Strager et al. (2011)
Banking Site Selection Model

The banking site selection model developed by Stager et al. (2011) applies a three-step analysis to identify priority sites for wetland and stream restoration and conservation. A coarse landscape prioritization analysis of GIS data is first used to identify all potential wetland and stream sites where compensatory mitigation may be possible. A more detailed rapid assessment field inspection is then applied in which each potential site is scored by an expert team for various wetland- or stream-specific criteria, which are then weighted based on expert input as part of the Analytical Hierarchy Process. Lastly, the expert team uses subsequent intensive field studies to further evaluate sites identified as having the highest combined wetland and stream mitigation scores in the rapid assessment analysis. The intensive field studies describe each of these sites in terms of actual and potential wetland mitigation area, in addition to several hydrological, geomorphic, and ecological parameters, to determine the site within each watershed for which combined wetland and stream mitigation would be most feasible. This approach is readily adaptable and transferable to other non-coastal regions for which GIS layers amenable to landscape prioritization site selection are available.

OVERVIEW

Lead developer(s): Michael Strager, James Anderson, and Ronald Fortney, West Virginia University; Joseph Osbourne, Trileaf Corporation.[1]

Year developed: 2011.[1]

Geographic area: The state of West Virginia (Figure 1).[2]

Resource types: Wetlands and streams.[1]

Restoration/conservation: Primarily preservation/protection, but also restoration (reestablishment and rehabilitation) and enhancement.[2]

Stakeholders: West Virginia Department of Natural Resources (WVDNR).[2]

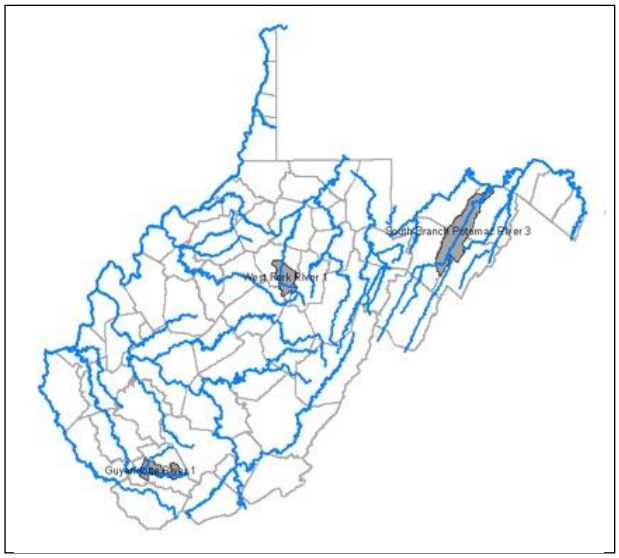

Figure 1. Strager et al. (2011) applied their banking selection method within the South Branch Potomac, West Fork River, and Guyandotte River HUC-10 watersheds. Used with permission from Dr. Michael Strager.

Current status: Though the input of state agency personnel at WVDNR was integrated into the weightings for selecting wetland and stream mitigation bank sites with this three-tiered framework, WVDNR is not currently using the mitigation bank site selection tool.[2]

PRIORITIZATION ANALYSIS

Landscape prioritization tool(s):

Wetland banking site selection model: The researchers identified potential wetland mitigation sites within HUC-10 watersheds by combining wetland soil type data from digital soil maps with a map of wetlands from the National Wetlands Inventory (NWI). The resulting wetland areas were then examined using aerial photos to remove areas from consideration in which development or conversion to impervious surface had occurred. Potential wetland areas identified in the aerial photos to contain natural land cover or permeable surface were selected for further evaluation in the subsequent rapid assessment analysis. The factors and data sources listed in Table 1 were used to identify potential wetland mitigation banking sites.[1]

Prioritization objectives assessed:

- Feasibility of restoration

Table 1. Factors and associated data sources used to identify potential sites for wetland mitigation.[1]

Factor used in analysis	Data source(s)
Historical wetlands on or adjacent to site	NWI wetland coverage
Hydric or somewhat poorly drained soils	SSURGO soil coverage
Non-permeable surfaces or natural land only	NLCD land use coverage
Evidence of development or conversion to impermeable surface	2006 color infra-red 1:12,000 Digital Ortho Quarter Quads (DOQQ) aerial photos with one meter resolution (flown during leaf-off)
Potential wetlands with natural land cover or permeable surface	

NWI = USFWS National Wetland Inventory; SSURGO = Soil Survey Geographic database; NLCD = National Land Cover Dataset.

