Discussion

Current Conditions and the Future Scenario: Analysis of the Mid-Atlantic Region

A series of assessment questions was developed for use in examining current and future conditions in the Mid-Atlantic. ReVA began this study by developing the following assessment questions.

1. What is the current spatial pattern of environmental condition?
2. How will the spatial pattern of condition change in the future?
3. How much will environmental condition change in the future?
4. What are the most important stressors in a region?
5. Which watersheds will become the most stressed in the future?
6. What are the most stressed resources in the region?
7. How will future change affect the least stressed watersheds in the region?
8. What watersheds are currently vulnerable to further impacts?
9. What watersheds may become vulnerable in the future?
10. Which watersheds are most vulnerable to irreversible change?
11. Which watersheds may be vulnerable to irreversible change in the future?

The Simple Sum and PCA Sum methods were used to address questions 1-3 and showed similar spatial patterns of environmental condition; highly urbanized areas were in poorest condition and watersheds that were not near urban centers were in the best condition (particularly those in the Highlands). The future scenario used for this study showed degraded environmental condition scattered across the Mid-Atlantic region with possible synergistic effects from multiple stressors impacting many of the Mid-Atlantic Highlands watersheds. The changes were not necessarily large, often involving only a shift of a single septile, but the degradation was widespread across the region.

The PCA Sum method accounts for the co-occurrence of stressors resulting in slightly better environmental condition than the Simple Sum on several watersheds. The better current and future condition predicted by the PCA Sum approach may be the result of underestimating the effect of multiple correlated stressors which act synergistically causing greater environmental damage than what was depicted. Therefore, the Simple Sum method might be a more conservative estimate of environmental condition and perhaps a better prediction of where cumulative effects can be expected.

The results of the matrix analysis were used to answer question 4 and indicated that the most threatening current stressors (urbanization and nutrient runoff) will also be the most threatening stressors in 2020. No changes in the ranking of the top stressors occur in the overall evaluation, although minor changes occur when individual sub-groupings were considered. In no case did more than one of the three most important stressors change and none of the new top stressors that appear in the 2020 analysis were based on significant coefficients. Therefore, changes were possible rather than probable and likely include cumulative and indirect effects rather than solely direct effects.

State Space analysis was used to answer question 5 and indicated that the least change between current and future condition was concentrated in watersheds along the Mid-Atlantic Highlands. Watersheds that changed the most were concentrated in suburban areas that surround the major urban centers:

Wilmington, Philadelphia, Baltimore, Washington, Pittsburgh, and Wheeling. Intermediate change was projected for parts of the coastal plain and piedmont. The observed pattern of environmental degradation was expected because the model used to project land cover change in the future scenario was primarily an urban sprawl model and concentrates land cover changes in the areas surrounding the major urban centers.

The Stressor-Resource Overlay method (questions 6-9) illustrates how a watershed can have many valued resources, but still not be vulnerable now or in the future because of the absence of stressors. Many watersheds in the highlands had high levels of resources, but were isolated from many of the land-cover changes that degraded other areas. On the other hand, a highly stressed watershed might not be considered vulnerable because its valued resources have been destroyed. For example, the watershed containing Baltimore was highly stressed, but was not among the most vulnerable because few valued resources remain. The most vulnerable watersheds often were those with intermediate to high levels of stressors together with intermediate to high levels of resources. The watersheds identified as vulnerable in the Stressor-Resource analyses were in rural areas that retain natural resources because they were not yet covered by urban sprawl and other development. Thus, vulnerable watersheds have valued resources in amounts intermediate to the best and worst areas and these resources might only be protected by careful planning.

The watersheds most vulnerable to irreversible change (questions 10-11) according to current and future Criticality analyses were concentrated in and around the Baltimore-Washington, DC, metropolitan area. These watersheds were so highly altered that they were unlikely to return to their pre-human natural state if human controls were removed. The important resources and stressors in the highly altered watersheds were similar to those indicated by the best and worst quintile methods, including measures of habitat condition, nutrient inputs, and invasive species. A few shifts occurred in the top 20 most vulnerable watersheds between the current and future scenarios; however, the majority of the watersheds remained in the same rank between time periods. The “fuzzy” definitions of the natural state used in the Criticality analyses give the appearance of bias toward false negatives (i.e., possibly underestimating the risk of catastrophic change) and this bias can be interpreted in either of two ways. First, it makes a strong case that the watersheds shown were indeed vulnerable and, second, the results should not be interpreted as meaning that other watersheds were “safe” from further degradation.

