

Presentation given at the Marine Katoomba meeting

**Katoomba XVI:  
Building a Blueprint to Harness New Investment for the Protection  
of Marine and Coastal Ecosystem Services**

February 9-10, 2010  
Moore Foundation, Palo Alto, CA

Hosted by the Katoomba Group



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# Marine ecosystem services: management, metrics, markets?





# Using ecosystem services to inform natural resource decisions in the ocean

- 1) Decision & governance context
- 2) Measuring changes in ecosystem services
- 3) Implications for market development?

Making explicit connections between human activities in one sector and impacts on other things people care about can improve decision-making

Time is ripe for this kind of work (e.g. support for EBM, U.S. Ocean Policy Task Force, MCAs)



# Assessments of Ecosystem Services



## GLOBAL, SYNTHETIC:

60% of global ES in decline (MA)

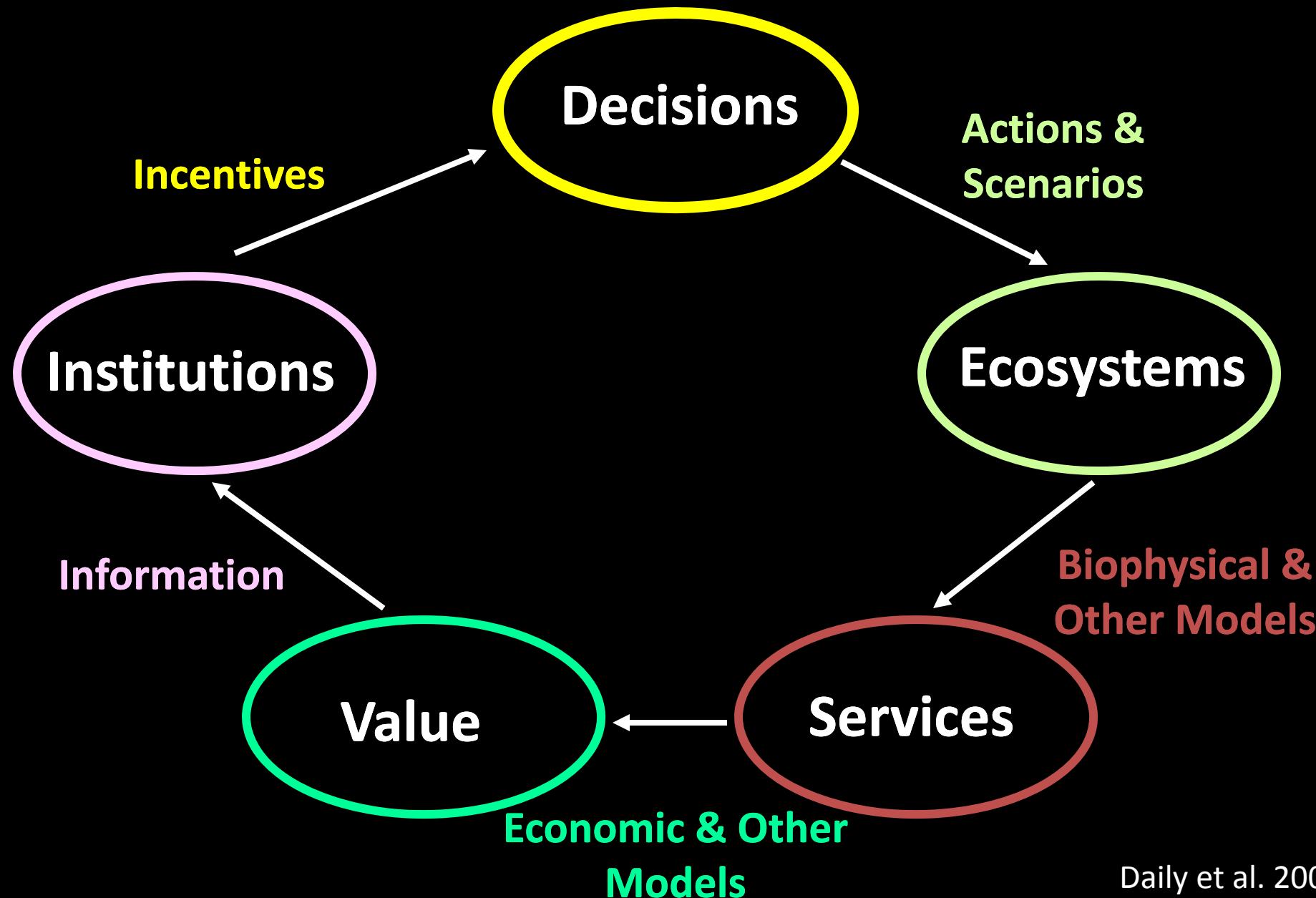
## NEEDED:

- region/landscape scale
  - spatially explicit
  - multiple services

## LOCAL, SPECIFIC:

2 forest patches: \$60K/year for pollination of nearby coffee plantations (Ricketts et al. 2004. PNAS); also mangroves





Daily et al. 2009

# Changes in ecosystem → Changes in ecosystem services



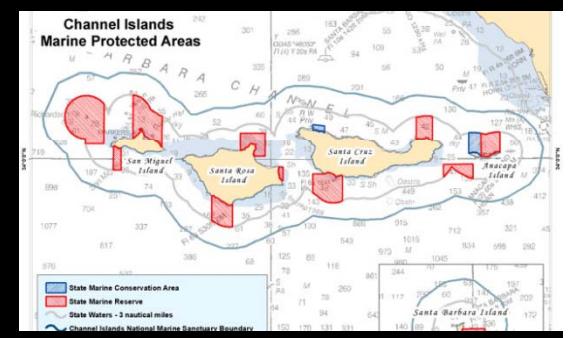
# Management Scenarios

How will the distribution and value of ecosystem services change....

With climate change?

With population growth?

Given a new policy or program?



# West Coast Aquatic Board



## Vancouver Island, British Columbia

### Creating a Marine Spatial Zoning Plan

Balances interests of multiple stakeholders:

- Capture fisheries  
Salmon, halibut, groundfish
- Aquaculture  
Salmon (Atlantic), Manila clams
- Recreation & Tourism  
Whale-watching, fishing
- Wave energy generation



# How might sea-level rise and coastal development affect:

*production of salmon from aquaculture*

*catch of Dungeness crab*

*beach going & surfing*

*recreational clamming*

*erosion control and*

*storm surge control?*



# Cultural and existence values





# Using ecosystem services to inform natural resource decisions in the ocean

- 1) Decision & governance context
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How will markets ever work if  
we don't know what we're  
buying?

# Marine InVEST

Recreation



Aquaculture



Fisheries



Coastal Protection



Nursery



Transformation & sequestration



Energy generation



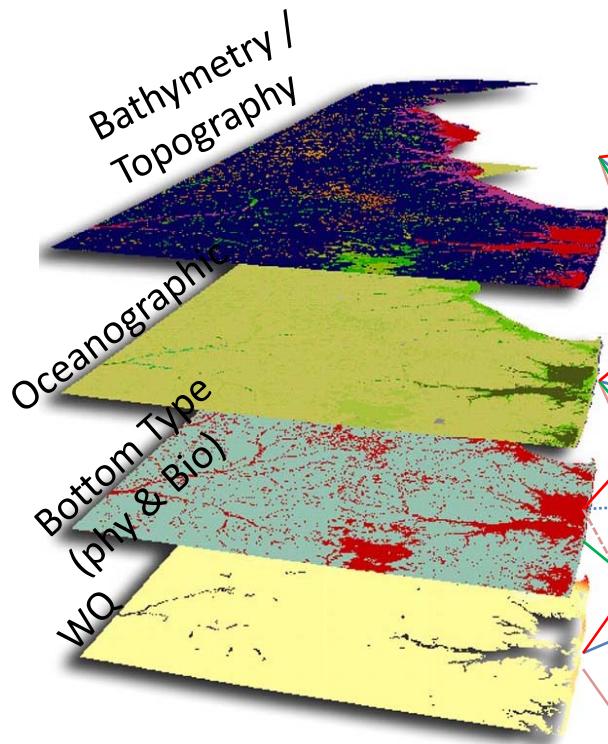


# InVEST tool

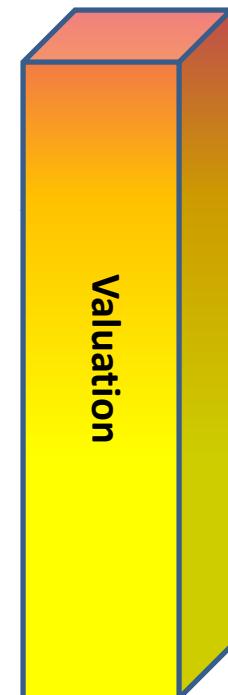
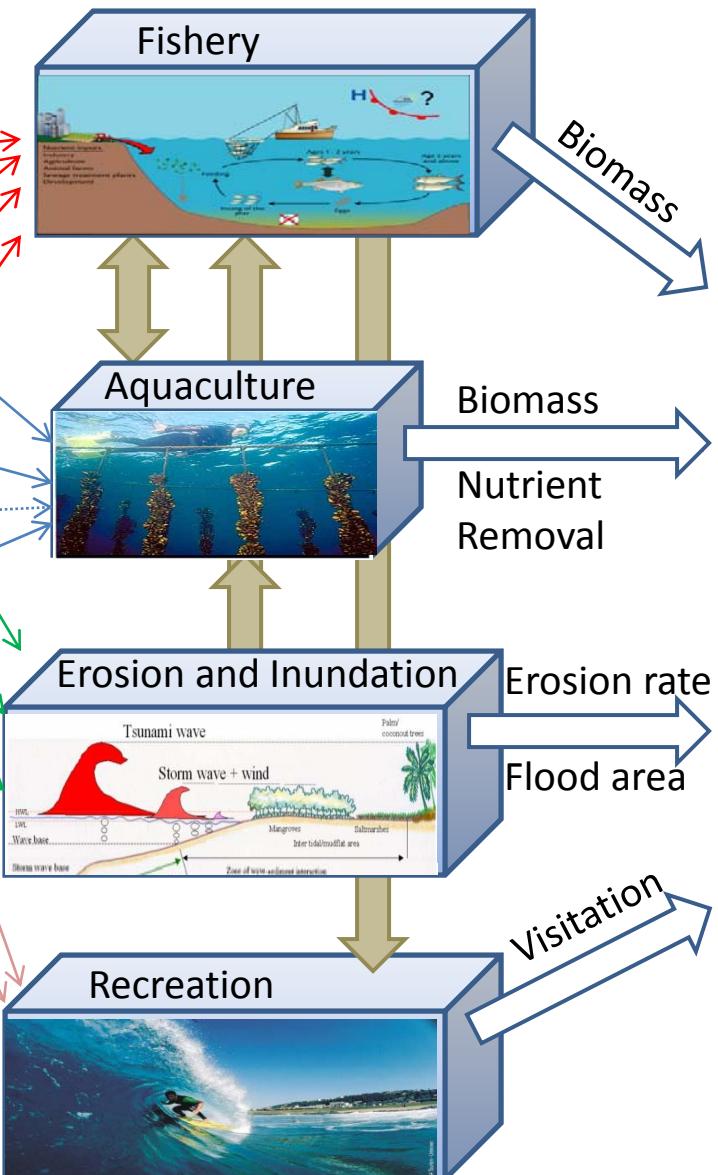
Driven by future scenarios  
Multiple services  
Spatially explicit  
Numerous currencies  
Flexible and transferable

