Wetlands Program

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Riparian Forest Buffer Restoration Targeting for the Rappahannock River Watershed

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Introduction

A little over three hundred years ago, more than ninety-five percent of the land within the Chesapeake Bay watershed was forested; today's estimate of forest cover is just over sixty percent (Forested Lands, 1997). Much of this deforestation has occurred in the riparian zone, an area of high ecological importance. The Chesapeake Bay Program recognizes that "forests along waterways, also known as 'riparian forests,' are an important resource that protects water quality" (Riparian Forest Buffers, 1996). In addition to protecting water quality, forests along the shore function to maintain the integrity of the stream channel, reduce the impact of upland pollution sources and supply food and habitat resources to fish and other wildlife (USDA, 1997 and US-EPA, 1996). In recognition of these many potential benefits, it has become the official policy of the Commonwealth of Virginia, as a partner in the Chesapeake Bay Program, to pursue reforestation of 610 miles of its shorelines by the year 2010. How is Virginia, in cooperation with the Chesapeake Bay Program, going to accomplish this task?

To be effective in increasing water quality and habitat resources within the Bay watershed, "riparian buffers need to be planned and implemented on a watershed scale" (US-EPA, 1996) and also located in areas where buffer function can be maximized. There are several approaches for prioritizing riparian zones for restoration efforts. The protocol developed by VIMS is based on an evaluation of environmental benefits provided by riparian forest buffers (RFB). The difficulty in designing a protocol based on environmental evaluation is that there is no well-defined paradigm for evaluation of potential environmental benefits associated with reforestation of riparian areas. Guidance must be developed by inference from a variety of extant studies on performance of specific functions by riparian forests. Another constraint on development of a targeting protocol applicable to large areas is the availability of data to support the decision rules. After receiving available data sets, it was decided to limit the targeting protocol to information about land use/land (LULC) cover adjacent to surface waters. This requires just two data sets: shoreline position and land use/land cover. The consequence of limited data is decision rules must be very simple. Despite these constraints, the targeting protocol developed for the Rappahannock River watershed proved capable of ranking areas at two different scales.

Approach

The riparian forest buffer restoration project undertaken by VIMS was designed to operate in ERDAS IMAGINE using classified Landsat TM data and digital shoreline data. The Landsat TM data gathered from 1991, 1992, and 1993 (leaf on coverage) was classified as part of the Multi Resolution Land Cover (MRLC) classification program. The protocol assumes that the basic resolution of the Landsat TM imagery defines the detectable riparian zone as a 30 meter wide swath. The protocol uses information about the land use/land cover (LULC) within the 30m riparian zone as well as information about conditions in the next two 30m zones moving inland. The digital shoreline maps were U.S. Geologic Survey files developed at a 1:100,000 scale. The hydrologic unit (HU) boundaries are defined by Virginia's Department of Conservation and Recreation as 8-digit hydrologic units.

The targeting protocol uses a two phase approach to designate priority restoration areas. The first phase attempts to rank HUs within a watershed based on their potential pollution contribution to the watershed. The second phase considers the riparian zone within a hydrologic unit and prioritizes shoreline reaches on the basis of opportunity and need for reforestation.

Phase one of the protocol is accomplished by using three indicators that assess the general opportunity and need for riparian reforestation within each hydrologic unit. In general, the protocol assumes that the need for reforestation is relatively higher in hydrologic units which: (1) have a high proportion of LULC which might contribute to nonpoint source pollution; (2) have a high proportion of riparian lands; and (3) have a high proportion of LULC within the riparian zone which might contribute to nonpoint source pollution. In order to determine which HUs contribute the most to nonpoint source pollution, each defined land use class in the MRLC classification is assigned to a category of potential pollution contribution. All developed and crop lands are assigned to the class of potentially polluting land uses, whereas wetlands, forested lands and barren lands are all considered non-polluting land uses.

