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Advances in Ecosystem Service Valuation and Implications for Wetland Management

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natural capital PROJECT

Why Measure Ecosystem Service Values?

- Ecosystems provide a wide array of goods and services of value to people
  - Climate regulation
  - Water supply
  - Water purification
  - Flood protection
  - Food and fiber production
  - Recreational opportunities
  - Aesthetic and cultural values
  - Biodiversity

- These values are often not accounted for in decision-making

Why Measure Ecosystem Service Values?

- Measuring the value of ecosystem services provides signal of true costs and benefits of alternative decisions

- Measurement is a necessary precursor to "mainstreaming"
  - Factor ecosystem services into everyday decisions by individuals, businesses and governments

The Rise of Ecosystem Services

- Call by ecologist to properly account for nature's contributions to human well-being

  - Ehrlich and Mooney. 1983. Extinction, substitution, ecosystem services. *BioScience* 33: 248-254
  - Daily. 1997. *Nature's services*
  - Costanza et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260

  - Historically- LA Dept. of Conservation estimated the value of fishing and fur trapping attributable to wetland areas to be $20 million in 1926

ECOSYSTEMS AND HUMAN WELL-BEING

Synthesis

MILLENNIUM ECOSYSTEM ASSESSMENT

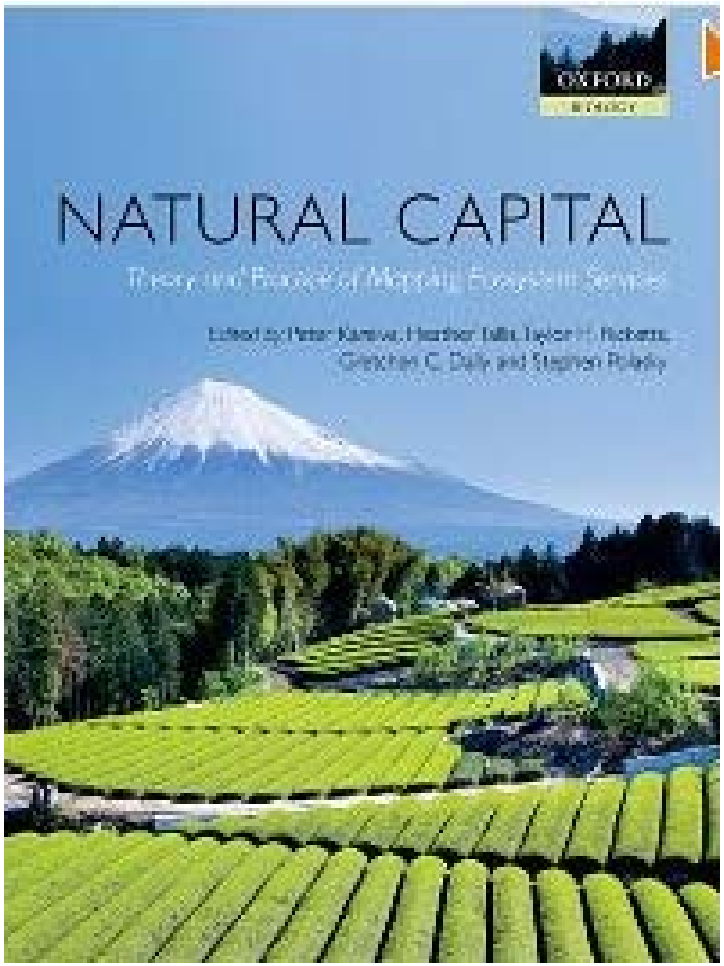
The Millennium Ecosystem Assessment (2005)

Ecosystems and biodiversity are essential for human well-being

Ecosystem services as a central organizing principle

Important Recent Developments

- Variety of names:
  - Natural capital
  - Value of ecosystem services
  - Green economy
  - Green accounting/ green GDP
  - Inclusive wealth
  - Full-cost accounting
- Other recent studies:
  - NRC (2005). Valuing Ecosystem Services: Towards Better Environmental Decision-making
  - US EPA Science Advisory Board (2009). Valuing the Protection of Ecosystems and Services
  - The Economics of Ecosystems and Biodiversity (TEEB; 2010)
  - Kareiva et al. (2011). *Natural Capital.*
  - UK National Ecosystem Assessment (2011)



