COUPLED COASTAL TOWN RISK FRAMEWORK to EVALUATE MANAGEMENT DECISIONS

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moffatt & nichol

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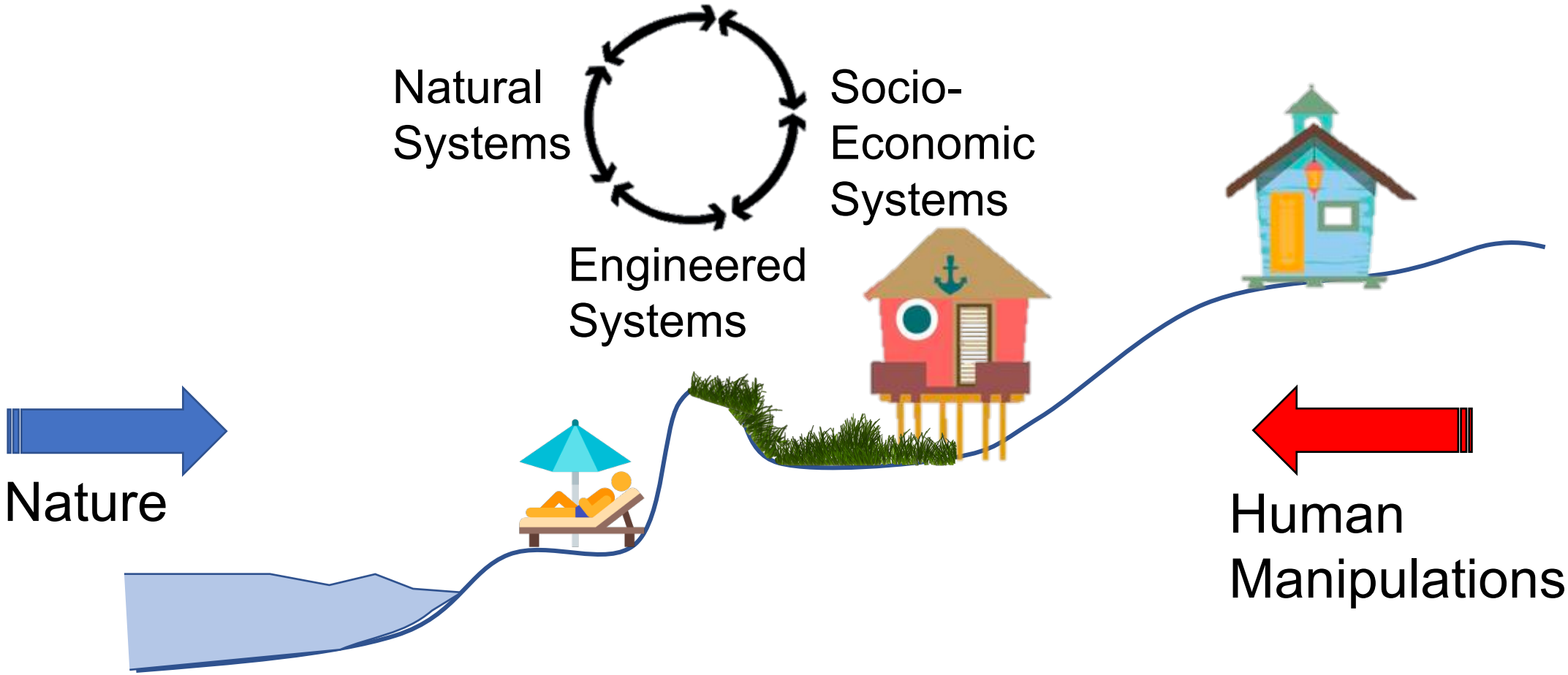
Coast as a coupled system



OBJECTIVE

represent change of coastal landforms (human and nature sourced)

involve social dynamics of coastal decision making

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DEVELOP HUMAN-NATURE COUPLED COASTAL TOWN MODEL

Nature

Human Manipulations

estimate consequences of abrupt changes to the system

CoMOD – Coastal Management and Occupation Dynamics Model

Represent the evolution of the coast

Integrate risk perception and amenities

DEVELOP HUMAN-NATURE COUPLED COASTAL TOWN MODEL

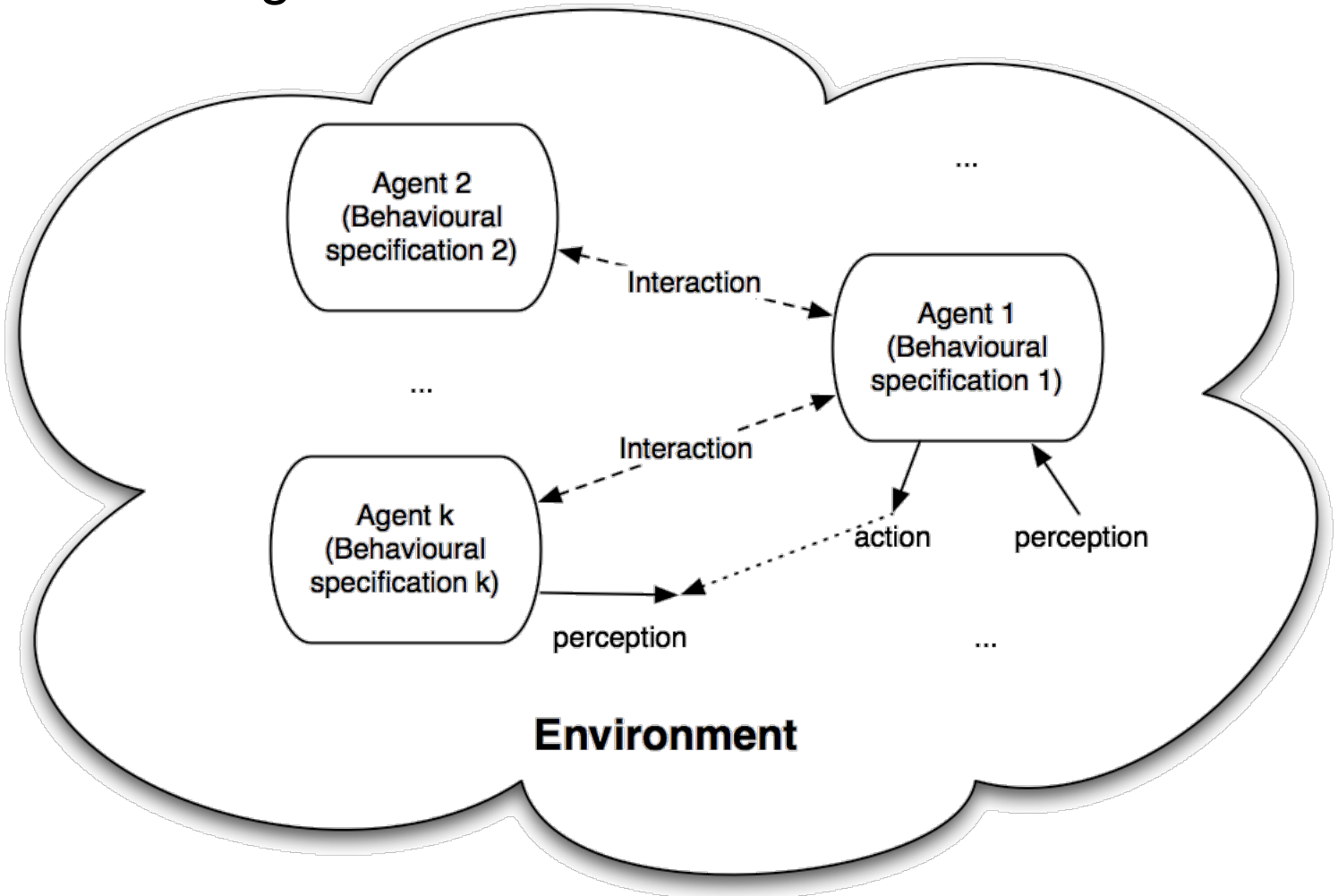
Simulate households, occupancy decisions

