for their generous donation which made this study possible.

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INTRODUCTION

The Greenbrier River is the water source for the City of Lewisburg's publicly-owned water treatment plant, which provides drinking water to approximately 4,704 customers (WVBPH, 2014). Additionally, the City of Ronceverte purchases drinking water from the Lewisburg system to supply approximately 1,033 customers. Drinking water is a necessity for everyday living. Therefore, it is imperative to ensure safe, adequate supplies and minimize the risk of contamination to water sources, such as the Greenbrier River. One potential strategy is to protect land in the area upstream of a drinking water intake to limit future development and ensure intact land buffers remain between surface waterways and potential pollutant sources (The Trust for Public Land, 2004). Intact buffers, such as a forested riparian corridor, serve as natural filters for runoff and other pollutants and help reduce the potential for contamination to reach a waterway, and ultimately minimizing the potential for pollutants to enter a treatment plant. The West Virginia Land Trust, Downstream Strategies, and a group of stakeholders from the Lewisburg area have taken on the task of identifying parcels of land to prioritize for conservation easements that would limit development and permanently protect land as a way to contribute to the protection of Lewisburg's drinking water source—the Greenbrier River.

Input from local stakeholders was sought throughout the study. Data sources to be included in the analysis were identified, a study area boundary was set, and an implementation plan was decided on during a series of public meetings. A Geospatial Information System (GIS)–based decision support model was utilized to assess areas with potential to negatively impact water quality and areas with natural qualities that contribute to high water quality. This document provides an overview of the methods applied and describes the results of the analysis—identification of more than 100 parcels for which conservation easements will be pursued by the West Virginia Land Trust.

Goal of this project: Identify parcels of land that show potential to contribute to maintenance of water quality and to decrease the risk of accidental releases of hazardous liquids into the Greenbrier River upstream of the intake for the Lewisburg Public Water System.

Lewisburg Public Water Supply System

The Lewisburg Public Water Supply System (PWS), located in Greenbrier County, draws water from an intake on the Greenbrier River to provide water to 10,050 people. The West Virginia Bureau for Public Health (WVBPH) completed a source water assessment report (SWAR) for Lewisburg in 2003, which determined that its source water is moderately susceptible to contamination (WVBPH, 2003). In addition, the Lewisburg PWS also supplies water to the City of Ronceverte, which does not have its own water intake and purchases its water from Lewisburg. The Ronceverte water system serves a population of 2,180.

The Lewisburg PWS plans to establish a new raw water intake approximately 1.5 miles upstream from the current intake. It is estimated that the new intake could be operational by late 2016. The PWS continues to explore alternative water sources as required by SB 373 (W.Va. Code §16-1-9c). This analysis considers both the current and projected intakes on the Greenbrier River, but does not consider a future alternative intake.

For surface water intakes, protection areas are called zones of critical concern (ZCCs). ZCCs include the land alongside the river and its tributaries such that surface water will reach the intake within five hours. The ZCC for a public water utility is described as "a corridor along streams within a watershed that warrants more detailed scrutiny due to its proximity to the surface water intake and the intake's susceptibility to potential contaminants within that corridor (WVDEP, 2014a)." Parcels within these protection areas represent the most immediate targets for potential land conservation by the West Virginia Land Trust.

The ZCC for the Lewisburg PWS extends approximately 10 miles upstream from the system's intake on the Greenbrier River and includes portions of tributaries with mouths in this extent (WVBPH, 2014b). It is estimated that the new intake could be operational in late 2016; therefore, for this study we estimated a ZCC for the new intake based on guidance from the West Virginia University (WVU) GIS Technical Center—the party responsible for delineating ZCCs for all water systems in the state (WVU GIS, 2015). Our estimated ZCC for the new intake is likely conservative and includes a greater length of each of the tributaries contained in the protection area. ZCCs for the current and future intakes are indicated on each map on the following pages.

Zone of Critical Concern (ZCC): A zone of critical concern is calculated using a mathematical model and represents a 5 hour travel time on a river and its tributaries. It includes 1,000 feet from each bank of the mainstem and 500 feet from each bank of tributaries.

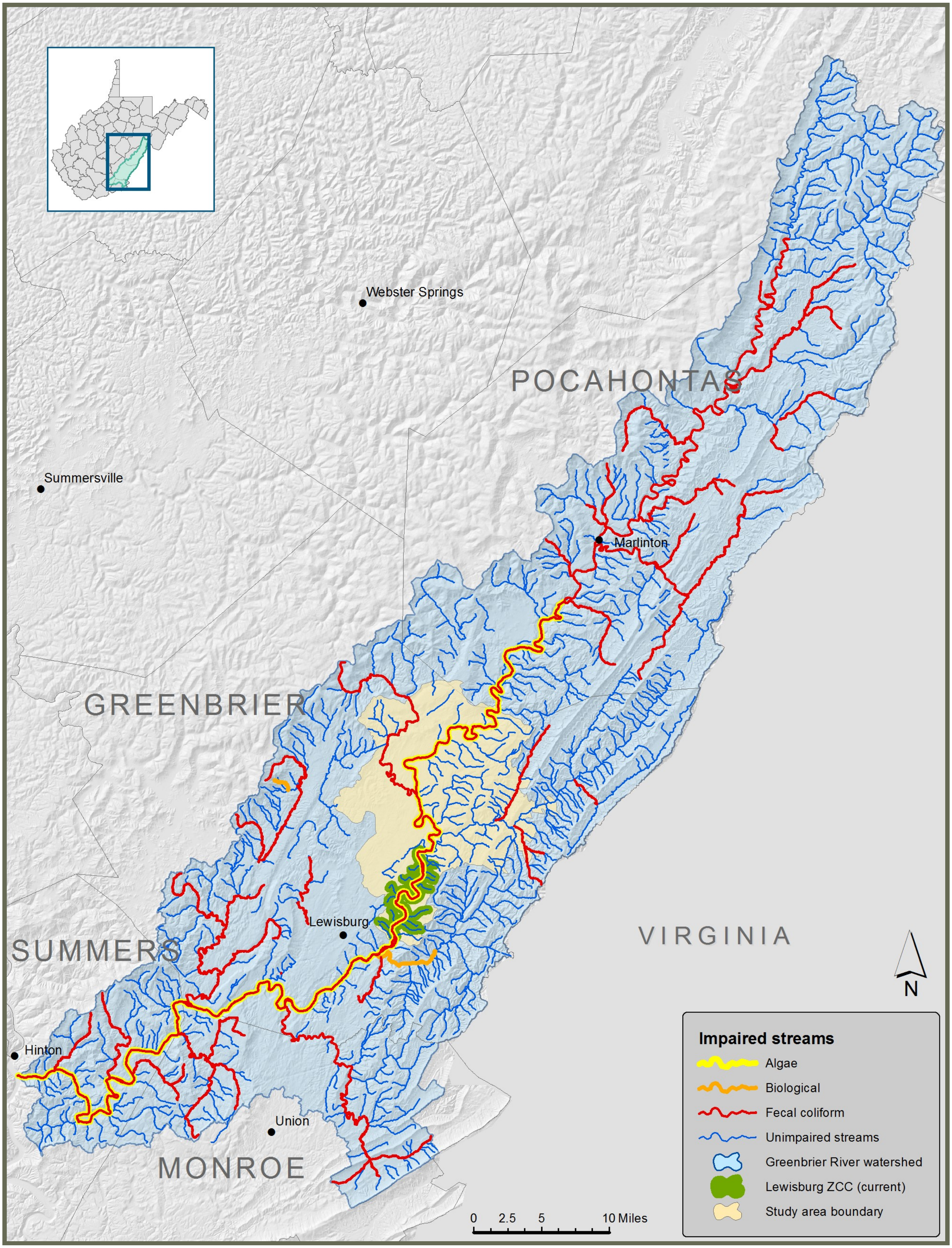
Greenbrier River Watershed

The Greenbrier River watershed spans four counties—Pocahontas, Greenbrier, Monroe, and Summers—in southeastern West Virginia. The Greenbrier River stretches 173 miles from its headwaters in northern Pocahontas County to its mouth near Hinton. The entire drainage area of the watershed encompasses 1,646 square miles, and the largest population center is Lewisburg. Much of the northern portion of the watershed is located within the Monongahela National Forest, and approximately 10% of the watershed sits upon a karst geologic formation. Karst terrain, created from the dissolution of the soluble rock limestone, is characterized by springs, sinkholes, and caves. This Swiss cheese–like formation allows pollutants to enter groundwater quickly, bypassing natural filtration through soil and sediment (USGS, 2014 and FOLGR, 2014).

