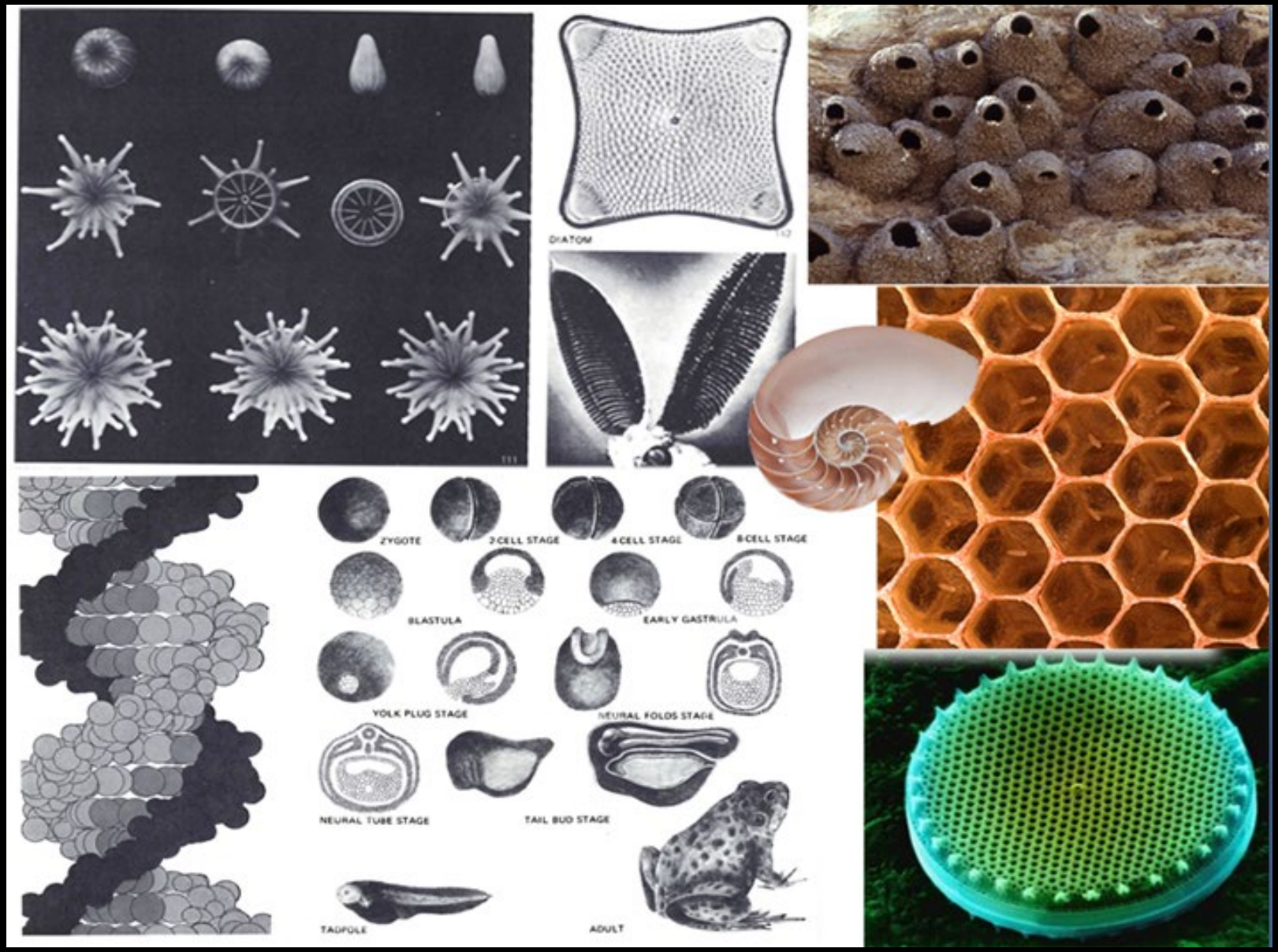
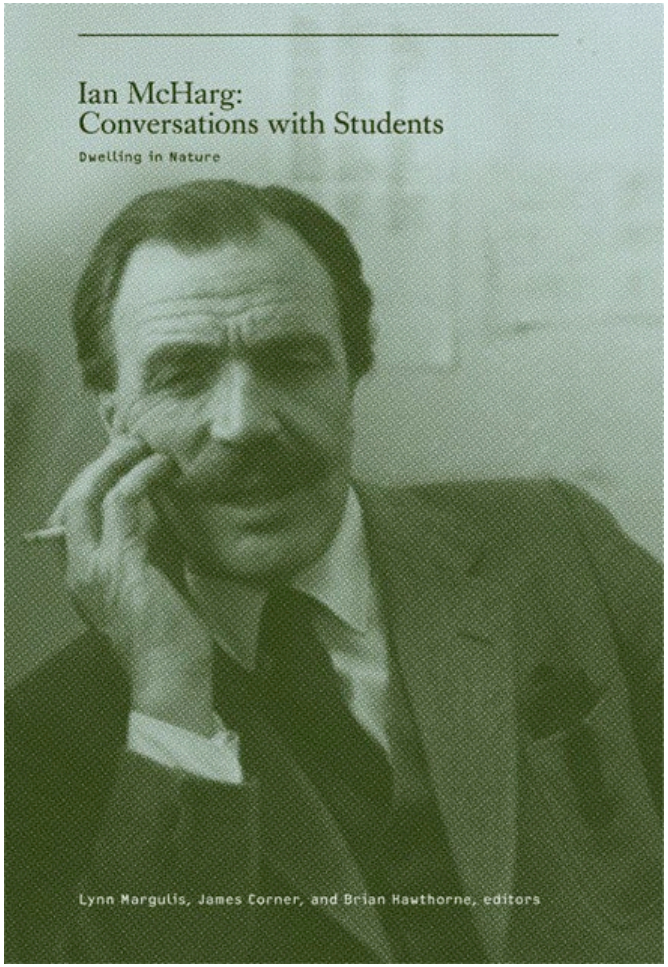
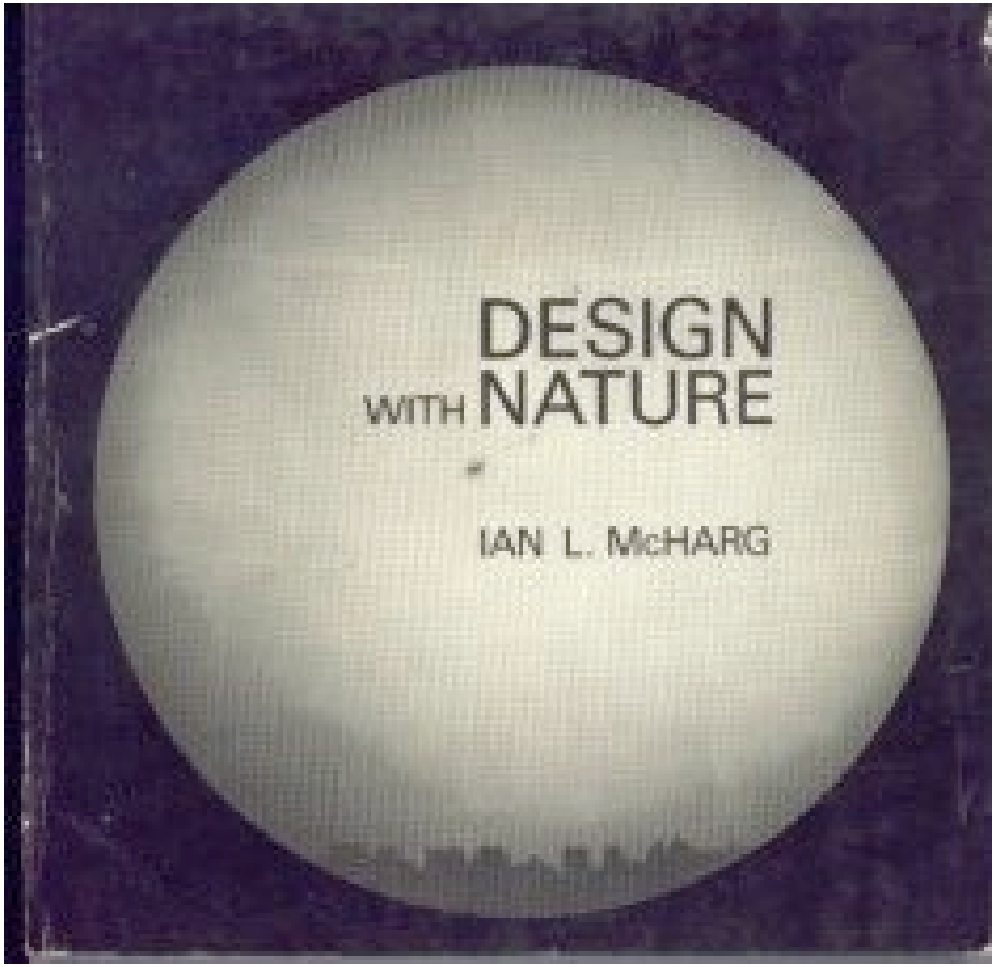


Ecological Design, Resilience +Adaptation

Ecological planning:
Ian McHarg





Ian McHarg, 1920-2001

*DNA, DOUBLE HELIX

**DEVELOPMENT OF A FROG

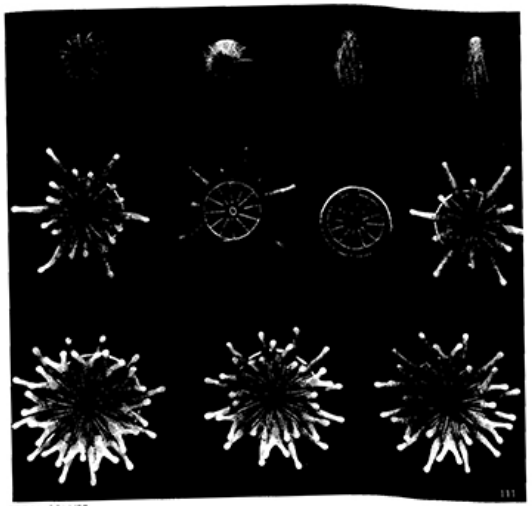
tains and valleys, minnow and whale, ostrich and owl. They too are able to discern the high craggy young mountains from the lower, soft-rounded residues of erstwhile giants, young rivers from old, piedmont from coastal plain. But many of them can also discern subtle variations within the region—the gentle escarpments revealing the stratification of terraces laid down by Cretaceous seas, the variation in soil color and texture, the adaptations of plants and animals in response to these. They know well of the changes that occur as one rises in elevation on the mountain or moves from sunlit to shadowed face, follows a gradient in rainfall or moves towards the equator. J

The world is, for the Naturalists, a great voice of "to whom it may concern" messages, clothed in form—the form of the spiral nebula and the orbits of electrons, the lattices of crystals and of viruses, the phantasmagoria of living things. Now much of this is unseen—it is below the level of vision or hidden within the organisms or consists only of invisible pathways bespeaking the interactions of communities. But much is visible and evident, for instance, the adaptations of birds' feet and bills—the claws of hornbill and woodpecker, osprey, mallard and coot, bittern and ptarmigan, or the bills of finch and toucan, fulmar and spoonbill, avocet and flamingo, kiwi and puffin. In each of these extremes, the form expresses the process: they are indivisible, and both are explanatory; this is elementary meaningful form at the level of the organ.

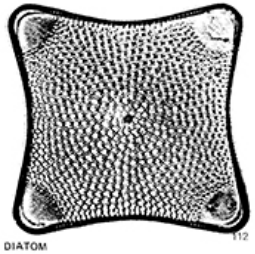
So too is there abundant evidence of the expression of process in the organism. The progression of shore birds offered a simple example—the solitary sandpiper, the lesser yellowlegs, the greater yellowlegs and then the willet. The progression continues into the plover, godwit, stilt and avocet, to bittern, egret, heron, ibis, crane, spoonbill and flamingo. In this ascending morphology of adaptations, the length of the legs and the shape of the bill are the most conspicuous

*Arthur Kornberg, The Synthesis of DNA, in *Scientific American*, Vol. 219, No. 4, p. 64, Copyright © 1968 by Scientific American, Inc., all rights reserved.

**After Charles W. Schmidt, *Bioscience*, by Robert B. Platt and George K. Reid, Reinhold Publishing Corp., New York, 1967, Fig. 20-15.



CORAL POLYPS



DIATOM

MOTH ANTENNAE

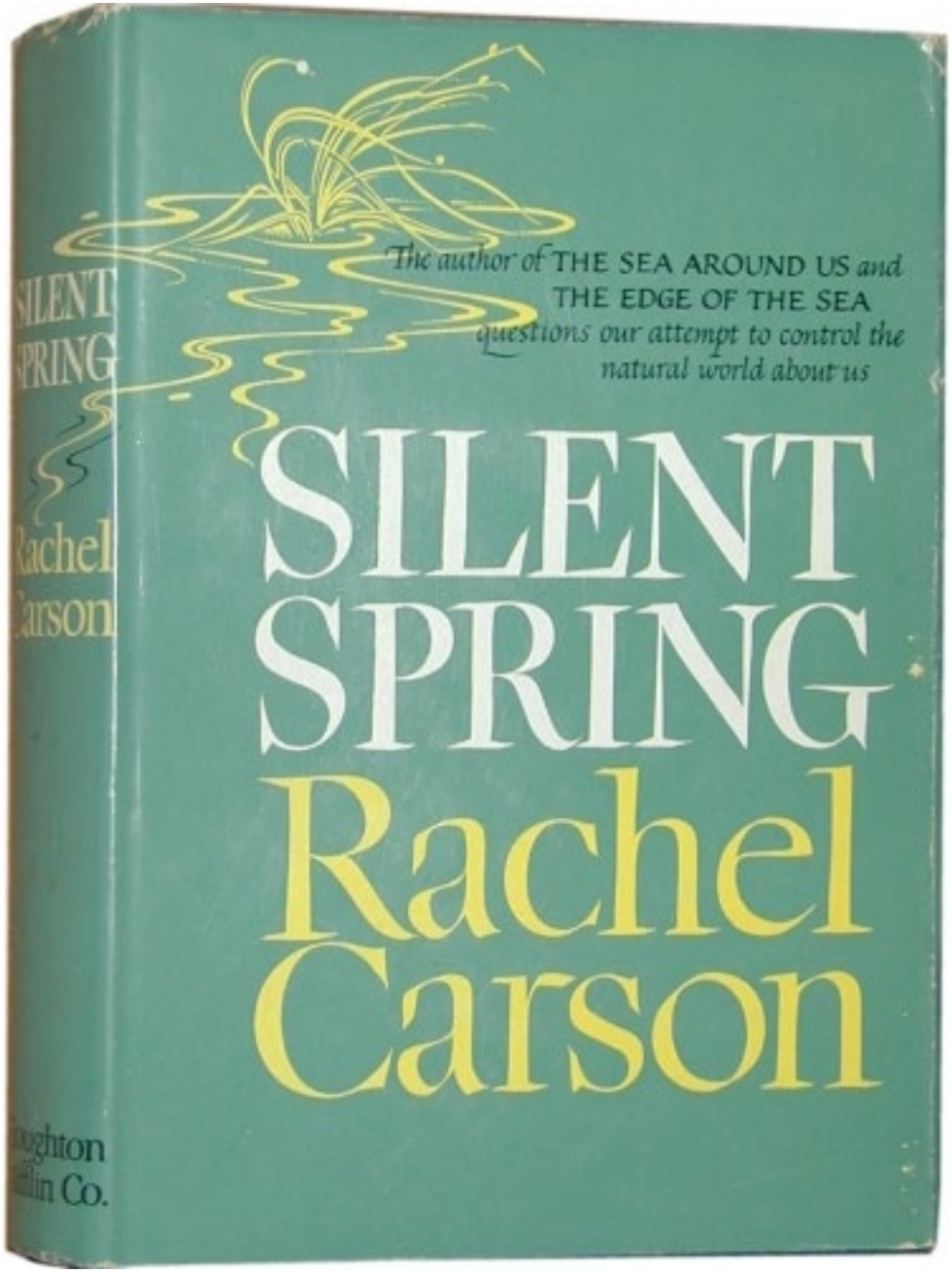
elements of form. Analogies can be found in fish and reptiles, in amphibians and mammals; and the morphology of adaptation was as clear in the steps reaching towards man.

But form is also communication, revealing creatures of the same species to each other, distinguishing between species, suppressing identity, as in camouflage, or misleading, as in mimicry. Form then is communication, the presentation of meaning.

If apperception is experienced, then communication is involved. Bits of information, questions that can be answered yes or no are the basis of the computer and much of communications theory. But information has one other attribute: meaning. There is an enormous difference in effect if, in a crowded theatre, one shouts, not "hello," but "fire." The bit of information is identical in energy, but the meaning of "fire" results in a totally different response. Energy may heat a body, the same energy may inform the body that it is being heated. So with information, the information may fall upon an unresponsive body or may be perceived as information and meaning.

When the astronaut first took his daily run through the forest, it was merely an undifferentiated shade. As he learned to discern some of the more striking forms, the information of the forest increased. In a continuous progression he came to learn of the inhabitants, their roles and their evolutionary history, and finally to see the forest as the present stage in a great evolutionary process—ordered, dynamic and indispensable to life. In this progression of learning the forest did not change—only the capacity of the astronaut to read meaning. So too with all form.

