Framework for Valuing Environmental Services in the Hudson and Delaware Estuaries

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1. Purpose

Use InVEST models to inform decision-making for optimal navigational dredging practices in two estuaries, accounting for the impact on ecosystem services.

2. Background

The Delaware and Hudson Estuaries have been heavily modified by humans since Colonial times. A main source of modification is navigational dredging to enhance shipping to major ports like Philadelphia and New York. In addition to direct economic benefits, dredging also alters the provision of environmental services. We aim to describe and quantify changes to environmental services from these dredging activities, and weigh them against the benefits of enhanced navigation in order to facilitate sustainable and ecosystem-wide decision-making.

3. Conceptual Approach

1. **Identify** all relevant ecosystem services
2. **Describe** possible scenarios for future dredging schedules
3. **Collaborate** with natural scientists to build and run physical/chemical models of estuary system under different dredging scenarios
4. **Run InVEST** with results from physical models to calculate change in value for each environmental service
5. **Sum and Compare** values of ecosystem services with that of changed navigation for each dredging scenario

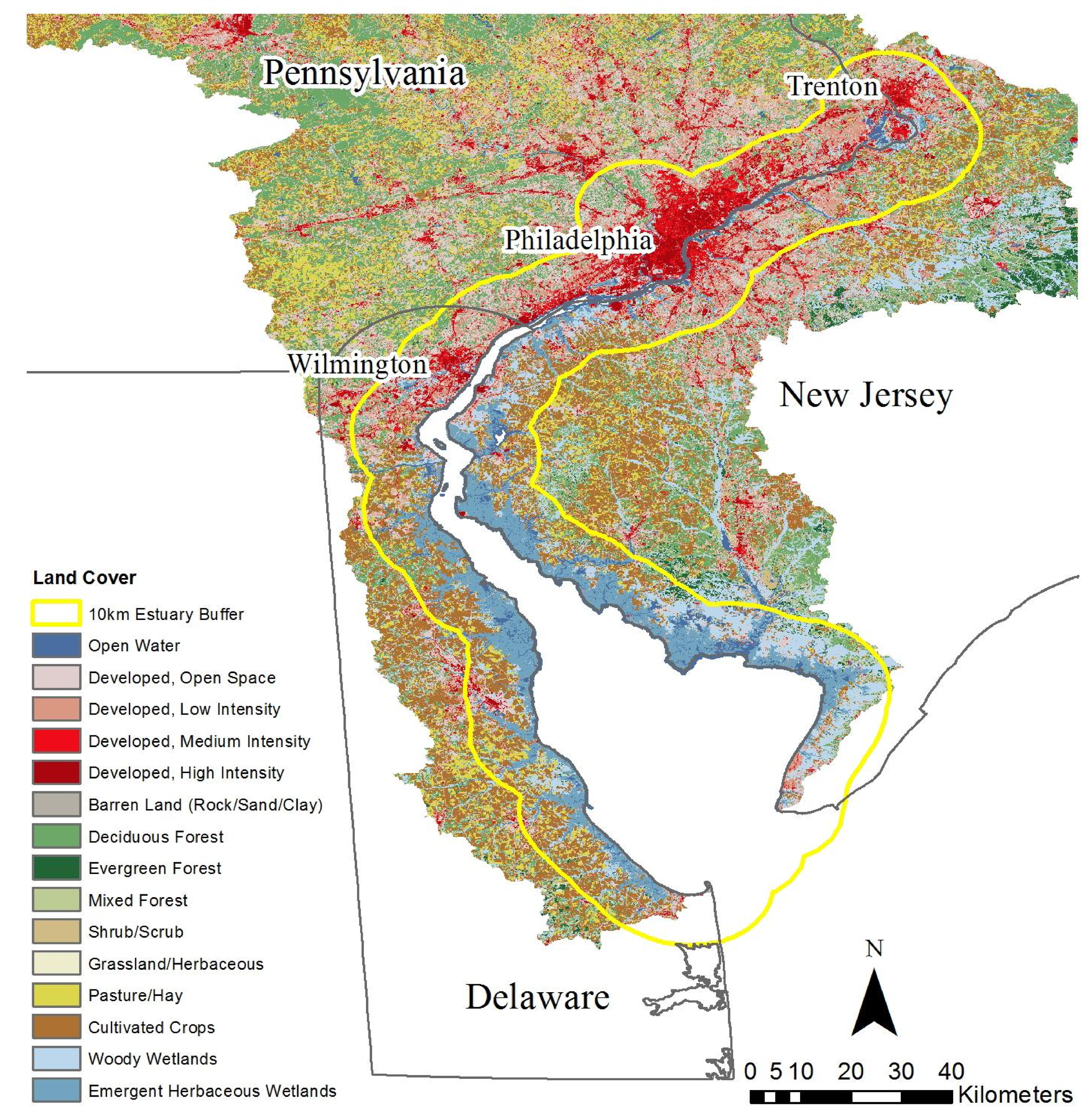
5a. Methods: Carbon Storage

1. Clip National Land Cover Data (NLCD) rasters from 2001 and 2006 to the Delaware River watershed within 10km of the Delaware Estuary shoreline
2. Identify literature values for carbon biomass storage in wetlands and forests
3. Calculate sequestration due to land cover changes using the InVEST Carbon module
4. Generate economic value of sequestration using a value of carbon of $43/tonne and discount rate of 3% (Tol et al. 2009)

As shown in the results table, wetlands within 10km of the Delaware estuary covered 1250km^2 in 2001 compared with 1240km^2 in 2006. A similar study using InVEST by Flight et al. (2012) suggests that this decline is a result of land use change and urban growth. Accurate characterization of future changes in wetland area due to dredging will be a central component of our study. As shown, a 0.8% reduction in wetland area between 2001 and 2006 resulted in a loss of over $9.5 million in carbon sequestration. Given these results we anticipate that dredging mediated changes in wetland area and associated carbon sequestration will be a significant component of total ecosystem value.

