APPLYING RESULTS FINDINGS: THE RECOVERY POTENTIAL PROJECT

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ABSTRACT

The growing body of evidence and results from numerous restoration projects, TMDLs, and other efforts demonstrate that the success of efforts to restore impaired waters is closely linked with watershed and waterbody traits that influence the potential of the waterbody to recover its functionality. Restoration success is not exclusively determined by the success or failure of the externally applied restoration techniques. Specific attributes of the waterbody itself and its watershed collectively indicate its recovery potential, and can be represented by metrics of three primary types: measures of ecological capacity to reestablish natural processes, measures of current and projected stressor exposure, and measures of social context. These metrics can be identified and evaluated at a screening level to compare recovery prospects across multiple sites, using landscape modeling methods as a tool for broad-area planning and priority-setting for impaired waters restoration. In the Clean Water Act's TMDL program and Section 319 nonpoint source grants program as well as in state restoration initiatives, states face challenging decisions on which sites to address in what order, with what fraction of limited restoration resources. Our project's goal was to develop and demonstrate statewide-scale analytical tools that could help states carry out these tasks with more systematic and science-based consideration of recovery potential as a primary driver. An extensive search of the restoration literature was used to initially identify recovery-potential-related traits from empirical studies and syntheses, and then evaluate the ability to translate each of these traits into spatial metrics with specific, GIS-based measurement protocols. This effort resulted in the development of over 80 recovery potential indicators across the aforementioned categories of ecological capacity, stressor exposure, and social context. Using as a hypothetical test bed the 2002 State of Illinois' 303(d) list for approximately 725 impaired waters, EPA impaired waters databases, and numerous supporting GIS datasets, we developed several approaches for prioritizing impaired waterbodies based on recovery potential. We focused on developing suites of prioritization options to demonstrate recovery potential as a flexible statewide screening tool, and because the differing context of each impairment suggests that a single prioritization scheme would not likely be suitable for all impaired waters or the priority decisions of all states. In the analyses presented here, we compare rank orders (highest rank = most recoverable) of selected measures of ecological capacity and social context to the nominal priority ranks of low, medium and high that accompanied the 2002 Illinois 303(d) list. The simple, single-indicator comparisons demonstrate site-to-site variability in factors that should influence likelihood of recovery. We close with a cluster analysis of recovery potential metrics, again comparing the cluster groups to the nominal priority rankings of low, medium, and high. The results of the cluster analysis suggest that there is a geography to recovery potential. We discuss how the geographic pattern in the cluster groups could be exploited as a TMDL and restoration prioritization tool.

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KEYWORDS

Clean Water Act, ecological recovery potential, GIS, impaired waters, landscape, restoration, socio-economic, stressor, TMDL

INTRODUCTION

States are required to monitor the condition of their waters on a biennial basis under section 305(b) of the Clean Water Act [P.L. 92-500]. Waters not meeting Water Quality Standards (WQS) established by the state are labeled as impaired and placed on the 303(d) list. Waters listed on section 303(d) must be restored. A major step toward the restoration process is development of a Total Maximum Daily Load (TMDL). TMDL studies identify and quantify the pollutants causing the impairment, and are used to guide development of restoration plans.

The number of impaired waterbodies is estimated to be about 38,800 nationwide (USEPA, 2006a). The nationwide estimate translates to an average of about 775 per state. Such a large number per state necessitates prioritization simply because manpower and fiscal resources cannot accommodate TMDLs, restoration plans, and their implementation at a rate that supports action on all impaired waters every year. However, there is little guidance in the CWA regarding prioritization. Priority-setting to optimize recovery (i.e., re-attainment of WQS) is a near-universal water program need, yet the *relative potential to recover* is not commonly assessed or factored into prioritization of the order of TMDL development from the 303(d) list at statewide scale.

