Virginia Department of Conservation and Recreation
GIS Model for Identifying Wetland Restoration Opportunities

With funding from the Federal Highways Administration, the Virginia Department of Conservation and Recreation (VDCR) developed an ArcGIS-based model for cataloging statewide wetland restoration and conservation opportunities. In a pilot project for the Pamunkey River watershed, the model scored individual wetlands and parcels in terms of three metrics: 1) wetland presence, the likelihood that a wetland was present at a site based on the National Wetlands Inventory (NWI) and the predicted locations of additional wetlands, based on modeling conducted as part of this work; 2) mitigation priority, the mitigation potential of a site based on multiple ecological and environmental factors; and 3) composite prioritization, a combination of the first two metrics. Also accounting for habitat and water quality functions, these metrics are intended to guide compensatory wetland mitigation decisionmaking within the state of Virginia and other states. VDCR has produced step-by-step documentation of the GIS procedures underlying the model, which relies on commonly-available national, state- and local-level types of data; making the model transferable to other states.

OVERVIEW

Lead developer(s): Jason Bulluck and Joe Weber, Virginia Department of Conservation and Recreation.[1]

Year developed: 2008, updated in 2010.[2]

Geographic area: Eleven subwatersheds of the Pamunkey River watershed (Fig. 1).[1]

Resource types: Wetlands.[1]

Restoration/conservation: The model is most effectively applied to restoration (reestablishment), with possible application to restoration (rehabilitation), creation, enhancement, preservation/protection, and acquisition without preservation/protection.[2]

Figure 1. In a pilot project, VDCR developed a model to prioritize wetlands within the 11 subwatersheds of the Pamunkey River watershed. Used with permission of Jason Bulluck, Virginia Department of Conservation and Recreation.

Stakeholders: Mitigation providers, particularly state departments of transportation.[2]

Current status: This pilot model could be applied to inform compensatory mitigation in the Pamunkey watershed. VDCR is currently expanding and enhancing the model for statewide coverage, which should make it much more useful to decision-makers throughout the state.[2]

Updated: 3/5/12

PRIORITIZATION ANALYSIS

Landscape prioritization tool(s):

VDCR GIS model: This model identified multiple "wetland source layers" for the Pamunkey watershed including data for known wetlands and streams (National Wetlands Inventory, National Hydrography Dataset, 303(d) impaired streams) and data predicting locations of unmapped wetlands (an analysis of hydric soil attributes and 100-year floodplain data) (Table 1). VDCR also identified "prioritization layers" (Table 1) that were each weighted to indicate the importance of the layer for selecting mitigation sites for biodiversity conservation and/or water quality. Wetland source and prioritization layers were analyzed and displayed based on parcel and subwatershed boundaries to produce a final output layer.[1]

Within this final output layer, a "wetland overlap" metric was calculated by summing the number of overlapping wetland source layers at each location. This metric served as an indicator of both the likelihood of that particular area being a wetland as well as the biodiversity conservation and water quality benefits provided at that location. In addition, a "mitigation priority" metric added the weights assigned for each prioritization layer, and rescaled the result to range from one to five, to produce an overall metric for mitigation potential at each location. Finally, the wetland overlap and mitigation priority metrics were added to produce a "composite prioritization" metric. The maximum values of wetland overlap and mitigation priority metrics for each wetland and parcel were used to assign values to each wetland and parcel.[1]

In developing the model, VDCR collaborated with VDEQ and The Nature Conservancy (TNC) to ensure that the model included basic components that would be important for VDEQ and TNC to consider when applying the model for their own purposes.

Prioritization objectives assessed:[1]

- Habitat quality
- Water quality

Table 1. Factors and associated data sources used to prioritize for habitat and water quality functions.[1]

Factor used in analysis		**Data source(s)**
Wetland overlap metric	Wetlands	NWI
	Streams	NHD
	303(d) impaired waters	N/A
	100-year floodplain data	DFIRM
	Hydric soils, as well as partially hydric soils that also have one of the following attributes: frequently flooded, occasionally flooded and somewhat poorly drained, minimum depth to water table of zero to 31 cm between April and June, or a ponding frequency of 75-100%	SSURGO
Mitigation priority metric	303(d) Impaired Waters of Virginia	VDEQ
	Healthy Waters of Virginia	VCU-CES
	Natural Heritage Priority Conservation Sites	VDCR

