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# ECOSYSTEM SERVICE VALUATION WITH INVEST

## CONCEPTS, METHODS AND APPLICATIONS

March 27, 2014

Rob Griffin, Shan Ma, and Justin Johnson

# HIGHLIGHTS

**What** is ecosystem service valuation?

**Why** value ecosystem services?

**How** InVEST values ecosystem services?

**Expanding** beyond InVEST

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# VALUE
## ECOSYSTEM SERVICES

Value depends on human well-being


Monetary and non-monetary valuation

# ECOSYSTEM SERVICES
## BENEFITS PEOPLE OBTAIN FROM ECOSYSTEMS

**Provisioning Services**
- Food
- Fresh water
- Wood and fiber
- Fuel
- ...

**Regulating Services**
- Climate regulation
- Flood regulation
- Disease regulation
- Water regulation
- ...

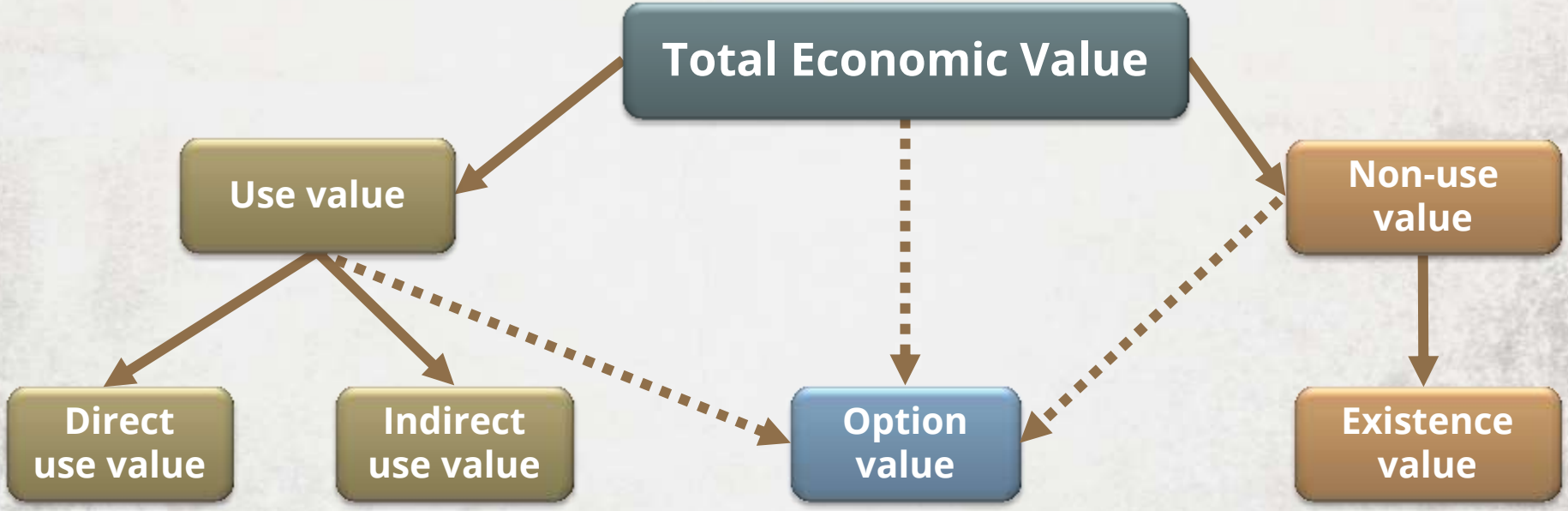
**Cultural Services**
- Aesthetic
- Spiritual
- Educational
- Recreational
- ...

**Supporting Services**

-Nutrient cycling - Soil formation - Primary production
-Water cycling - Provision of habitat

Millennium Ecosystem Assessment

# MONETARY VALUATION
## ECOSYSTEM SERVICES




*Pagiola et al, 2004*

# VALUATION THEORY
## SUPPLY AND DEMAND SET VALUE

### Coastal Vulnerability


nature climate change

LETTERS

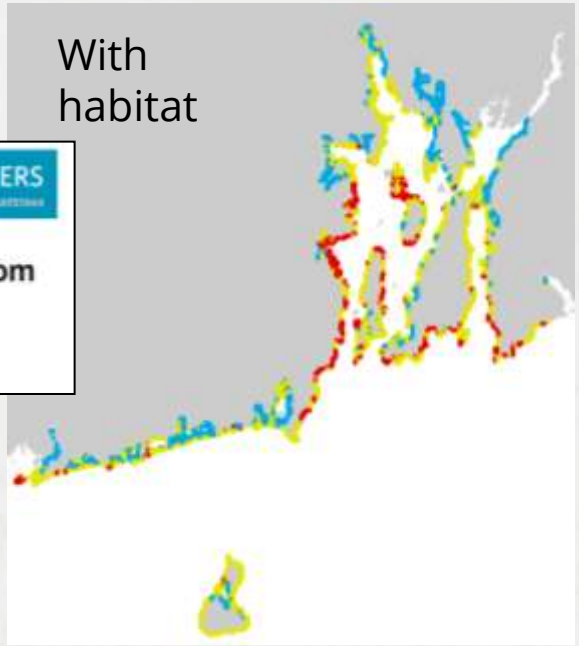
PUBLISHED ONLINE: XX MONTH XXXX | DOI: 10.1038/NCLIMATE2448

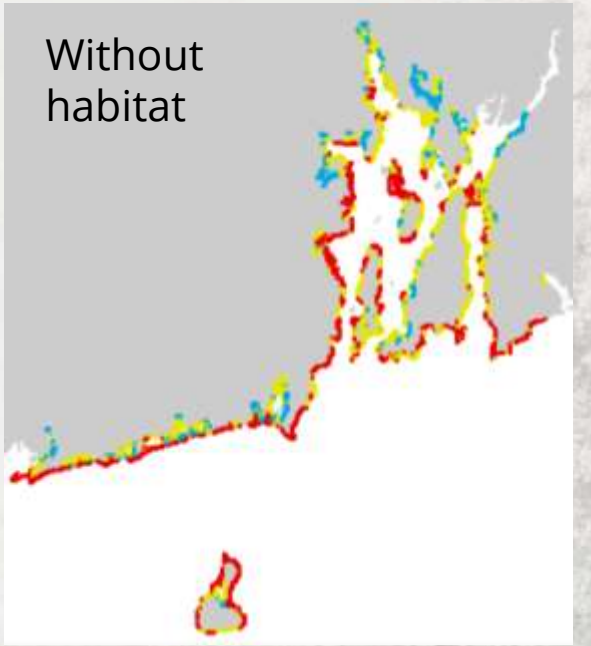
**Coastal habitats shield people and property from sea-level rise and storms**

Katie K. Arkema[1]*, Greg Guannel[2], Gregory Verutes[1], Spencer A. Wood[2], Anne Guerry[2], Mary Ruckelshaus[2], Peter Kareiva[2], Martin Lacayo[2] and Jessica M. Silver[2]

