Protocols for Implementation of a GIS-based Model for the Selection of Potential Wetlands Restoration Sites Southeastern Virginia

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Introduction

The motives for restoring wetlands are variable. Environmental initiatives funded through government and non-profit organizations steer many activities seeking to restore habitat function. Local governments and developers restore wetlands for storm water treatment and water quality benefits. Developers and land owners initiate wetlands restoration as a form of mitigation for wetland losses. There are other examples as well.

Irrespective of the objective, all wetlands restoration projects must identify a location on the landscape appropriate for the activity. While there are characteristics unique for specific goals, there are also several basic criteria which must always be considered. These basic criteria are the premise upon which this targeting protocol has been developed. The protocol is intended to assist in the selection of future wetlands restoration sites across the landscape. It has been applied to a selected pilot region encompassing 3,800 km^2 (938,995 acres) of southeastern Virginia (Figure 1). Appendix 3 includes a set of maps which illustrate selected sites that meet these basic criteria. These maps are tools, and do not replace the need for site visitation and inspection.

(Figure 1)

Acknowledgments

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Recreation's Division of Natural Heritage provided GIS data to support the protocol. The VIMS Publications Center provided assistance in final report layout.

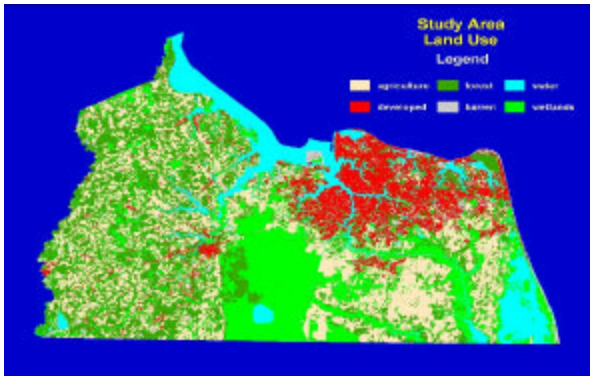
Protocol Development

This project has been driven by two underlying requirements. First, the model will be GIS based, and the protocols for site selection must be interpretable from existing GIS coverages or themes. Second, ultimately site selection for restoration of wetlands will be governed by opportunity to convert an existing land use to a wetland landscape. The protocol ranks potential sites based on the number of conditions met. A simple appraisal system that classifies an area as a 1) potential, 2) good, 3) high, 4) excellent site for restoration is employed.

Best professional judgement combines scientific, management, and engineering experience related to wetlands ecology and restoration. Staff of the Center for Coastal Resources Management defined the criteria to be used. The GIS staff of the Comprehensive Coastal Inventory Program developed the GIS models to reflect the decision rules underlying the protocol. GIS data to support the model were collected from a variety of sources. Verification of the final products was a combined effort.

The protocol is a hierarchical approach for evaluating a suite of conditions within the landscape. The foundation of the hierarchy is land use. The evaluation considers only land use types with a high degree of probability that the land could be converted to a wetland if other physical requirements are present. Therefore, the starting point in the decision tree begins by looking across the landscape for land use types that offer the opportunity for future conversion.

The source for land use data is the National Land Cover Dataset (NLCD) which was published in 2000 and represents land cover conditions between 1989-1992 in the study area. NLCD is derived from Landsat Thematic Mapper imagery captured by satellite. The imagery has a 30 meter pixel resolution. Products are distributed by the United States Geological Survey (USGS). The classification is based on a level 2 Anderson model (Appendix 1), and the distribution of cover types is illustrated in Figure 2 for the study area. Given this classification, the restoration targeting tool considers only land cover types classified as forested or agriculture. The



analysis clusters NLCD row crops, probable row crops, and hay/pasture/grass into agriculture, and deciduous, conifer, and mixed as forest. The remaining steps (Levels) in the protocol use only these designated polygons.

Figure 2. NLCD Land Use in Study Area

Level 1. Level 1 of the protocol requires that **hydric soils** be present. Using two sources of digital soils data (VIRGIS, SSURGO), a GIS soils coverage was clipped for the study area boundary. All hydric soils greater than 0.25 acres within forested or agricultural land uses were considered plausible sites regardless of hydric soil type. In the final analysis, these polygons are classified as "potential" restoration sites.

