Landscape-scale conservation planning

Basic overview of principles and methods

For Appalachian Landscape Conservation Cooperative

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Big problem

- Less than 20% of the terrestrial surface of the planet is in protected status and estimates for adequate coverage of ecosystems that are managed for biodiversity range to 50% and higher

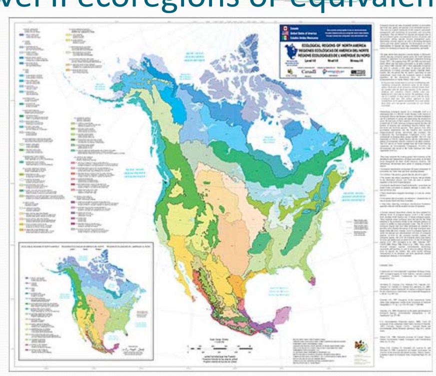
Big goal

- Represent diversity of species, habitats, ecosystems in a system of interconnected reserves that is large and connected enough to support current populations and restore extirpated ones, while providing for ongoing evolutionary processes including response to environmental change

Methods

- Primarily a spatial problem in which data of varying grain sizes are incorporated within one or more modeling environments (e.g., ArcGIS, related software)
- Spatial extent varies by project goals but most typically is ecoregional in scale; in other words a scale that captures variation within a relatively homogeous zone.

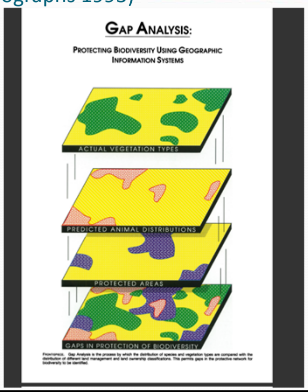
Level II ecoregions or equivalent



Transcending the local

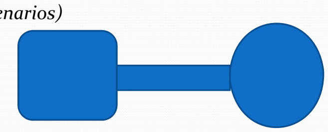
- In some ways, the purpose of landscape-scale conservation is to transcend localized, single species, or purely opportunistic conservation
- Ecoregional approaches to ecology date back a century; new technologies have enabled their incorporation into conservation
- Spatial tools, dating back to GAP Analysis (Scott et al., 1993), are used to integrate the local into larger plans that will in return, provide protections for local processes

The early days of conservation planning (classic paper in Wildlife Monographs 1993)

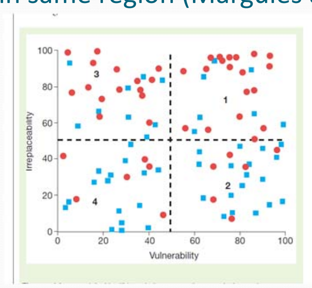


Recent thinking and methodologies are highly systematic making use of spatial models, complex software, and mapped data at multiple scales

- Recent books and numerous articles (see selection at end of presentation)
- Three primary tasks:
  - **Representation**: *core reserves*
  - **Connectivity**: *gene flow, migration, and climate response*
  - **Threat assessment**: *mapped and modeled threats (often scenarios)*



Primary goal is to ***prioritize*** areas for conservation action, relative to other areas in same region (Margules and Pressey 2000)



- 100 potential conservation areas in a region
- Red are selected as potential sites that meet some conservation goals
- Blue are potential replacements
- Quadrat location suggests level of threat/urgency/vulnerability and relative value/irreplaceability
- Locations in graph will change through time with added protection status and threat

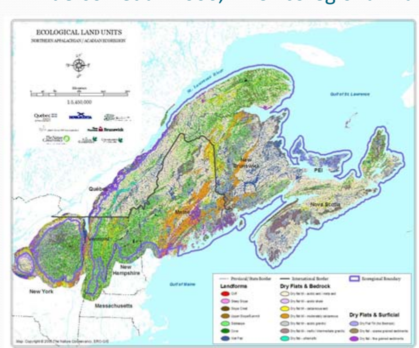
Methods

- Representation
  - The goal of representation is to have a reserve system that incorporates the diversity of the region at a level that it can be maintained through time
    - Not only species diversity, but diversity of land forms and ecosystems so as to preserve the *stage* for evolutionary responses to change
      - *We don't assume a static landscape*
        - Part of diversity is maintenance of natural disturbance