If evolutionary success is revealed by the existence of things and creatures, then their creative adaptations will be visible, not only in the organs and the organisms, but in eco-



Rachel Carson,
marine biologist

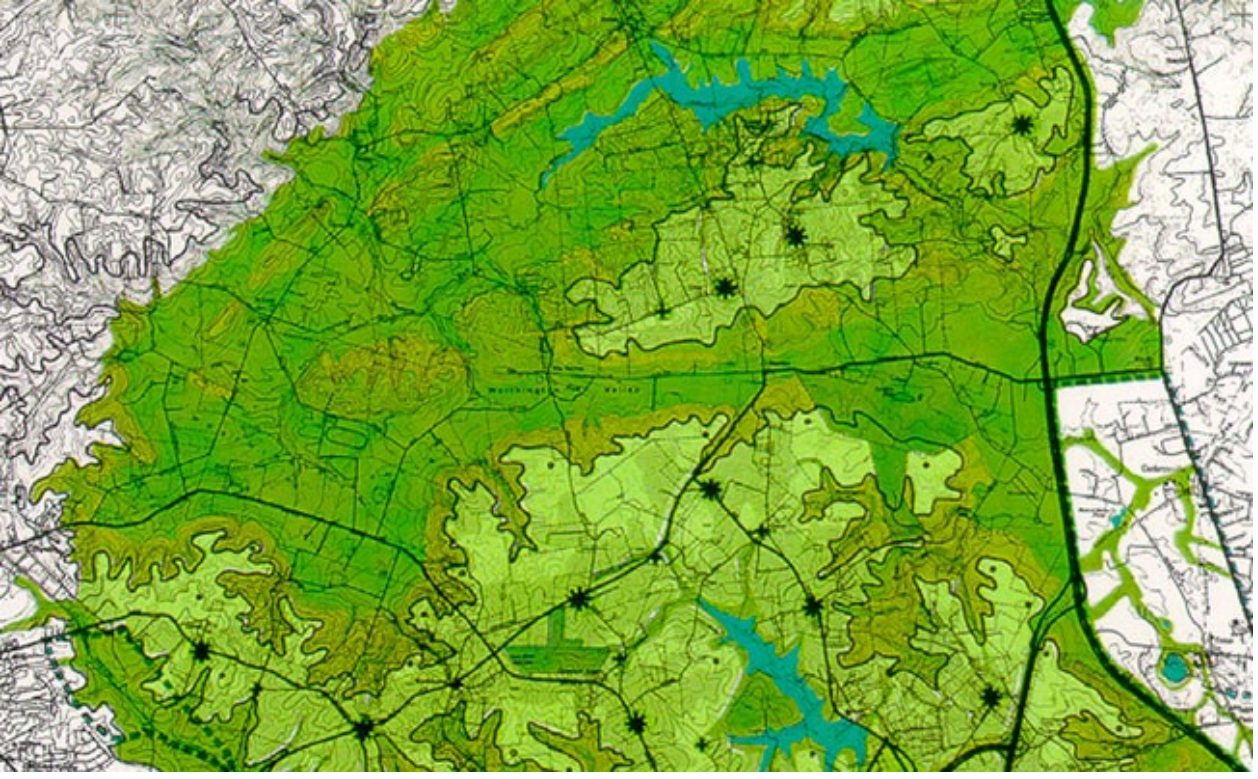
- *Silent Spring* (1961) documented the effects of pesticides on the environment, especially birds

- led to a nationwide ban on DDT for agricultural uses
- and inspired an environmental movement

- led to the creation of the U.S. Environmental Protection Agency

The Worthington, Green Spring, and Caves Valleys, bird's-eye view. Source: The Plan for the Valleys (1964)

Forested Plateau Development



Plan for the Valleys, WMRT 1964

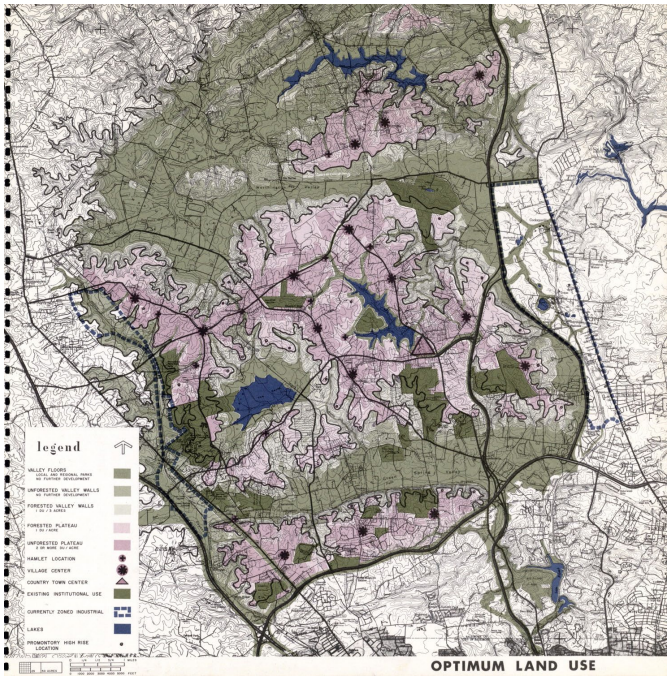
70 square miles of valley farmlands and forested uplands north of Baltimore, Maryland.

- First project of Wallace McHarg Roberts and Todd (WMRT)
- Vs planned expressway that would bring new suburban development, residents wanted to preserve the scenic beauty and environmental quality
- Recommendation that new development take place on open plateaus and that wooded slopes and open valleys be preserved: limestone formation made the aquifer vulnerable (groundwater pollution with leaking sewers)
- Never implemented, but several policy mechanisms enacted to preserve farmland with conservation easements

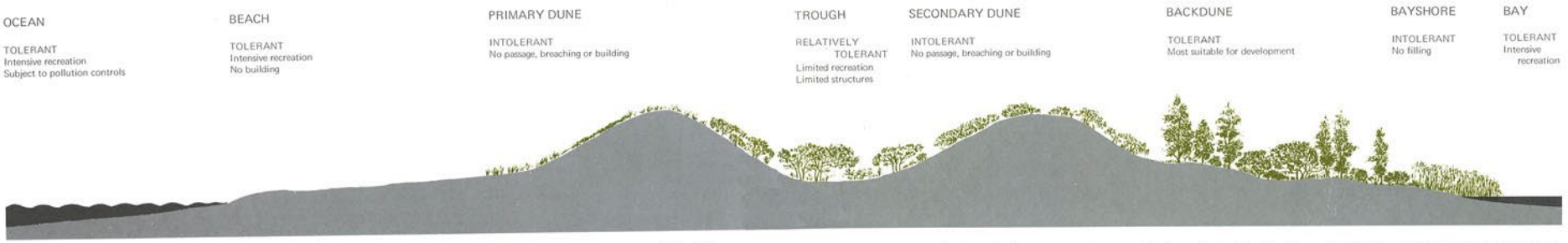
From the Introduction to the ***Plan for the Valleys***
- Wallace McHarg Roberts Todd (WMRT), 1964

- *The area is beautiful and vulnerable;*
- *Development is inevitable and must be accommodated; uncontrolled growth is inevitably destructive; development must conform to regional goals;*
- *Observance of conservation principles can avert destruction and ensure enhancement;*
- *The area can absorb all prospective growth without despoliation; planned growth is more desirable and as profitable as uncontrolled growth;*
- *Public and private powers can be joined in partnership in a process to realize the plan*

The basic amenity of the valleys: the valley floors and the forested walls. Source: The Plan for the Valleys (1964)



The ideal development pattern for the Valleys, mixing settlements with preserved valley floors. The developed areas are in gray and the valley floors in white. Source: The Plan for the Valleys (1964).



and it is here, propitiously, that the most delightful, diverse, safe and tolerant environment exists.

We could now consider positive recommendations for development of the shore based upon this little knowledge. The backdune's widest stretch would appear to offer the maximum opportunity for the concentration of facilities, be it a village, a group of houses or a recreational center—depending upon actual dimensions. There will of necessity be a highway. It will inevitably run parallel to the sea and the dunes and could well be located on the backdune. If sufficiently elevated, it could not only proffer splendid views of the ocean and the beach, but it could provide a third dune, the equivalent of the Dutch Dreamer.

This backdune could offer protection from winter storms and could prevent the breaching of the sandbar from the bayshore as has happened in the past. In creating works like an artificial dune to support a highway, it is important that the sand be withdrawn from the ocean and not from the bay. The beach is not a very rich environment while the bay is the very richest. As Dr. Stanley Cain, the eminent ecologist, has revealed,* dredging of such rich environments can produce biological deserts.

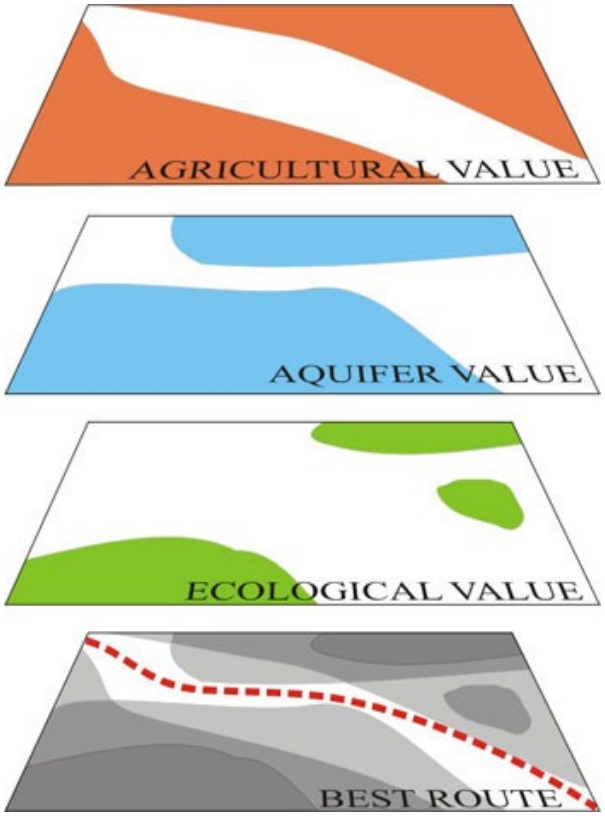
Now if communities are established there arise the problems of water supply and sewage disposal. First let us consider the matter of water. There are resources of groundwater in the sandbars as we have seen, but the water level must not be lowered so far as will extinguish the stabilizing vegetation. This suggests that withdrawal be distributed among a number of wells. But water from this source will be a limiting factor to growth. Sewage presents another problem. The silts of the bayshore are unsuitable for septic tanks and, moreover, the employment of this technique is certain to pollute the groundwater supply. Both a sewer and a sewage treatment plant will be necessary before development is permitted on the dune.

We now have the broad outlines of an ecological analysis and a planning prescription based upon this understanding. A spinal road could constitute a barrier dune and be located in the backdune area. It could contain all utilities, water, sewer, telephone and electricity and would be the guardian defense against backflooding. At the widest points of the backdune, settlement could be located in communities. Development would be excluded from the vulnerable, narrow sections of the sandbar. The bayshore would, in principle, be left inviolate. The beach would be available for the most intensive recreational use, but without building. Approaches to it would be by bridges across the dunes, which would be prohibited to use. Limited development would be permitted in the trough, determined by groundwater withdrawals and the effect upon vegetation. A positive policy would suggest accelerating the stabilizing processes, both of dune formation and of vegetative growth. To do this the appropriate vegetation for the associations would be planted. Particular attention would be given to marram grasses on dunes and to planting red cedars and pines on the backdune.

In the Netherlands, confronted with a similar situation, it became a matter of national resolve to reclaim land from the sea and a positive policy was developed towards that end. If this were applied to the New Jersey Shore it would involve the creation of continuous dikes and dunes facing the sea. There would be locks at these locations where the lagoon was connected to the ocean. Fresh-water flow from the land mass into the bay would be regulated as would incursions of salt water from the ocean. Constraints would be exercised to maintain dunes and dikes, groundwater withdrawals and native vegetation.

Sadly, in New Jersey no such planning prin-

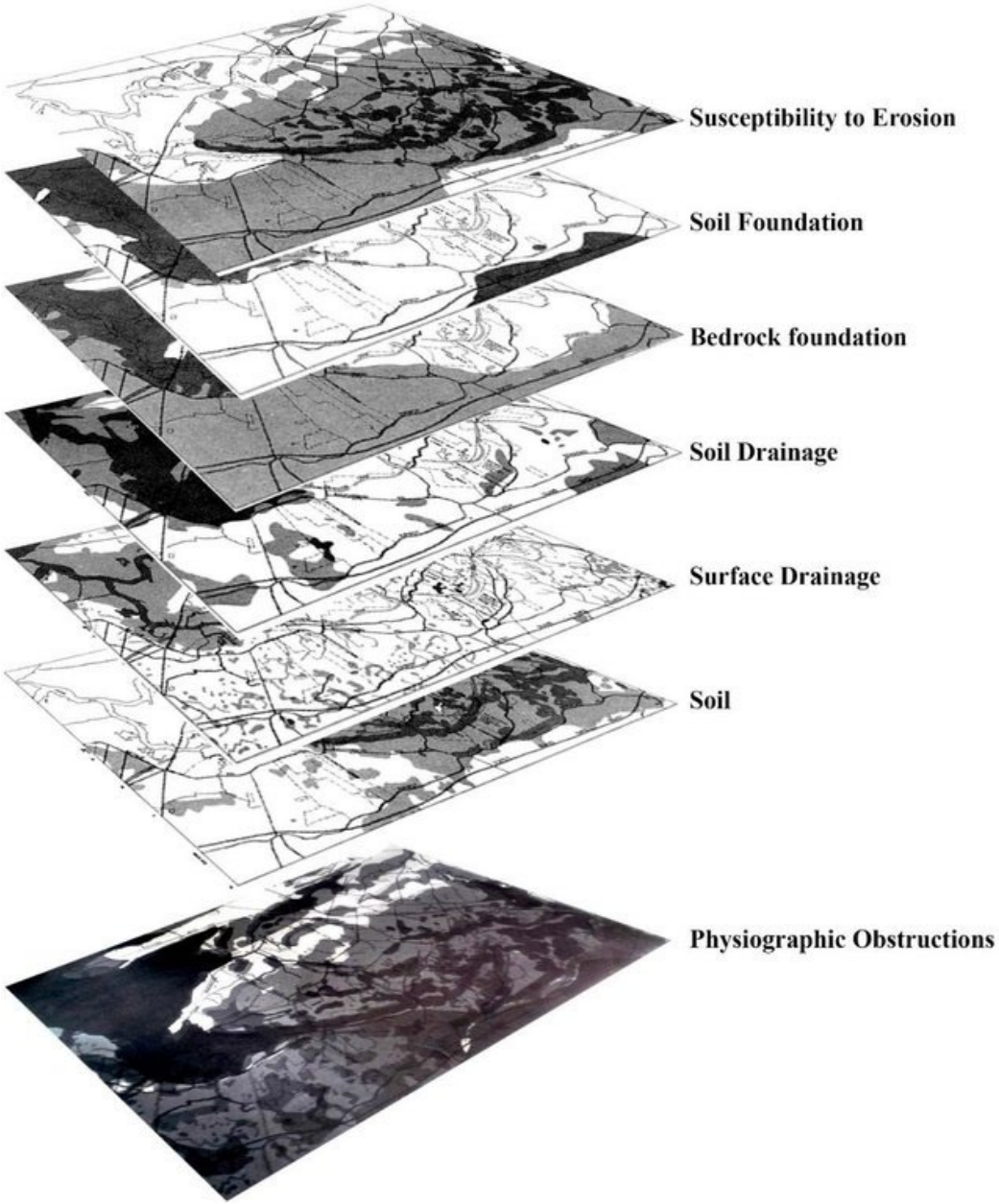
*Stanley A. Cain, Letter to the Editor, ***Landscape Architecture Quarterly,*** Jan., 1967, Volume 57, page 103.



"Nature is process and value, exhibiting both opportunities and limitations to human use."