5b. Land Cover for Carbon Analysis

Land Cover in the Lower Delaware Watershed



4. Ecosystem Services Identified

Human Use (Benefit)	Ecosystem Services	Ecosystem Services Function (Description)
Transport	Channel depth/width	Provides a low-cost mode for the shipment of economic goods
Drinking Water	Water supply	Provides a source of low-salinity, low-sediment freshwater
Waste Disposal	Waste sink	Physical, chemical, or biological processes flush, dilute, assimilate, breakdown, or sequester anthropogenic effluents
Carbon Sequestration	Carbon storage	Above- and underground biomass in wetlands, intertidal, and submerged lands stores fixed carbon
Cooling Water	Water supply	Provide water quantity/quality for industrial processes and power plants
Recreation	Places to work or play	Beaches, open water, and wetlands provide both a physical environment for recreation and habitat for fauna and flora valued by humans
Storm Protection	Shoreline areas that are protected from or resilient to flooding and erosion	Wetlands and beach-dune systems serve as physical barriers to floodwater inundation and land erosion; wetlands absorb excess stormwater
Commercial Fishing	Fish stocks	Increased wetland area provides nursery and refuge habitat for variety of aquatic species, preserving biodiversity
Spoil Recovery or Deposition	Raw materials	Amending beach/intertidal/wetland area, provide raw materials for construction
Biodiversity	Ecosystem robustness/ adaptability; genetic resources	Biological complexity contributes to robust ecosystems. Biological material is used for medical and research purposes
Aesthetic/Cultural	Aesthetic, Cultural, Artistic, Educational, Spiritual, and Historic	Supplies of clean water, undisturbed landscapes, ways of life, spiritual connections to undeveloped land and native species have local importance
Non-use	All of the above	Passive values attributed to the components of the estuary

5c. Results

Land Cover	Woody Wetlands	Herbaceous Wetlands	Sum	Carbon Storage (TonneC)	Net Present Value (USD)
2001 Area (km^2)	570	680	1250	28,160,001	
2006 Area (km^2)	570	670	1240	27,864,259	
Change in Area (km^2)	0	-10	-10	-235,659	**-9,560,010** ($43/tC) **-35,029,706** ($43/tCO2)

Woody wetland biomass: 54.9 MgC/ha Bridgham et al. (2006); Herbaceous wetland biomass to a depth of 1m: 370 MgC/ha Chmura et al. (2006)

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Images:

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