# Coastal Development

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# Concept Paper: Land Use
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## BACKGROUND

### National and Regional Significance of Land Use Change

The widespread impacts of land use change on our environment are increasingly evident. A recent NASA-funded study concludes that the contribution of human-induced land cover change on climate is at least as important as that of carbon dioxide (Pielke *et. al*, 2002). A report on the impact of urbanization on groundwater supplies estimates losses to groundwater recharge in 20 American metropolitan areas to be in the tens of billions of gallons per year (Otto et. al, 2002). The Nature Conservancy reports that up to one-third of the country's animal and plant species are at risk of extinction due mainly to habitat loss and degradation from land use changes (Stein and Flack, 1997).

Coastal waters are no exception. The Pew Commission (2001, 2002) reports that over 20,000 acres of coastal habitat disappear each year, and that every 8 months an amount of oil equivalent to the *Exxon Valdez* spill enters coastal waters via runoff. EPA's latest National Water Quality Inventory reports that 51% of assessed estuaries and 78% of assessed Great Lakes shoreline are impaired, with urban runoff being the second leading pollutant of estuaries (EPA, 2000). The National Coastal Condition Report reached similar conclusions, giving the status of the nation's estuaries a "fair" grade, and the Northeast a "poor" grade, based on seven basic criteria of coastal condition (EPA, 2001).

### State of Land Use Change in America and in the Region

America is an urbanizing country. According to the latest estimates by the USDA Natural Resources Inventory (NRCS, 2003), between 1982 and 2001 about 34 million acres – an area the size of Illinois – were converted to developed land from forest and farm land. The majority of this urbanization is occurring in coastal areas. More than half of the U.S. population lives in coastal counties, and NOAA projects that by 2010, more than 75 percent of the U.S. population is expected to live within 50 miles of the coast (Culliton *et al*., 1990). The Pew Commission (2003) reports that the resident population along the coast is expected to increase by 25 million people by 2015.

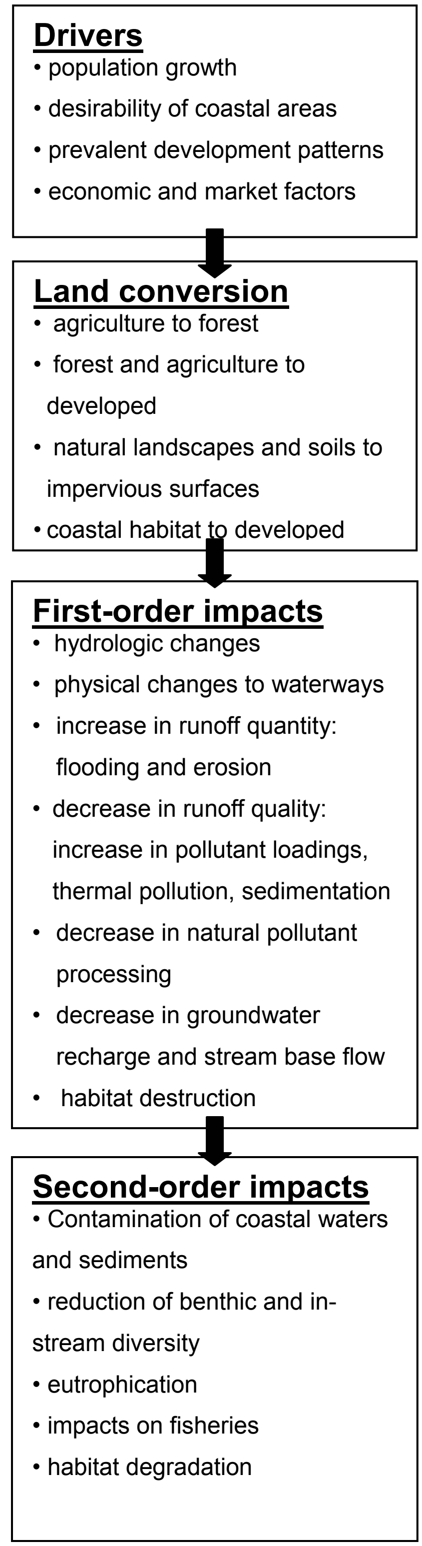
Population growth, however, is not the sole driver of the urbanization process. As many have reported, the post World War II land-consumptive form of development often known as "sprawl" generates land conversion rates that far outstrip population growth. For instance, a study in the Charleston, SC area found that over the 21-year period from 1973 to 1994, urban land use growth exceeded population growth by a 6:1 ratio (Allen and Lu, 1998). A recent NOAA-funded report estimates that by 2025, the nation's top 20 coastal and Great Lakes metropolitan regions are likely to increase their "urban footprints" by 46%, expanding an additional 9,000 square miles (McGrath, 1999).