Simulate towns, management decisions

Utilize geospatial data, census data and historical reports

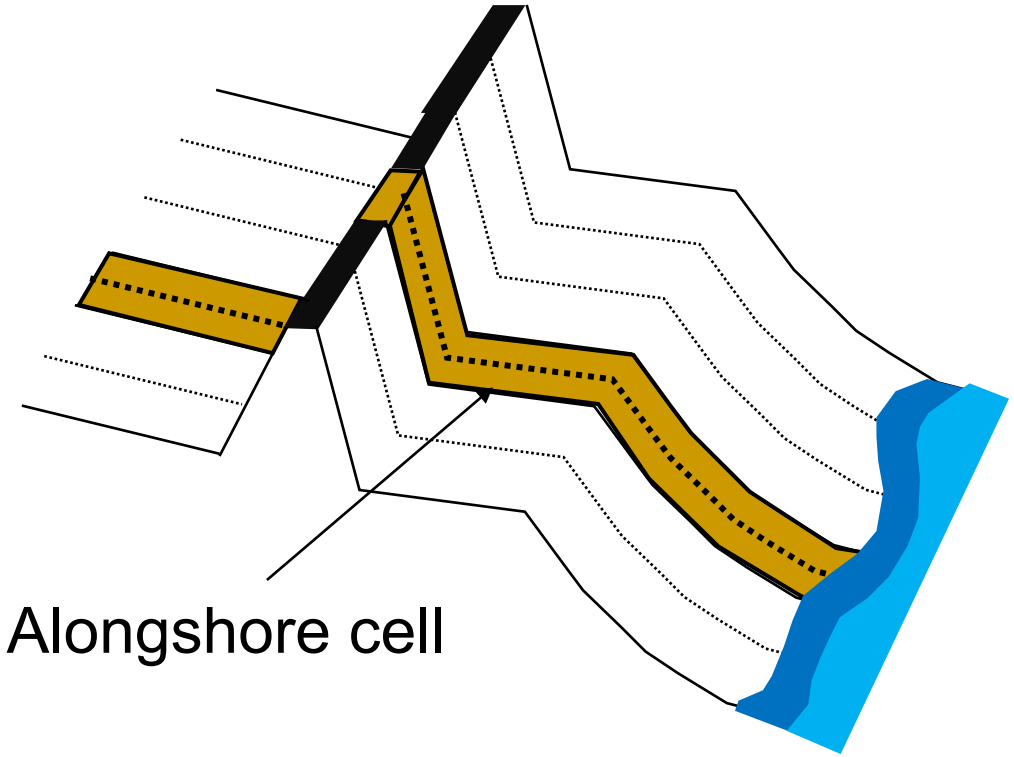
AGENT BASED MODELING

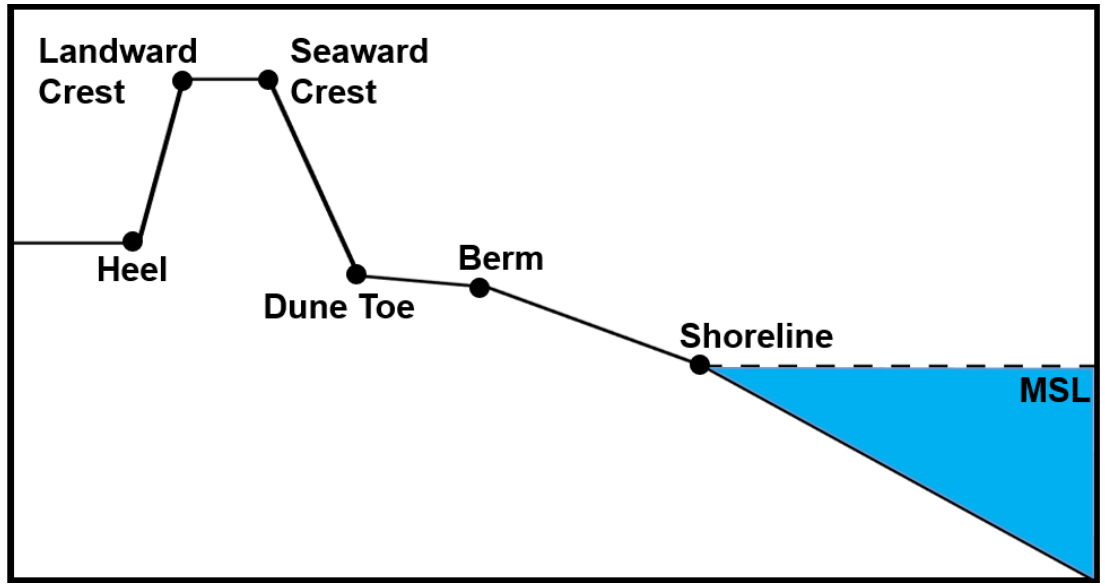
A representation of a system in which **agents** interact with each other and their **environment** using a set of **rules**



