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## ECOSYSTEM SERVICES RESEARCH PROGRAM

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

# Incorporating Ecosystem Services into Coastal and Watershed Management



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ORD/NHEERL/Atlantic Ecology Division

## Ecosystem Services: the benefits people obtain from ecosystems

Tourism & Recreation



Fishing

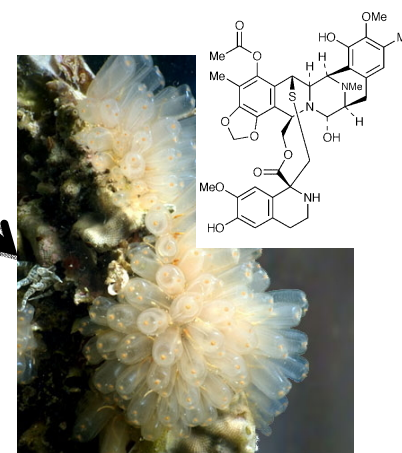


Ecosystem Integrity



Shoreline Protection

Natural Products



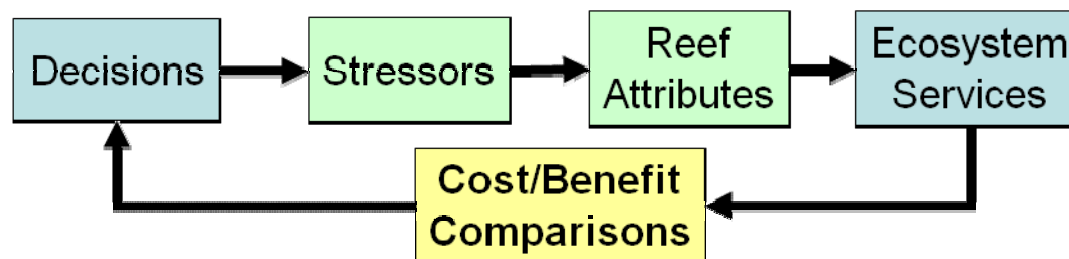
# **Ecology will Replace Physics as the Master Science**

*(Thomas Homer-Dixon 2009)*

- The dominant scientific discipline of a historical epoch.
- Generates and orders the concepts through which society understands itself and its relation to its surroundings.

## Research Areas

- 1) Understanding human land- and water-use decisions
- 2) Links between human activity (stressors) and coral reef condition (reef attributes)
- 3) Links between coral reef condition and delivery of ecosystem services
- 4) Understanding consequences of decisions on delivery of coral reef ecosystem services
- 5) Methods to communicate and incorporate information and analyses into future decisions



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## Decision Workshops



- Characterize the biophysical landscape
  - Overviews on state of the ecosystem, primary stressors and proposed management plans
  - Plotting in a DPSIR framework
- Identify priority environmental issues
- Characterize the decision landscape
  - Social Network Analysis: who interacts with whom on what matters
  - Legislation
  - Scientific information
- Elaborate potential management options





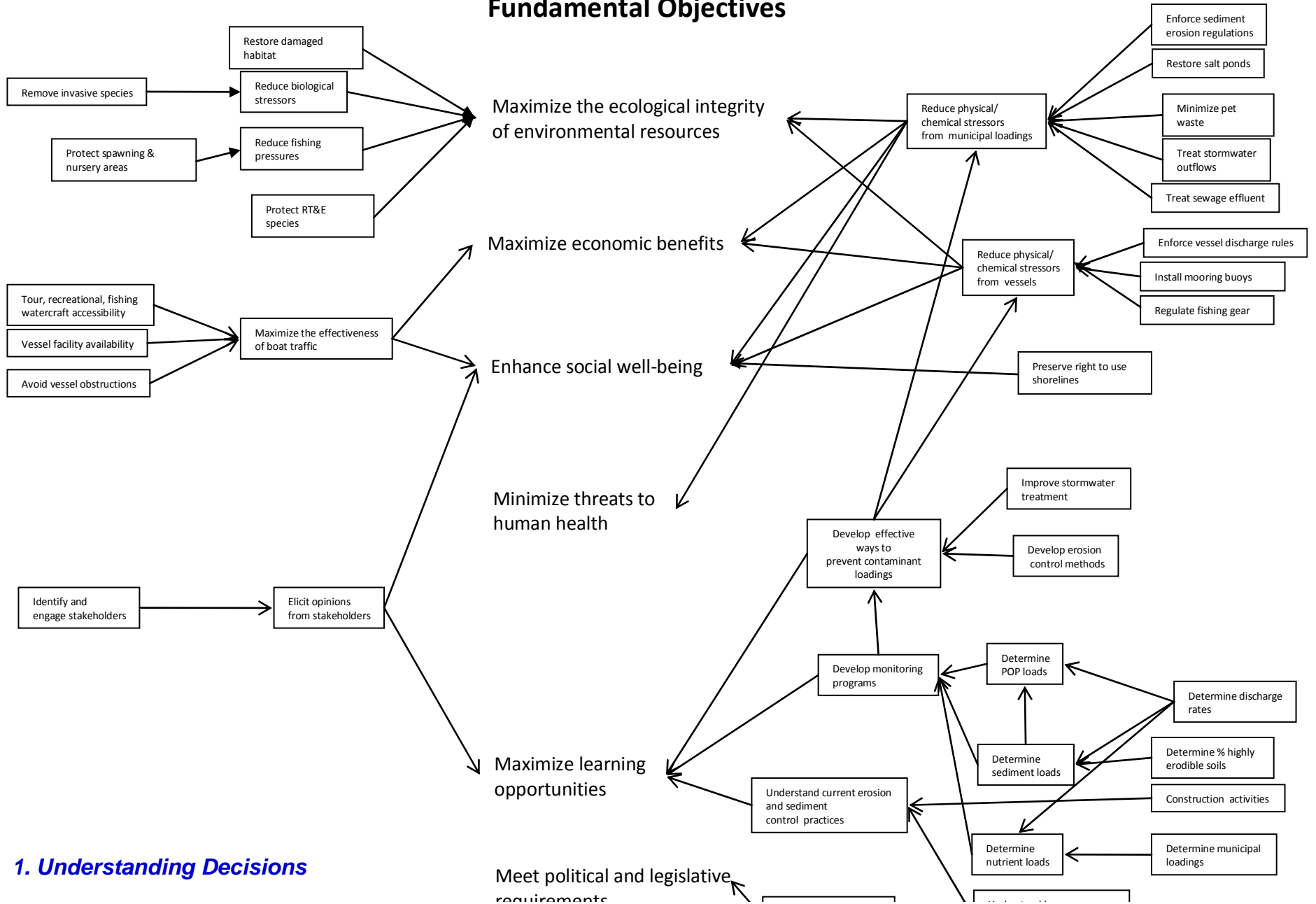
# Objectives Hierarchy

Manage coastal resources to improve quality of life in USVI

1. Maximize **ecological integrity** of reefs
  - a. maximize diversity & abundance of reef species
2. Maximize economic benefits
  - a. maximize economic benefit from **tourism**
  - b. maximize **sustainable fisheries** (quantity & quality)
  - c. minimize **shoreline erosion** and **storm damage**
3. Enhance social well-being of residents
  - a. maximize **aesthetic value** of resources
  - b. maximize **recreational opportunities**
4. Minimize threats to human health from floods, pathogens, and poor **water quality**
5. Maximize learning opportunities
  - a. maximize **educational opportunities** and communicate risks
  - b. maximize use of information in decisions
6. Meet political and legislative requirements in decision-making