Stream banking site selection model: The researchers also identified potential stream mitigation sites by first delineating subwatershed boundaries around individual stream segments between stream confluences and tributaries. Those stream segments with drainage areas ranging from 1 to 130 km^2, and which were biologically impaired due to sedimentation, temperature, or animal waste runoff (i.e., listed on WVDEP's 303d list of impaired waters), were identified as mitigation priorities (Table 2).[1]

Prioritization objectives assessed:

- Water quality
- Feasibility for restoration

Table 2. Factors and associated data sources used to identify potential sites for stream mitigation.[1]

Factor used in analysis	Data source(s)
Uninterrupted stream segments between confluences and tributaries	NHD
Steams that drain between 1 and 130 km^2	N/A
Streams on impaired due to sedimentation, temperature, or animal waste runoff	WVDEP 303d impaired waters list

NHD = USGS National Hydrography Dataset; WVDEP = West Virginia Department of Environmental Protection.

Refinement of landscape priorities: Following the landscape prioritization analysis, Strager et al.'s method narrowed its list of potential wetland and stream mitigation sites by conducting rapid assessment reconnaissance surveys carried out by an expert team composed of specialists from academia and WVDNR. These field-based assessments scored wetlands for 23 criteria and streams for 15 criteria that addressed various ecological, engineering, construction, and anthropogenic factors (see Appendices A and B of Stager et al. (2011) for a complete list of these criteria). Weightings were developed for each of these criteria using the Analytical Hierarchy Process, which asked each scientist on the project team to evaluate a series of pairwise comparisons to assess the perceived importance of each criterion. By applying Strager et al.'s approach, expert-defined weights could be applied to the field-measured criteria scores. Wetland scores were then obtained by adding all weighted wetland criteria scores, while stream scores were obtained by adding all weighted stream criteria scores. Summing wetland and stream scores produced an overall score for each site, which was then converted to a rank based on its magnitude relative to all other scores in the HUC-10 watershed (e.g., the highest score was then assigned a rank of one, and so on).[1]

Based on the results of the rapid assessment analysis, a more intensive on-site assessment was next applied to evaluate which of the three highest ranked sites within each HUC-10 watershed was most feasible for combined wetland and stream mitigation banking. The first step in this intensive assessment was to determine the total area of wetland already within the site (using U.S. Army Corps of Engineers wetland delineation procedures) and subtract this area from the overall potential wetland restoration area. This allowed researchers to gain a more accurate understanding of how much area was actually restorable within each site. The researchers next assessed several hydrological, geomorphic, and ecological parameters for each potential wetland or stream site. These parameters included measuring surface water runoff (rational runoff method); longitudinal profile and cross-section (topographic surveys); ten ecological parameters of streams and floodplains (e.g., epifaunal substrate, vegetative protection, etc.); stream dimension, pattern, and profile (used to measure classification and condition); stream bank stability (important for describing restoration potential); and several water quality parameters (e.g., temperature, pH, etc.). Numerical scores obtained from these assessments were used by researchers to determine the top site in each watershed for combined wetland and stream mitigation banking.[1]

Prioritization products: Outputs from Strager et al.'s method include static maps and GIS data identifying priority sites. Strager et al. (2011) included maps for each of the three HUC-10 watersheds studied that illustrate the identified potential mitigation sites (e.g., see Figure 2). In addition, the researchers have ranked individual wetland and stream sites available to WVDNR on a county-by-county basis, which is convenient for DNR planning.[2]