Key Challenges

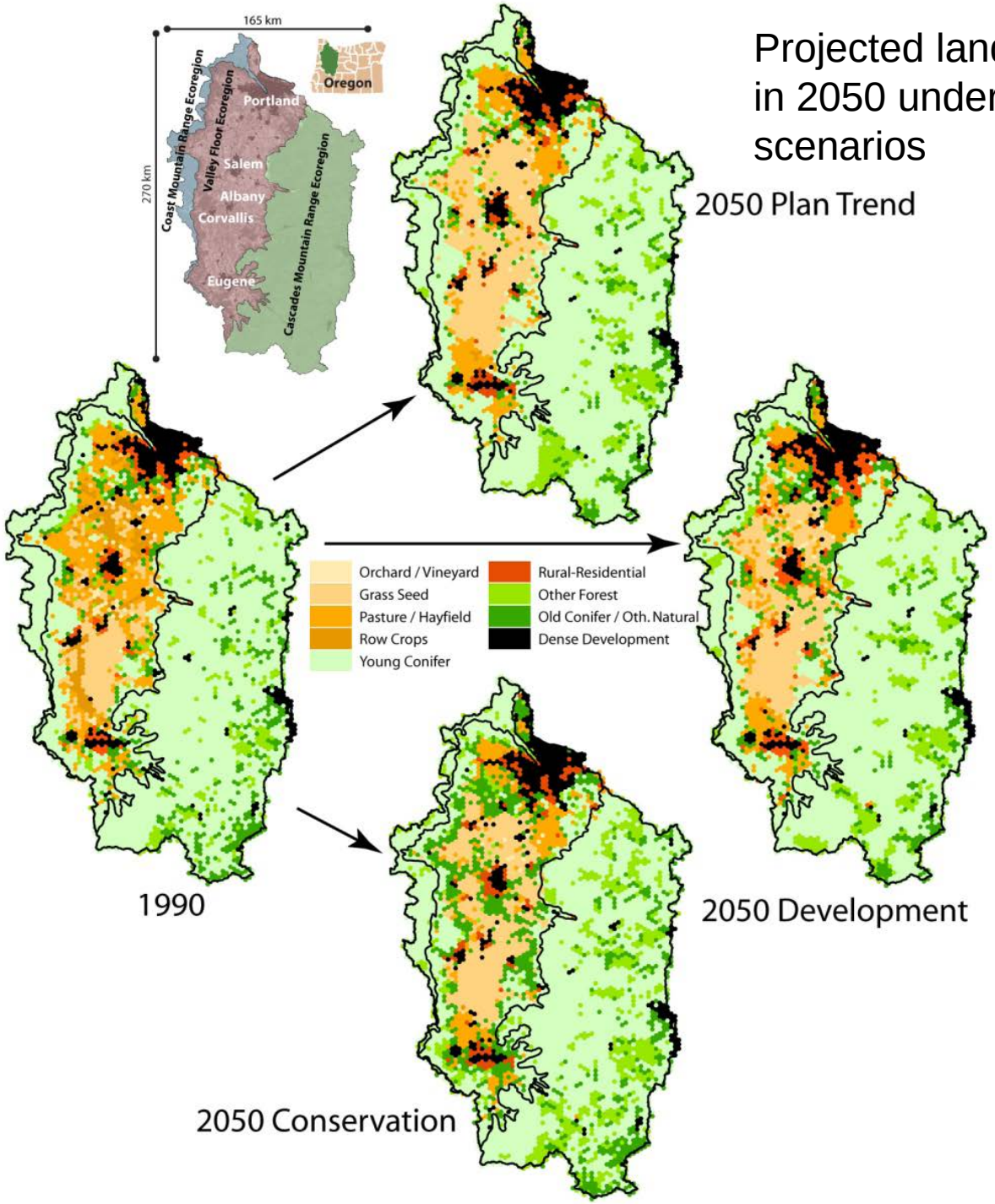
"The fundamental challenge of valuing ecosystem services lies in providing an explicit description and adequate assessment of the links between the structures and functions of natural systems, the benefits derived by humanity, and their subsequent values." (NRC 2005)

- Many inputs/outputs
- Spatial and temporal variation
- Complex biophysical relationships
- Translation to economically relevant ecosystem changes
- Consistency with ecological and economic principles/theory