The impaired waters of the US are highly variable and have widely differing restoration needs and pathways to recovery. We define recovery potential as: *the likelihood of an impaired water to re-attain Water Quality Standards or other valued attributes, given its ecological capacity to regain lost functionality, its exposure to stressors, and the socio-economic context affecting efforts to improve its condition*. There are several important aspects to our definition of recovery potential. A key attribute of recovery potential is that it is site-specific. The site-specific aspect of recovery potential is contained in the terms ecological capacity, stressors, and socio-economic context in our definition. Place-to-place changes in ecological capacity, number and type of stressors, and socio-economic context will result in changes in recovery potential (Schlosser, 1990; Detenbeck et al., 1992; Lowrance et al., 1997; Keller et al., 1999; Palmer 2005). The site-specific aspect of our definition of recovery potential also links it to the ecological theories of homeostasis and nonlinear dynamics (Holling, 1973; Westman, 1978; Pimm, 1984; Cairns, 1999). Recovery has been documented in many cases (see Niemi et al. 1990, Detenbeck et al. 1992), supporting the concept of return to equilibrium (homeostasis). At the same time, others have found that recovery was incomplete or lacking (Keller et al., 1999; Bond and Lake, 2003), supporting the concept of nonlinear dynamics. Ecosystem dynamics may not be defined by return to equilibrium (Holling, 1973); pre-existing conditions may not reoccur once disturbances are removed (O'Neill, 1999). Lastly, recovery potential is related to but not synonymous with restoration. Restoration is an activity (e.g., fencing to exclude livestock, re-vegetation, stormwater wetlands) intended to re-establish a prior ecosystem condition or function (Bradshaw, 1993; Davis and Slobodkin 2004). Restoration effectiveness can be compromised by the failure to distinguish between the potential of the site and the quality and suitability of the restoration technique applied to the site. The efficacy of restoration activities can be aided by a strategic assessment of potential locations (see Roni et al., 2002; Yetman, 2002). Recovery potential is used here as the strategic assessment to guide prioritization of the TMDL schedule.

Recovery of impaired waters is the primary desired outcome of multiple EPA and state water programs. The purpose of this project is to investigate, develop, and demonstrate screening methods for prioritizing the restoration of waters based on recovery potential for programs such as TMDLs and 319 nonpoint source control. States and others vary widely in how they set priorities, and despite the universal goal of recovery, recovery potential is seldom if ever among the primary decision criteria. In practice, effective priority-setting is often hindered by the large number of potential factors to consider, limited consistent data across large areas, and the lack of relatively simple tools. Limited resources and other factors drive states to make difficult priority-setting decisions when planning and carrying out recovery-oriented programs like TMDLs (specifically, setting a prioritized schedule for TMDL development among 303(d)-listed waters), Section 319 nonpoint source control projects, and watershed planning. Within these programs, EPA currently provides little guidance or technical tools specifically for setting priorities based on optimizing recovery and on-the-ground results. Considering recovery potential may help improve program results through: 1) Achieving results earlier and more consistently by targeting efforts toward “fixable” waters; 2) Maximizing the ecological and societal benefits gained by prioritizing work on waters that can achieve better condition over waters with very limited recovery prospects, and; 3) achieving results more often by prioritizing waters where improvement is feasible, independent of whether their impairments are mild or severe.

METHODOLOGY

Demonstration of recovery potential as a screening and prioritization tool was undertaken using the 2002 303(d) list for the State of Illinois. Lists of impaired sites and the prioritization schedule for TMDL development and restoration are developed by each state individually. Development of a screening and prioritization tool therefore necessitates a statewide perspective and use of indicators that can be measured consistently and efficiently across a state.

We initiated the recovery potential project with an extensive literature review to ascertain measurements of recovery that could be measured consistently statewide. The literature review revealed numerous measurements covering the three main components of our definition of recovery potential (ecological capacity, stressors, socio-economic context) that could be measured consistently with available data (Table 1). The main data sources for development of recovery potential measurements included USEPA databases (Dewald, 2006; USEPA 2006b, 2006c), the National Elevation Data (NED) (Gesch et al., 2002) for delineation of watersheds defined by the most downstream point of the impaired waterbody, land cover and impervious surface from the MultiResolution Land Characteristics (MRLC) Consortium (Vogelmann et al., 2001; Homer et al., 2004) and other legacy land-cover data (Fegeas, 1983), and socio-economic factors from Census datasets.

Table 1 - Example measurements of recovery potential. Measurements are applicable to the watershed, waterbody, or linear shoreline. Not all measurements are shown due to space limitations. A complete list is in Norton et al. (unpubl.).

