

THE STANDARD GIS METHODOLOGY FOR WETLAND ANALYSIS

INTRODUCTION

The definition and, therefore, mapping of wetlands is a complex process. No universal definition of wetland exists. Regulatory definitions must meet strict legal tests and must be site-specific. For purposes of the state wetland plan, site-specific data are not available and not essential since the purpose is to provide an overview of wetland patterns, losses and needs over a fairly large watershed or landscape. Furthermore, a rigorous definition of wetlands at this level of detail is not easy to develop or apply. A commonly accepted general definition which has been adopted by the Arkansas Water Resources and Wetlands Task Force (slightly modified by MAWPT) is:

"A wetland is an area that has water at or near the surface of the ground during the growing season (wetland hydrology). It supports or is capable of supporting plants that are adapted to wet habitats (hydrophytic vegetation) and has soils that have developed under wet conditions (hydric soils)."

These are general guidelines, and they are not universally applicable. For example, young wetlands and constructed wetlands may not yet have hydric soils. However, it is possible to develop very useful planning level maps of wetlands using map data of the above three major criteria which have been converted to a digital format and analyzed using a geographic information system. These computer systems are ideal for mapping complex environments such as wetlands. The computer maps can integrate data from soils, vegetation and hydrology to allow the development of county, regional or statewide wetland maps. In addition to simply showing wetlands, such maps can be used to evaluate and prioritize existing wetlands for protection as well as identify and prioritize candidate areas for restoration. They can also produce consistent status reports. The National Research Council in its 1993 publication, "Toward a Coordinated Spatial Data Infrastructure for the Nation", has identified geographic information system methods as a key element in future wetland management programs. A final decision for any specific location requires on-the-ground assessments but it is possible to do high quality planning and regional assessments with digital data only.

The methodology described here is meant to be applied at approximately the scale of the Wetland Planning Areas defined elsewhere in this report. It is meant to be applicable at the watershed and regional levels, rather than the site-specific level. It relies heavily on the analytic power of Geographic Information Systems (GIS) using existing or affordable data layers (however, the needed digital data layers are seldom inexpensive). At this time, the process is designed to assist the planners involved in the project rather than provide a self-contained decision-support system. It is anticipated, however, that as the project proceeds, detailed decision-making will become more standardized and eventually a stand-alone decision-support program may be developed. For the foreseeable future the digital maps and analyses will be used to augment the knowledge of state agency wetland specialists.

The desired outcome of the process is the development of priorities for both restoration and protection of wetlands within a given watershed or landscape, based on existing and desired landscape patterns, bearing in mind the economic and social practicality of achieving goals primarily through voluntary

and incentive programs. The approach is inherently geographic and focuses primarily on landscape structure (such as wetland area and distribution), although it is likely that overall goals and measures of success will eventually be based partly on ecosystem function (such as water quality and species population viability). In addition, structure can, in some cases, be a valuable indicator of presence or absence of specific functions.

OUTLINE OF THE METHODOLOGY

- 1) Assemble appropriate data on ecosystem components needed for decisionmaking (emphasis on existing watershed-scale geographic data).
- 2) Review maps of ecosystem components (e.g., water, soil, vegetation) to begin to understand wetland patterns, problems and potentials in the watershed. Verify on-ground as needed.
- 3) Prepare component overlay maps to investigate relationships between individual wetland components (e.g., to what extent does existing forest occur on hydric soils). Verify on the ground as needed.
- 4) Develop general wetland goals and objectives of the project, emphasizing measurable and mappable structural attributes (e.g., highest priority goal or goal may be establishment of a naturally-vegetated corridor along mainstem of the river; an objective may be to restore a minimum 60-meter wide buffer along ditches. Both of these address mappable structural attributes).
- 5) Implement GIS-based procedures to generate priority maps of protection and restoration priorities based on objective, clearly stated criteria.
- 6) Review priority maps, verify on-ground as needed, evaluate resulting maps and revise criteria as appropriate (if priorities fail to meet defined goals).
- 7) Synthesize knowledge of watershed characteristics and wetland protection programs into a strategy for wetland protection and restoration based on goals developed for the state and watershed.
- 8) Develop monitoring and evaluation plan for the watershed strategy.