As illustrated in Figure 2, more than 500 stream miles within the Greenbrier River watershed are impaired—approximately 26% of all stream miles. Almost all of the impaired stream miles, 494 miles, are impacted by fecal coliform bacteria. Of these fecal-impaired stream miles, 108 miles—including the stretch where the current and projected Lewisburg water system intakes are located—are also impaired by algae. Just under eight miles of stream are characterized as having conditions not suitable for biological life. (WVDEP, 2014b)

Filamentous algae blooms have been documented in the Greenbrier River watershed. When growth of these algae is excessive, large mats can cover significant portions of a river. When this occurs near a drinking water intake, public water systems often receive complaints about the odor and/or the taste of the water, which requires additional treatment expenditures. (WVDEP, 2014c)

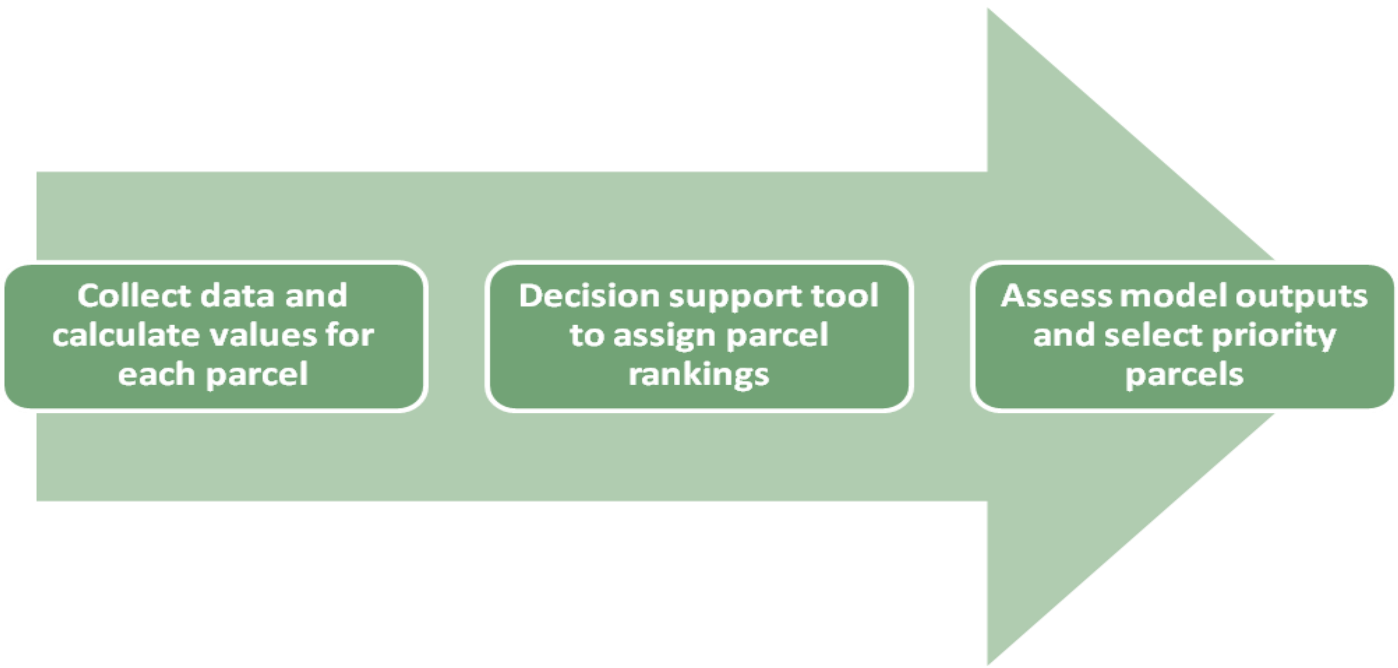
Figure 1. Water quality in the Greenbrier River watershed



PROCESS

This study relied heavily on input from Lewisburg area stakeholders to help recognize the most important local threats to water quality and portions of the watershed on which to focus our efforts. Stakeholder contributions were combined with a GIS-based decision-support model to create maps showing parcels of land that were characterized as having natural qualities suitable to contribute to healthy water quality and parcels with the highest potential to contribute contaminants that could harm water quality. These model outputs were combined to identify greater than one hundred parcels to prioritize for conservation easements, should the landowners be willing (See Figure 2).

Figure 2. Process overview

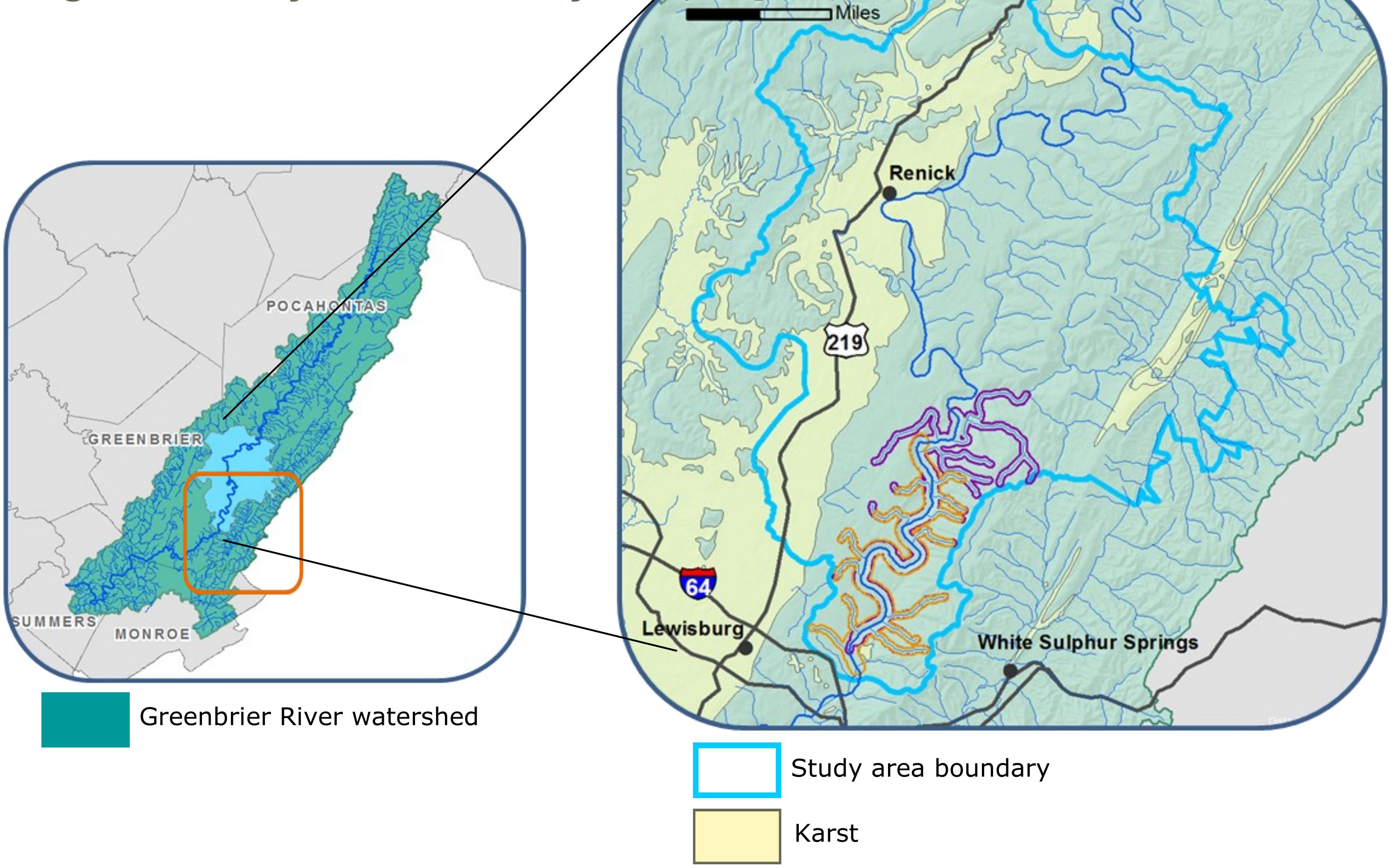


The study area

As shown in Figure 3, this study examined parcels of land located within both the current and projected ZCC for the Lewisburg intake as well as areas further upstream. While the releases of pollutants within the ZCC pose a more immediate threat to the water supply, preservation of upstream reaches can also help protect water quality at the intakes. The study area boundary for this project was decided on with considerable input from stakeholders.

A suite of data sources were examined to help determine the study area boundary, including watershed boundaries, river miles upstream from the intakes, potential significant contaminant sources, and populated areas. Federally owned land—the Monongahela National Forest, for example—and properties in existing conservation easements were not included in this study.

Figure 3. Study area boundary



1 Collect data and calculate values for each parcel

Data describing locations of potential sources of pollutants and natural qualities of land in the study area were collected. The raw data were then summarized by tax parcel. This provided a value for each type of data for each parcel. For example, the number of stream miles that transect each parcel was calculated.

All data were separated into two categories: contamination potential and natural quality. This allowed for identification of parcels most likely to contribute pollutants to waterways and those with natural qualities that may attenuate discharge of pollutants or that are ideal candidates for conservation easements.

Data representing contamination potential were included because contaminants may contribute to issues at the treatment plant. The main issues include increased treatment costs, taste and odor complaints, formation of disinfection byproducts, wear and tear on infrastructure or equipment, and extreme situations—such as hazmat spills or toxic algae blooms—that result in shutting down intakes and/or service. These issues result in extra expenses to the treatment plant and also pose unnecessary risks to the health of consumers. Lack of water service during "do not drink" orders may result in undue expenses to businesses. The water provider and/or communities may also accrue costs from emergency response efforts related to hazmat spills or other harmful contamination incidents.

Data used to assess contamination potential

Threats to drinking water can generally be divided into those that lead to a long-term decline in water quality by gradually releasing pollutants over time and those that pose the threat of a sudden release of a contaminant to surface water, resulting in an emergency situation for the water treatment plant.

Road density
Roads threaten drinking water quality in a variety of ways. Both paved and unpaved roads act as conduits for pollutants, particularly during wet weather events. Erosion and runoff from unpaved roads contribute sediment into waterways and paved roads carry sediment, as well as other pollutants, such as fuel and other vehicle fluids. Additionally, accidents involving vehicles transporting chemicals, fuel, or other substances also pose acute threats to waterways and treatment systems. Parcels of land with established road networks have higher potential for future development and thus higher potential for transportation accidents that lead to surface water pollution.