Measurement	Description
Ecological Capacity	
Confluence density	Number of unimpaired waters that intersect 303(d)-listed waterbody. Measure of recolonization potential (Wallace 1990, Yount and Niemi 1990, Detenbeck et al. 1992).
Sinuosity	Straight-line distance “start” to “end” of impaired water divided by actual length of impaired water. Values close to 1 are an approximate measure of channelization. Channelization substantially retards recovery (Detenbeck et al. 1992). For comparing lotic systems only.
Watershed size	Size of watershed in areal units. Traits linked to the ability to recover from disturbance are inversely related to watershed size (Schlosser 1990), and small streams (i.e., small watersheds) are better able to assimilate nutrients (Smith et al. 1997, Peterson et al. 2001).
Percentage forest	Percentage forest in watershed. Positively correlated with water quality (Beaulac and Reckhow 1982, Frink 1991, Diamond and Serveiss 2001)
Riparian forest	Percentage of watershed stream length in forest at 0-, 30-, and 90-m buffer distances. Aquatic conditions improve with increasing percentage riparian forest (Peterjohn and Correl 1984).
Rare taxa	Number of broad taxonomic groups (e.g., amphibian, bird, fish) with vulnerable or imperiled species as defined by the National Heritage Program. Also a socio-economic variable as it may motivate public concern for protection.
Stressor	
% ag., urban	Percentage agricultural or urban land cover per watershed.
Legacy urban, agriculture	Percentage agriculture or urban from ca. 1970 historical land-cover data (Fegeas et al. 1983). Stream biotic diversity may be more strongly correlated with historical than present-day land cover (Harding et al. 1998).
Riparian urban, agriculture	Percentage of stream length in urban agriculture at 0-, 30-, and 90-m buffer distances.
Impervious surface	Percentage of watershed in impervious cover. A host of water quality problems arise as impervious cover increases (Paul and Meyer 2001, Brabec et al. 2002).
Impairment number & type	Based on 303(d) listing causes. Recovery potential may decline as the number of impairments increases because restorations are more complex. Pollutants vary in the difficulty of remediation.
Distance to nearest dam	Stream distances (downstream only) to nearest dam. Dams interrupt flow regime, the primary functional aspect of lotic systems (Poff et al. 1997), and block migration (Detenbeck 1992)
Socio-Economic	
Protected lands	Protected land from GAP stewardship database in categories 1 and 2. Categories 1 and 2 have land use restrictions. Watersheds with extant protected areas may be “attractors” for additional conservation.
Watershed groups	Number of groups dedicated to preservation that are active in the watershed. Based on data from EPA’s ADOPT database (http://www.epa.gov/adopt). A measure of stakeholder interest and capacity for restoration. Stakeholder interest is a measure of the likelihood that restoration will be implemented (Palmer et al. 2005).
Population	Number of persons per watershed. **Note** – all revenue, expenditure, debt, income, and other population measurements are also expressed as per capita by dividing by population.
Own revenue	Amount of local government revenue less federal and state sources. Limitations often exist on the use of federal and state funds, so this provides a more accurate picture of the local revenue base.
Debt	Total indebtedness of all local governments with jurisdiction in a watershed.
Res. units	Number of housing units in watershed. Measure of urbanization pressure.
Residential value	Aggregate value of owner-occupied residential units in watershed. A measure of homeowner value in the watershed. Several studies have validated the connection between water quality and property value as well as its role in motivating restoration (Bergstrom et al 2001).
Built 1950, 1970, 1990, 1990s	Housing built prior to 1950, 1970, and 1990, respectively, and housing built between 1990 and 2000 (1990s). Provides measures of urbanization pressures and trends. These measurements are also expressed as a percentage by dividing by number of housing units.

The numerous measurements listed in Table 1 provide initial evidence that available, geographically-based data can be used to advance the concept of recovery potential as a basis for prioritizing 303(d)-listed waters for TMDL development and restoration. It is beyond the scope of this paper to discuss every measurement we assessed, and those metrics listed in Table 1 are only a partial subset. A few of these metrics will be discussed in more detail to elucidate the value of available, statewide data for quantifying measurements of recovery potential.

The proximity of refugia has been noted by many as an important factor controlling recovery from disturbance (Wallace, 1990; Yount and Niemi, 1990; Detenbeck 1992). We measured "refugia" as the number of confluences of the impaired waterbody with unimpaired waters. Impaired waters with a greater number of confluences with unimpaired waters may have a greater likelihood for recolonization once appropriate restoration practices are put in place.

Percentage impervious surface has emerged as an important indicator of watershed disturbance (Arnold and Gibbons, 1996; Paul and Meyer, 2001; Brabec et al 2002). Increases in impervious surface decrease watershed storage, increase watershed runoff and flashiness, introduce organic contaminants and other pollutants, and elevate bacterial counts. Arnold and Gibbons (1996) have proposed 10% and 30% as thresholds of overall watershed imperviousness at which degradation becomes consistently measurable and severe, respectively. Although imperviousness thresholds are not crisp (Brabec et al. 2002), the wide-ranging impacts of imperviousness suggest that it is a significant and important stressor even at relatively low proportions in a watershed. Others point out that imperviousness is difficult to remediate (Booth and Jackson 1997). Imperviousness' combined aspects of significant impacts at relatively low thresholds and resistance to mitigation suggest that recovery potential may be low as percentage imperviousness surpasses 10%.