THE METHODOLOGY IN GREATER DETAIL

1) Appropriate data for planning

Several existing or affordable map data sources have been identified as being most useful in developing the mapping component of an effective, comprehensive statewide wetlands management plan for Arkansas. These are:

1. Hydrologic unit map
2. Hydrography (streams and water bodies)
3. County soils
4. Satellite derived vegetation and land cover maps
5. Corps of Engineers or other maps of floodplain boundaries
6. Natural Resources Conservation Service (formerly Soil Conservation Service)
potential farmed wetland map
7. National Wetlands Inventory (NWI) maps
8. Public lands (including private lands with public easements/agreements)
9. Transportation, political boundaries, etc. (for reference mapping purposes)

Several of these are maps of wetland components derived from the general definition of wetland - an area with wetland hydrology, hydric soils and hydrophytic vegetation. The list also includes previously-mapped wetlands. In

addition, public lands are included as valuable indicators of priority. The immediate priority for developing wetland planning area plans is the Delta Wetland Planning Region, as the portion of the state which had the most acreage of wetlands initially and the highest wetland losses.

Maps 1-5 detail the wetland components. The existing hydrologic unit map shows boundaries of watersheds at several levels of hierarchy. It is useful in identifying wetland planning area and regions. Hydrography maps show the locations of major streams. They provide the riparian context for palustrine wetlands while mapping riparian wetlands in detail. They are readily available but eventually more detail and accuracy may be desired. County soils maps can be reclassified into hydric and upland soils to suit most watershed planning needs. County soils maps of the Delta Wetland Planning Region are currently being digitized through an appropriation from the Arkansas Legislature. Maps of the 1-yr., 3-yr., 10-yr. or other floodplains are available for some watersheds, and where they exist are very helpful. However, they are far too expensive to create new for a wetland planning project (est. \$70,000 per river mile). A map of the vegetation of Arkansas at a suitable level of detail has been produced by the Arkansas Gap Analysis Project using satellite imagery at a resolution of 30 meters and is freely available.

Map 6 is useful both as an existing wetland map and as a model for practical mapping of wetland hydrology. In this map, areas on which surface water was detected by a satellite during representative floods are shown. Some variant of this methodology is likely to be the most affordable data source for consistent mapping of wetland hydrology over wetland planning regions or the entire state. For state planning purposes, more flood events might be mapped to provide more accurate mapping. Furthermore, the existing map does not cover all of northeastern Arkansas, and that area should be added. In addition to being a map of wetland hydrology, this map shows farmed (cleared) wetlands, and is the only source to do so.

Map 7, National Wetland Inventory maps, are principally useful as existing wetland maps, but are also valuable for information on wetland vegetation and hydrology. The classification system used by NWI may be useful in functional assessment. Unfortunately, most of the Arkansas National Wetland Inventory maps are not digitized and some are over two decades old. Therefore these will have to be evaluated before determining whether to digitize them or not. The NWI might be repeated for some areas of the state, but this is an expensive process and money is not presently available for remapping large areas.

A public lands layer, when overlaid on maps of wetlands, provides an essential context for prioritization in the future. Boundaries of public lands were produced in the Arkansas GAP and are freely available. However, that map does not always show areas which are not owned outright by the public, but in which the public owns a partial interest or has a long-term agreement. Such areas include those covered under the Wetland Reserve Program, the Conservation Reserve Program and areas that have been restored as mitigation for wetland losses incurred elsewhere. Knowledge of locations of these areas would help to define priorities for further state action.

These layers comprise the essential databases for prioritization of wetlands within the state. They were chosen because they were available or could be produced for large areas of the state. However, because the data vary in quality over the state and because other data are available in certain areas, an analysis of a particular wetland planning area may not use all of these, or may include others.

2) Review maps of ecosystem components

The purpose of the standard methodology is to assist, not replace, human expertise. The MAWPT includes wetland planning specialists from throughout state government, assisted as needed by federal government and private specialists. Therefore, the initial analytic step in the process is to inspect the maps produced in step one to quality-check the maps (field visits may be necessary) and to become familiar with wetland patterns in the planning area. This may show, for example, that one portion of the planning area has channelized streams and little forest cover or natural wetlands left, whereas another has unchannelized streams and a fairly continuous and often fairly wide belt of naturally-vegetated wetlands along it. This may mandate separate analyses and strategies for the two areas.