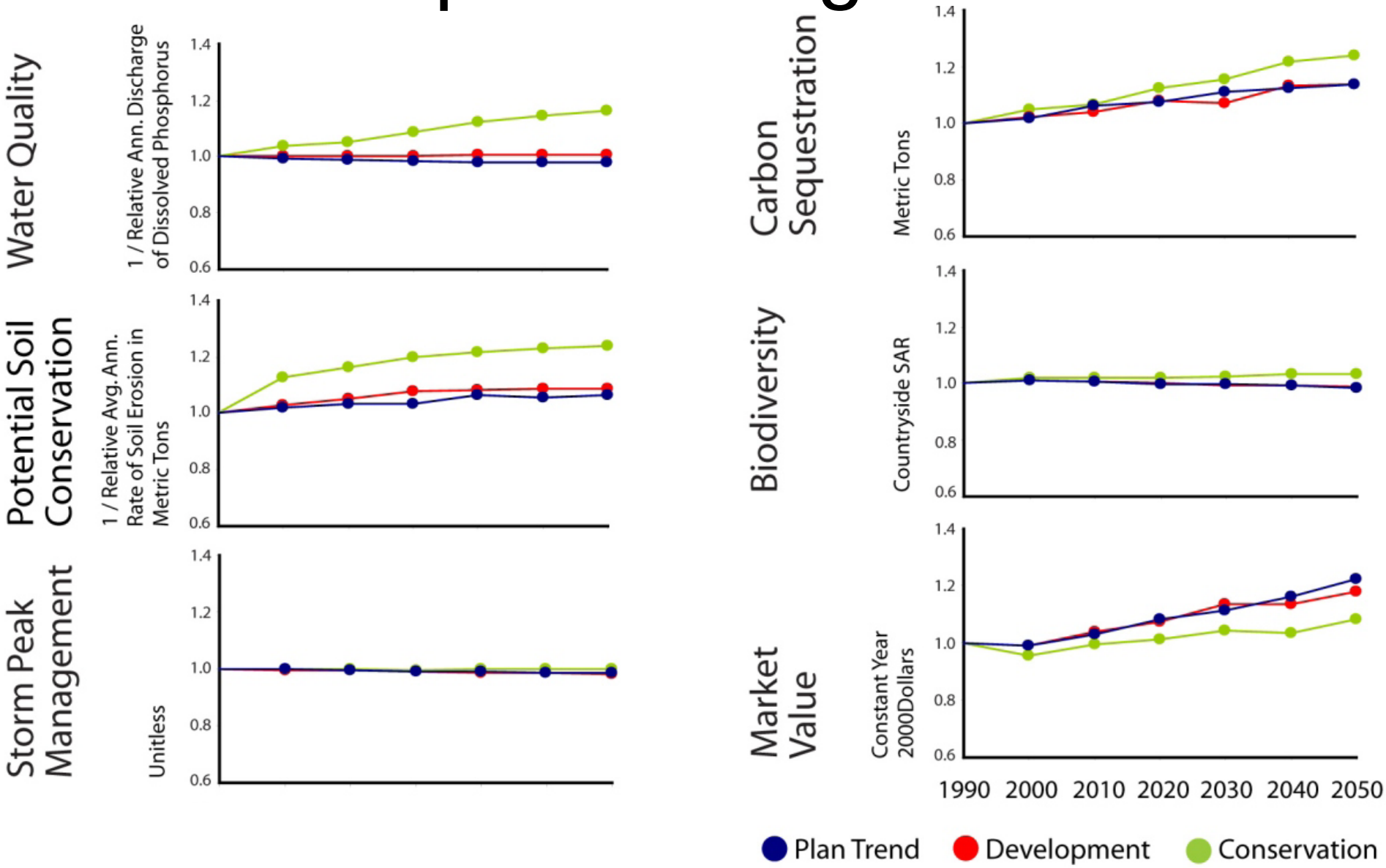
InVEST Approach

- Integrated Valuation of Ecosystem Services and Tradeoffs
  - Series of open-source GIS models
  - Multiple services
  - Spatially explicit
  - Site-specific biological/physical data
  - Driven by policy-relevant scenarios
  - Biophysical and economic endpoints