# Means-Ends Network

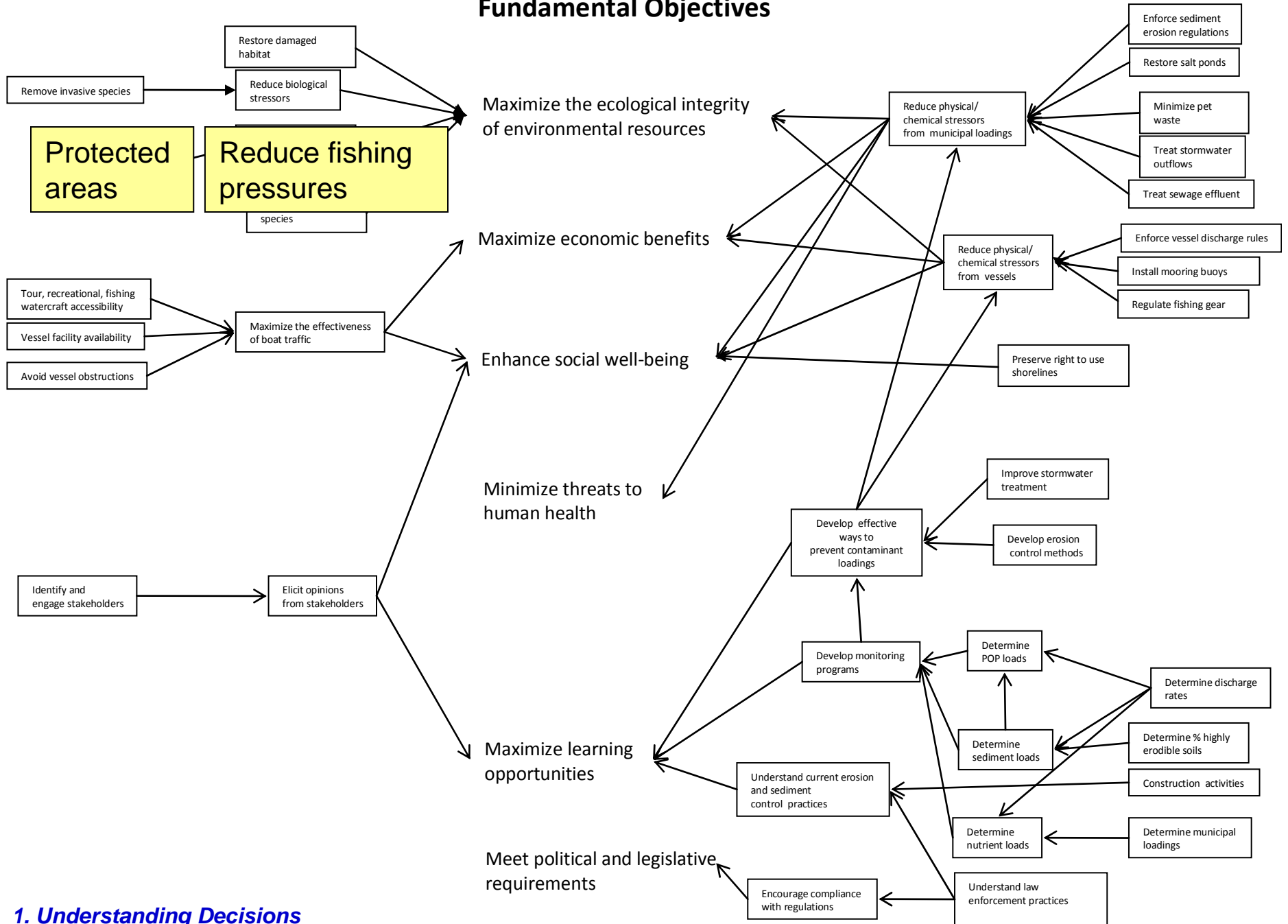
## Fundamental Objectives



### 1. Understanding Decisions

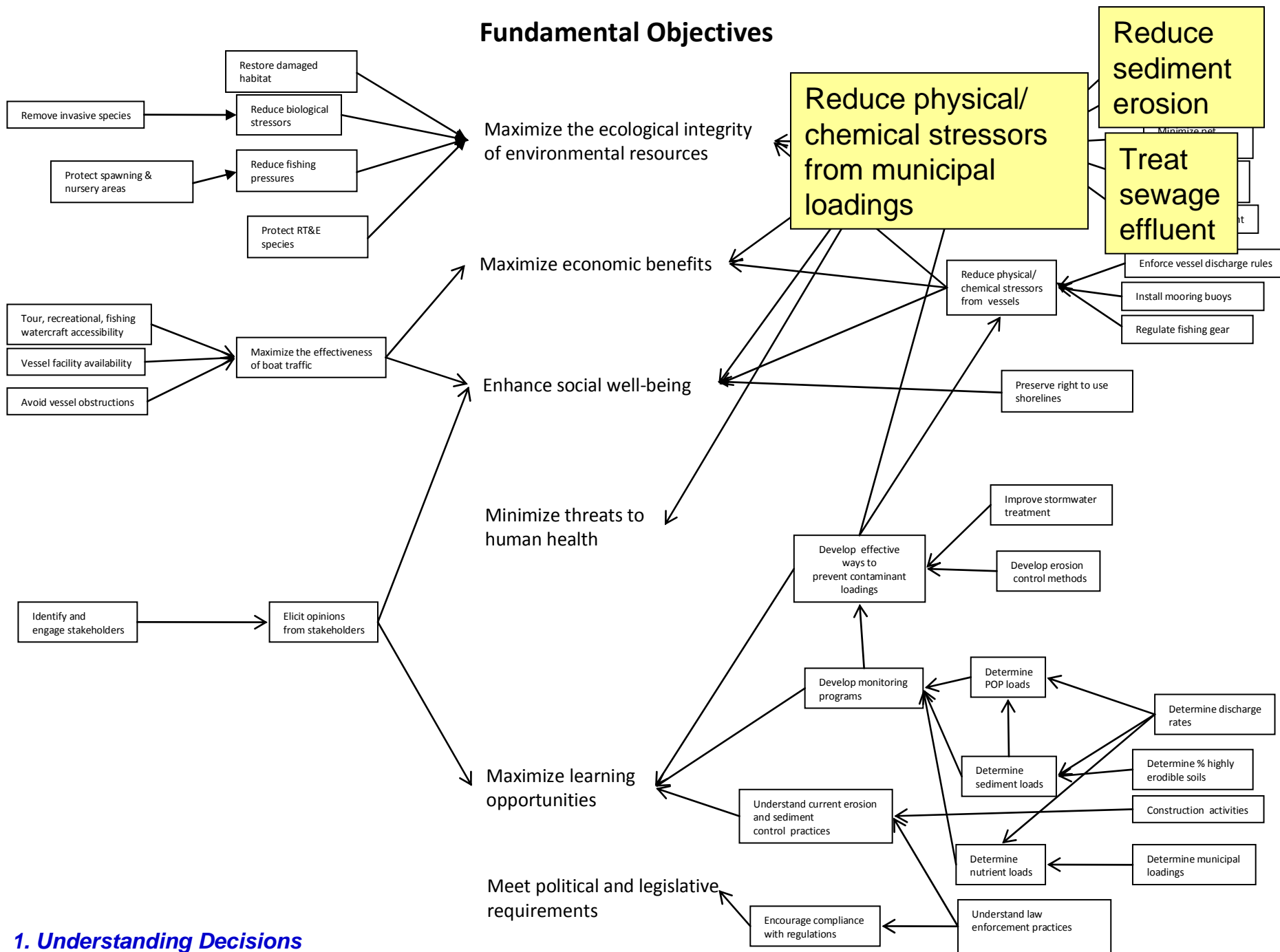


# Fundamental Objectives



## 1. Understanding Decisions

# Fundamental Objectives



## 1. Understanding Decisions

# Knowledge Base

## Literature Database

- **Identifies the published literature relevant to coral reef ecosystems**

## Legislative Atlas

- **Identifies the laws, regulations, and policies that are currently in place (at vastly different scales - from global to national to state levels) related to coral reef ecosystems**