	Ecological cores and corridors		VDCR (the VaNLA)
	Existing wetland mitigation banks		RIBITS
	Farmed wetlands	Agricultural land use	2005 CCAP data

VCU-CES = Virginia Commonwealth University – Center for Environmental Studies; VDEQ = Virginia Department of Environmental Quality; VDCR = Virginia Department of Conservation and Recreation; NHPCS = National Heritage Priority Conservation Site; VaNLA = Virginia Natural Landscape Assessment; RIBITS = ACOE Regional Internet Bank Information Tracking System; CCAP = NOAA Coastal Change Analysis Program; NWI= USFWS National Wetland Inventory; USGS NHD = National Hydrography Dataset; DFIRM= FEMA Digital Flood Insurance Rate Map; SSURGO = NRCS Soil Survey Geographic Database.

Validation of the landscape prioritization tool(s): The VDCR GIS model is not calibrated or validated using rapid assessment/intensive data. This project and funding were focused on methodological development. A statewide expansion of the model is underway and will include groundtruthing.[3]

Prioritization products: Outputs from the VDCR GIS model include maps displaying the ranks generated from wetland source layer overlap, mitigation priority, and composite prioritization metrics. Maps were produced that assigned these metrics to both individual wetlands (Fig. 2A) as well as the specific parcels containing those wetlands (Fig. 2B). In addition, tabular products scoring each wetland and parcel were produced (Fig. 3).[1] Tabular outputs can be altered (i.e. manipulation of weights assigned to prioritization factors) by a desktop GIS user to display varying map outputs with emphasis on different mitigation values.[3]

Furthermore, to support potential efforts to repeat its prioritization analysis for different areas, VDCR provides in its technical report, detailed step-by-step instructions that describe how its analysis was carried out in ArcGIS.[1]