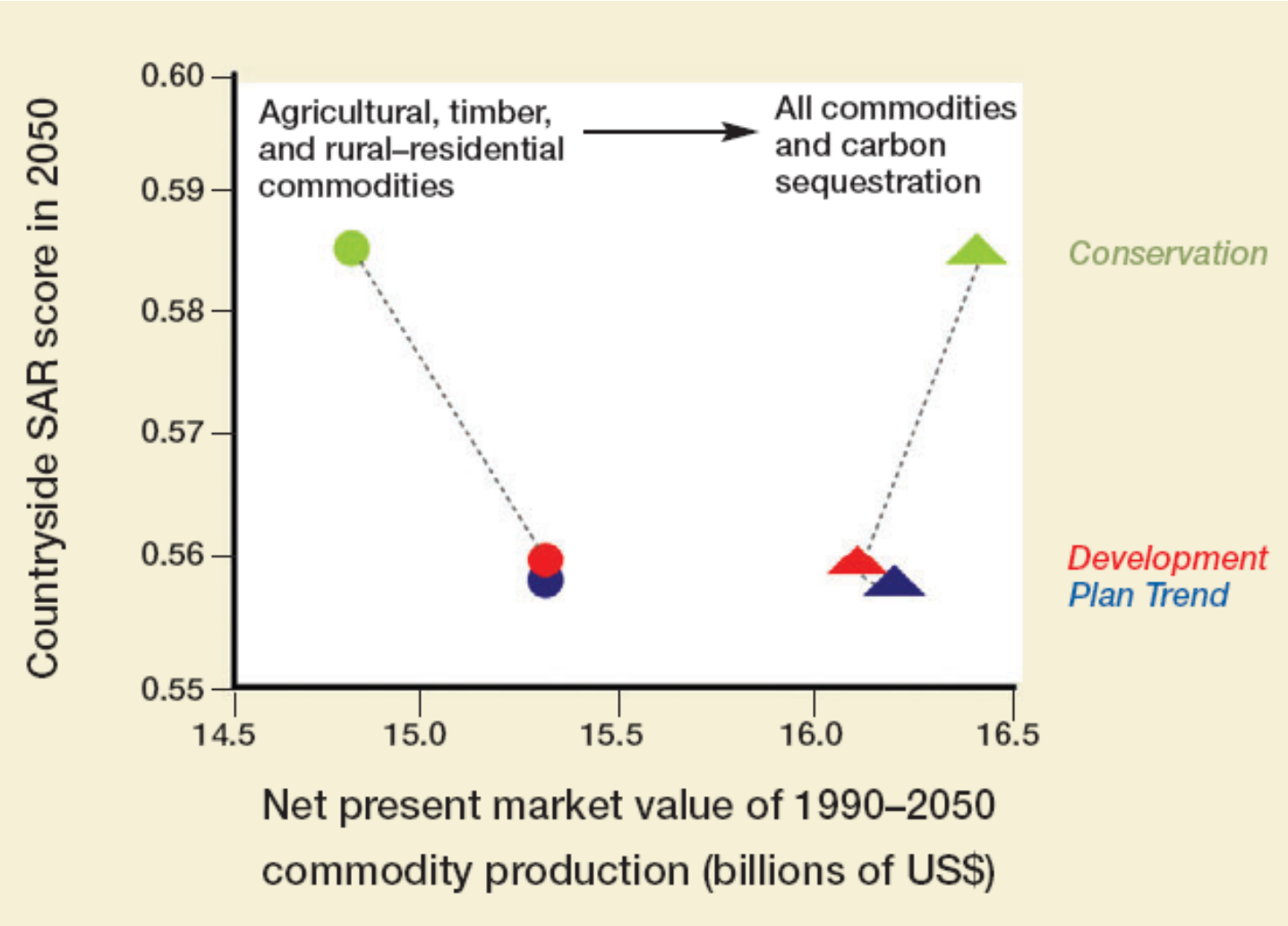
Projected land use change in 2050 under the three scenarios