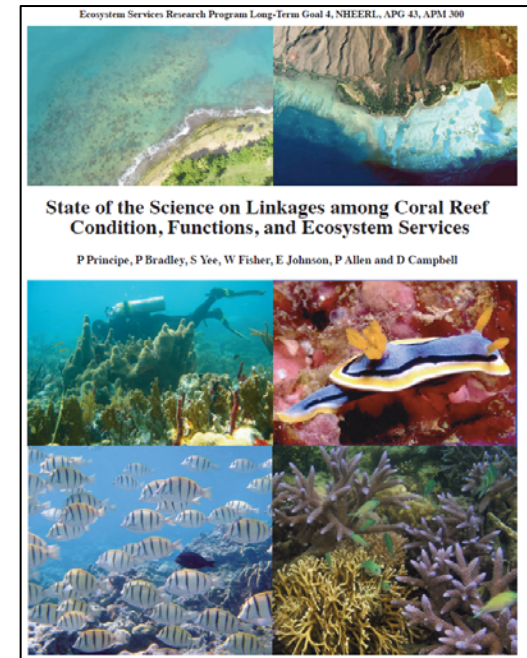
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# Connecting Reef Attributes to Ecosystem Services

## Literature Review

- What services have been identified?
- How were services measured?
- How were services valued?
- How can reef attributes be translated into services?
- What indicators estimate delivery of services?



## Reef Attributes relevant to Ecosystem Services

Attributes	Shoreline Protection	Fishing	Natural Products	Tourism and Recreation				
				Diving, Snorkeling & Underwater Photography	Sport Fishing	Surfing	Beach Activities	Viewing Nature
Overall Marine Diversity & Abundance								
Fish Diversity & Abundance								
Coral Diversity & Abundance								
Water Clarity								
3D Reef Structure								
Wildlife Diversity								
White coralline Sands								
Invertebrate Diversity								
Shallow Water								

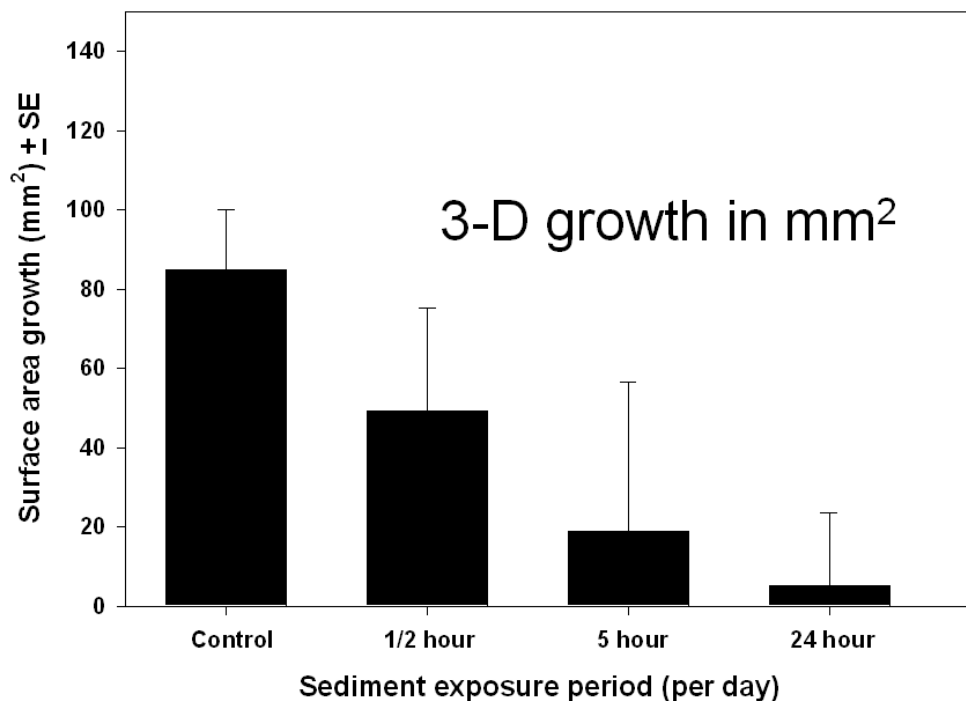


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# Dose-response Relationships

2-week sediment exposure period



# Human-disturbance Gradient

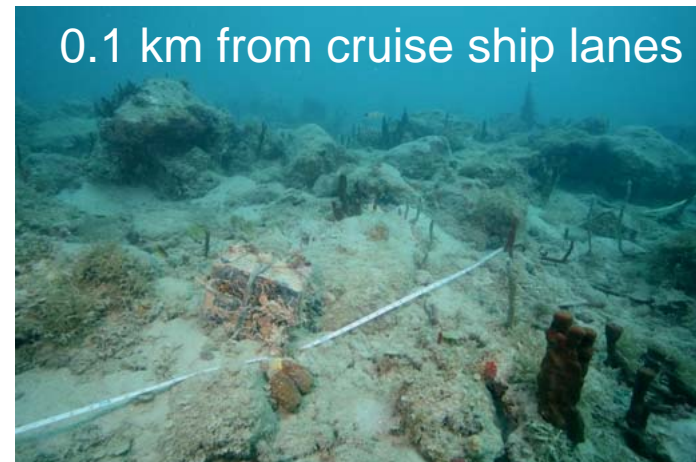
Including:  
Sediment  
Nutrient  
Contaminants  
Physical damage

1 km from cruise ship lanes

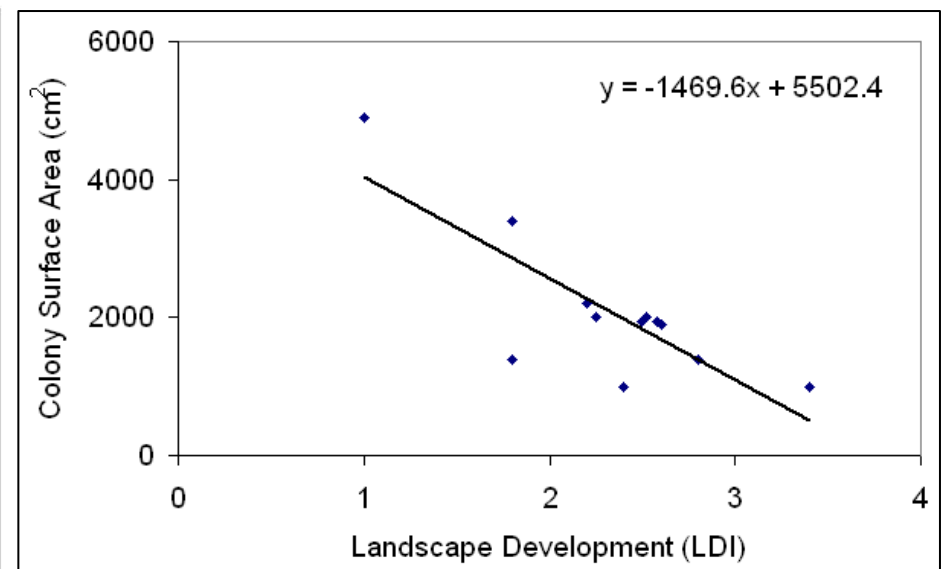
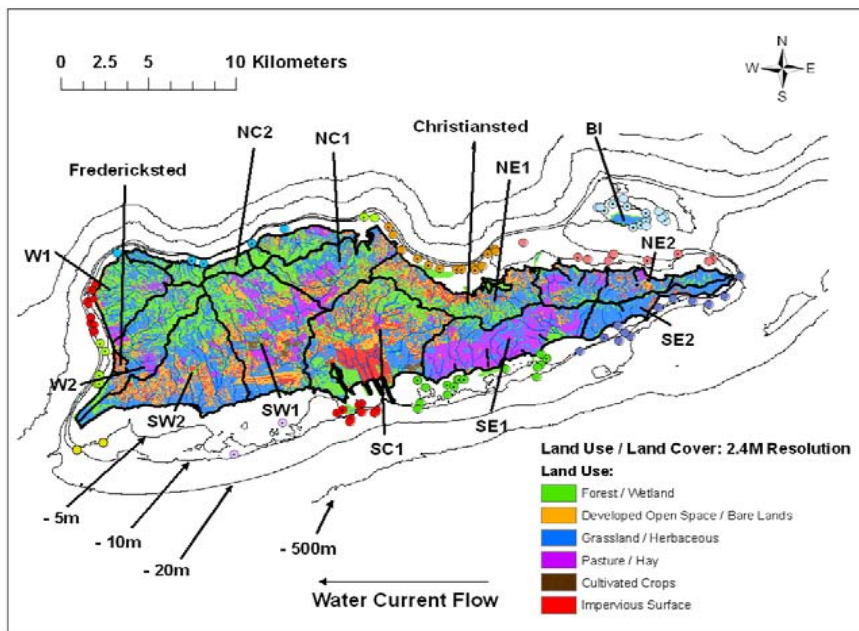