Level 2. Level 2 assumes that in addition to hydric soils, **hydrologic connectivity** to the hydric soil polygon is present. Using USGS DLG hydrography, the soil polygons with intersecting streams were identified. Only those that are coincident with either forest cover or agricultural uses are integrated. These areas become classified as "moderate" choices for future wetlands restoration sites.

Level 3. Level 3 integrates existing **wetlands** into the model. Using data provided by the National Wetlands Inventory Program (NWI) of the US Fish and Wildlife Service, tidal and nontidal wetland polygons adjacent to hydric soils polygons with hydrologic connectivity were searched. The premise behind this level in the hierarchical protocol rests in an assumption that success of a restored wetland should be enhanced if placed in a wetland landscape. Therefore, selecting a site currently forested or agricultural, that meets soils and hydrologic conditions and is adjacent to an existing wetland increases probability that the restoration effort will succeed.

A distinction at this level is made between forest cover and agriculture. If the polygon is currently forested the ranking is "good". If, however, the polygon is agricultural the ranking is "high". This distinction is made for two reasons. Preferential selection is given to agricultural lands due to the ecological values of forest cover, and the desire to preserve forest buffers. Second, in southeastern Virginia, as in many other regions of the country, wetlands were filled to create farmland. The actual location of what are known as "prior converted wetlands" or PCWs has not been mapped as a GIS coverage. This model assumes that agricultural land meeting soils and hydrology conditions has the potential of being a PCW when adjacent to a wetland. Therefore they are valued higher than forest areas as a potential site for restoration.

Level 4. Level 4 introduces the last criteria for site selection, **existing conservation areas**. Conservation areas can include officially designated sites such as parks, and wildlife refuges, or special management areas noted for critical habitat that support rare, threatened, or endangered species. Mapped areas were delineated by the Commonwealth's Natural Heritage Division within the Department of Conservation and Recreation. Adjacency to existing conservation areas is used as a modifier for Level 3 ranking. Any areas ranked as "good" under Level 3 (forested polygons with hydric soils, intersecting hydrology, and adjacency to existing wetlands) will be elevated to a rank of "high" if these polygons are also adjacent to a conservation area. Areas ranked as "high" under Level 3

(agricultural polygons with hydric soils, intersecting hydrology, and adjacency to existing wetlands) will be elevated to a rank of "excellent" if these polygons are also adjacent to a conservation area.

Protocol Evaluation/Validation

Remote sensing techniques using high resolution 1994 digital orthophotography were applied to validate the results of the GIS model output. This step reviewed polygons classified by the protocol as a wetland restoration site, and verified that the proposed sites meet basic criteria. These sites could only be verified for land use, hydrology, and wetlands. Soils could not be verified using this technique.

The results of the validation exercise indicated that landuse in this developing region of Virginia had changed to such a degree that 1989-92 imagery did not always yield accurate land cover type results. In addition, there were obvious misclassification errors in the NLCD classification. Therefore a number of areas ranked as "good" or better were already developed. Many of these were areas classified as forest cover, but were actually developed. The NLCD frequently misclassified major transportation corridors as forest cover due to the presence of trees within the median. To reduce these errors, the model was rerun using a 1997 classified dataset that was more accurate. This dataset was not available for the entire study area. However, applying this dataset to those areas available improved the overall margin of error from 50% to less than 15%.

Additional modifiers were also included to refine the accuracy of the final product. Thirty-five (35) meter buffers were established around transportation (roads and rails) networks to eliminate the selection of medians and right of way as restoration sites. Within NWI dataset, the coverage for wetland "arcs" was buffered by 2m. This buffer creates polygons which generates connectivity between wetlands and hydrology. Minimum restoration unit considered in the model is one (1) acre. Therefore no sites less than an acre are identified. Sliver wetlands, defined as very long thin wetlands typical of drainage ditches, were ultimately eliminated from the model as they do not provide good restoration sites.

Final results of this landscape assessment in southeastern Virginia are illustrated in a series of maps (Appendix 3). Maps are developed on the basis of half quadrangles using the boundaries of USGS 7.5 minute, 1:24,000 scale, topographic maps. The nomenclature uses USGS conventions followed by N (north) or S (south) (e.g. Runnymeade Quad N = northern half of the Runnymeade Quadrangle). The maps can also be viewed and downloaded from this url: http://www.vims.edu/ccrm/projects.html#cci under the project listing for "Advanced Identification of Wetland Restoration Sites".