Agriculture
The Greenbrier River is impaired by fecal coliform bacteria and algae. While agriculture is not the sole contaminant source, nutrient-rich runoff from agricultural land has been found to contribute to both fecal coliform bacterial counts and algal growth in the Greenbrier River and its tributaries. Fertilizers, pesticides, and herbicides have the potential to run off into surface waters when applied to agricultural fields in excess, and thus present another possible contaminant source. Therefore, agricultural land is included as a threat to water quality. Agricultural lands identified in the WVU Natural Resources Analysis Center land use/land cover dataset, which is based on National Agricultural Imagery Program orthoimagery files, are used in this study.

Logging
Logging poses a threat to water quality by increasing sediment inputs and decreasing the ability of forested land to slow and filter stormwater runoff. Logging operations may develop new roads, which can add sediment to surface waters. Intensive harvesting of trees immediately adjacent to streams also leads to increased water temperatures during the summer, which can support growth of algae. However, impacts to water quality resulting from logging are temporary in comparison to the time scale of the benefits of land protection.

Potential significant contaminant sources (PSCSs)
A PSCS can be defined as a facility or land use that stores, uses, or produces substances known or suspected to cause harm from human exposure that can potentially release those substances in significant enough quantities to contaminate a drinking water supply, or require immediate response to protect the drinking water supply. This study relies on three different data sets to identify PSCSs in the study area. The first data source is the SWAR completed in 2003 by WVBPH. Sources identified in this report include residential septic systems, auto repair shops, and gas stations, among others. The second data source utilized is the United States Environmental Protection Agency (USEPA) permitted facilities database, which identifies facilities, sites, or places subject to environmental regulations. The West Virginia Department of Environmental Protection (WVDEP) database of aboveground storage tanks (WVDEP, 2014d) was also utilized to identify PSCSs. Other data, such as the WVDEP oil and gas wells and mining permit boundary databases, were also reviewed, but did not contribute additional contaminant sources in our study area.

Developed land use
The Landuse/Landcover of West Virginia dataset, produced by the WVU Natural Resource Analysis Center (NRAC) with National Agricultural Imagery Program (NAIP) aerial imagery, includes a land use category for developed or barren lands. This land use type includes areas with dense urban or industrial development and barren lands.

Highly developed regions—including areas of commercial, industrial, and dense residential development—have more impervious surface area, and thus less water penetrates the ground. This excess stormwater runs off into surface waters carrying pollutants with it. These areas are also more likely to be home to facilities that store pollutants in large quantities that could be released accidentally into surface waters.

Designated growth area
The Greenbrier County Comprehensive Plan identifies areas of the county as designated growth areas, which are "areas or districts which are deemed to be appropriate for the full range of development (commercial, residential, industrial), are served by public water and sewer, and are adjacent to major transportation corridors" (Greenbrier County Comprehensive Plan, 2014, p. 74). The designated growth area extending north from Lewisburg along US 219 was digitized from a map included in the Comprehensive Plan for use in this study.

The designated growth area has higher potential than other areas included in this study for future development that would include impervious areas and facilities that may store pollutants in large quantities.

Data used to assess natural quality

This section describes data used to assess natural qualities of parcels of land that would make them suitable for protection in a conservation easement and contribute to protection of the public drinking water source. All natural quality datasets, described below, were assigned a high weighting factor in the decision support model.

Percent within the zone of critical concern
The ZCC for a public water utility is described as "a corridor along streams within a watershed that warrants more detailed scrutiny due to its proximity to the surface water intake and the intake's susceptibility to potential contaminants within that corridor (WVDEP, 2014)." Any continual or one-time release of a pollutant in the ZCC will have a larger impact on raw water quality due to proximity to the intake. An emergency situation in this area will allow a much shorter time for reaction by the water treatment plant operator and staff, in comparison to an incident outside of the ZCC.

Forested land use
Forested land plays an important role in maintaining water quality. Intact forest land filters pollutants in runoff before they reach surface waterways, decreases erosion and sedimentation, keeps water temperatures down, refills aquifers, and reduces flooding. The NRAC land use/land cover dataset was used to identify forested land cover in this analysis.

Wetlands
Wetlands are beneficial to water quality because they act as living filters and remove pollutants from water as it passes through them. Wetlands also provide recharge and reduce flood peaks by holding water. Floods threaten water quality and infrastructure. Protection of wetlands is therefore beneficial to water quality in a watershed. US Fish and Wildlife Service National Wetlands Inventory data was used in this analysis.

Soil type
Protection of lands containing soils susceptible to erosion—clays and silts—will minimize sedimentation impacts to water quality. The National Resources Conservation Service SSURGO soil data (Soils Survey Staff, 2015) was used to determine soil type for properties within the study boundary.

Proximity to protected land
Protecting properties adjacent to land that is already protected increases the total unfragmented protected area. Intact forest, wetlands, riparian, and other ecosystems provide buffer zones, which can absorb pollutants, thus preventing them from entering surface and groundwater. The natural ability of ecosystems to protect water quality is diminished when natural ecosystems are divided or 'fragmented'. Thus, preserving large, intact swaths of land maintains the ability of ecosystems to efficiently protect water quality.

Streams
Land adjacent to the Greenbrier River and its tributaries has significant potential to negatively impact surface water quality. Protecting land adjacent to streams from known threats will keep land uses that have the potential to diminish water quality away from streams and can act as a natural buffer zone for the stream.

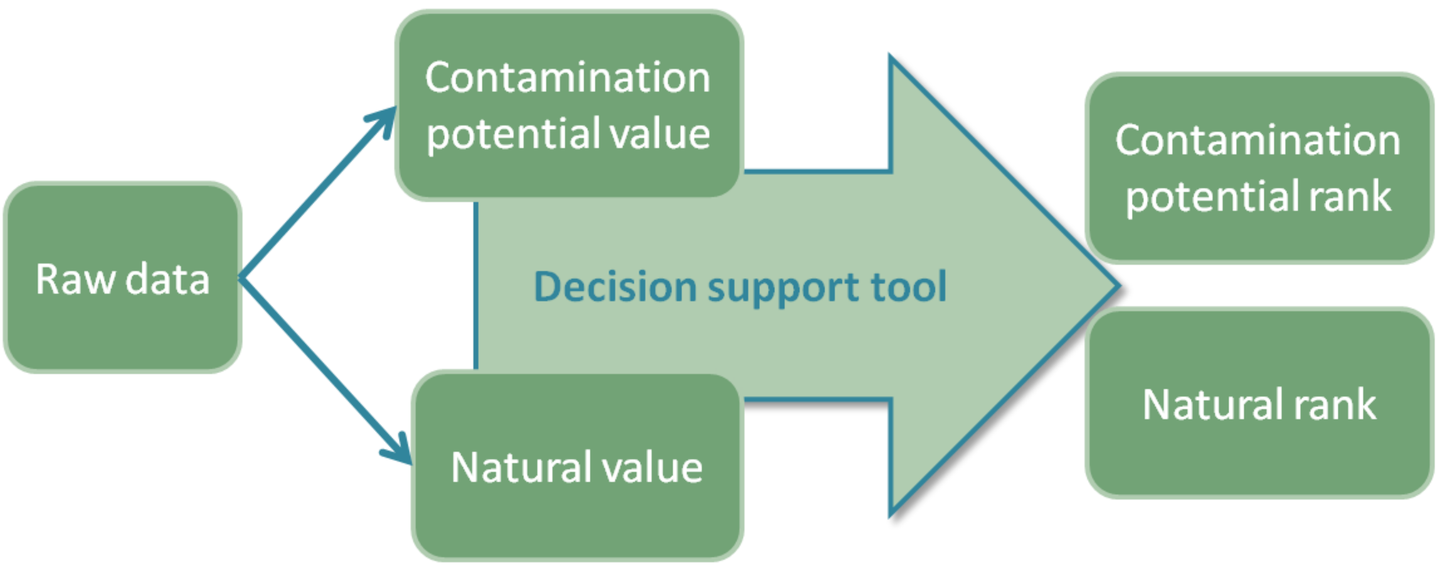
Karst
Karst geology acts as a transport pathway for pollutants to reach surface waters via groundwater pathways. Thus, preserving lands overlying karst areas will decrease the potential for pollutants to make their way to the Greenbrier River.

Floodplain
An intact floodplain is important for its ability to minimize the effects of floods, which can carry heavy loads of pollutants. Floodplains also play a role in filtering pollutants out of water and should be kept intact to avoid erosion and provide a buffer between the river and any development.

2 Implementation of the decision-support model

A GIS-based decision support model was used to assess areas with potential to negatively impact water quality and areas with natural qualities that contribute to high water quality (See Figure 4). The model allows the user to assign different weights (high, medium, low), which represent the importance of each type of data to the outcome. The model was run two times—once to rank parcels for contamination potential (Figures 5-8) and once to assign natural quality rankings (Figures 9-12).

Figure 4. Decision-support model flow diagram



Model data weights

The decision support tool allows the user to assign weights to each type of data to be used during ranking calculations. The weighting schemes applied in this study are documented in the tables below. All natural quality data were assigned an equal weight and were therefore essentially un-weighted.