Each indicator is essentially a percentage. For example, indicator 1 (proportion of LULC which might contribute to nonpoint source pollution) is calculated for each hydrologic unit as the percentage of all land within the HU which is developed or agricultural. After the values for a particular indicator were calculated for all hydrologic units, they were sorted by score. The one-third with the highest scores were given a numerical value of "3". The middle one-third of scores were assigned a rating of "2", and the lowest one-third a rank of "1". After all three indicators are similarly developed the final prioritization of all hydrologic units is accomplished by simply adding the respective values for each of the three indicators. The result is a population of cumulative values ranging from 3 to 9. Hydrologic units receiving the highest values (cumulative score of "8" or "9") would be those areas within the watershed which have the highest proportion of developed or agricultural lands, the highest proportion of land adjacent to surface waters, and the highest proportion of developed or agricultural riparian lands. The protocol assumes that these three conditions create the greatest relative potential for nonpoint source pollution which might be ameliorated by RFBs.

The second phase of the protocol studies the riparian zone within a hydrologic unit. All of the shoreline within a HU is assessed on a reach by reach basis for both opportunity and need. For the purposes of this protocol, a reach is defined as a length of shoreline with a continuous, similar land use greater than 1000ft. in length. By impressing a minimum reach length of 1000ft, an inappropriately