St. Thomas, USVI

0.1 km from cruise ship lanes



# Linking Landscape Activity to Reefs



Landscape Development Intensity (LDI) Index: Quantifies human impact in the watershed

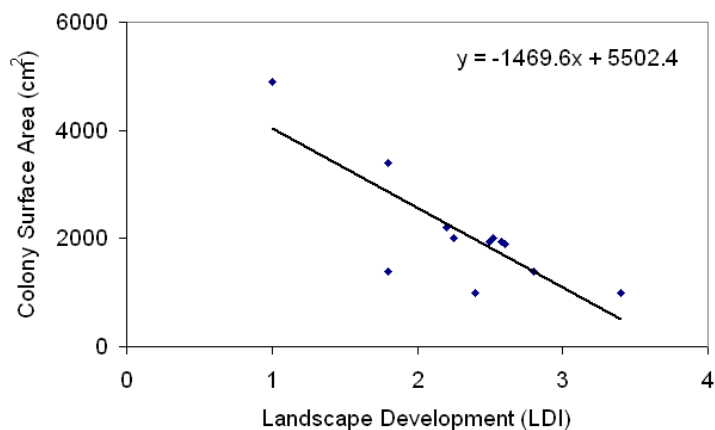
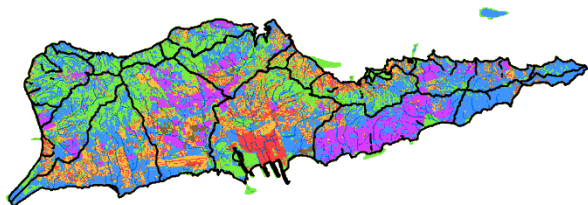
## Significant correlations between LDI & coral attributes

- Coral density
- Taxa richness
- Average colony surface area
- 3D Total cover

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# Building a Bayesian Network



LDI	
0 to 1	0
1 to 2	100
2 to 3	0
3 to 4	0
4 to 5	0
5 to 9	0
1.5 ± 0.29	

LDI	
0 to 1	0
1 to 2	0
2 to 3	0
3 to 4	0
4 to 5	0
5 to 9	100
7 ± 1.2	

Coral Colony Surface Area (cm <sup>2</sup> )	
0 to 1000	7.23
1000 to 2000	7.23
2000 to 3000	7.23
3000 to 6000	78.3
3850 ± 1500	

Coral Colony Surface Area (cm <sup>2</sup> )	
0 to 1000	57.2
1000 to 2000	19.4
2000 to 3000	11.7
3000 to 6000	11.7
1390 ± 1400	

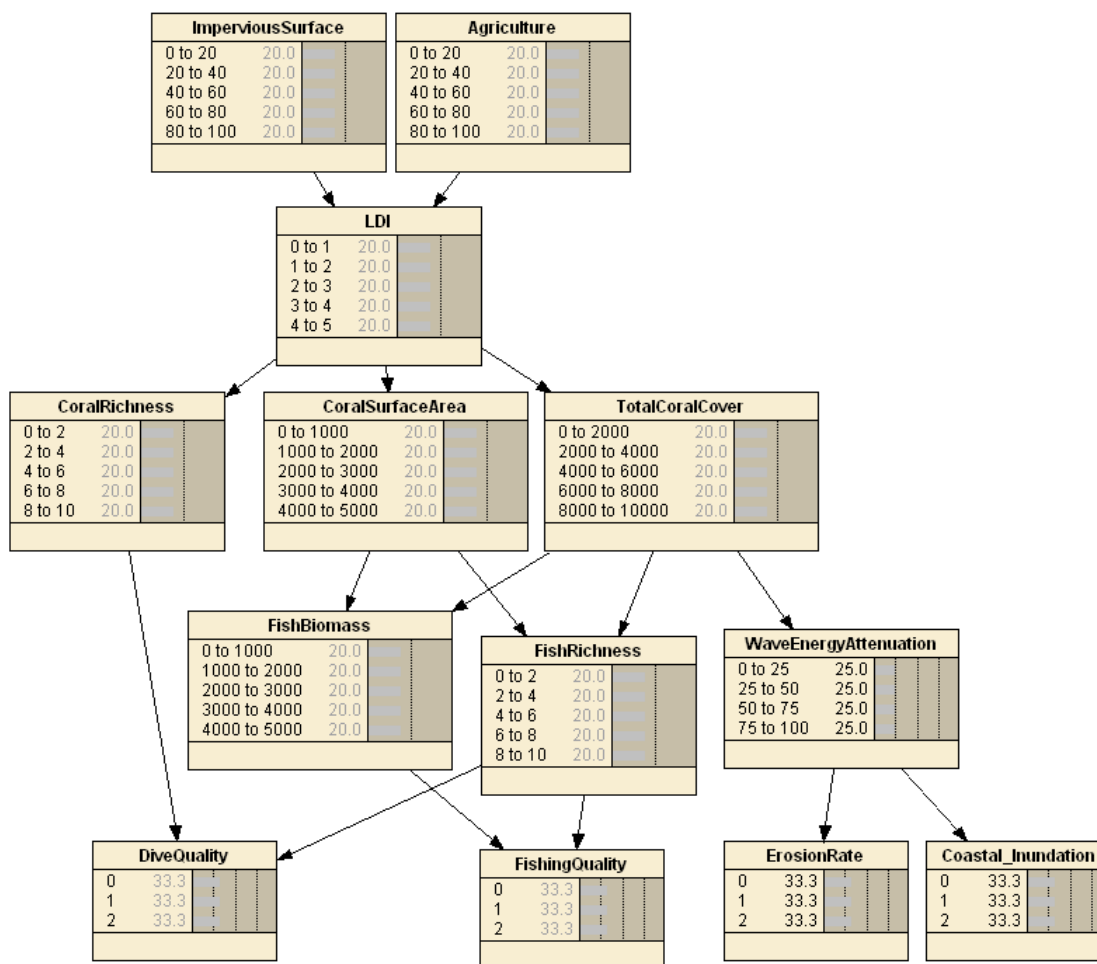
- LDI from 1 to 2
- 78% chance coral surface area >3000