MODEL ENVIRONMENT

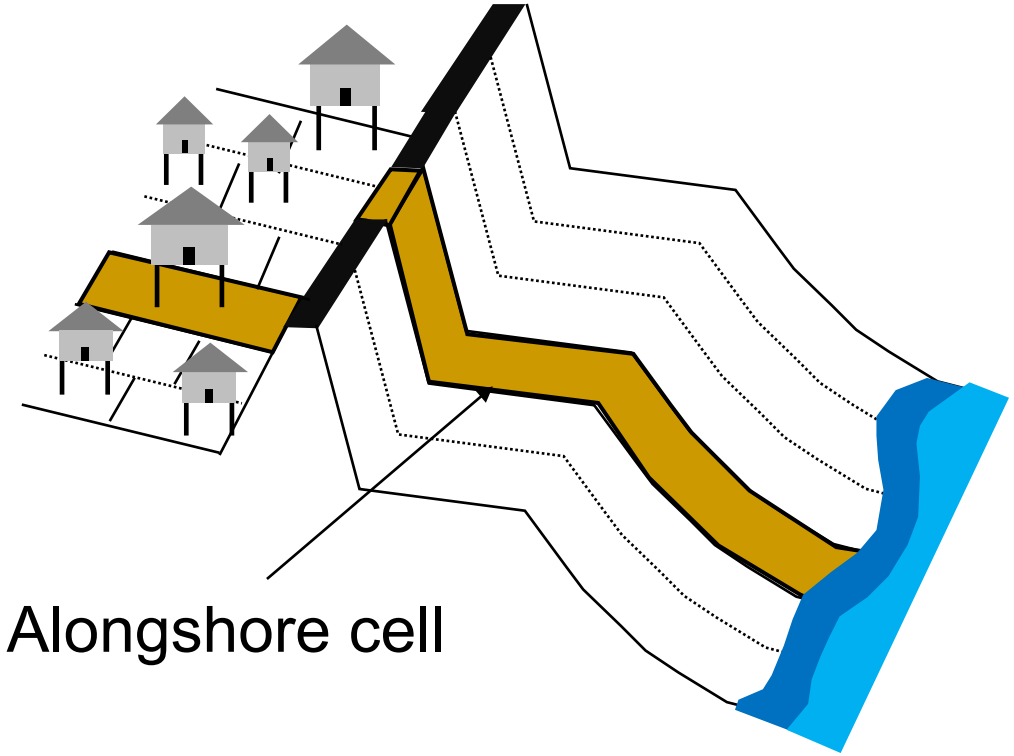
Topographic Layer

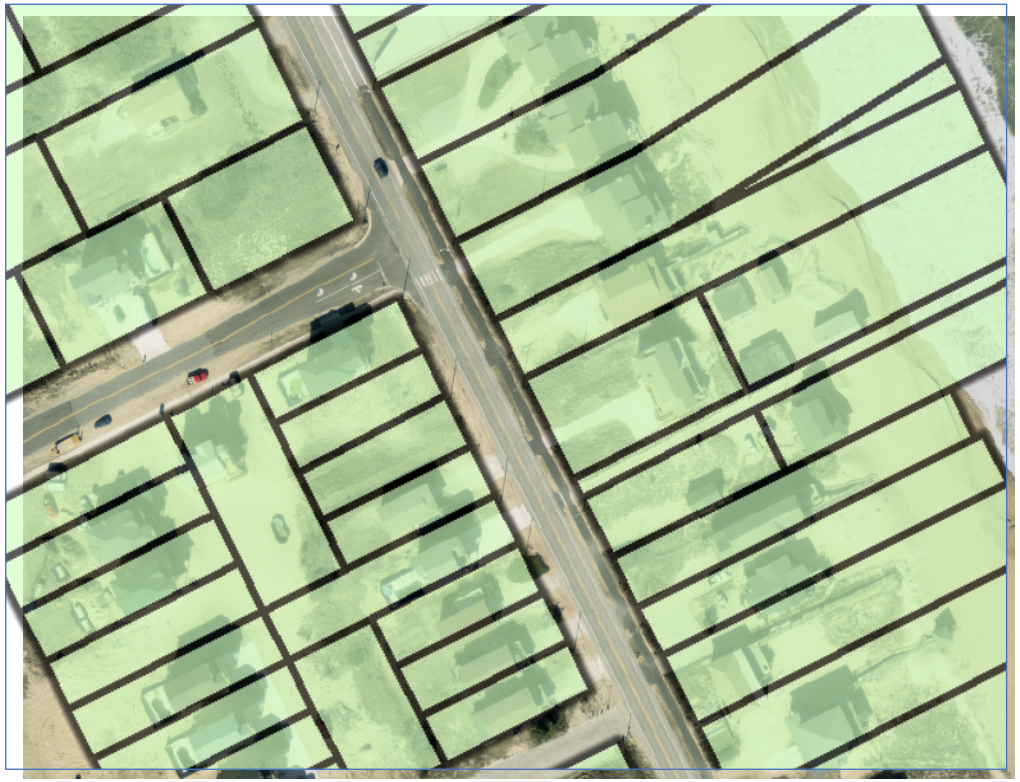


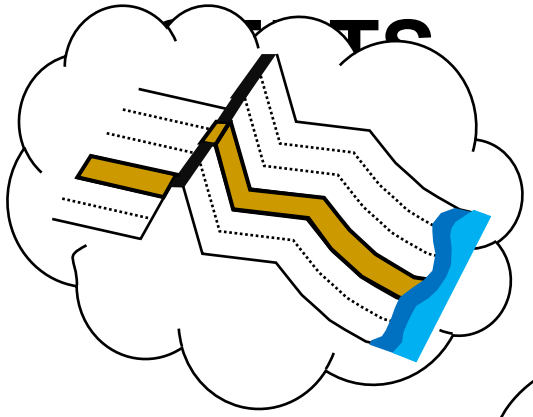


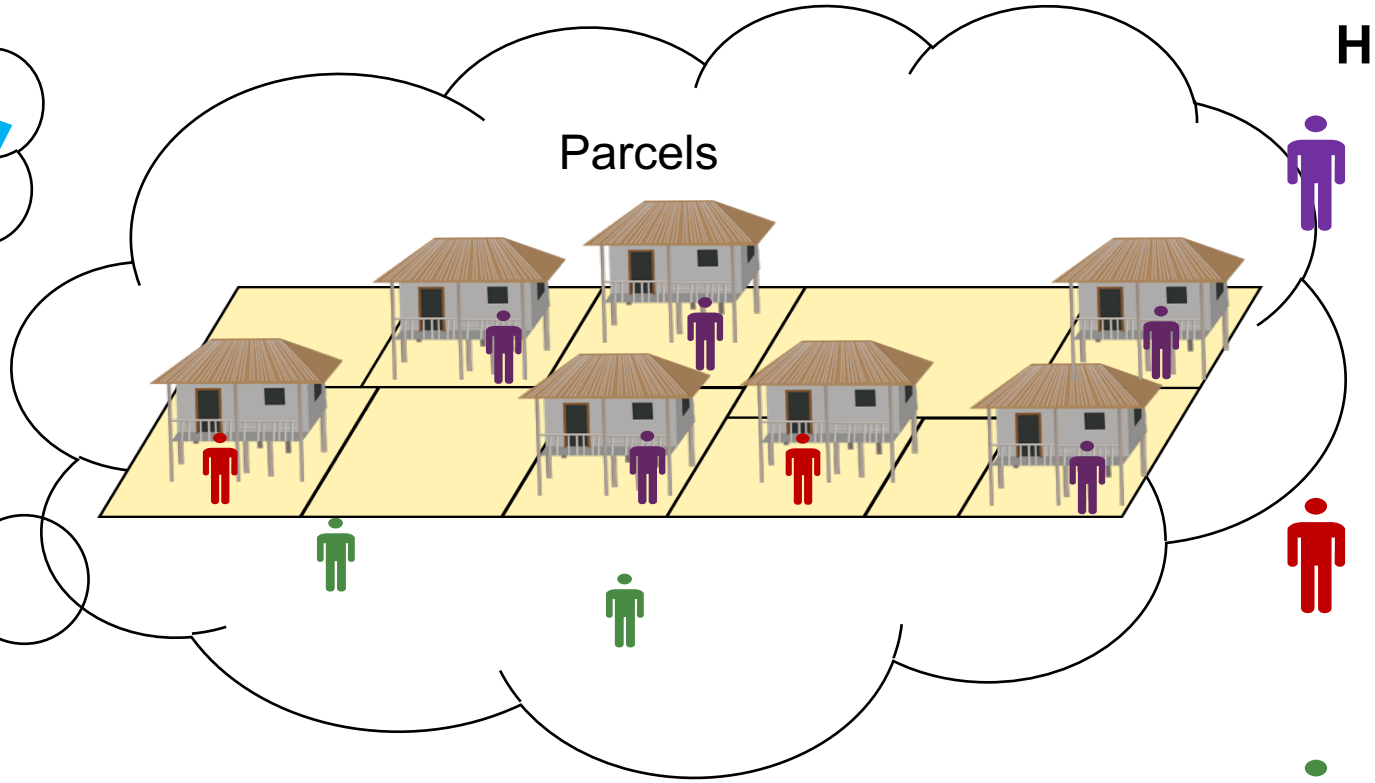
MODEL ENVIRONMENT

Parcel Layer









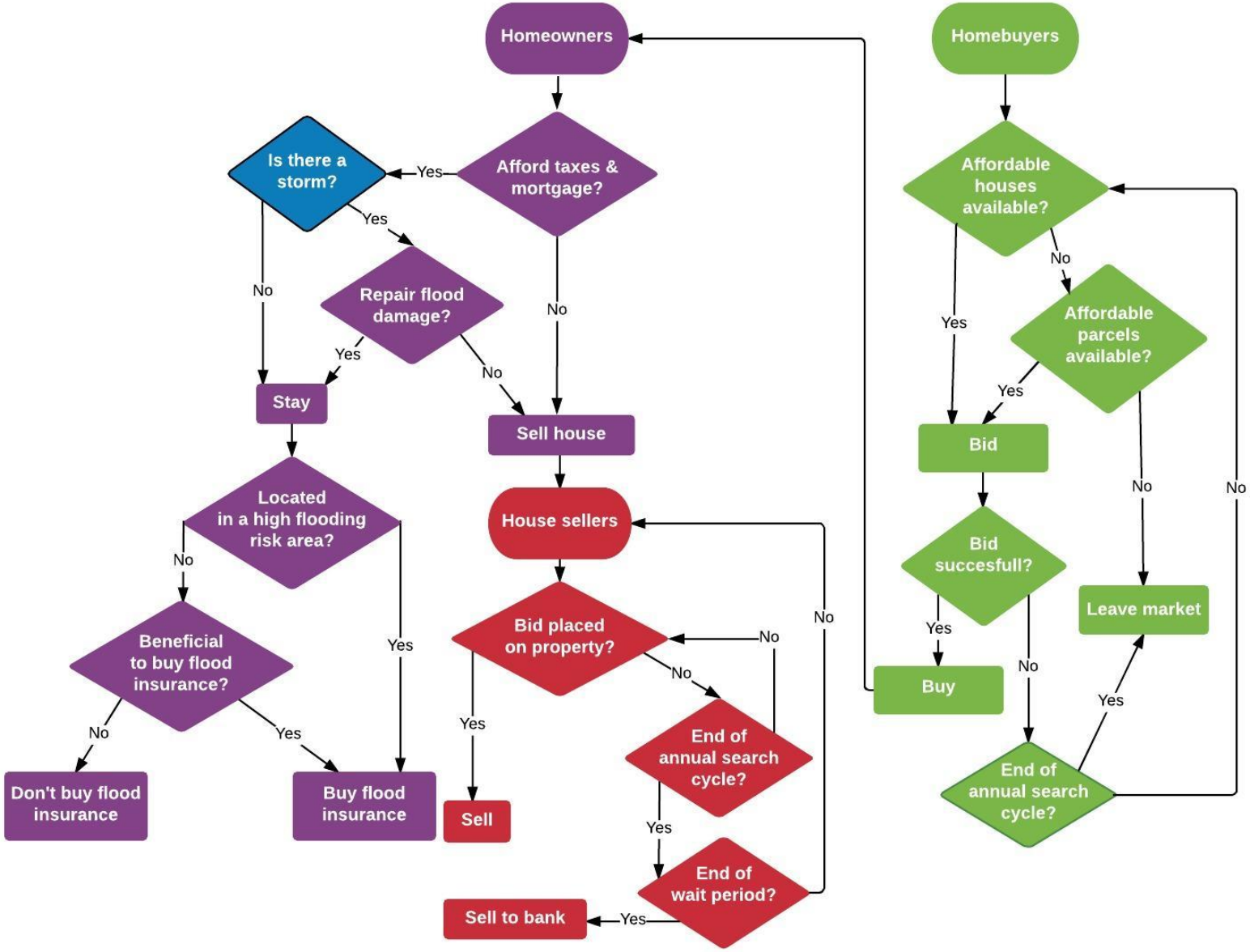
Manager Agent
- Evaluates and undertakes beach protection projects
- Adjusts taxes

Household Agents

Homeowner
- Maintains the house
- Pays taxes
- Buy/not buy flooding insurance

House seller
- Searches for potential buyers

Homebuyer
- Searches for an affordable house/parcel



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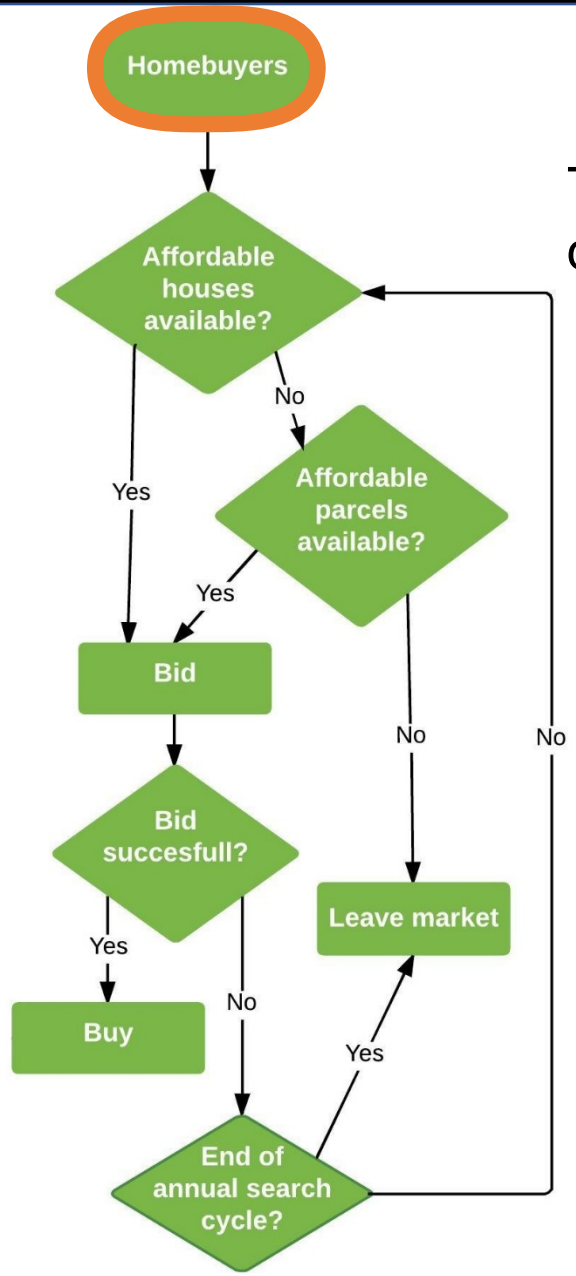
CoMOD – Rules



Homebuyer

The number of households moving into the community at each time step, depends on the **physical and socioeconomic conditions** of community