natural  
capital  
PROJECT

# Input Data Layers



# Models



# Fisheries models

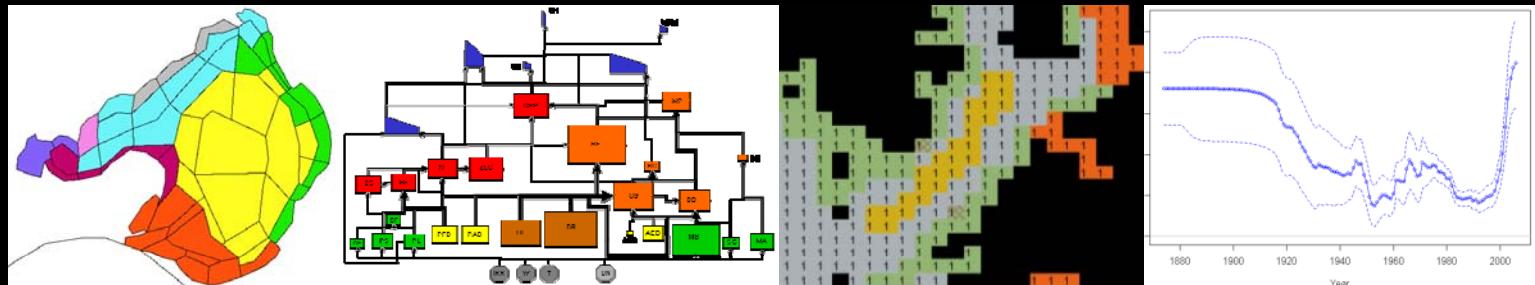
## SERVICES

- ❖ Food
- ❖ Supporting habitat



## 2 EFFORTS

1. Wrap around existing, complex models



2. Build simple single-species models: habitat-dependant & -independent



# Aquaculture models

## SERVICES

- ❖ Food
- ❖ Filtration



## 2 EFFORTS

1. Shellfish: suspended and on-bottom



2. Finfish: effects of downstream pollution to be included



# Wave Energy Capture

The potential world-wide wave energy is equal to 10% of world electricity consumption (Clement et al. 2002)