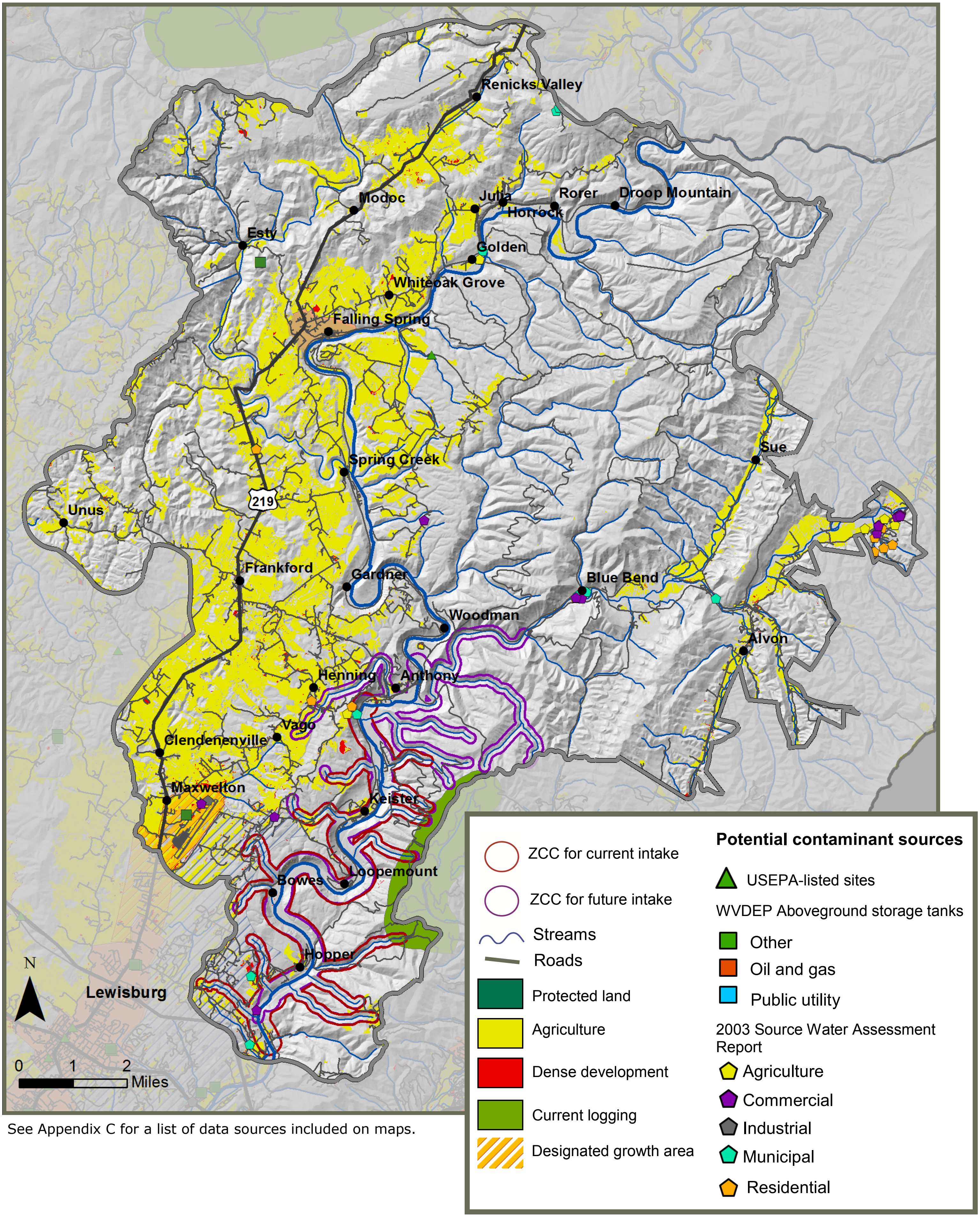
Table 1. Weights applied in the model for ranking of potential to contribute contaminants

Data	Weight
Roads	High
Developed land use	High
Designated growth area	Medium
Agriculture	Medium
Logging	Medium-Low
Potential significant contaminant sources	High

Table 2. Weights applied in the model for ranking of natural quality

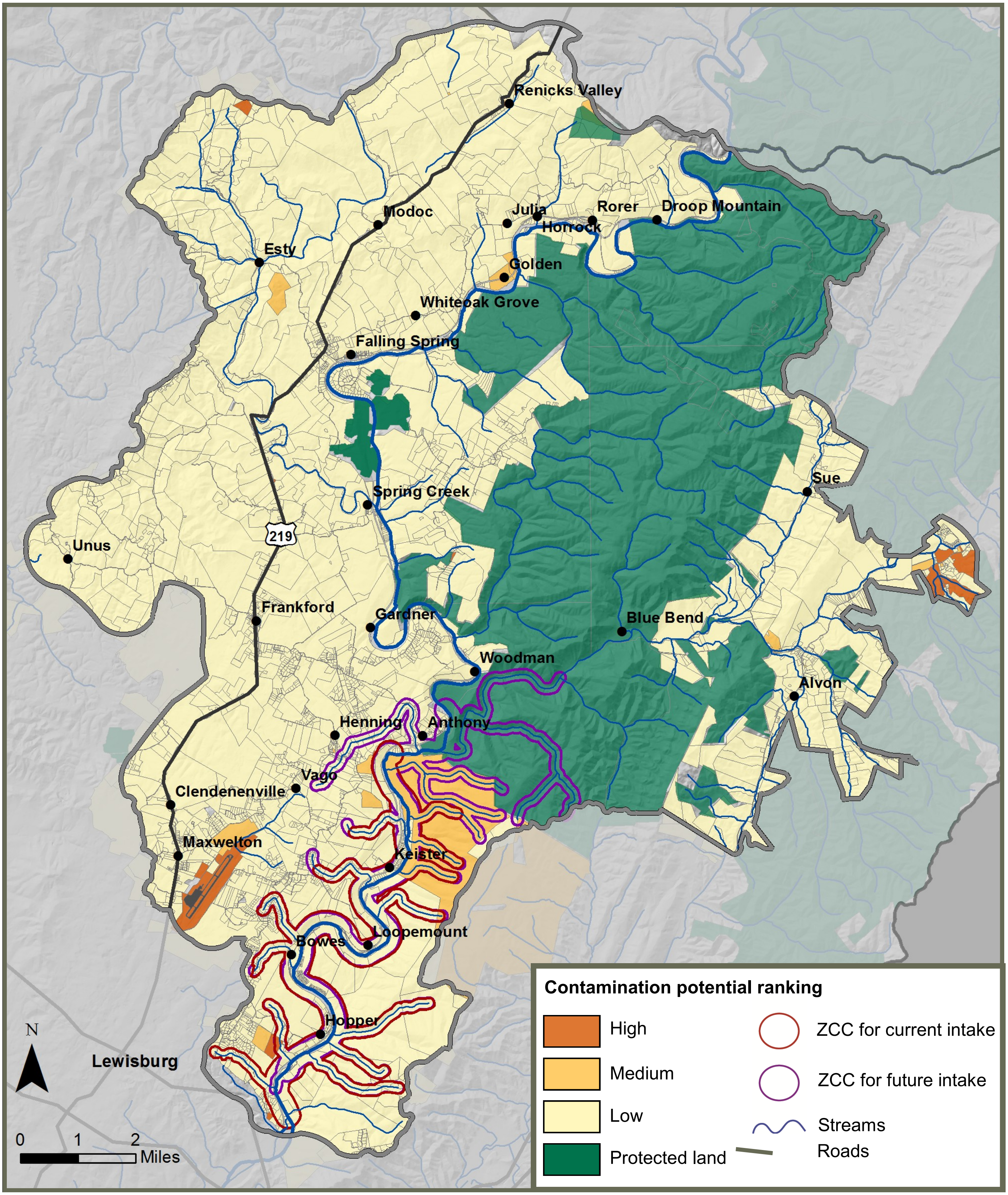
Data	Weight
Streams	High
Karst	High
Percent within the zone of critical concern	High
Forested land use	High
Wetlands	High
Soil type	High
Floodplain	High
Proximity to protected land	High

