# Introduction

## Background

The U.S. EPA's Regional Vulnerability Assessment (ReVA) program develops and demonstrates approaches to assessing broad-scale environmental vulnerabilities through the analysis of spatial data and models (Smith *et al.* 2001). A necessary component of such ecological vulnerability assessment is a characterization of ecological condition and identification of stressors that can degrade condition in the future. ReVA was designed recognizing that regional assessments are primarily the responsibility of regional decision-makers (Moss 2002) who need concise measures of condition and vulnerability and the ability to use projections or forecasts to make proactive decisions. Therefore, two of ReVA's objectives are (1) to develop and evaluate techniques to integrate information on exposure (stressors and resources) and effects so that ecological risk due to multiple stressors can be assessed, compared, and management actions prioritized; and (2) to project consequences of potential environmental changes under alternative future scenarios (Smith *et al.* 2001). ReVA scientists have researched, developed, and published methods and guidance for integrating exposure information into vulnerability assessments (objective 1) in a previous EPA report *Regional Vulnerability Assessment for the Mid-Atlantic Region Evaluation of Integration Methods and Assessment (EPA/600/R-03/082)*. In that study, ReVA tested how well data integration methods performed. This current report describes the application of these methods to a future scenario (objective 2). The goal is to show how ReVA's approach, including integration methods, can be used to identify current stressors and resources and how those stressors and resources can change across the landscape under some future scenario. The scenario described here is not a prediction of what will happen, but is an evaluation of what could happen under a plausible future scenario.

Vulnerability has multiple elements in its definition, but is most simply represented by the likelihood that future condition will change in a negative direction. Thus, the vulnerability of an ecological system increases as the number, intensity, and frequency of stressors increase. In this report, ReVA uses vulnerability to refer to the relative amount and number of resources and stresses present in a watershed. While reading this document, it is important to remember that the vulnerability of a watershed is a relative rather then absolute measure. In fact, an absolute measure of vulnerability in a probabilistic sense would be difficult to derive for any watershed with confidence, let alone for all the watersheds in a region. Although ReVA's analyses do not provide estimates of the probability of change, they do provide a set of powerful screening tools for identifying the most and least vulnerable watersheds in a region. This can enable decision makers to focus resources and prioritize planning for multiple types of questions.

## Purpose of this Report

This report presents analyses supportive of our strategic priority to assess condition and develop methods to examine scenarios and alternative futures in support of assessment and management. Arguably, management prioritization involves balancing many different factors that can be addressed through a series of assessment questions. Taking that approach, the report focuses on methods that can be used to address 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?

## Study Area, Temporal Extent, and Reporting Units

ReVA's pilot area was the Mid-Atlantic region used as part of the Mid-Atlantic Integrated Assessment (MAIA; Bradley and Landy 2000). The Mid-Atlantic encompasses portions of eight states and several ecoregions (Figure 1). Current conditions described here were derived from 1992 National Land Cover Data (NLCD) and all current conditions described here are for 1992; future projections are for the year 2020. Data is summarized and reported by hydrologic units (8 digit HUCs).