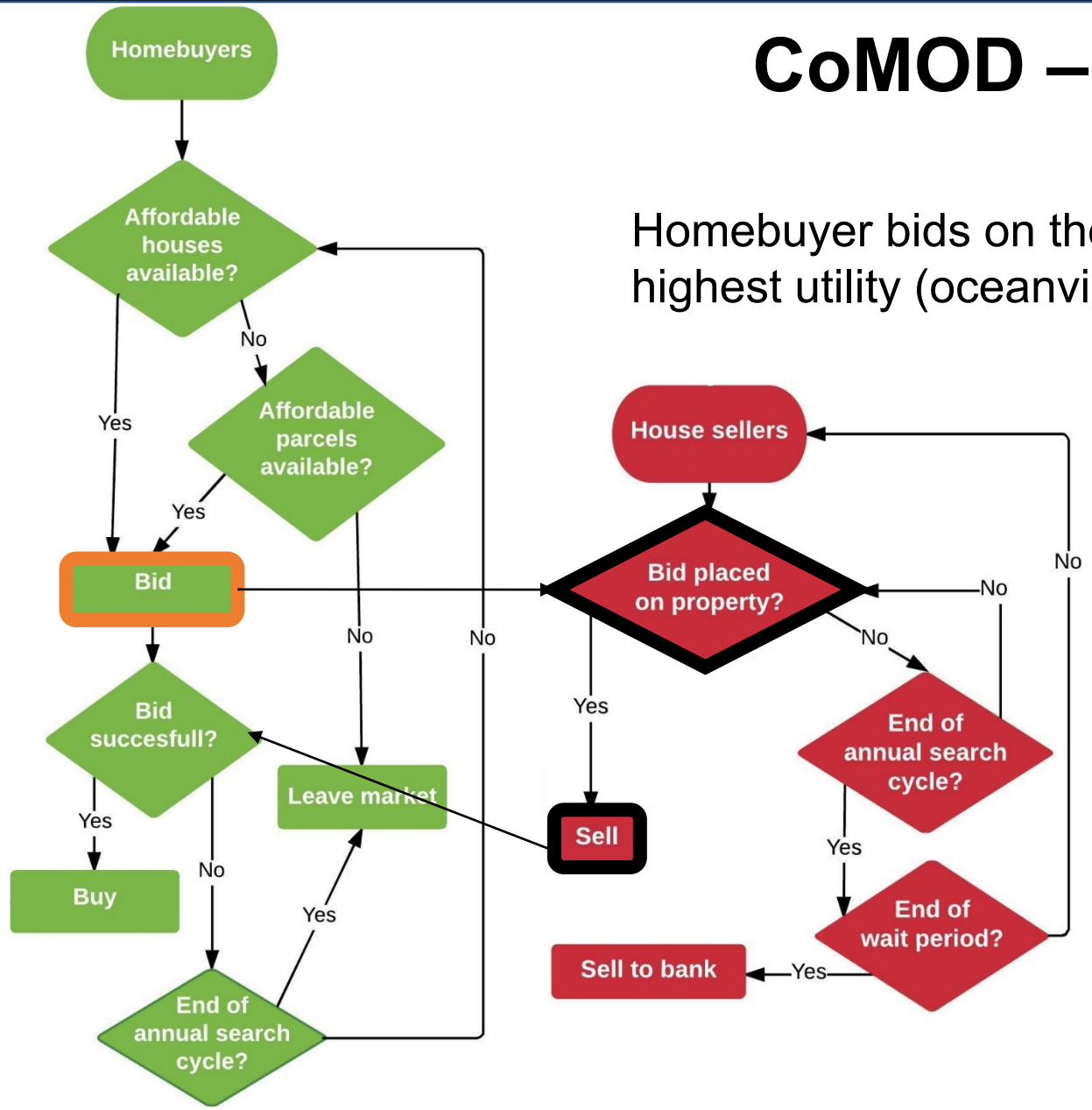
Relative Community Attractiveness

- Housing Density
- Affordability
- Expected flooding damage
- Beach Width

CoMOD – Rules

House seller

Homebuyer

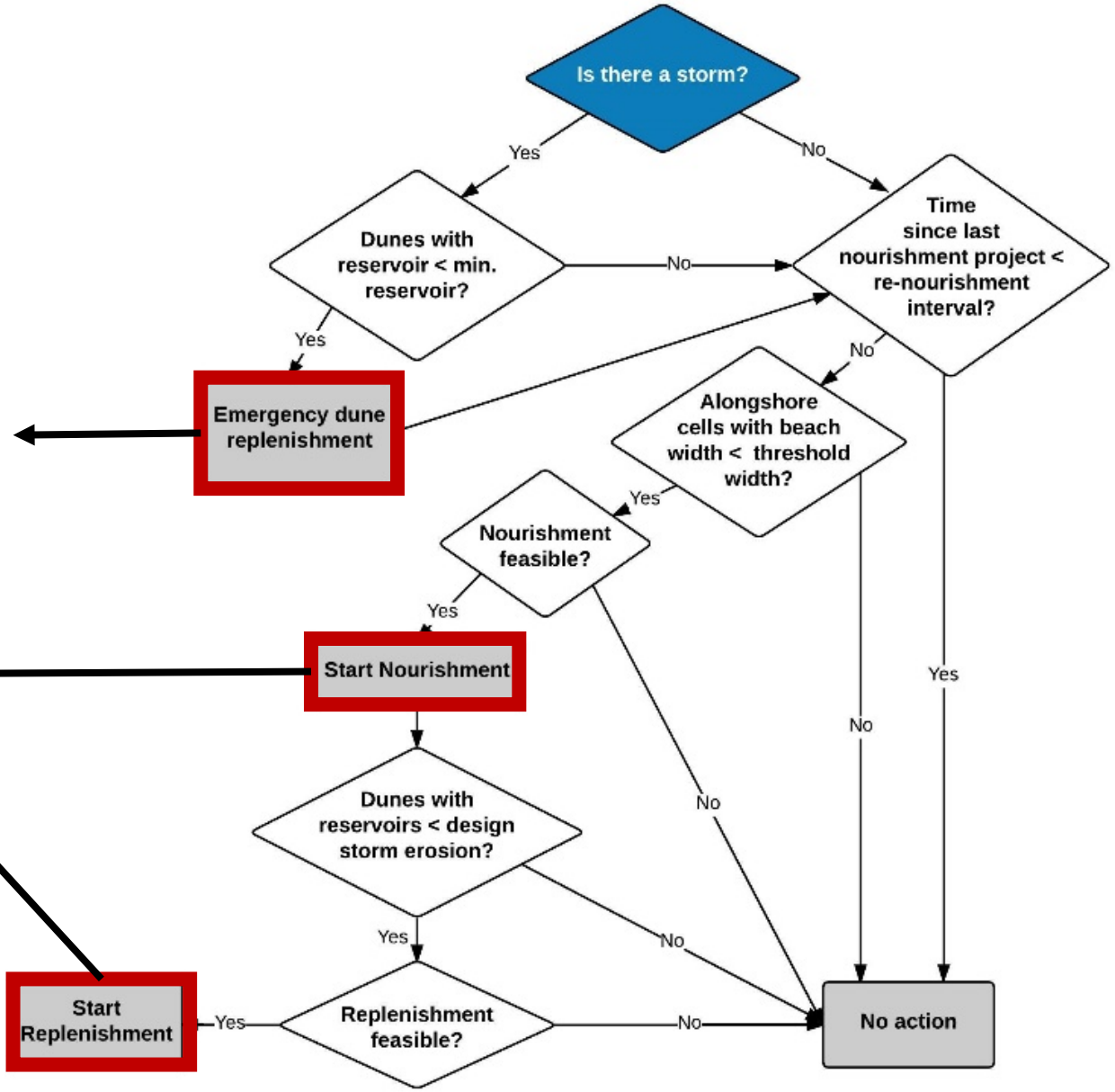


Homebuyer bids on the affordable house or parcel with the highest utility (oceanview, beachwidth, floodzone).

House seller sells the property to the highest bidder.

CoMOD – Rules

Town Manager



Emergency Dune Replenishment

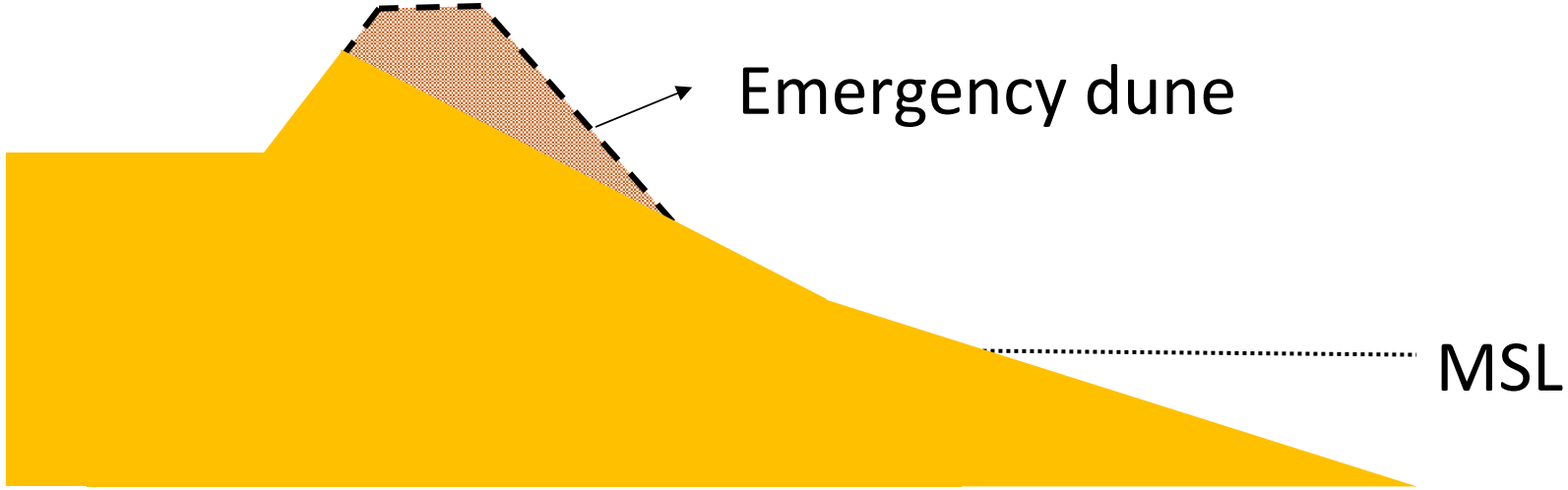
Nourishment + Replenishment

CoMOD – Rules

Town Manager

Emergency Dune Replenishment

- If manager identifies dunes containing insufficient sand in their representative area, an emergency dune recovery project is initialized.
- 75% of the project is funded by FEMA and rest is covered by an increase in taxes



CoMOD – Rules

Nourishment

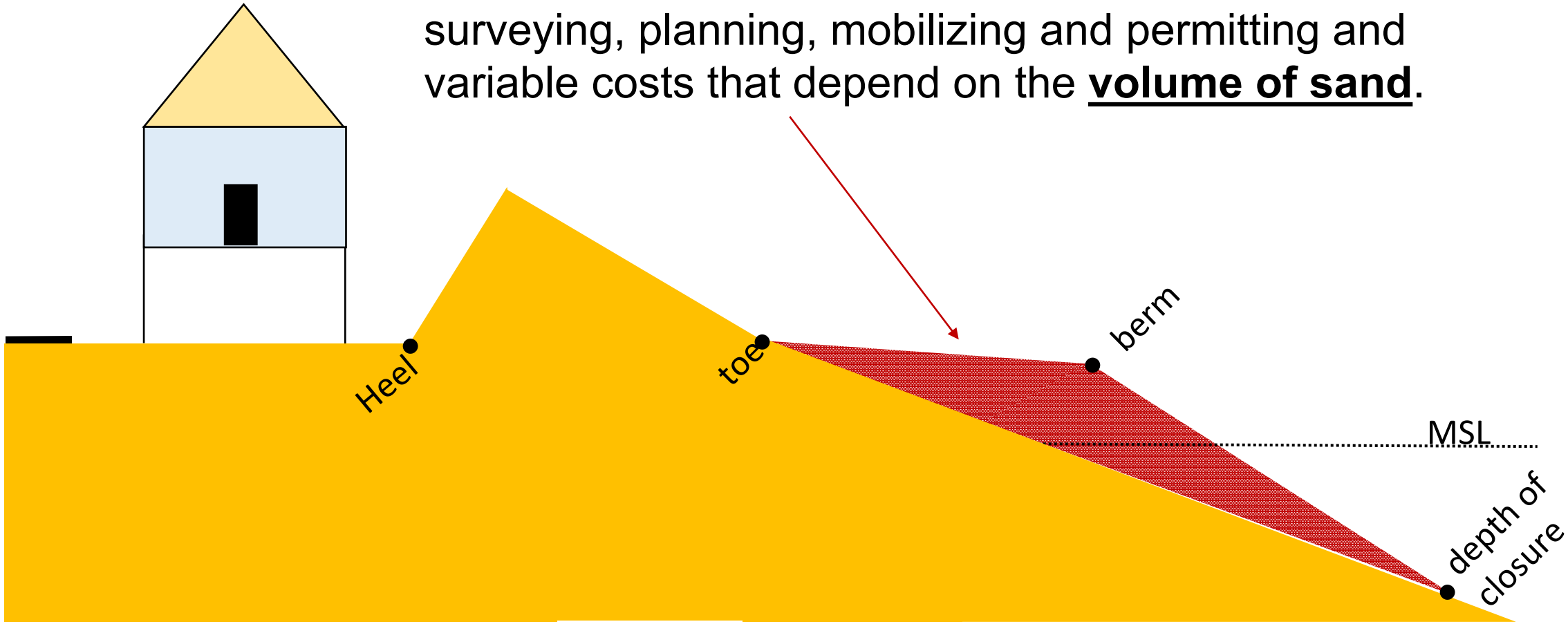
If there exist locations with narrow beaches, the manager agent employs a benefit cost analysis to determine the feasibility of a nourishment project.