detailed assessment of the shoreline is avoided. Since RFBs may be desired for water quality functions or for habitat functions, the protocol is designed to evaluate the need for each function separately. This second phase of the protocol is based entirely on

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existing LULC in the 30m riparian zone and in the adjacent 60m wide inland area.

Opportunity for restoration of the riparian zone is assessed by considering the existing riparian LULC. The protocol assumes that reforestation is not equally possible on all nonforested areas. Opportunity within a riparian zone is determined to be high for agricultural lands, moderate for barren lands, and low for developed lands, existing forests, wetlands, and beaches.

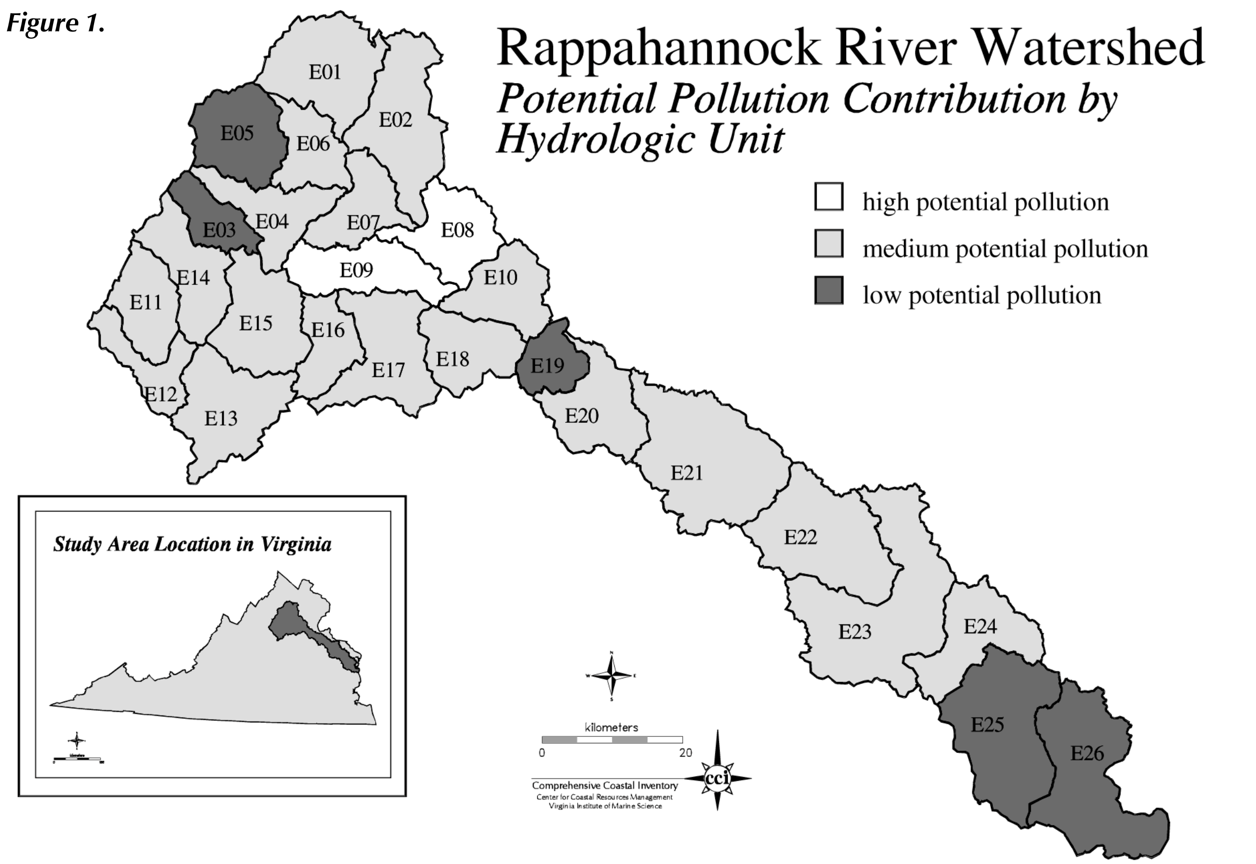
Need for reforestation is assessed based on LULC in the inland zones of the 30m riparian area. The need for RFB water quality functions is assumed to be high when the adjacent inland area is developed or agricultural. It is assumed to be moderate for any other adjacent inland LULC. The need for RFB habitat functions is assumed to be high when the adjacent inland LULC is agriculture or wetland. Developed areas and barren areas are assumed to create a moderate need, and forested areas or beaches are judged to establish a low need. Riparian reaches are assigned a priority ranking for RFB restoration for water quality functions based on the combined opportunity and water quality need values. The same approach is used for habitat function ranking. A final cumulative priority ranking is developed by simply compositing the two function specific rankings.

