ISAT and N-SPECT

GIS Management Tools For Estimating Water Quality Changes

Background

Multi-temporal analyses of land cover change not only document anthropogenic changes, but also can be used to help quantify the impacts of those changes on water quality. However, complex interactions between terrestrial and aquatic systems pose challenges to coastal zone managers who need to understand the relationships between land cover and water quality. The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center developed two geographic information system (GIS) based tools that allow managers to explore these relationships. The Impervious Surface Analysis Tool (ISAT) calculates the percentage of an area covered by impervious surfaces using land cover and population density information. The Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) estimates pollution and erosion within an area using land cover, soils, topography, and precipitation data.

Impervious surfaces impact water quality by preventing infiltration, and increasing mobilization and transport rates from source areas to surface water bodies. The Center for Watershed Protection described the relationship between watershed impervious cover and stream quality (Figure 1). Low impervious surface cover (<10%) is associated with waters that can support aquatic life but remain sensitive to degradation. As impervious surface coverage increases, aquatic life is impacted and, at high percentages of impervious surface cover (>25%), aquatic life is no longer supported. ISAT, which calculates impervious surface cover, adopted this model as a way to interpret the data.

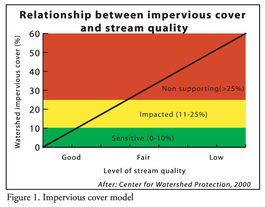


Figure 1. Impervious cover model

Nonpoint source pollution occurs when runoff carries pollutants from land into local waters. The amount of pollution can be related to the land cover from which the runoff occurred. For instance, runoff from agricultural lands may have much higher nutrient concentrations due to fertilizer use. N-SPECT calculates pollution and erosion from land cover, using relationships that can be customized. N-SPECT calculates the total amount of pollution coming from an area and tracks the pollution as it accumulates downstream.

This study used Coastal Change Analysis Program (C-CAP) land cover data from 1990 and 1995 to estimate water quality change in Horry County, South Carolina (Figure 2). The same two land cover data sets were used in ISAT and N-SPECT. The standard land cover classification system employed by C-CAP enables this type of multi-temporal analysis.

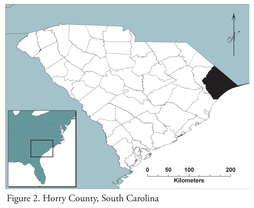


Figure 2. Horry County, South Carolina

Conclusions

By using multi-temporal data and two GIS-based tools, we were able to examine the impacts of land cover change on water quality through time. ISAT provides a general understanding of the impacts of change on water quality. This tool quantifies percent impervious cover within defined areas, which allows managers to detect landscape patterns that will impact water quality. In contrast, N-SPECT provides a more detailed examination of the impacts of change on specific pollutants and sediment loads. In addition, this tool allows managers to detect specific pollutant and sediment source areas. Combined, these two tools reveal landscape attributes that are related to water quality in both space and time.

C-CAP

Coastal Change Analysis Program Land Cover Classification

- Bare Land
- Cultivated Land
- Deciduous Forest
- Estuarine Emergent Wetland
- Estuarine Forested Wetland
- Estuarine Scrub/Shrub Wetland
- Evergreen Forest
- Grassland
- High Intensity Developed
- Low Intensity Developed
- Mixed Forest
- Palustrine Emergent Wetland
- Palustrine Forested Wetland
- Palustrine Scrub/Shrub Wetland
- Scrub/Shrub
- Unclassified
- Unconsolidated Shore
- Water

ISAT

Impervious Surface Analysis Tool

Inputs:
- Classified landcover (C-CAP) 1990 and 1995
- Analysis units (census blocks)
- Population density (census blocks) 1990 and ~1995
- Impervious surface coefficients

Output:
- % Impervious surface cover

N-SPECT

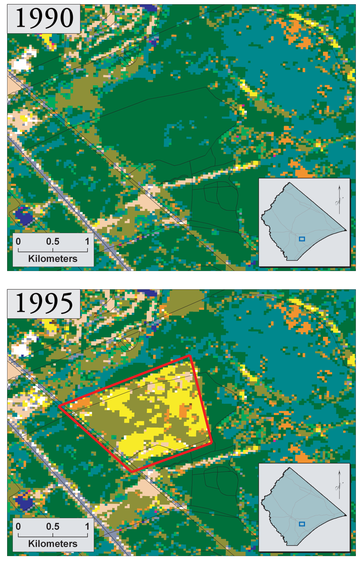
Nonpoint-Source Pollution and Erosion Comparison Tool

Inputs:
- Classified land cover (C-CAP) 1990 and 1995
- Elevation (U.S. Geological Survey)
- Soils (Soil Survey Geographic Database)
- Precipitation (National Weather Service)
- R-factor (U.S. Department of Agriculture)
- Pollutant coefficients

Outputs:
- Runoff volume
- Accumulated pollutants
- Pollutant concentrations
- Accumulated sediment
- Sediment concentration
- Pollutant comparisons to water quality standards

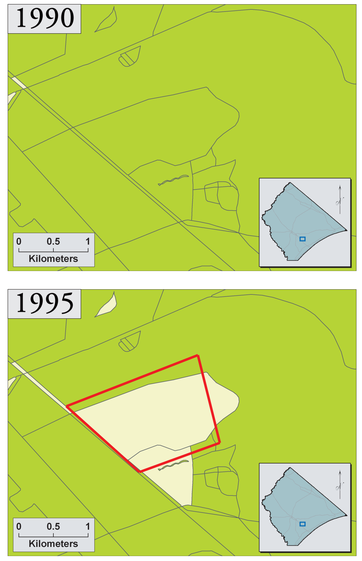
For More Information:
C-CAP: www.csc.noaa.gov/crs/lca/ccap.html
ISAT: www.csc.noaa.gov/crs/cwq/isat.html
N-SPECT: www.csc.noaa.gov/crs/cwq/nspect.html