Figure 5. Data used to assess contamination potential



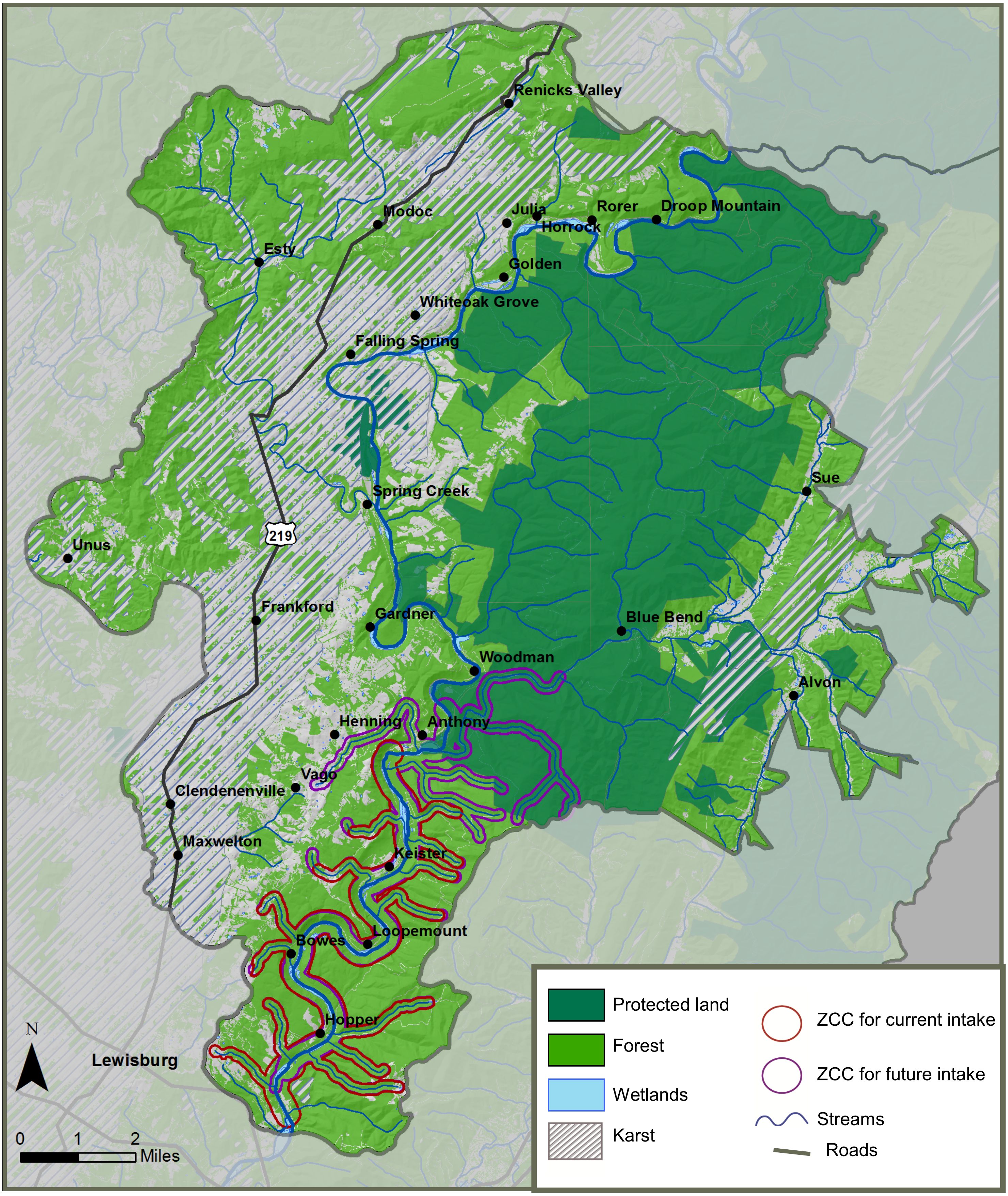
See Appendix C for a list of data sources included on maps.

Figure 6. Model ranking of contamination potential



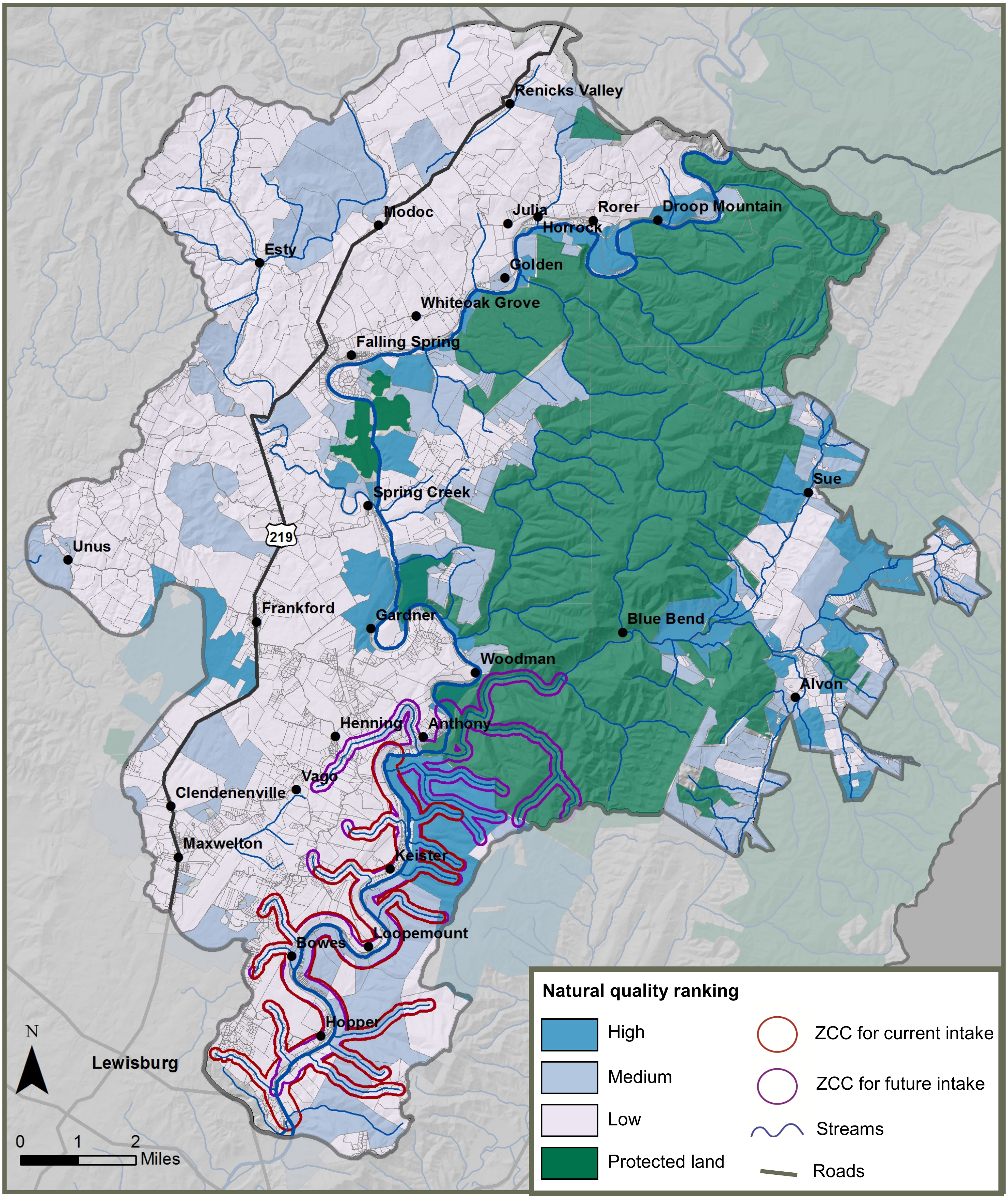
See Appendix C for a list of data sources included on maps.

Figure 7. Data used to assess natural quality



See Appendix C for a list of data sources included on maps.

Figure 8. Model ranking of natural quality



See Appendix C for a list of data sources included on maps.

3 Selection of priority parcels

The decision support model provided information about the parcels most likely to contribute contaminants to surface waters and those with natural landscapes showing potential for conservation that may be able to attenuate contaminants coming from nearby properties. Only parcels greater than 50 acres were included in the final selection because they provide more return on the investment in an easement through greater potential for attenuating pollution and safeguarding water quality.

The following process was followed to select parcels to prioritize for conservation easements.

Figure 9. Process for selection of priority parcels

High natural quality parcels

All parcels greater than 50 acres with a high natural quality ranking were included in the list of priority parcels.

↓

Parcels with high contamination potential

Each parcel with a high contamination potential was examined to determine the predicted flow path from the contaminant source to a surface or groundwater body. Parcels with a high contamination potential and all parcels located downgradient were assessed. If either the parcel with high contamination potential itself or a parcel located between the threat and a water body had capacity to provide a buffer that could attenuate flow of contaminants to surface waters or karst sinkholes, that parcel was added to the list of priority parcels for conservation. The following factors were reviewed

- medium natural quality ranking
- landcover type that shows potential for attenuating pollutants, such as forest or low intensity agriculture
- slope and subwatershed boundaries

↓

Parcels within the current and future ZCCs

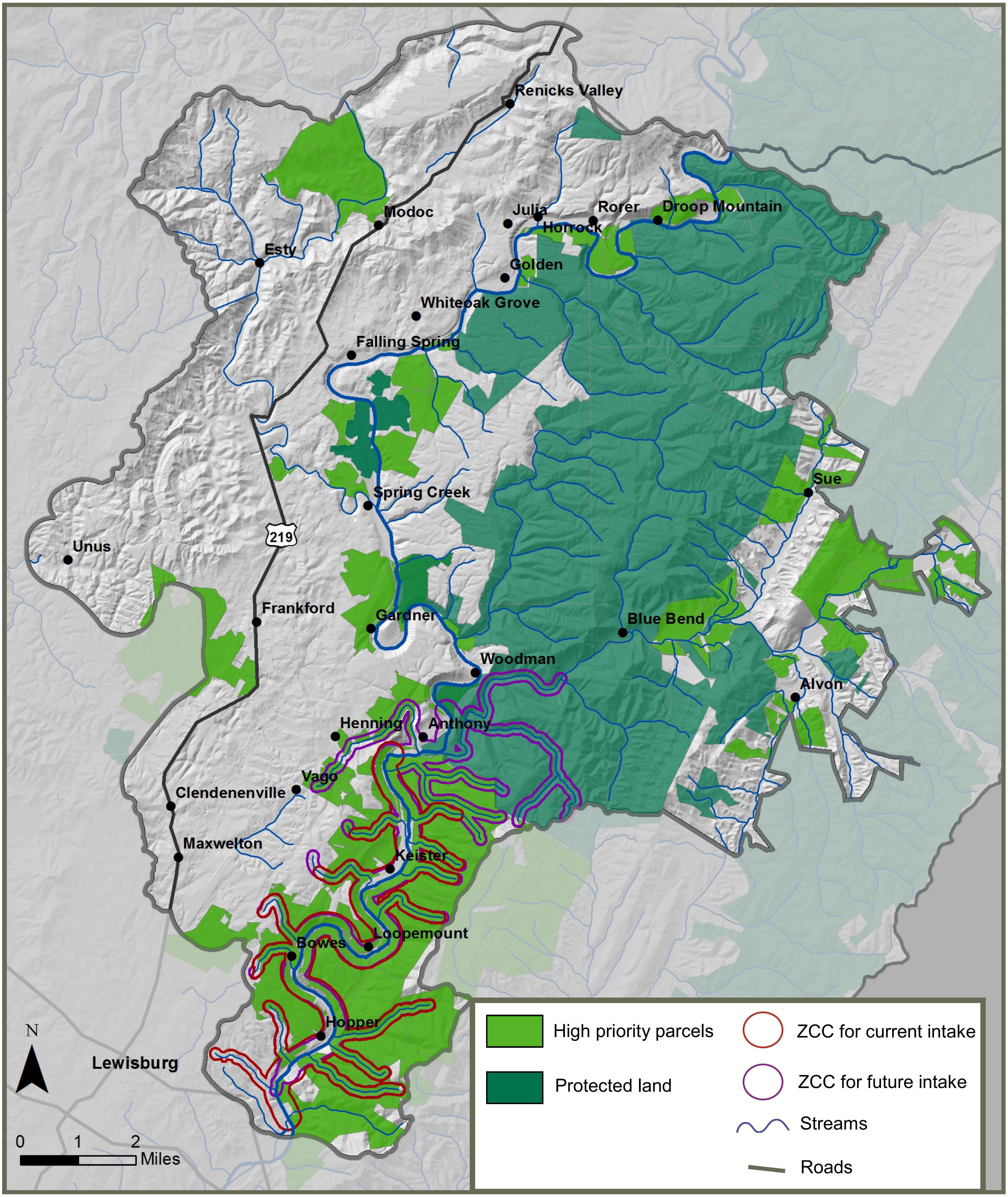
All parcels greater than 50 acres located within both the current and estimated future ZCCs were included.