Results

VIMS applied the targeting protocol to the Rappahannock River watershed. Application of the protocol to this watershed generated the findings presented below.

HU Prioritization: There are twenty six hydrologic units identified within the Rappahannock River watershed. Figure 1 presents the ranking of each HU based on their cumulative scores for the three prioritization indices. The figure shows that only two of the HUs rank high for potential nonpoint pollution contribution. These two HUs rank high for all three indices. Five of the twenty-six hydrologic units within the watershed have a cumulative low ranking for potential contribution of nonpoint source pollution. All of these HUs rank low for at least two of the three indices. Thus, a combination of factors such as having a small proportion of agricultural lands within the unit coupled with a small amount of riparian land indicates that potential pollution

Figure 1.



contribution is low for these HUs and these units are not a high priority for restoration of riparian lands. The remaining nineteen HUs have a cumulative moderate ranking. A variety of situations lead to a moderate ranking. For example, E23 ranks high for proportion of riparian lands, moderate proportion of LULC which might contribute to nonpoint source pollution and low for the proportion of riparian lands that contribute to nonpoint source pollution. Of these nineteen units, however, only one (E16) ranked high for more than one indice. Its cumulative score is moderate, however, due to its low ranking for its proportion of riparian lands.

Riparian Zone Targeting: Table 1 lists the total shoreline miles, miles of shoreline in each of the HUs determined by the protocol to have an op-

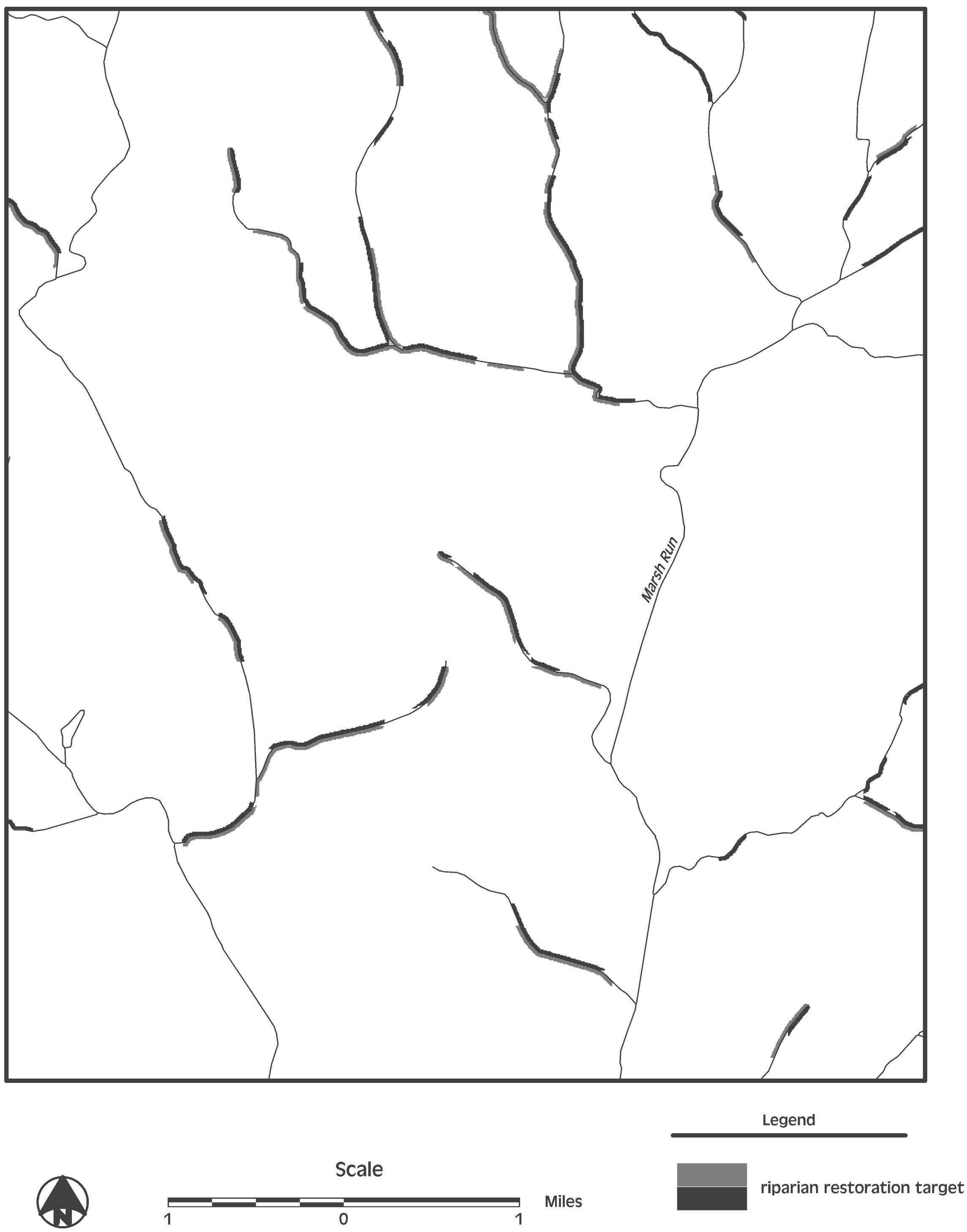
Table 1: *Phase two results for each hydrologic unit within the Rappahannock River watershed.*

