Landscape Architecture Foundation – Landscape Performance Grant, Spring 2015

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Rhode Island School of Design

BACKGROUND AND OVERVIEW

The Ecological Planning and Design Seminar is part of the core curriculum in the graduate Landscape Architecture program at RISD. It is a required course for all 3 year Master of Landscape Architecture students but is open to students from the whole school. This year we had 20 students enrolled in the course and all were graduate Landscape Architecture students except two undergraduate students; one from industrial design and one from interior architecture. The course met once a week for 3 hours. The overarching goal of the seminar was to introduce students to site from the regional to the site specific scale. Every week the course addressed a different topic relate to environmental landscape performance including water quality, biodiversity, urban habitat, soil quality, and landscape connectivity. Each session drew the connection of these systems from the regional to the site specific scale. The course was structured as a mix of lectures, reading discussions, and in class workshops.

This class is taught concurrently with the studio Site|Ecology|Design that explores the interaction between human and natural systems at the regional, city, and site scale. This year the Site|Ecology|Design studio focused on the design of a Providence Ferry Park at a coastal site in Providence, RI. In addition to being the point of embarkation to access the proposed Narraganset Bay Park System, the students were asked to investigate the potential for an urban ecology of layered habitats, reveled natural processes, and (re)emergent vegetation within the built environment of the city. The Ecological Planning and Design seminar was designed to complement and expand on the topics that are covered in the studio course. I was co- teaching the studio as well as the seminar and so I was able to modify each course so the schedules and assignments worked together.

Some of the specific components of the Ecological Planning and Design course were as follows:

1. During the semester students were introduced to the BACI (Before After Control Impact) technique of site inventory and monitoring. Two site monitoring workshops gave the students hands on experiences gathering site data. The first workshop had students gathering water samples from the Providence River to measure temperature, salinity, dissolved oxygen, nitrogen, phosphorous and to study the plankton under the microscopes. The second workshop introduced the students to vegetation transects and calculating percent cover of different plant species in a salt marsh. These techniques were discussed within the context of how to use site data to study landscape performance over time.

2. The course provided 2 week long workshops on GIS as a tool to visualize spatial data at different scales. Although it was a short and intensive introduction to GIS, the students were exposed to the range of capabilities of the program and asked to use GIS in their site analysis for the studio project. Weekend work sessions during the 2 weeks of the GIS tutorial provided the students the opportunity to ask questions and move forward with their projects.

3. Students worked in small groups to do case studies with the specific goal of understanding how site analysis informed design decisions. Students were asked to look at water strategies, planting strategies, grading, and other aspects of each project to explore the translation from analysis to design. The case studies were presented to the whole class.

REFLECTIONS ON TEACHING AND COURSE CONTENT

Parts of the course were very successful and some need to be further developed next year. The following is a summary of the strengths and areas for future development with a specific focus on landscape performance:

1. In order to understand landscape performance students need to understand how to measure performance benefits. The site monitoring workshops gave the students the skills to understand how environmental landscape performance is measured through introducing them to the tools and techniques for gathering empirical site data. Whether in the future the students are gathering the data themselves or working with allied professionals (hydrologists, engineers, ecologist), this course provided them with an understanding of the process of monitoring, the tolerances of the tools and techniques, and how to set up a scientific study. This background will help them incorporate performance benefits into their work and know what data needs to be collected during the initial site analysis to allow for comparison of landscape performance before and after construction.

2. For the site monitoring workshops we worked with the RISD Edna Lawrence Nature Lab. The goal of the Nature Lab is to "provide a forum, sustained by resources and guidance, for the exploration of connections among art, design, and nature". This collaboration was very successful as the Nature Lab had scientists and staff that assisted during the site monitoring workshops. They also provided the tools (water quality kits, microscopes, seine, and transect) that we were able to use in this course.

3. Connecting the work in the seminar with the studio work helped strengthen and expand on what each course could cover individually. The Ecological Planning and Design Course gave the opportunity for lectures, seminar discussions, workshops and readings and the studio focused on the application of the topics in design. This was the first time coordinating between the classes and although it was generally successful it can use some refinement in the future to ensure that the objectives of each course compliment each other but remain independent.

4. Because of the broad scope of this class and the focus on ecological planning and design, in the end we were not able to cover the social and economic performance benefits. Although these are important components of landscape performance I would not change this in the future. This class is already trying to cover a lot of material and would benefit from going deeper into each topic rather than trying to cover more material.

5 . Although landscape performance was discussed throughout the course, we introduced the students to the Landscape Performance Series towards the end of the semester. In the future, I would introduce the students to the

landscape performance series earlier in the semester and use it as a way to frame each topic. Specific case studies from the series could be used in each lecture to highlight the performance benefit and discuss methodology.