Outputs through time



Ranking of scenarios depends on set of ecosystem services considered

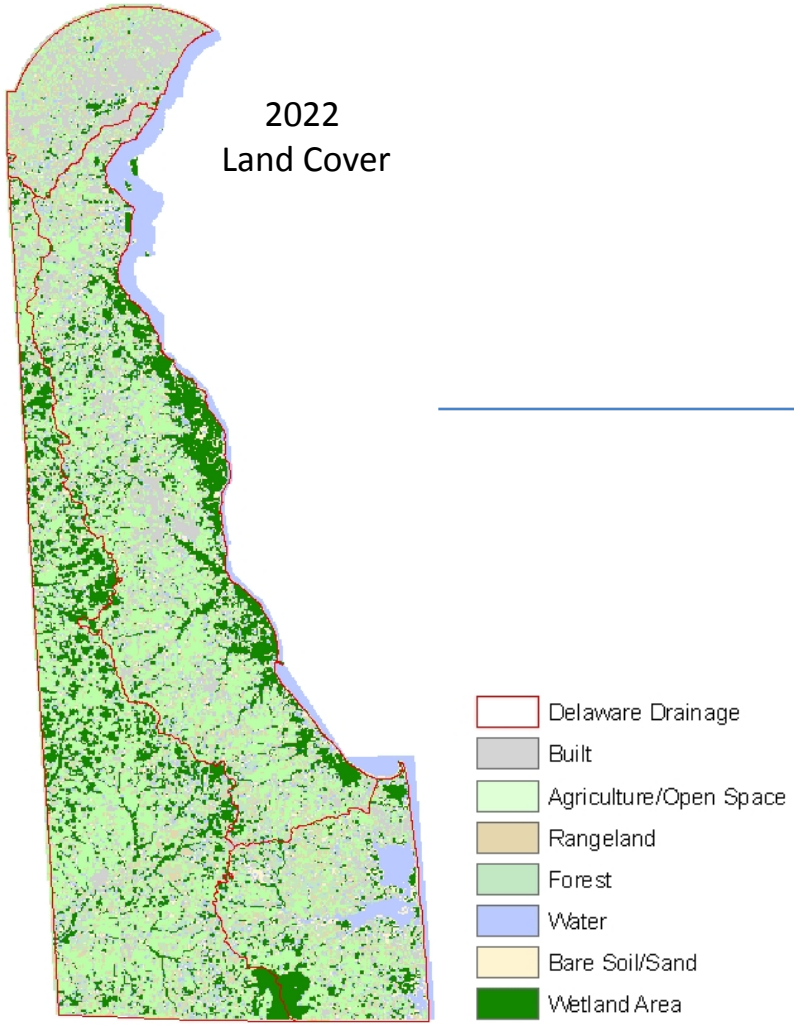


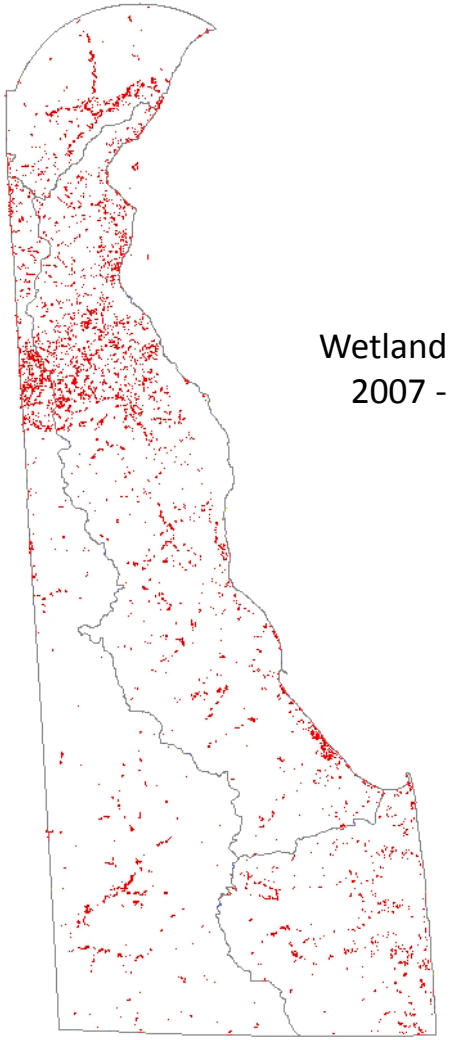
Applications of InVEST

Delaware Study

- Baseline is current statewide land-use/land cover
- Identify past trends in wetland loss/conversion
  - Type, location, rate, 1992 to 2007
- Project trends through 2022- for illustrative purposes this represents “no additional protection” alternative
- Apply InVEST framework to measure resultant changes in ecosystem services and economic implications