Coastal Hazard

Highest Intermediate Lowest



# VALUATION THEORY
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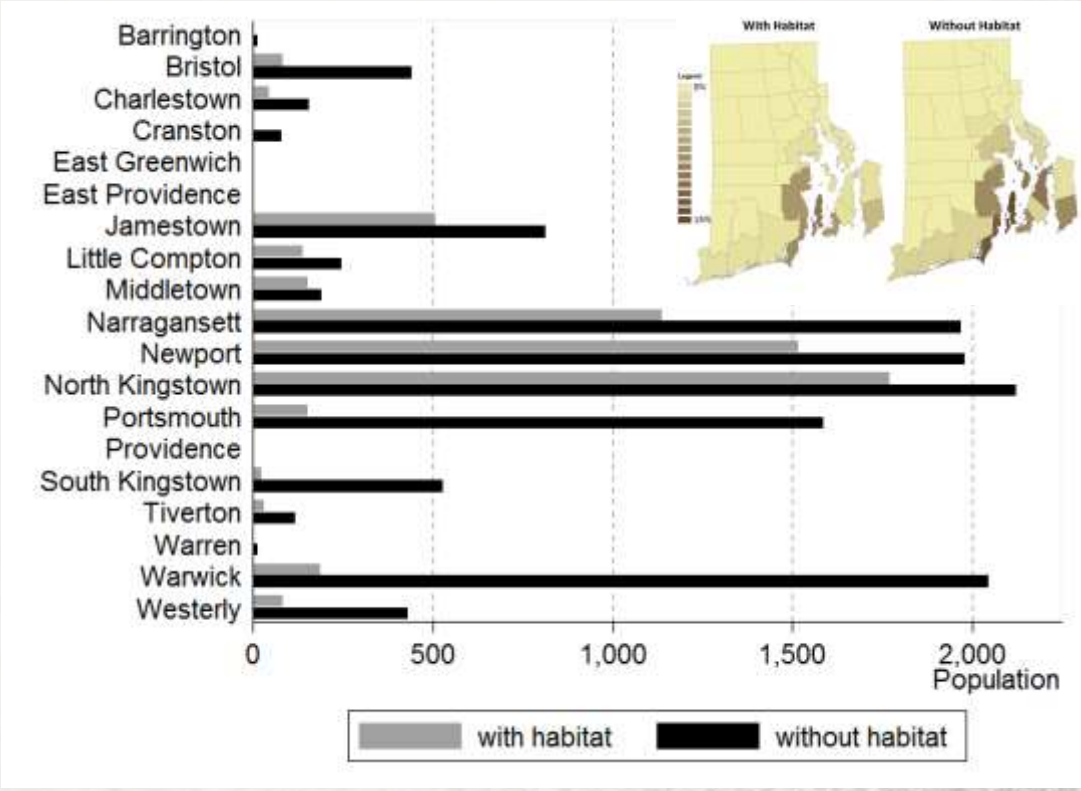
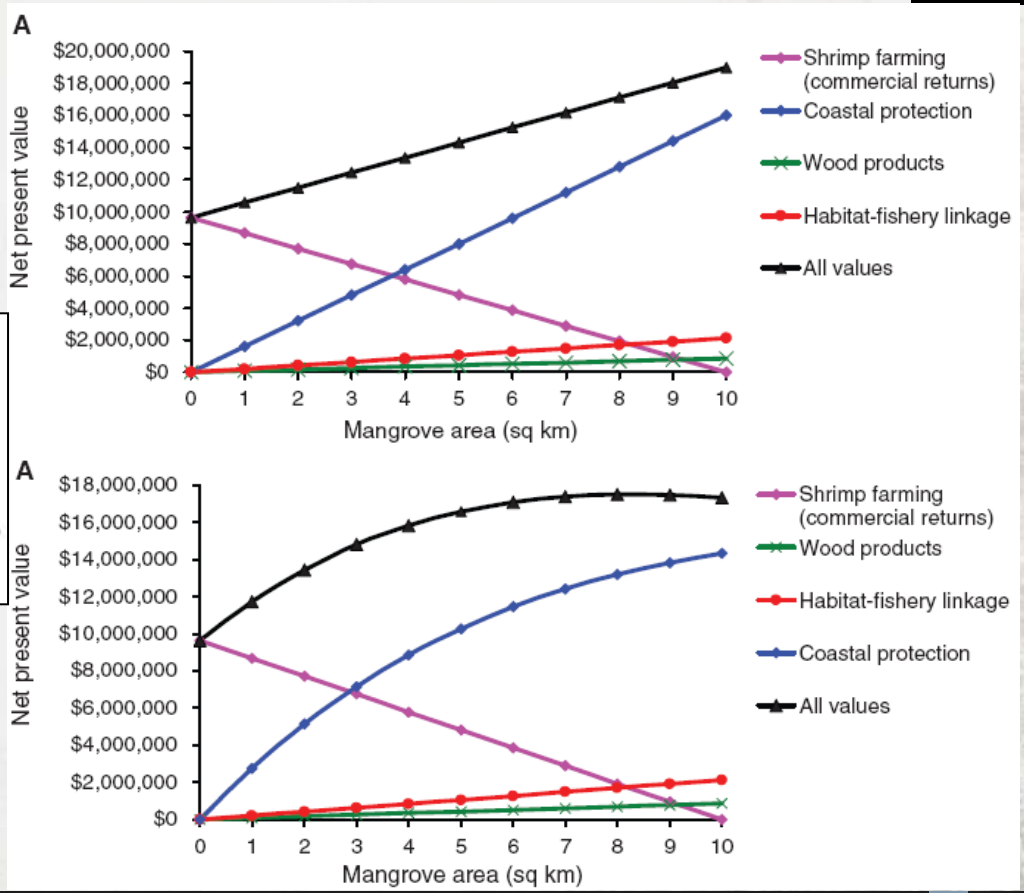
*Where are habitats important for reducing the numbers of people most exposed to coastal hazards?*



# VALUATION THEORY
## MARGINAL VALUE

**Coastal Ecosystem–Based Management with Nonlinear Ecological Functions and Values**

Edward B. Barbier,[1]* Evamaria W. Koch,[2] Brian R. Silliman,[3] Sally D. Hacker,[4] Eric Wolanski,[5] Jurgenne Primavera,[6] Elise F. Granek,[7] Stephen Polasky,[8] Shankar Aswani,[9] Lori A. Cramer,[10] David M. Stoms,[11] Chris J. Kennedy,[1] David Bael,[8] Carrie V. Kappel,[12] Gerardo M. E. Perillo,[13] Denise J. Reed[14]