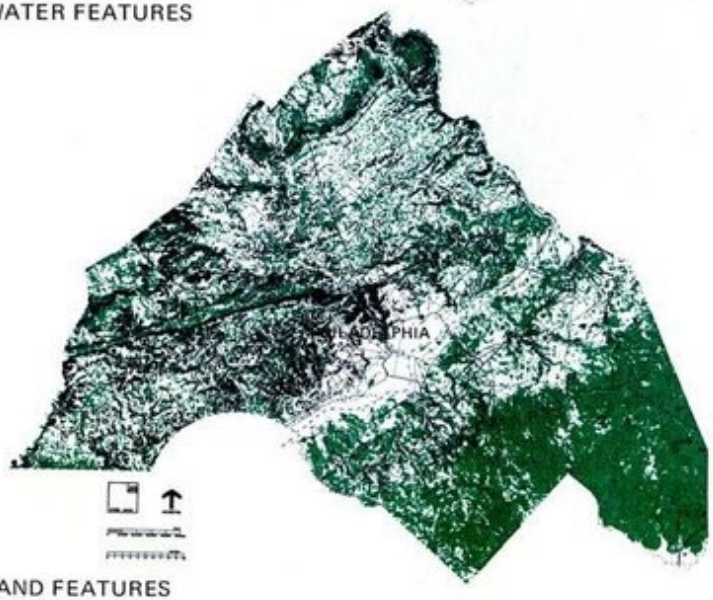
Ian McHarg,

Design with Nature



Ian McHarg, Design with Nature, 1969

WATER FEATURES

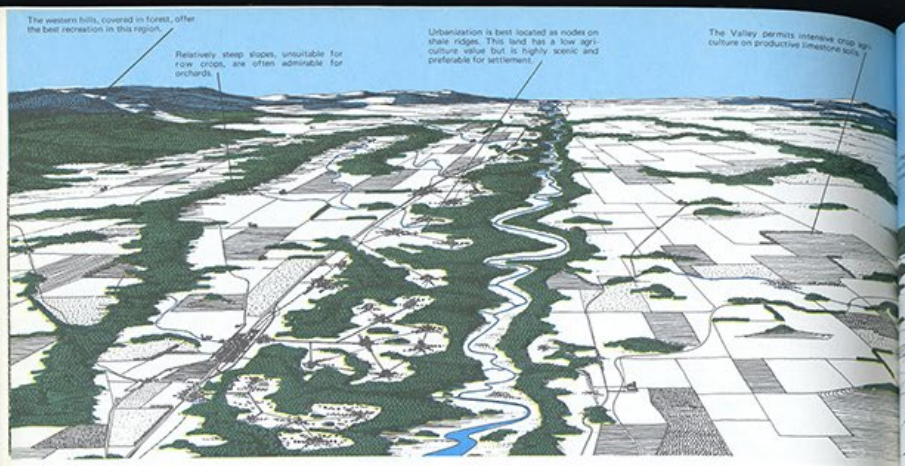


LAND FEATURES

PHENOMENA	RECOMMENDED LAND USES
Surface water and riparian lands	Ports, harbors, marinas, water-treatment plants, water-related industry, open space for institutional and housing use, agriculture, forestry and recreation.
Marshes	Recreation.
50-year floodplains	Ports, harbors, marinas, water-treatment plants, water-related and water-using industry, agriculture, forestry, recreation, institutional open space, open space for housing.
Aquifers	Agriculture, forestry, recreation, industries that do not produce toxic or offensive effluents. All land uses within limits set by percolation.
Aquifer recharge areas	As aquifers.
Prime agricultural lands	Agriculture, forestry, recreation, open space for institutions, housing at 1 house per 25 acres.
Steep lands	Forestry, recreation, housing at maximum density of 1 house per 3 acres, where wooded.
Forests and woodlands	Forestry, recreation, housing at densities not higher than 1 house per acre.

SUMMARY MAP OF WATER & LAND FEATURES FOR PART OF THE METROPOLITAN AREA

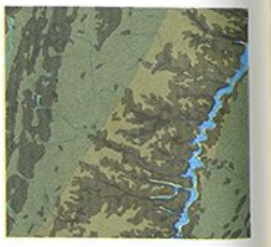
Ian McHarg, *Design with Nature*, 1969.

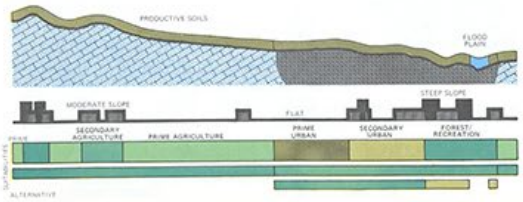


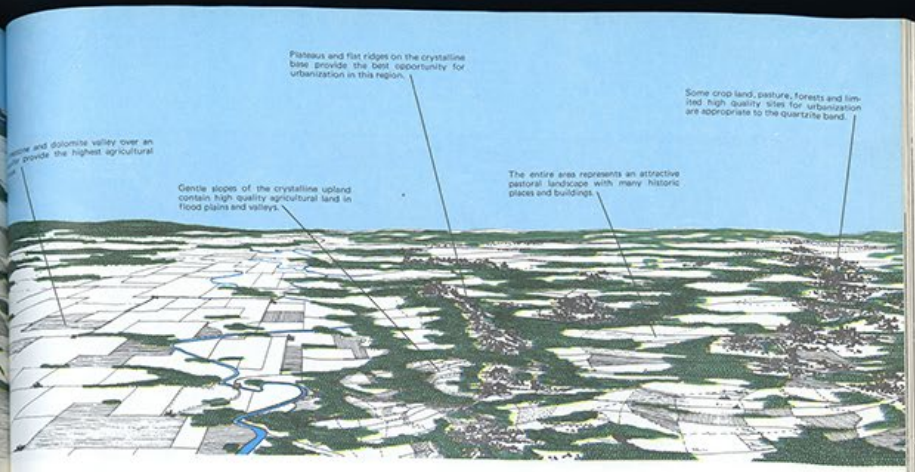
THE GREAT VALLEY

The Great Valley is one great agricultural region east of the Rockies—a broad, generally flat valley with predominantly rich limestone soils. There are, however, three subdivisions—the western hills on sandstone, shale, limestone and quartzite, the wide belt of Martinsburg shale and the valley proper of limestone and dolomite. In brief the hills provide the maximum recreational potential, the limestone the agricultural resource, and the shale the best locations for urbanization. This last is important as it ensures that urbanization does not occur over the aquifer.

The resources and their distribution are most felicitous—wooded hills, a fertile valley, a swath of shale suited for urbanization, the latter bordered by a fine river and exhibiting considerable scenic quality.

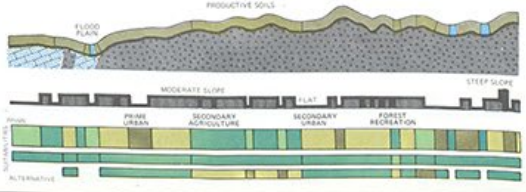


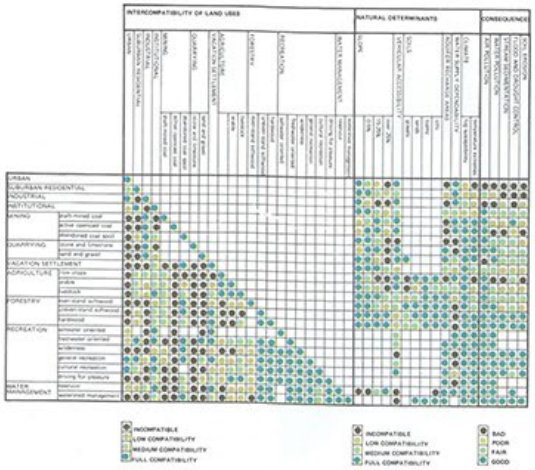




THE PIEDMONT

The section of the Piedmont illustrated reveals a great complexity—a limestone and dolomite valley, a preCambrian upland of crystalline rocks fissured with intrusions, a broad band of quartzite, yet another of shales. Intrinsic suitabilities respond to geology and the consequential physiography, hydrology and soils. The limestone and dolomite valley is most suited for agriculture, the shales for pasture and non-commercial forests, some crops, pasture and forests are appropriate to valleys and flood plains in the crystalline area. The most suitable urban sites fall in the crystalline region on flat plateaus and ridges. They are absent on limestone, rare on the shales. This is an area on the edge of urbanization. Opportunities abound but planning must respond to the specific opportunities and constraints afforded by the region.





DEGREE OF COMPATIBILITY

Optimum Multiple Land Uses

The preceding studies of intrinsic suitabilities for agriculture, forestry, recreation and urbanization reveal the relative values for each region and for the basin within each of the specified land uses. But we seek not to optimize for single, but for multiple compatible land uses. Towards this end a matrix was developed with all prospective land uses on each coordinate. Each land use was then tested against all others to determine compatibility, incompatibility and two intervening degrees.

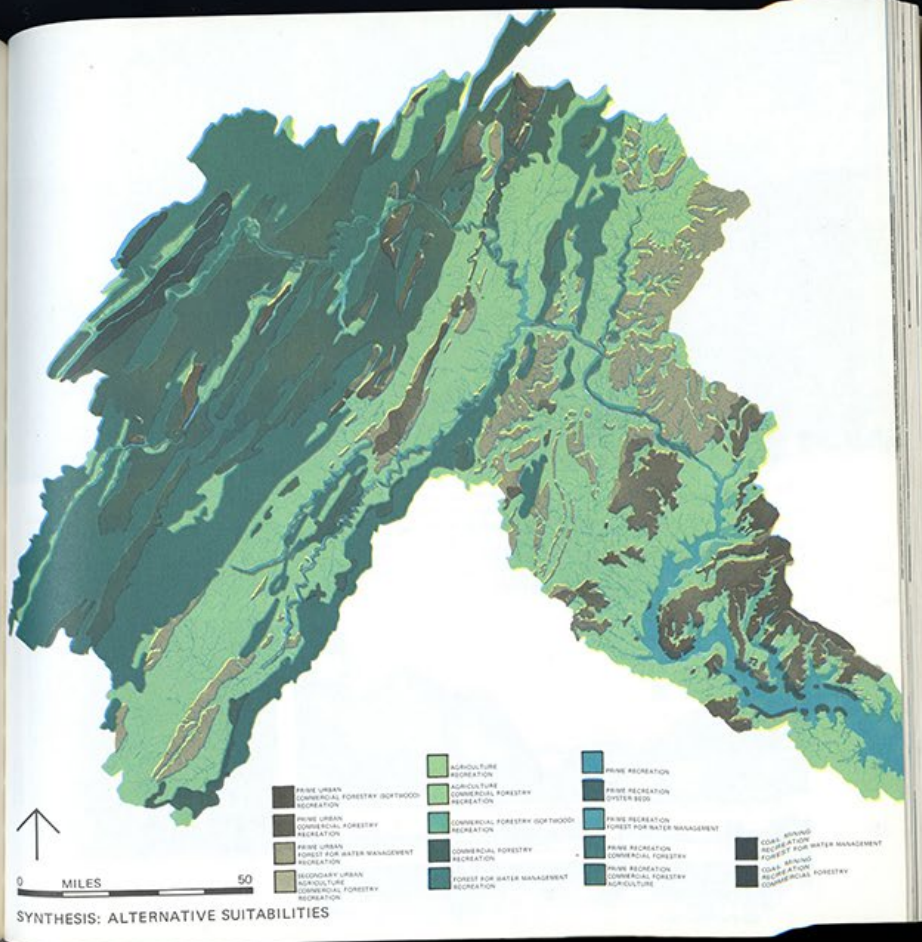
From this it was possible to reexamine the single optimum and determine the degree of compatibility with other prospective land uses. Thus, for example, an area that had been shown to have a high potential for forestry would also be compatible with recreation, including wildlife management. Within it there might well be opportunities for limited agriculture—pasture in particular—while the whole area could be managed for water objectives. Yet, in another example, an area that proffered an opportunity for agriculture as dominant land use could also support recreation, some urbanization and limited exploitation of minerals.

Adjacent to the matrix on intercompatibility is another that seeks to identify the resources necessary for prospective land uses—productive soils for agriculture, coal and limestone for mining, flat land and water for urban locations, and so on. The final matrix is devoted to the consequences of the operation of these land uses. Where there is coal mining, there will be acid mine drainage; agriculture is associated with sedimentation, urbanization with sewage, industry with atmospheric pollution. The sum of these, in principle, allows one to consider the intercompatibility of land uses, the natural determinants for their occurrence and the consequences of their operation.

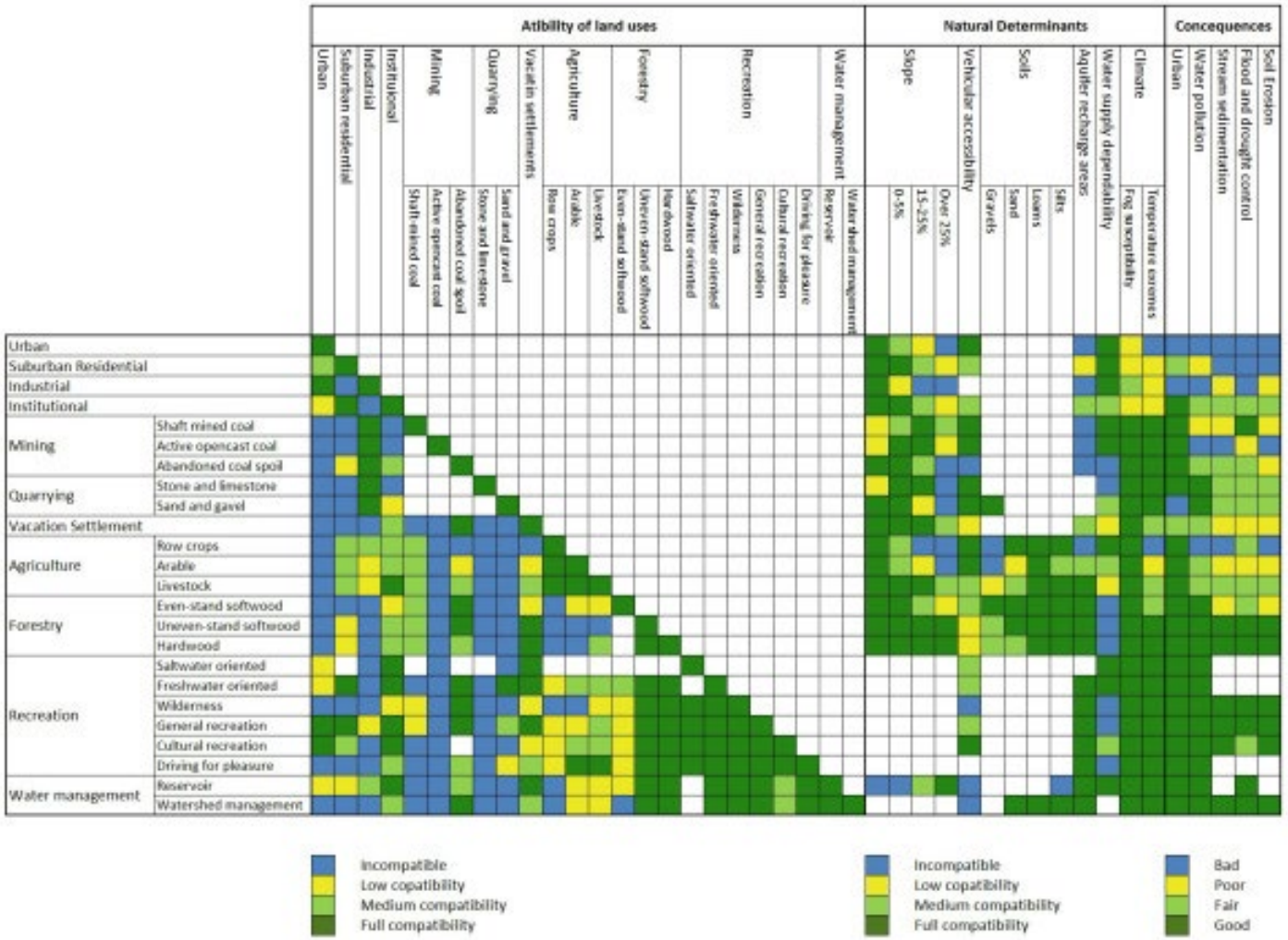
When the results of the matrix are applied, the maximum potential conjunction of coexisting and compatible land uses for the basin is revealed. In every case the dominant or codominants are associated with minor compatible land uses.

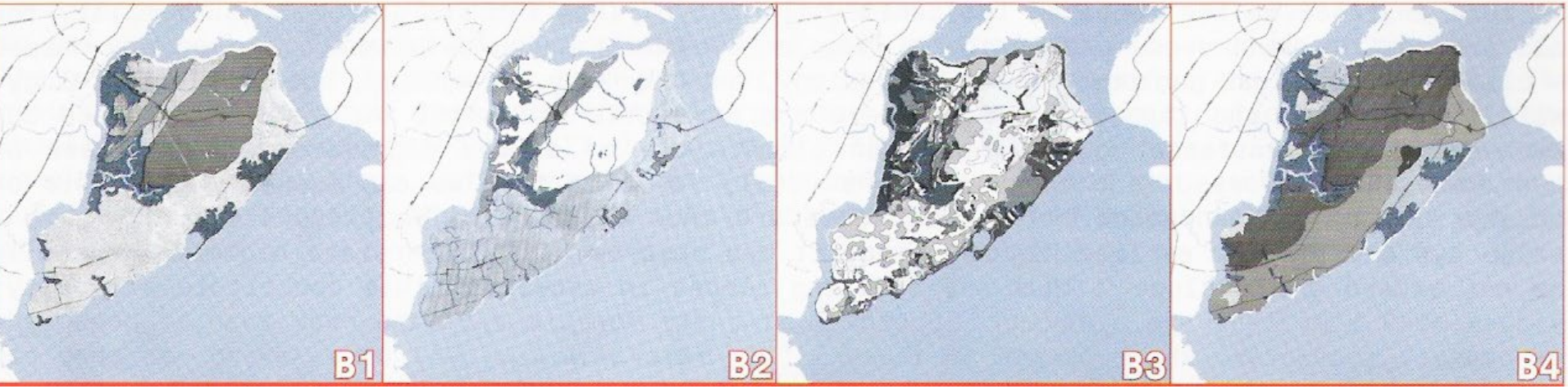
When the results are examined, it is clear that mining, coal and water-based industry offer the maximum opportunity in the Allegheny Plateau, with forestry and recreation as subordinate uses. In the Ridge and Valley Province, the recreational potential is dominant, with forestry, agriculture and urbanization subordinate. In the Great Valley, agriculture is the overwhelming resource, with recreation and urbanization as lesser land uses. The Blue Ridge exhibits only a recreational potential, but of the highest quality. The Piedmont is primarily suitable for urbanization with attendant agriculture and nondifferentiated recreation. The Coastal Plain exhibits the highest potential for water-based and related recreation and forestry, and a lesser prospect for urbanization and agriculture.