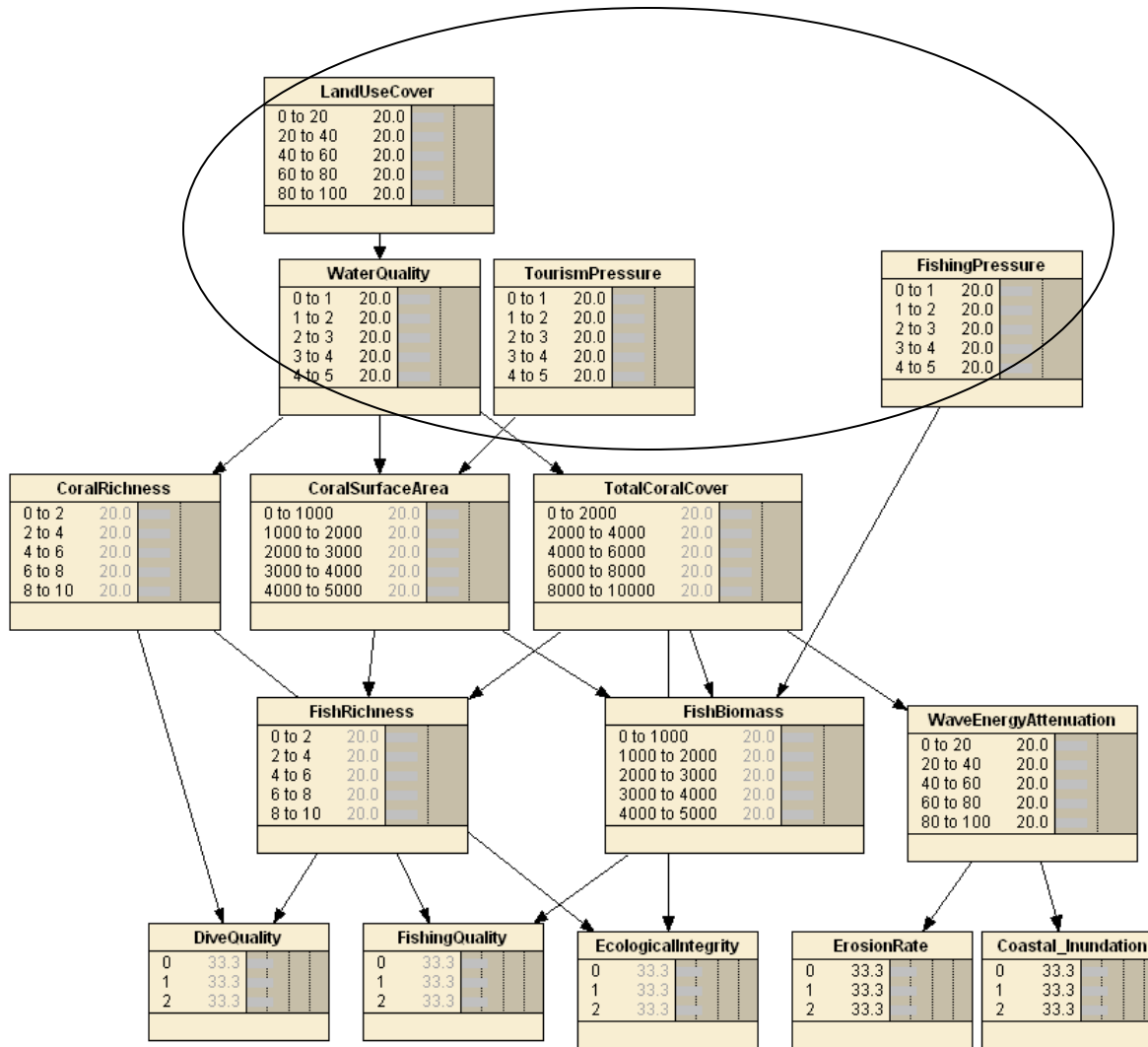
- LDI from 5 to 9
- 57% chance coral surface area <1000