While the Northeast has the distinction of being the one area of the country that is gaining in forested land (due to the rapid abandonment of active farmland), it is also the most urbanized portion of the country. According to the USDA National Resources Inventory (1997, updated yearly), the East Region (New England plus NY, NJ, PA, DE, MD and WV) gained 4 million acres of developed land during the 1982 to 1997 period, and has nearly twice the national average of developed land and almost 4 times the national population density. The Northeast accounts for about 35% of the nation's coastal population (Culliton *et al.,* 1990).

### Status of Research

The impacts of urbanization on coastal resources are well documented but not necessarily well understood. Studies of nonpoint source loadings and their relationship to land use, for instance, have only been in existence for about 20 years, and the majority of such studies have concentrated on agricultural, rather than urban, runoff. Key research areas relevant to issues of monitoring and assessment include:

- ***Impervious surface and other landscape indicators***. A rapidly growing body of literature suggests that impervious surfaces are a key indicator of urbanization and its impacts on aquatic resources (Brabec *et al*., 2002; Arnold and Gibbons, 1996; Schueler; 1994), although a recent literature review points out that studies on the impacts of impervious cover on wetlands and coastal resources are relatively few (Schueler, 2003). The use of impervious cover as an indicator and basis for land use regulation has been growing. However, lately concerns have been raised that an over-emphasis on limiting imperviousness at the site level may promote low density, large lot development. Other, related indicators have been used in attempts to characterize or measure urban growth patterns or the intensity of "sprawl." These include everything from complex landscape analyses (Wilson *et al*., 2003) to individual landscape features like stream crossings (Booth *et al*., 2003) to socioeconomic measures (Ewing *et al.,* 2003). In the region, the New Hampshire Estuary Program recently completed a report that considers a number of coastal land use indictors (Trowbridge, 2003). Some researchers are investigating other land cover factors, such as the percentage of forest cover, as possible "reverse" indicators of potential watershed health, rather than of impairment
- ***Riparian buffers***. It is becoming generally recognized that riparian zones have high potential to function as nitrogen sinks, because of their position at the interface between terrestrial and aquatic components of the landscape and because they are often dominated by wet, anaerobic soils that support denitrification (Gold *et al.,*2001). However, many uncertainties remain on the temporal and spatial variation of riparian N processing, as well as the ability of buffers to reduce the impacts of other pollutants – including thermal pollution.
- ***Loading models and risk assessment tools***. Pollutant loading models built upon runoff models, and driven in large part by land use information, have come into increasing use across the country. Examples in the Northeast include a nutrient loading model in Waquoit Bay, Massachusetts (Bowen *et al*., 2002) and a sediment contaminant loading model in the mid-Atlantic and Southern New England (Paul *et al*., 2003). The MANAGE model developed at the University of Rhodes Island is a watershed risk-assessment tool that evaluates pollution risks associated with various land use and landscape features. (URI web site). In the Midwest, the *Long-Term Hydrologic Impact Assessment (L-THIA)* model developed at Purdue uses land use and soil characteristics, combined with



thirty years of precipitation data, to determine the average impact that a particular land use change or set of changes will have on both the annual runoff and the average amount of several non-point source pollutants (Bhaduri *et al.*, 2000).

## KEY ASSESSMENT AND MANAGEMENT QUESTIONS

### Key Considerations

"Land use" is a term encompassing a wide range of processes and impacts that overlap with the other major categories of indicators being discussed as part of this effort (diagram, page 2). Thus, a coordinated effort to assess and monitor land use change must be very closely integrated with the other monitoring and assessment efforts being considered under this initiative. In addition, several key issues must be considered:

- *Basic and Applied Research Base*: How far can we extrapolate our modest research base on the links between land use and coastal resource health? What can be done to improve our understanding of such critical topics as the relationship of land use to pollutant loadings, and the effect of nonpoint source "best management practices" on reducing NPS impacts?
- *Scale*: At what scale(s) must land use be monitored and assessed? There is probably a need for both large-scale watershed indicators and finer-scale water body-specific indicators, depending on the management questions to be addressed.
- *Methods*: What technologies are most appropriate, accurate, and feasible to produce regionally comparable data? Advances in remote sensing science and technology have made possible landscape characterizations that were impossible even 5 years ago. What are the trade-offs between resolution, repeatability, and price, and what is the best combination of remote and field monitoring techniques? What can we do to ensure comparable and uniform regional data?
- *End purpose*: Compounding the issue of urbanization and its impacts is the fact that land use is a local issue, decided primarily at the county and municipal level. As such, controlling or influencing land use is not particularly amenable to federal or state laws. A recent report by the General Accounting Office concluded that education, technical assistance and incentives were the most effective means to reduce the air and water quality impacts of land use decisions (U.S. GAO, 2000). Given this fact, what is to be done with the data once collected and interpreted? Who are the primary target audiences for this data, and how can the information be used to help influence land use change and its impacts?

### Key Management Questions

Basic management questions that remain after the key considerations (above) have been considered include:

- What are the type, rate and pattern of land use and land use change?
- What are the broad watershed-scale impacts of these uses and changes?
- What are estimated pollutant loadings to the coast associated with these uses and changes?
- What are the localized biotic and abiotic effects effects of these uses and changes?
- What nonpoint source BMPs are being implemented, and where?
- What are the effects of these BMPs?
- What is the role and relative importance of natural areas (riparian buffers, vegetated landscapes) in preventing and/or ameliorating the impacts of land use change?
- What policies and programs can help to influence land use change and/or reduce the impacts of such change?

## POTENTIAL INDICATORS & ASSESSMENT METHODS

In general, land use monitoring is sporadic and greatly variable. Fine scale monitoring is very labor intensive. Large scale monitoring is primarily dependent on remote sensing technologies that have evolved with time, thus making temporal comparisons of different data sets problematic. Despite these problems, however, the potential is great for the use of remote sensing technology to make regular, relatively inexpensive temporal assessments. USGS, EPA and a consortium of other federal agencies have developed the National Land Cover Data (NLCD) program, which created a nationwide land cover dataset for 1992 and is completing a comparable set for 2000. In the region, the University of Connecticut Center for Land use Education and Research is just completing a four-date RS-based land cover change study covering the period from 1985-2002, and will follow next summer with a similar temporal tracking of impervious cover. The University of New Hampshire Complex Systems Research Center has done impervious surface estimates for the 1990-2000 period for the coastal region of New Hampshire (Justice and Rubin, 2003). In Massachusetts, the Natural Heritage and Endangered Species Program and the UMass Extension Service have completed *BioMap*, which identifies critical habitat and natural buffer areas, and are developing the *Conservation Assessment and Prioritization System* (CAPS), a GIS-driven decision-support system designed to assess the biodiversity value of every location based on natural community-specific models.

Indicators addressing the impacts of land use change include both biological and physical indicators of aquatic health, and physical and social indicators of the degree of watershed development. This concept paper focuses on the latter, since the former are expected to be included in the other topical areas being considered at this conference. For discussion purposes, the potential indicators listed below are broken down into two major scale-dependent categories. "*Overall land use*" refers to broad land use changes from which broad conclusions can be reached, based on our knowledge about the relationship of land use to resource health. "*Specific landscapes*" refers to particular habitat or other resource areas of interest that may require more frequent and/or higher resolution, finer-scale monitoring.

**<u>Overall land use</u>**

- % urban/forest/farm land and changes over time
- % impervious surface and changes over time
- demographic data (population, density, housing starts, etc.)
- pollutant loadings models and coefficients
- type and pattern of urban growth; examples include:
    - acres urban land/capita
    - acres impervious cover/capita
    - total road miles
    - road crossings
    - watershed landscape fragmentation indices
    - "reverse indicators" such as % forest cover, riparian continuity indices

**<u>Specific Landscapes</u>**

- Miles intact stream buffers (how wide?)
- Acres tidal wetland, eelgrass or other critical habitat
- Acres & location of invasive species
- Acres & location of permanently protected natural lands ("open space")
- acres and location of restored habitat
- specific landscape integrity indicators (fragmentation, direct disturbance [fill, hydrologic alterations, etc.], indirect disturbance)

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