CoMOD – Rules

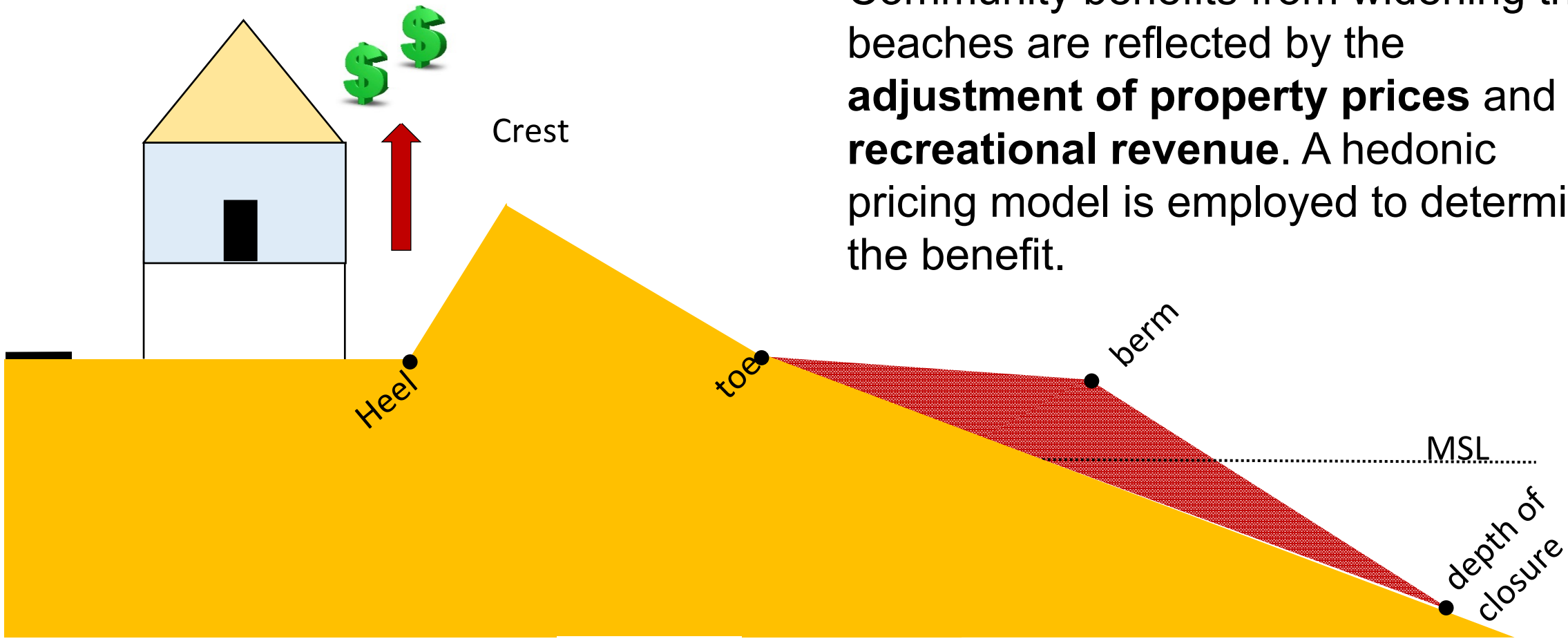
Town Manager

Nourishment Costs

Nourishment costs include fixed costs associated with surveying, planning, mobilizing and permitting and variable costs that depend on the **volume of sand**.



CoMOD – Rules

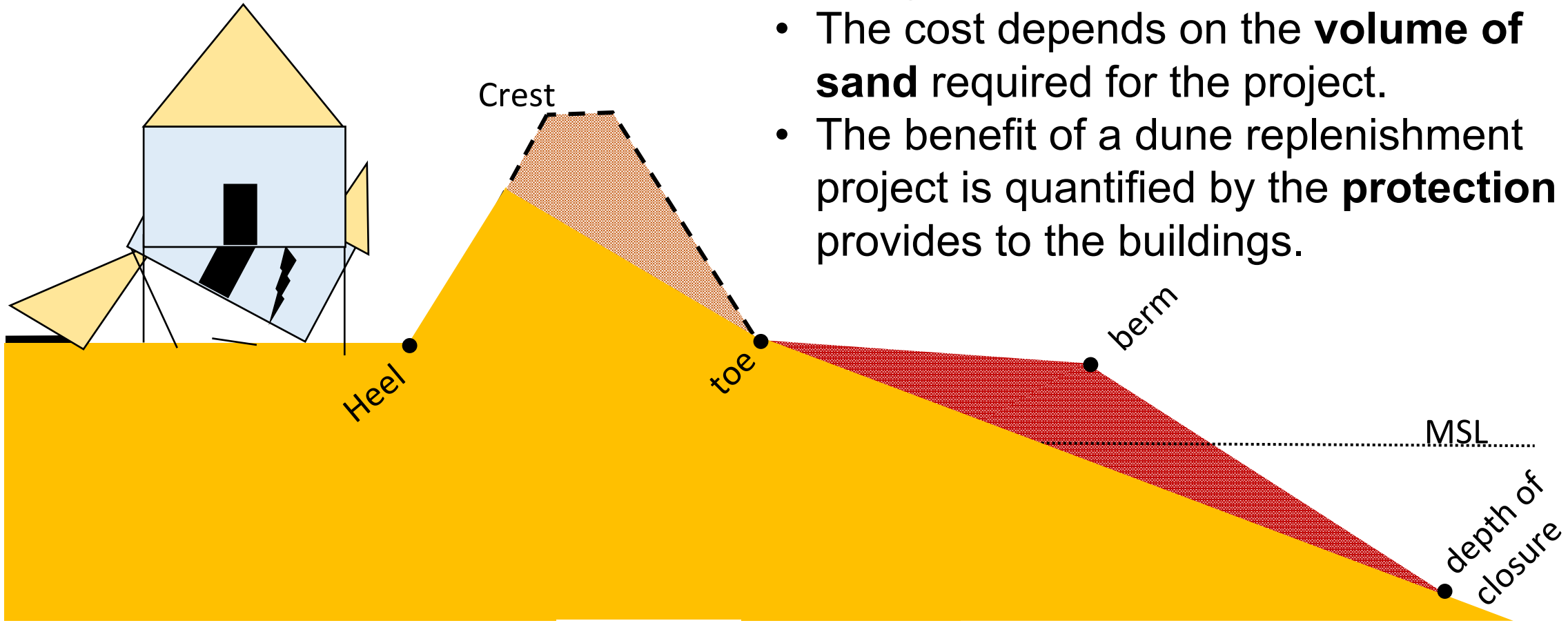


Nourishment Benefits
Community benefits from widening the beaches are reflected by the **adjustment of property prices** and **recreational revenue**. A hedonic pricing model is employed to determine the benefit.

CoMOD – Rules

Nourishment + Replenishment

- Dune replenishment is carried out alongside nourishment.
- The cost depends on the **volume of sand** required for the project.
- The benefit of a dune replenishment project is quantified by the **protection** it provides to the buildings.



