**EPA** United States
Environmental Protection
Agency

# A National Assessment of Change in Green Infrastructure Using Mathematical Morphology

# Internal Report

R E S E A R C H   A N D   D E V E L O P M E N T

# A National Assessment of Change in Green Infrastructure Using Mathematical Morphology

# Internal Report

James Wickham

U.S. Environmental Protection Agency
National Exposure Research Laboratory
Environmental Sciences Division
Landscape Ecology Branch
Research Triangle Park, NC

APM 161 (FY09)

Title: **A national assessment of change in green infrastructure using mathematical morphology**
PI: J. Wickham

*Background*

Green infrastructure is a popular framework for conservation planning.  The main elements of green infrastructure are hubs and links.  Hubs tend to be large areas of natural vegetation and links tend to be linear features (e.g., streams) that connect hubs.  Within the United States, green infrastructure projects can be characterized as: 1) reliant on classical geographic information system (GIS) techniques (e.g., overlay, buffering) for mapping; 2), mainly implemented by states and local jurisdictions, and; 3) static assessments that do not routinely incorporate information on land-cover change.  We used morphological spatial pattern analysis (MSPA) as a complementary way to map green infrastructure, extend the geographic scope to the conterminous United States, and incorporate land-cover change information.  MSPA applies a series of image processing routines to a raster land-cover map to identify hubs, links, and related structural classes of land cover.  We identified approximately 4,000 large ($\geq$ 100 hubs) networks within the conterminous United States, of which 10 percent crossed state boundaries.  We also identified a net loss of up to 1.76 million ha of links and 1.72 million ha of hubs between 1992 and 2001.  Our national assessment provides a backbone that states could use to coordinate their green infrastructure projects, and our incorporation of change illustrates the importance of land-cover dynamics for green infrastructure planning and assessment.
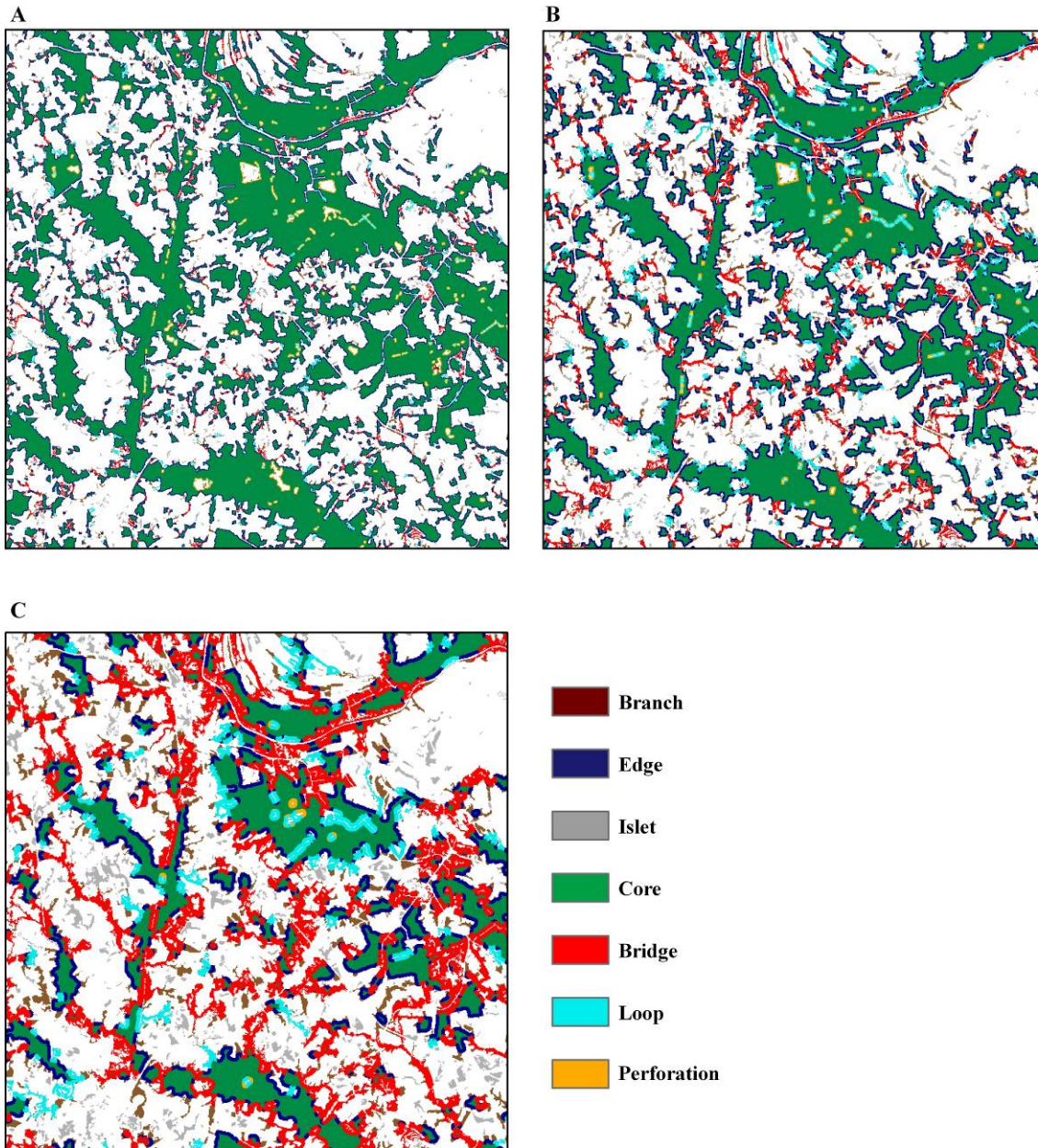
*Clients*