# HIGHLIGHTS

**What** is ecosystem service valuation?

**Why** value ecosystem services?

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**Expanding** beyond InVEST

# RESEARCH QUESTION

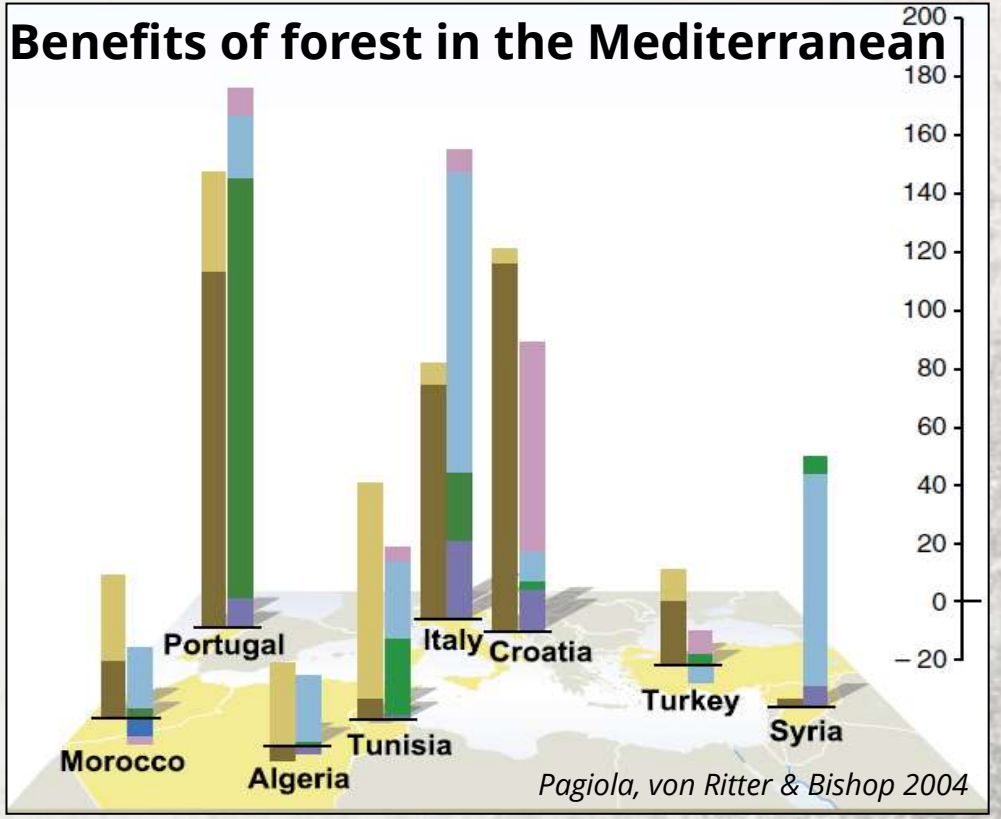
## DETERMINE THE TOTAL FLOW OF BENEFITS FROM ECOSYSTEMS

Commonly Measured

- Grazing
- Timber and fuelwood

Non-market and other values

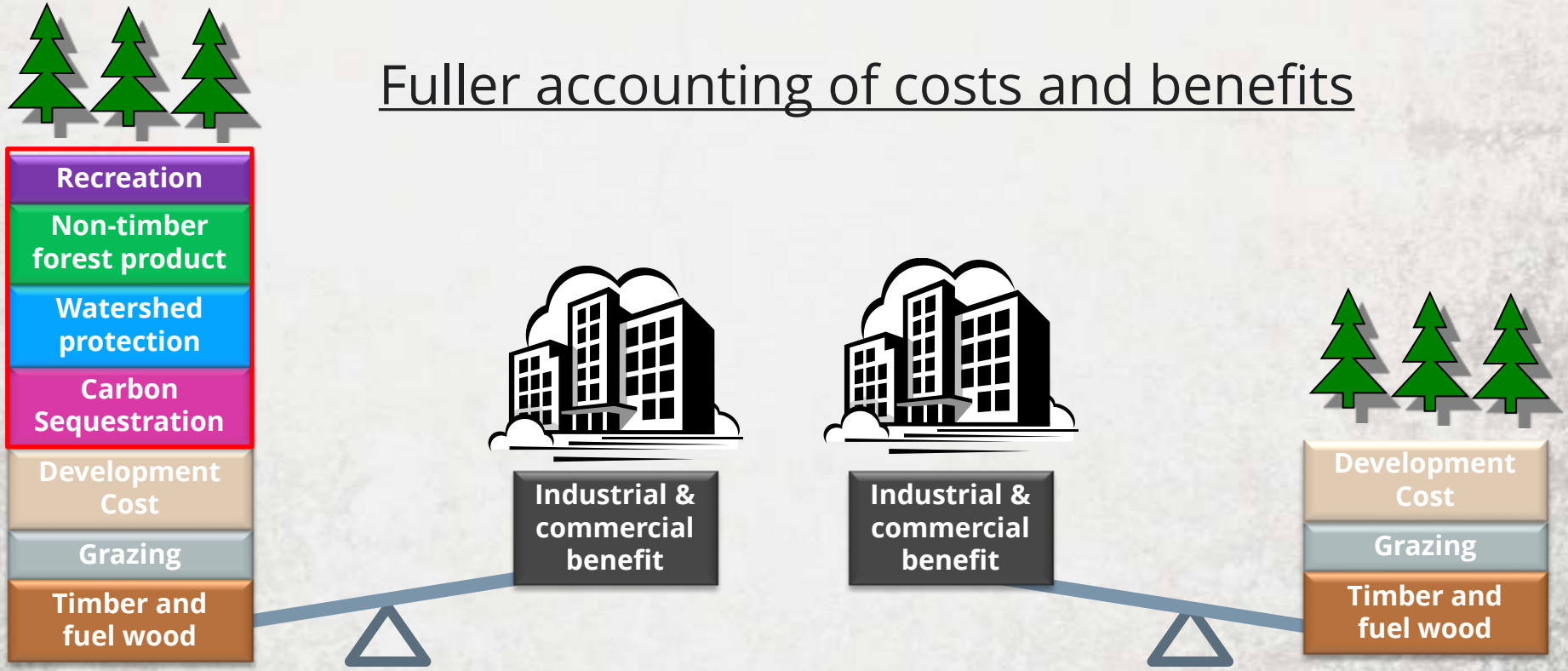
- Carbon sequestration
- Watershed protection
- Non-timber forest products
- Recreation and hunting