This is a method by which the nature of the place may be learned. It is because . . . and so, it varies. In its variety, it offers different resources. The place must be understood to be used and managed well. This is the ecological planning method.

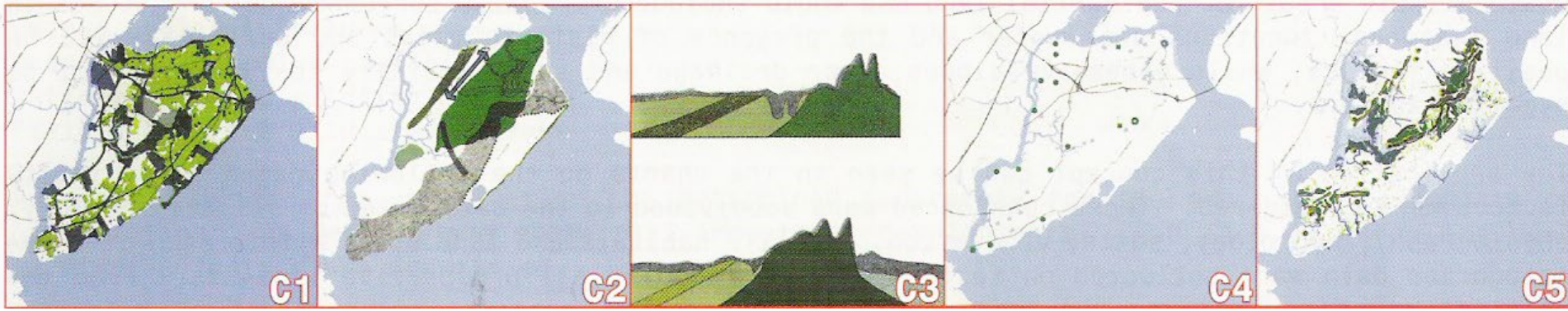


SYNTHESIS: ALTERNATIVE SUITABILITIES


Atibility of land uses
Natural Determinants
Concequences
Urban
Suburban residential
Industrial
Institutional
Mining
Shaft mined coal
Active opencast coal
Abandoned coal spoil
Quarrying
Stone and limestone
Sand and gravel
Vacation settlements
Agriculture
Row crops
Arable
Livestock
Forestry
Even-stand softwood
Uneven-stand softwood
Hardwood
Recreation
Saltwater oriented
Freshwater oriented
Wilderness
General recreation
Cultural recreation
Driving for pleasure
Water management
Reservoir
Watershed management
Slope
0-5%
15-25%
Over 25%
Vehicular accessibility
Gravels
Sand
Loams
Silts
Soils
Aquifer recharge areas
Water supply dependability
Climate
Fog susceptibility
Temperature extremes
Urban
Water pollution
Stream sedimentation
Flood and drought control
Soil Erosion
Incompatible
Low copatibility
Medium compatibility
Full compatibility
Incompatible
Low copatibility
Medium compatibility
Full compatibility
Bad
Poor
Fair
Good



Bedrock geology | Hydrology | Soil drainage | Surficial geology



Existing land use | Geologic features | Geologic sections | Historical landmarks | Physiographic features

Staten Island, NY

Ian McHarg

Ian McHarg's "OVERLAY SYSTEM" (*Design with Nature*, 1969)

1. Any place is the sum of historical, physical and biological processes
2. These processes are dynamic
3. Processes constitute social values
4. Each area has an **intrinsic suitability** for certain land uses
5. Certain areas lend themselves for multiple, co-existing land uses.

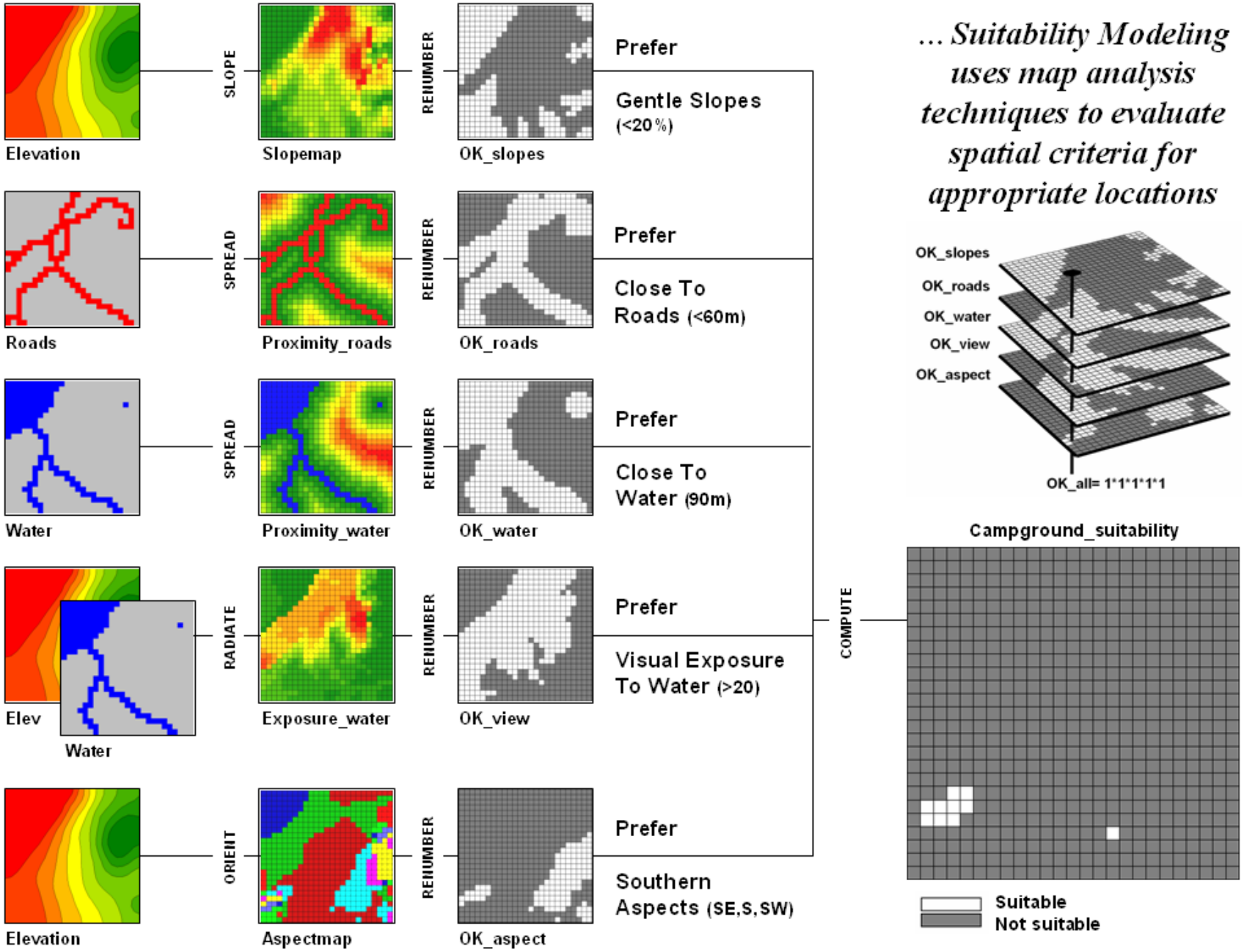
1. כל מקום הוא סכום של תהליכים היסטוריים, פיזיים וביולוגיים.

2. תהליכים אלה הם דינאמיים.

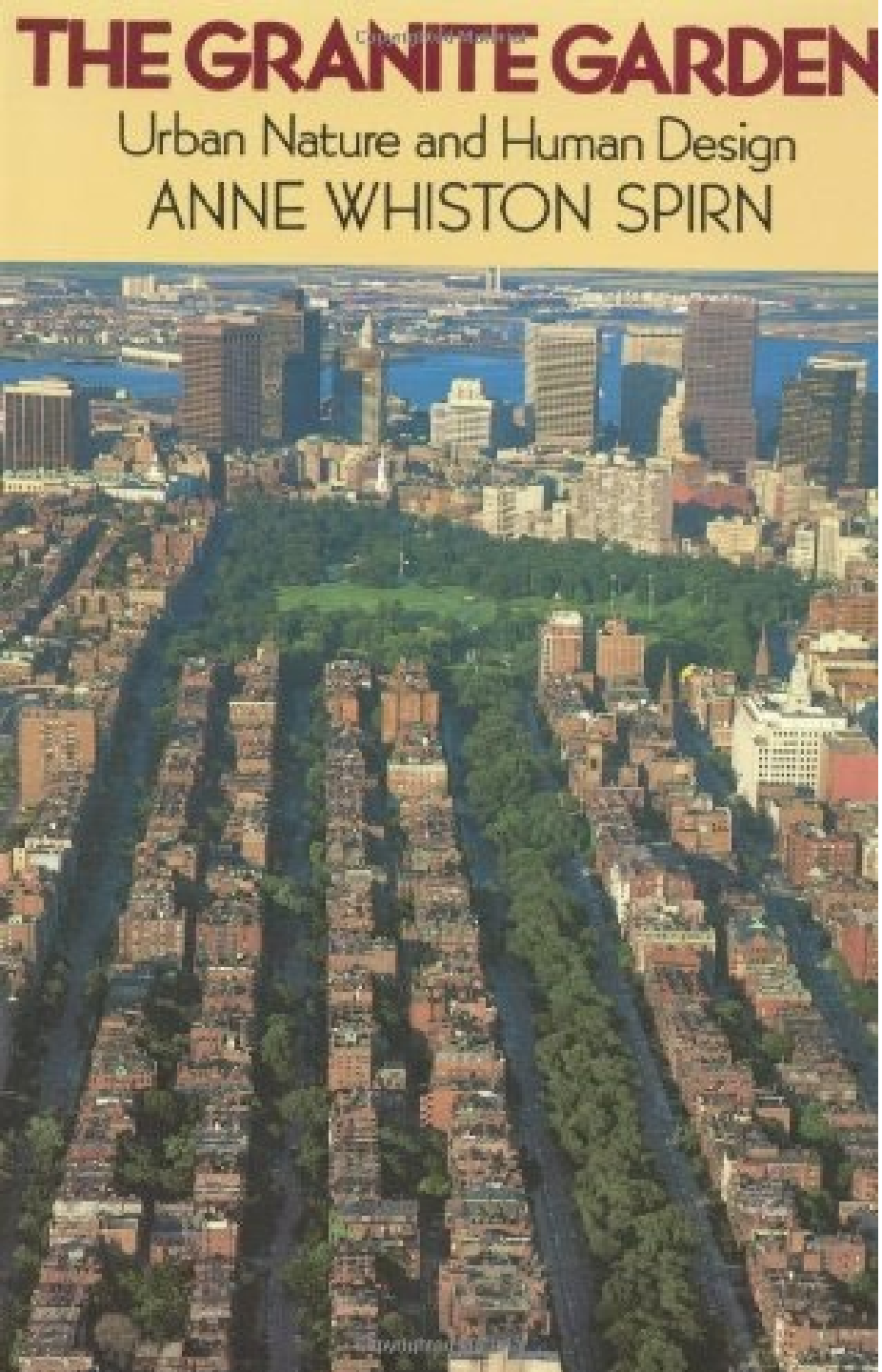
3. תהליכים מהווים ערכים חברתיים.

4. לכל אתר יש התאמה אינהרנטית/ מהותית ליעודי קרקע מסוימים.

5. לאתרים מסוימים יש התאמה ליעודי קרקע מרובים



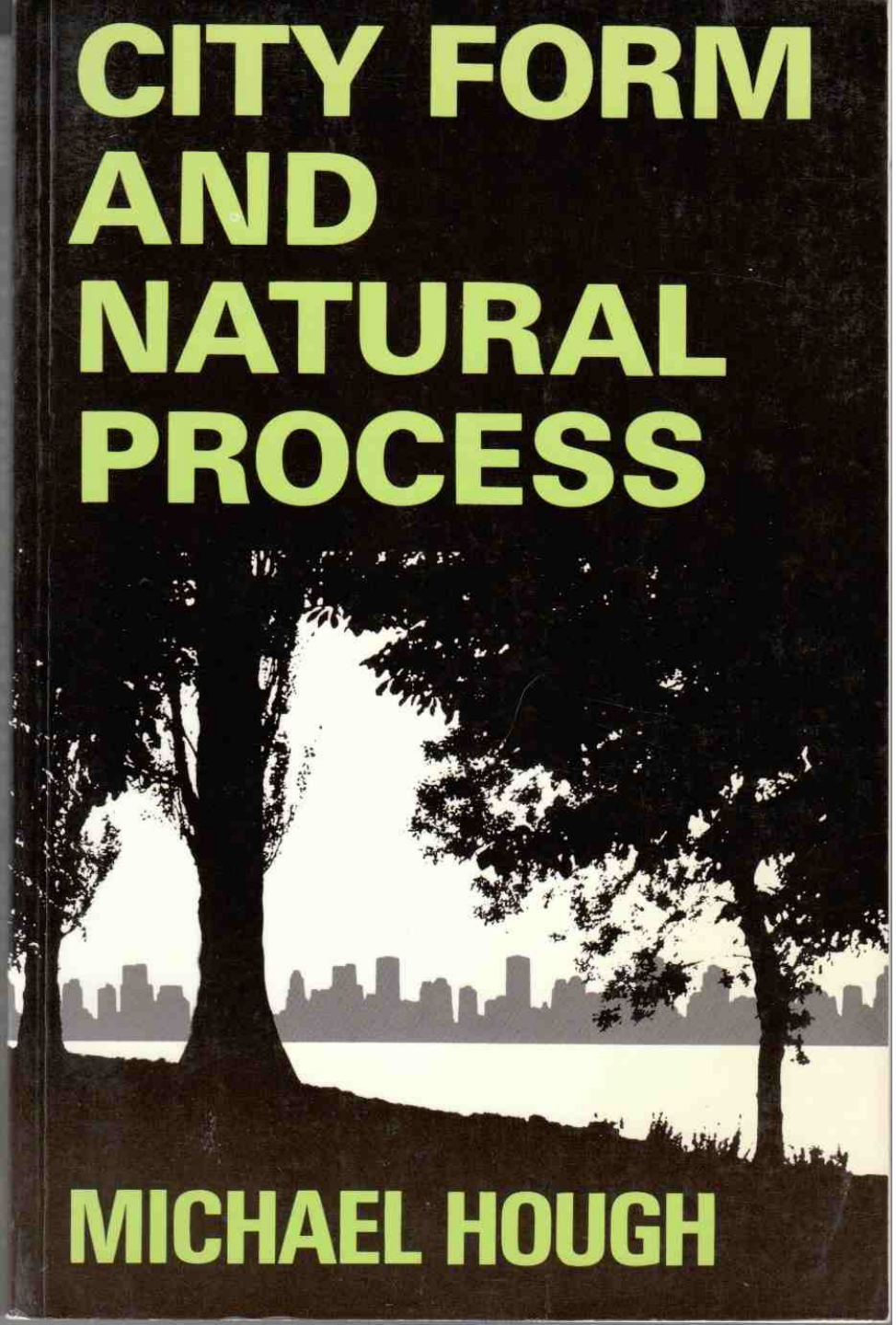
-from GIS Modeling and Analysis. Joseph K. Berry



"Nature in the city is far more than trees and gardens, and weeds in sidewalk cracks and vacant lots. It is the air we breathe, the earth we stand on, the water we drink and excrete, and the organisms with which we share our habitat."