The general pattern for the future scenario used here shows that forests will continue to dominate the landscape, but human disturbances will increase around existing metropolitan centers and will also spread in the Mid-Atlantic Highlands, especially in West Virginia. The coastal plain, which was dominated by urbanization, was forecasted to receive even more pressure from urban development. The other likely large-scale land-cover change was in mining, which increased most in the Mid-Atlantic Highlands. The spread of mining as presented is the worst case scenario, however, because all permitted areas were assumed to be mined by 2020, all mining was assumed to cause surface disturbance, and no reclamation was included.

Using ReVA’s approach, decision makers in the Mid-Atlantic and in other regions can identify current stressors and resources and how those stressors and resources can change across the landscape under some future scenario. Conventional ecological vulnerability assessment is mainly based on “source-based” approach (single stressor on single resource) where the concept of probability is dominant. However, it is almost impossible to derive a probabilistic vulnerability in a “place-based” and/or regional method as in ReVA where data are multiple stressors and resources collected from various sources with different types of uncertainty (or no information of uncertainty at all). In that context, future scenario analysis in ReVA portrays the vulnerability concept in a "qualitative" and "relative" context. The concept is based on relative comparison and spatial relationships among watersheds. The use of various simple methods (e.g., Simple Sum, Principal Components Analysis, State Space analysis, Criticality analysis, and Stressor-Resource Overlay) to address a set of vulnerability assessment questions demonstrates successfully the concept of relative vulnerability. It also shows that different methods can facilitate different tasks of environmental planning, in general, and future scenario analysis, in particular, to different extents.

The following are recommendations for the use of the integration methods described in this report:

- Address a set of assessment questions at the same time: as management prioritization involves balancing many different factors, future scenario analysis should be addressed through a series of assessment questions to cover the various aspects of the system under study.

- Use a suite of integration methods: there is no single integration method that can fully address future scenario analysis. Each method has advantages and disadvantages. The use of multiple methods in a complementary manner will help the user look at the problem from different angles/perspectives.

- Pay attention to your data: how data are coded or transformed can have substantial influence on the integration results. Try to keep a balance between data transformation and data interpretation.

Other Uses of ReVA Assessments

Environmental Conservation

Ecological conservation is often carried out at small scales, and, combining approaches from both conservation biology and landscape ecology provides a suitable approach to examine problems and questions at a regional scale. The analyses in this report provide powerful insights for such integrated approaches. By examining those analyses collectively and comparatively, scientists and policymakers can identify not only the best watersheds for conservation at the local level but also identify the critical ecological linkages that can facilitate regional conservation efforts. Such insights cannot be found in a single analysis of a single question with a single method or tool.

Results presented in this report are potentially useful in numerous ways. First, the questions and the methods used to answer them help depict a comprehensive assessment of a region's current and possible future environmental condition. Second, the information can be used to target risk reduction actions and prioritize use of resources at the regional and sub-regional level. Third, it illustrates how different integration techniques developed and presented in the first report (Smith *et al.* 2003) can be used in a complementary manner to examine various issues of environmental planning and management, especially on environmental risk reduction, restoration, and mitigation.

Ecological Restoration

Arguably, many of the principal keys to the restoration of aquatic systems (USEPA 2000) are applicable to terrestrial ecosystems. Our report highlights and augments many of these principles. The analyses in our report suggest ways to locate ecosystems in the best condition for conservation. By identifying these most intact ecosystems, the biodiversity needed for recovery is preserved. Many of the analyses used for this report, in particular State Space and Criticality analyses, depend on comparison to some reference watershed(s) in best ecological condition with similar structure and function. The watersheds in the best quintiles may be used as models for restoration projects, as well as a reference for measuring the progress of the project.

Restoration is most appropriately done at a watershed-wide scale and not simply done at a single most degraded point within a watershed. By conducting an assessment on a regional scale, the relationships of watersheds to each other as well as their ecological settings, resources, stressors, and changes that occur within individual watersheds can be examined. Ecological integrity refers to the overall condition of an ecosystem in terms of its structure, composition, and natural processes of the biotic communities and physical environment. The indicators and integration techniques used in this report aid in the analysis of the ecosystem's structure, composition, and its dynamics. We provide through our Criticality analyses a method for understanding the natural potential of a watershed and an evaluation of irreversible changes that may affect the ability of a watershed to be restored. Addressing ongoing causes of degradation within a watershed is vital for restoration planning and avoiding irreversible changes. Our Stressor-Resource Overlay analyses are one method of identifying the important stressors that should be remediated wherever possible. Furthermore, by including spatial and temporal dynamics in all our analyses we provide planners a way to anticipate foreseeable ecological and societal changes.

A final principle often stated for restoration is the need to develop clear, achievable, and measurable goals that are set at levels achievable ecologically, financially, and with the support of the community. In our analyses, the criteria for choosing candidates for conservation can be modified and relaxed to some extent to achieve realistic conservation goals and objectives.