COMMONWEALTH of VIRGINIA

Virginia ConservationVision: Agricultural Model 2015 Edition

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Division of Natural Heritage
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Virginia ConservationVision: Agricultural Model 2015 Edition

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Abstract

The Virginia Agricultural Model was developed to quantify the relative suitability of lands for agricultural activity across the state. It is presented as a raster data set and associated maps, in which the relative agricultural value of lands ranges from 0 (unsuitable) to 100 (optimal). This provides some of the information needed for prioritizing lands that may be placed under conservation easements in the interest of sustaining agricultural values and uses.

In this model, agricultural value is assessed primarily based on inherent soil suitability, but also accounts for current land cover as well as travel time between agricultural producers and consumers. Among others, staff at the Natural Resources Conservation Service (NRCS) and the Virginia Department of Agriculture and Consumer Services (VDACS) were consulted to ensure a robust model. The Virginia Agricultural Model is one of several in a suite of conservation planning and prioritization models developed by the Virginia Natural Heritage Program and partners, known collectively as Virginia ConservationVision.

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Introduction

As human populations and demand for resources expand, natural areas and rural lands are increasingly threatened by encroaching development. The Virginia Department of Conservation and Recreation (DCR), Division of Natural Heritage (DNH), has a mission to protect Virginia's native plant and animal life and the ecosystems upon which they depend. As part of its work, DNH develops and maintains a suite of geospatial models intended to guide strategic land conservation and management decisions. This suite of models is known as Virginia ConservationVision. The models under the ConservationVision umbrella address a variety of conservation issues and priorities, and include a Natural Landscape Assessment Model, a Cultural Model, a Recreation Model, an Agricultural Model, a Watershed Integrity Model, a Forest Economics Model, and a Development Vulnerability Model.

Agricultural lands are important to the local and regional economy, with economic activity cascading through a value chain of physical and technical inputs, production of crops and animals, processing and transformation of products, distribution, and consumption (Antle et al. 2015). The Virginia Department of Agriculture and Consumer Services estimates that agriculture has an impact of $52 billion annually and provides 311,000 jobs in the Commonwealth of Virginia (VDACS 2015a). Agricultural lands also provide myriad benefits that cannot be readily quantified in dollars: opportunities for recreation and tourism in scenic rural areas; maintenance of wildlife habitat and biodiversity; and protection of soil and water resources.

Despite the benefits of maintaining rural lands in agricultural production, over five million acres of Virginia's farmland were lost to other land uses between 1960 and 2012 (VDACS 2015b). The collective desire to preserve active farmlands in Virginia is evidenced by the establishment of the Office of Farmland Preservation in 2001. This office was charged with developing a program for the Purchase of Development Rights (PDR) on agricultural lands.

> Under a PDR program, a landowner voluntarily sells his or her rights to develop a parcel of land to a public agency or a qualified conservation organization charged with the preservation of farm and/or forest land. The landowner retains all other ownership rights attached to the land, and a conservation easement is placed on the land and recorded on the title. (VDACS-FPTF 2005, p. 5)

The Virginia Land Conservation Foundation (VLCF) provides state funding to purchase or establish conservation easements on various lands of conservation concern, including farmlands (VDCR, n.d.). Given limited funds, it is essential to have a means of prioritizing lands worthy of preservation. The purpose of the Virginia Agricultural Model is to quantify the relative suitability of lands for agricultural activity. It provides some of the information needed for prioritizing lands to be placed under conservation easements in the interest of sustaining agricultural values and uses.

A first edition of the Agricultural Model was produced in 2007. Since then, more detailed soils data have become available through the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The update to the Agricultural Model described in this report takes advantage of the new soils data, and also incorporates some considerations that were not included in the first edition. The current edition was developed from a variety of spatial data sets using a suite Geographic Information Systems (GIS) tools. It is presented as a raster data set and associated maps, in which the relative agricultural value of lands ranges from 0 (not suitable) to 100 (optimal). The relative agricultural value of lands is assessed primarily based on inherent soil suitability, but also accounts for current land cover as well as travel time between agricultural producers and consumers.

Methods

The Agricultural Model is derived from three major components, which are scored values ranging from 0 (unsuitable) to 100 (optimal). The Soil Quality Score quantifies inherent soil suitability, based on soil classifications provided by NRCS in their Gridded Soil Survey Geographic (gSSURGO) database. The Foodshed Score is based on travel times between agricultural producers and their potential consumers, an important consideration for foodshed analysis (Peters et al. 2008). The Land Cover Score quantifies how current land cover affects the potential for the land to be used for agricultural purposes. The Land Cover Score is used as a multiplier, meaning it is used as a final modifier of the score derived from a weighted average of the Soil Quality and Foodshed Scores, which are weighted 80% and 20%, respectively.

Soil Quality Score

The Soil Quality Score is based entirely on soils data provided by NRCS (Table 1). The primary geodatabase, *gSSURGO_VA.gdb*, contains the complete spatial and tabular soil survey data for the state of Virginia. From this we used the *MUPOLYGON* (map unit polygons) feature class, and the tables *mapunit* and *component*. A supplementary geodatabase, *Valu_fy2015.gdb*, contains additional attributes aggregated to the map unit level, in tabular form. To quantify soil suitability for agriculture, we extracted three variables: farmland classification, nonirrigated capability class, and National Commodity Crop Productivity Index (NCCPI). We assigned numeric scores from 0 (unsuitable) to 100 (optimal) to the values of each of these variables.

> The farmland classification designates map units as prime farmland, farmland of statewide importance, farmland of local importance, or farmland of unique importance….
>
> Prime farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. (NRCS, n.d.)

Farmland classification was extracted from the *mapunit* table of the *gSSURGO* geodatabase. Because the score assignments for these classifications were subjective, we enlisted three internal and six external reviewers (Table 2). Each was given a review package consisting of a model overview, definitions, score sheets, and a set of instructions for completing the sheets. The results were compiled and compared to our initial score assignments, which were modified if deemed appropriate (Table 3).

The land capability classification is "a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time" (NRCS, n.d.). Although the classes are in an obvious rank order, the numeric model value assignments are still somewhat subjective, so reviewers were enlisted to assign model scores as with the farmland classification. The final score assignments are presented in Table 4 along with the respective capability class definitions. The nonirrigated capability class was extracted from the *component* table of the *gSSURGO* geodatabase. Because a map unit can be comprised of multiple components, the component scores were aggregated to the map unit level using a weighted average based on each component's percent contribution to the map unit.

NCCPI is an index ranging from 0.01-1.00 that "arrays soils according to their inherent capacity to produce dryland (nonirrigated) commodity crops" (NRCS 2012). The NCCPI variable was extracted from the *valu1* table of the supplementary geodatabase. These values were simply multiplied by 100 to obtain the agricultural value scores, so no reviewer input was needed.

The scores derived from each variable were averaged, with equal weights, to produce a composite Soil Quality Score for each map unit, corresponding to a mapped polygon in the *MUPOLYGON* feature class. In some cases, only one or two of the three selected soil quality variables were available. In those cases, the score was based on the variable or variables available. In other cases, no soil variables were available at all. Many of these were determined to be polygons representing water or a dam, and were assigned a score of 0, but some map units (primarily in developed areas) remained with no valid score.

The soil scores were joined to the *MUPOLYGON* feature class, which was then projected to the Virginia Lambert coordinate system. The projected feature class was converted to a raster using the composite Soil Quality Score as the output cell values.

Foodshed Score

The Foodshed Score is intended to measure the ease of transporting agricultural products to potential consumers. It is a composite of travel time variables: time to the nearest farmers' market, time to the nearest urban area (population > 2500), and time to the nearest metropolitan area (population > 50,000). These variables were derived from a variety of data sets, including population data from the 2010 Census, farmers' market locations, road centerlines with speed limits, land cover data, and a representation of urban areas derived from road density (Table 1). To avoid boundary effects, a 5-km buffer was applied to the state border of Virginia for all processing. For this reason, border states' data had to be included.

The Virginia road centerlines data were checked for discrepancies, and speed attributes modified in some cases. Any road with the speed listed as 0 or any value that was not a multiple of 5 was visually inspected over the most recent aerial photography from the Virginia Base Mapping Program (VITA 2015), and a new speed value was set depending on the type of road and surrounding context. Some road segments were clearly for planning purposes only, and did not correspond to any actual existing roads on the ground. The lowest allowable speed for walkways and other non-roads included in the data was set to 3 mph, on the assumption that this is a reasonable walking pace. The data from other states were accepted as is, without further quality control. For those data sets lacking an explicit road speed attribute (i.e., the data obtained from the U.S. Census), road speeds were assigned based on MTFCC codes, as done by

Strickland (2010; see his Table 1).

Travel time, in minutes per meter, was calculated for each road centerlines data set. It was derived from the appropriate road speed attribute based on Equation 1.

Equation 1:

$$Travel\ Time\ (min/m) = \frac{0.037}{Speed\ Limit\ (miles/hr)}$$

The roads data sets were projected to the Virginia Lambert coordinate system and merged, then converted to a raster. For those raster cells where no roads were present, the land cover raster was used to set background travel times. Open water and emergent herbaceous wetlands were set to null, on the assumption that these are impassable. Everything else was set to the travel time corresponding to a walking pace of 3 miles/hr. The composite raster derived from the combination of road speeds and land cover was used as a cost surface raster, with travel time in minutes per meter as the cost.

The farmers' market locations were obtained as tabular data with x-y coordinates. The coordinates were used to produce point feature classes, which were merged and projected to the Virginia Lambert coordinate system, then converted to raster.

A raster representing population density was generated from the census data in combination with the NLCD land cover data. The population census polygon shapefiles were first merged and reprojected, then converted to two rasters: one using the population number, and one using the block identification code as the value. The block code was used to define discrete zones in which population density would be calculated. The NLCD land cover raster was used to remove the uninhabitable areas (open water and emergent wetlands) from the zones. Subsequently, the zonal area, in square meters, was calculated for each block code. Population density, in units of persons per raster cell (30m x 30m in size), was calculated using Equation 2.

Equation 2:

$$Population\ Density\ (persons/cell) = 900 * \frac{Zonal\ Population\ (persons)}{Zonal\ Area\ (m^2)}$$

The "Roads-Delineated Urban Areas in Virginia" raster, listed in Table 1, was developed for another ConservationVision model, and identifies potential urban areas based on road density at three different scales. Large metropolitan areas are coded as 2, smaller urban clusters as 1, and everything else as a background value of 0. The ArcGIS “Region Grouping” tool was used to generate individual zones from each contiguous urban area. The population density values of all cells within a zone were summed to determine the total population for that zone. Any zone with population > 2500 was coded as 1 in the output “Urban Areas” raster. Any zone with population > 50,000 was coded as 1 in the output “Metro Areas” raster. Thus, metro areas are a subset of urban areas. The urban and metro zones delineated are roughly equivalent but not identical to “Urban Areas” and “Urbanized Areas”, respectively, as defined by the U.S. Census Bureau (Urban Area Criteria for the 2010 Census, 2011).

Travel time to urban areas and to metro areas (more restrictive) was determined using the “Cost Distance” tool with the travel time cost surface raster. Similarly, travel time to market was determined using the rasterized farmers’ market locations. The three travel time rasters were rescaled so that all scores would fall between 0 and 100, with shorter travel times corresponding to higher scores. Travel time was truncated at 120 minutes (2 hours), with the score set to 0 for any travel time above 120 minutes. The score was also set to 0 for all cells with null values. The three scores were averaged (weighted equally) to derive the final composite Foodshed Score raster.

Land Cover Score

Current land cover must be considered in determining the suitability of an area for agricultural uses. We used the NLCD land cover data set for 2011 (Table 1). In this model, land cover is used as a multiplier to modify the composite score derived from the weighted average of the Soil Quality and Foodshed Scores. If current land use is agricultural, then the multiplier is set to 100%, and does not affect the final score. If current land use absolutely precludes conversion to agriculture uses (e.g., high intensity development), then the multiplier is set to 0% so the final Agricultural Model score is also 0, regardless of soil quality or potential contribution to the foodshed based on travel times. Other land uses fall somewhere along the continuum, and we enlisted the model reviewers to help assign model scores to the different land cover categories (Table 5). These scores were used to reclassify the land cover raster to a Land Cover Score raster.

In addition to NLCD data, we used a polygon feature class representing fields in agricultural production in Virginia (Table 1). We converted the feature class to raster and used it to override NLCD data. Any cell identified as agriculture based on the agricultural polygons was given a Land Cover Score of 100, regardless of the NLCD classification. As a final override, we used the travel time cost surface raster to impose a score of 0 for all cells containing a road (cost value: travel time less than 0.012 minutes per meter).

Final Agricultural Value Score

The Soil Quality Score, Foodshed Score, and Land Cover Score rasters were combined according to Equation 3 to generate a final Agricultural Value Score (AVS) raster.

Equation 3:

$$AVS = \frac{Land\ Cover\ Score}{100} \times [(0.8 \times Soil\ Quality\ Score) + (0.2 \times Foodshed\ Score)]$$

Because the Soil Quality Raster had some cells with no valid scores, Equation 3 could yield a null value. For this reason, all cells with a Land Cover Score of 0 were immediately set to 0, and Equation 3 was only applied to the remaining cells. This greatly reduced, but did not entirely eliminate, the presence of null-value cells in the output. The AVS raster was clipped to the Virginia border to create the final output.

Results

The final output of the modeling process described above is a raster dataset covering the state of Virginia, with cell values representing the agricultural value score. Model values ranged from 0 to 100, although the highest value actually achieved was 98.6 (Table 6). At the planning district level, mean agricultural values ranged from 7.7 for the Roanoke Valley – Alleghany planning district to 27.7 for the Rappahannock – Rapidan planning district (Table 6). The spatial distribution of agricultural values across the state is represented in Map 1, with the values shown by planning district in Maps 2-22.

A small proportion of cells in the raster have missing values; these comprise only 0.12% of the data set. The missing values are due to only nine map unit polygons which had no farmland classification, nonirrigated capability class, or NCCPI attributes assigned. The polygons with missing data are the cities of Winchester, Staunton, and Waynesboro; Coast Guard and Navy installations at Yorktown; and park lands of the Blue Ridge Parkway.