Anne Spirn,
The Granite Garden, 1984

principles for an ecological approach to the design of cities



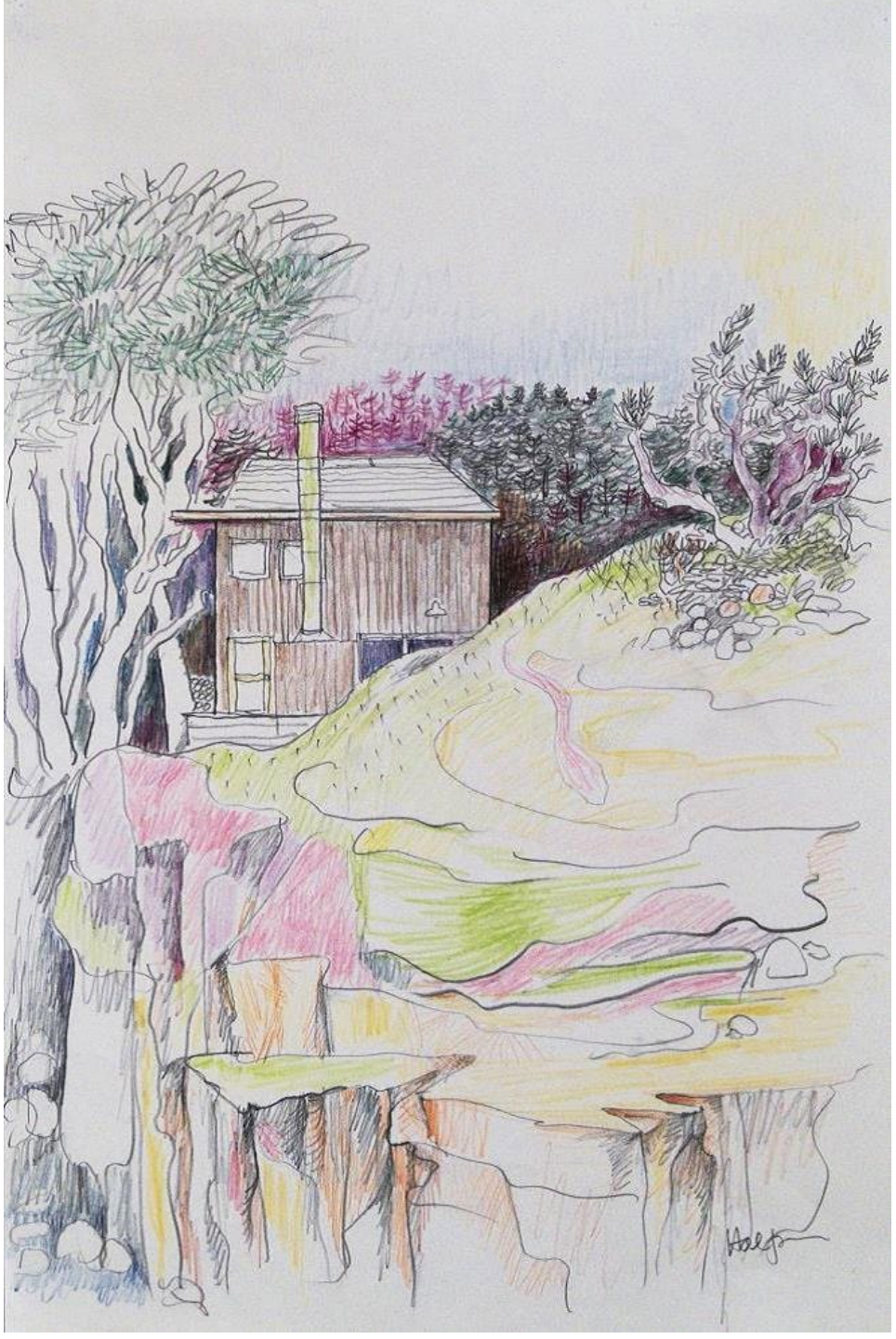
Michael Hough,
City Form and Natural Process,
1985

Sea Ranch, Sonoma CA, MLTW Architects, Lawrence Halprin, Landscape Architect 1962-5

"The quality of living with nature and allowing it to manifest itself is different than the quality of living in a city, especially a dense city."

(Sea Ranch Water Motion Study) From Halprin, "Notebooks 1959 to 1971"

Lawrence Halprin (1916–2009) c. 1960s

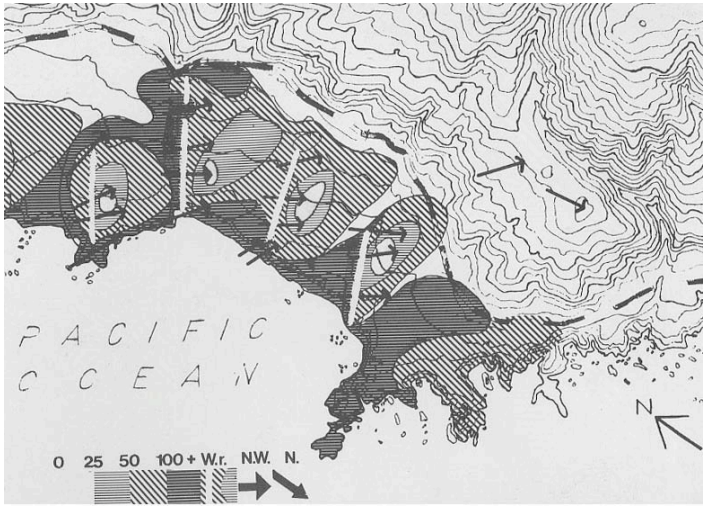


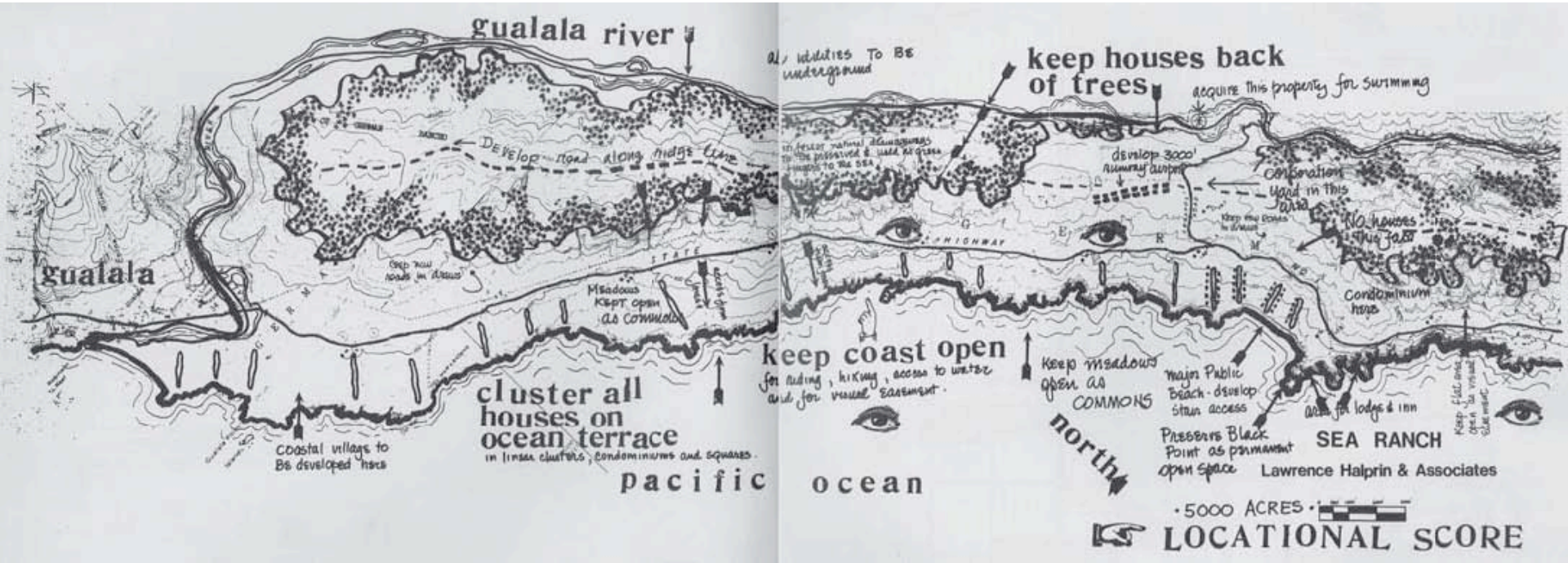
The Sea Ranch environment: redwood forested uplands, meadowed ocean terraces, rocky cliffs, sandy beaches.

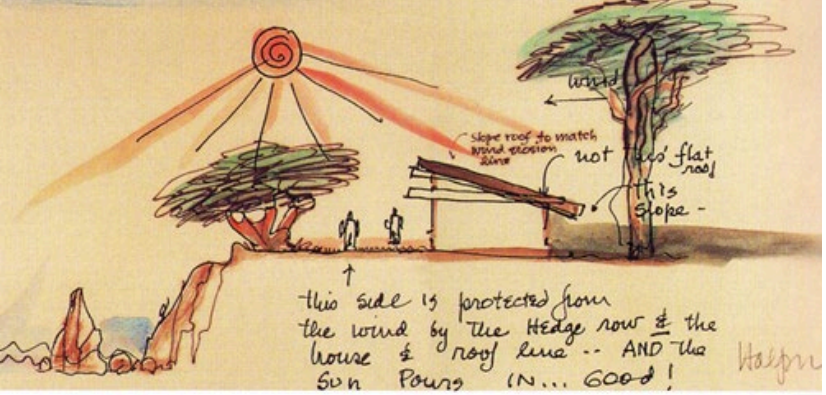
Wind: controlled by sloped roofs, siting houses behind windrows.
Forestry: controlled thinning, controlled burns of forest litter to minimize risk of fire.
Planting: use of native plants, groundcovers instead of lawns

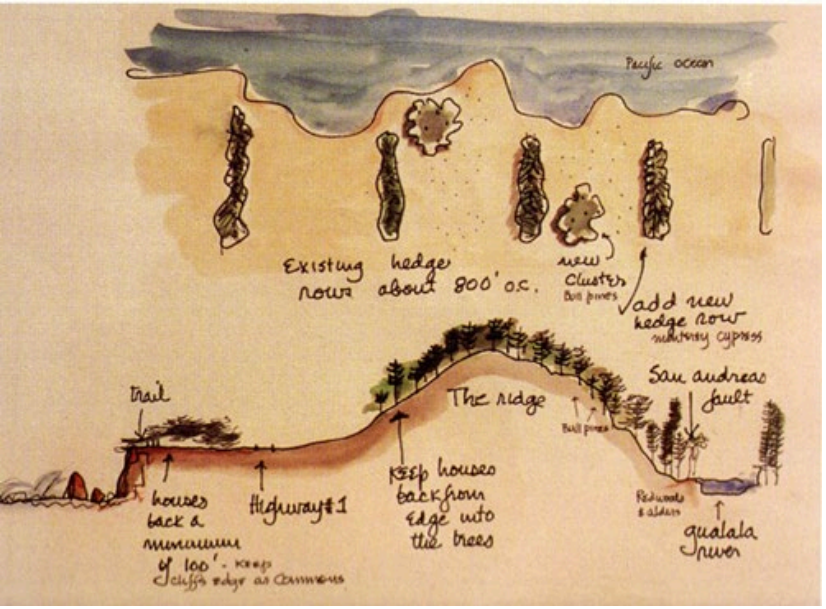
Use of hedgerows to control wind

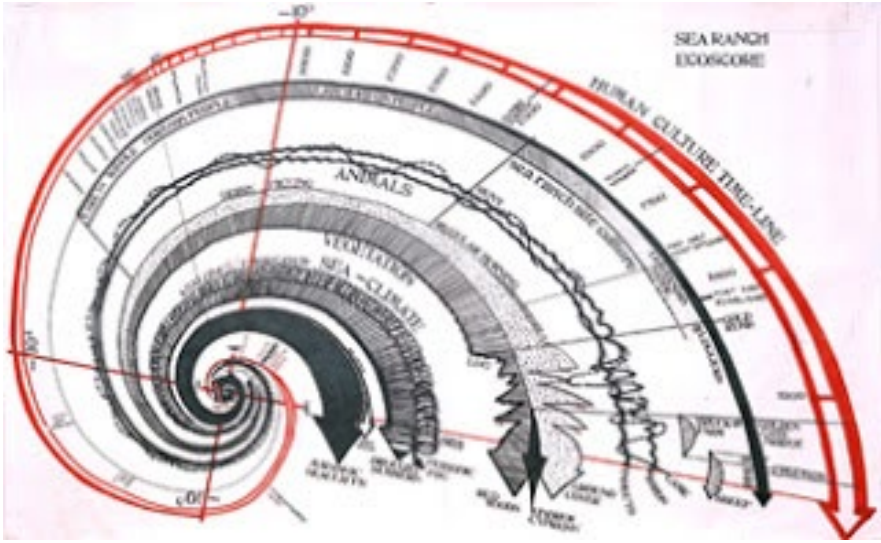
Land use policies:
cluster housing around courtyards, kept behind tree line, keep meadows as “commons”, road along ridge line



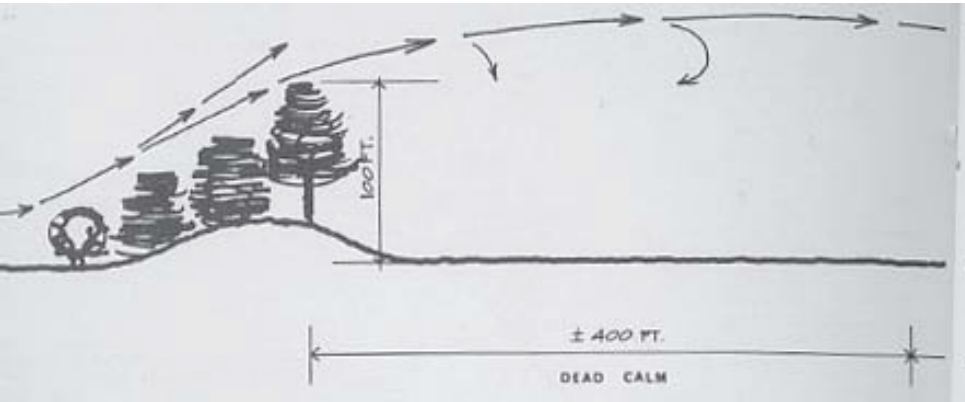


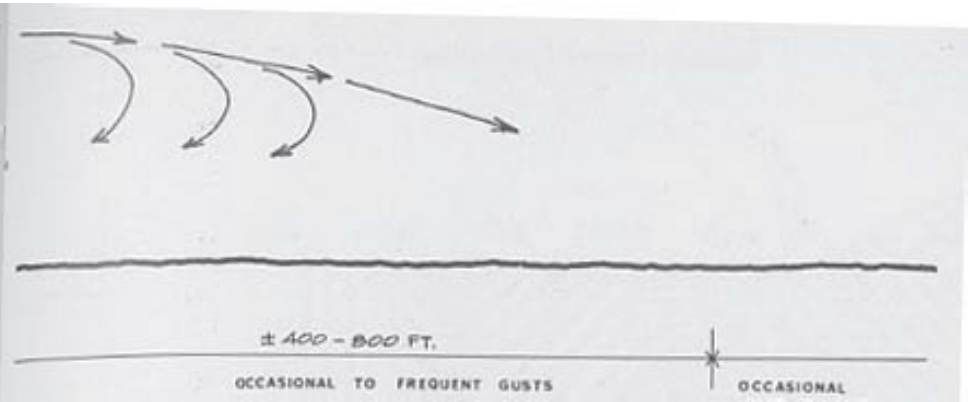






Hedgerows, plant groupings of native species, and berms sheltered the buildings from coastal winds, and created protected areas for recreation