3) Overlay components to investigate relationships

After quality-checking component maps and familiarization with their content, the next step in adding to insight of the planners is to overlay component maps in order to discern relationships among them. Such overlay may show that most remaining areas of forest are on hydric soils or that a distinct corridor of cleared hydric soils occurs along certain streams or ditches. This step will lead to development of more accurate wetland maps than any individual component could and will also uncover discrepancies between component maps or help update the information of those maps. This part of the process may suggest effective strategies for wetland conservation in the planning area and specific analyses to be conducted.

4) Develop general wetland goals and objectives

General priorities are developed by the planning team based on the knowledge developed during the previous steps. Often the existing naturally vegetated and functioning wetlands are considered priority for protection and become the focus for planning restoration, since it is often more productive to plan restoration efforts that connect and enlarge existing wetlands rather than beginning with a substantially altered system and having to virtually recreate the wetland system. Other factors may alter the strategy, though.

In planning to date, emphasis has been given to protection and restoration of a forested corridor along the main streams of the watershed. Other wetlands than those in the corridor could be emphasized, however. For example, in this region, "drier" wetlands have been more subject to clearing than the wettest wetlands (USFWS 1994). However, these have often been reduced to scattered, small and probably relatively non-functional remnants, whereas wetlands in the riparian corridor still retain a considerable degree of natural function.

As an example, the Waterways Experiment Station study of a reach of Cache River that encompasses Black Swamp in Woodruff County shows that this reach of about 11 miles removes approximately 12% of the silt load of the stream. In turn, sedimentation in this area has been measured in centimeters per year, indicating that these wetlands cannot continue to perform this function indefinitely. Such knowledge shows that tributaries must be protected and restored in order to enhance the function of the mainstem.

In addition to water quality improvement, the riparian corridor offers a large, connected block of bottomland habitat that is of high value to species population viability.

Based on these considerations we have concluded that the riparian corridor contains the most important wetlands from a functional sense, and that they and their associated streams are imperiled through water quality impacts if not direct clearing. Therefore we have emphasized the goal of restoring and protecting a riparian corridor. Isolated functioning wetlands which are close to the streamside corridor are of high priority as well, with those that are further away being lower priority. Similarly, those isolated fragments that are larger are higher priority than those that are smaller. Cleared wetlands that intervene between forested blocks and can serve to reconnect the existing forested wetlands are high priority for restoration; those that are adjacent to functional wetlands are of high priority for adding to the functional integrity of the existing wetland, whereas those further away are of lower priority. Those which occur along tributaries of the mainstem are typically high priority.

The relative priorities among all of these classes of wetlands can be set by a planning team so that even while emphasis is given to establishment and maintenance of a riparian corridor, it is not the sole focus of conservation efforts. Some isolated wetlands may be given relatively high priority for attention because of their size, their proximity to a mainstem or tributary corridor, or for other specific reasons. Using computers and GIS the priority system may be much more complex and objective than using human experts alone.

These priorities only consider the values of a typical wetland system in Arkansas. Unique wetlands, such as those with unusual communities, rare/endangered species, outstanding wildlife values, etc., must be evaluated with those characteristics in mind. Agencies with responsibility for these are represented on the MAWPT and can provide input on specific needs.

5) Implement GIS procedures to map priority wetland areas

After priorities based on goals and objectives for the WPA have been set by the planning team, they must be made objective and sometimes quantitative in order to be input into a GIS for analysis. In many cases it must be possible for the GIS to place a value on each area (a polygon or pixel) within the planning area, and the GIS must have objective rules for evaluating a specific area based on both its intrinsic priority and its relationship to the entire wetland system.

Most efforts utilizing digital technologies for wetland mapping have focused on the methodology of "polygon overlay". Polygons representing different feature types are spatially co-located using the GIS. Thus the map of hydric soil unit locations is overlaid on the 1 year floodplain and those locations that are both hydric and floodplain are identified. Such an approach has considerable merit. Using this approach, locations can be identified that share those criteria that are recognized as important characteristics of wetlands. Such an approach can allow an initial ranking of locations. For example, those locations that have all three characteristics (wetland hydrology, soils and vegetation) may be of a higher priority than those with only two. Using the GIS it is also possible to identify the size(s) of these overlapping areas and assign them priorities based on size. A larger area may have a greater priority than a smaller one. Or perhaps, for some situations (such as cleared lands judged for restoration), smaller units may have priority over larger.