Wetland Losses under “No Protection” Scenario

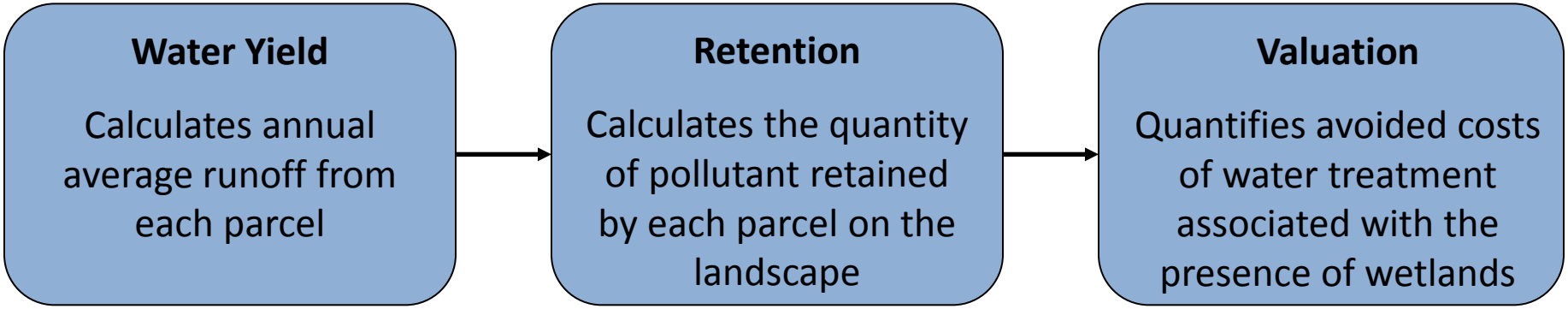




SERVICE	BIOPHYSICAL CHANGE	ECONOMIC VALUE
Carbon Storage:	Tons of C Stored	Social Cost of C
Water Purification:	N and P Loading Sediment Loading	Avoided Treatment Costs
Biodiversity:	Level of Habitat Threat	
Flood Control:	Storm Peak Coastal Storm Surge	Avoided Damages (Land and Property Values)

Water Purification Models

- Purpose: Calculate the change in nutrients and sediment retained and exported to waterways across landscape to determine a change in water quality associated with wetland losses



- Draws on information/data on terrain, precipitation, soil and vegetation characteristics from DNREC, USGS, NRCS, DEOS and published literature

Water Purification: Results by Drainage

Drainages	% Change in N	% Change in P	% Change in Sediment	Total Value Lost 2007-2022 (PV, 3%)
Piedmont	1.5%	1.2%	0.9%	$1,140,000
Delaware Bay	1.9%	1.4%	2.5%	$4,310,000
Chesapeake Bay	0.8%	0.6%	0.7%	$2,830,000
Inland Bays	0.8%	0.4%	0.9%	$1,380,000
Statewide	**1.2%**	**0.9%**	**1.3%**	**$9,670,000**