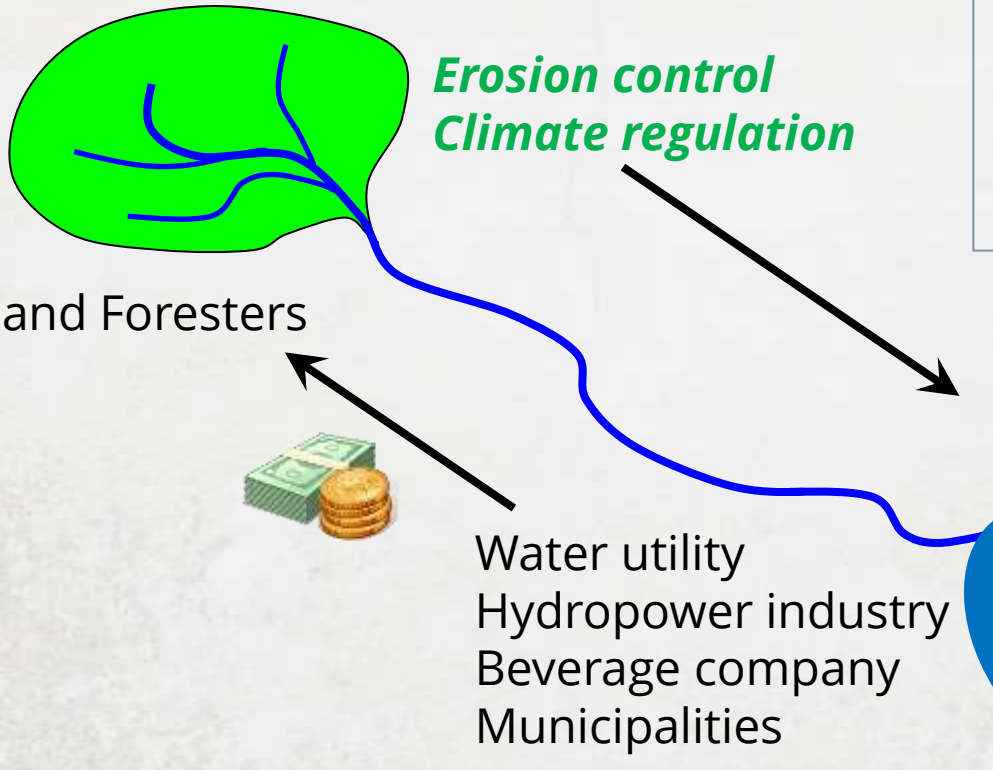
# RESEARCH QUESTION

## COST BENEFIT ANALYSIS

Fuller accounting of costs and benefits



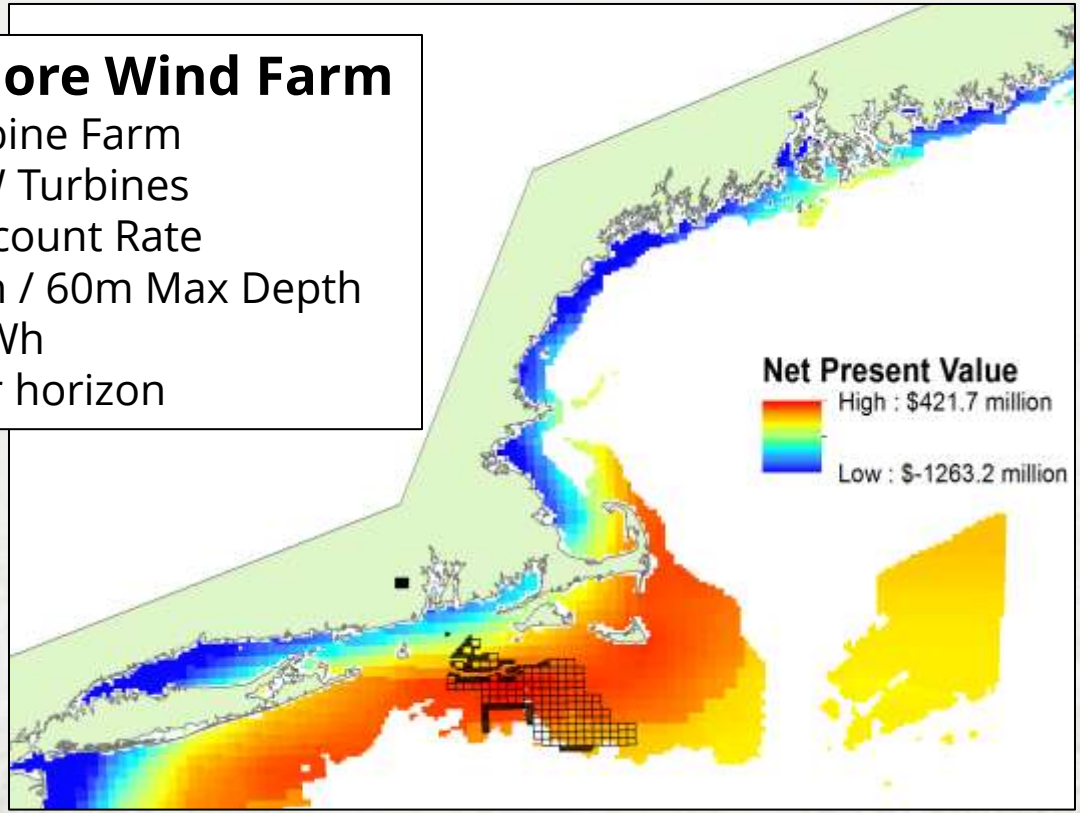
# RESEARCH QUESTION
## FINANCE ECOSYSTEM CONSERVATION




Pagiola, von Ritter & Bishop 2004

# RESEARCH QUESTION
## OPTIMAL SITING DECISIONS

**Offshore Wind Farm**
80 Turbine Farm
3.6 MW Turbines
7% Discount Rate
3m Min / 60m Max Depth
$.18/kWh
20 year horizon



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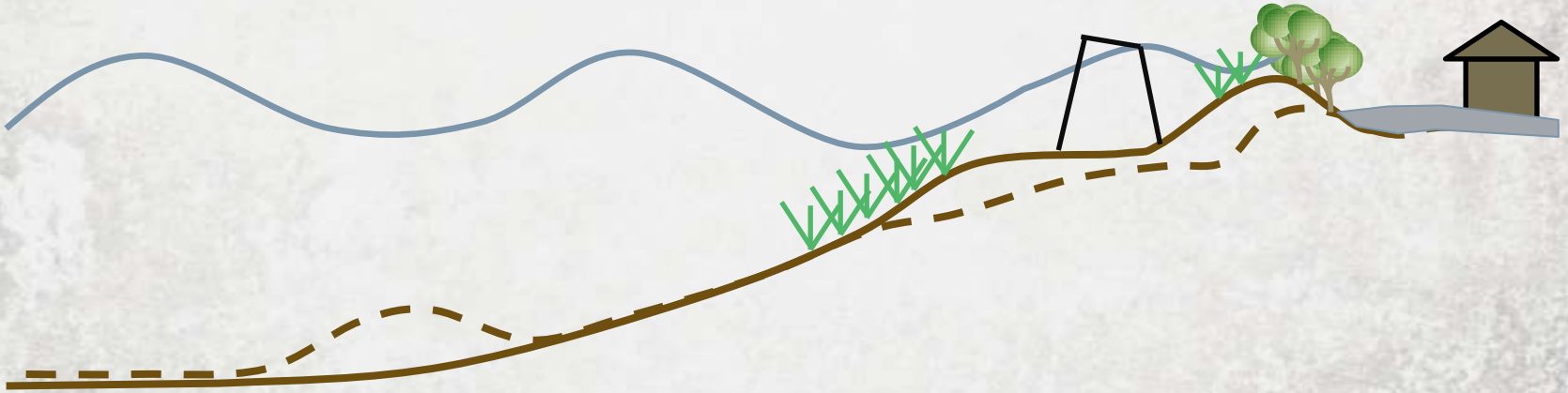
# PROCESS BASED MODELS
## COASTAL PROTECTION

| Forcing Conditions | → | **Attenuation** | → | Hydrodynamic Output | → | Erosion Flooding |
|---|---|---|---|---|---|---|
| Waves<br>Baseline tide<br>Long-term sea-level rise<br>Currents<br>Wind | | **Biogenic habitat**<br>**Abiotic morphology**<br>**'Hard' structures** | | Wave height<br>Mean water level<br>Runup<br>Storm surge | | Near property and people |