Wetland Function Analysis

The Chesapeake Bay Program's Wetlands Assessment, developed by the Wetlands Workgroup of the Living Resources Subcommittee, was applied to all polygons classified as good, high, or excellent sites for wetland restoration. The Wetlands Assessment is a tool which evaluates

individual wetlands for the probability of performing a specific function. Five functions are addressed: water quality, flood control, sediment control, erosion control, and habitat. The assessment considers wetland type, landscape position, and surrounding land use or cover to determine the probability that a particular function will be performed.

Since the Wetlands Assessment is applied to an existing wetland, in order to assess the restoration sites for function, it was necessary to assume the site had already been restored successfully to a specific wetland type. For simplicity, all restoration sites were assumed to be palustrine forested wetlands. Variations in this functional assessment may occur if the site was restored s to some other wetland type (e.g. emergent). The results of the analysis are illustrated in Appendix 4 for the study area.

Summary

Table 1 summarizes the criteria used to evaluate the landscape for potential sites suitable for the restoration of wetlands. The protocol is constrained by available data and the accuracy of data. Modifiers were integrated into the model to minimize errors associate with outdated and misclassified material. This landscape evaluation was executed using GIS technology and the ArcInfo® software. Analytical programs written in Arc Macro Language (aml) are designed for flexibility as new datasets become available spatially and temporally. The protocol can be applied anywhere if these basic GIS datasets are available: soils, hydrology, wetlands, landuse, and conservation areas.

Within the pilot region, 15.21 km^2 (3,759 acres) of landscape meet the Level 4 criteria as an excellent site for wetlands restoration. Sites with a Level 4 "high" potential cover 257 km^2 (63,629 acres). Sites meeting criteria at level 3, good, equal nearly 154 km^2 (36,120). Approximately 8 km^2 are elevated to high status under Level 4 due to their adjacency to conservation lands. More detailed metrics are reported in Table 2. Appendix 3 provides maps to illustrate the distribution of sites within the pilot area.

Table 1. Summary of Protocol Hierarchy

Level	Landscape Requirements	Ranking
1	forested , hydric soils	potential
1	agricultural, hydric soils	potential
2	forested, hydric soils, hydrologic connectivity	moderate
2	agricultural, hydric soils, hydrologic connectivity	moderate
3	forested, hydric soils, hydrologic connectivity, wetland adjacency	good
3	agricultural, hydric soils, hydrologic connectivity, wetland adjacency	high
4	forested, hydric soils, hydrologic connectivity, wetland adjacency, conservation area	high
4	agriculture, hydric soils, hydrologic connectivity, wetland adjacency, conservation area	excellent

Table 2. Final Summary Analysis for southeastern Virginia (acres)

Level	Ranking	Area	Current Land Cover
1	potential	96,446	forest
1	potential	128,451	agriculture
2	moderate	63,985	forest
2	moderate	82,504	agriculture
3	good	38,120	forest
3	high	65,338	agriculture
4	high	63,629	forest
4	excellent	3,759	agriculture

A functional assessment technique was applied to evaluate the probability that the restored sites may perform five different wetland functions. This assessment assumed that all potential sites would be restored to palustrine forested wetlands. The final results are mapped by function, and are illustrated in Appendix 4.

APPENDICES

Appendix 1. National Land Cover Data - Classification

Land Use Value

high intensity developed

low intensity developed

row crops *

probable row crops *

hay/pasture/grass *

deciduous forest *

conifer forest *

mixed *

emergent wetlands

wood wetlands

barren; quarry

barren; coal mines

barren; beach areas

barren; transitional

water

* Considered as potential sites for future wetland restoration activities

Appendix 2. GIS Data

Coverage	Origin/Source	Date(s)*
NLCD	USGS/USEPA	1989-92
Virgis	VaTech	1970s
SSURGO	USDA	various
DLG Hydrology	USGS	various
NWI	USFWS	1970s-80s
Conservation Lands	Va DCR/Natural Heritage	2000

USDA: United States Department of Agriculture
USEPA: United States Environmental Protection Agency
USFWS: United States Fish and Wildlife Service
USGS: United States Geological Survey
VaTech: Virginia Polytechnic University
VaDCR: Virginia Department of Conservation and Recreation

DLG: Digital Line Graph
NLCD: National Land Cover Dataset
NWI: National Wetlands Inventory
SSURGO: Soil Survey Geographic Database
Virgis: Virginia GIS

Appendix 3. Restoration Targeting Maps

Appendix 4. Functional Assessment Maps