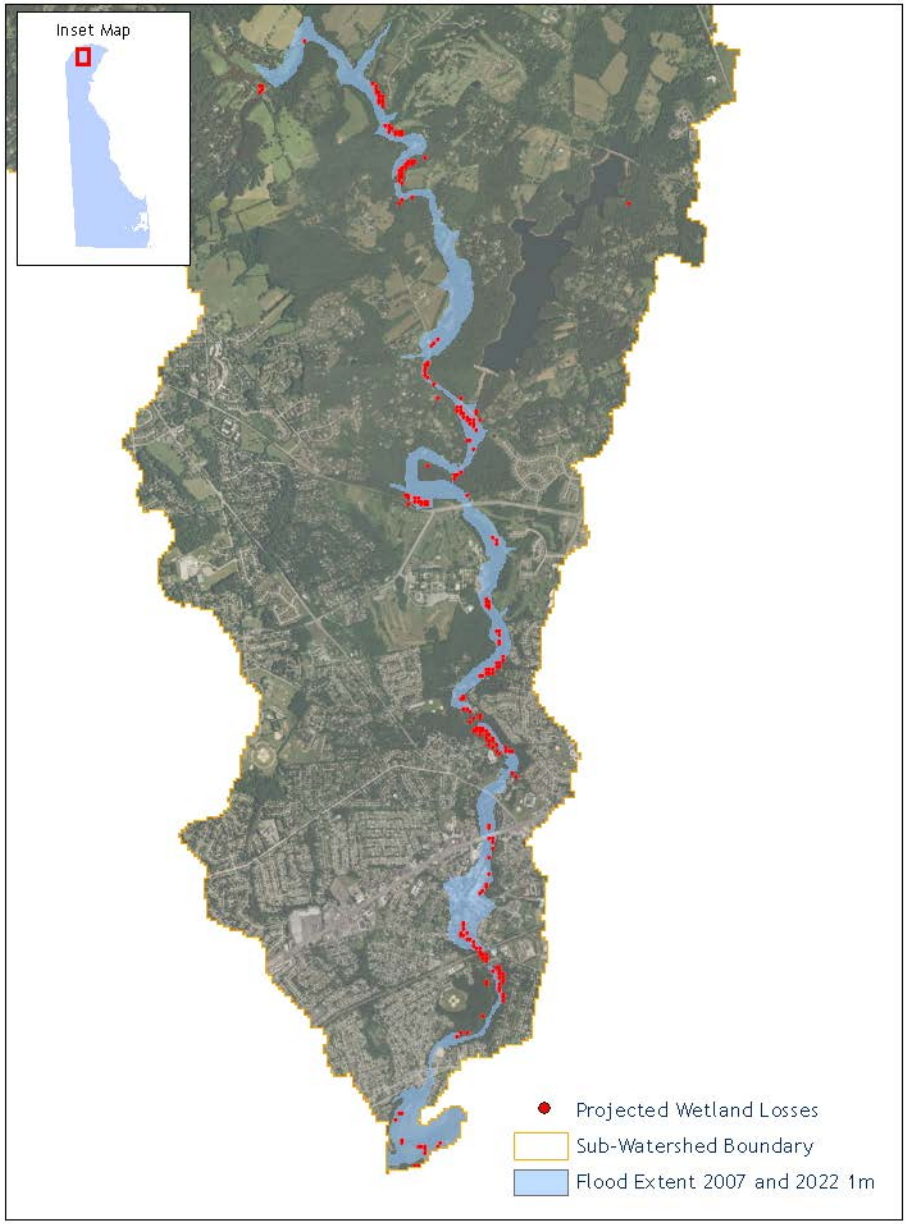
Flood Protection Model

- Purpose: Estimate changes in flood areas and flood heights for a given storm due to wetland loss

- Data/information:
  - Storm depth associated with rainfall events
  - Wetland depth
  - Land cover specific velocity (roughness coefficients) and curve numbers to estimate runoff
  - Estimates of damages associated with increased flood heights (e.g., houses, cropland)