Discussion

Model comparison with previous edition

The current edition of the Virginia Agricultural Model differs substantially from the edition produced in 2007. Both the data inputs and the valuation scheme of the output have changed. The previous model output consisted of categorical data, with agricultural value represented as discrete values ranging from 1 (low suitability) to 5 (high suitability). In contrast, the current model uses a continuous valuation system ranging from 0 (unsuitable) to 100 (optimal).

The current model benefits from much more detailed soils data that were not available when the first edition was produced. The first edition considered only the farmland classification ("prime farmland" designation) and had to rely on coarsely mapped STATSGO data (Soil Survey Staff, n.d.) for many areas. The current edition uses only the more finely mapped SSURGO soils data, and incorporates farmland classification as well as two additional soil quality variables provided by NRCS.

The previous model incorporated the presence/absence of culturally significant historic farms. The current model omits this aspect entirely, as it is deemed more appropriate for inclusion in the Virginia Cultural Model. On the other hand, the current model embraces the concept of foodsheds (Peters et al. 2008), and incorporates travel times between agricultural producers and consumers. Foodsheds were not considered in the previous model.

For land cover, the previous model used a classification of 2000 imagery, produced by the Regional Earth Science Applications Center (University of Maryland). Different land cover categories were assessed as either suitable or unsuitable for prime farmland. Unsuitable land cover types were simply masked out. In contrast, we used National Land Cover Database classification of 2011 imagery, and different land cover types were assigned suitability scores along a gradient from 0 to 100.

Model applications and limitations

The Virginia Agricultural Model is intended as a guide to the relative agricultural value of lands across the state. We expect the model to be helpful to state and local governments, planning districts, environmental consultants, land trusts, and others involved in land use planning and conservation prioritization. In many, if not most cases, this model should be used in conjunction with other pertinent information and data models, including other ConservationVision models.

The output raster data set does include some cells with missing data, but these are negligible (< 1% of all cells). The cells with missing data are located in areas which would likely never be used for agriculture: cities, military installations, and lands managed by the National Park Service. It would not be unreasonable to recode these cells with an agricultural value of 0, but we opted to let the user make this decision.

This model, like any other model, is limited by the data inputs as well as by the assumptions made and processes used in combining these inputs. For example, the input land cover data has a 30-m pixel size, and the raster output was generated to match. This may be unsatisfactory for detailed planning at local scales. Each user must decide whether this model meets their particular purpose.

We have made our modeling approach as transparent as possible, both to allow for quick updates in the future, and to allow users to produce customized versions of the model as desired. Most of the GIS processes used to produce the Agricultural Model are available on request in the form of a customized ArcGIS toolbox containing a suite of tools organized logically into toolsets. Users may employ these tools to produce a customized model for their particular area of interest. Examples of customizations that could be made include:

- Using higher-resolution land cover data as an input
- Combining the Soil Quality, Foodshed, and Land Cover Score rasters with a different equation rather than our Equation 1
- Conducting a more rigorous foodshed analysis and substituting that output for the Foodshed Score raster
- Assigning different model scores to soil categories and/or land cover classes

The maps presented in this report, and the underlying raster model used to produce them, should be considered as a snapshot in time, reflecting both current ground conditions and current assumptions about agricultural value. Ground conditions will certainly change over time so that updates will be needed in the future. We expect that the agricultural valuation assumptions and modeling processes will evolve as well. We encourage users to send us their constructive feedback so that we can take that into consideration in future editions of the model.

Acknowledgements

We thank NRCS staff members David Harper and David Faulkner, who assisted us by answering various questions about the soils data. We appreciate the input from all the reviewers who contributed model value scores, which was essential to building a robust model. We thank Noah Vaughn for his help in processing the Virginia Road Centerlines data.

Finally, we are grateful to Jason Bulluck for reviewing an earlier draft of this report. Any errors that remain are our own.

References

Antle, J. M., B. O. Basso, R. T. Conant, C. Godfray, J. W. Jones, M. Herrero, R. E. Howitt, B. A. Keating, R. Munoz-Carpena, C. Rosenzweig, P. Tittonell, and T. R. Wheeler. 2015. Towards a New Generation of Agricultural System Models, Data, and Knowledge Products: Model Design, Improvement and Implementation. AgMIP. Retrieved August 11, 2015 from https://www.agmip.org/refbase/uploads/antle/2015/220_Antle2015.pdf.

Peters, C.J., N.L. Bills, J.L. Wilkins, and G.W. Fick. 2008. Foodshed analysis and its relevance to sustainability. Renewable Agriculture and Food Systems 24(01):1-7.

Soil Survey Staff, United States Department of Agriculture, Natural Resources Conservation Service. N.d. Web Soil Survey. Accessed August 12, 2015 at http://websoilsurvey.nrcs.usda.gov/

Strickland, H. 2010. Convenience analysis of the Oregon Paint Management Pilot Program (Master's thesis). Duke University, Durham, NC.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS). N.d. National Soil Survey Handbook, title 430-VI. Part 622: Interpretive groups. Accessed August 12, 2015 from http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs142p2_054226.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS). 2012. User guide for the National Commodity Crop Productivity Index (NCCPI), Version 2.0.

Urban Area Criteria for the 2010 Census; Notice of final program criteria, 76 Federal Register 164 (August 24, 2011), pp. 53030-53043.

Virginia Dept. of Agriculture and Consumer Services, Farmland Preservation Task Force (VDACS-FPTF). 2005. A model Purchase of Development Rights (PDR) program for Virginia. Retrieved August 11, 2015 from http://www.vdacs.virginia.gov/preservation/pdf/pdfprogram.pdf.

Virginia Dept. of Agriculture and Consumer Services (VDACS). 2015a. Virginia Agriculture 2015 – Facts and Figures. Retrieved August 11, 2015 from http://www.vdacs.virginia.gov/agfacts/pdf/AgFactsbrochure.pdf.

Virginia Dept. of Agriculture and Consumer Services (VDACS). 2015b. Office of Farmland Preservation website. Accessed August 11, 2015 from http://www.vdacs.virginia.gov/preservation/index.shtml.

Virginia Dept. of Conservation and Recreation (VDCR). N.d. Virginia Land Conservation Foundation brochure. Retrieved August 11, 2015 from http://www.dcr.virginia.gov/virginia_land_conservation_foundation/documents/vllegalbro.pdf.

Virginia Information Technologies Agency (VITA). 2015. VBMP Orthophotography. Website accessed August 18, 2015 from http://www.vita.virginia.gov/isp/default.aspx?id=8412.

Tables

Table 1. Data sources used to produce the Virginia Agricultural Model

Data Description	Data Use[1]	Data Type	Data Source	Data Files
NRCS soil survey: complete spatial and tabular data for Virginia	SQ	File geodatabase	Geospatial Data Gateway. Retrieved May 2015 from gdg.sc.egov.usda.gov	*gSSURGO_VA.gdb*
NRCS soil survey: National Value Added Lookup Table	SQ	Geodatabase table	Geospatial Data Gateway. Retrieved May 2015 from gdg.sc.egov.usda.gov	*Valu_fy2015.gdb/valu1*
U.S. Census data from 2010: population numbers by census block, for Virginia and neighboring states	FS	Polygon shapefile	United States Census Bureau: TIGER/Line with Selected Demographic and Economic Data. Retrieved June-August 2015 from census.gov/geo/maps-data/data/tiger-data.html.	*tabblock2010_nn_pophu.shp*, where 'nn' is the 2-digit code for the state or District of Columbia.
Farmers' market locations for Virginia and neighboring states	FS	Tabular data in CSV-format	USDA Agricultural Marketing Service: National Farmers Markets Directory. Retrieved May-July 2015 from search.ams.usda.gov/farmersmarkets	Individual export files were obtained for each state, then converted to Excel spreadsheets
Roads-Delineated Urban Areas in Virginia, ca. 2011 (NLCD modified)	FS	Raster	Virginia Dept. of Conservation and Recreation, Division of Natural Heritage. Produced internally.	*Roads_Urban.gdb /UrbanAreas_2011_NLCDmod*
Road centerlines: Virginia	FS	Geodatabase line feature class	Virginia Geographic Information Network: VA GIS Clearinghouse. Retrieved August 2014 from tinyurl.com/vgin-rcl	*2014Q3_VBMP_RCL_FGDB.gdb/RCL*
Road centerlines: Maryland	FS	Line shapefile	Maryland State Highway Administration, Data Services Engineering Division, Office of Planning and Preliminary Engineering. Obtained June 2015 as email attachment by request.	*2014_SPEED_LIMIT_SEGMENTS.shp*
Road centerlines: Kentucky	FS	Line shapefile	Kentucky Highway Information System GIS Extracts. Retrieved July 2015 from transportation.ky.gov/Planning/Pages/HIS-Extracts.aspx	*Sl.shp*

[1] Used to produce Soil Quality Score (SQ), Foodshed Score (FS), and/or Land Cover Score (LC)

Data Description	Data Use[1]	Data Type	Data Source	Data Files
Road Centerlines: District of Columbia and Virginia-bordering counties in North Carolina, West Virginia, Tennessee	FS	Line shapefile	United States Census Bureau: Roads data. Retrieved August 2015 from ftp2.census.gov/geo/tiger/TIGER2014/ROADS	*tl_2014_nnnnn_roads.shp*, where '*nnnnn*' is a 5-digit code representing the state and county.
NLCD Land Cover: Virginia, 2011	FS, LC	Raster	Multi-Resolution Land Characteristics (MRLC) Consortium. Original data retrieved April 2015 from www.mrlc.gov/index.php. Virginia subset produced from the original data by the Virginia Dept. of Conservation and Recreation, Division of Natural Heritage	*nlcd_2011_landcover_2011_edition_2014_10_10.zip*
Agricultural Field Polygons (based on 2011-2013 imagery	LC	Geodatabase polygon feature class	Virginia Dept. of Conservation and Recreation, Division of Soil and Water. Received February 2015 as a network share by request.	*statewide_land_units.gdb\ DCR_AGR_FINAL_G1*

Table 2. Reviewers of the Virginia Agricultural Model

Reviewer	Title and Organization
Internal Reviewers	
Jason Bulluck	Information Manager Virginia Dept. of Conservation and Recreation Division of Natural Heritage
Joseph Weber	GIS Projects Manager Virginia Dept. of Conservation and Recreation Division of Natural Heritage
Anne Chazal	Species Modeling Project Manager Virginia Dept. of Conservation and Recreation Division of Natural Heritage
External Reviewers	
Andrew Sorrell	Coordinator, Office of Farmland Preservation Virginia Dept. of Agriculture and Consumer Services
Karl Huber	Environmental Specialist Virginia Dept. of Conservation and Recreation Division of Soil and Water
Fred Garst	GIS Specialist, Water Resource Operations United States Dept. of Agriculture Natural Resources Conservation Service
Brad Copenhaver	Director of Government Affairs Virginia Agribusiness Council
Trey Davis	Assistant Director of Governmental Relations Virginia Farm Bureau
SAL Students	Undergraduate students, Spatial Analysis Laboratory University of Richmond (Students as a group delivered consensus input, and were treated as a single reviewer.)

Table 3. Model scores assigned to farmland classifications.

Farmland Classification	Initial Score[1]	Reviewer Scores			Final Score[2]
		Mean	Median	Mode(s)	
All areas are prime farmland[3]	100	n/a	n/a	n/a	100
Farmland of statewide importance	80	77.8	80	80	80
Prime farmland if irrigated	70	55.6	60	60, 70	60
Prime farmland if drained	60	50.0	50	60	50
Prime farmland if protected from flooding or not frequently flooded during the growing season	60	43.3	40	20, 40, 50	40
Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season	60	25.6	30	30	30
Not prime farmland[3]	0	n/a	n/a	n/a	0

[1] Initial scores were assigned by the modelers prior to requesting input from reviewers, and were not revealed to the reviewers.
[2] Final scores were assigned by the modelers after consideration of the reviewers' scores.
[3] Score was set by modelers and not subject to review.

Table 4. Model scores assigned to nonirrigated capability classes.

Nonirrigated Capability Class	Initial Score[1]	Reviewer Scores Mean	Median	Mode(s)	Final Score[2]
Class 1: soils have few limitations that restrict their use[3]	100	n/a	n/a	n/a	100
Class 2: soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices	80	85.6	90	90	90
Class 3: soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both	50	65.6	70	70	70
Class 4: soils have very severe limitations that reduce the choice of plants or that require very careful management, or both	40	50.0	50	40, 60	50
Class 5: soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat	30	36.7	40	30, 40	30
Class 6: soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat	20	23.3	20	20, 30	20
Class 7: soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat	10	10.0	10	10	10
Class 8: soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes[3]	0	n/a	n/a	n/a	0

[1] Initial scores were assigned by the modelers prior to requesting input from reviewers, and were not revealed to the reviewers.
[2] Final scores were assigned by the modelers after consideration of the reviewers' scores.
[3] Score was set by modelers and not subject to review.

Table 5. Model scores assigned to NLCD land cover classes.

NLCD Land Cover Class	Initial Score[1]	Reviewer Scores			Final Score[2]
		Mean	Median	Mode(s)	
11 – Open Water[3]	0	n/a	n/a	n/a	0
21 – Developed, Open Space	40	31.1	30	40	40
22 – Developed, Low Intensity	0	20.0	20	20	20
23 – Developed, Medium Intensity	0	11.1	10	10	0
24 – Developed, High Intensity[3]	0	n/a	n/a	n/a	0
31 – Barren Land	0	16.7	10	10	10
41 – Deciduous Forest	30	51.1	50	50	40
42 – Evergreen Forest	40	51.1	50	40, 50	50
43 – Mixed Forest	30	50.0	50	50	40
52 – Scrub/Shrub	60	60.0	60	60	60
71 – Grassland/Herbaceous	90	77.8	80	80	80
81 – Pasture/Hay	100	85.6	90	90	100
82 – Cultivated Crops[3]	100	n/a	n/a	n/a	100
90 – Woody Wetlands	10	17.8	10	0, 10	10
95 – Emergent Herbaceous Wetlands	0	13.3	10	10	0

[1] Initial scores were assigned by the modelers prior to requesting input from reviewers, and were not revealed to the reviewers.
[2] Final scores were assigned by the modelers after consideration of the reviewers' scores.
[3] Score was set by modelers and not subject to review.