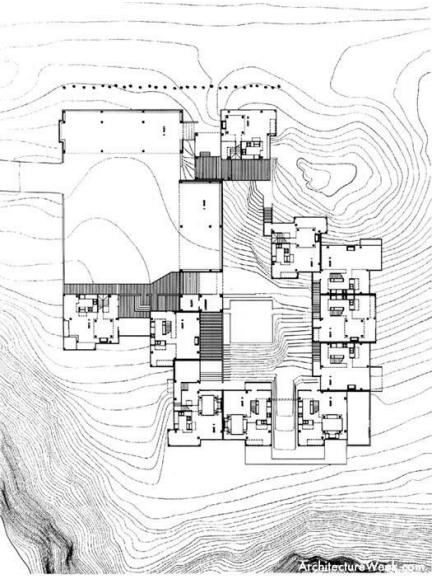


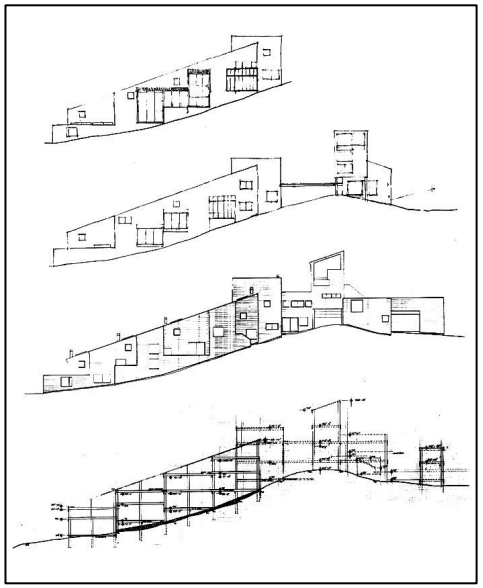


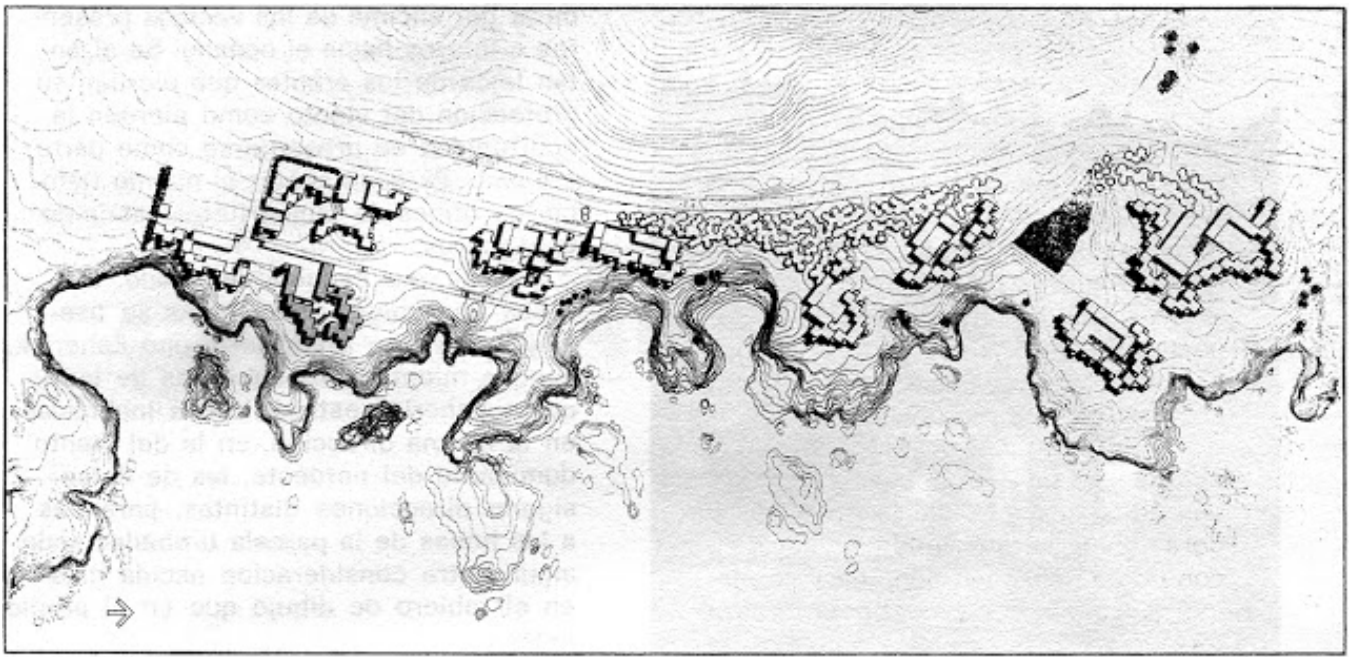


Condominium One, (10 units) Joseph Esherick, and the architectural firm Moore Lyndon Turnbull and Whitaker (MLTW), 1965. Placed on the National Register of Historic Places in 2005

Meadow swales, Sea Ranch, California, by Lawrence Halprin Associates, 1962







Sustainability/Resilience

ecological succession …dominated plant biology during the early 20th century and became the basis for the new integrated science of plants, animals and the environment eventually known as ecosystem ecology.

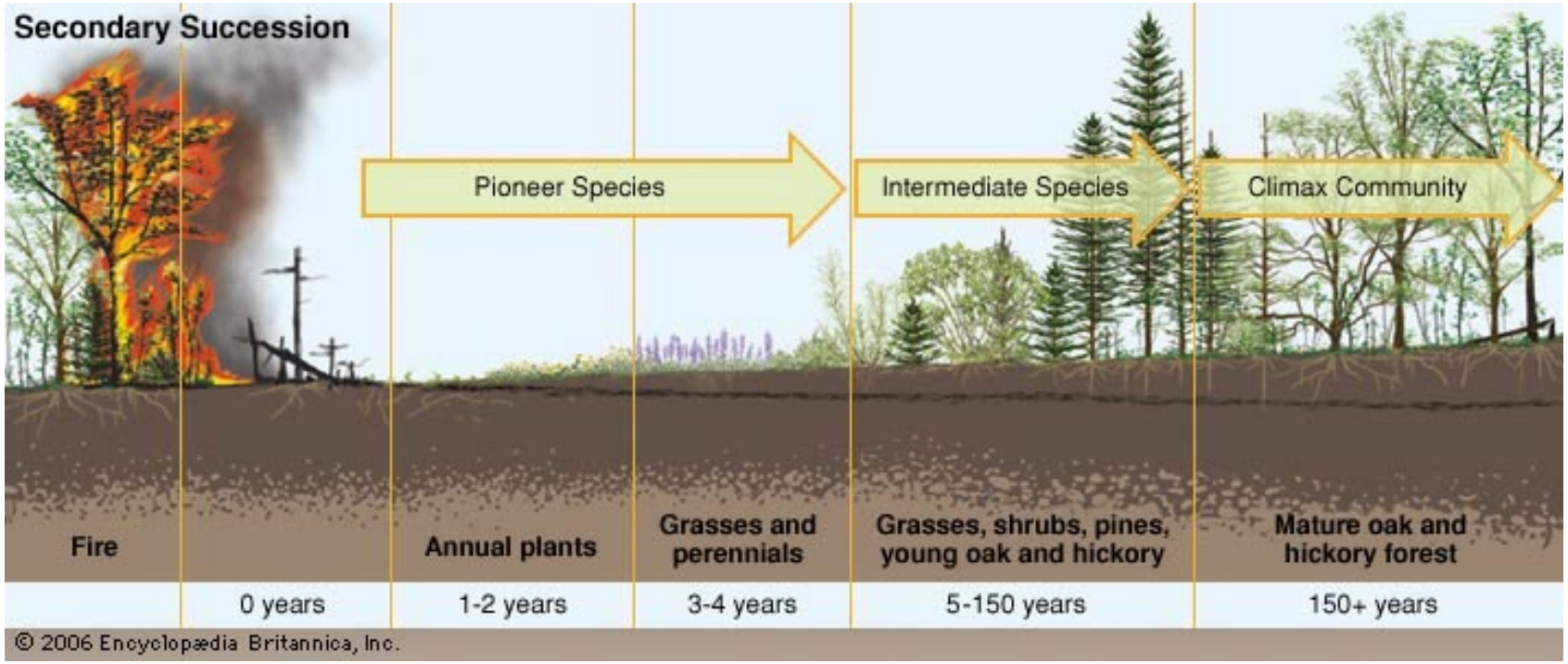
Plant Ecology- CLIMAX COMMUNITY and "Balance of Nature" model.

Frederick Clements, *Research Methods in Ecology,* 1905

"The plant formation is 'an organic unit'."
Plant associations: the healthy ecosystem is an integrated, efficiently functioning entity that can be defined, described, and measured quantitatively.

Eugene Odum, *Fundamentals of Ecology,* 1954

"Ecosystem development, or what is more often known as ecological succession…is an orderly process of community development [that] is reasonably directional and, therefore, predictable.



EQUILIBRIUM PARADIGM

Systems are materially closed

Systems are internally regulated

Systems have as single equilibrium state

Systems are deterministic

Disturbance is an exceptional event

Humans are external to ecological systems.

NON-EQUILIBRIUM OR DISTURBANCE PARADIGM

Ecological systems are open: to energy flows, chemical materials, nutrients, pollutants.

Ecological systems may be externally regulated

Ecological systems may have multiple,or no stable state(s)

Ecological systems have probabilistic dynamics, eg. succession

Disturbance (events that disrupt the physical structure of systems) may be a component of a system at a specified scale.

Humans are part of ecosystems..

Based on S.T.A. Pickett et al (2004)

Sustainability

according to the Brundtland Commission, 1987

“development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

(*World Commission on Environment and Development* 1987, chaired by Gro Harlem Brundtland).

Emphasizes:

- balance between **society** and **nature**
- equity between generations
- The idea of limitations

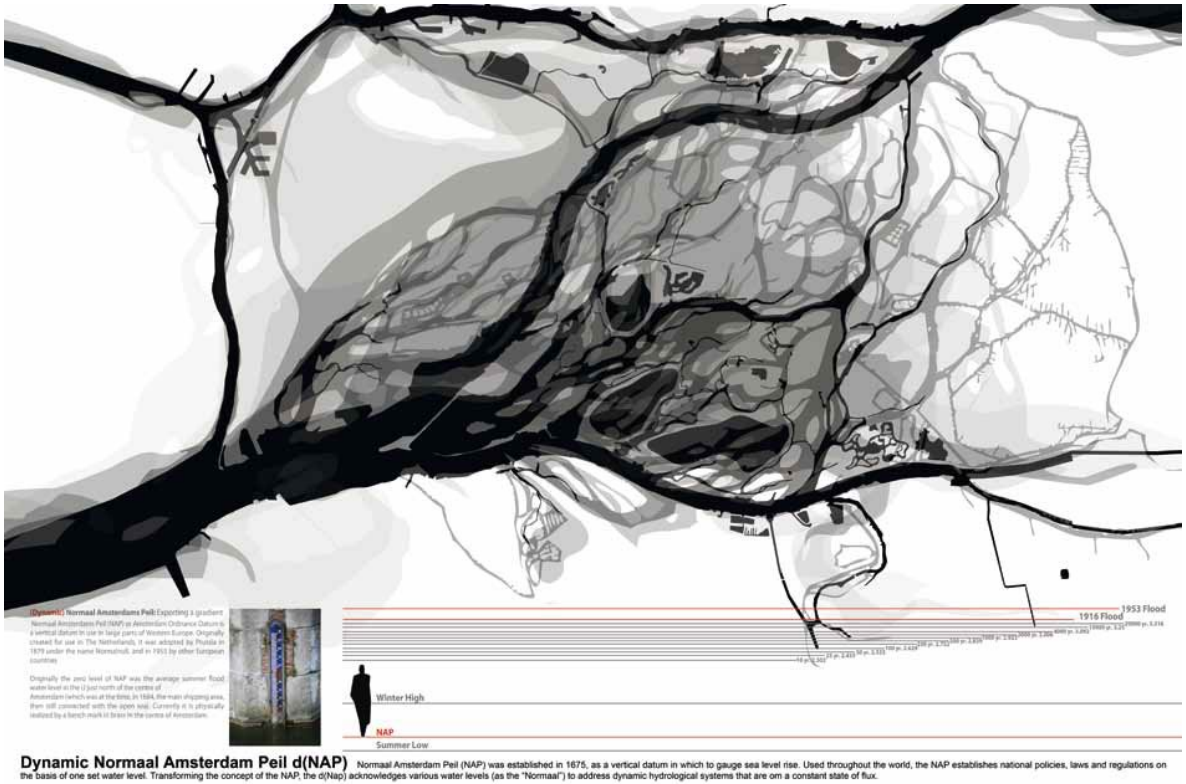
United Nations

Resilience

“the ability of a system to absorb change and disturbance without changing its basic structure and function or shifting into a qualitatively different state” Holling (1973)

focuses on the system’s abilities to self-organize and adapt to changes
self-organization- local interactions at small scales result in emergent patterns at larger scales

- a resilient city “anticipates,plans, and acts to prepare for and respond to unexpected crises



MULTIPLE STABLE STATES, THRESHOLDS, REGIME SHIFTS

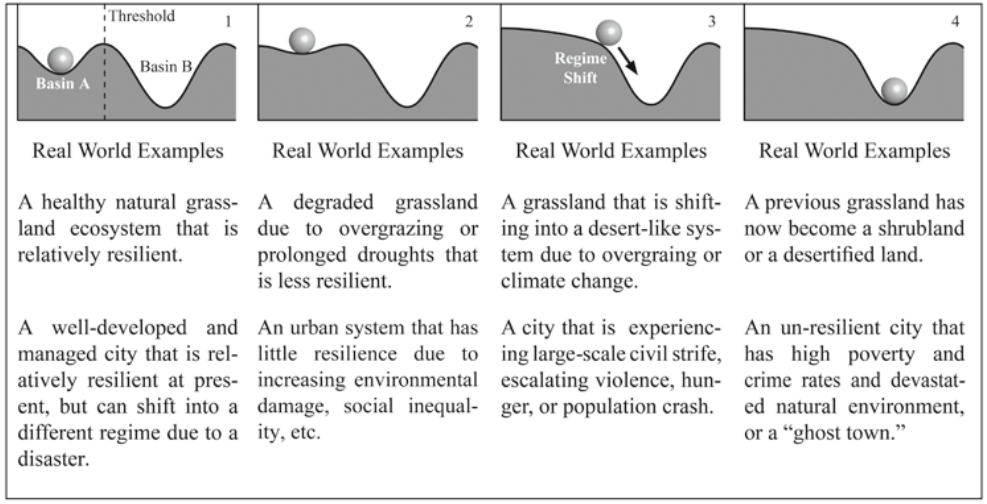
"A critical assumption behind the concept of ecological resilience is the existence of **multiple stable states**…

Thresholds—a concept similar to tipping points—refer to the boundaries between (stable states), crossing which leads the system to a different regime. Such transitions of social-ecological systems between alternate stable states are known as **"regime shifts"**

(Wu and Wu, 2013)

Regime shifts may result in abrupt and dramatic changes in system structure and function in some cases or more continuous and gradual changes in other situations.

For instance, a grassland may change to a shrubland due to overgrazing or climate change that pushes the system over a threshold in terms of vegetation cover and soil properties (Walker and Salt 2006)."



Real World Examples	Real World Examples	Real World Examples	Real World Examples
A healthy natural grassland ecosystem that is relatively resilient.	A degraded grassland due to overgrazing or prolonged droughts that is less resilient.	A grassland that is shifting into a desert-like system due to overgraing or climate change.	A previous grassland has now become a shrubland or a desertified land.
A well-developed and managed city that is relatively resilient at present, but can shift into a different regime due to a disaster.	An urban system that has little resilience due to increasing environmental damage, social inequality, etc.	A city that is experiencing large-scale civil strife, escalating violence, hunger, or population crash.	An un-resilient city that has high poverty and crime rates and devastated natural environment, or a "ghost town."

(Wu and Wu, 2013)

Suitability—Goal was to put things in the right place, given long-term historical conditions.

Sustainability—Goal was to keep what we have, while mitigating/reducing carbon emissions.

Resilience—Goal is to recover more quickly and with fewer losses after disaster events. **Preserving the ability to self-organize in the face of disturbances is a crucial characteristic of resilient systems.**

Kristina Hill, (2016) Climate Change: Implications for the Assumptions, Goals and Methods of Urban Environmental Planning

The ability of a city to persist without qualitative change in structure and function in spite of disturbances. (Wu and Wu 2013)

From a resilience perspective, sustainability is not about maintaining a system at its equilibrium state by reducing the variability in system dynamics or optimizing a system's performance, but rather sustainability should focus on the system's capacity ***to create and test opportunities and maintain adaptive capabilities*** *(Holling 2001).*

-Wu and Wu (2013)

1. **Diversity**: create and maintain diversity, complement "homogenizing trends"
2. **Ecological variability**: understand that you can't control or tame these systems
3. **Modularity**: Avoid over-connectedness
4. **Acknowledging slow variables**: Understandingthe "slow" or controlling variables that underpin the condition of a system, especially in relation to thresholds.
5. **Tight feedbacks loops**: We should see clear and quick consequences of our actions, allows us to see if approaching threshold, such as pollution

Wu and Wu (2013)

Nature Based Solutions and Green Infrastructure

Nature-based solutions (NBS) refers to the sustainable management and use of nature for tackling socio-environmental challenges.

The challenges include issues such as **climate change, water security, water pollution, food security, human health, and disaster risk management**.