Hydrolgic Unit #	Total Shoreline Miles	Reforest Opportunity (miles)	Water Quality Benefits (miles)	Habitat Benefits (miles)
E01	226.24	45.98	37.97	38.32
E02	426.36	77.66	60.92	59.32
E03	75.96	16.01	14.14	14.14
E04	144.14	23.86	17.52	17.27
E05	158.46	36.26	29.09	29.04
E06	102.63	20.91	18.59	18.58
E07	182.77	40.93	29.99	30.03
E08	232.39	80.61	67.22	66.20
E09	257.73	91.32	82.56	80.32
E10	234.71	14.79	10.84	10.84
E11	159.24	18.45	13.91	14.32
E12	124.82	39.14	31.60	31.79
E13	242.18	76.91	59.79	60.00
E14	185.98	61.77	43.63	44.87
E15	230.50	66.68	50.79	51.90
E16	115.77	39.32	35.25	36.01
E17	335.77	81.24	70.88	70.70
E18	217.95	11.01	7.33	7.31
E19	146.41	6.71	4.98	4.75
E20	268.15	20.53	15.89	15.58
E21	573.25	34.51	30.01	31.02
E22	468.42	36.64	29.45	30.21
E23	643.06	11.48	8.70	9.50
E24	280.63	6.29	5.46	5.16
E25	371.89	8.68	6.62	6.15
E26	374.15	6.50	3.30	2.89

Figure 2.

Rappahannock River Watershed Riparian Forest Buffer Restoration
Cumulative Priority

Portion of Hydrologic Unit E08



portunity for reforestation, and miles of shoreline that represent potential water quality or habitat benefits if reforested. Across all hydrologic units, there are 6793 miles of shoreline in the Rappahannock River basin, 29% of these are unforested. Of the 1977 miles of unforested shoreline, a total of 974 miles had LULC which seemed to provide an opportunity for reforestation, and 779 of those miles had adjacent inland conditions which indicated reforestation might have both water quality and habitat benefits. The results of the protocol for hydrologic unit E08 determined that approximately 80 miles of shoreline provide an opportunity for reforestation and approximately 66 miles demonstrate the potential for both habitat and water quality benefits. Figure 2 details a small section of this hydrologic unit, showing the riparian areas where reforestation benefits both water quality and habitat given the parameters of the protocol.

Conclusions

The VIMS RFB restoration targeting protocol is intended to provide a framework for decision making over relatively large areas. Overall, as indicated by the Rappahannock River watershed application, the protocol seems to fulfill its objectives; the decision basis is explicit and the assumptions are clear. As technical understanding about the relationships between RFB and surrounding landscapes improves, the protocol provides a useful framework for adding sophistication to the targeting process. Even without further technical knowledge, the decision rules of the protocol can be easily modified as additional information or alternative opinions are applied. In addition, the protocol clearly succeeds at reducing the population of potential sites (based on unforested conditions) to some smaller group (39% of the unforested riparian area in the Rappahannock case).

Two important things remain unknown at this point. The first is the validity of the assumptions about the relationships between LULC and potential benefits of riparian forested buffers. While the assumptions inherent in the protocol developed here represent the best professional judgment of the authors and their colleagues, they may not represent a consensus of all experts in the field. Furthermore, any assumption in a decision model should be subjected to validation through field studies. The second unknown is the accuracy of the targeting resulting from application of this protocol. There has been no ground truth survey conducted to assess the accuracy of the basic satellite and map information used as the basis for this analysis. The decision model may be perfectly acceptable and useful, but it can be only as accurate as the information it uses. Ground truth surveys are essential before any decisions are based on the protocol output, since the project is seeking to generate spatially referenced analysis at least as accurate as the resolution of the base information. It should be noted that the application of this protocol is limited to regional planning, particularly around low ordered streams, where the current resolution of the Landsat TM imagery becomes a significant limitation. Although the protocol's spatial resolution could be enhanced with higher resolution data, computer processing times would limit the area of application significantly.

Despite these inherent limitations, the protocol appears to be a useful planning tool. While we would not recommend it for site specific planning, it does seem to provide a relatively rapid assessment of very large areas. Results from the Rappahannock River watershed application suggest that it can be very useful in focusing efforts to areas in which there may be a particularly beneficial return on the effort to restore forested buffers.

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