Coastal Landform Change

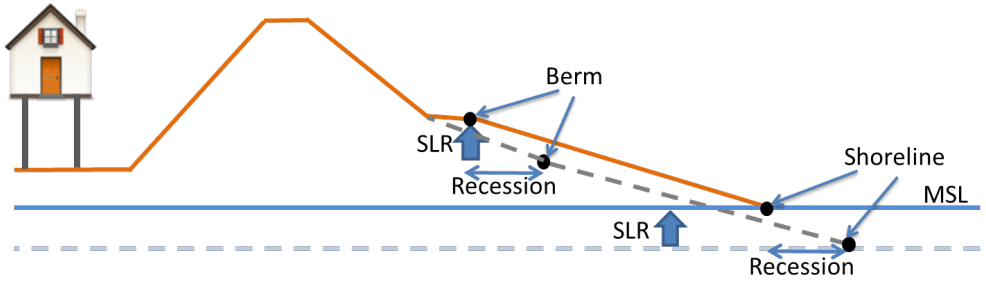
Long-term processes

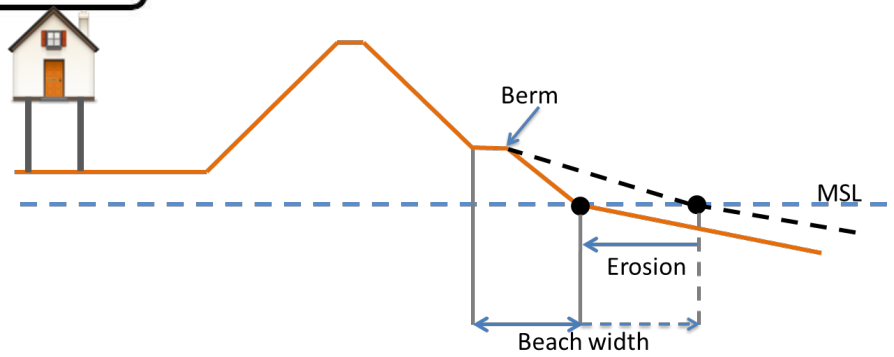
Brunn Rule

Sea Level Rise + **Long-term Erosion**

Historical Annual Erosion Rates

Modify Alongshore Cells

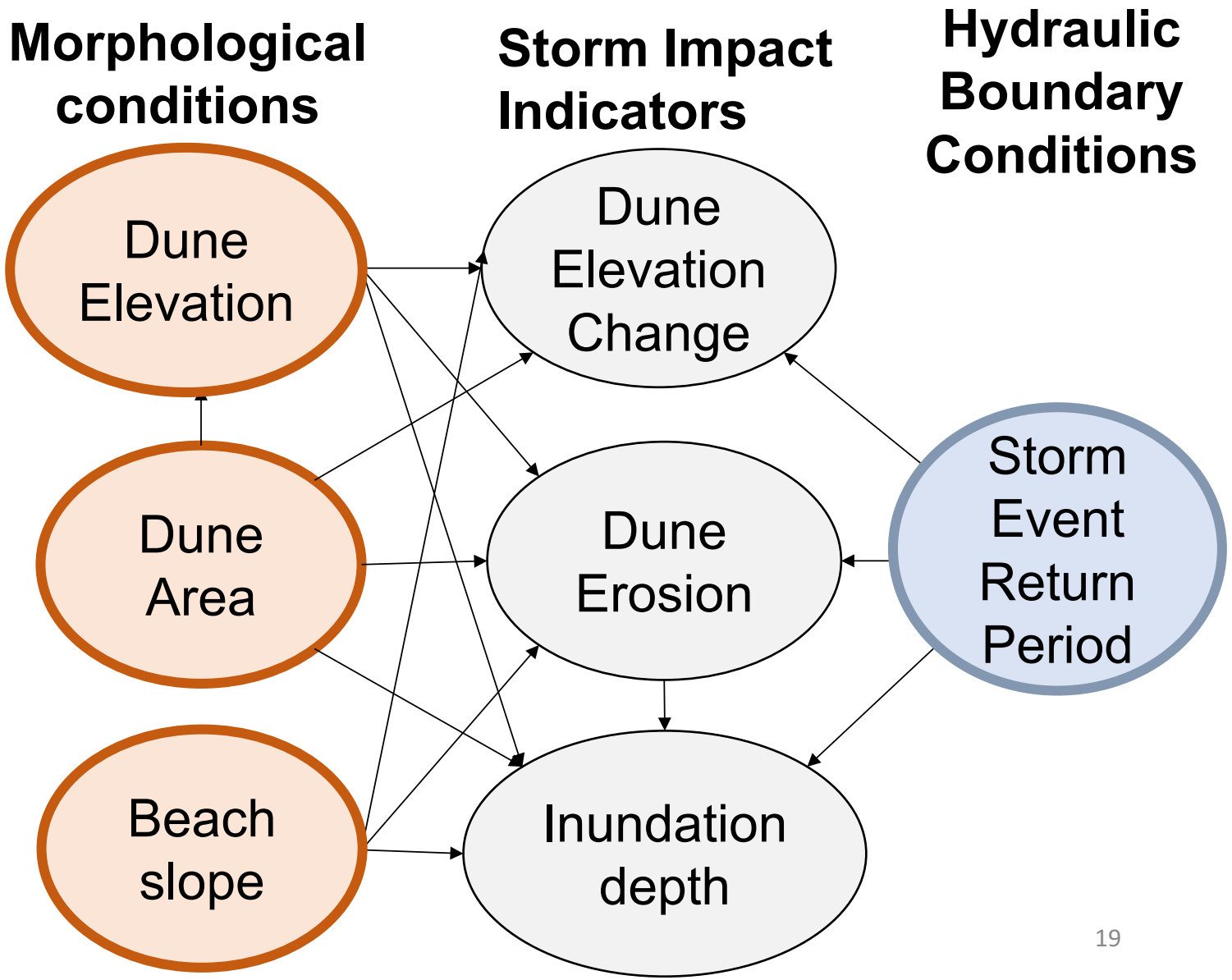




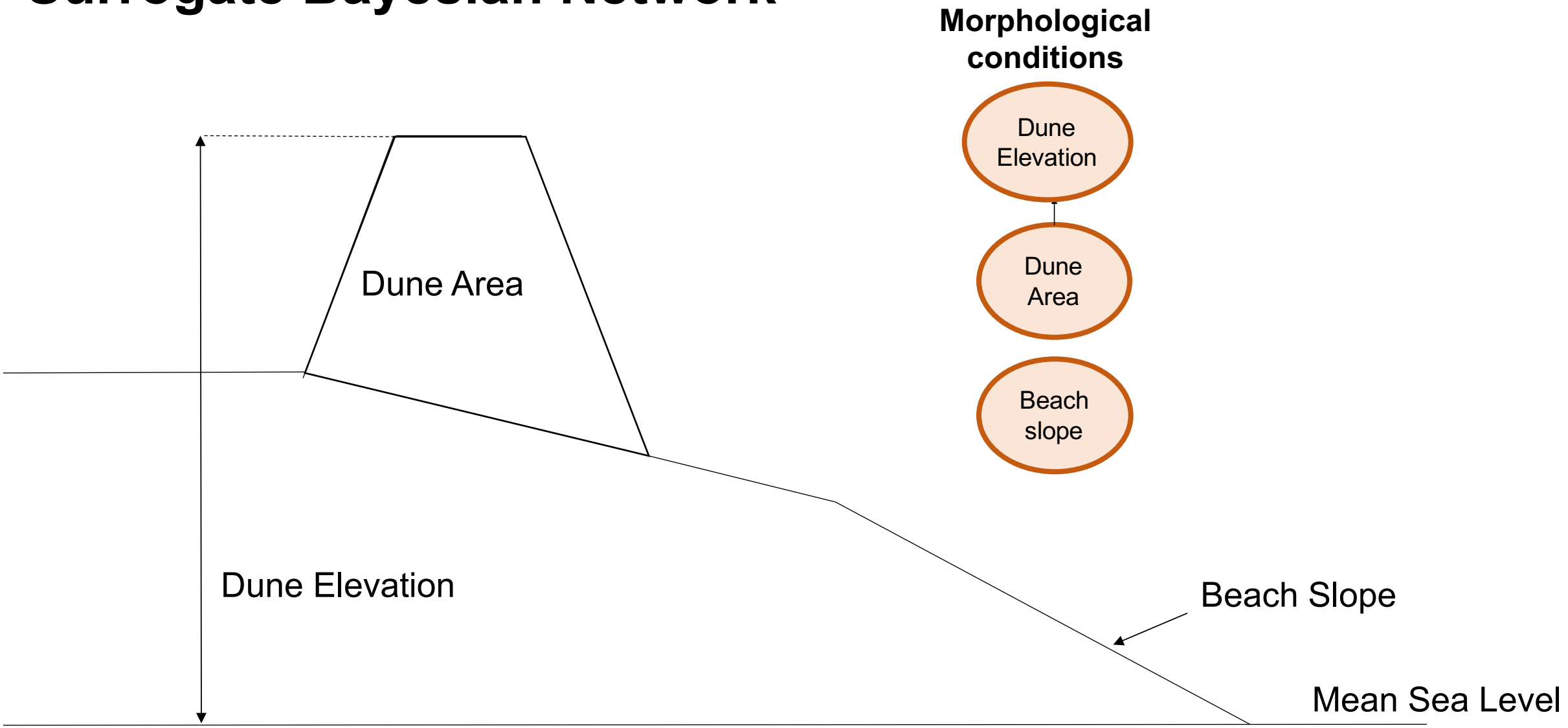
Storm Impact Surrogate Bayesian Network

BN linking

- subaerial morphological conditions
- hydraulic boundary conditions
- three storm impact indicators



Surrogate Bayesian Network



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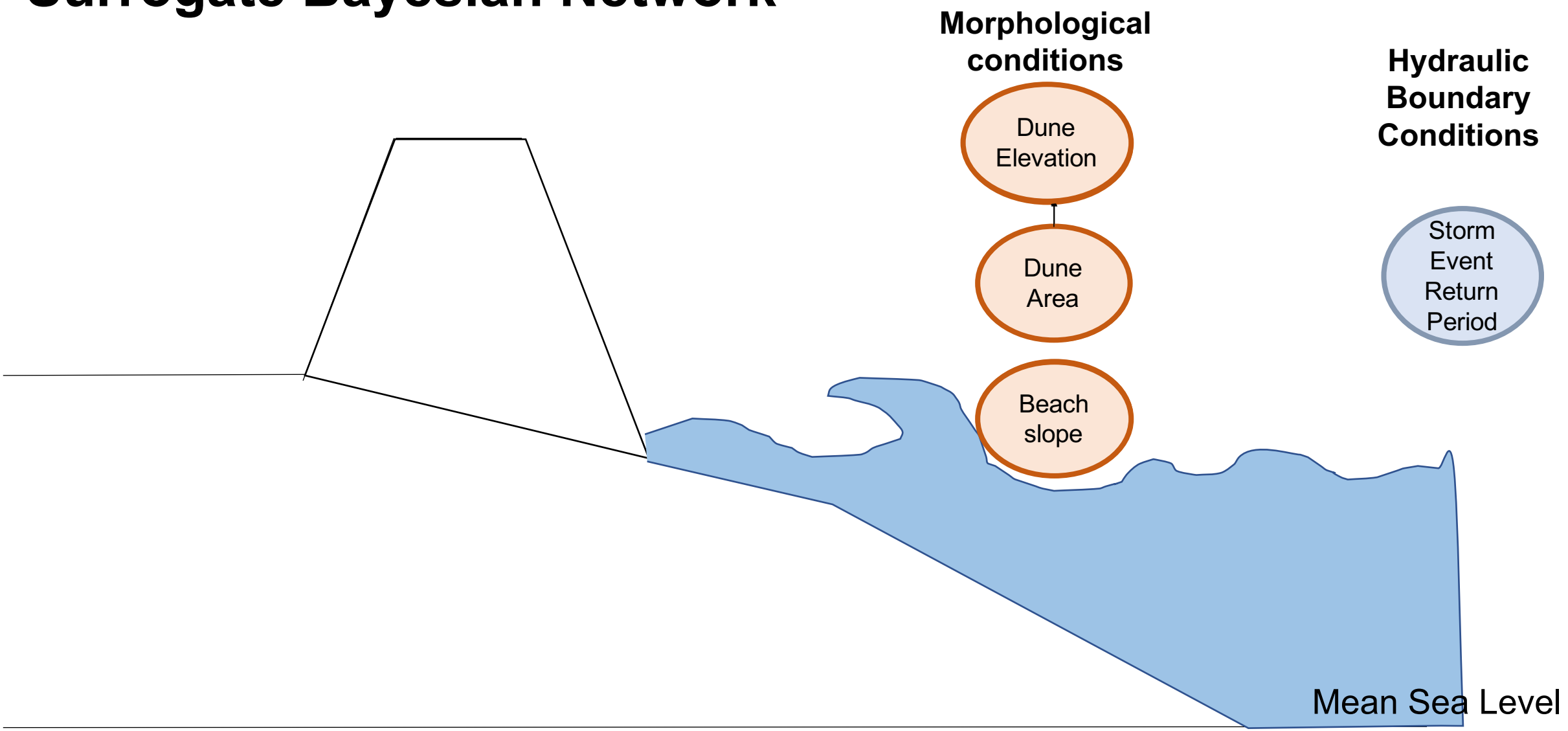