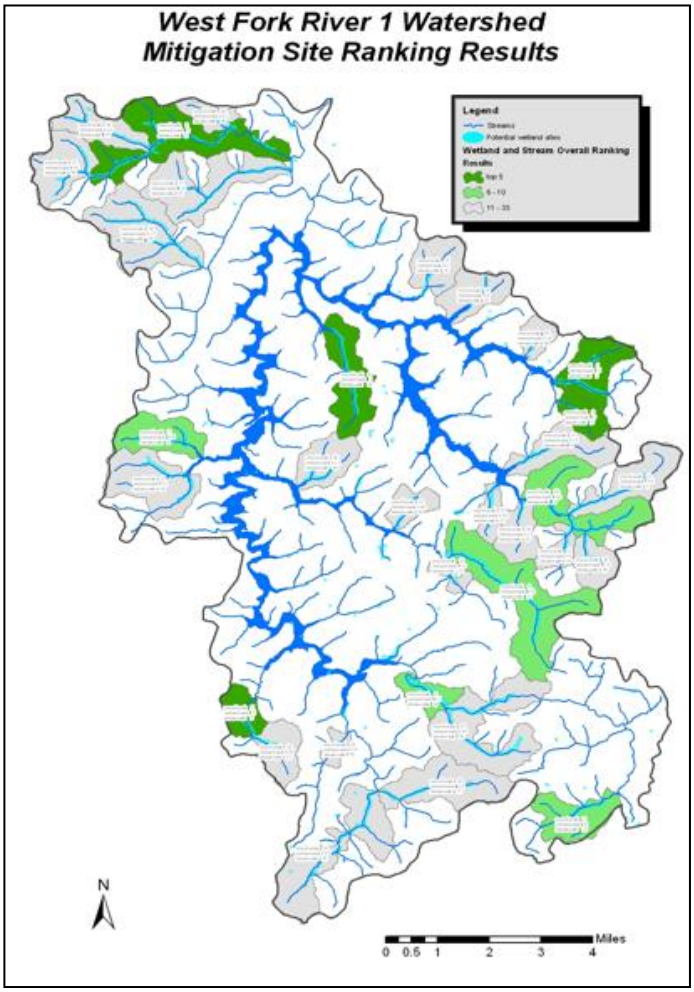

Figure 2. In the West Fork River watershed, Strager et al.'s landscape prioritization analysis identified potential wetland and stream mitigation sites (all shaded areas above). In the rapid assessment analysis, each of these areas was scored, weighted, and ranked based on a variety of criteria. Highest ranked sites are indicated by the most darkly shaded areas above.[1] Used with permission from Dr. Michael Strager.

IMPLEMENTATION

Regulatory/non-regulatory programs:

- Section 404 wetland and stream compensatory mitigation.[2]
  - Watershed approach to compensatory mitigation: Using Strager et al.'s method, scores for individual sites can be aggregated to obtain scores for individual segment-level watersheds, which can be ranked within individual HUC-12 watersheds. Scores for segment-level watersheds can then be aggregated in order to rank HUC-12 watersheds within HUC-8 hydrologic units.[2]
- WVDNR planning: The researchers have made the individual site rankings from the model available to WVDNR on a county-by-county basis (which is convenient for their planning purposes). WVDNR has combined site rankings with information from field-based wetland assessments and wildlife models to support project planning. The researchers have also developed an ArcGIS extension (i.e., spatial compromised

programming model) that allows WVDNR to alter model rankings by manipulating underlying criteria and weightings using an ArcGIS toolbar.[2]

- According to West Virginia researchers, the WVDEP Division of Mining and Reclamation could use the Strager et al. (2011) model to analyze functions provided by wetlands constructed as a consequence of mining activity. The only functions that WVDEP currently assesses for these wetlands are water quantity- and quality-related, such as runoff collection and silt reduction. While wetlands created by mining activity support limited functions, they are known to support wildlife, amphibian, and reptile species.[2]
- Cumulative impacts analysis: Strager et al.'s method applies network connectivity analysis to stream segments and segment-level watersheds to identify headwater watersheds and pass-through watersheds. This facilitates true calculations of cumulative effects.[2]
- West Virginia Department of Transportation (WVDOT) avoidance of impacts: Strager et al. are using their method to analyze the impacts of different possible routes for the King Cole highway on ecological resources, particularly wetlands. The results will help WVDOT select a route that minimizes impacts to aquatic resources.[2]

Transferability:

- The basic framework underlying Strager et al.'s method can be reapplied in any non-coastal geographic area – in Strager et al. (2011) it was successfully used for three different physiographic regions within West Virginia.[2]
- The GIS data used by Strager et al. for landscape prioritization site selection must be available for other geographic areas considering adopting the method.[2]

Data gaps:

- High-resolution National Agriculture Imagery Program (NAIP) multi-spectral leaf-off data would have been helpful for mapping wetlands for the landscape prioritization analysis. Limitations in mapping data available at the start of the landscape prioritization analysis represented the most significant limitation to SBSM results.[2]

Barriers:

- Maintaining the customized ArcGIS toolbar developed for WVDNR is difficult because programming formats in ArcGIS change frequently (e.g., from ArcGIS 9.3 to ArcGIS 10). Staff time is required to keep this tool up-to-date.[2]

Future goals:

- West Virginia University researchers would like more agencies to become involved in wetland prioritization. They explained that because many stakeholders may not realize that wetlands have unique values based on their location, stakeholder understanding of the importance of spatial data may be limited. More training and information could help to achieve this goal.[2]

[1] Strager MP, Anderson JT, Osbourne JD, and Fortney R. 2011. A three-tiered framework to select, prioritize, and evaluate potential wetland and stream mitigation banking sites. Wetlands Ecology and Management 19:1-18.
[2] Interview on 1/12/2012 with Michael Strager, Assistant Professor, Division of Resource Management, West Virginia University.