Data

- Grain size and extent are major issues in spatial data for conservation planning
- Lacking fine-scale data of a suitable extents as well as uncertainty over the future, has lead to coarse filter planning
  - Biodiversity surrogates
    - Geophysical diversity
      - Ecological Land Units (ELU)
      - Land Facets

ELUs from the Northern Appalachian/Acadian ecoregion – Anderson et al. 2006, TNC Ecoregional Plan



- Elevation
- Bedrock
- Surficial geology
- Moisture
- Landform

Data used in conservation planning

- Species distribution data
- Mapped ecosystems
  - Riparian areas, alpine zones, large bogs, etc.
- Topographical data, land forms
  - Ecological Land Units
  - Land Facets
- Threats, modeled and real
  - Roads, development, mines, etc.
  - Ambient conditions
    - Climate

Modeling tools – Representation in core reserves

- Reserve selection
  - MARXAN
  - MARXAN with Zones
  - Design clumped reserve systems that make sense to the planner (Ball et al. 2009 in Moilanen et al.)

A feature of all of these programs is that they have user-driven targets (what we want to conserve) and goals (how much we want to conserve) and these are ideal avenues for involving stakeholders from the beginning of a planning process

Note: use of terms "target" and "goal" varies in the literature! Sometimes "targets" are simply called "feature types".

Example of MARXAN reserve selection outputs for the Northern Appalachian/Acadian Ecoregion (Trombulak et al. 2008, 2C1Forest)

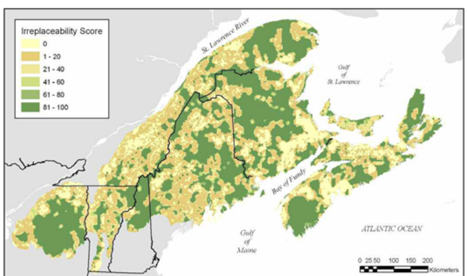
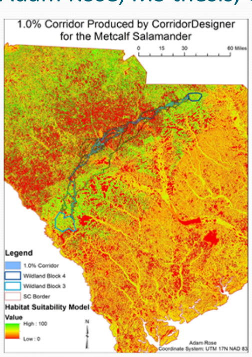


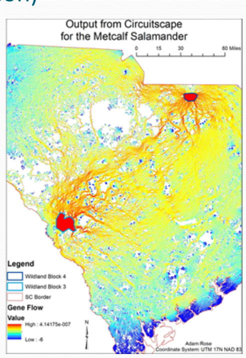
Figure 5.4. *Irreplaceability of planning units under the medium target scenario.*

Modeling tools – Connectivity

- Connectivity
  - Least Cost Path– *CorridorDesigner*
  - Circuit Theory– *Circuitscape*
  - Centrality – *Connectivity Analysis Toolkit*
  - *Linkage Mapper*

Single species LCP comparison with Circuitscape (Adam Rose, MS thesis, Clemson)





Modeling tools – Climate corridors

- Land Facets (example from Beier and Brost 2010)

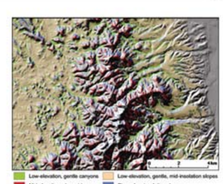


Figure 2. Illustration of the geographic distribution of land facets, defined on the basis of elevation, slope, insolation, and topographic position, draped over a hillshade map. For clarity, not all land facets in the landscape are shown.

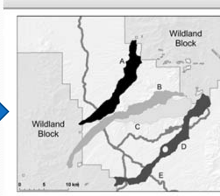
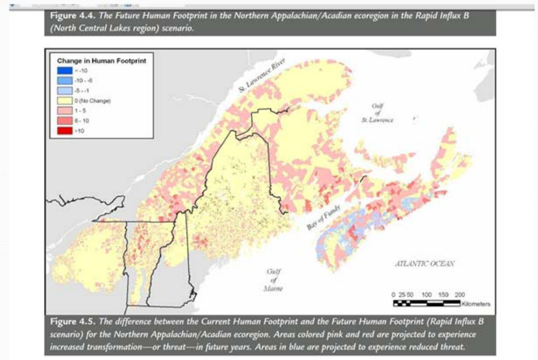


Figure 5. A multistranded linkage of land facets designed to allow species to shift their range in response to climate change and to support movement during periods of quasi equilibrium. Area A optimizes continuity for high local diversity of land facets. Other areas provide the best continuity of high-insolation, steep slopes (area B), low-elevation, gentle canyons (area C), and low-elevation, gentle ridges (area D). Area E encompasses the region's main river and its only perennial tributaries from each wildland block.