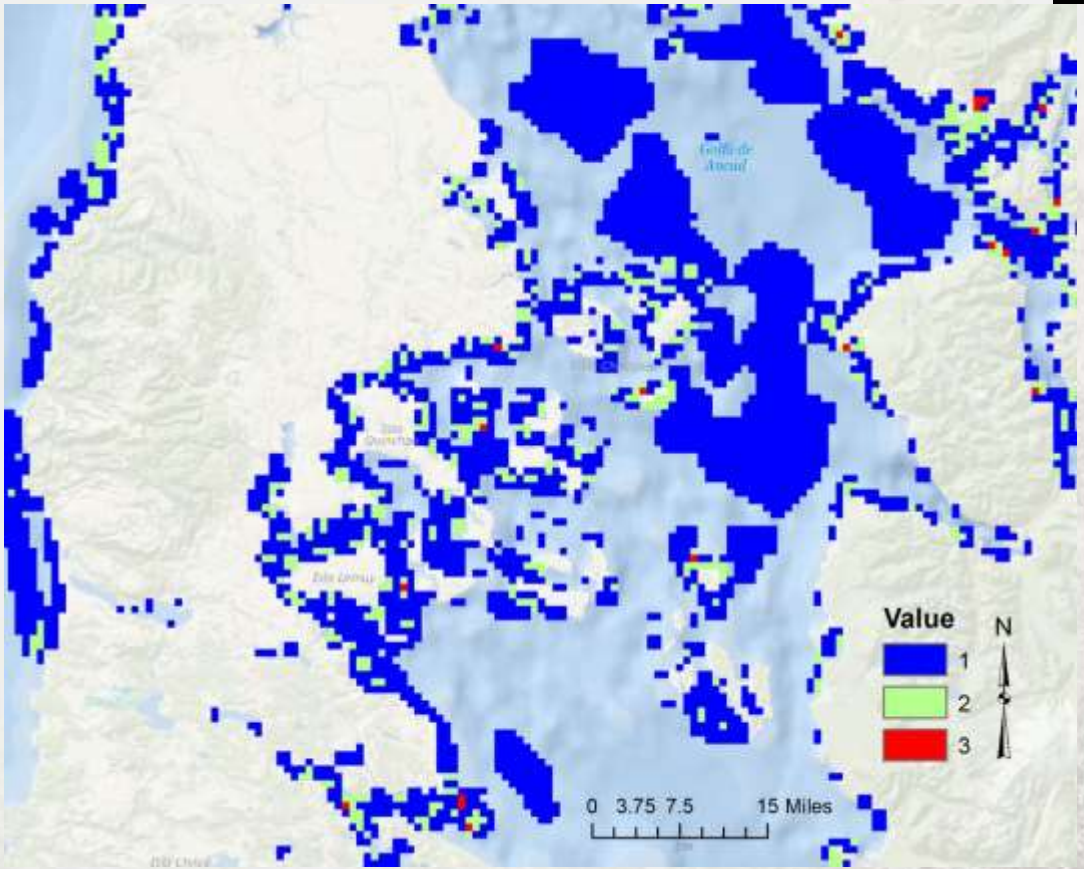


# NON-MONETARY VALUE

## INTENSITY OF USE

**Overlap Analysis tool**

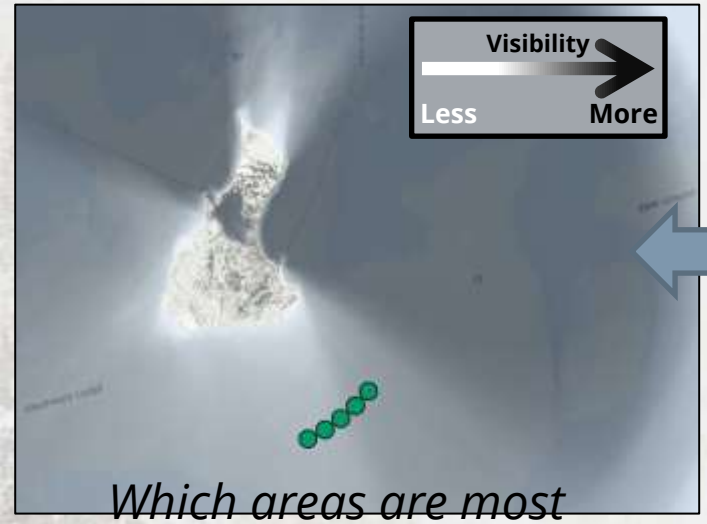
*Which areas are used most intensively?*



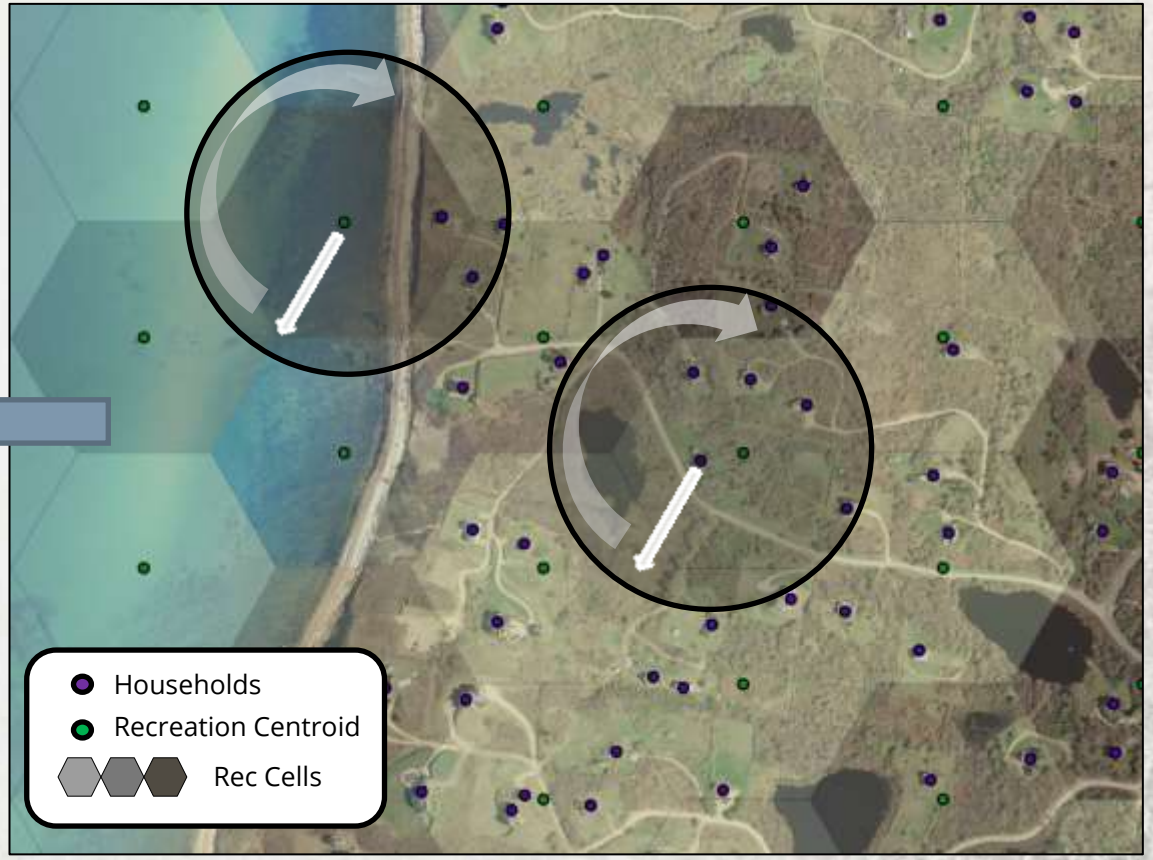
# NON-MONETARY VALUE

## AFFECTED PEOPLE

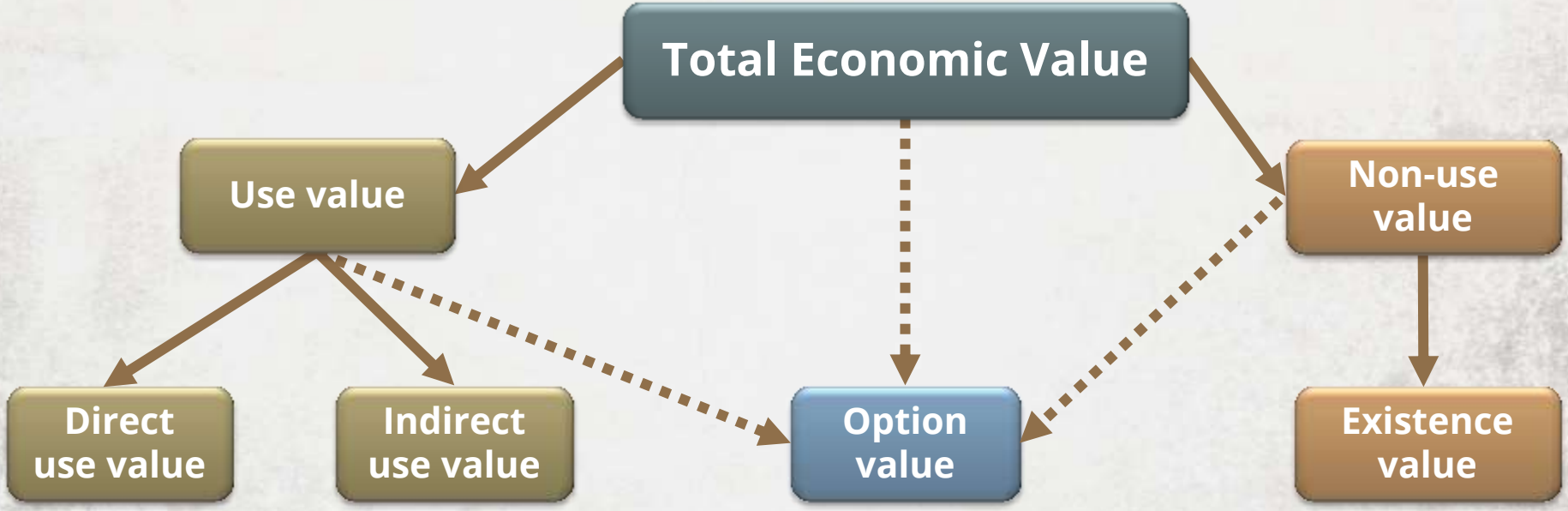
### Aesthetic Quality and Recreation Models