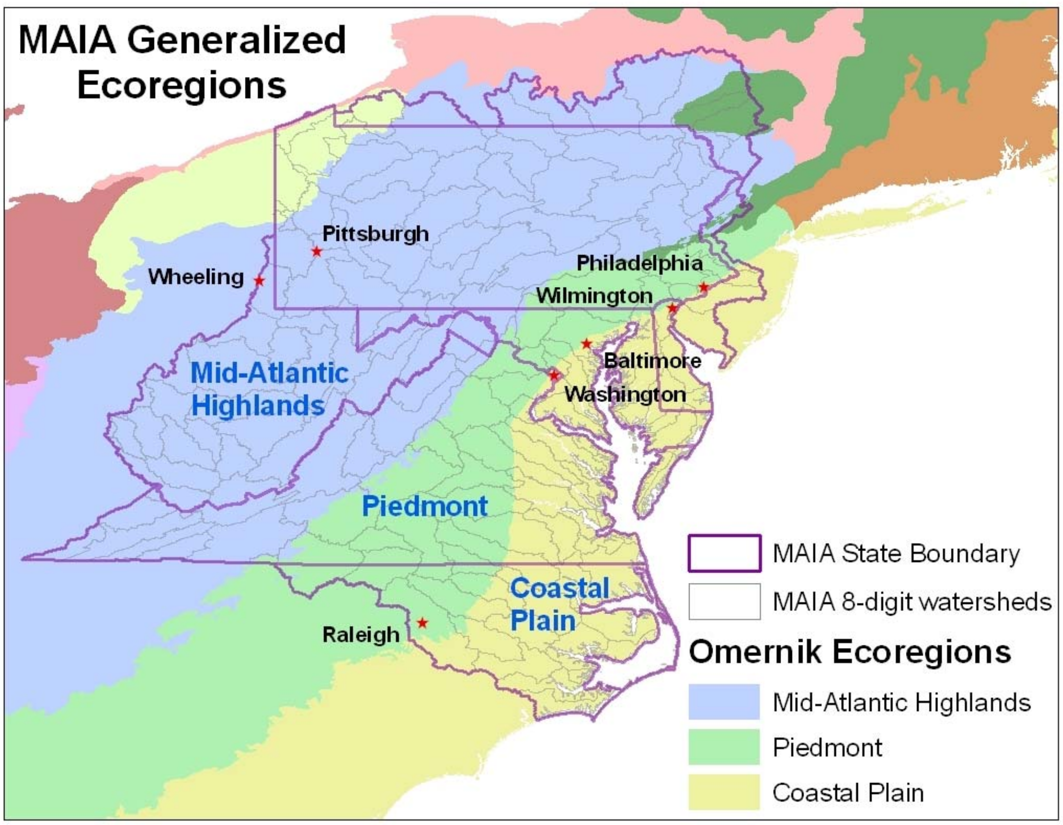


**Figure 1. Study area.**

Regionally, temperate forest is the dominant Mid-Atlantic land cover (Figure 2), despite the long history of human presence. Urban development dominates the coastal plain and most of the large cities in the region lie along the geologic boundary between the coastal plain and the piedmont. The piedmont includes most of the region's agricultural lands, with smaller cities and forestland scattered throughout.

The Mid-Atlantic Highlands retains the world's largest remaining contiguous temperate forest (Riitters *et al.* 2000), interspersed with small- to medium-sized cities, some agriculture, and numerous mines. In essence, there is a gradient from the coastal plain (urban/agricultural matrix) to the piedmont (agriculture/forest matrix) to the Mountains (forest matrix).

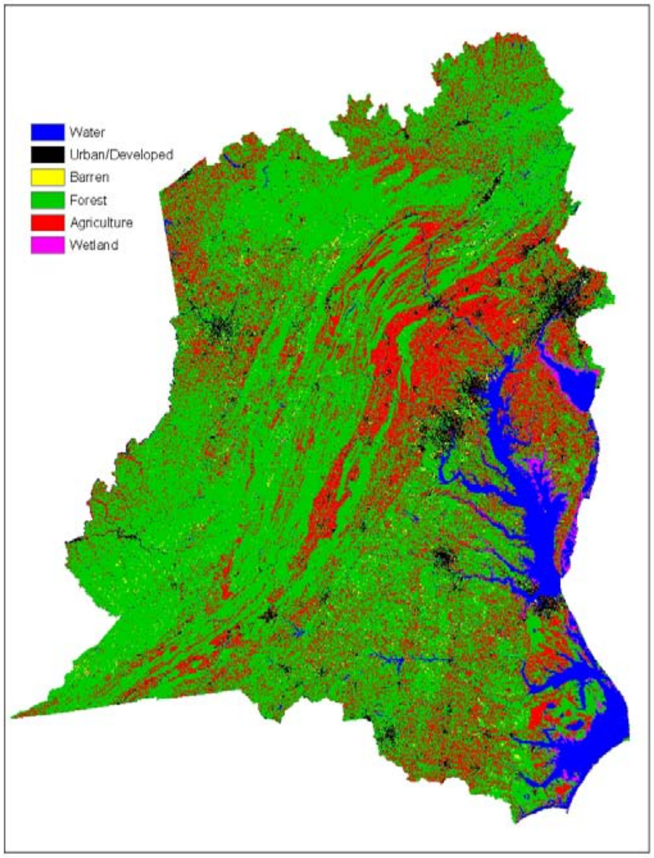


**Figure 2. National Land Cover Data (NLCD) land-cover map of the Mid-Atlantic region (1992).**

## Projecting the Drivers of Change in the Mid-Atlantic Region

Projections of the major drivers of change were used to develop a future scenario for the Mid-Atlantic. Changes in land use were projected using a combination of planned new roads and road improvements along with a model of future development (SLEUTH - Slope, Land use, Exclusion, Urban, Transportation, Hillshading; Clarke *et al*. 1997) that projects changes based on projected population changes from the Woods & Poole Complete Economic and Demographic Data Source (CEDDS) (2002). Changes in the spread of non-indigenous species were made for major problem species using a niche model (Genetic Algorithm for Rule-set Prediction - GARP; Stockwell and Peters 1999) to predict probability of a species becoming established across the region (see Appendix 1). Resource extractions were projected using existing areas permitted for future mining obtained from individual states. Changes in human population distributions were also included to evaluate impacts to human health and well being.