# Recreation models

## SERVICES

Ecological characteristics

Human use = visitation rates



## 2 EFFORTS

1. Define specific activity



2. Determine factors that might influence



# Coastal protection models

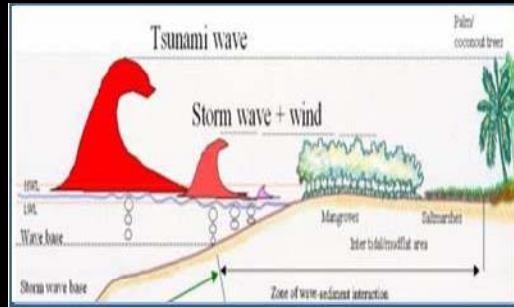
## SERVICES

- ❖ Erosion control
- ❖ Inundation control



## 2 EFFORTS

1 . Cross shore processes: short term



2. Longshore processes: long term



# Erosion control model

Kelp forest



Coral reef



Seagrasses



Marsh



Mangroves



# How will markets ever work if we don't know what we're buying?

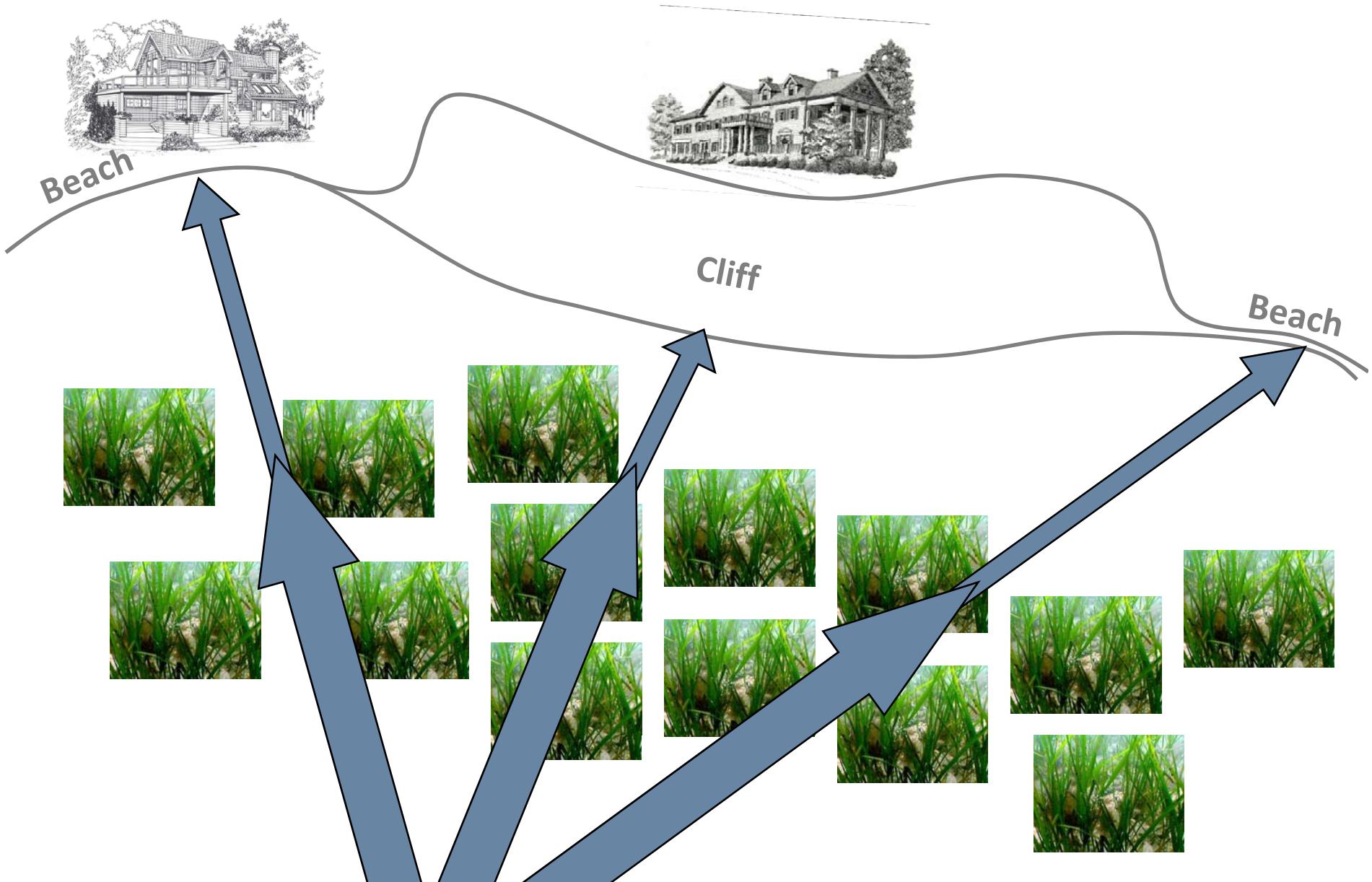
Supply —————> Service —————> Value

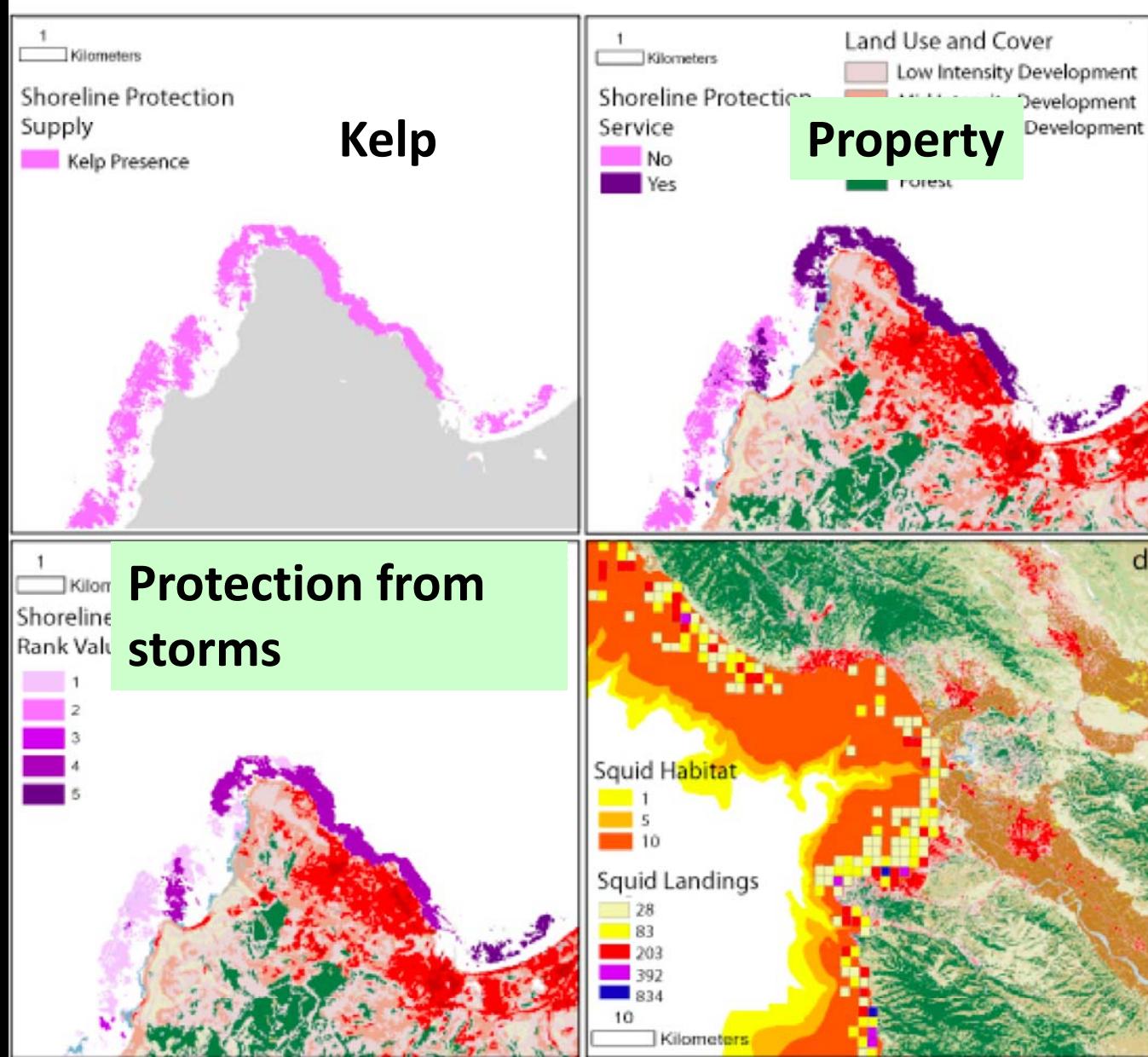
Ecological functions  
Ecosystem elements

Supply  
+  
Location and activity  
of beneficiaries

Service  
+  
Social preference

# Shoreline Protection – erosion control





Tallis et al in review

<b>Service</b>	<b>Supply</b>	<b>Demand</b>	<b>Value</b>
<b>Food from fisheries (nursery habitat)</b>	Fish biomass	Landed biomass	Market \$, NPV \$
<b>Food from aquaculture</b>	biomass	Harvested biomass	Market \$, NPV \$
<b>Protection from coastal erosion or inundation</b>	Wave attenuation, dune/beach loss or accumulation; inundation	Change in beach area, #people or structures affected	\$ avoided damage or \$ shoreline protection, beach nourishment
<b>Wave energy</b>	Power density, potential wave E	Captured wave power	\$ NPV captured wave electricity
<b>Recreation</b>	Whale, bird abundance; beach conditions	# sightings, visitation rates	# passengers, revenues/profits \$
<b>Water quality maintenance by shellfish</b>	Biomass, area of shellfish; clearance rates of nutrients	Nutrients removed from water column	\$ avoided cost kgN removed via other methods
<b>Carbon storage and sequestration</b>	Biomass/ha C stored, sequestered by habitat	Expected damage from climate change	\$ value of habitat protection or restoration

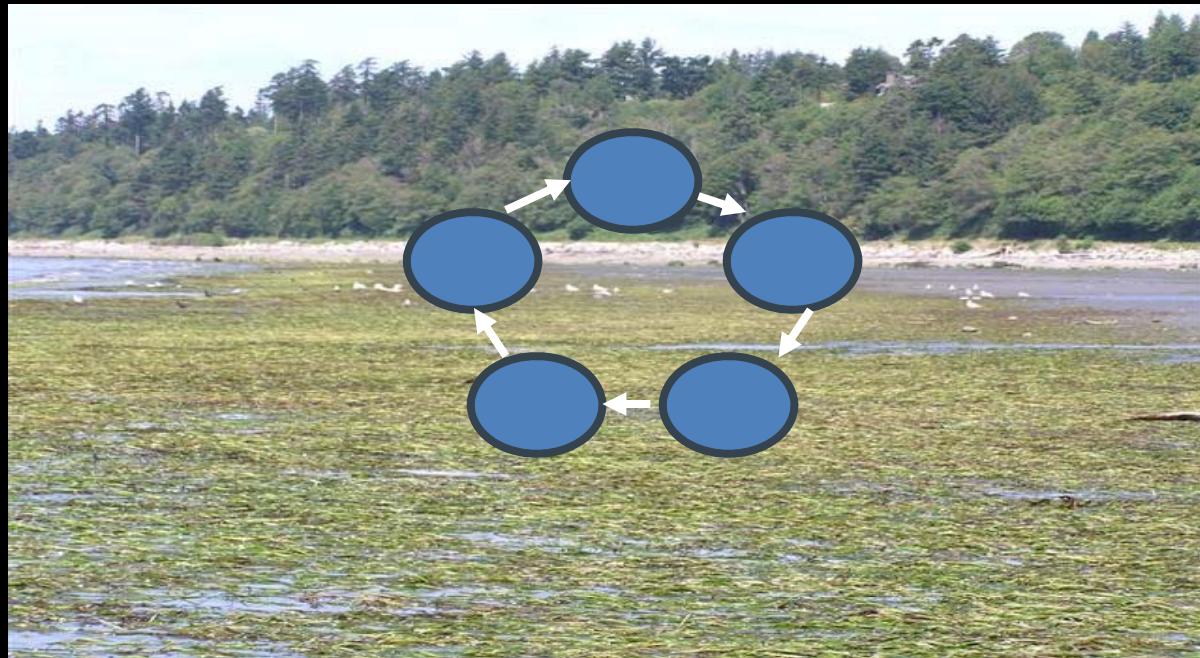
Changes in eelgrass can lead to changes in. . .