The clients for our green infrastructure work include: 1) ORD Ecosystems Services Research Program, 2) EPA Region III, 3) Landscope, and 4) The Conservation Fund.  Our national green infrastructure maps will constitute one element of the planned national atlas of ecosystem services.  The national atlas of ecosystem services is a research project for the ORD Ecosystem Services Research Program.  EPA Region III initiated development of a green infrastructure community of practice in 2009.  The green infrastructure maps were delivered to EPA Region III colleagues.  The principal investigator also gave an invited presentation on green infrastructure and landscape ecology at the EPA Region III Annual Regional Science Workshop (Annapolis, MD, February 2009).  Landscope (http://www.landscope.org) is an online resource for the public and land-protection community that was developed by NatureServe and the National Geographic Society.  Landscape is posting our green infrastructure products on their website.  The Conservation Fund (http://www.conservationfund.org), a non-governmental organization dedicated to advancing America's land and water legacy, became aware of our green infrastructure products through contact with Landscope, and they too have expressed interest in our work.  An overview of our work was delivered electronically to The Conservation Fund.

*Products*

1) MSPA maps for the conterminous United States for four edge widths and two points in time (ca. 1992 and ca. 2001).  The maps are organized into nine regions.

2) Ecological networks of connected hubs for two edges and two points in time (ca. 1992 and ca. 2001).  The maps are organized into nine regions.

*Examples of products*



A          B

C

Legend:
- **Branch** (dark red)
- **Edge** (dark blue)
- **Islet** (gray)
- **Core** (green)
- **Bridge** (red)
- **Loop** (cyan)
- **Perforation** (orange)

Graphics A, B, and C are examples of the first product, MSPA maps. The maps show changes in MSPA classes based on using different widths, from narrow (A) to wide (C). Core areas (hubs) connected by bridges comprise the second product (networks). Additional GIS processing was applied to the MSPA maps to determine the hubs that were connected by bridges. Networks are not shown, but are easily inferred from the example graphics of MSPA classes shown above.

*Publications and Presentations*

Wickham JD, Riitters KH, Wade TG, Vogt P.  accepted. A national assessment of green infrastructure and change for the conterminous United States using morphological image processing. Landscape and Urban Planning.

Wickham JD. 2009. (invited).  A personal account of landscape ecology and green infrastructure with a view towards future research considerations. EPA Regional Science Workshop, Green Infrastructure: Linking People, Nature, and Landscapes through Sound Science, February 9-11, 2009, Annapolis, MD.

*Supporting Publications*

Wickham JD, Riitters KH, Wade TG, Homer CG.  2008.  Temporal change in fragmentation of continental U.S. Forests.  Landscape Ecology 23:891-898.

Fry JA, Coan MJ, Homer CG, Meyer DK, Wickham JD.  2009.  Completion of the National Land Cover Database (NLCD) 1992-2001 Land Cover Change Retrofit product.  U.S. Geological Survey Open-file Report 2008-1397, Denver, CO.

Vogt P, Riitters KH, Estreguil C, Kozak J, Wade TG, Wickham JD. 2007.  Mapping spatial patterns with morphological image processing.  Landscape Ecology 22:171-177.

**EPA**

United States
Environmental Protection
Agency