*Which areas are most visible? How many people are impacted by the siting of a visual (dis)amenity?*



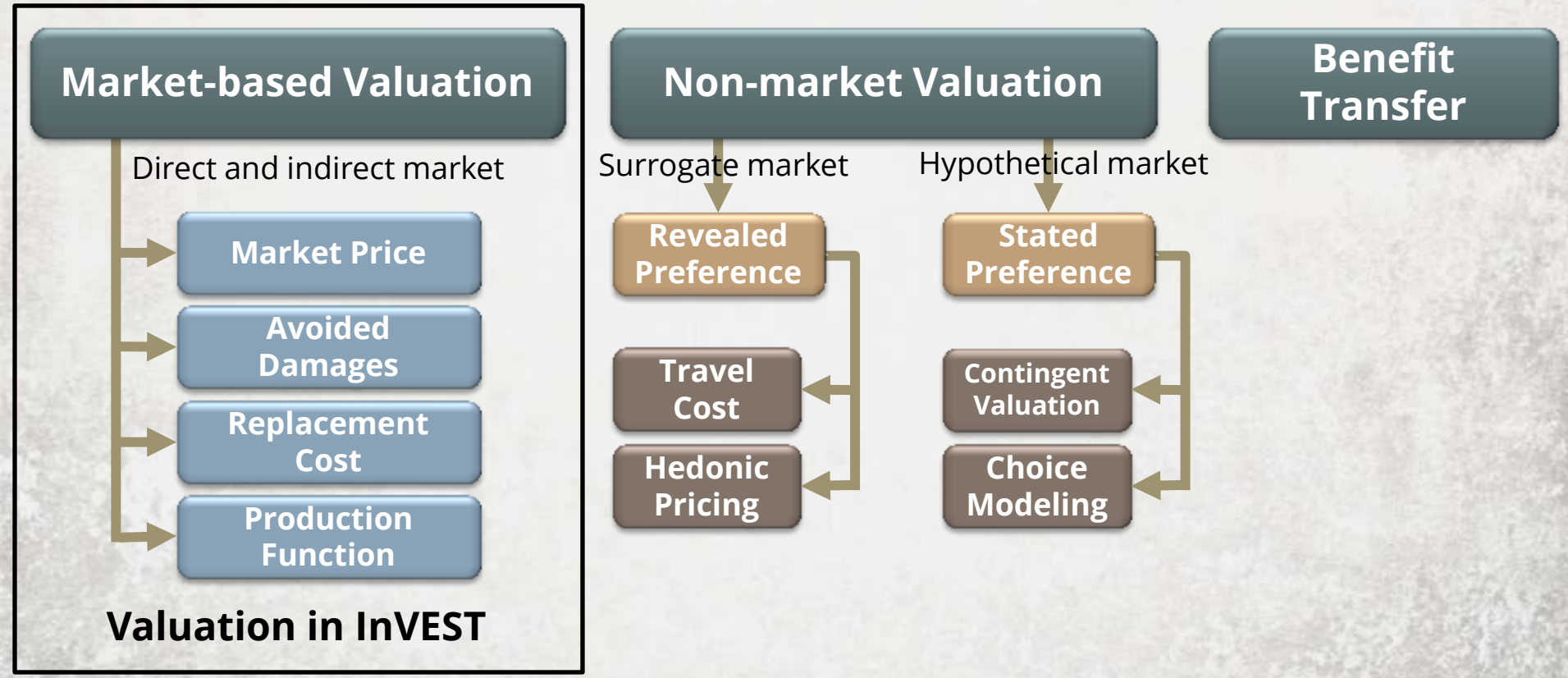
# MONETARY VALUATION




Market-based valuation and non-market valuation

Non-market valuation

# MONETARY VALUATION



# MARKET PRICE
## EXAMPLES FROM INVEST

OFFSHORE WIND ENERGY

TIMBER

RECREATION (EXPENDITURES)