Lessons learned from meta-analyses of TMDL studies indicate that stakeholder involvement and funding are keys to recovery (Benham et al. 2007). Our recovery potential dataset includes several measures of stakeholder involvement (or interest) and the fiscal ability to underwrite restoration. One measure is the number of watershed groups active in the impaired watershed (http://www.epa.gov/adopt). Two measures of fiscal ability to underwrite restoration are funding eligibility and own source revenue. Funding eligibility counts the U.S. Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) programs in the watershed. Own source revenue is the amount of local government revenue less transfers from federal and other sources. According to the meta-analyses of Benham et al. (2007) and other socio-economic research (Palmer, 2005), for two impaired waters with more or less equivalent ecological capacity and stressors, the one with greater stakeholder involvement and greater fiscal resources should have greater recovery potential than the one with less stakeholder involvement and more modest fiscal resources.

The 2002 303(d) list for Illinois included 723 waterbodies, of which 580 were streams or rivers, 119 were lakes, and 24 labeled as channels, ditches or canals. The recovery potential measurements (see examples, Table 1) were used to order each of the 723 sites according to its recovery potential, which could then be compared to the nominal prioritization of low, medium and high provided in the 303(d) list to demonstrate that a large body of information on likelihood of recovery can be used as a flexible tool to aid prioritization among numerous waters in need of restoration. To that end, we compare individual recovery potential measurements with the nominal prioritizations, and close with a comparison of a cluster analysis versus the nominal prioritization. Although we used a real statewide impaired waters dataset and ancillary landscape modeling data, our analyses were hypothetical and meant to demonstrate the basic process and flexibility of our approach as a screening and planning tool. Below, we contrast some of our example metrics with the results of the state's nominal prioritization; however, as it is a highly simplified example using few metrics, we do not imply that this demonstration by itself is preferable.

Cluster analysis is a convenient method to integrate many indicators to uncover patterns in the data (Aldenderfer and Blashfield, 1984). We used iterative partitioning cluster analysis incorporating a subset of uncorrelated (i.e., orthogonal) indicators from Table 1. All variables were standardized to a mean of 0 and a variance of 1 prior to clustering.

RESULTS

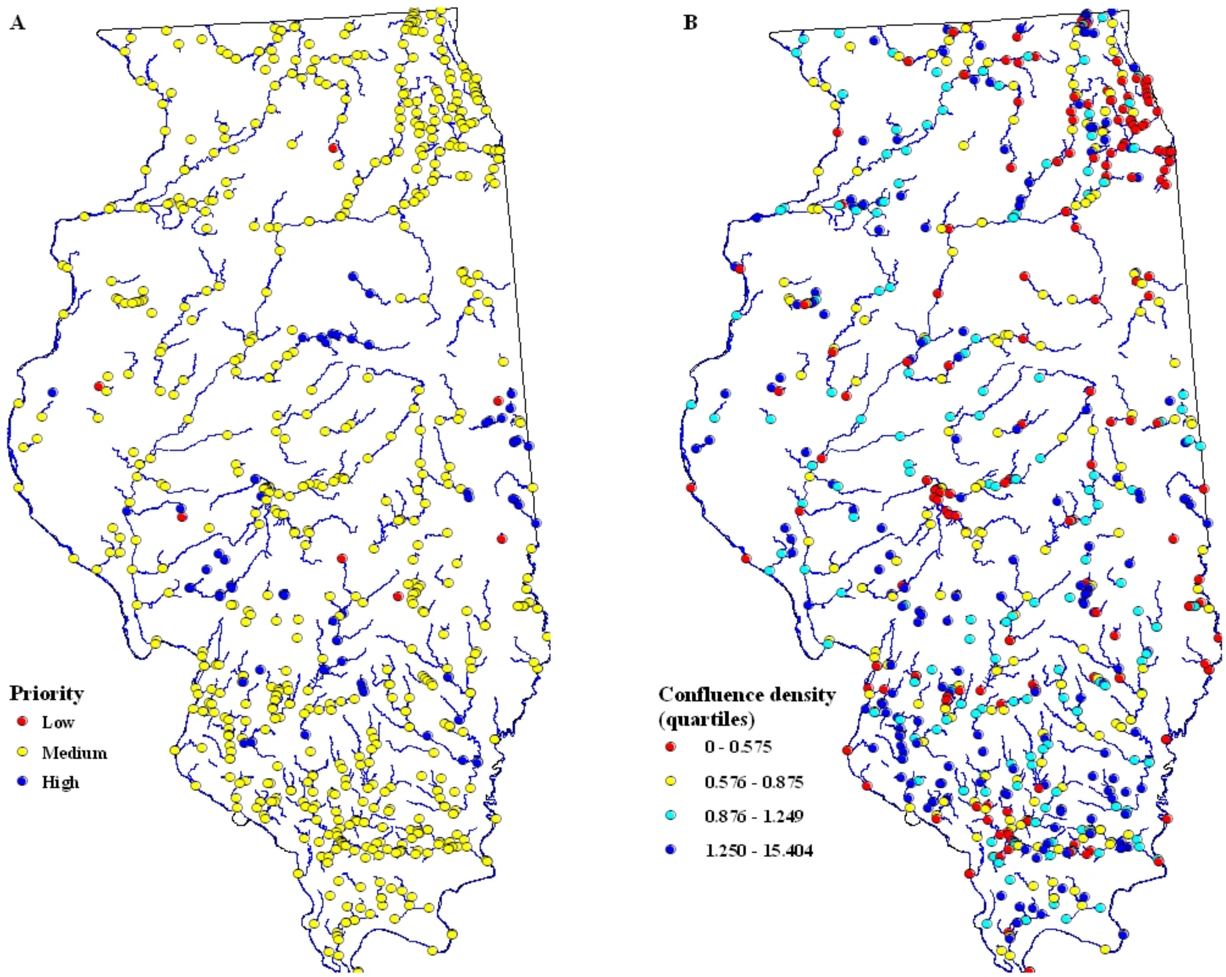
The nominal prioritization of Illinois 303(d)-listed waters ranked 59 sites as high, 657 sites as medium and 7 sites as low. Comparison of nominal rankings with a quartile rank ordering of confluence density (Fig. 1) demonstrates the potential value of including site information into prioritization schemes. Four of the 7 sites with a nominal ranking of low are in the highest confluence density quartile. The admittedly very simplistic assumption that higher confluence densities translates to higher likelihood of recovery suggests that the priority of these four sites should be elevated.