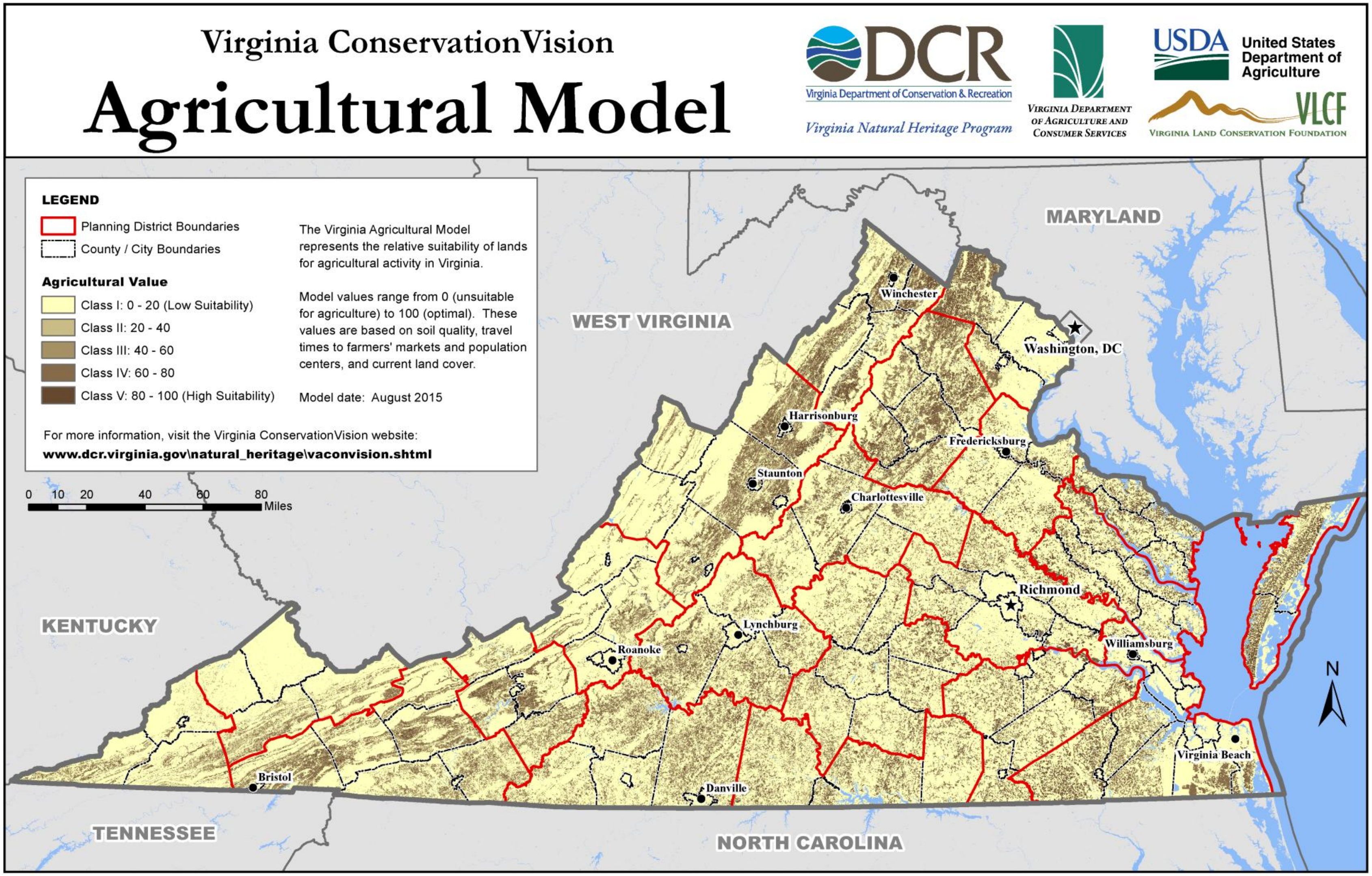
Table 6. Summary statistics for the Virginia Agricultural Model output values.

Geographic Area	Max[1]	Mean	Std. Dev.	Null Cells[2]
Virginia (statewide)	98.6	16.0	30.1	146,751 (0.12%)
Accomack-Northampton PDC	86.8	18.9	33.5	2333 (0.09%)
Central Shenandoah PDC	93.0	16.6	28.8	25,411 (0.26%)
Commonwealth Regional Council PDC	94.6	14.9	30.1	0
Crater PDC	94.1	15.7	32.3	0
Cumberland Plateau PDC	92.2	8.2	19.0	18 (0.00%)
George Washington PDC	90.7	11.4	27.6	6 (0.00%)
Hampton Roads PDC	95.6	15.0	30.1	77,126 (0.99%)
LENOWISCO PDC	92.3	10.1	22.1	210 (0.01%)
Middle Peninsula PDC	93.1	15.6	32.1	0
Mount Rogers PDC	94.9	19.2	29.5	20 (0.00%)
New River Valley PDC	91.5	16.9	28.6	9 (0.00%)
Northern Neck PDC	90.9	19.9	34.4	50 (0.00%)
Northern Shenandoah Valley PDC	93.8	21.8	32.7	13,058 (0.28%)
Northern Virginia PDC	92.7	17.1	32.2	22 (0.00%)
Rappahannock-Rapidan PDC	90.5	27.7	34.9	0
Region 2000 PDC	95.0	18.3	31.7	20,832 (0.34%)
Richmond Regional PDC	94.6	11.7	27.9	0
Roanoke Valley – Alleghany PDC	95.1	7.7	21.6	7,623 (0.16 %)
Southside PDC	92.9	15.5	30.6	0
Thomas Jefferson PDC	94.9	14.4	29.3	0
West Piedmont PDC	98.6	18.0	31.9	3 (0.00%)

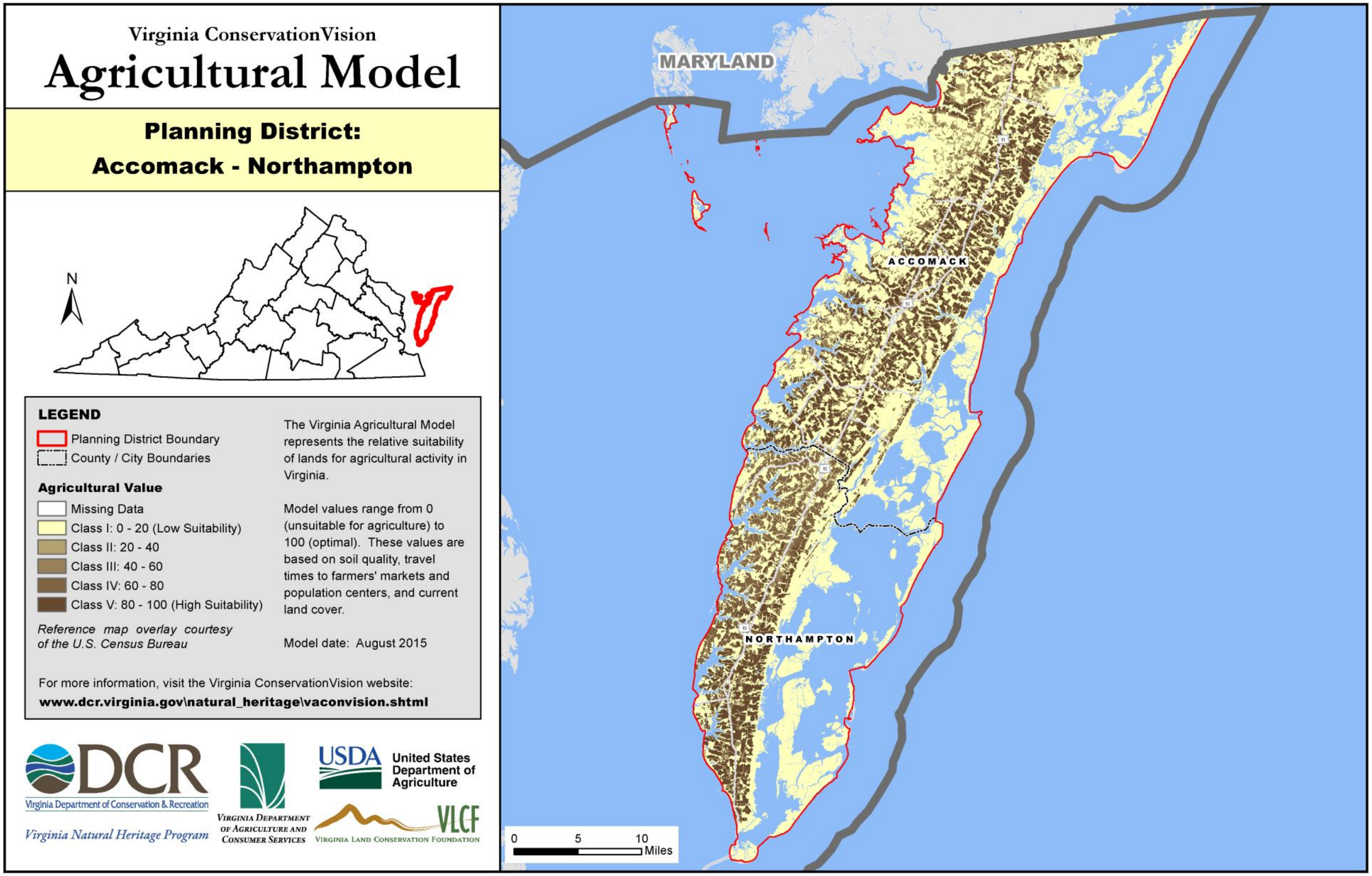
[1] The theoretical maximum is 100. Both the theoretical and the actual minimum value were 0 for all areas.
[2] Number (and percentage) of cells with null output due to missing data. Null cells were coded as -1 and not included in the other summary statistics.