NON-TIMBER FOREST PRODUCTS

# AVOIDED DAMAGES/REPLACEMENT COST

## EXAMPLES FROM INVEST

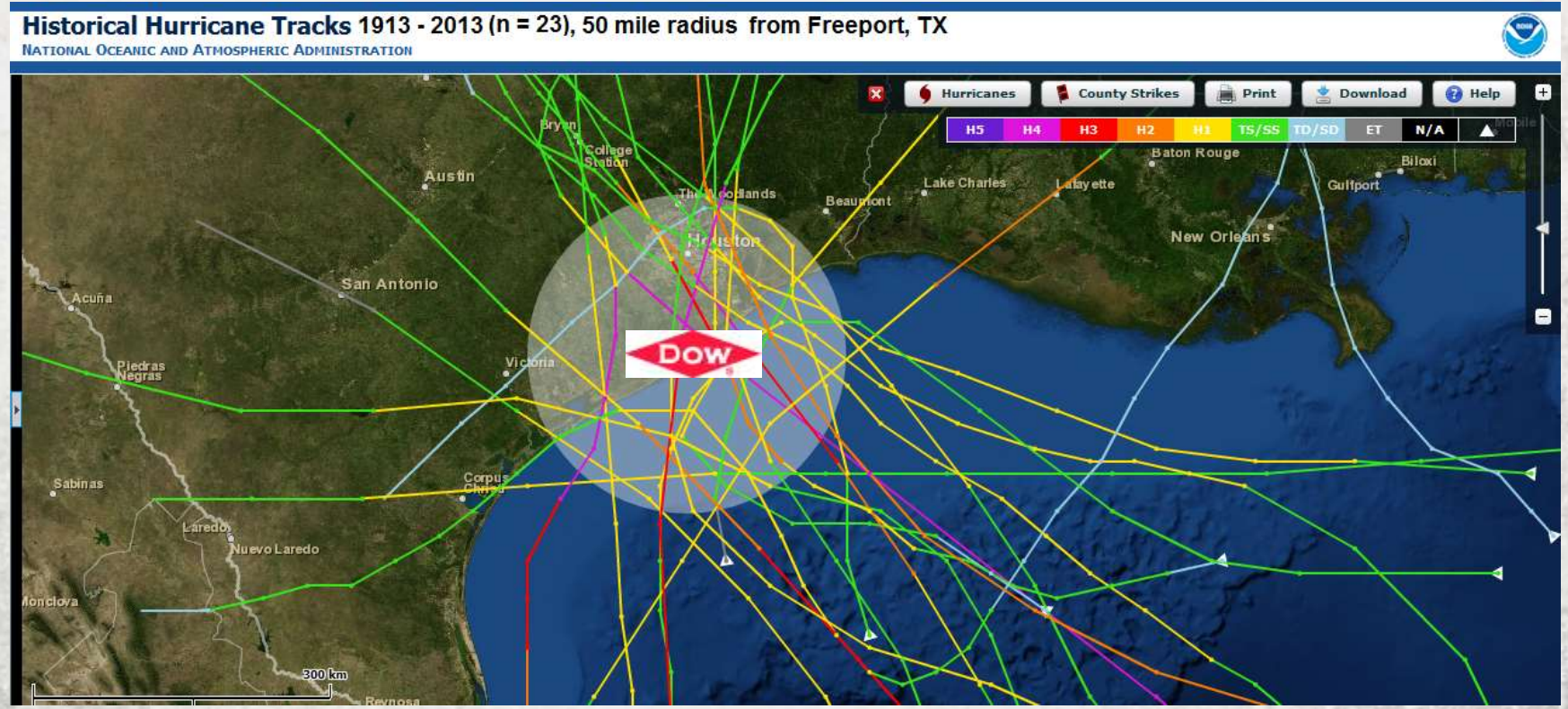
SEDIMENT RETENTION

CARBON SEQUESTRATION (SOCIAL COST)

COASTAL PROTECTION

# COST-BENEFIT ANALYSIS

## COASTAL PROTECTION FOR DOW CHEMICAL FACILITIES



# COST-BENEFIT ANALYSIS

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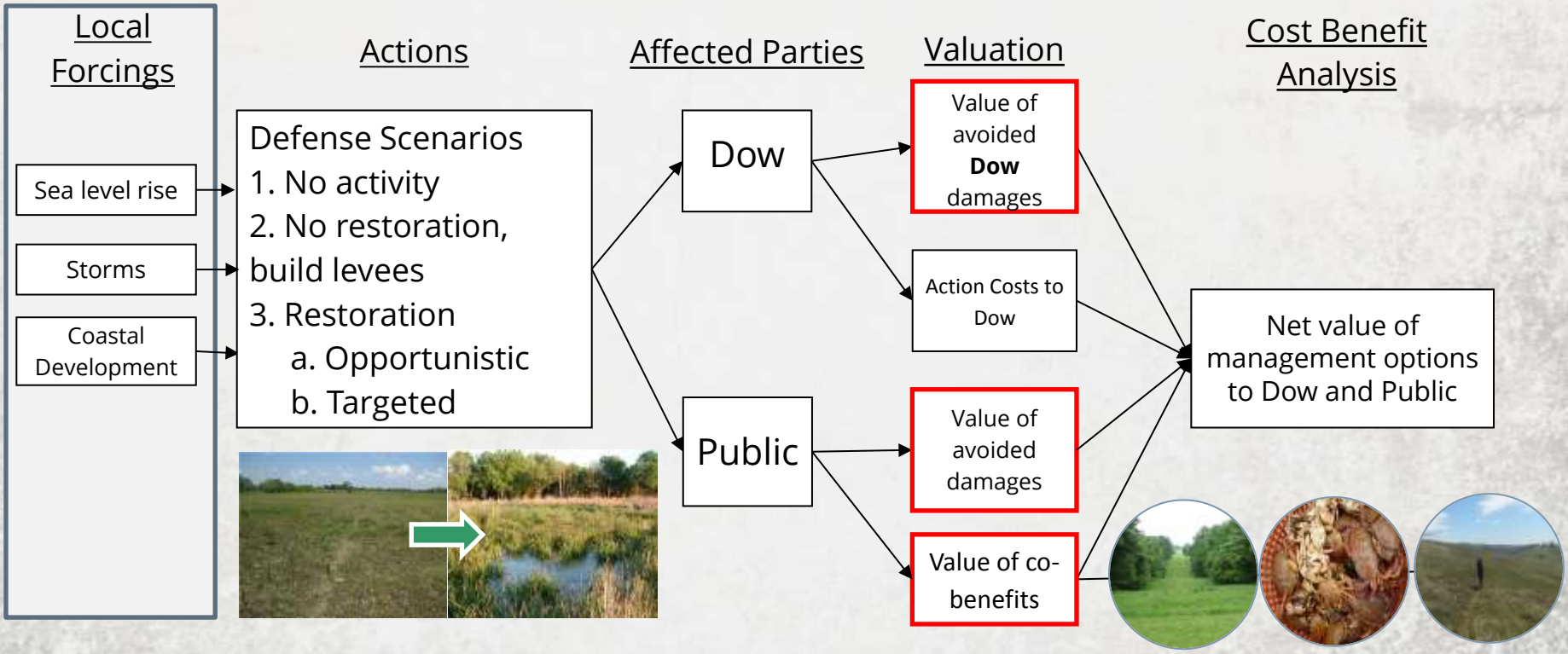
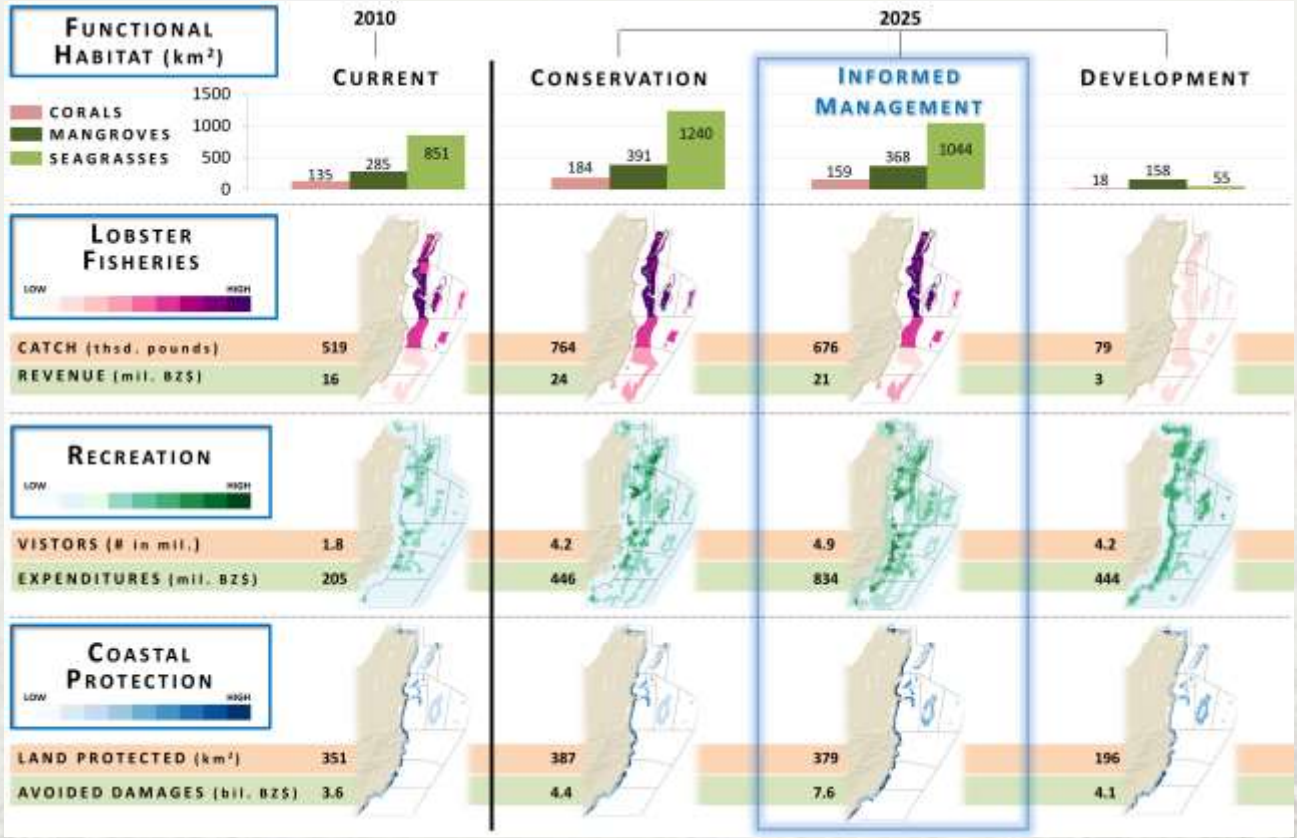