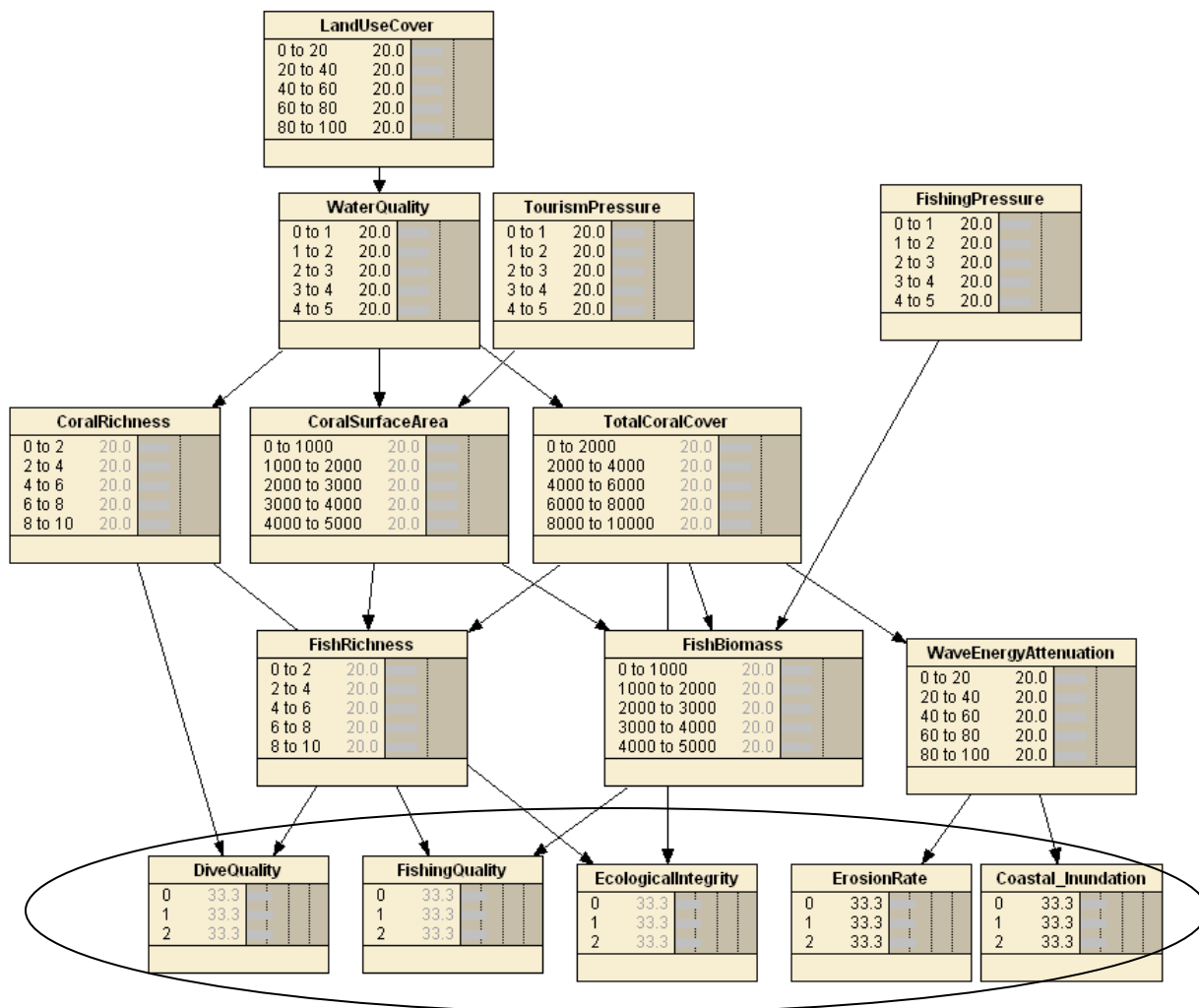


# Link condition to ecosystem services



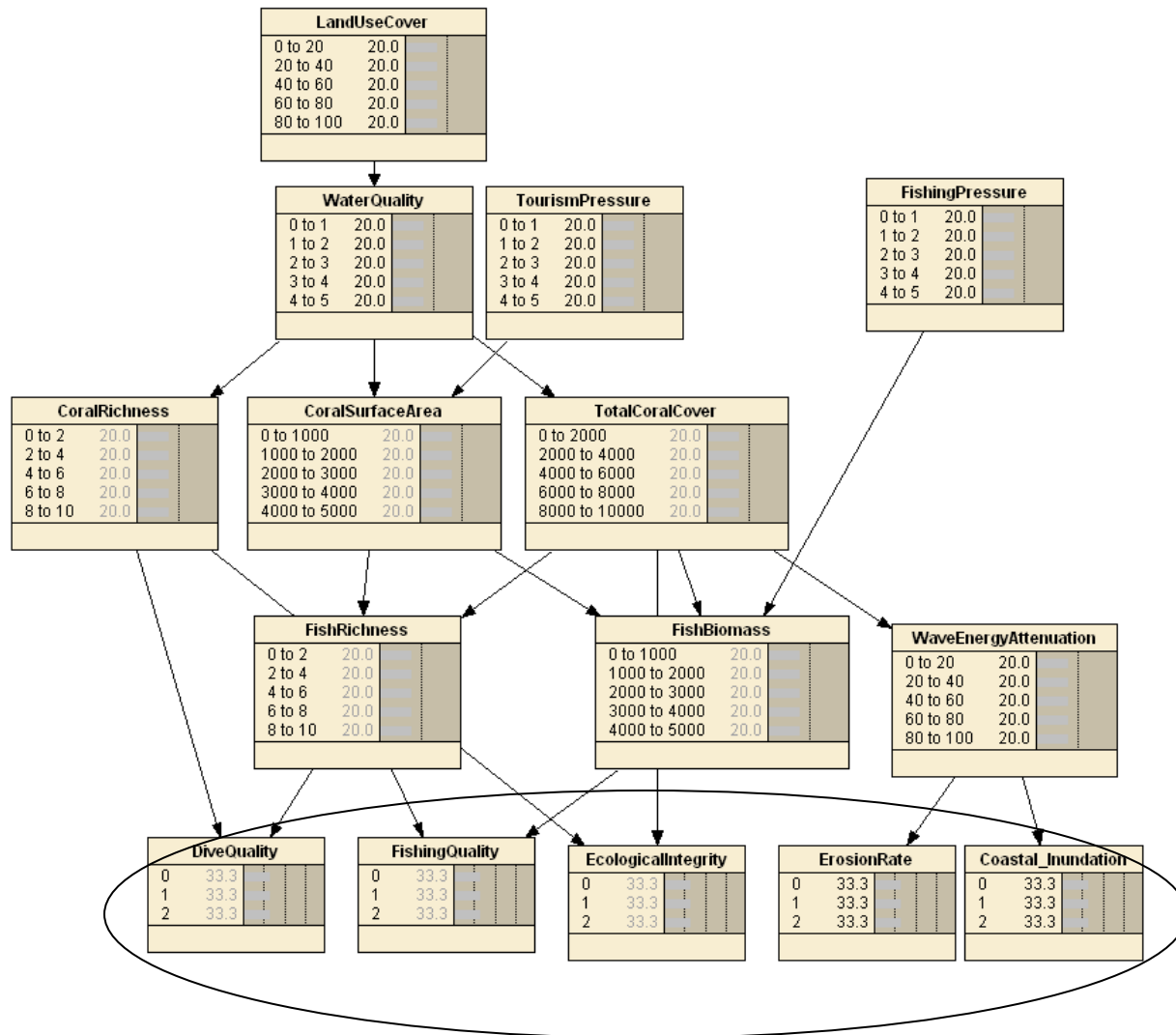


If we change this pressure...

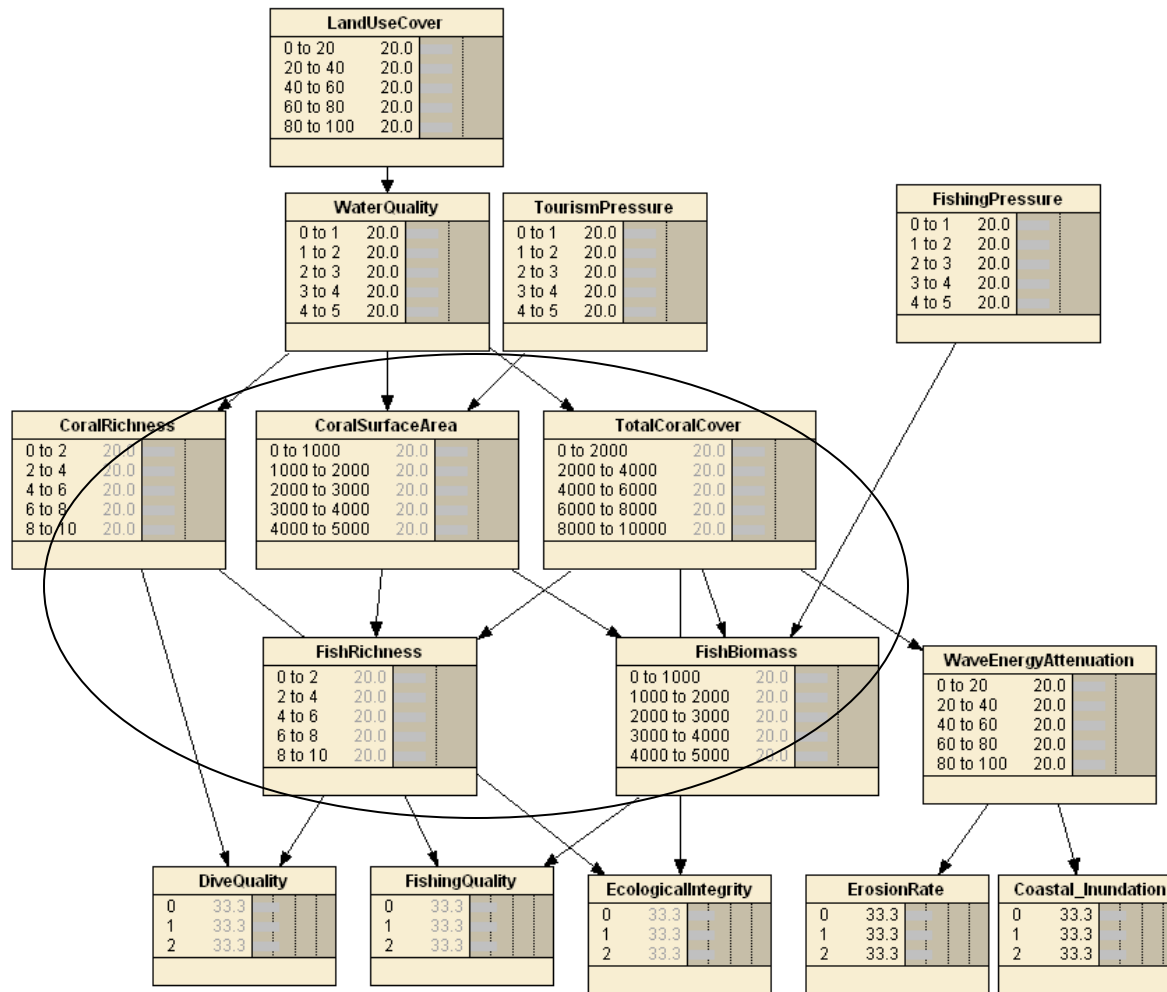


If we change this pressure...