Modeling threats: quantitative measures of degree of influence or naturalness in any grid cell

- Current and future land use change
- "Natural landscape integrity" (Theobald 2010)
- "Human Footprint" (Sanderson et al. 2002; Woolmer et al. 2008)
- Such maps can produce the "x" axis of the irreplaceability-vulnerability matrix

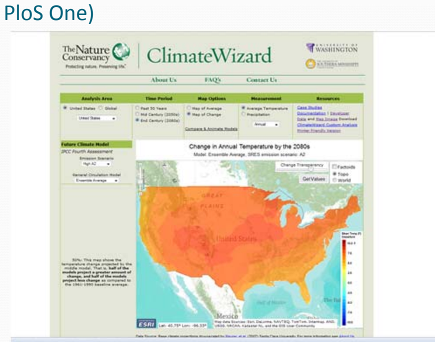
Example: modeled "Future Human Footprint" scenario; degree of change expected from current



Climate change is a bit different

- Usually used in "bioclimatic envelope models" to anticipate shifts in species' ranges
- Currently coarse scale
- Being downscaled in many regions and localities
- ***Need to consider climate-land use interactions!***

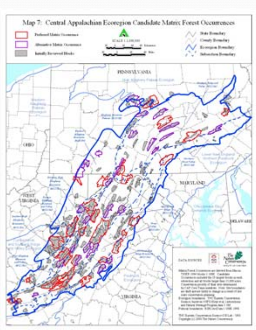
Some accessible climate change tools and datasets are coming online, for conservation planning (Girvetz et al. 2009 PloS One)



Related conservation planning approaches are in play and some are quite effective and backed by organizations capable of implementing conservation plans

- The Nature Conservancy Ecoregional Assessments
  - Northern and Central Appalachians completed
  - Southern Appalachians underway

This approach uses many of the same principles and data, if not the same software and algorithms. Sometimes used in concert with MARXAN



Stakeholder involvement is critical

- Nested groups of stakeholders involved in range of activities from parameterizing models (e.g., setting targets and goals using expert opinion) to identifying potential conservation opportunities and drawing actual reserve/corridor boundaries

What comes after planning?

After planning comes the design phase; after design comes implementation

- *Stakeholders in design and implementation will include conservation groups with active programs in the region, agencies, municipal and county land use planners, local and regional land trusts*

Stakeholders (in this instance, regional conservation professionals) examining MARXAN outputs in Northern Appalachian/Acadian Ecoregion 2007

Selected Resources

- Books
  - Moilanen, A., K.A. Wilson, H.P. Possingham, eds 2009. Spatial Conservation Priorization: Quantitative Methods and Computational Tools. Oxford.
  - Trombulak, S. and R. Baldwin, eds. 2010. Landscape-scale Conservation Planning. Springer.
- Foundational articles
  - Margules CR, Pressey RL (2000) Systematic conservation planning. Nature 405:243-253
  - Groves C et al. (2002) Planning for biodiversity conservation: putting conservation science into practice. Bioscience 52:499-512
  - Carroll C, Noss RF, Paquet PC, Schumaker NH (2003) Use of population viability analysis and reserve selection algorithms in regional conservation plans. Ecological Applications 13:1771-1789
  - Beier P, Majka DR, Spencer WD (2008) Forks in the road: choices in procedures for designing wildland linkages. Conservation Biology 22:836-851
  - McRae BH, Dickson BG, Keitt TH, Shah VB (2008) Using circuit theory to model connectivity in ecology, evolution, and conservation. Ecology 89:2712-2724
  - Beier P, Brost B (2010) Use of land facets to plan for climate change: conserving the arenas, not the actors. Conservation Biology 24:701-710
  - Anderson MG, Ferree CE (2010) Conserving the stage: climate change and the geophysical underpinnings of species diversity. PloS One 5:e11554
  - Beier P, Spencer WD, Baldwin RF, McRae BH (2011) Toward best practices for developing regional connectivity maps. Conservation Biology 25:879-892

Selected Resources

- Websites
  - http://corridordesign.org/
  - http://www.uq.edu.au/marxan/
  - http://www.circuitscape.org/Circuitscape/Welcome.html
  - http://www.natureserve.org/prodServices/vista/overview.jsp
  - http://conserveonline.org/workspaces/ecs/napaj/nap