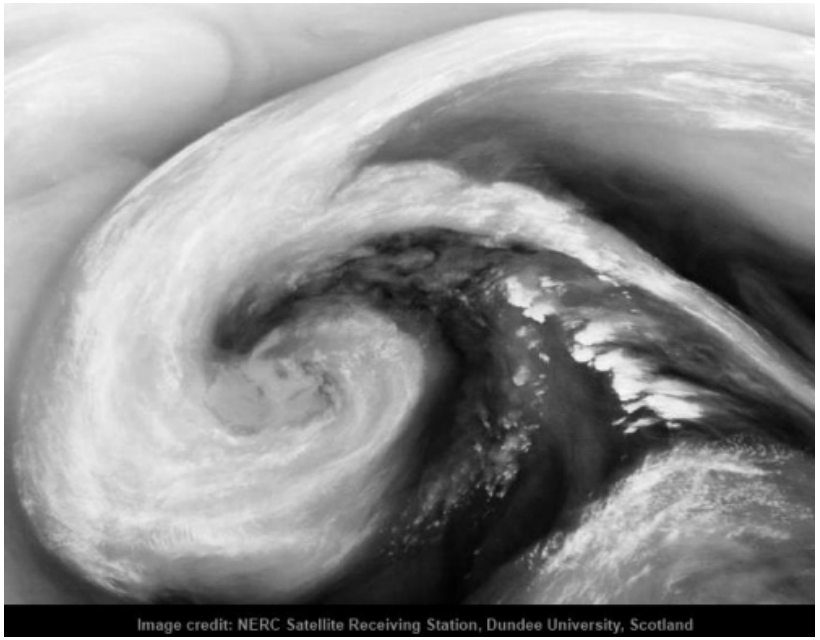
פתרונות מבוססי טבע (NBS) מתייחסים לניהול ושימוש בר-קיימא של מערכות טבעיות להתמודד עם אתגרים חברתיים-סביבתיים. האתגרים כוללים **סוגיות כמו שינויי אקלים, אבטחת מים, זיהום מים, אבטחת מזון, בריאות האדם וניהול סיכוני אסון.**

GREEN INFRASTRUCTURE

‘‘all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales’’. Tzoulas et al. (2007)

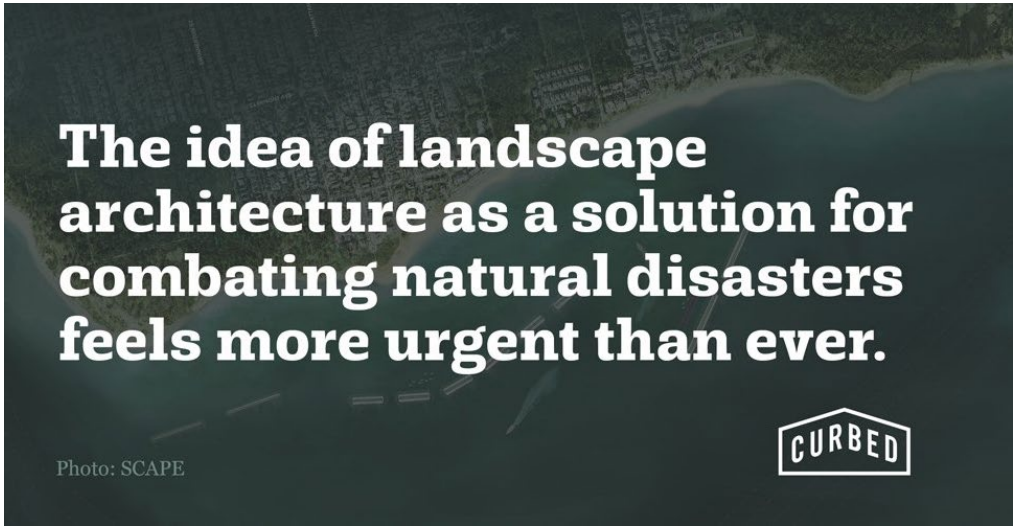
“a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services.” European Union

‘‘An adaptable term used to describe an array of products, technologies, and practices that use natural systems—or engineered systems that mimic natural processes—to enhance overall environmental quality and provide utility services’’ The United States Environmental Protection Agency (EPA) 2020



A water vapor satellite image of Superstorm Sandy

Global warming-related sea level rise

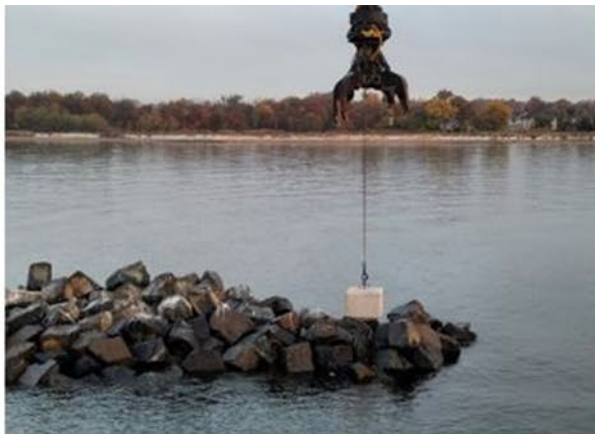


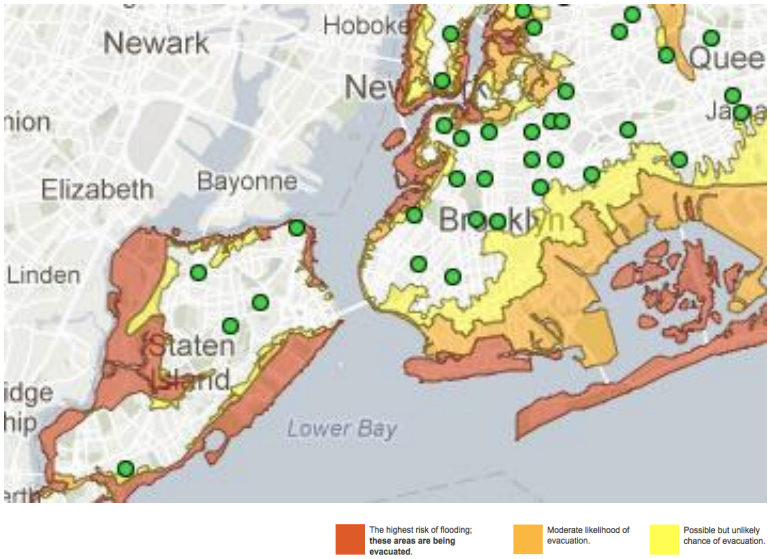
REBUILD
BY
DESIGN

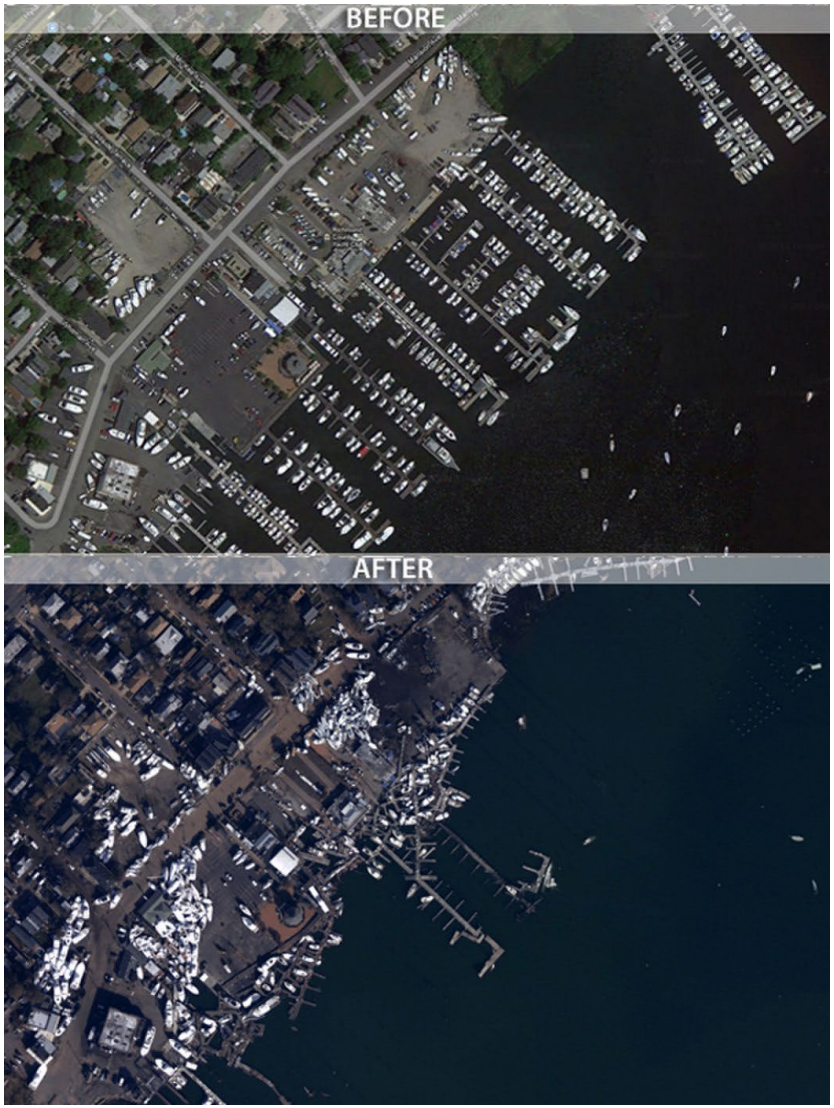
LIVING BREAKWATERS

SCAPE / LANDSCAPE
ARCHITECTURE TEAM

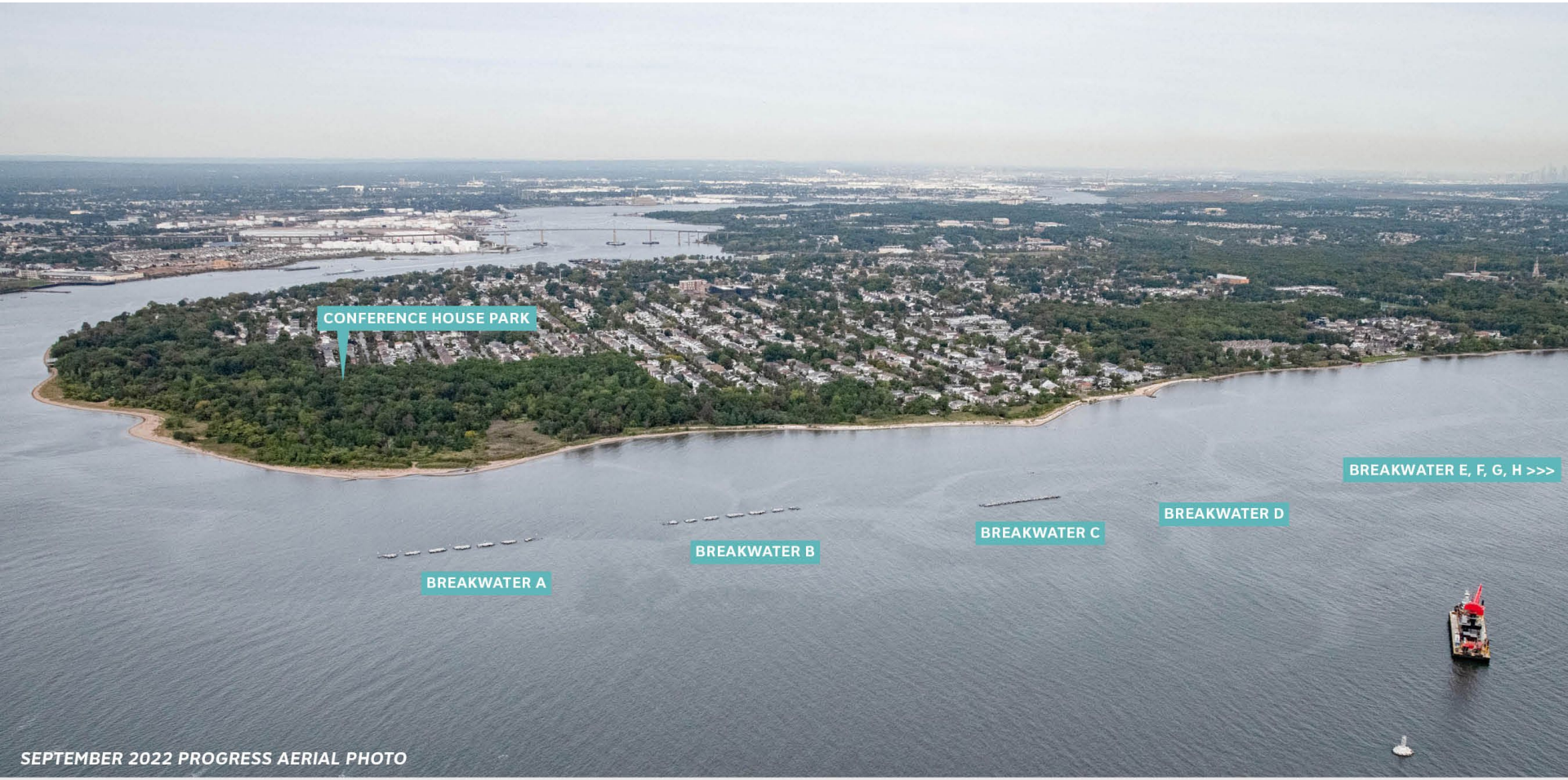
CLIENT
•U.S. Department of Housing and Urban Development
COLLABORATORS
Parsons Brinckerhoff
Stevens Institute of Technology
Ocean and Coastal Consultants
SeArc Ecological Marine Consulting
The New York Harbor School
LOT-EK
MTWTF
Paul Greenberg







Staten Island, N.Y., before and after Hurricane Sandy.
Credit: Google/NOAA's National Geodetic Survey



SEPTEMBER 2022 PROGRESS AERIAL PHOTO

LIVING BREAKWATERS PROJECT AREA

Note: Location of construction aids for navigation are subject to regular change depending on conditions encountered and construction progress.

CONFERENCE HOUSE PARK VISITOR CENTER

Swinnerton St.
Main St.
Chelsea St.
Brighton St.
Manhattan St.
Yetman Ave.
Rockaway St.
Loretto St.
Sprague Ave.
Joline Ave.
Beechwood Ave.
Page Ave.
Billop Ave.

LIVING BREAKWATERS CONSTRUCTION AREA ENVELOPE

A
B
C
D
E
F
G
H

ANCHOR SPREAD

RED BANK REACH (35' DEPTH)

FEDERAL NAVIGATION CHANNEL

WARD POINT BEND
EAST REACH (35' DEPTH)

Navigation Aids

E-crane & Excavators placing stones

Materials Barge

BREAKWATERS UNDER CONSTRUCTION IN SUMMER 2022

FUTURE BREAKWATERS

EXISTING CHANNEL MARKERS

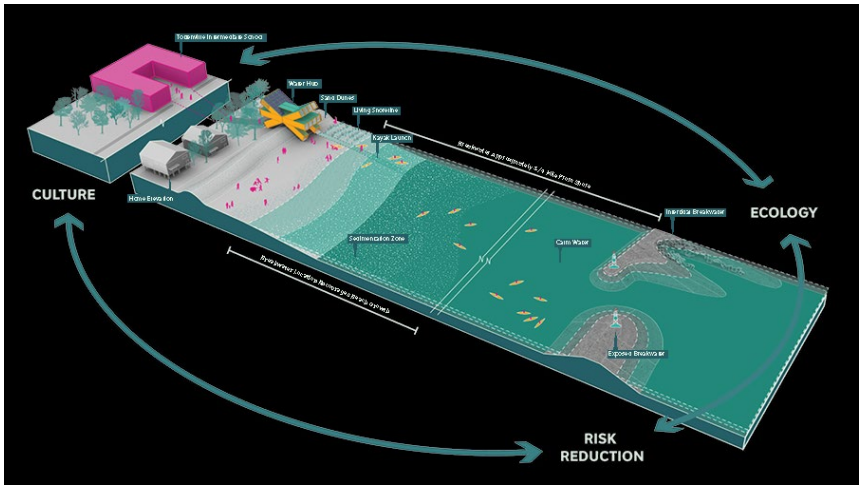
NORTH

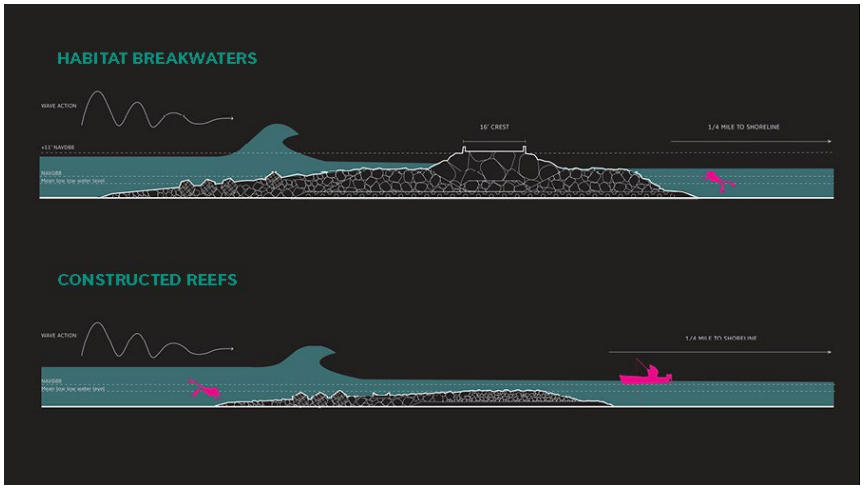
0' 200' 800' 1600'

https://www.nbcnews.com/video/how-one-billion-oysters-could-protect-nyc-from-the-next-superstorm-128990789893


NBC NEWS

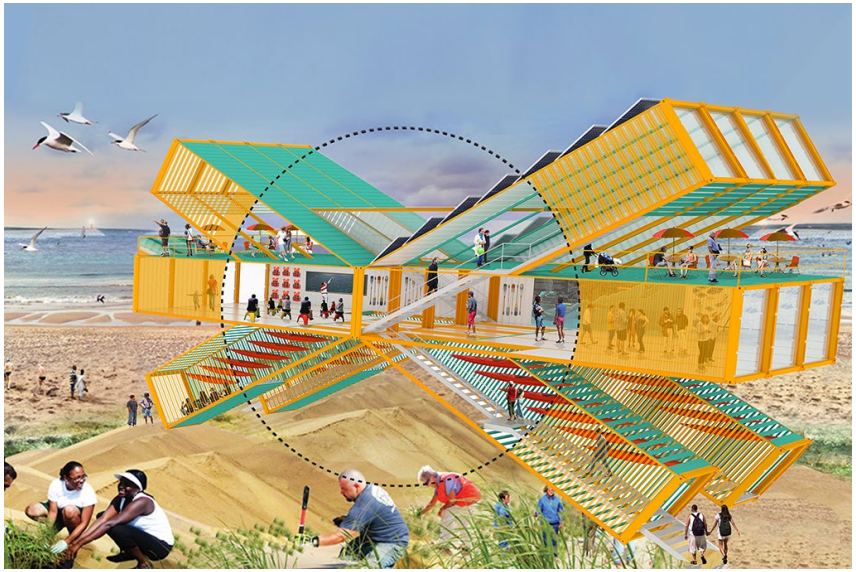

Annadale & Crescent Beach Reach
Lemon Creek & Wolfe's Pond Reach
Tottenville Reach
GREAT KILLS HARBOR
RARITAN BAY