Marine harvest and \$

Abundance and \$ of species people care about

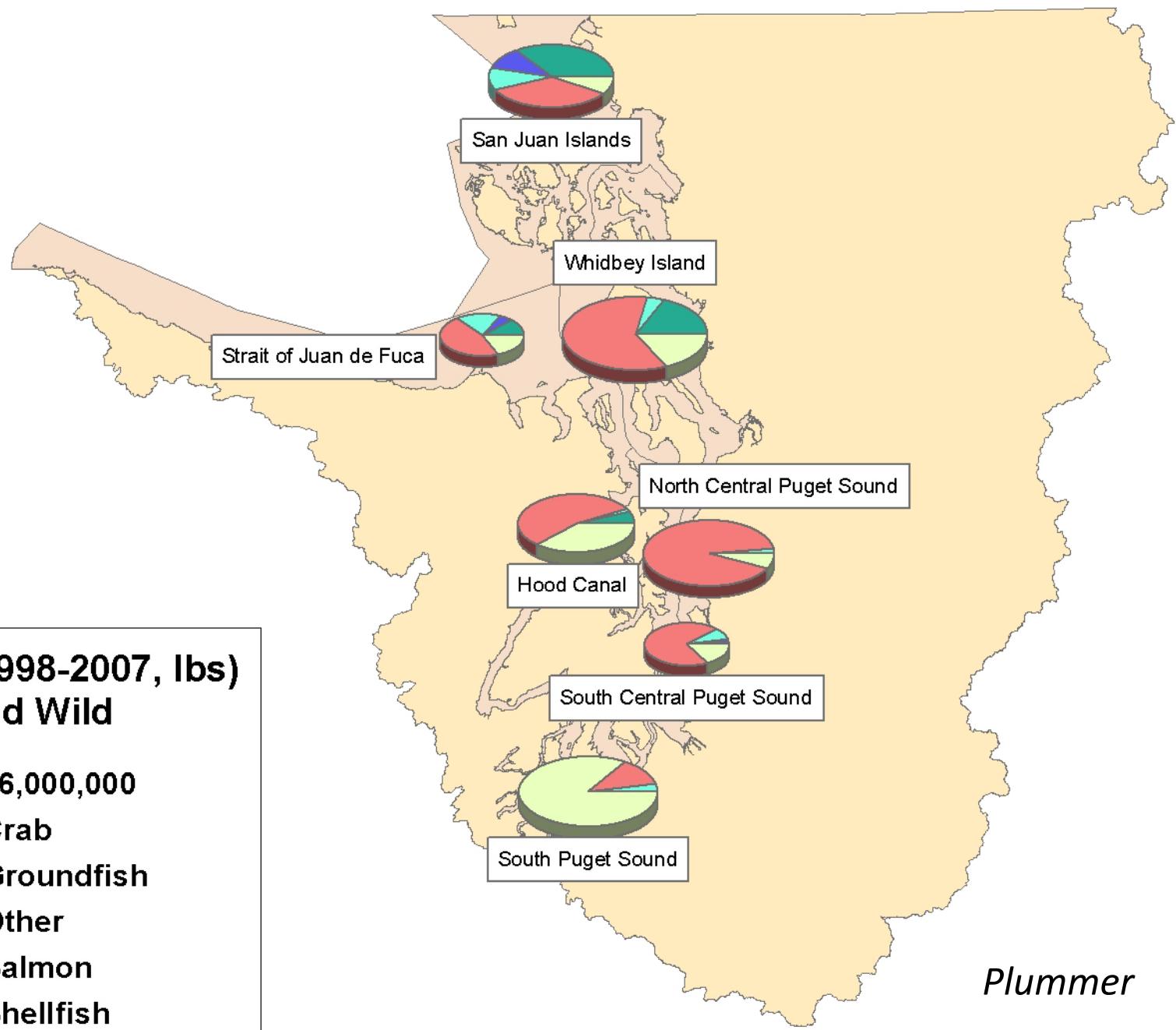
Carbon storage and sequestration

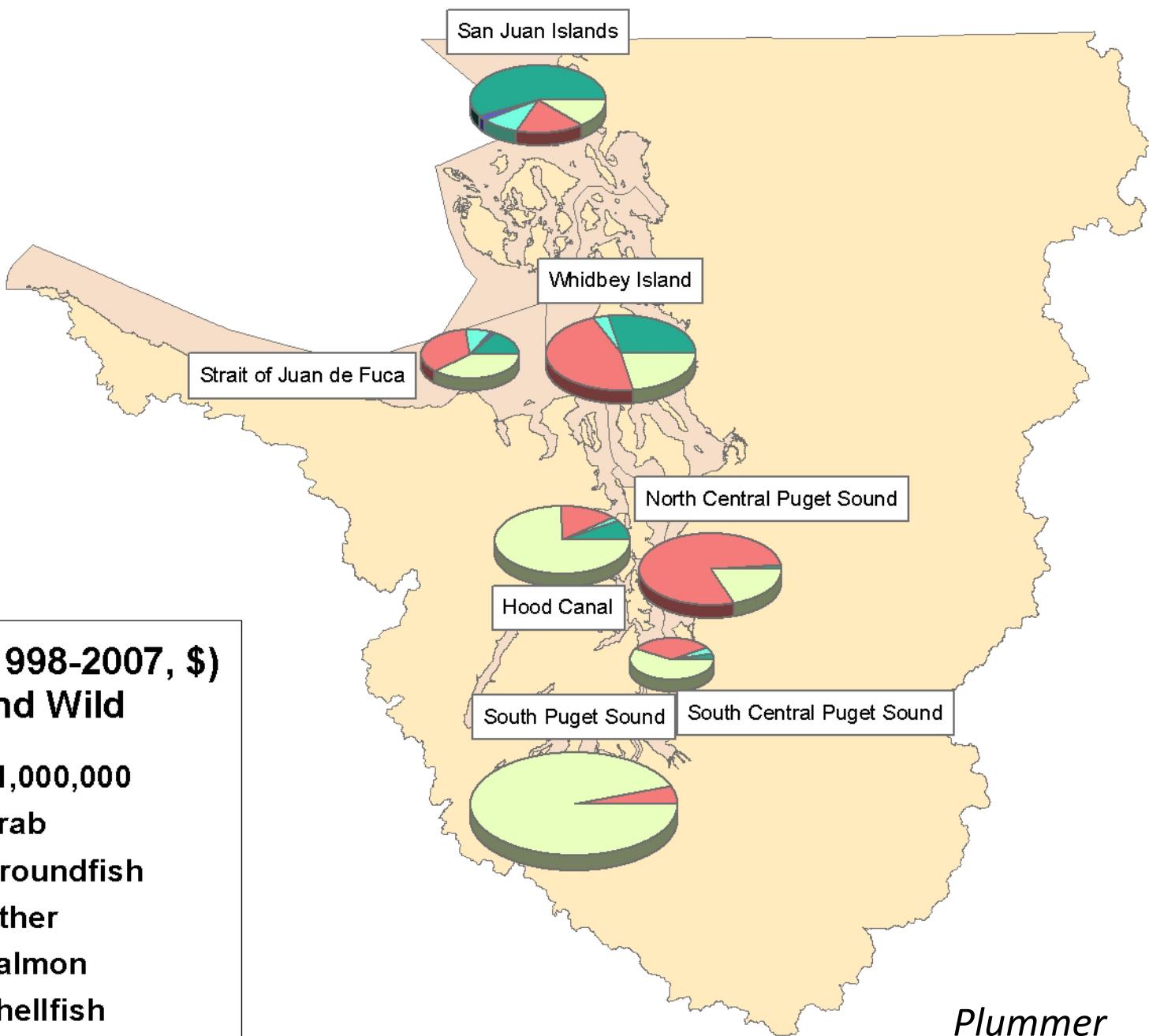
The ability of the nearshore to break down toxics



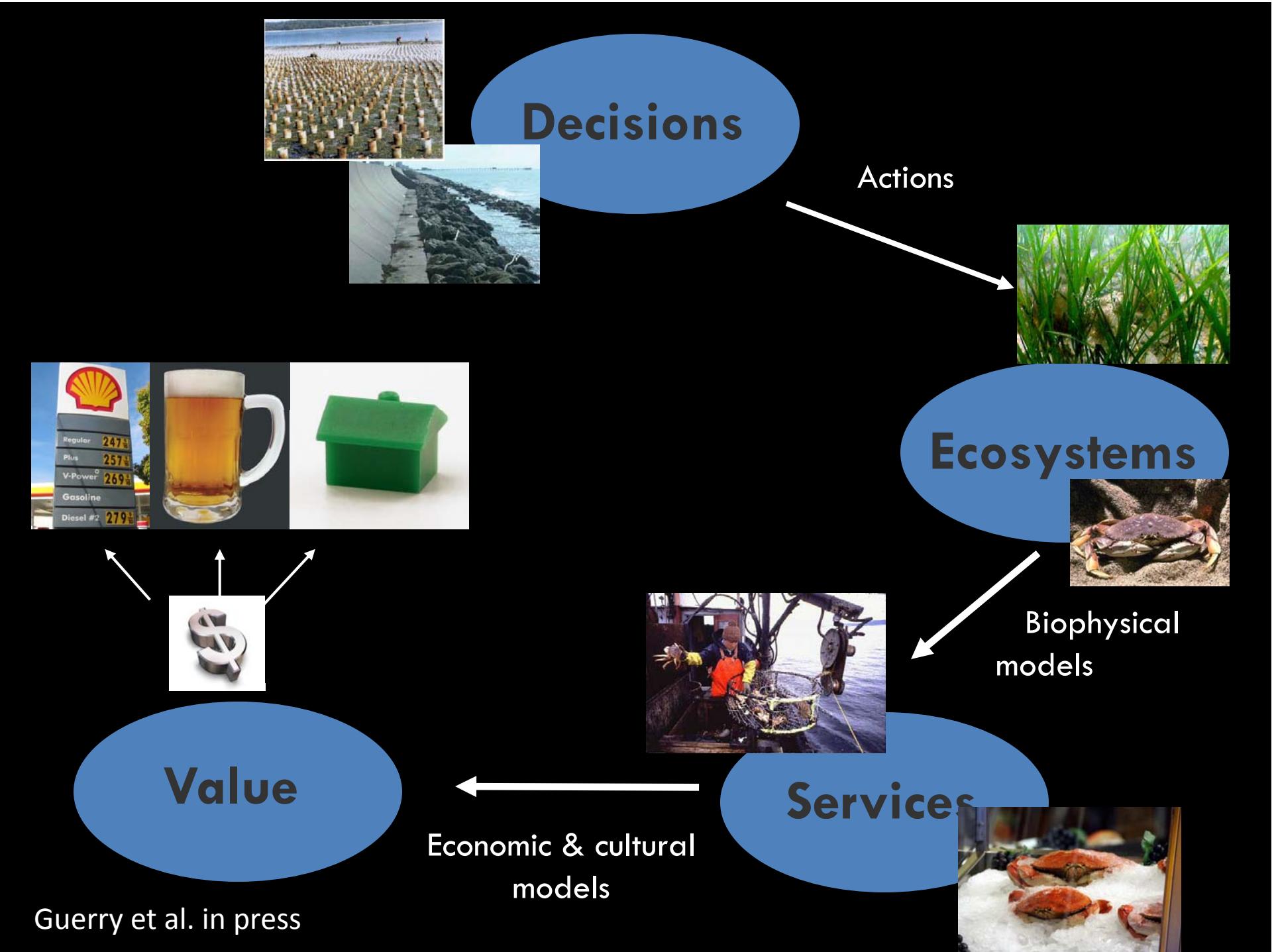
*Guerry, Plummer, Harvey and Ruckelshaus, In press*

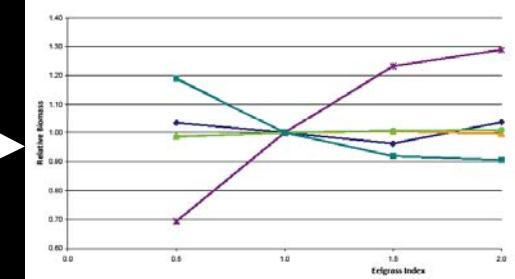
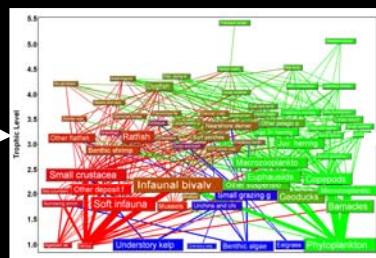
## Harvest (1998-2007, lbs) Farmed and Wild





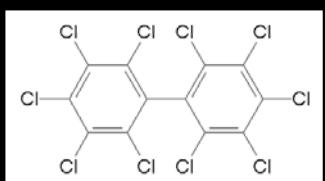
*Plummer*





C

\$\$\$ protection  
\$ restoration



etc...