C-CAP

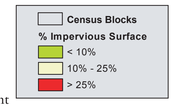


The C-CAP data between Myrtle Beach and Conway, South Carolina show small areas of anthropogenic change. For example, the development of a golf course (red box) is seen in the land cover data as change from evergreen forest to a mixture of bare land, scrub/shrub, and palustrine scrub/shrub wetlands. The effects of this change on impervious surface cover and erosion are shown in the panels to the right.

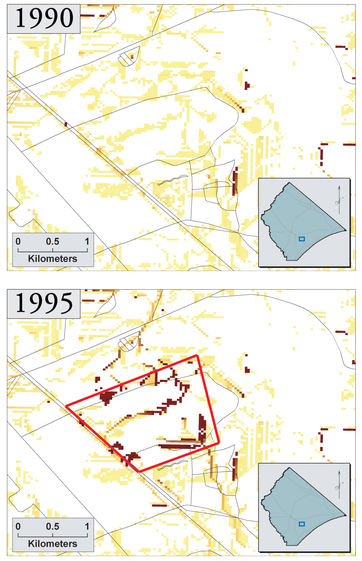
ISAT



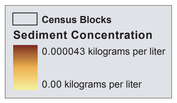
ISAT identified areas in which impervious surface cover increased and water quality was degraded. The impervious surface cover changes resulted from the golf course development and associated land cover changes (red box). In addition, an increase in population density from a small residential development led to increased impervious surface cover in the small triangular area adjacent to the golf course.



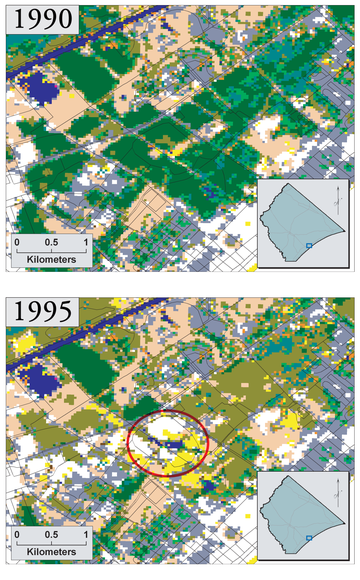
N-SPECT



Average annual sediment concentrations inside the red box shown above increased between 1990 and 1995. The increase was again due to the development of a golf course and the conversion from evergreen forest cover to bare land and scrub/shrub. Average annual sediment accumulations downstream from this site increased about 390 percent.

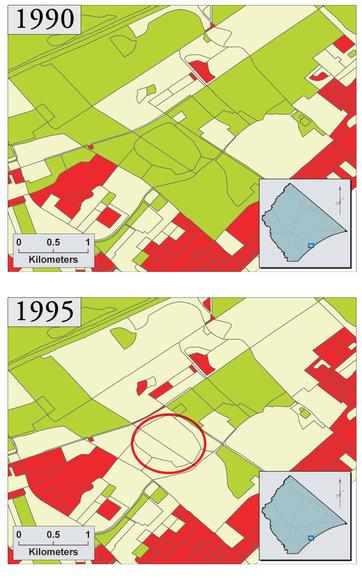


C-CAP

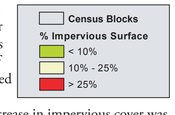


Increasing development in Myrtle Beach, South Carolina is seen in the land cover data as change from evergreen forest and mixed forest classes to a mixture of bare land, scrub/shrub, and high intensity developed classes. The area in the center of the 1995 image above (red oval) was developed into the largest entertainment complex in the state (Broadway at the Beach). The impacts of this change on impervious surface cover and phosphate concentration are shown in the ISAT and N-SPECT columns to the right.

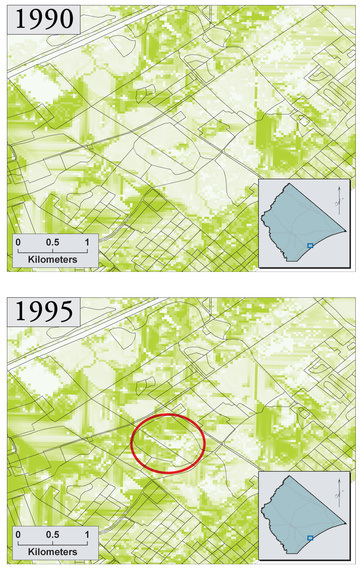
ISAT



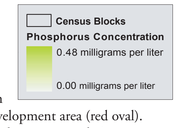
ISAT identified several areas in which impervious surface cover increased and water quality was degraded. In this area, most of the land contributed to degraded water quality (see red oval). While most of the modeled increase in impervious cover was due to changing land cover classes, an increase in population density also contributed to impervious surface cover increases.



N-SPECT



Phosphorus concentrations increased in most of the areas that experienced land cover change. Average annual phosphorus concentrations increased about 260 percent in the Broadway at the Beach development area (red oval). However, average annual phosphorus accumulations downstream from this area reflected a smaller increase of 13 percent due dilution effects.



NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

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