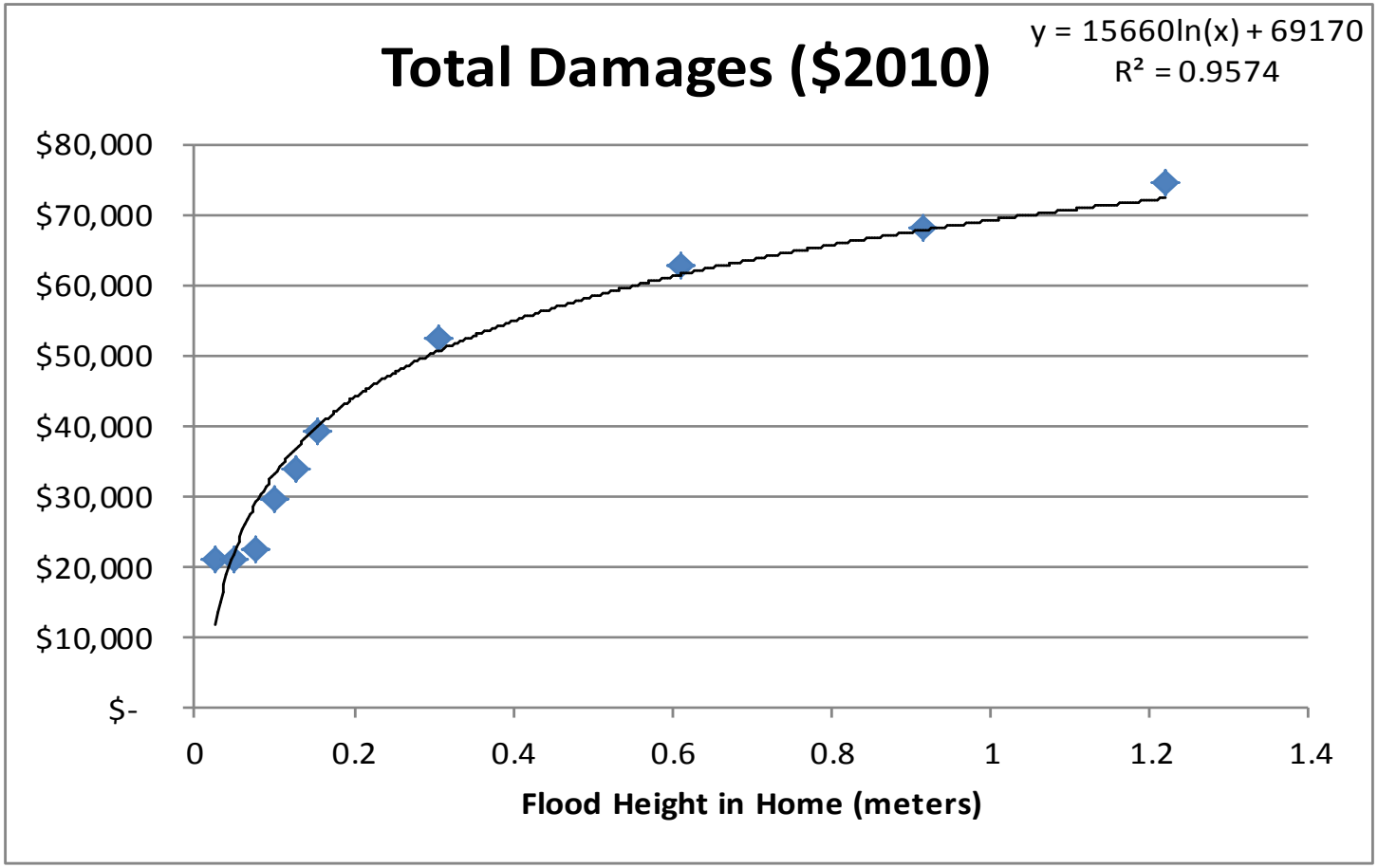
Case Study Approach

- Four sites
- Incremental flooding overlapped residential development in Red Clay Creek Watershed



Damage as a Function of Flood Height

- FEMA NFIP data on total damages associated with various flood levels in 2,000 homes



Inland Flooding: Results

- Value of incremental flooding damages due to wetland loss associated with a 25 year storm event at Red Clay Creek

	LOW	HIGH
Increased Impact of 25 year Event	$2,860	$84,470

- Range based on assumptions regarding wetland depth, number of flooded homes, and foundation height of homes

Coastal Storm Protection Model

- Purpose: Estimate change in coastal flooding associated with storm event due to wetland loss
- Data/information:
  - Baseline coastal flood area and flood heights
  - Wetland storm surge attenuation rate
  - Estimates of damages to houses associated with varying flood heights

Coastal Storm Protection Model

- Utilized DNREC's map of coastal floods associated with varying SLR scenarios as approximation
- Applied MHHW plus 1.5 meter water height scenario as a proxy for coastal flooding following a storm event (comparable in inland inundation levels with annual coastal storm events recorded by DEOS)
- Assume a marginal surge attenuation rate of 1 m per 13 km (from literature)

Coastal Surge Protection: Results by Drainage

Drainages	Total Value Lost 2007-2022 (PV, 3%)
Delaware Bay	$7,340 - $116,000
Inland Bays	$40,300 - $185,000
Statewide	**$47,600 - $301,000**

- Same valuation method as inland flood example. Range based on assumptions regarding number of flooded homes, and foundation height of homes.
- Assume equal probability of a storm event each year

Use of Information

- Information on wetland ecosystem service values can enhance resource management efforts
- Site and context-specific
  - Establishing conservation goals
  - Evaluating permitting decisions
  - Measuring natural resource damages (for purposes of seeking compensation)
  - Setting restoration priorities

Conclusions

- Wetland ecosystems provide valuable services in the form of flood protection and water quality, among others
- The value of these services to the public is not readily apparent or widely appreciated
- Economic information is a means to communicate values and influence decision-making

- However, it must be credible from both an ecological and economic standpoint (and integrated) to be effective