Comparison of nominal rankings with quartile rankings based on the number of watershed groups shows the value of considering socio-economic factors for assessing the likelihood of recovery (e.g., Palmer, 2005; Benham et al., 2007) (Fig. 2). None of the sites with a nominal ranking of high occur in the highest quartile for number of watershed groups, and 37 of the 59 sites (63%) of the sites with a nominally high ranking have 5 or fewer active watershed groups.

Comparison of Figures 1B and 2B reveals some interesting spatial correlation. Although the broad geographic patterns in Figures 1B and 2B are quite different, several sites in the 3rd and 4th quartiles for confluence density (Fig 1B) are also in the 3rd and 4th quartiles for number of watershed groups (Fig 3B). In other words, there are several sites that have high ecological and high socio-economic capacity for recovery. These sites are south and east of St. Louis, in east-central Illinois on the border with Indiana, and in the northwest corner. Many of these sites have a nominal prioritization ranking of medium.

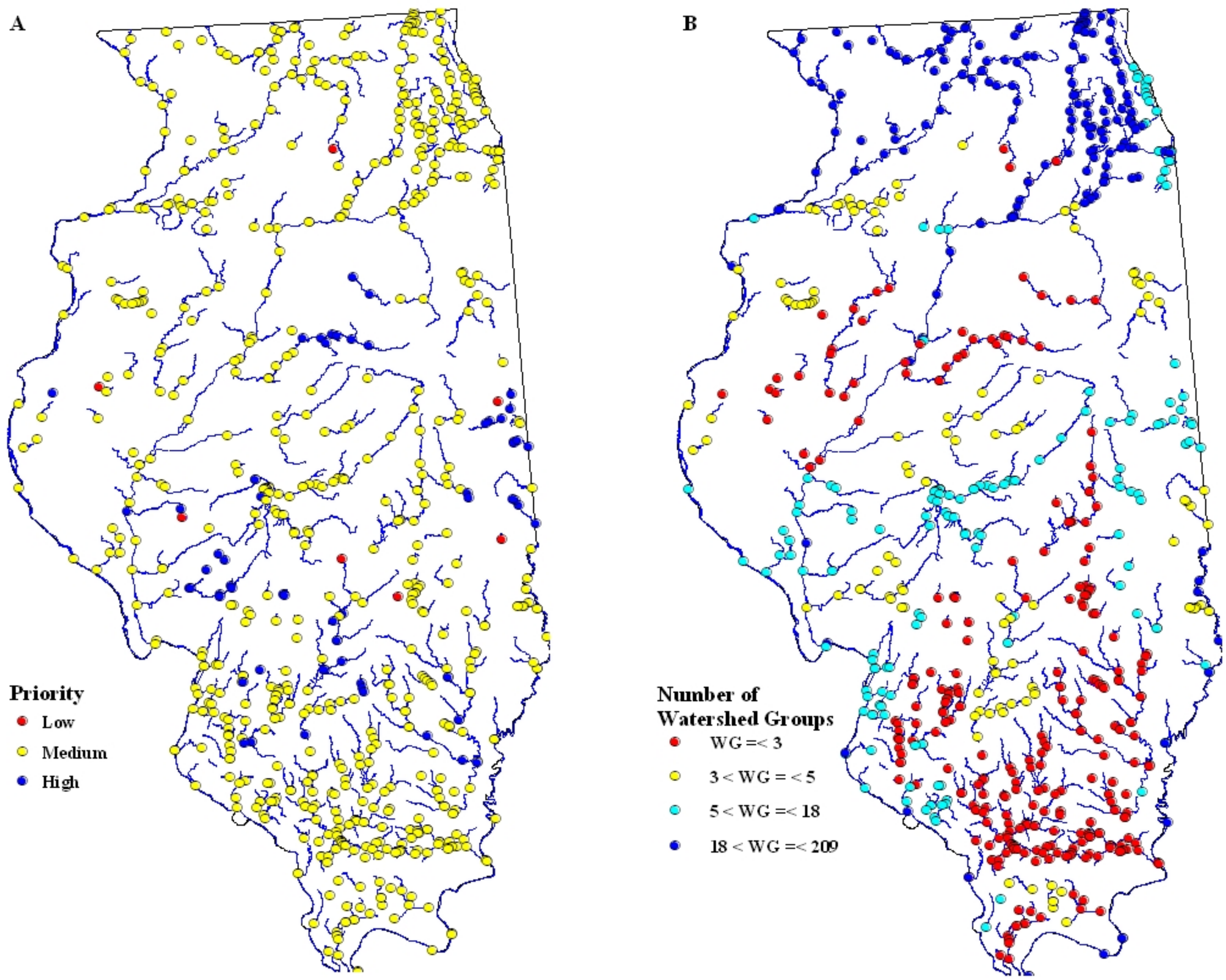
The two, single-indicator examples above demonstrate the potential value of considering site characteristics for developing statewide TMDL prioritization schedules. The cluster analysis results (Fig. 3), in many ways, synthesize the patterns in Figs. 1B and 2B. Cluster 1 is characterized by higher proportions of forest (both riparian and entire watershed), and is comparatively steep-sloped and therefore tends to have higher confluence densities. This group also tends to have fewer cited causes of impairment (the same waterbody can be placed on the