Maps

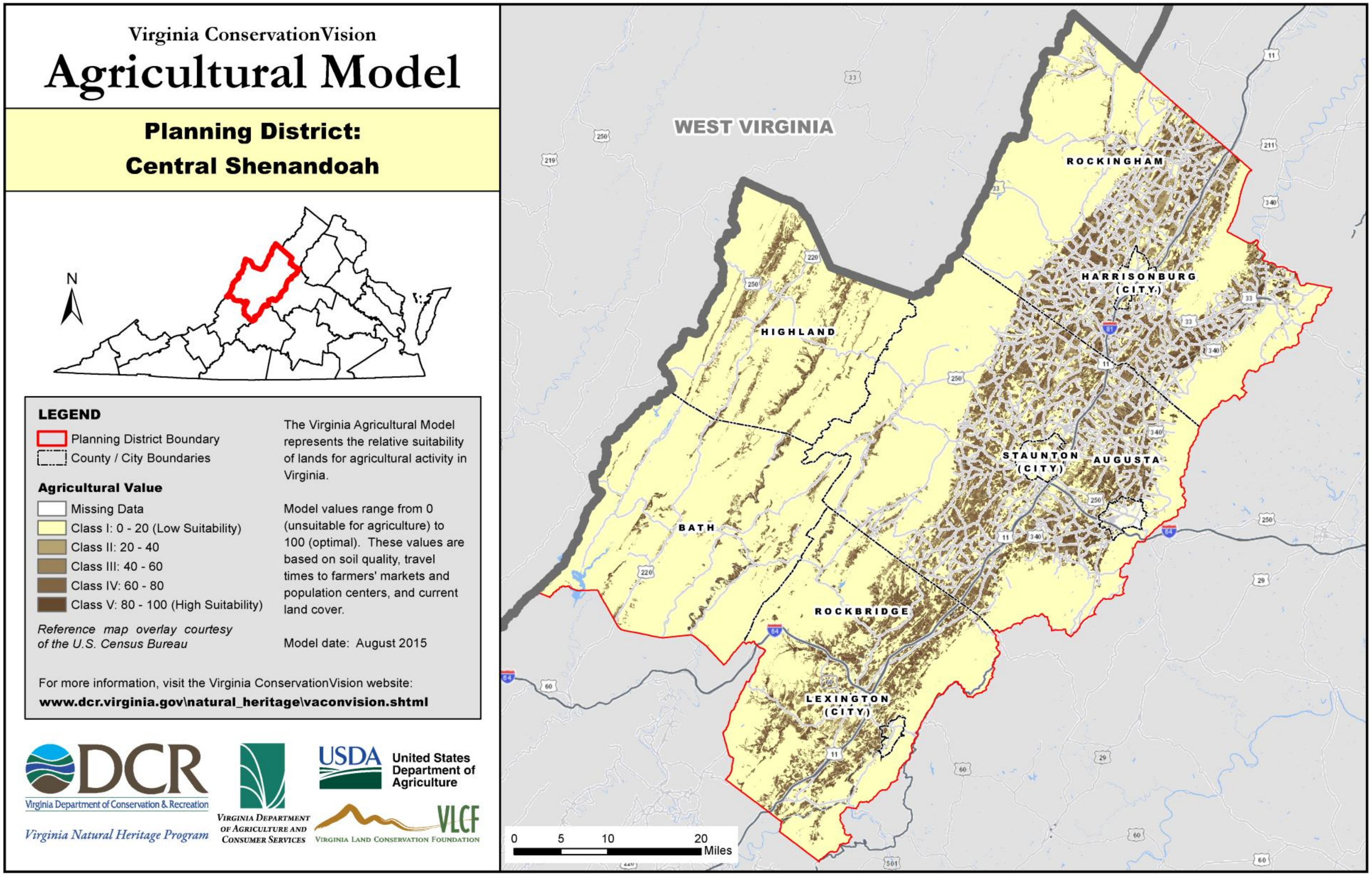
Map 1: Statewide Agricultural Model



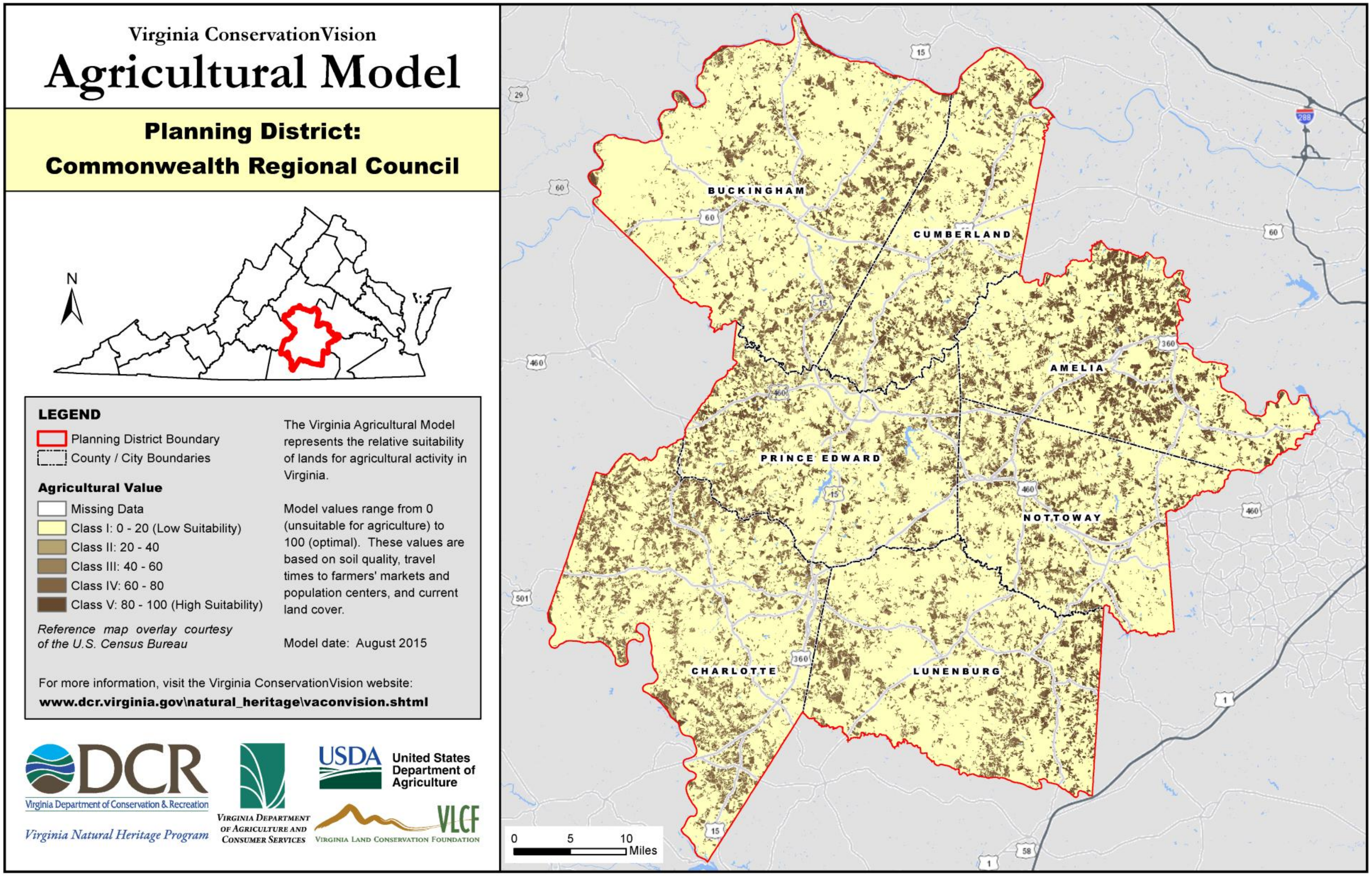
Map 2: Accomack-Northampton Planning District



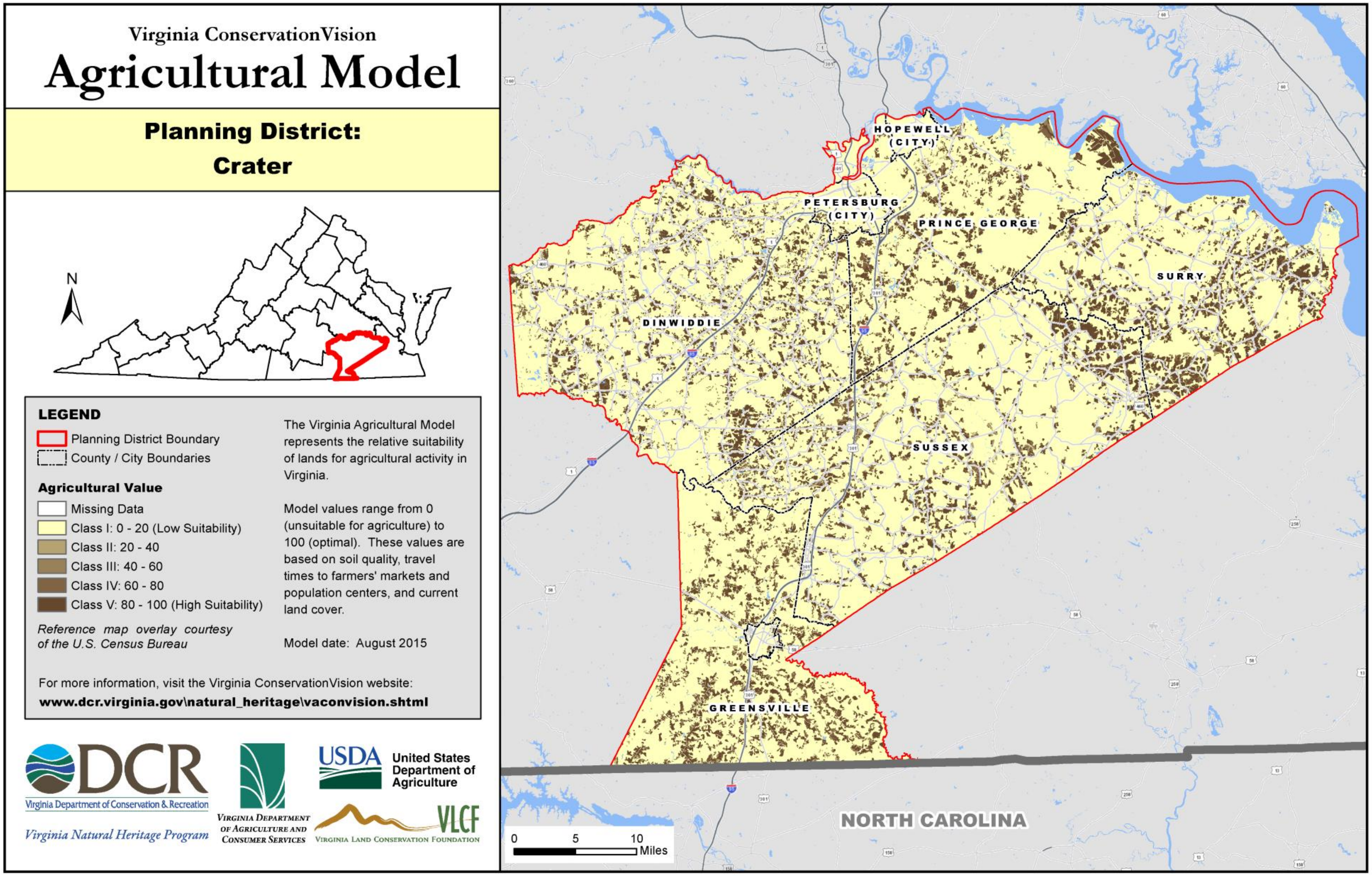
Map 3: Central Shenandoah Planning District



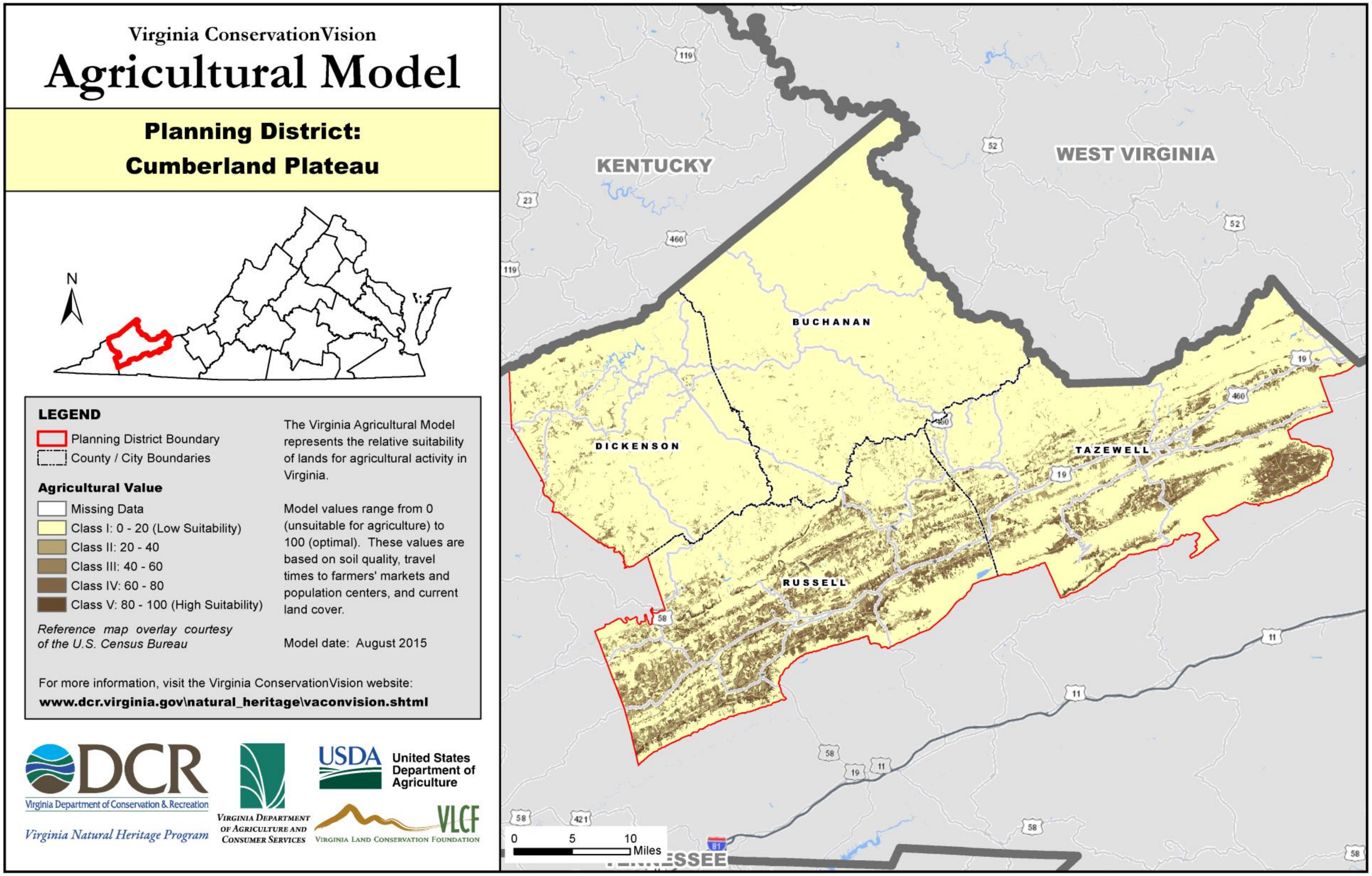
Map 4: Commonwealth Regional Council Planning District