How is this overlay done in the GIS? One way is to define the location of lines that bound polygons and calculate the area of intersection between two

polygons. This vector-based method is not trivial to accomplish. The raster-based methods that we have used are based on defining the landscape in terms of small cells or pixels 30 meters on a side (or any other convenient size). A map of hydric soils, then characterizes the soil of each pixel in the map. Other maps characterize other features of each pixel. Then it is a simple though tedious matter to characterize all the pixels with a given characteristic in terms of their other characteristics. Of course, computers are very useful for performing tedious operations.

In our analyses, the polygon overlay method is used for initial analysis. In addition to this basic method, however, there are numerous spatial analysis methods that are possible within the context of a geographic information systems based approach. Some of these may provide substantially more useful measures of the spatial characteristics that can be used in prioritization schemes. For example, it is possible to rank all cleared wetland locations based on their proximity to existing wetlands. Thus a degraded wetland location nearest to an existing wetland may have a higher priority for restoration than a location at a considerable distance from any existing wetland.

For example, the 3-year floodplain (assuming it has been mapped) may be considered the highest priority both for protection of existing wetlands and restoration of cleared wetlands. This approach will eventually cause the restoration and protection of a streamside wetland corridor to maintain and restore water quality, wildlife habitat and other values that have been identified. Such a simple approach may not (and probably does not) meet all the needs for wetland conservation within the planning area, however. The GIS can be used not only to map this priority corridor, but also to calculate and map more complex priorities.

As an example, all of the forested areas on hydric soil outside that 3-year floodplain, may be considered next highest priority and each is given the numeric value of 0 (lowest number equals highest priority). Cleared areas of hydric soil outside the 3-year floodplain but inside the 100-year floodplain may be assigned a value of 1. Areas of non-hydric soil located within the 100-year floodplain are given a value of 3. Areas outside the 100-year floodplain are eliminated from consideration. By this means, each small unit of area (a square plot 30 meters on a side is the smallest unit used in current GIS wetland planning in Arkansas) is given a wetland priority ranking based on its location in a floodplain (hydrology), presence or absence of native vegetation, and hydric or nonhydric soils with low values indicating high priority.

The next step in prioritization is to sum the values from the boundary of the 3-year floodplain (which was already deemed the highest-priority corridor) to each point out to the boundary of the 100-year floodplain. If the condition between a given point and the boundary of the 3-year floodplain is mostly forested hydric soils, the sum of values to the point will be low and the resultant priority is high. If however, the condition is cleared, non-hydric soils, the sum will be high and the resultant priority low. This process, therefore, prioritizes each plot of land according to its intrinsic wetland character, its proximity to the high-priority corridor, and the character of the intervening landscape. It will encourage widening the corridor where it is most efficient to do so. It will also encourage restoration efforts where they connect an isolated wetland that is close to the main corridor.

In practice, the prioritization process is more complex than this, with consideration given to areas outside the 100-year floodplain, along tributaries, to isolated tracts that are large, and to areas in proximity to public lands.

6) Review Priority Maps

Again, the expertise of state wetland planners is employed to determine whether the priorities generated by the GIS fit the needs of the planning area. If areas are unexpectedly given low or high rankings, the cause must be determined and if necessary the GIS process altered. At this point, input from decision-makers and the public will provide valuable perspective to the planners. If priorities do not suit economic or social needs they will not be attained.

7) Develop wetland protection/restoration strategy for the watershed.

The SWCP has outlined overall goals and objectives, along with descriptions of agency programs for protection and restoration of wetlands, some of which are applicable for incorporation into a strategy for any given planning area. However, it is up to the planning team to determine which of these will be most effective, given the specific needs and opportunities of the planning area. Landowners may have considerable interest in using federal agricultural incentive programs or alternatively state agencies may be interested in acquiring fee or easements to lands to enhance wildlife values. The particular mix of approaches will be unique to the planning area.

8) Develop appropriate monitoring criteria

In order to evaluate success, specific monitoring goals will need to be established and implemented for each planning area. These may be in terms of acreage of wetland restored, water quality exiting from the area, plant or animal population monitoring, recreation use, or other criteria.