Figure 1 – Comparison of nominal ranking of 303(d) sites (A) with a quartile ranking based on confluence density (B).



303(d) list for more than one listing cause, e.g., nutrients and metals). The main limitation of the cluster is that it tends to have fewer watershed groups (Fig. 2B). Cluster 2 is dominated by the major urban centers of Chicago and St. Louis. These impaired sites tend to have high impervious surface percentages, little forest, low confluence densities (especially in the Chicago vicinity), and a relatively high number of watershed groups (the number of watershed groups is correlated with population). Cluster 3 is characterized by flat, agriculturally dominated watersheds concentrated in the “tileshed” (tile-drained soils) of east-central Illinois. Tile drains are used for removing excess soil water from cropland, and tend to obviate the nutrient filtering benefits of riparian vegetation (Osborne and Kovacic, 1993). The Illinois tileshed is bounded on the north by the Illinois River and extends south and east toward the Wabash River. These sites also tend to be listed for only a few causes of impairment (not shown) and tend to have a comparatively high number of watershed groups. Cluster 4 sites, like cluster 3, are also dominated by agriculture. However, cluster 4 sites tend to occur in more

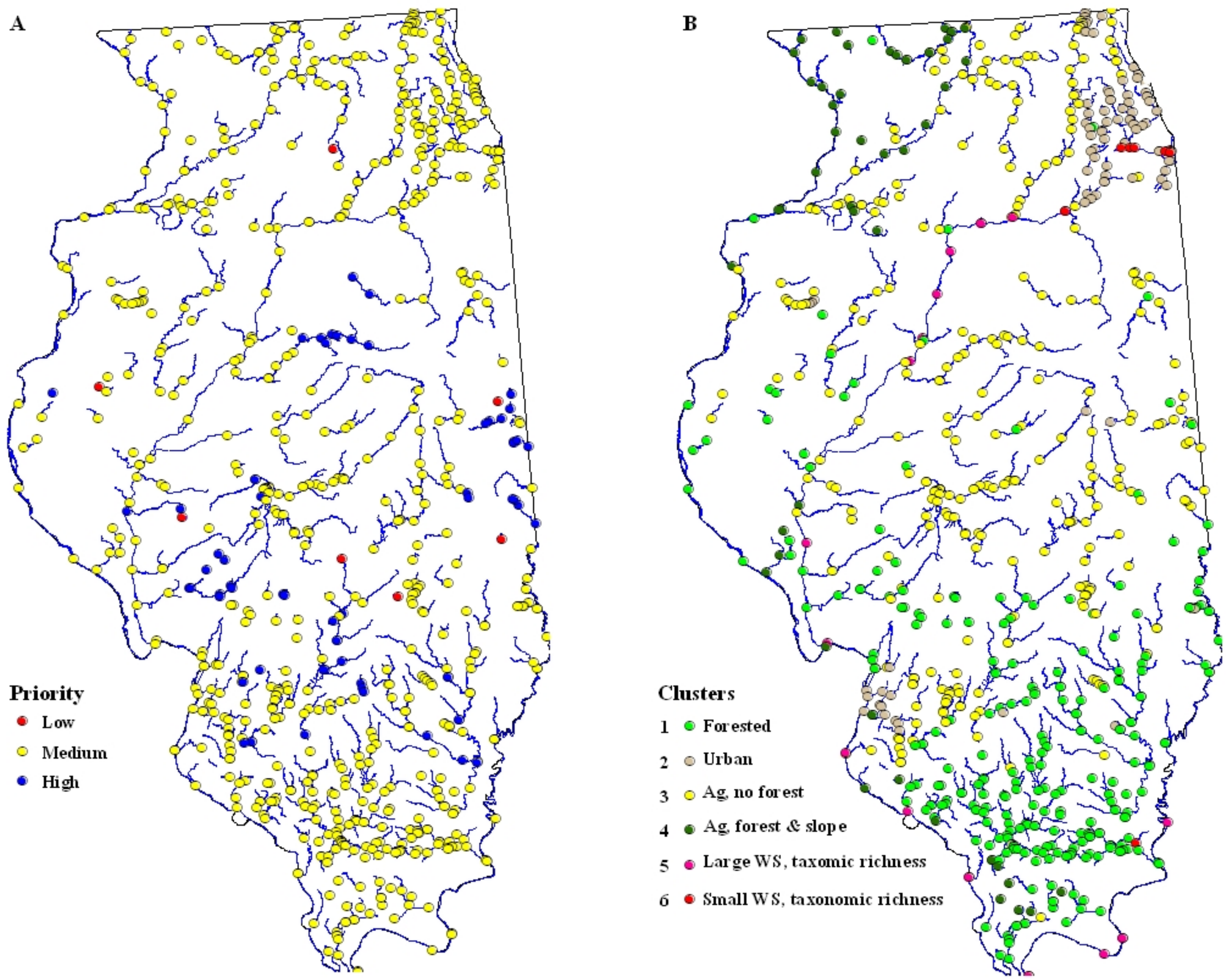
Figure 2 - Comparison of nominal ranking of 303(d) sites (A) with a quartile ranking based on the number of watershed groups (B).



rolling topography with a greater amount of forest and higher stream and confluence densities. Cluster 4 sites also tend to have a high number of watershed groups (Fig. 2B). Clusters 5 and 6 are characterized by relatively high number rare and endangered taxa (data from National Heritage Program). Sites in cluster 5 tend to be on large rivers, while sites in cluster 6 tend to be in small rivers. Sites in cluster 5 tend to be cited for only a few potential causes of impairment.