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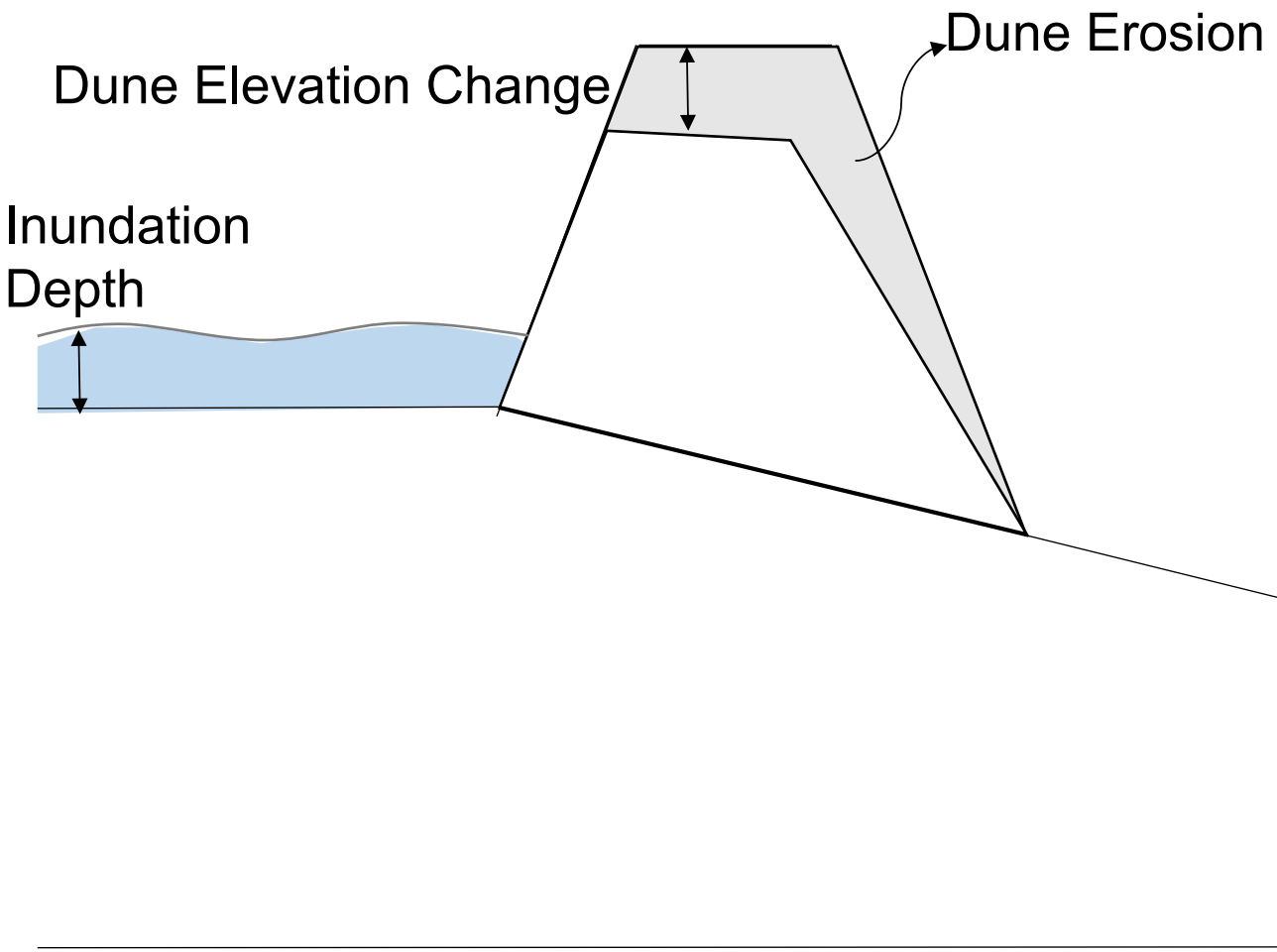
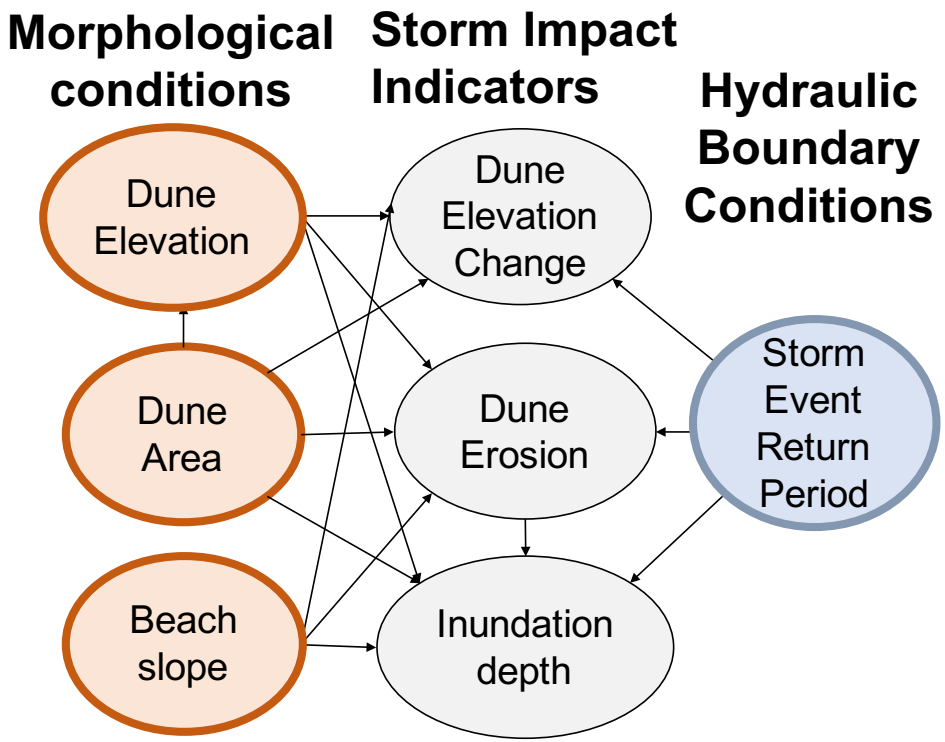
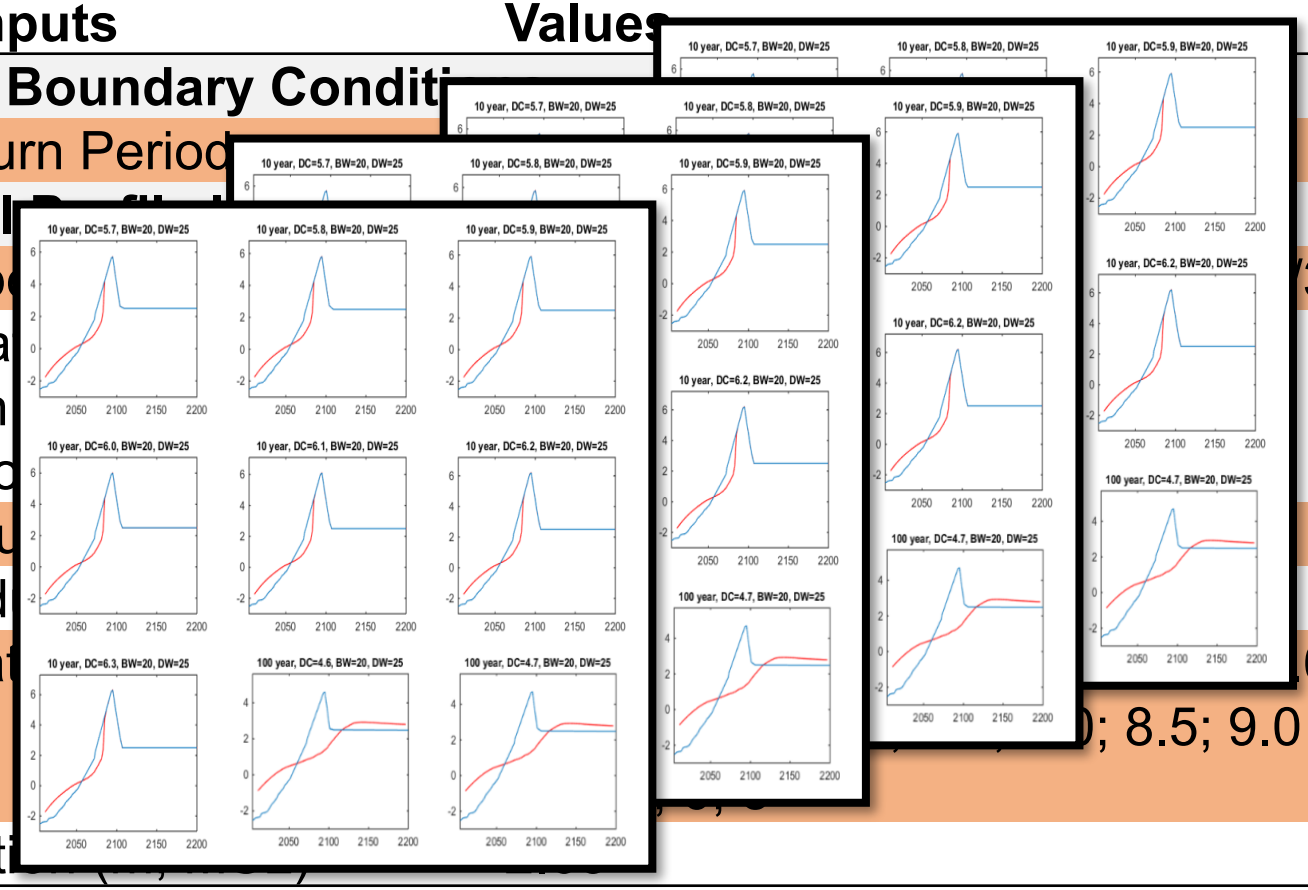