...what is the effect on ecosystem services?

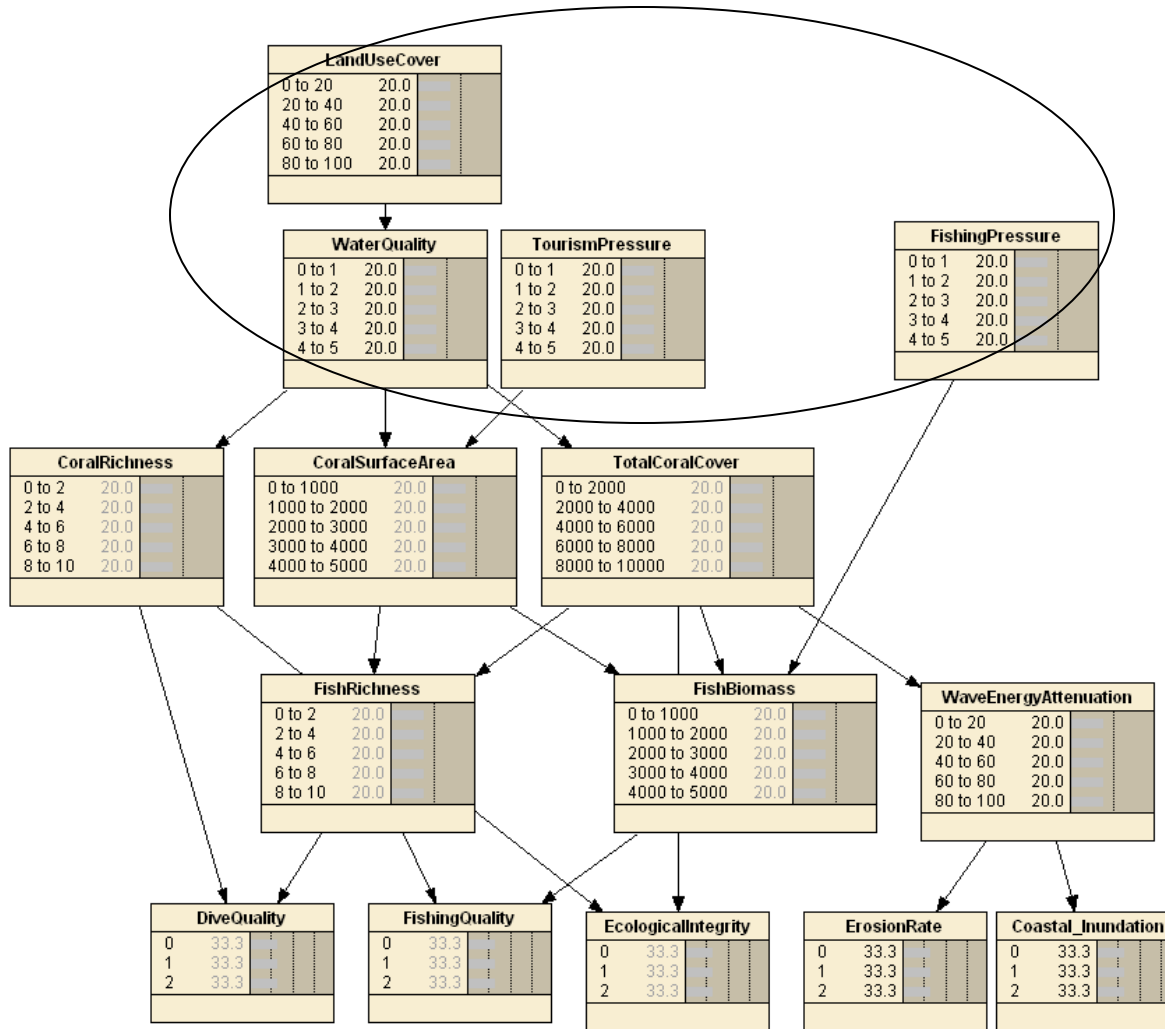


If we want to achieve this level of ecosystem services...



What level of reef condition do we need?

If we want to achieve this level of ecosystem services...



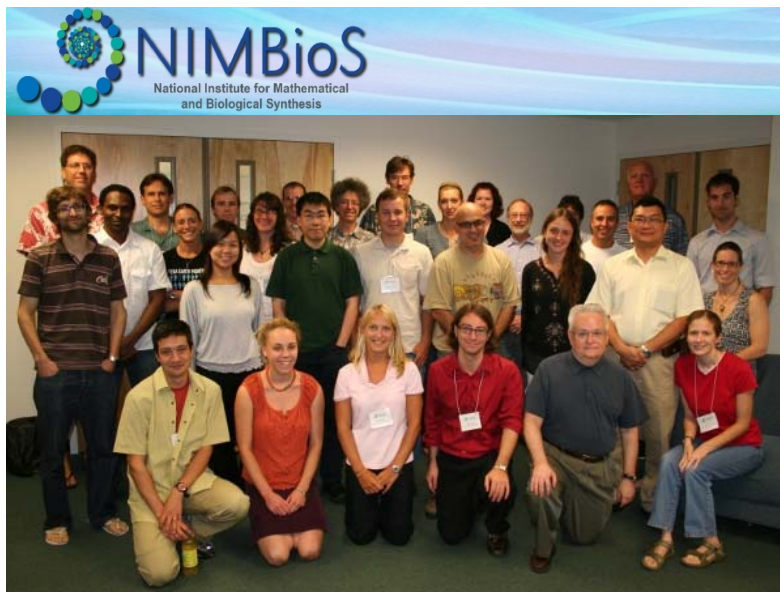
And to what level must we reduce pressures?

What level of reef condition do we need?

If we want to achieve this level of ecosystem services...