The cluster analysis results indicate that there is a geography that could potentially be exploited in TMDL prioritization. Based on our informal analysis of the cluster results, cluster 1 sites appear to have the greatest recovery potential. Sites in cluster 1 tend to be smaller watersheds with fewer cited causes for impairment, contain greater amounts of forest, and have higher streams and confluence densities. Recovery potential is likely inversely related to watershed size. Smaller watersheds are characterized by biota adapted to disturbance, having shorter life spans and shorter times to maturity (Schlosser 1990). Smaller watersheds are also drained by smaller streams, and smaller streams tend to have a greater capacity to assimilate nutrients than

Figure 3 - Comparison of nominal ranking of 303(d) sites (A) with cluster groups (B). Cluster numbers are to the left of the color symbols and cluster labels are to the right.



larger streams (Smith et al. 1997, Peterson et al. 2001). Sites in cluster 4 likely rank second behind cluster 1 sites in recovery potential and prioritization for TMDLs. Agriculture is more dominant in Cluster 4 sites, but the sites are also characterized by a tendency toward few cited causes of impairments, higher stream and confluence densities, and a large number of watershed groups (Fig. 2B). In our view, sites in cluster 3 rank third for TMDL prioritization. Sites in cluster 3 are dominated by agriculture that that tends to be tile drained. Cluster 3 sites also tend to have larger watersheds. The main advantage of cluster 3 sites is the tendency to be characterized by a large number of watershed groups. Sites in cluster 2 appear to rank last for scheduling and implementing TMDLs. Cluster 2 sites suffer from the effects of urbanization and high percentages of impervious surface. The effects of urbanization on aquatic systems may be difficult to mitigate and costly (Booth and Jackson, 1997), but a higher tax base for potential restoration support may offset these negatives.