Surrogate Bayesian Network

~19,600 XBeach Runs (1D) - Creation of Storm Response Database

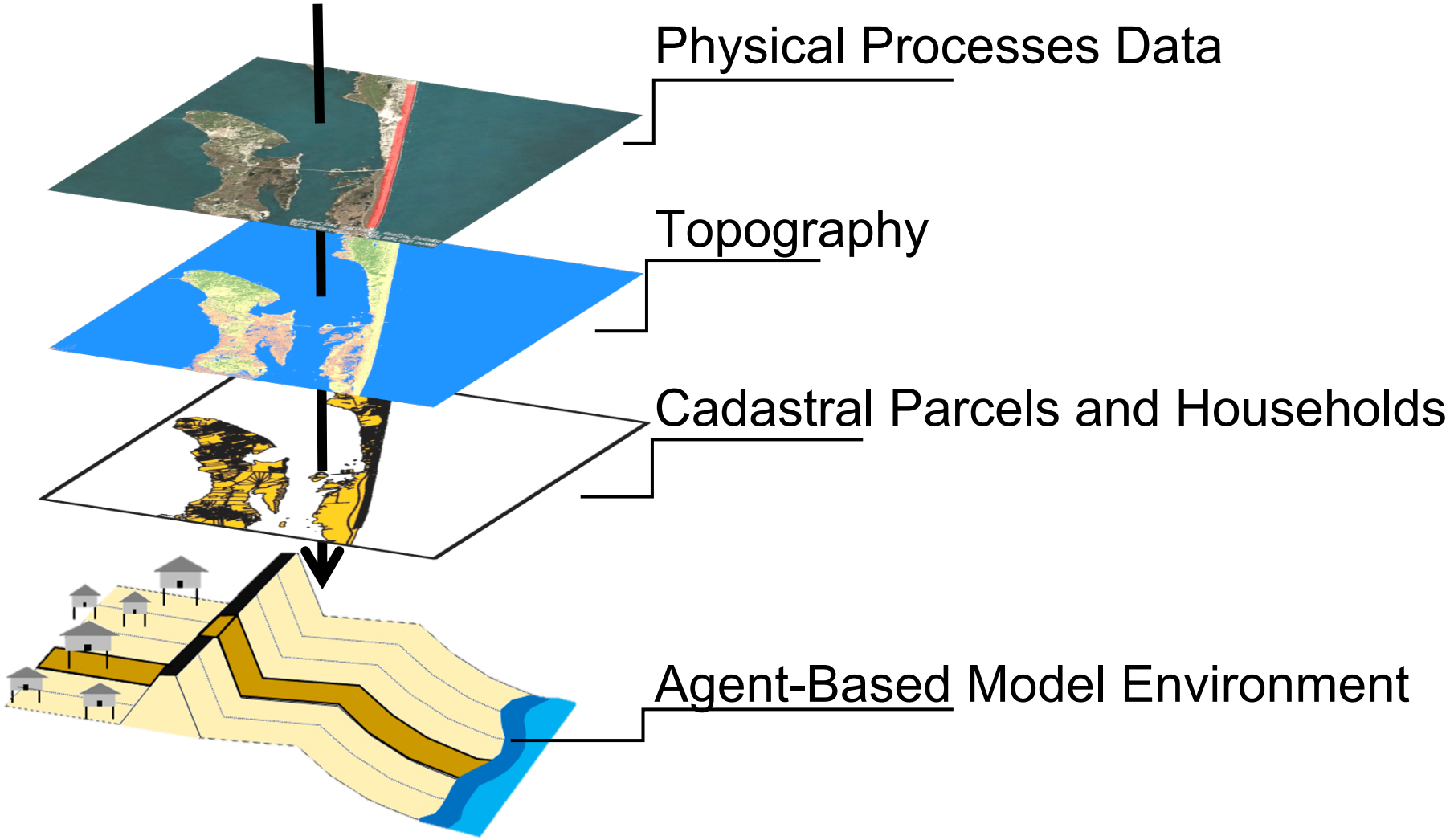
XBeach Inputs	Values
Hydraulic Boundary Conditi	
Storm Return Period	
Sub-Aerial	
beach slope	32
berm elevation	
berm width	
toe elevation	
seaward dune	
landward dune	
crest elevation	6; 5.8; 6.0; 6.2; 0; 8.5; 9.0
crest width	
heel elevation	



Study Area: Town of Nags Head

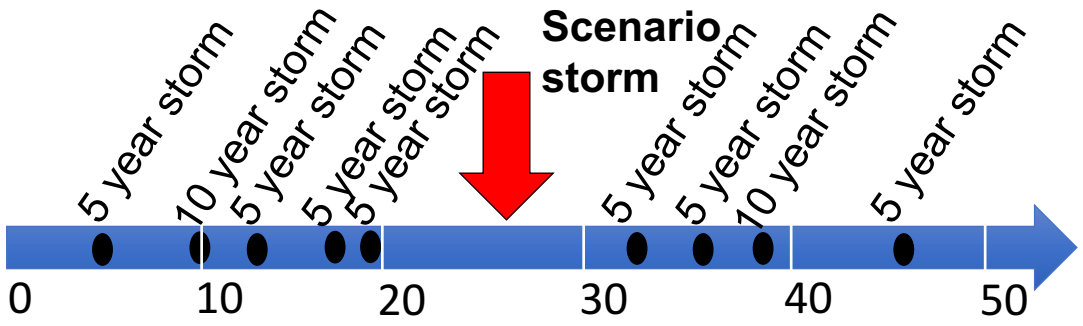
- 30 kilometers south of the US Army Corps of Engineers Field Research Facility (FRF) pier
- Historical wave and water level data.
- Numerous lidar data sources for past years are available.
- Structures Inventory (1998) (Overton et al., 1999)

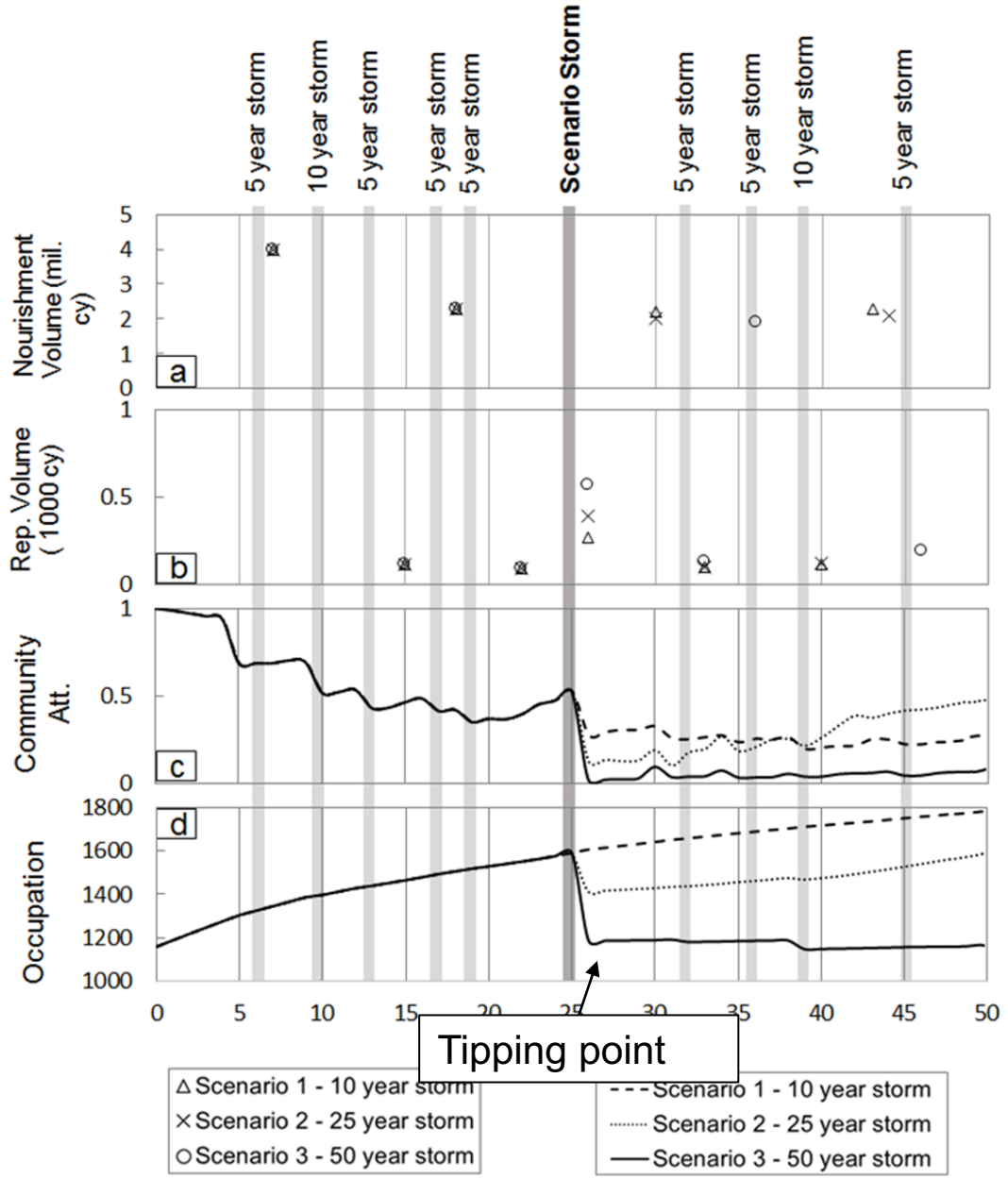
Data Used


Physical Processes Data
Topography
Cadastral Parcels and Households
Agent-Based Model Environment

Storm Disturbance

Simulations were performed to investigate the effect of storm intensity on **occupation dynamics** and **protection measures** taken.





Influence of Soft-Engineered Design Alternatives

1) 200 different storm arrival scenarios for a 50 year period
2) 25 design combinations
3) generated 5,000 simulations

Light colors represent lower occupancy numbers and dark colors indicate higher numbers.

CoMOD can be used to

- Show trends which emerge from "bottom up" household decisions.
- Integrate risk perception & amenities into coastal management evaluation.
- Evaluate management strategies.
- Address and explore emerging challenges

LIMITATIONS

FUTURE OPPORTUNITIES?