# Using ecosystem services to inform natural resource decisions in the ocean

- 1) Decision & governance context
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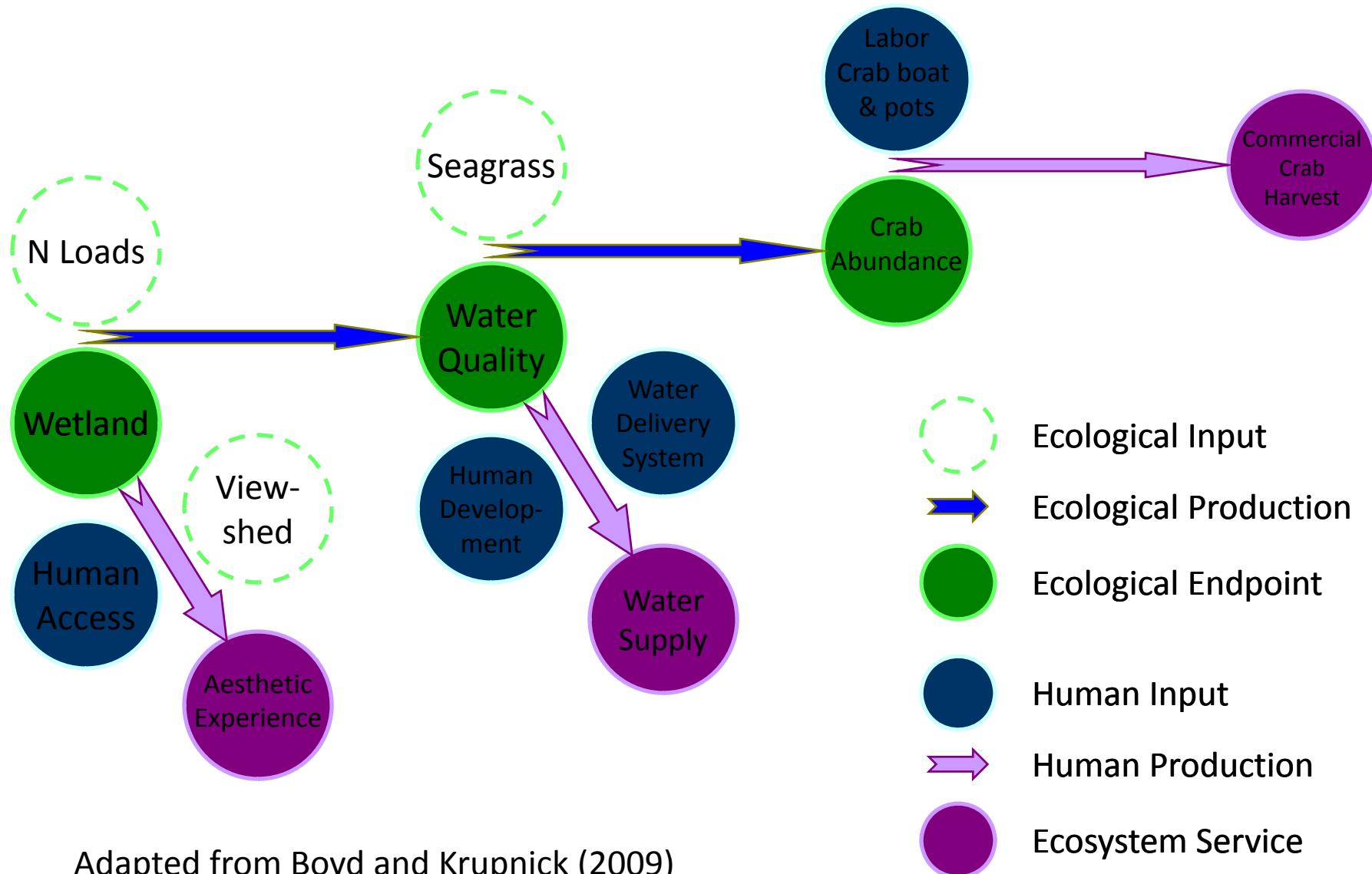
# Market opportunities?

- ITQs, other catch-share approaches
- Payments for tourism protected areas
- Fisheries certification schemes (e.g., MSC)
- Growing interest in Marine Conservation Agreements (e.g., TNC)





# Ecological Processes and Ecological Endpoints



# WEFAM Output

## 1. Wave power resource

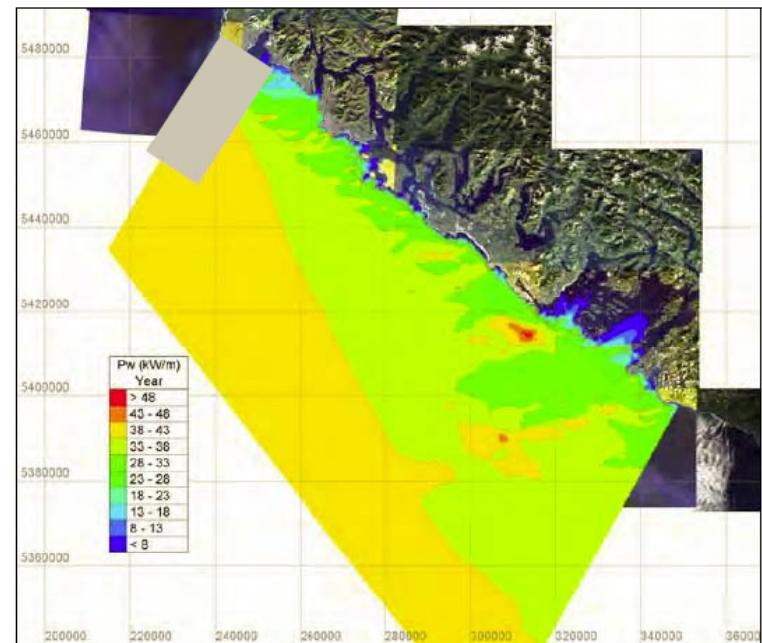
Map, Graph & Table

## 2. Captured wave power

## 3. Cost of electricity

## 4. Environmental impact

## 5. Site selection

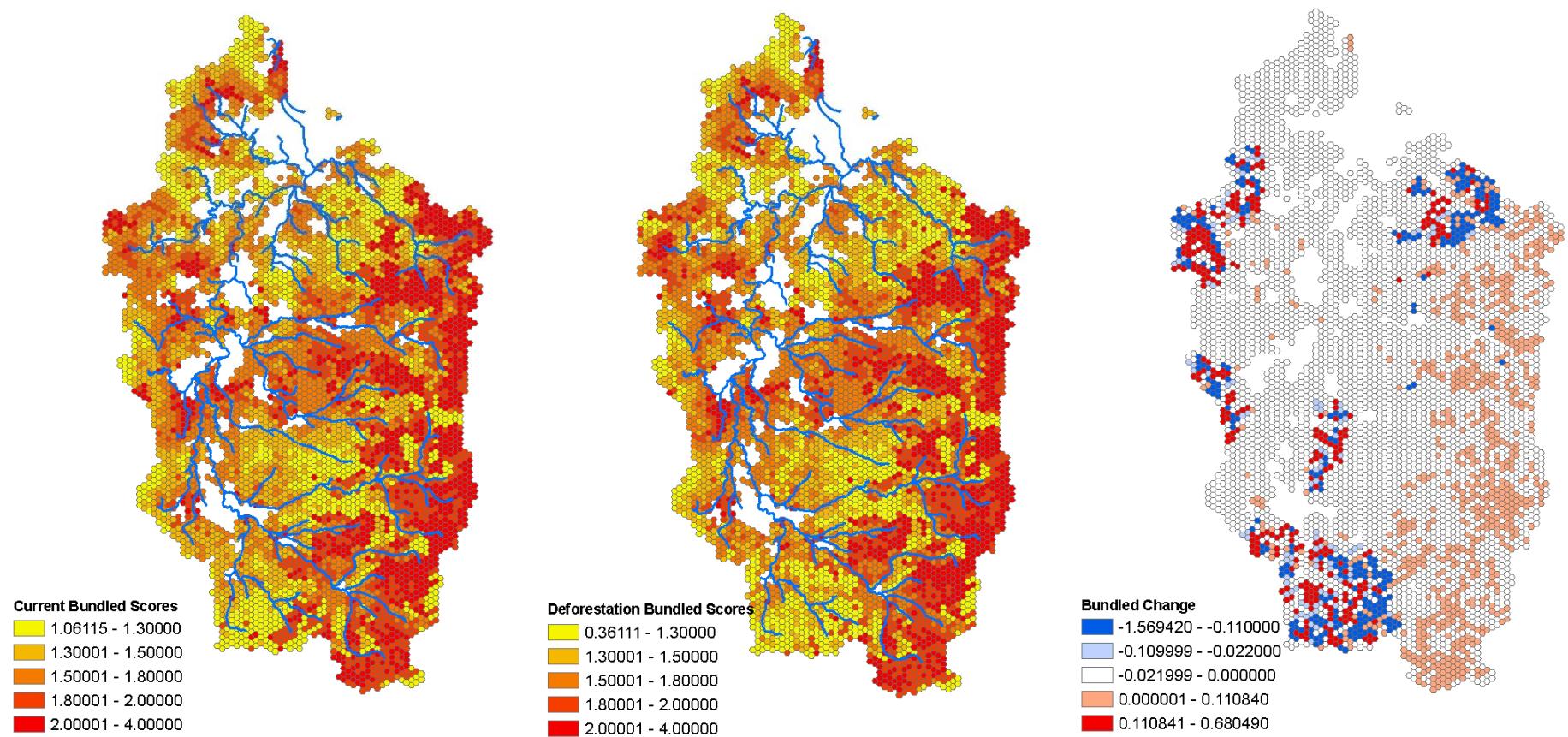


# Outputs: Balance Sheets

- Sample Balance Sheet

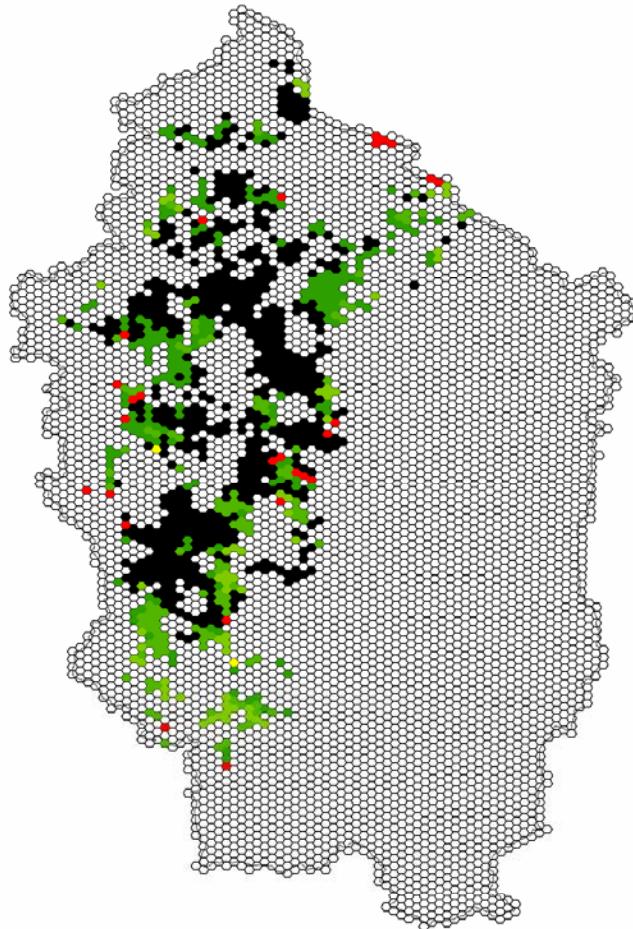
Scenario	Agricultural (Billion \$)	Forestry (Billion \$)	Cultural Sites (% intact)	Biodiversity (* of Species)
A	-12	+15	0	+2
B	+11	-15	+5	+11
C	+12	+14	-8	-6