↓

Priority parcels for conservation easements

The final selected parcels are identified in Figures 14 and 15.

Figure 10. Parcels selected as highest priority for conservation easements



See Appendix C for a list of data sources included on maps.

CONCLUSION AND NEXT STEPS

The process described here—which included geospatial modeling techniques and incorporated significant feedback from stakeholders with local knowledge—resulted in a database of more than 100 parcels with the highest potential to protect Lewisburg's public drinking water source. Protection of these properties in conservation easements could contribute to maintenance of water quality in the Greenbrier at the Lewisburg PWS drinking water intake. The West Virginia Land Trust will pursue conservation easements on these properties through direct communication with landowners.

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APPENDIX A: MODEL DOCUMENTATION

This study relied on a decision-support model to spatially identify tax parcels with the highest natural qualities and those with the highest contamination potential. This model integrates spatial data, user input, and a ranking algorithm within a multiple criteria analysis (MCA) framework. The goal of this framework is to provide a tool to integrate spatial data with a MCA– solving algorithm called compromise programming (CP), which allows users to quickly and interactively explore and analyze data based on polygons—tax parcels in this case.

MCA is an alternative approach to traditional economic evaluation techniques. The basic idea behind MCA is to provide a framework for analyzing choices with multiple criteria and conflicting objectives (Malczewski, 1999). A spatial MCA approach aids in the identification of the most suitable management solution for a given purpose. The approach also allows users to examine the effects of alternative options and presents options in a variety of forms such as monetary units, physical units, and qualitative judgments. This makes it possible to analyze trade-offs between different objectives and address potential conflicts at an early stage, thereby providing the ability to analyze the sensitivity and robustness of different choices.

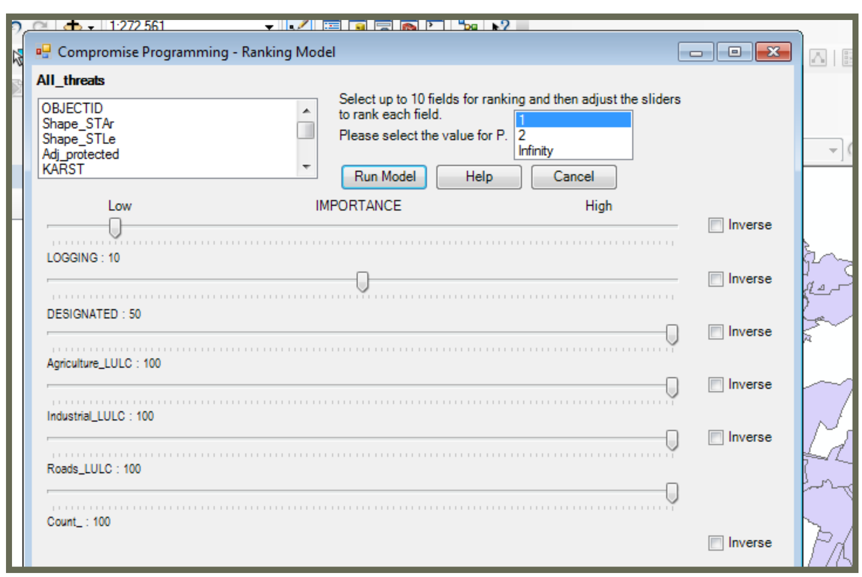
The CP ranking algorithm was chosen because it allows a more theoretically significant ranking of alternatives as compared to a linear weighted model. It also allows the user to integrate sensitivity analysis by altering weights and parameter values to highlight the concern of the decision maker over the degree of separation or difference from the ideal criteria score. The highest ranked results are those that are closest to the ideal or furthest from the least preferred alternatives. CP algorithms have been used in many different MCA applications including preference ranking of irrigation technologies (Tecle and Yitayew, 1990), water resource system planning (Duckstein and Opricovic, 1980; Gershon and Duckstein, 1983), developing forest watershed management schemes (Tecle et al., 1988a), selecting wastewater management alternatives (Tecle et al., 1988b), defining hydropower operations (Duckstein et al., 1989), river basin planning (Hobbs, 1983), and prioritization of parcels for conservation by a Land Trust (Strager and Rosenberger, 2006).

The tool compares each parcel's score or index—related to the threat and contamination potential attributes—and allows the decision maker to assign a weight (or importance value) to each criterion and then to combine all criteria together for a comprehensive overall result. End users can combine and map the various factors for ranking contamination potential and natural quality in the study area. The final spatial model uses the GIS framework, as an extension to ESRI's ArcGIS software.

The extension consists of a graphical interface designed to guide a user through the process of interactively specifying risk factor criteria weights and viewing results.

The main window of the ARC Ranking Toolbar is the ranking model, which provides the ability to display the top- and bottom-ranked counties and to map spatial clusters.

Tool interface



The CP ranking model requires that the user first highlight or make active a shapefile in the table of contents that contains attributes the user wishes to use for the ranking. It is assumed that the user already calculated or added the needed fields to the table in order to use the ranking model. Examples of attributes may be boating access locations, fishing access locations, or water quality indicators. All of the criteria are normalized by the program so that the user does not have to worry about non-commensurate data. All that is required is the direction of value influence. For example, if a higher value for an attribute is desired, then nothing has to be altered in the compromise programming interface; this is the default. However, if the user feels that a lower value is preferred, the inverse button should be selected.

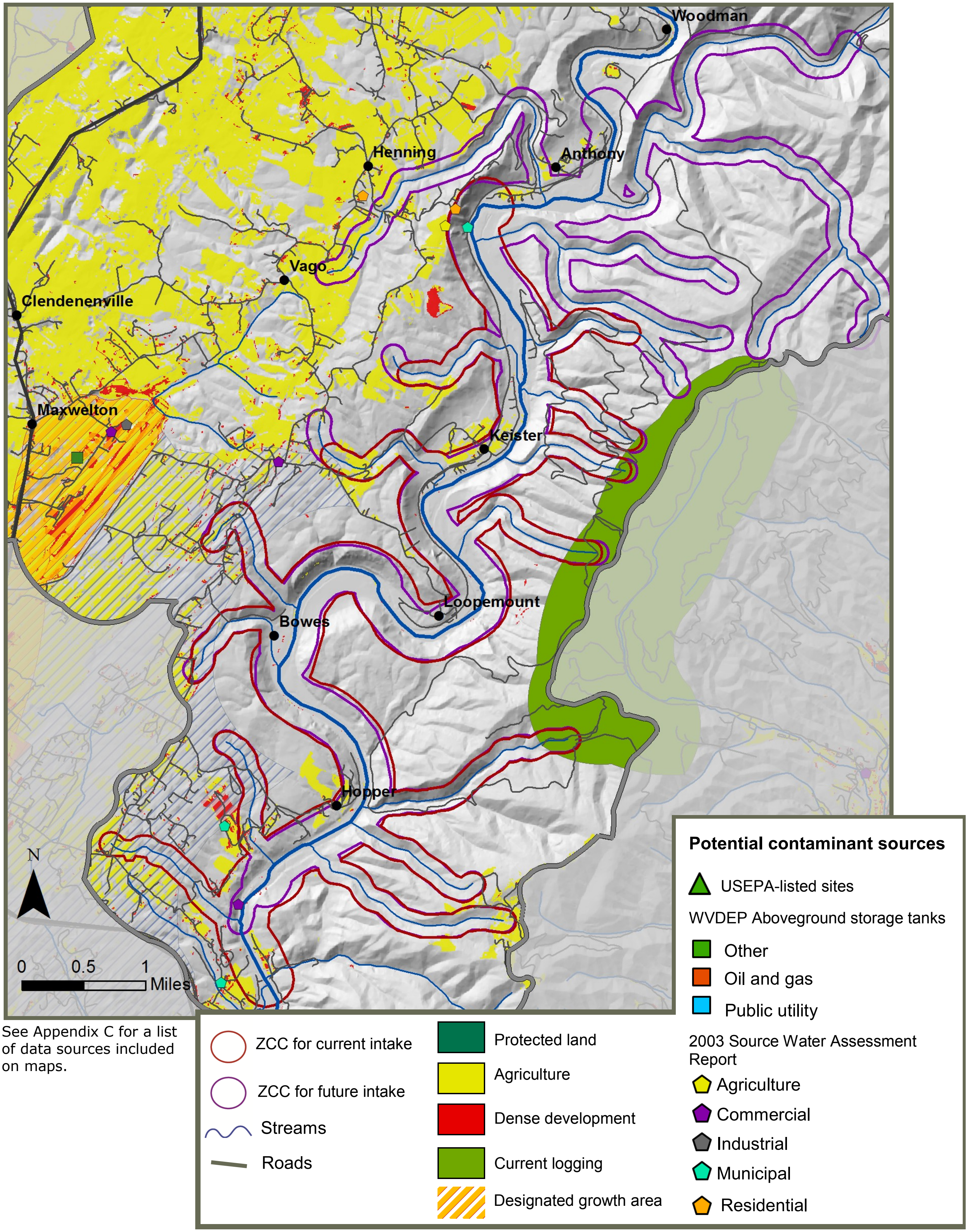
The result of the model run is the addition of a new field to the shapefile—the *Lp* compromise programming metric. Lower values are preferred and a legend is produced automatically for the user. This legend can always be altered to show a different display of the ranked polygons. The true utility of the tool is in the ability to quickly run different scenarios and to test the spatial sensitivity of results.