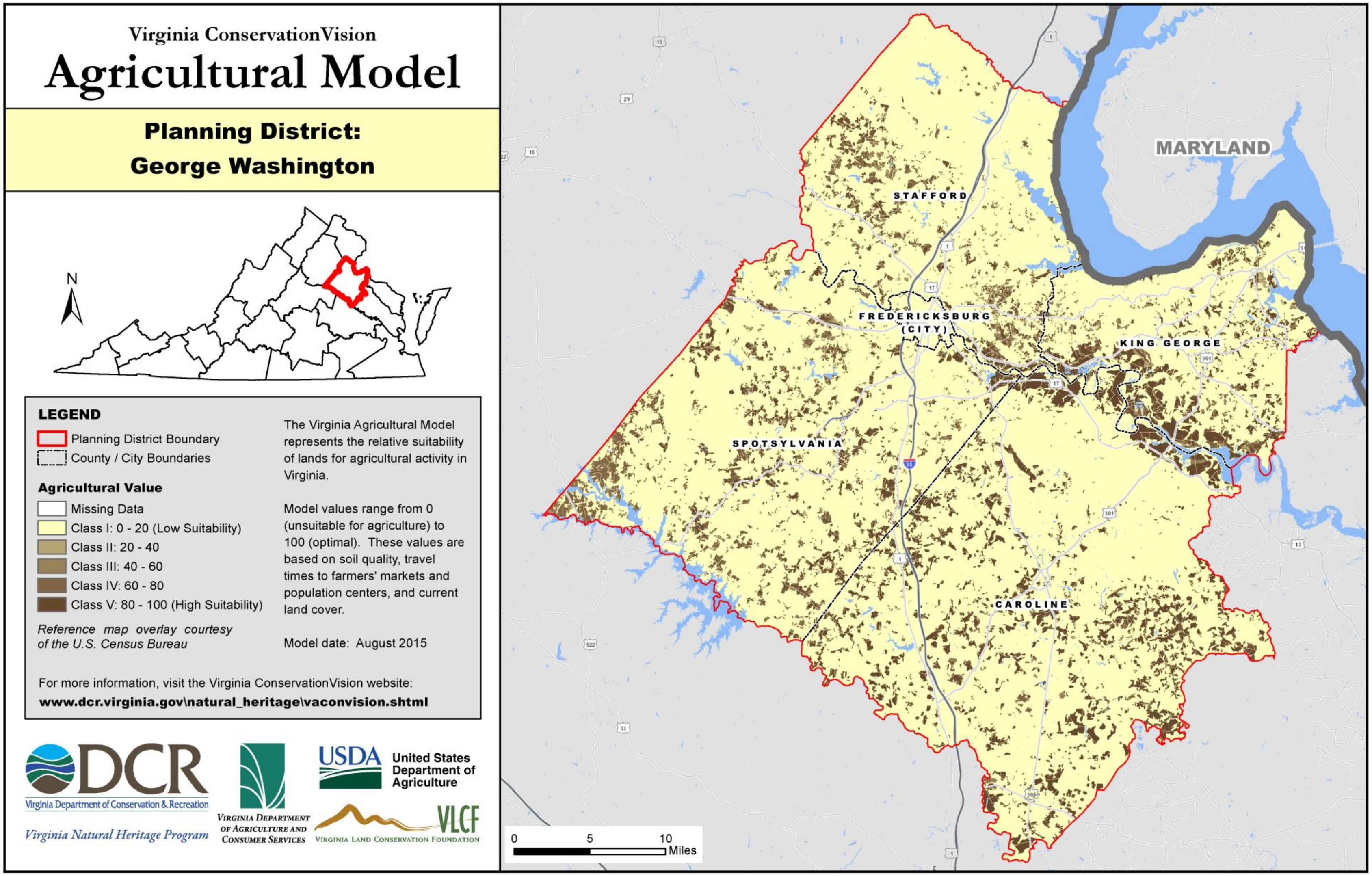
Map 5: Crater Planning District



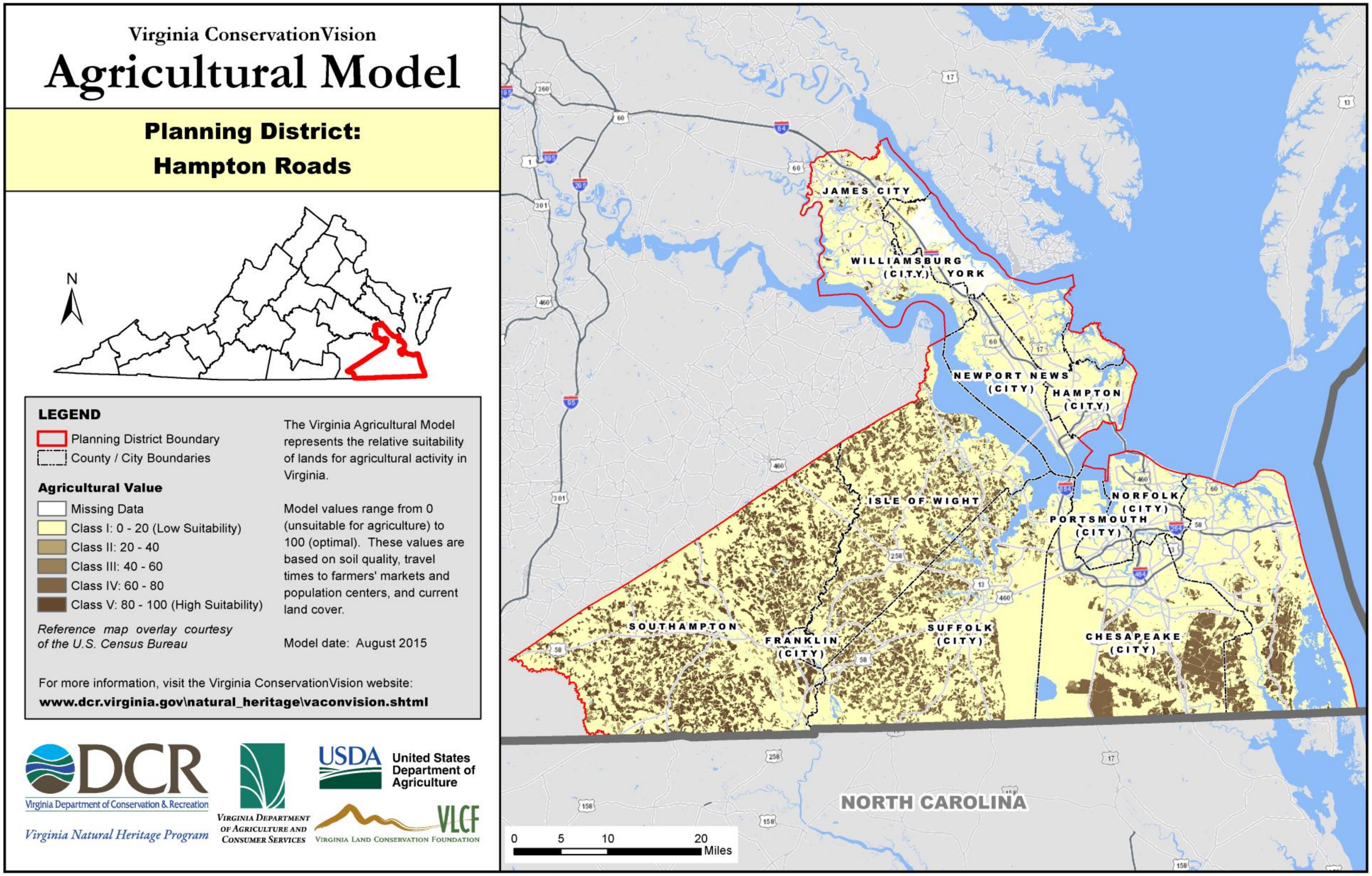
Map 6: Cumberland Plateau Planning District



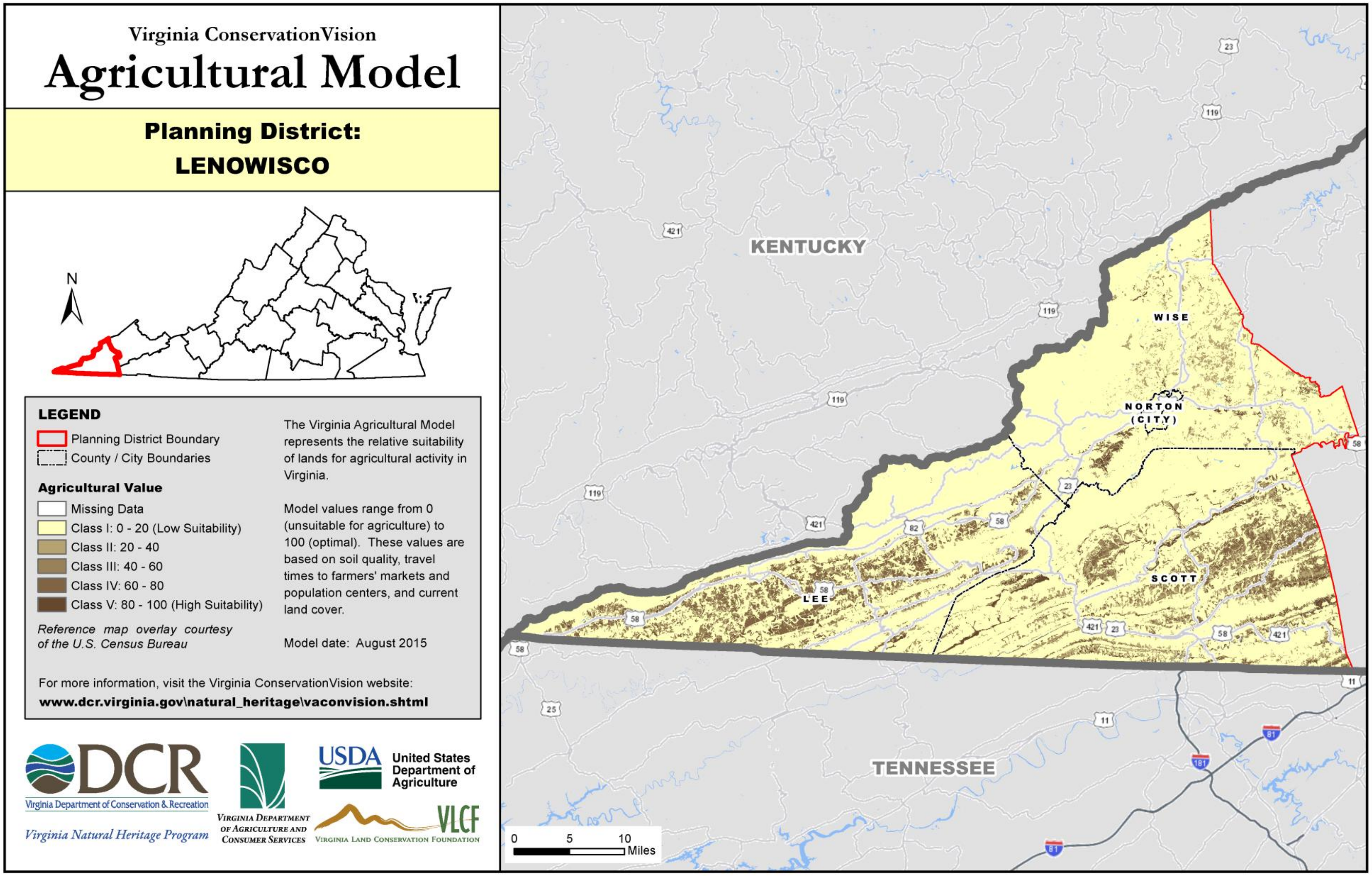
Map 7: George Washington Planning District