# Outputs: Multiple Services

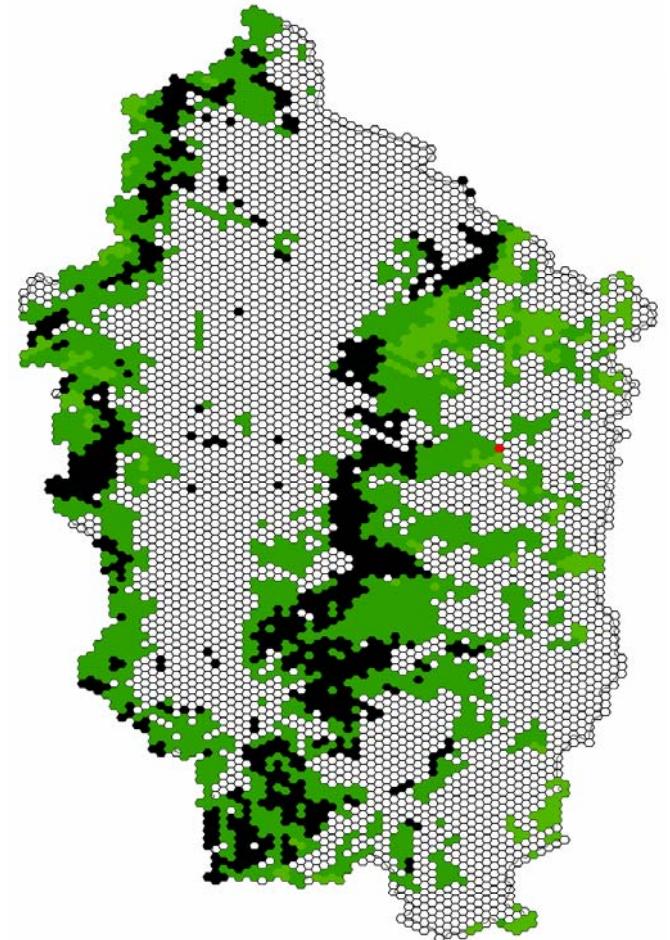


# Outputs: Dollar Values

Agriculture

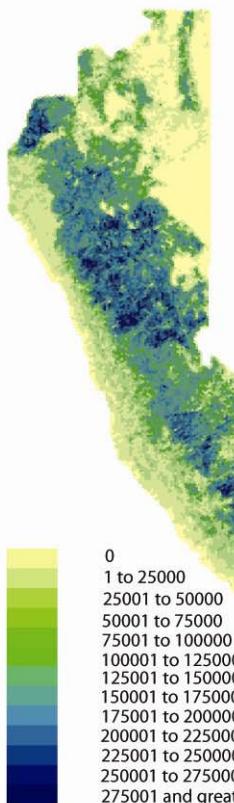


Timber



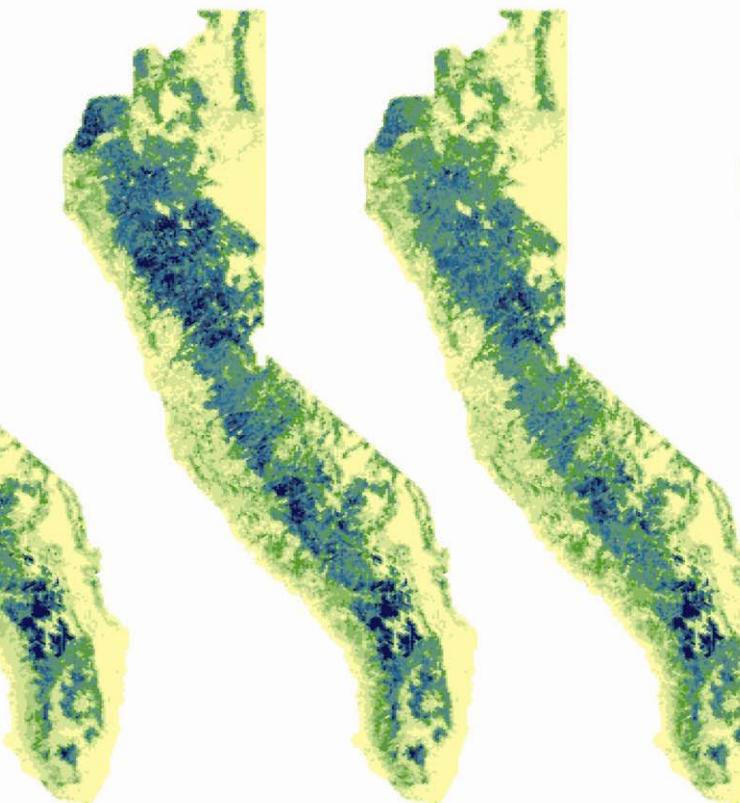
# Outputs: Single Service

Current Landscape



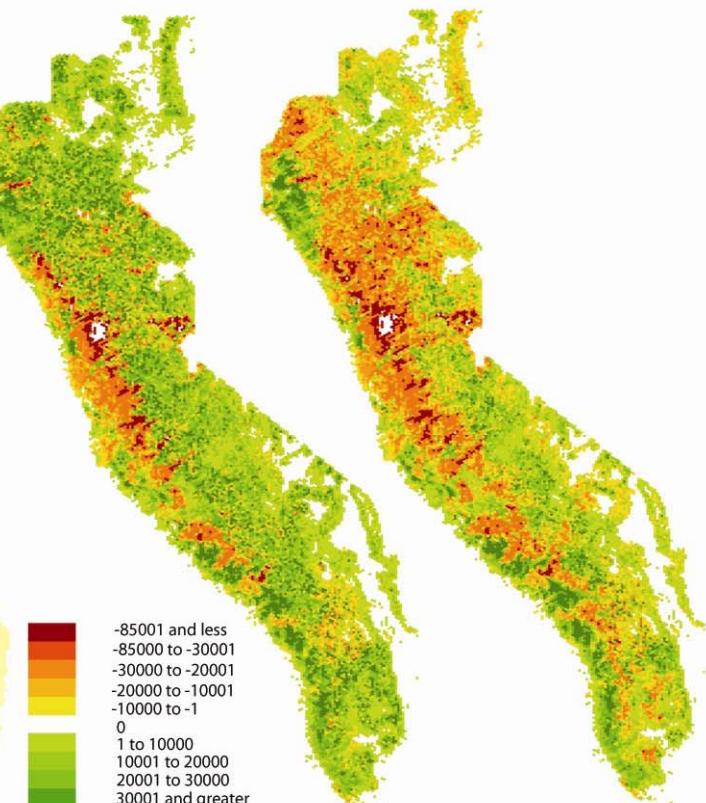
Potential Future Landscapes

*Urbanization      Urbanization + Fire*



Difference Across Current and Future Landscapes

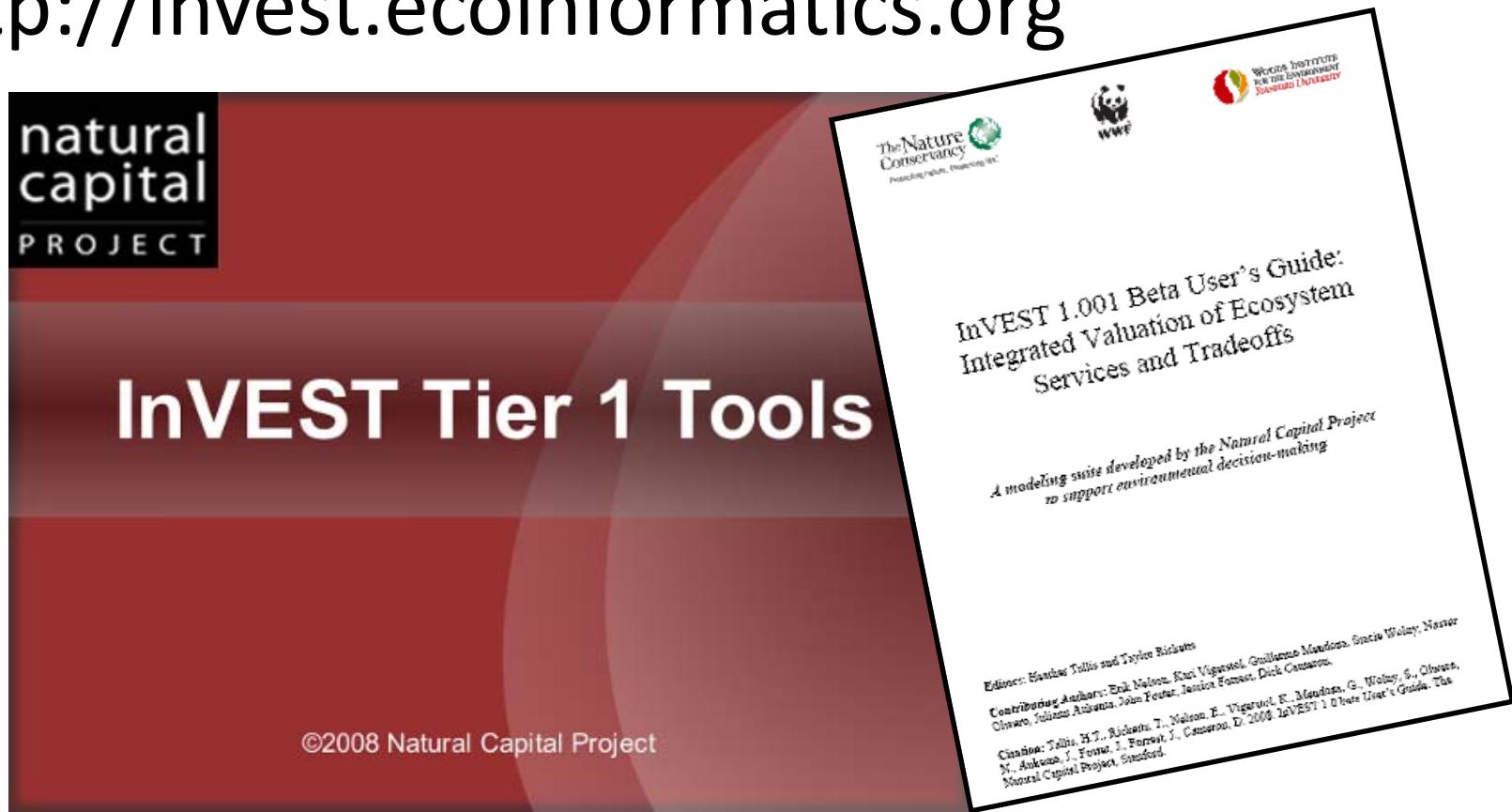
*Urbanization      Urbanization + Fire*