Sites in clusters 5 and 6 may demonstrate another aspect of our definition of recovery potential: "… other valued ecological attributes..." Our view is that the sites in both clusters would rank low in their recovery potential and hence priority for TMDL studies. Cluster 5 sites tend to be on very large rivers (primarily, the Illinois, Mississippi, and Ohio Rivers), and therefore they likely incorporate the upstream impacts of many other impaired waters; ecological recovery of cluster 5 sites might not occur until upstream impairments are removed or mitigated. Sites in cluster 6, like those in cluster 2, are also heavily urbanized and may be appropriately included as a subset of cluster 2. Sites in cluster 5 and 6 are distinguished by higher occurrences of rare and endangered taxa. The priority for TMDLs for these sites might be elevated not because of a high likelihood of recovery, but rather to do whatever can be done to preserve their species richness.

DISCUSSION

The sheer number of 303(d)-listed waterbodies overwhelms human and fiscal resources. Yet, neither the Clean Water Act nor USEPA provide guidance on prioritization of impaired waterbodies. Lack of prioritization strategies leads states to a case-by-case approach to TMDL scheduling; although best professional judgment may have the insights to make some good case-by-case decisions, combining these insights with consistent statewide datasets on recovery factors offers a more objective approach. Reliance on a case-by-case approach may limit the success of impaired waterbody restoration by overlooking less severely impaired waterbodies and placing too much attention on relatively few but perhaps more severely impaired waterbodies. Overlooking less severely impaired waterbodies likely results in a lower rate of success, and an overemphasis on more severely impaired waters ignores the possibility that recovery may not be a realizable outcome for such waterbodies (O'Neill, 1999; Keller et al., 1999).

The basis of recovery potential is statewide development of site characteristics that can be used as indicators of the likelihood of recovery. The use of broad-area analysis as a strategy for targeting restoration has been used proposed for restoration of salmon habitat (Roni et al., 2002) and re-vegetation (Yetman, 20002). We demonstrated how site characteristics varied across the State of Illinois using confluence density and number of watershed groups. Confluence density was used as an ecological indicator of available "refugia" (Wallace, 1990; Yount and Niemi, 1990; Detenbeck, 1992), and number of watershed groups was used as a socio-economic indicator of stakeholder interest (Palmer, 2005; Benham et al., 2007). Comparison of confluence density against the nominal TMDL prioritization of low, medium and high showed that 4 of the 7 sites that had a nominal TMDL prioritization of low were among the upper quartile for confluence density. Comparison of the nominal TMDL prioritization against the number of watershed groups showed that 63% of the 59 sites with an nominal TMDL prioritization of high were in the lower 50th percentile for number of watershed groups, and none of the 59 sites were in the upper quartile.

We carried the single-indicator analysis further by using uncorrelated recovery potential measurements in a cluster analysis. The cluster groups could be interpreted as an option for prioritizing the TMDL schedule. Sites in cluster 1 were identified as having the highest potential for recovery. On average, sites in cluster 1 had higher scores for three important indicators of ecological capacity (watershed size, forest percentage, and confluence density), and low scores for two important stressors (impervious surface and number of cited causes for impairment). Their main limitation was comparatively few watershed groups (Fig. 2B). Recovery potential for clusters 4, 3, and 2 were ranked 2, 3, and 4, respectively. Clusters 5 and 6 served to demonstrate an additional aspect of our definition of recovery potential – "… other valued attributes …" Cluster 5 and 6 sites were deemed to have low recovery potential, but did have high scores for rare and endangered taxa. Prioritizing sites in clusters 5 or 6 may be an acknowledgement to preserve what remains rather that restoring lost ecological condition and function.

Cluster analysis is only a starting point for organizing the impaired waters. Members (sites) are included in a particular cluster based on their distance from a cluster average. Scores for some members will be close to the cluster mean, while others will be more deviant. Closer examination of individual (site) indicator values would likely change the prioritization of some sites. Cluster analysis is only an organizing framework.

Our prioritization demonstration is fuzzy rather than crisp, which underscores the complexity of the TMDL program and prioritization of impaired waterbodies. More rigorous prioritizations would factor in state goals, types of impairments, and many other additional recovery-relevant factors. Our objective was not to find *the* prioritization methodology, but rather to demonstrate a process within which site characteristics can be used to infer likelihood of recovery, which in turn can be used to carry out prioritization more strategically. A more thorough examination of recovery potential is a long-term process that requires more state participation. Through active application of the approach and tools in more states, recovery potential screening methods can be improved. Further, as more evidence of fully recovered waters is compiled, additional testing of recovery metrics can take place with empirical data from those sites. The substantial resources expended on restoration, and the ecological and societal values at stake, provide strong incentives to assess recovery potential in the interest of optimizing restoration success.

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