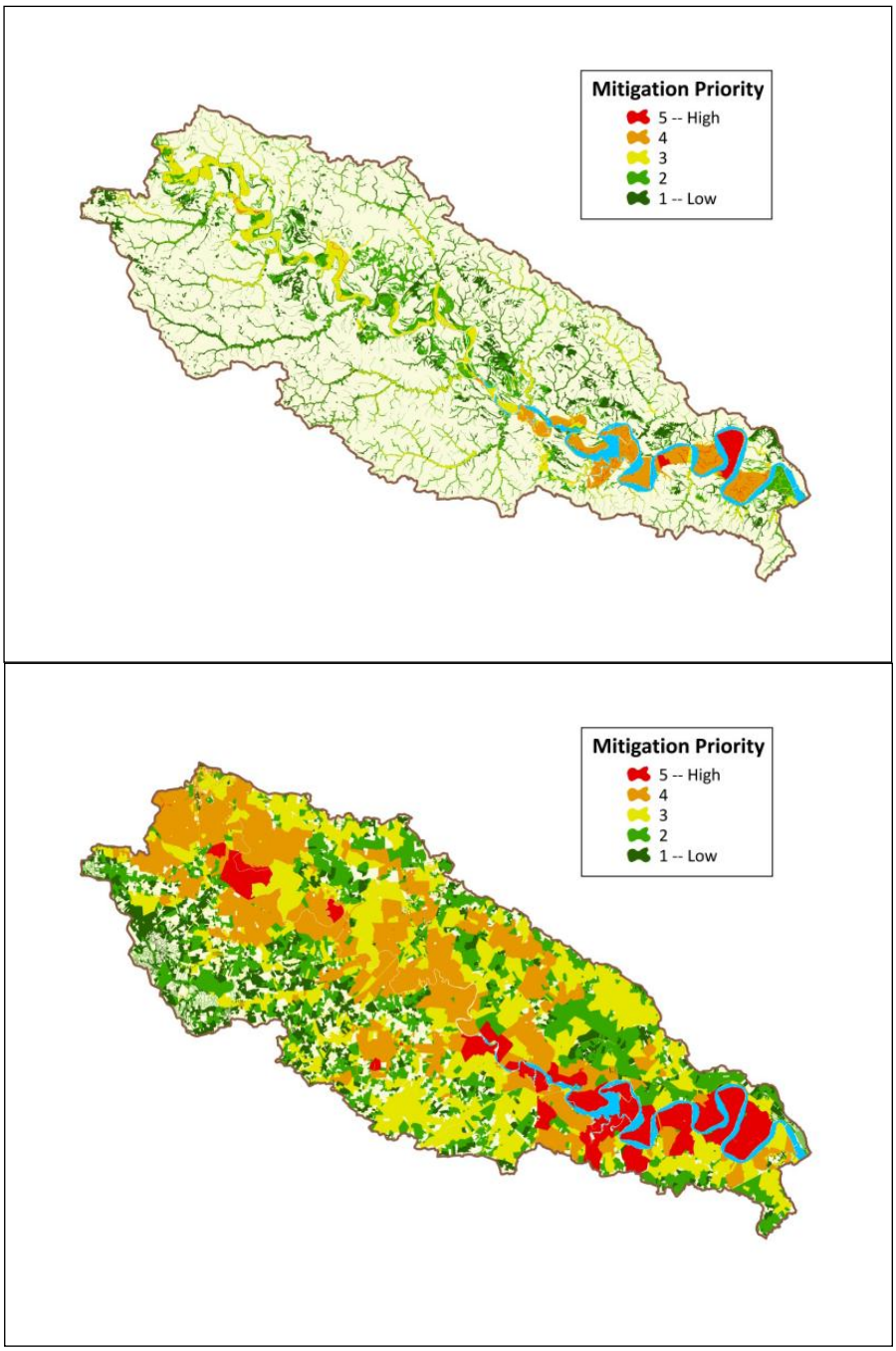

Figure 2. The Virginia model assigned mitigation priority scores to all identified wetlands (*top*), as well as individual parcels (*bottom*), in the Pamunkey River watershed. Used with permission of Jason Bulluck, Virginia Department of Conservation and Recreation.

ParID	WSID_1	WSID_2	WSID_3	WSID_4	PS1W	PS2W	PS3W	PS4W	PS5W	WetOver	MitPrior	CompPrior	Reclass5
127-584	NWI99332	NHD02080106006070	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006075	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006076	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006070	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006075	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006070	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006076	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006075	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006076	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006070	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006075	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5
127-584	NWI99332	NHD02080106006076	DFIRM2134	SSURGO21133	2	3	1	0	3	4	9	13	5

Figure 3. Attribute tables from VDCR spatial products, such as that shown above, provide values for wetland likelihood overlay, mitigation value, and composite prioritization scores. Wetland likelihood overlay (columns with "WSID…" header) and mitigation values (columns with "PS#W" header) are weighted and used in a calculation to assign the composite prioritization score (CompPrior), which is classified into 5 classes for map display from 1-Low to 5 – High. Tabular output tables and the underlying algorithm can be manipulated by GIS desktop users to generate varying map outputs with emphasis on different mitigation values.[3] Used with permission of Jason Bulluck, Virginia Department of Conservation and Recreation.

IMPLEMENTATION

Regulatory/non-regulatory programs:

- Section 404 compensatory mitigation
  - State DOT wetland and stream mitigation for infrastructure projects: The model was funded by the Federal Highways Administration specifically to help improve mitigation decisionmaking by state DOTs.[2]
  - Watershed approach to compensatory mitigation: The model identifies individual wetland and stream priorities, as well as priority parcels, to target for compensatory mitigation at watershed scales (e.g., Fig. 2).[2] In addition, mitigation opportunities with hydrological connectivity to impaired or healthy waters can be prioritized to improve or sustain water quality at a watershed level.[3]
  - TNC's Virginia Aquatic Resource Trust Fund in-lieu fee (ILF) program. VDCR would like to see the pilot or upcoming statewide VDCR model used to inform the selection of sites for wetland restoration and enhancement by TNC's ILF program, and/or the NRCS' Wetland Reserve Program.[2]
- Endangered species mitigation: The model may be used as supporting data for wetland species restoration and conservation efforts.[3]
- Organizations seeking to acquire and protect high quality lands (e.g., land trusts): The model's prioritization of individual parcels may support aquatic resource protection efforts.[2]

Transferability:

- The method underlying the model was designed specifically so that it could be transferred readily to other state DOTs or natural resource agencies, enabling them to produce Wetland Restoration Catalogs of their own to inform compensatory mitigation decisionmaking.[2]
- In a technical report, VDCR documented step-by-step GIS procedures for building its prioritization model. Other states could use this documentation to identify opportunities to tailor the model specifically for their needs.[2]

- Many datasets used by the model are national datasets (e.g. SSURGO data) that can simply be reapplied if the model is transferred to other states. Other datasets used in the model are state-level datasets that may not necessarily be the same as those in other states, though there are likely similar datasets available (e.g., state Natural Heritage Program habitat data).[2]
- VDCR's approach is generally more cost-effective than the traditional piecemeal approach used by some government agencies and developers to address their mitigation obligations. This benefit of VDCR's tool is particularly relevant for state/federal transportation agencies. VDOT, for example, has provided matching funds on VDCR's current effort to enhance these methods for a Virginia-specific, statewide catalog. In addition, the Federal Highway Administration has embraced the VDCR Model for its ability to support long-term planning for compensatory mitigation for transportation impacts.[4]

Data gaps:

- Aquatic habitat data: High-quality fish and macroinvertebrate data, maintained by Virginia Commonwealth University's INSTAR (Interactive Stream Assessment Resource) database, are not consistently available for western Virginia. This limits VDCR's ability to prioritize streams for restoration and conservation. However, VCU is always adding data to their INSTAR database, so existing data gaps are being filled.[2] The statewide Wetlands Catalog revision will include new data from throughout Virginia.
- Current SSURGO soils data are incomplete. However, the Natural Resources Conservation Service is always working to obtain more soils data and achieving a complete dataset is just a matter of time.[2] Great improvements will be made in the statewide wetlands modeling due to more thorough soils data for Virginia.
- Climate change data: VDCR would like to integrate the effects of climate stressors (e.g., sea level rise) into the model, which are important to consider for wetland preservation.

VDCR is considering using sea level rise data from the Sea Level Affecting Marshes (SLAM) model. It is also considering using predicted precipitation/temperature data from recently downscaled climate models developed by the Virginia Department of Game and Inland Fisheries and from Intergovernmental Panel on Climate Change (IPCC) step-down climate models.[2]

Groundtruthing: Due to funding limitations in the Pamunkey watershed pilot, and the focus of developing a transferable wetlands catalog *methodology*, groundtruthing was not conducted to assess the accuracy of predicting wetlands that are not included in the National Wetlands Inventory.

Barriers

- The funding barrier, to complete a statewide application of the model,[2] has now been overcome, as the NRCS, DCR, VDOT, TNC and VCU have funded the development of a Virginia statewide wetlands catalog. Challenges once this effort is complete (Summer 2014) will pertain to supporting the use of the catalog by various local, state and federal partners, for various wetland preservation and restoration efforts.

Future goals:

- Completion of a statewide wetlands catalog, expected Summer, 2014. This product will be based on the methods developed in the Pamunkey watershed pilot, but will be enhanced via statewide focus; inclusion of additional Virginia-specific datasets for prioritizing wetlands; a groundtruthing effort to validate the wetlands modeling component; and map outputs that rank restoration and preservation opportunities distinctively.
- Implementation of the model by other state agencies (e.g., VDOT) and TNC's Virginia Aquatic Resources Trust Fund (VARTF) ILF program. TNC's VARTF already has an approach for identifying priority sites, which could make them less likely to adopt the VDCR model. [2]

[1] Weber JT, Bulluck, JF. 2010. Methodology for developing a parcel-based wetland restoration, mitigation, and conservation catalog: A Virginia pilot. Natural Heritage Technical Report #10-22. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia 34 pp.
[2] Interview on 8/9/2011 with Jason Bulluck, Natural Heritage Information Manager, Virginia Department of Conservation and Recreation, Division of Natural Heritage.
[3] Feedback received on 3/7/2012 from Jason Bulluck, Natural Heritage Information Manager, Virginia Department of Conservation and Recreation, Division of Natural Heritage.
[4] Feedback received on 6/15/2012 from Jason Bulluck, Natural Heritage Information Manager, Virginia Department of Conservation and Recreation, Division of Natural Heritage.