Carbon Storage (Metric Tons of Carbon per Hexagon)

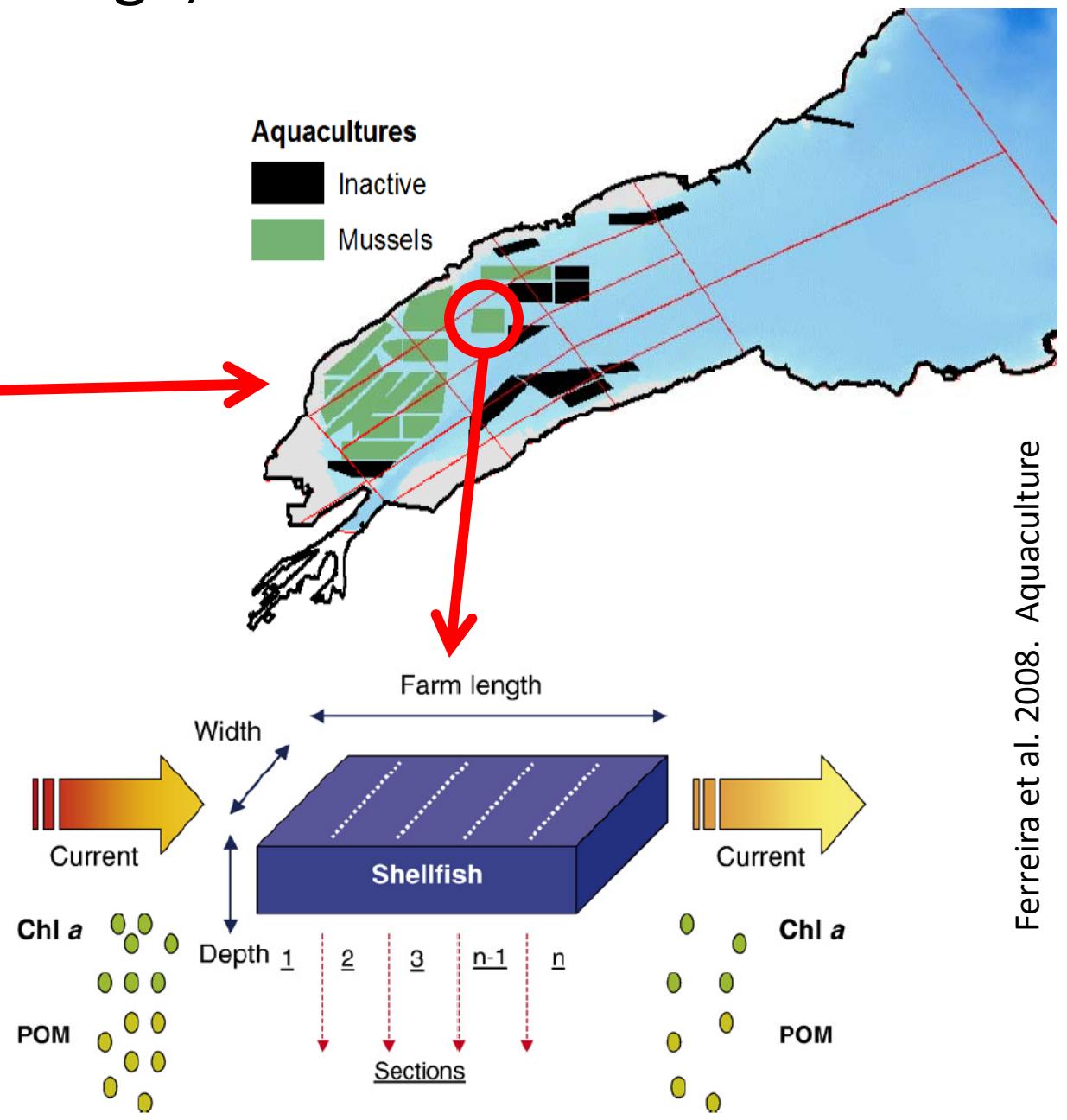
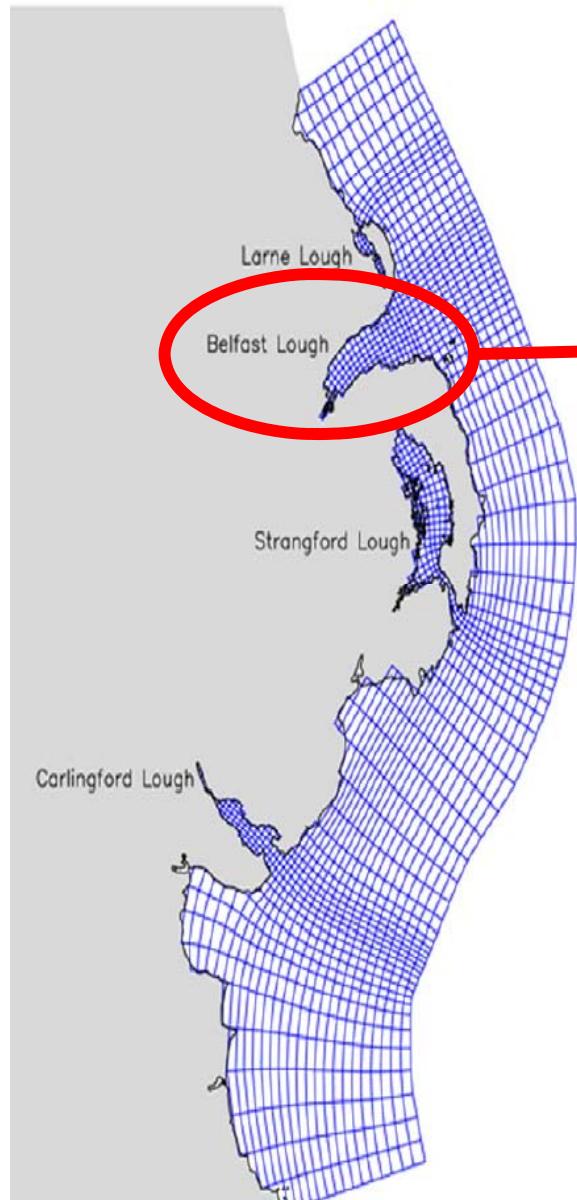
Carbon Sequestration  
(Change in the Metric Tons  
of Carbon per Hexagon)

Download InVEST at  
<http://invest.ecoinformatics.org>



- Daily et al. 2009, Frontiers in Ecology and Evolution
- Nelson et al. 2009, Frontiers in Ecology and Evolution
- Kareiva, Ricketts, Daily, Tallis, & Polasky, Eds. 2010. *The Theory & Practice of Ecosystem Service Valuation in Conservation*. OUP.