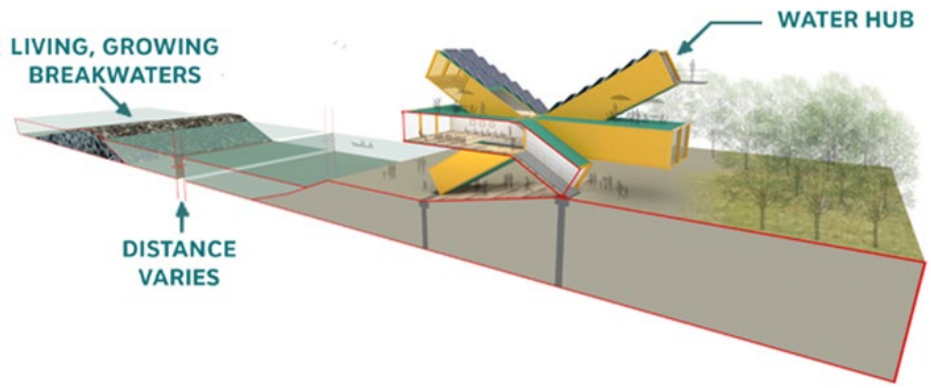




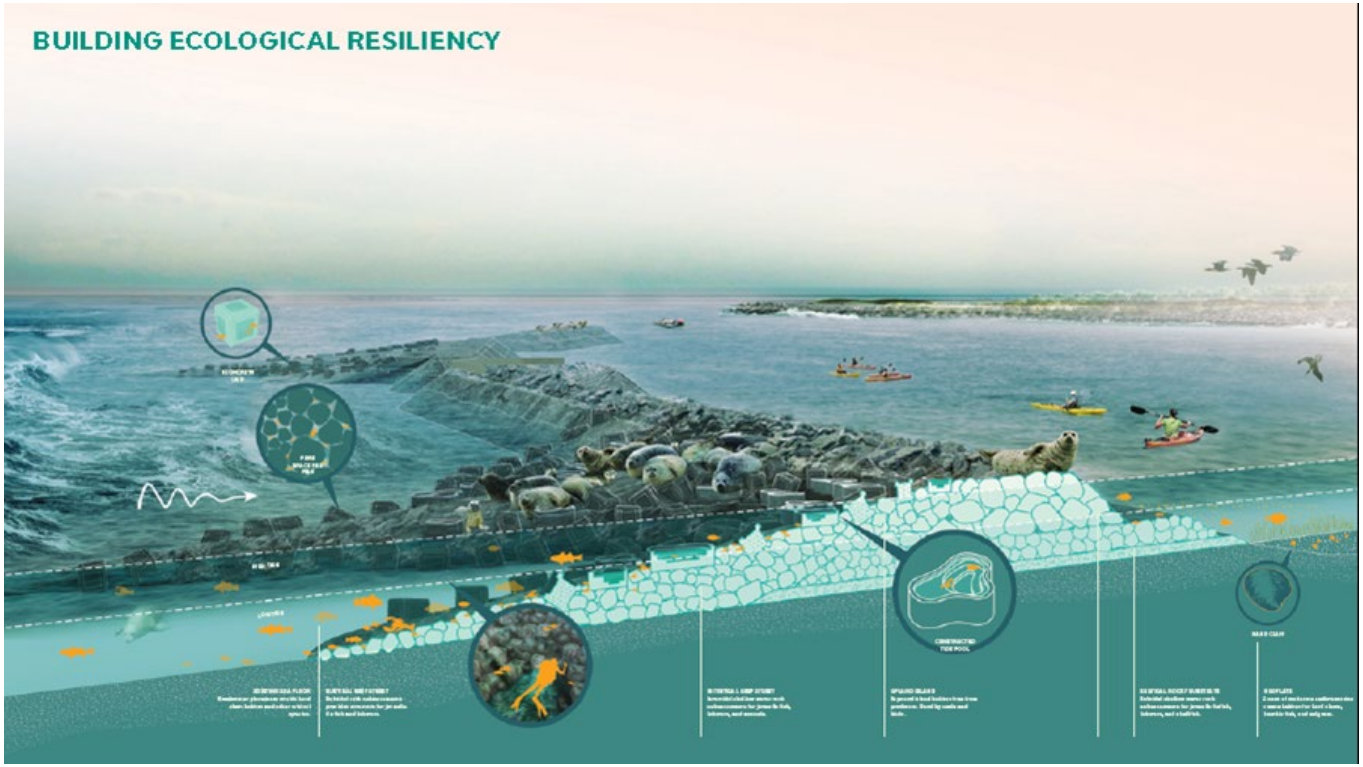
Living Breakwaters, SCAPE

Community hubs along the shore

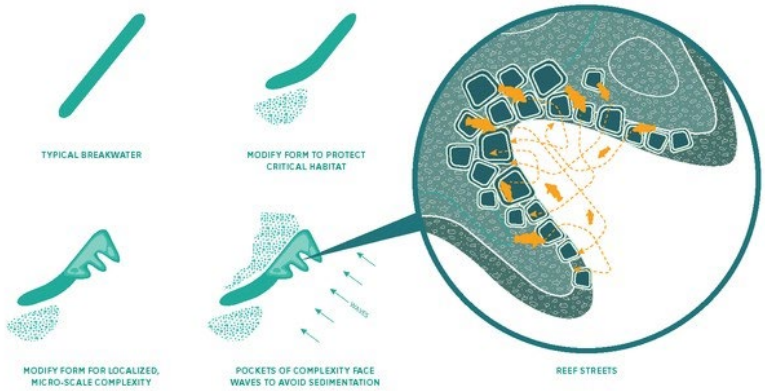




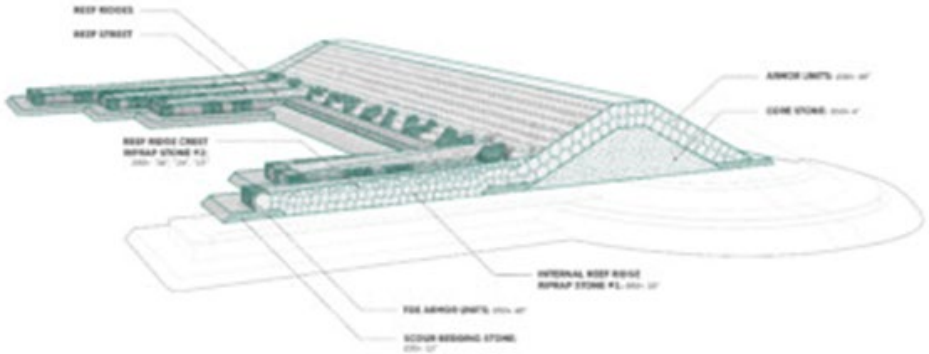
BUILDING ECOLOGICAL RESILIENCY



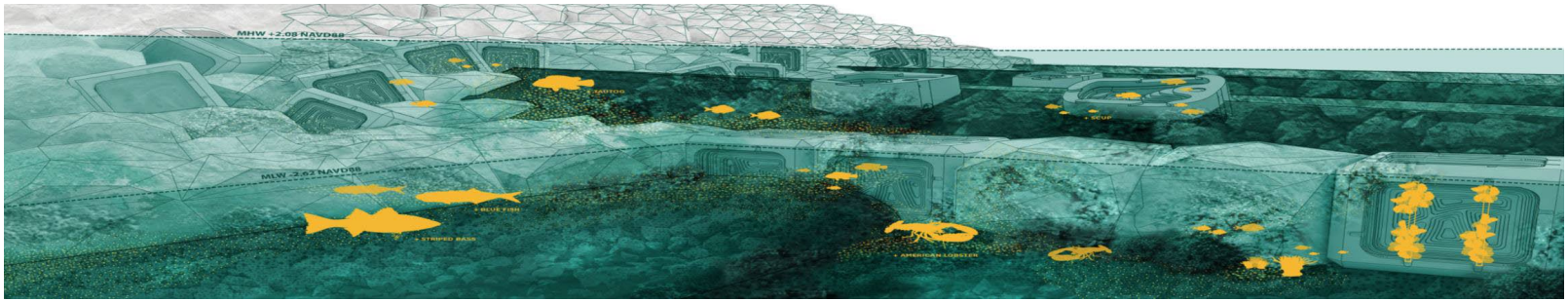
DESIGNING FOR HABITAT



CREATE NICHES AND COMPLEXITY



Textured perforated concrete block- ECOncrete to promote marine habitat

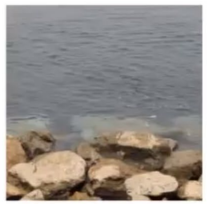


MATERIALS

GEOTEXTILE

RIP RAP STONE #2

STANDARD ARMOR STONE



TOE ARMOR STONE

BIO-ENHANCING CONCRETE INSERTS

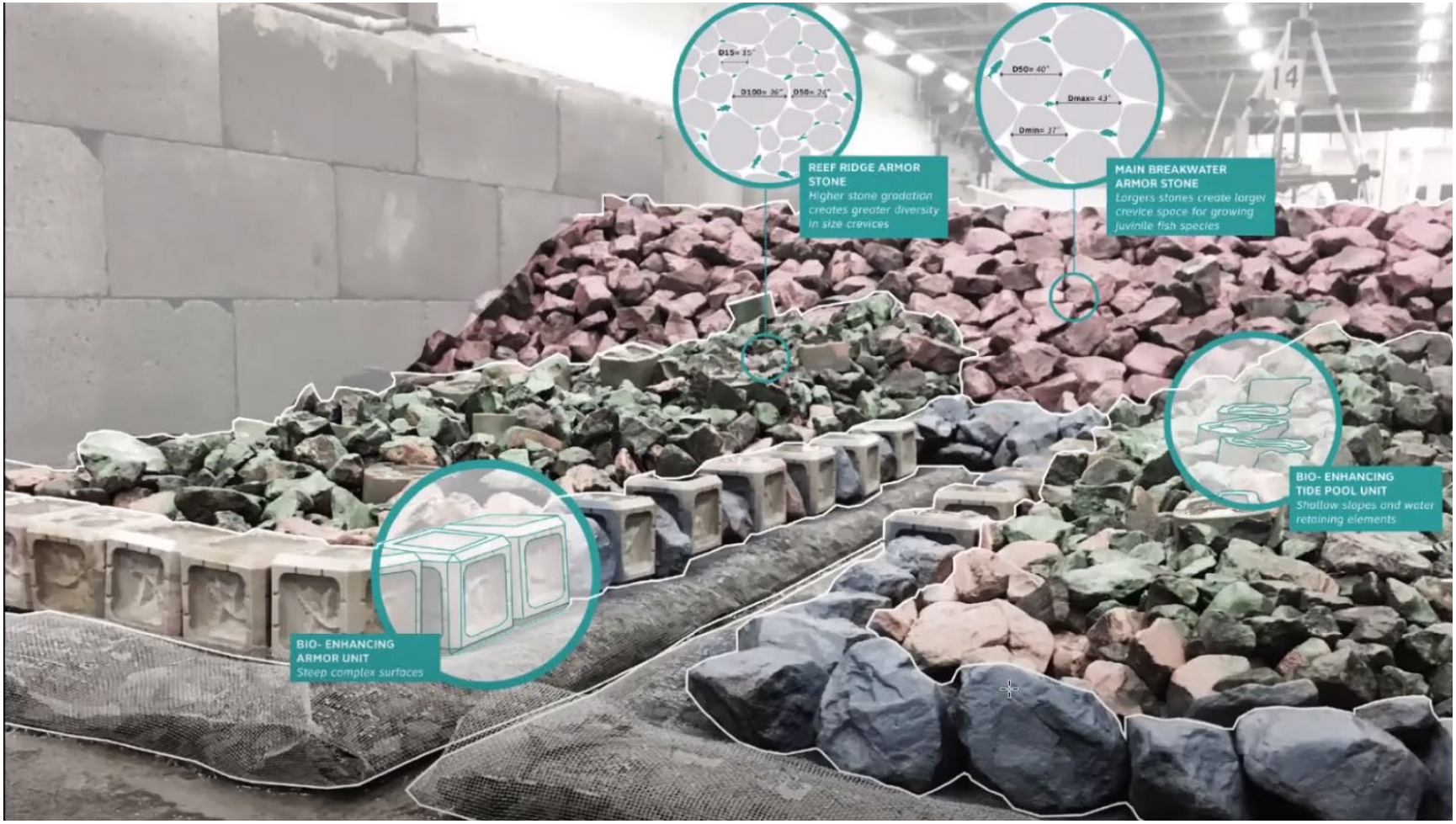
CORE STONE

MARINE MATTRESS

RIP RAP STONE #1

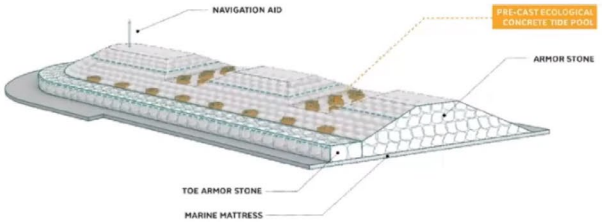
BIO-ENHANCING CONCRETE UNITS

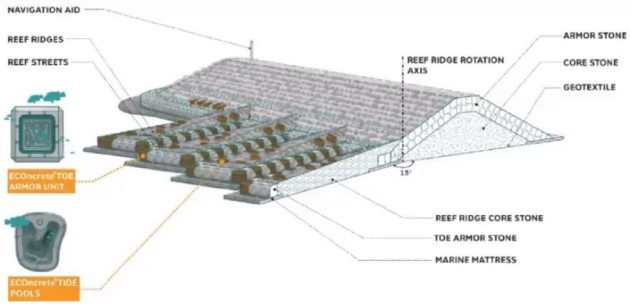
BIO-ENHANCING TIDE POOL UNITS


D15= 35"
D100= 36"
D50= 24"
REEF RIDGE ARMOR STONE
Higher stone gradation creates greater diversity in size crevices
D50= 40"
Dmax= 43"
Dmin= 37"
MAIN BREAKWATER ARMOR STONE
Largers stones create larger crevice space for growing juvinile fish species
BIO- ENHANCING TIDE POOL UNIT
Shallow slopes and water retaining elements
BIO- ENHANCING ARMOR UNIT
Steep complex surfaces

ECONCRETE (TIDEPOOLS & ARMOR UNITS)

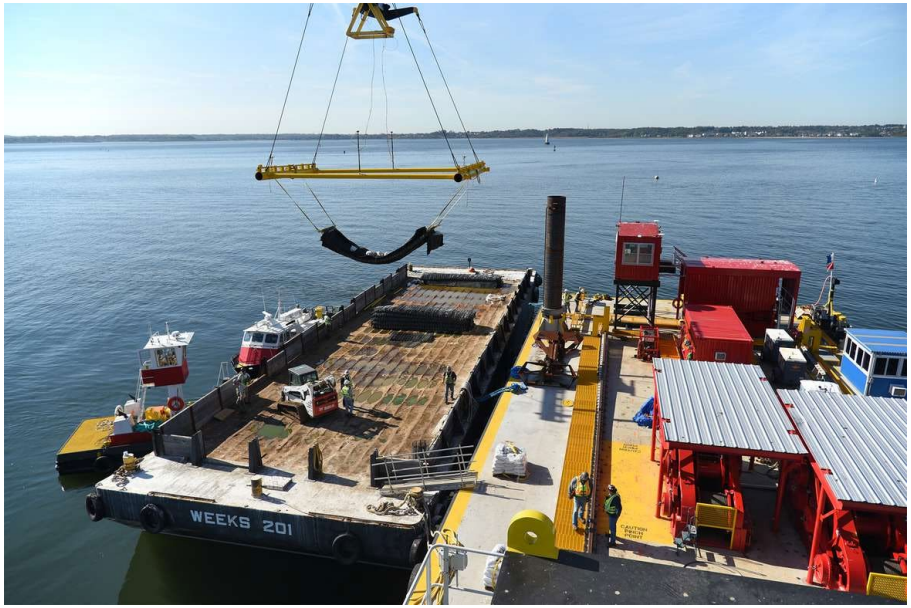
PRODUCTION: SEPTEMBER 2021 - ONGOING, TIDEPOOL PLACEMENT: FEBRUARY 2022 - ongoing





The Living Breakwaters are now being installed off the coast of Staten Island, October 27th, 2021

A smaller barge holds the stone-filled marine mattresses, which are lowered one at a time to the bottom of Raritan Bay. Each mattress is 22 feet long, October 27th, 2021.



A stone-filled marine mattress being moved into position off the southern tip of Staten Island. The mattress is part of Breakwater 2, October 27th, 2021.