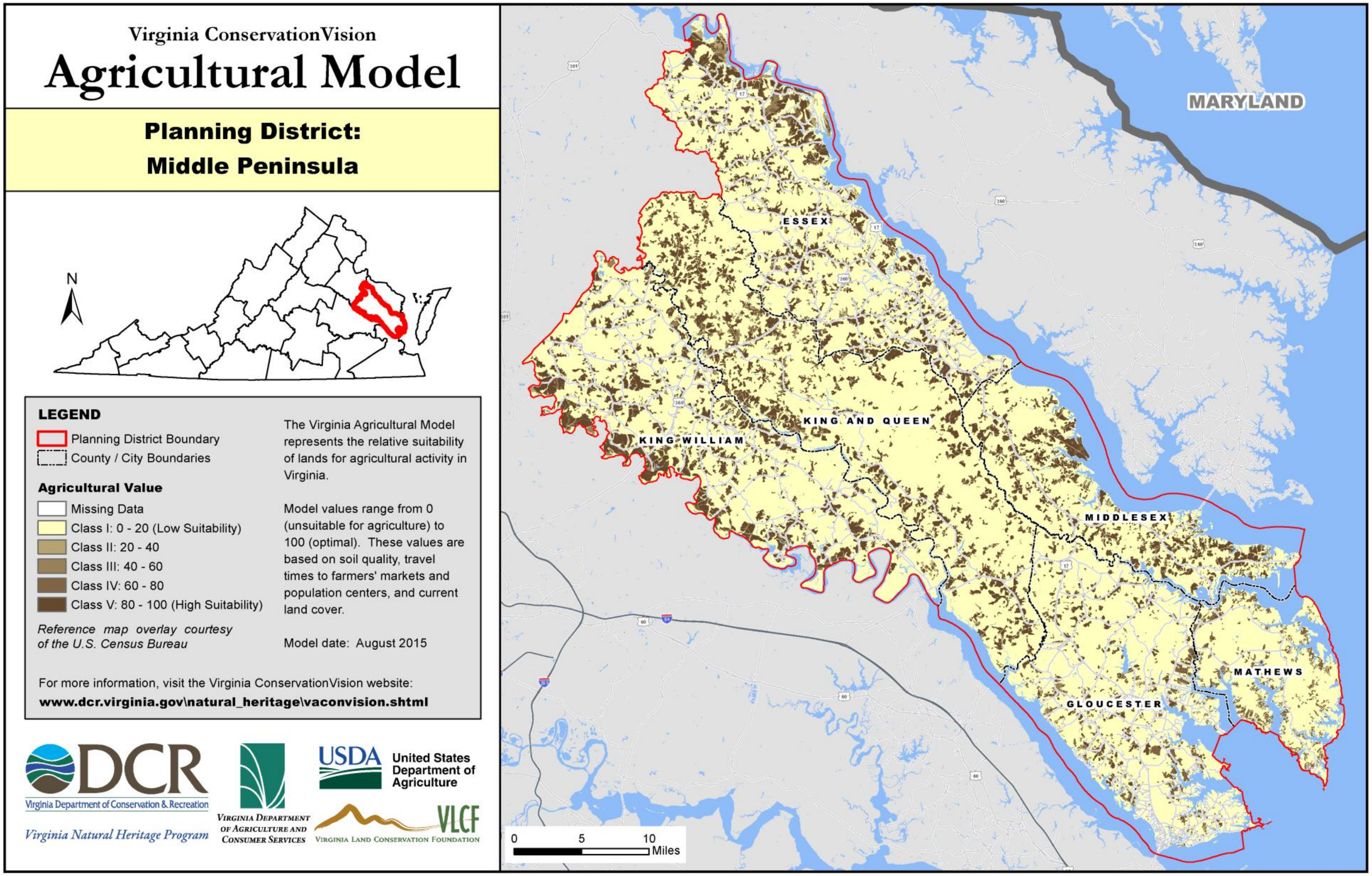
Map 8: Hampton Roads Planning District



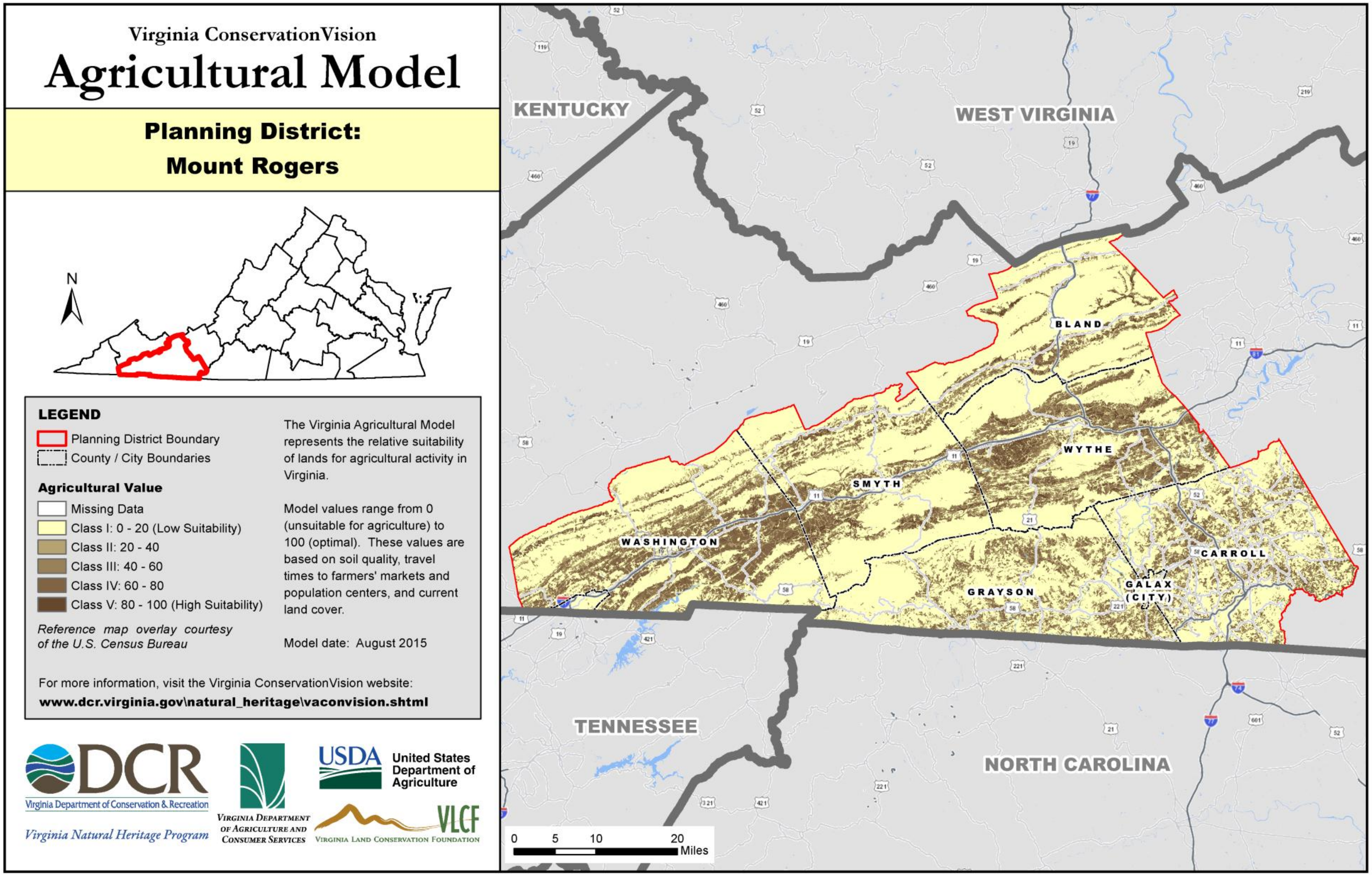
Map 9: LENOWISCO Planning District



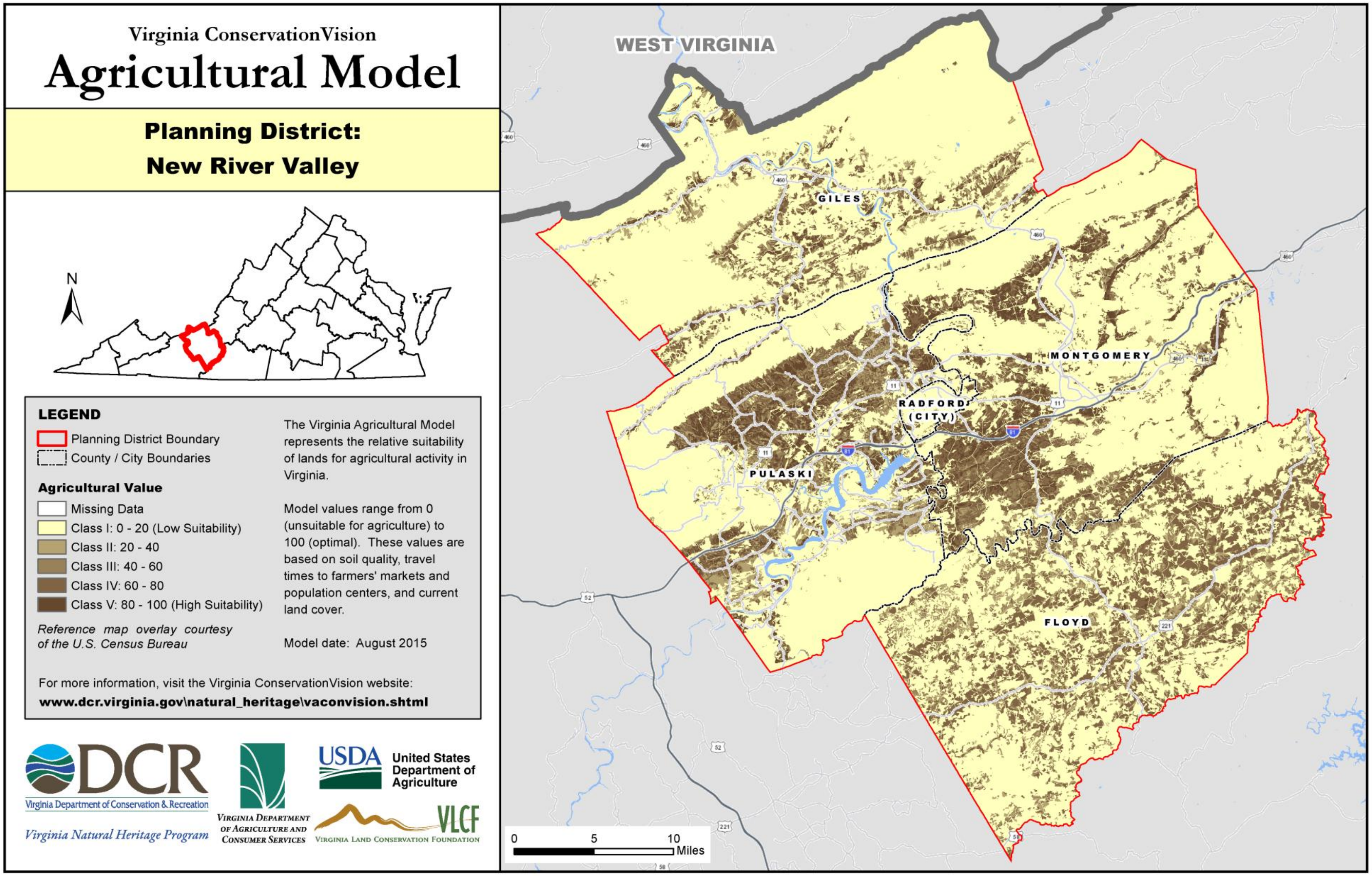
Map 10: Middle Peninsula Planning District



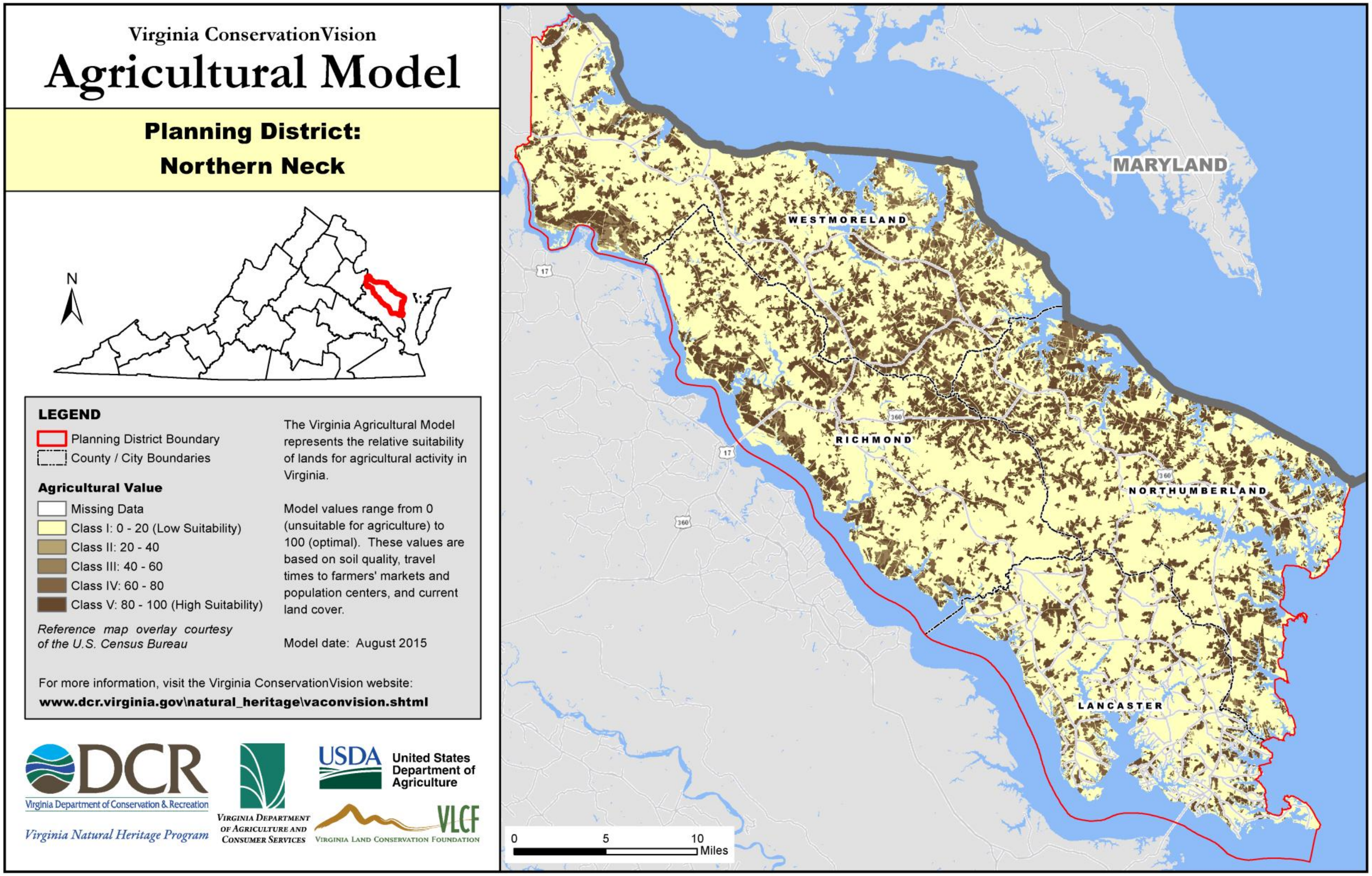
Map 11: Mount Rogers Planning District



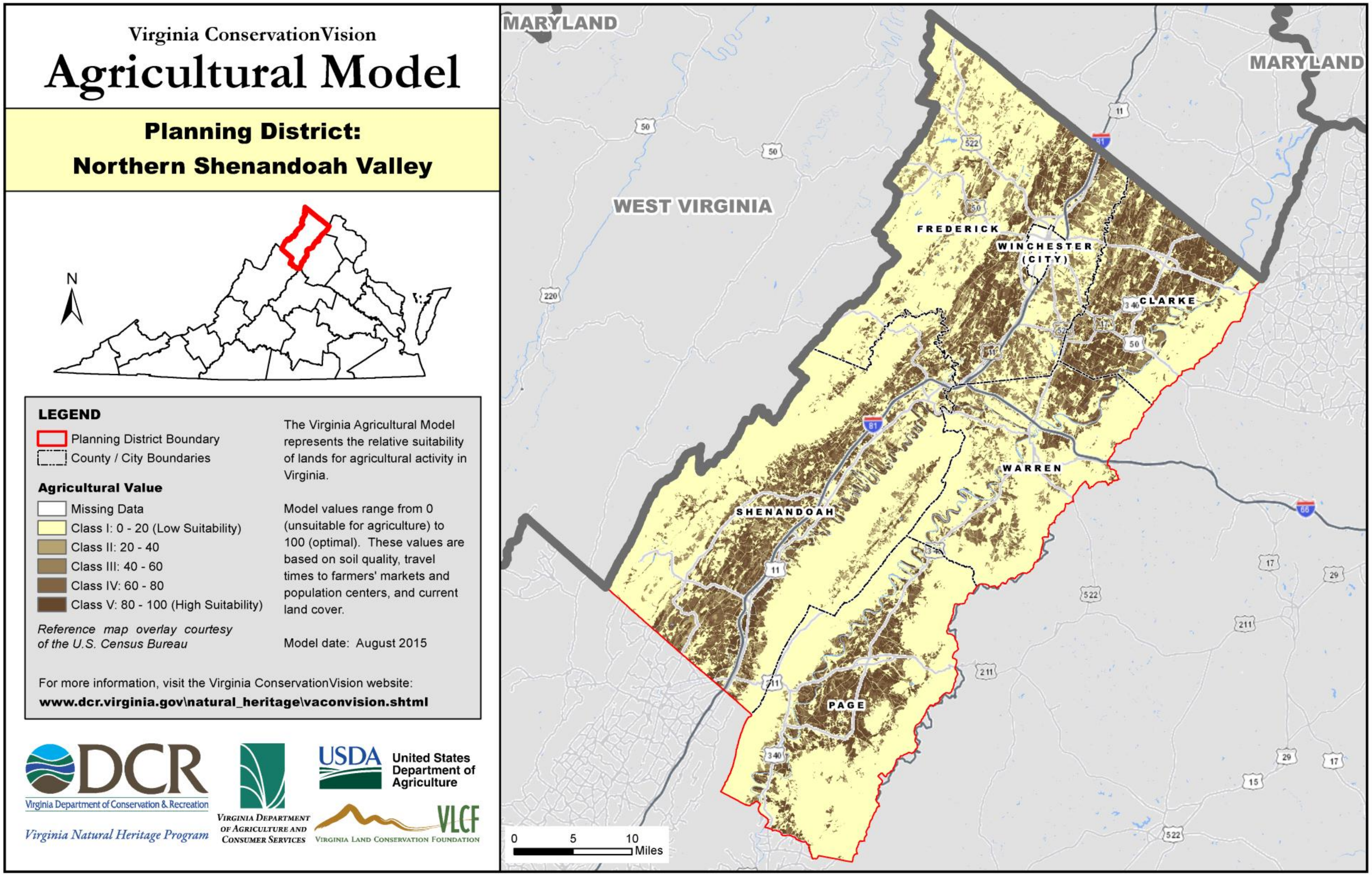
Map 12: New River Valley Planning District