# Shellfish: Belfast Lough, Northern Ireland



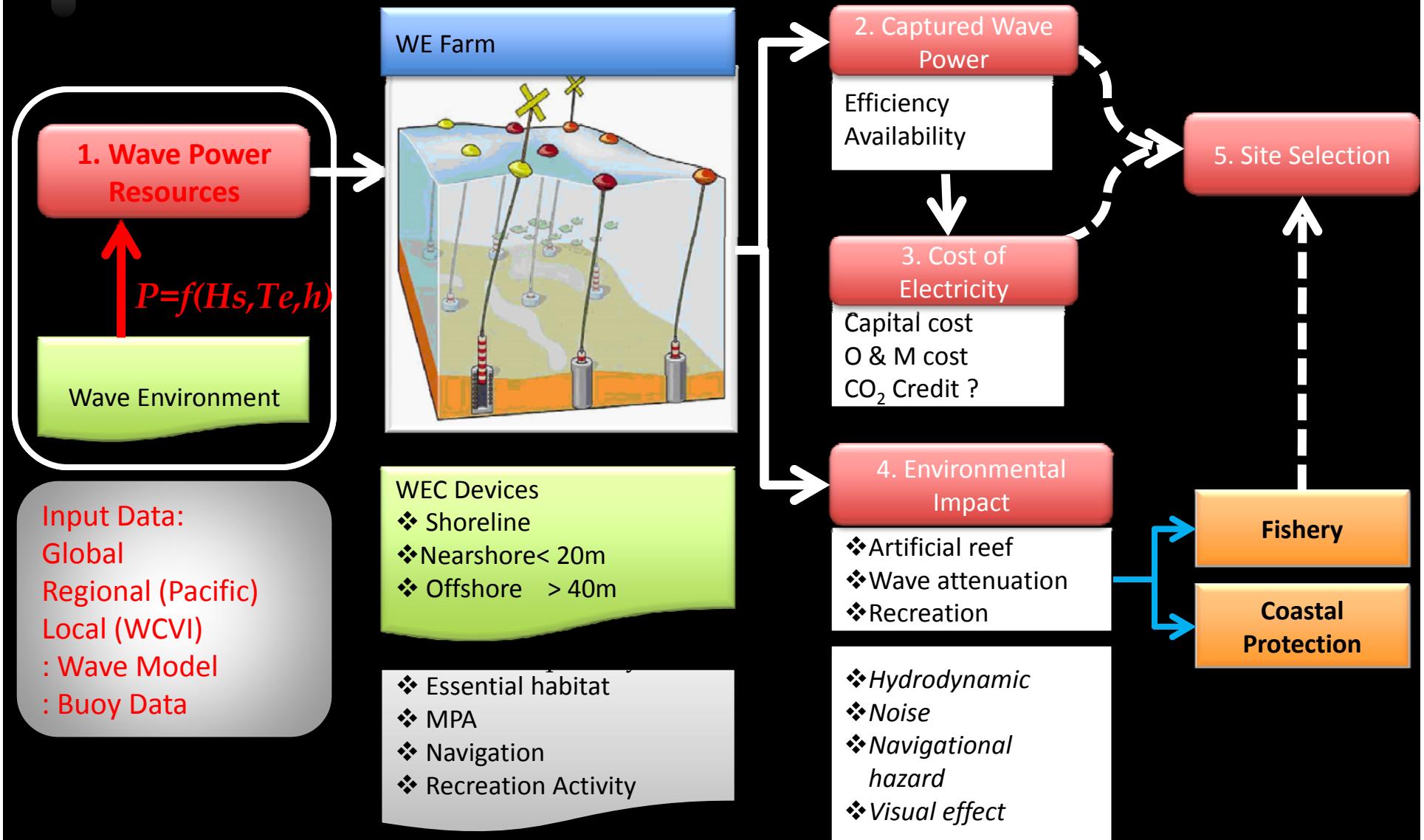
Ferreira et al. 2008. Aquaculture

# Wave Energy (WE) Farm Model Assesses;

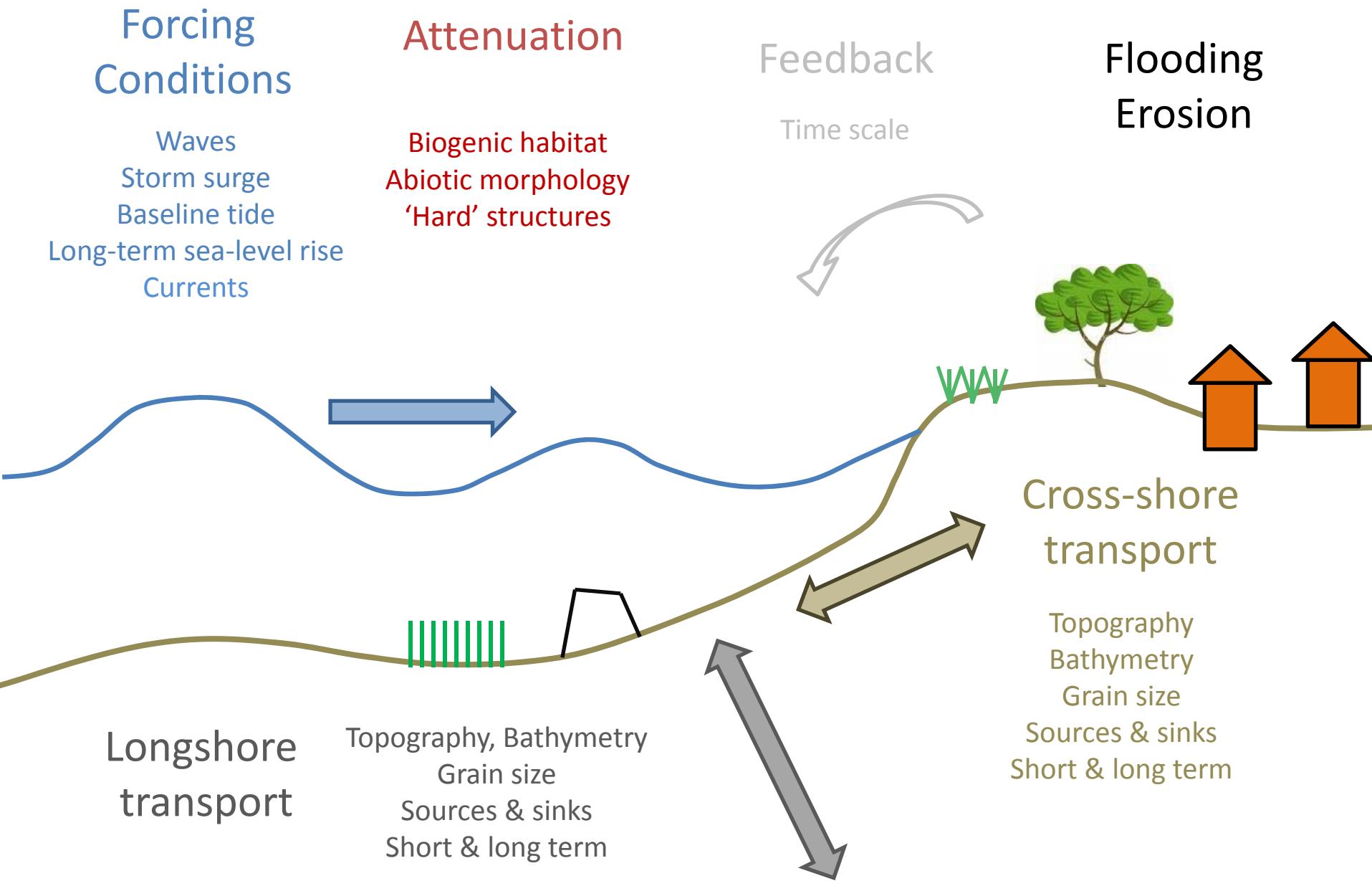
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1. Wave power resources
2. Captured wave power
3. Cost of electricity
4. Environmental impacts

## 5. Site Selection



# *Coastal Protection – avoided area & damages from erosion & flooding*

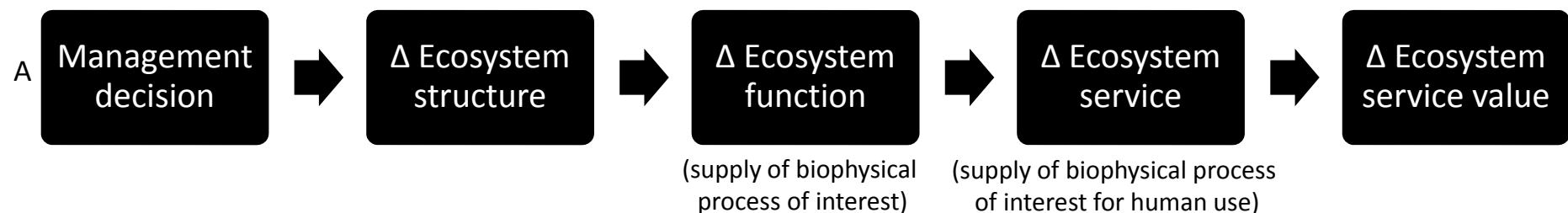




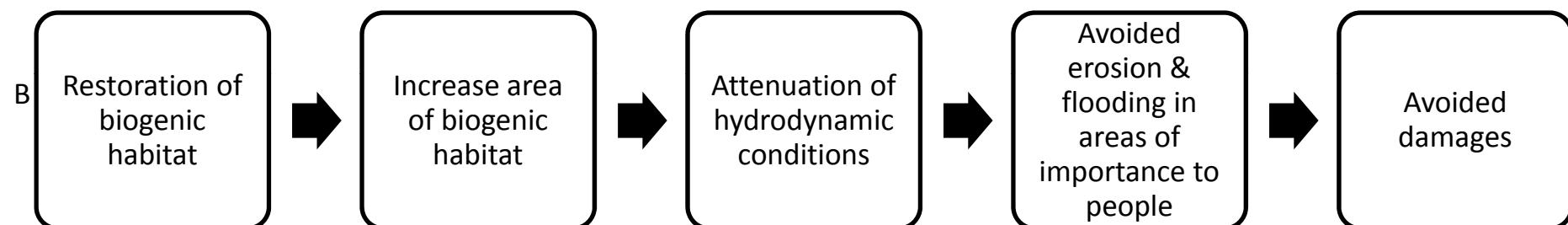
# Models for coastal protection

- 1) Storm surge control for public and private property protection
- 2) Erosion control for public and private property protection
- 3) Sediment transport and retention for beach nourishment
- 4) Dredging avoidance for marine transportation
- 5) Sea level rise inundation (i.e., adaptation) control for public and private property protection
- 6) others.....

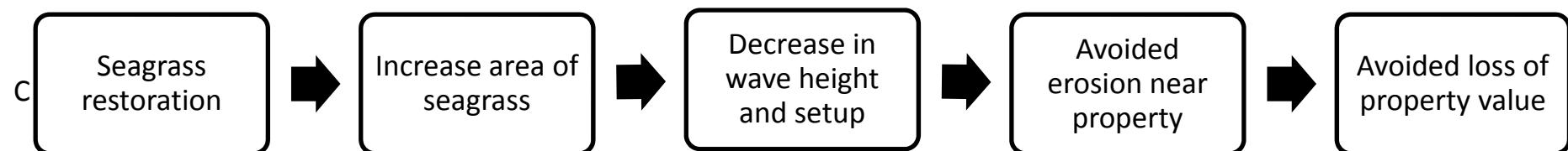
General framework for modeling ecosystem services (adapted from Daily et al. 2009)



Framework for modeling coastal protection services provided by biogenic habitats



Framework for modeling an example coastal protection service: property protection by seagrass from erosion



# Combining spatially explicit data to identify areas of differentiated ES value