The decision-support model utilized in the study was created by Downstream Strategies and Michael Strager (WVU) with funding provided by the Appalachian Regional Commission.

APPENDIX B: ZONE OF CRITICAL CONCERN MAPS

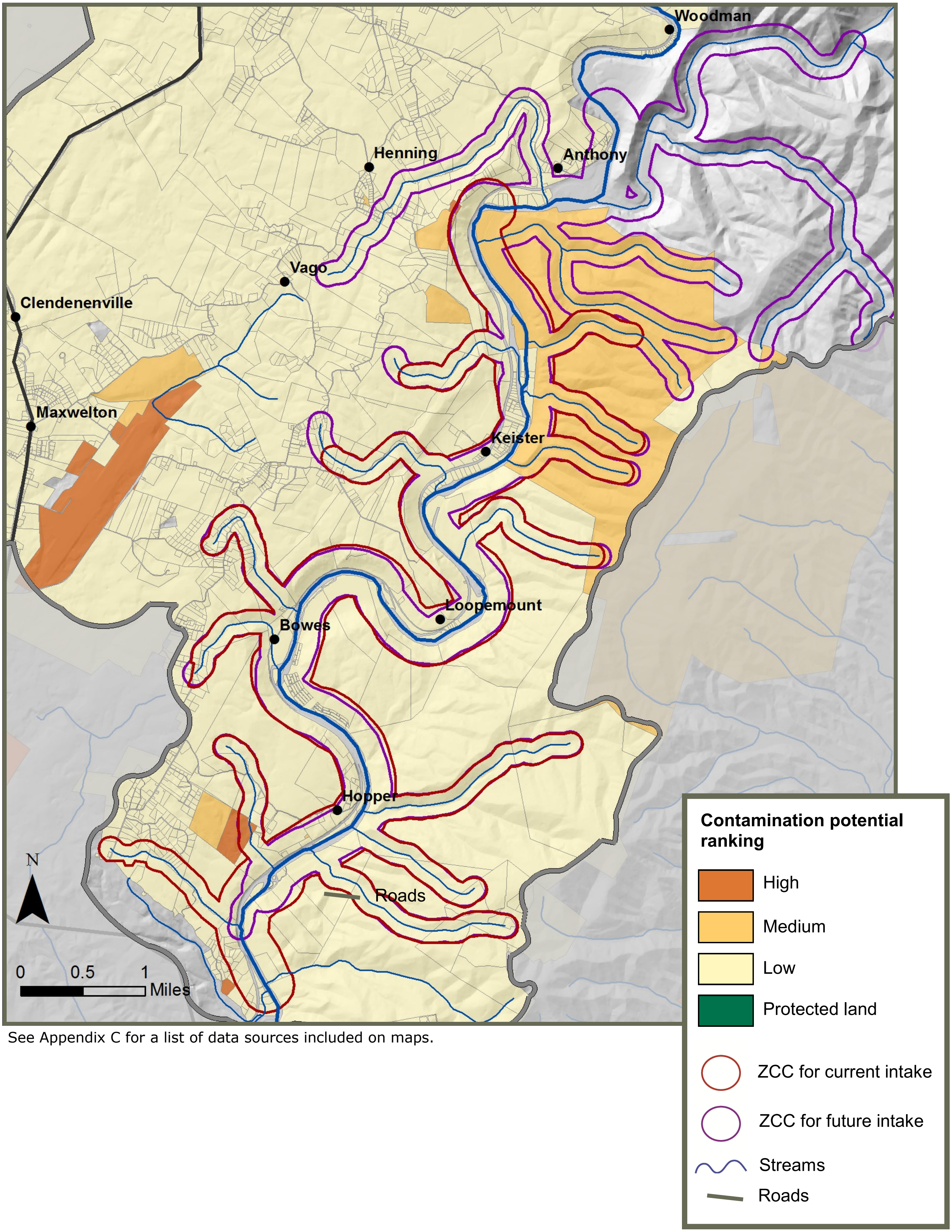
The following pages include maps showing the same data as presented in maps in Figures 5 through 9 in the Zone of Critical Concern—both for the current and projected raw water intakes. While it is important to assess an area larger than the ZCC for potential properties for conservation easements, the area within the ZCC is important. Releases of contaminants within the ZCC have a shorter travel time to the raw water intake, and therefore, would allow a much shorter amount of time for water plant staff to react during an emergency.

Figure 11. Data used to assess contamination potential in the ZCC



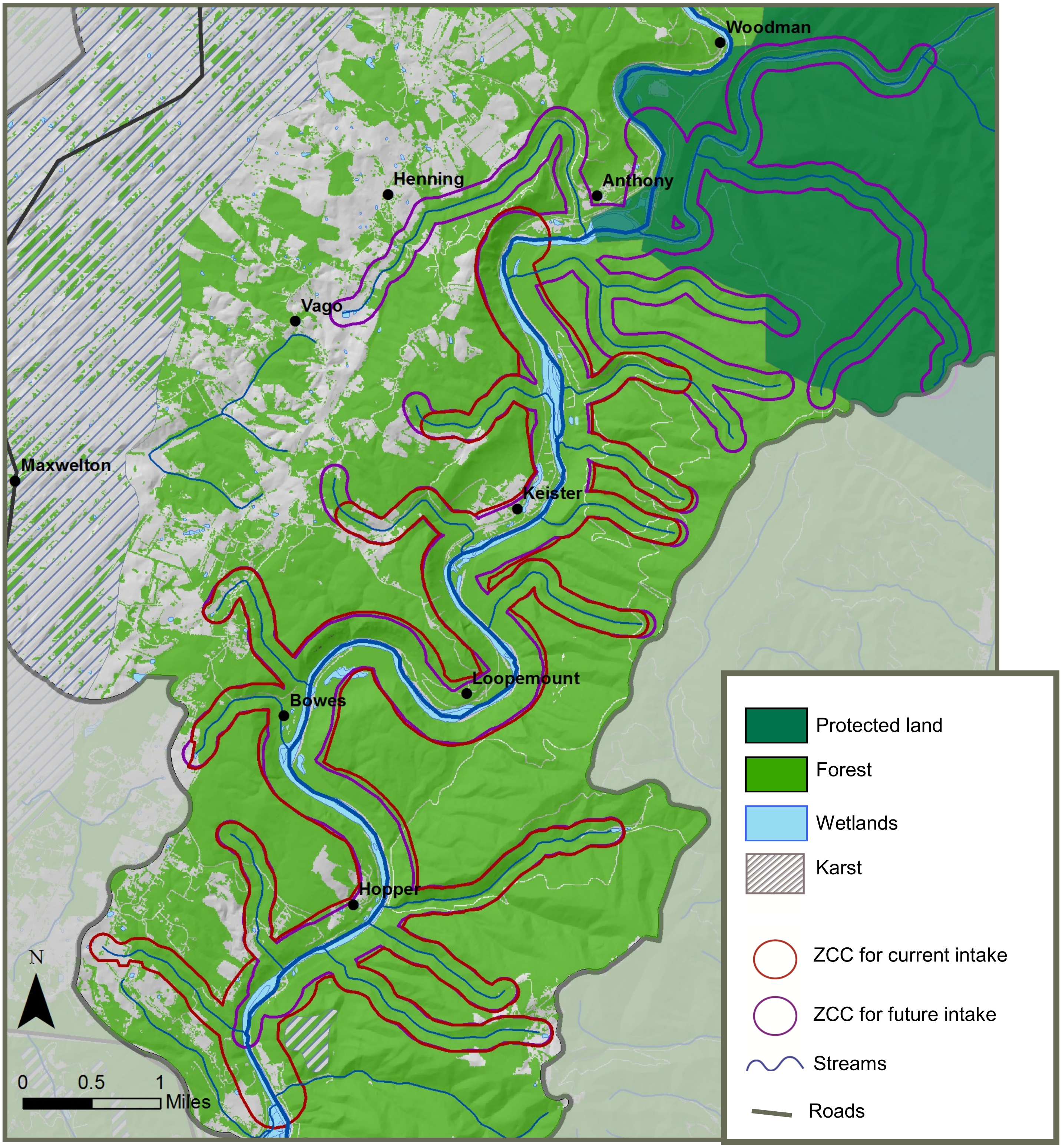
See Appendix C for a list of data sources included on maps.