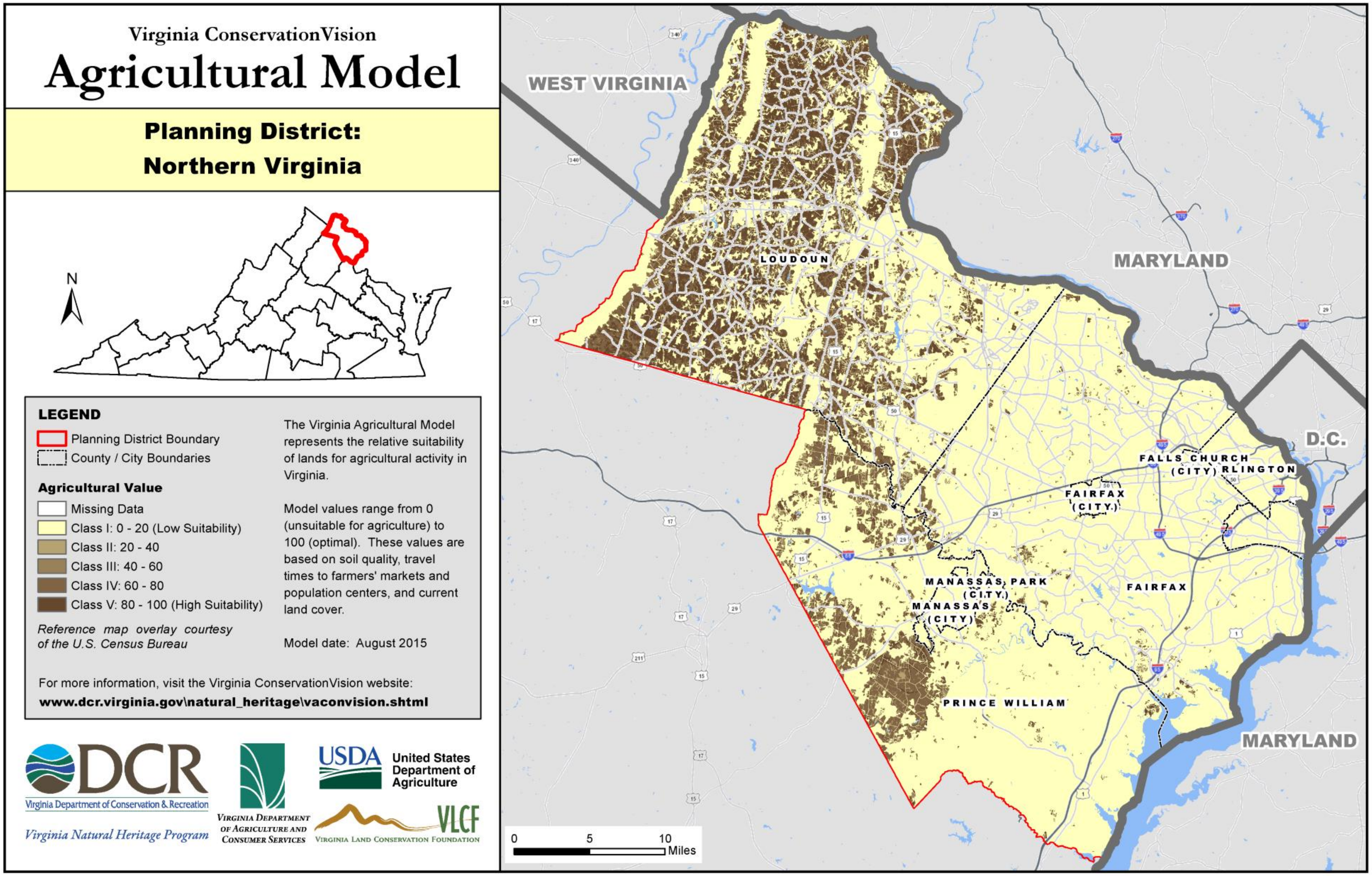
Map 13: Northern Neck Planning District



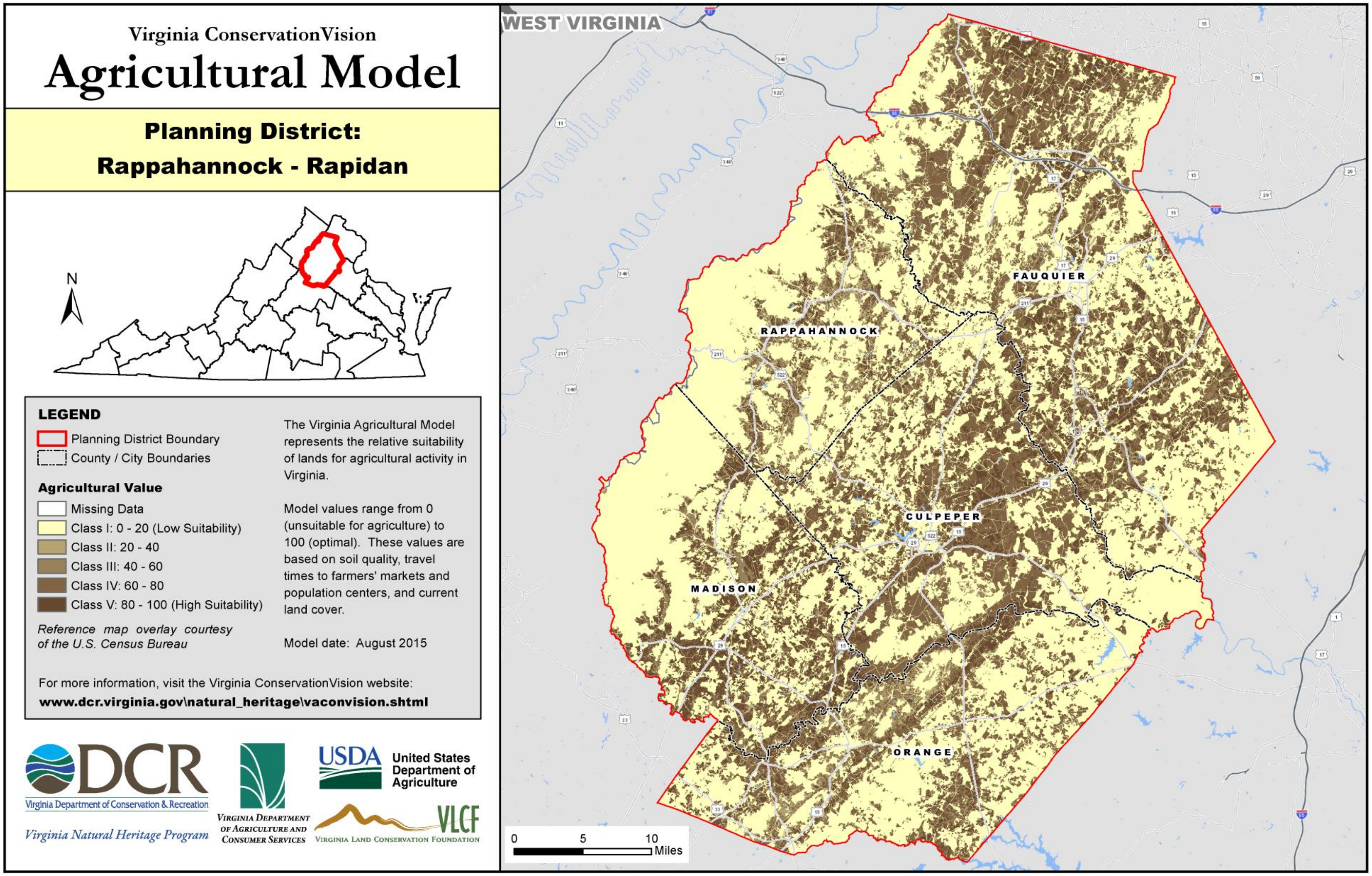
Map 14: Northern Shenandoah Valley Planning District



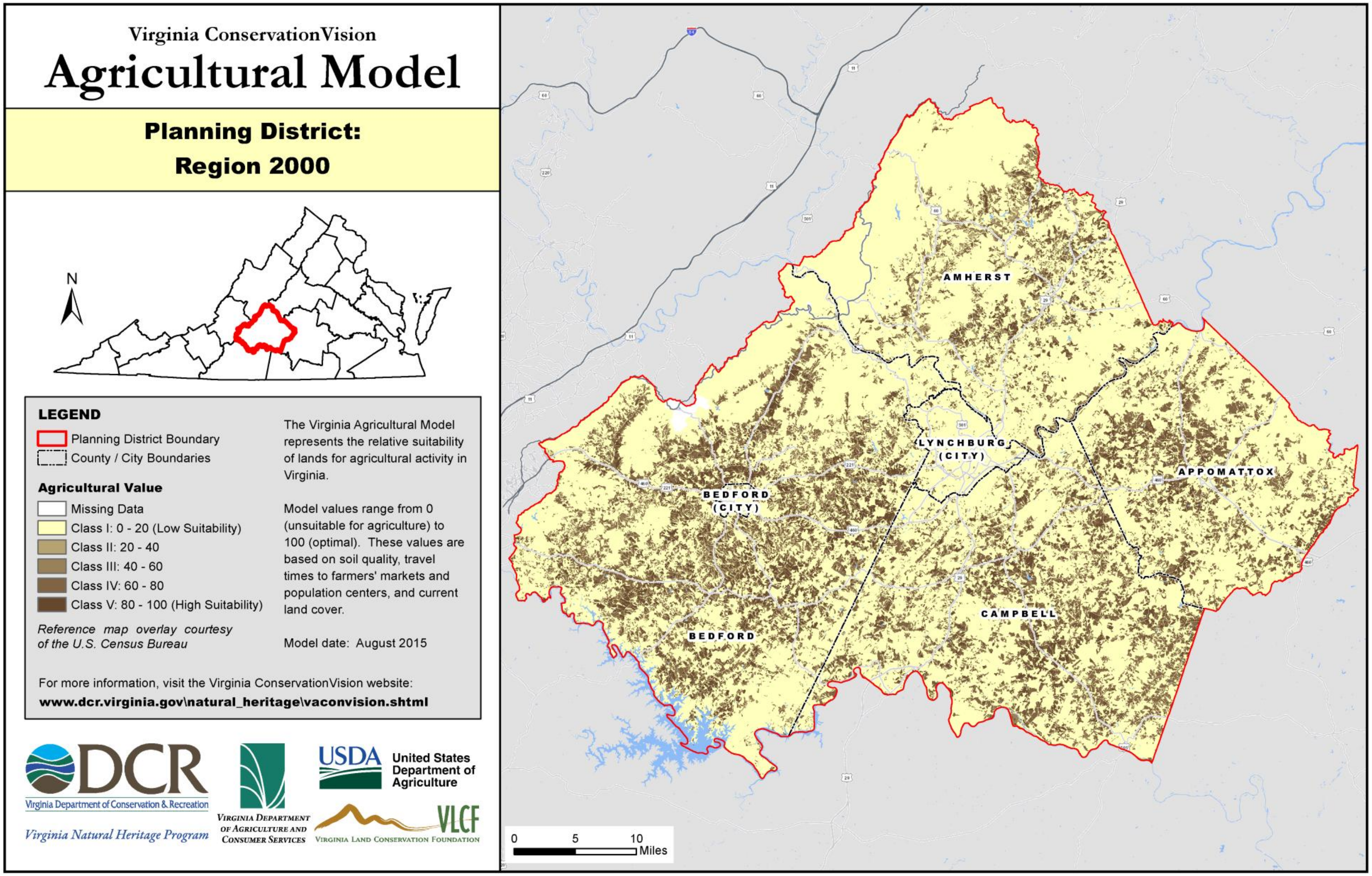
Map 15: Northern Virginia Planning District