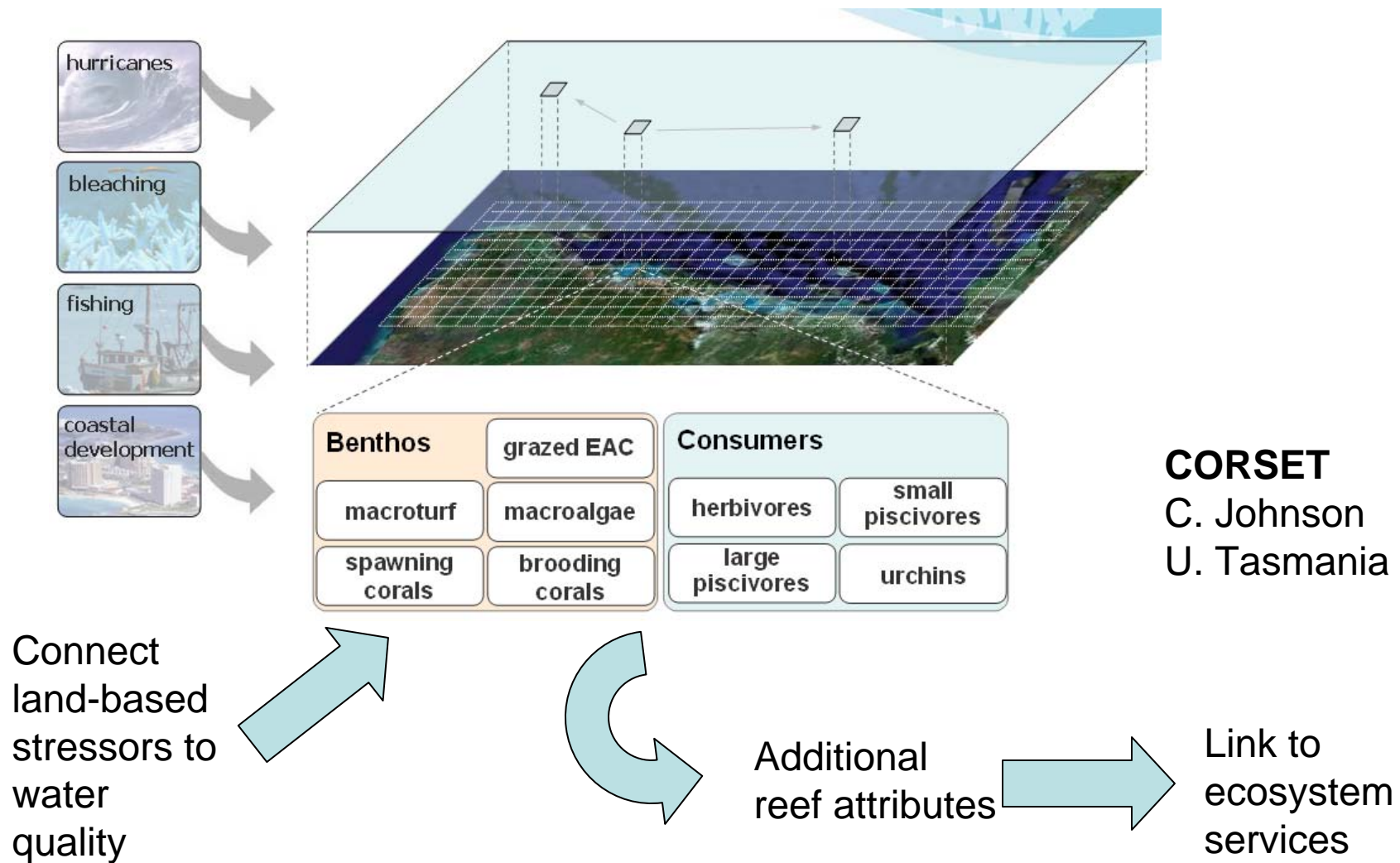


# Modeling Sustainable Delivery of Reef Ecosystem Services

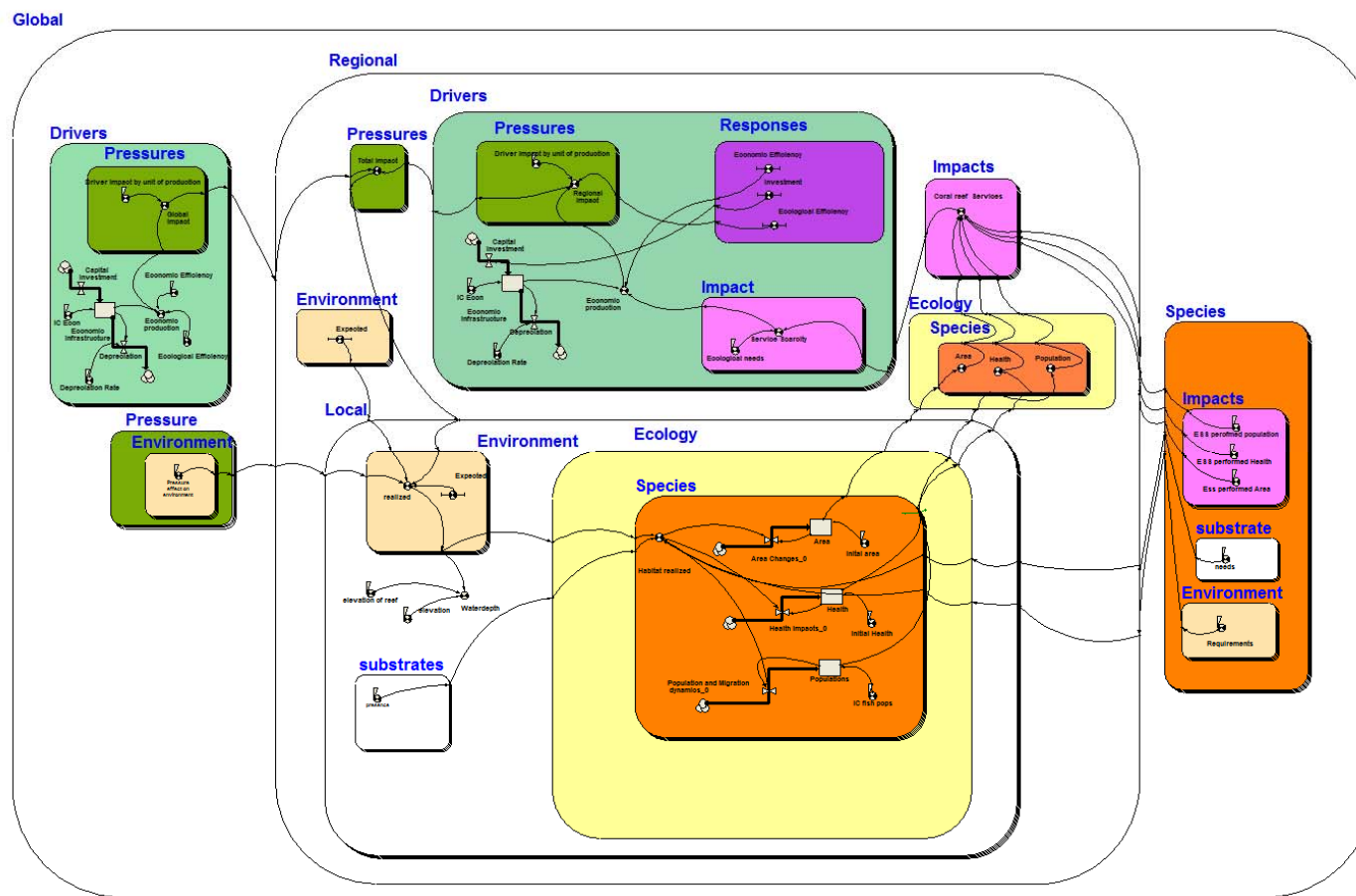


- **A systems dynamic approach for Spatial Dynamic, Modeling and Valuation of Ecosystem Services.**

- **Simulate Ecosystems and Human Systems in Space**
- **Simulate Ecosystems and Human Systems over Time**
- **Simulate the interactions between the eco and human systems through coupling**



## Decision-support whole-systems models



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**EPA** United States Environmental Protection Agency

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## Reef Decision Support Database

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### Reef Ecosystem Services & Decision Support Database

#### A Systems Approach to Managing Reef Ecosystems

A brief description of the DSD. A brief description of the DSD. A brief description of the DSD. description of the DSD. A brief description of the DSD. A brief description of the DSD. A brief description of the DSD. More information...

#### Explore the Conceptual Systems Model and Database

Whole Systems Concept Map

Concept Maps by Topic

Database by Topic


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## DPSIR Framework

- Driver - Pressure - State - Impact - Response

Basic DPSIR Concepts

**DPSIR Overview - DPSIR Framework**

The **Driver-Pressure-State-Impact-Response (DPSIR)** scheme is a flexible framework that can be used to assist decision-makers in many steps of the decision process. DPSIR was initially developed by the Organisation for Economic Co-operation and Development (OECD) and has been used by the United Nations and European Environmental Agency to relate human activities to the state of the environment.

DPSIR has been widely used for many applications including

- Management of water resources (Boja, LaJeunesse, Mysiak et al. 2005)
- Wetlands (Turner)

Outline Notes Slide 2 of 45 Slide Show