# COST-BENEFIT ANALYSIS

## BELIZE EXAMPLE



# SCENARIOS AND OPTIMIZATION

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InVEST

integrated valuation of environmental services and tradeoffs

Scenario-based analysis and optimization using Python

Optimal conservation for watershed ecosystem services under a budget

RIOS

# HIGHLIGHTS

**What** is ecosystem service valuation?

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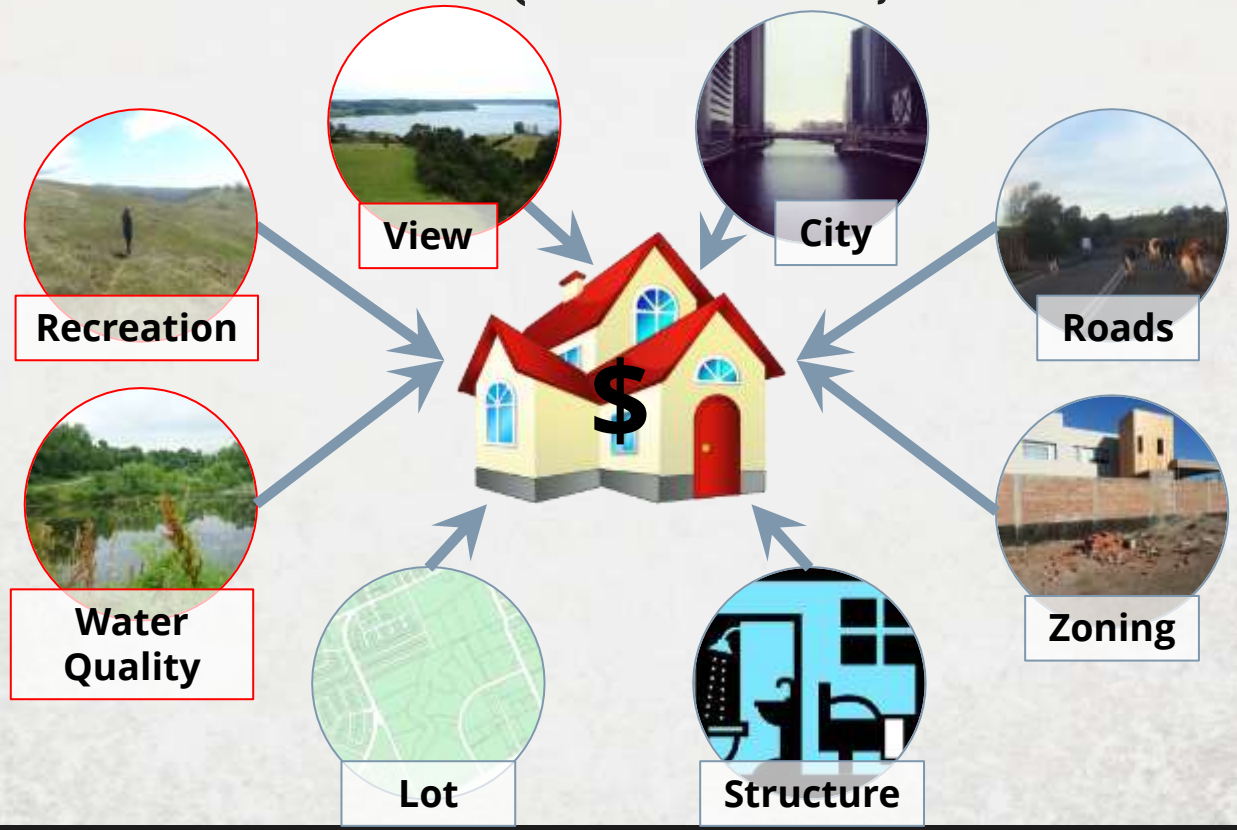
# HEDONIC PRICING

## LAND/PROPERTY PRICE= *F* (ATTRIBUTE1, ATTRIBUTE2,…)



# STATED PREFERENCE
## CONTINGENT VALUATION AND CHOICE MODELLING

### Contingent valuation

Ask respondents to express their willingness to pay (WTP) or willingness to accept (WTA) for changes in ecosystem services

### Choice modeling

Ask respondents to rank/rate/choose alternative choice sets which have different combination of price attribute and ecosystem attributes

# BENEFIT TRANSFER
## CONCEPTS

Benefit transfer uses values from existing studies to estimate value elsewhere

Value transfer → $/unit

Function transfer → f($, site or study attributes)

# BENEFIT TRANSFER
## EXAMPLE

FEMA (Federal Emergency Management Agency)
Mitigation Policy FP-108-024-01
2013

*Service Based*

Notes

1. Service based (not bundled by land cover type)
2. Constant $ per acre
3. Similarity of
    a. Service
    b. Context

*Constant*

$ Benefits per acre per year

| | GREEN OPEN SPACE | RIPARIAN |
|---|---|---|
| Aesthetic Value | $1,623 | $582 |
| Air Quality | $204 | $215 |
| Biological Control | -- | $164 |
| Climate Regulation | $13 | $204 |
| Erosion Control | $65 | $11,447 |
| Flood Reduction | -- | $4,007 |
| Food Provisioning | -- | $609 |
| Habitat | -- | $835 |
| Pollination | $290 | -- |
| Recreation | $5,365 | $15,178 |
| Storm Water Retention | $293 | -- |
| Water Filtration | -- | $4,252 |

# BENEFIT TRANSFER
## RESOURCES

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Recreation Use Values Database

OSU Oregon State University

Envalue

New South Wales
Australia

EARTH ECONOMICS
ecosystem valuation toolkit

# NON-MONETARY VALUE

- Jobs/employment
- Poverty
- Food security
- Vulnerability
- Health/nutrition
- Cultural importance
- Happiness

- *Biophysical measures of services*

# THANKS!

## MODEL SUMMARY

| Method | ES type | InVEST model |
|---|---|---|
| Market price | Provisioning Service | **Fish Aquaculture**<br>**Managed Timber Production**<br>**Wave Energy**<br>**Hydropower Production**<br>**Wind energy**<br>**Recreation (expenditures)**<br>**Agricultural Production**<br>**Non-timber Forest Product Production**<br>**Fisheries** |
| | Regulating Service | **Carbon Sequestration (Marine, Terrestrial)**<br>**Water for Irrigation** |
| Avoided damages/ replacement cost | Regulating Service | **Nutrient Retention**<br>**Sediment Retention**<br>**Carbon Sequestration**<br>**Coastal Protection**<br>**Storm Peak Mitigation** |
| Non $ Values | All | **Overlap Analysis**<br>**Scenic Quality**<br>**Coastal Vulnerability**<br>**Pollination** |
| NA | Cultural/Supporting /Regulating Services | Biodiversity/Habitat quality and rarity<br>Habitat risk assessment |

# Q&A