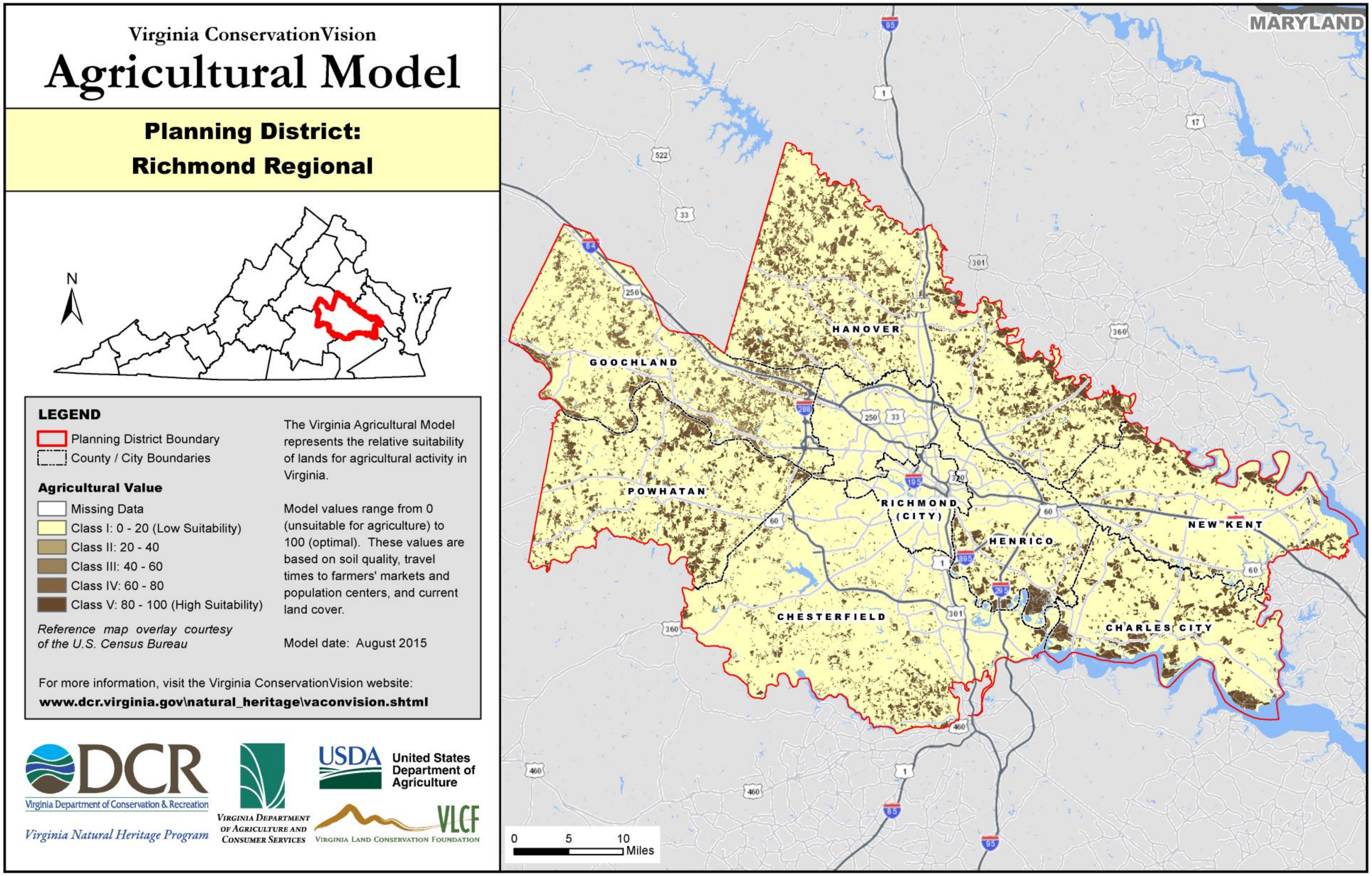
Map 16: Rappahannock - Rapidan Planning District



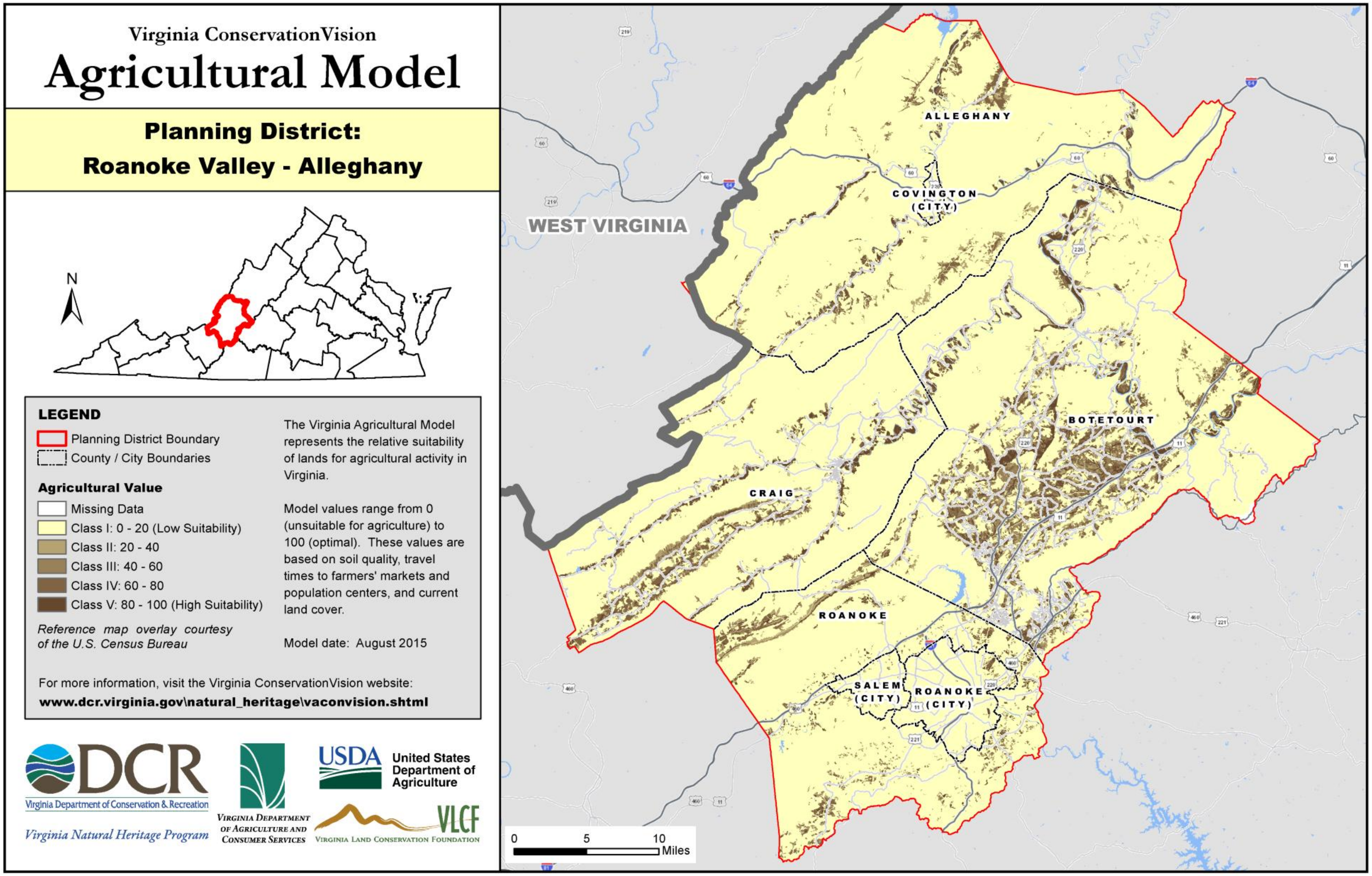
Map 17: Region 2000 Planning District



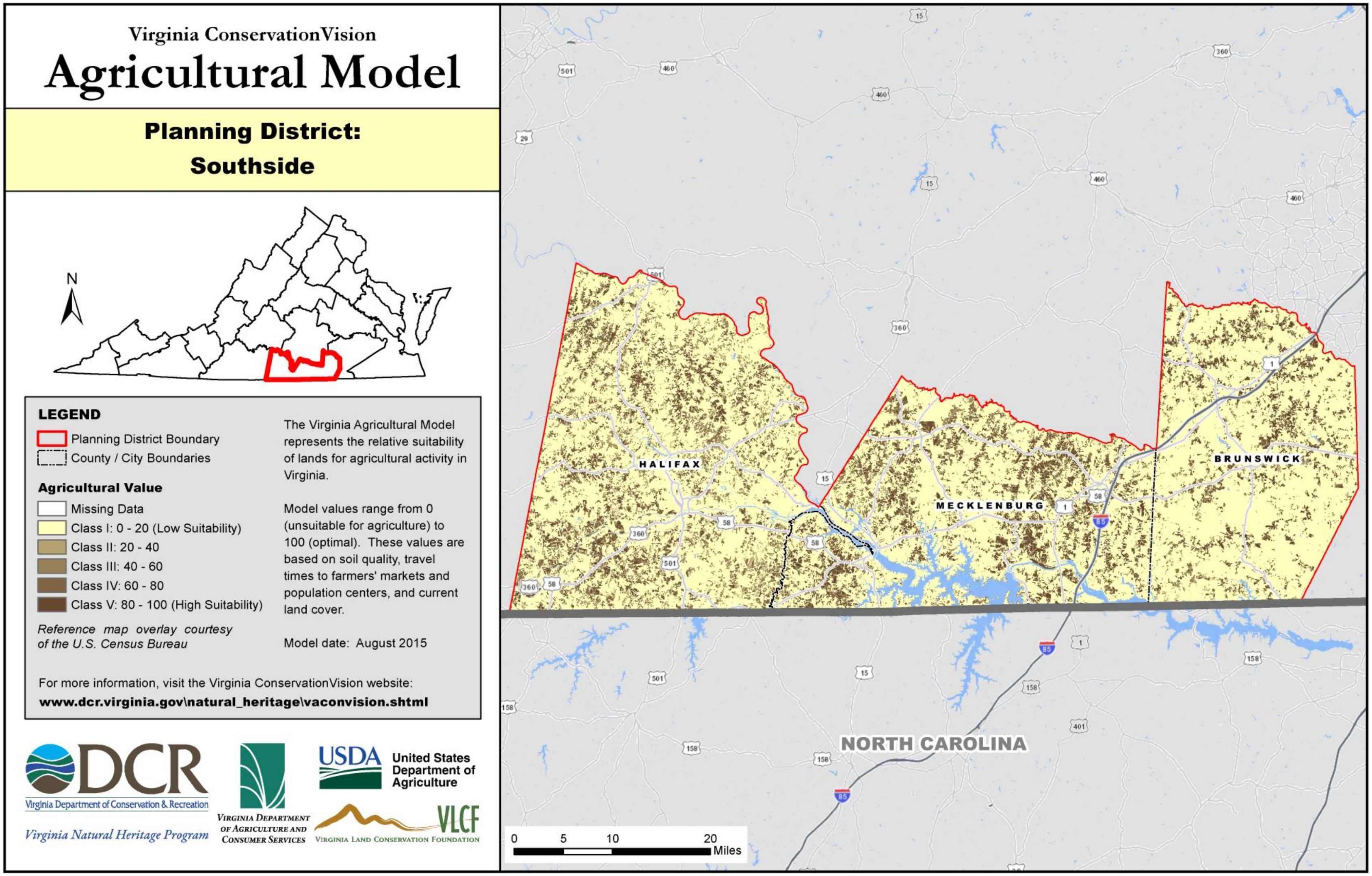
Map 18: Richmond Regional Planning District



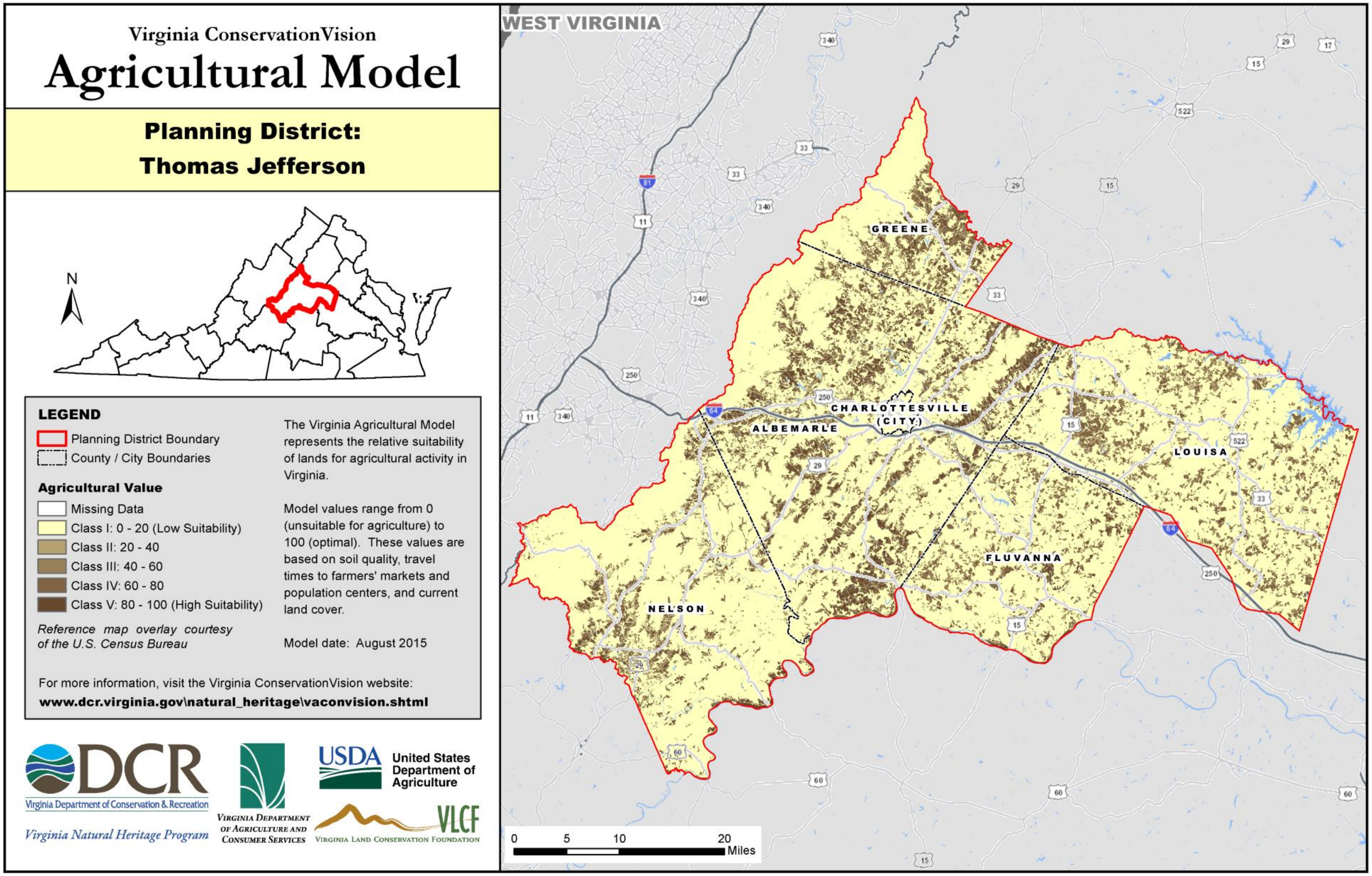
Map 19: Roanoke Valley - Alleghany Planning District



Map 20: Southside Planning District



Map 21: Thomas Jefferson Planning District



Map 22: West Piedmont Planning District