Figure 12. Model ranking of contamination potential in the ZCC



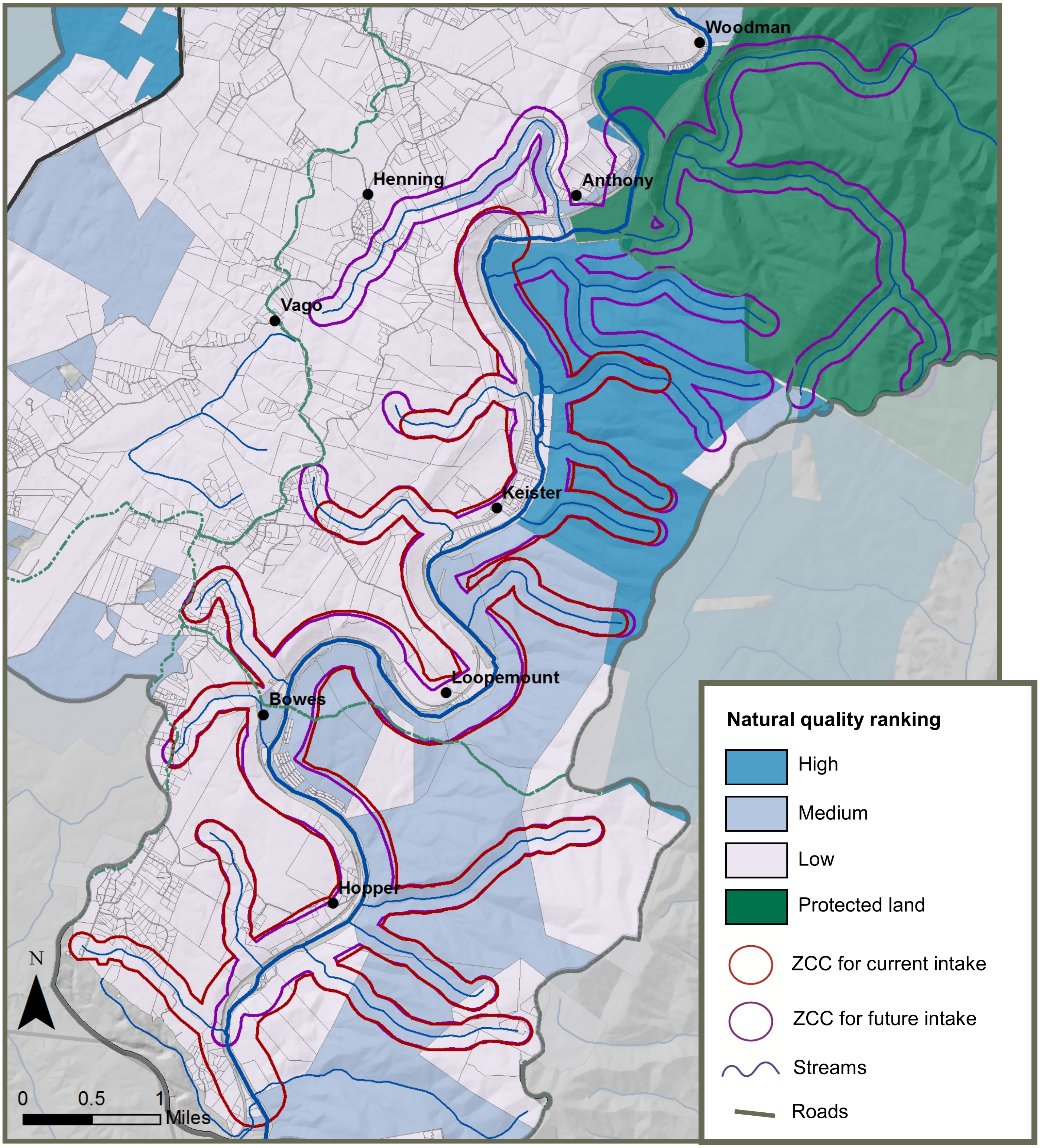
See Appendix C for a list of data sources included on maps.

Figure 13. Data used to assess natural quality in the ZCC



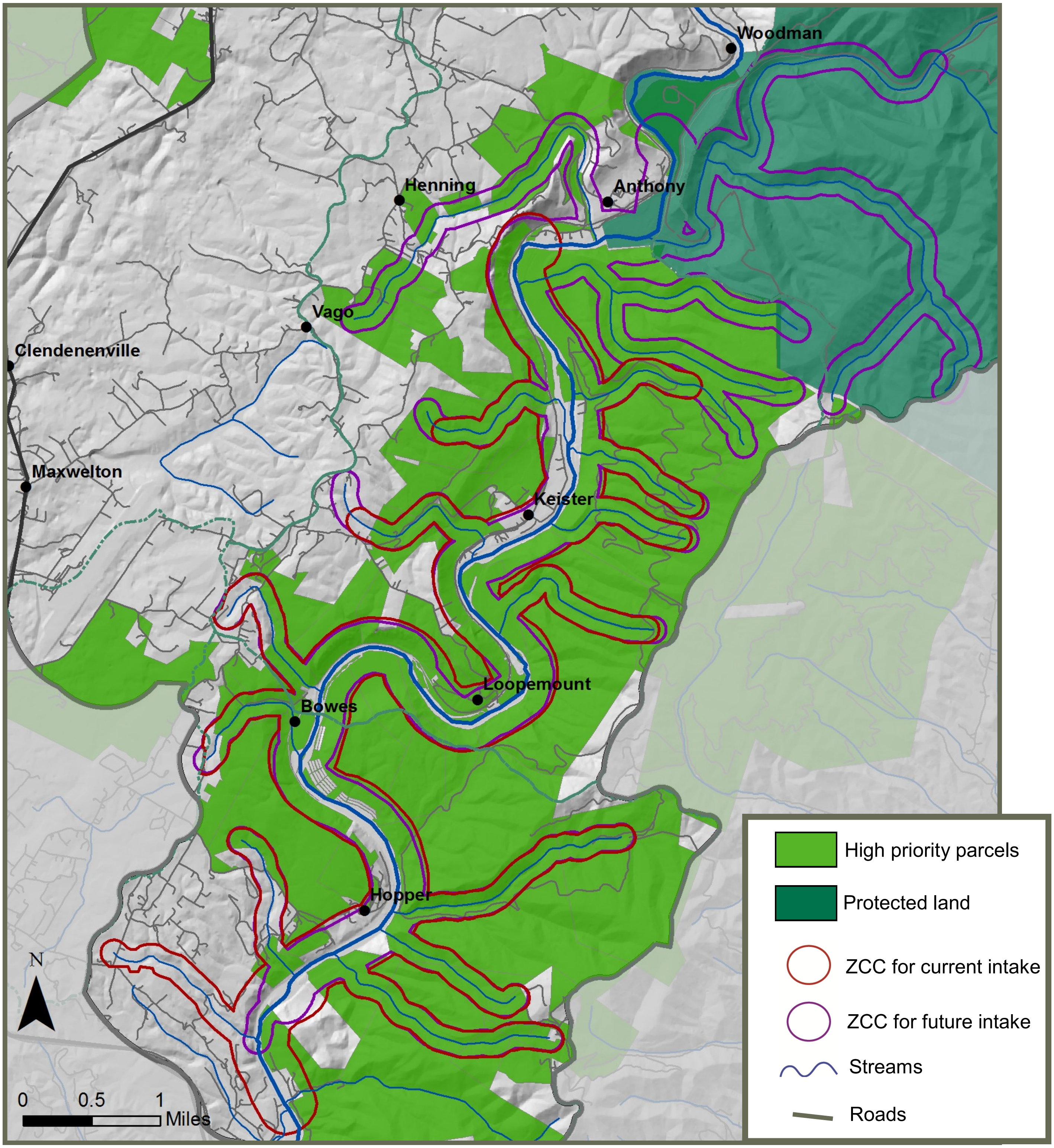
See Appendix C for a list of data sources included on maps.

Figure 14. Model ranking of natural quality in the ZCC



See Appendix C for a list of data sources included on maps.

Figure 15. Parcels selected as highest priority for conservation easements in the ZCC



See Appendix C for a list of data sources included on maps.

APPENDIX C: GIS DATA SOURCES

Data	Source
Roads	U.S. Census Bureau, 2011
Agriculture	Landuse/Landcover of West Virginia, WVU, Natural Resource Analysis Center, 2011
Logging	Georeferenced from sketches provided by stakeholders at the
Potential contaminant sources	USEPA's Facility Registry System, 2002 WVDEP Aboveground Storage Tank database, 2014 WVBPH SWAR, 2003
Developed land use	Landuse/Landcover of West Virginia, WVU, Natural Resource Analysis Center, 2011
Designated growth area	Georeferenced from Greenbrier County Comprehensive Plan,
Zone of critical concern	Current: WVBPH, 2014 Future: Approximated for this study
Forested land use	Landuse/Landcover of West Virginia, WVU, Natural Resource Analysis Center, 2011
Wetlands	U.S. Fish and Wildlife Service National Wetlands Inventory, 1996
Soil type	National Resources Conservation Service, SSURGO, 2014
Protected Land	U.S. Forest Service (National Forest), 2004; WV Division of Forestry (State Forest), 2013; WV Division of Natural Resources and NRAC (State Parks), 2011; The Nature Conservancy (Nature Conservancy preserves), 2013; Robert Martin of the Farmland Protection Agency (Farmland Protection easements), 2014
Karst	WV Geological and Economic Survey, 1968
Floodplain	Federal Emergency Management Agency, 2013