ECOLOGICAL PLANNING + DESIGN

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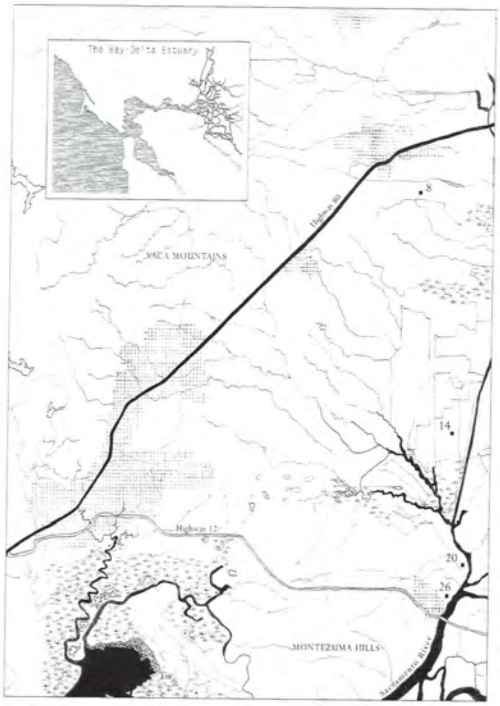
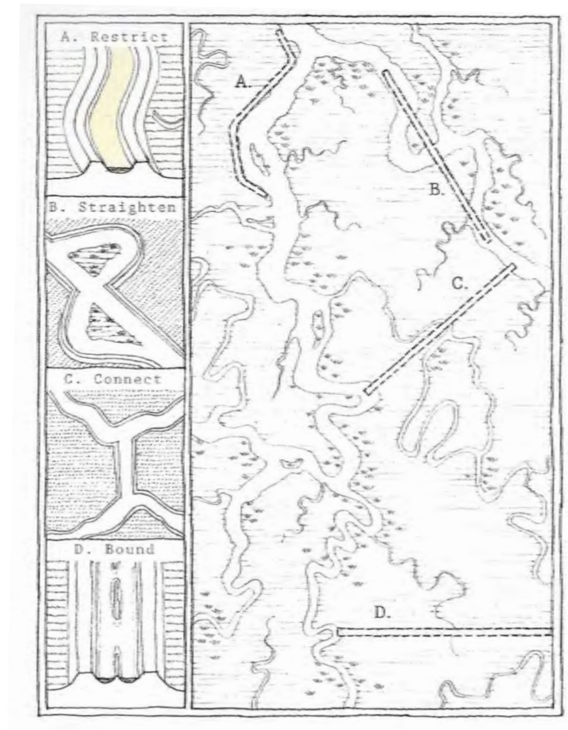
Spring 2015





Jane Wolff | Delta Primer

This course will introduce students to the ecological forces that shape a site from the regional to the site specific scale. By exploring the connections between ecological science, site analysis, and land-use planning we will investigate the role of landscape architecture in helping to navigate the interface between culture and nature. Through weekly lectures, in class workshops and field exercises, students will learn about a range of physical, biological and cultural site metrics that inform the design process. In the classroom, lectures will discuss bioregional landscape issues, site inventory techniques for hydrology, geology and plant communities, and integration and synthesis of site data into sustainable design solutions. In the field, students will learn about tools and techniques for gathering empirical site data such as vegetation transects, water and soil testing, and microclimate.

COURSE OBJECTIVES

Develop an understanding of ecological systems and processes relevant to design,
Develop an understanding of sites as part of bioregional systems,
Develop methods for inventorying, recording and mapping site data,
Develop skills to integrate and synthesize data into sustainable design solutions,
Gain an overview of projects and practices that incorporate ecological thinking into design,
Acquire technical GIS skills to help visualize and analyze spatial data,

READINGS

Readings will being assigned on each week's topic. Required readings must be read before the next class. Optional reading lists will be provided and students are strongly encouraged to chose one additional reading for each week.

SCHEDULE – (Topics, order and schedule subject to change)

2/16 WEEK 1 – INTRODUCTION: Region To Site

Required Readings:

• Pickett, Steward T. A. and Cadenasso, Mary L. Urban Principles for Ecological Landscape Design and Management: Scientific Fundamentals. Cities and the Environment.

Optional Readings:

• Burns, Carol J and Kahn, Andrea. Site matters. Why Site Matters. Routledge, NY. 2005.
• Girot, Christophe. Four Trace Concepts in Landscape Architecture. In Recovering Landscapes. Princeton Architectural Press. NY 1999.
• Cronon, William."The Trouble with Wilderness; or, Getting Back to the Wrong Nature," in Uncommon Ground: Rethinking the Human Place in Nature (W.W. Norton& Co., 1996), 69-90.
• McHarg, Ian. Design With Nature. Sea Survival. Wiley Publishers, 1969.

2/23 WEEK 2 – VISUALIZING SPATIAL DATA 1

Required Readings:

• James Corner. 'Agency of Mapping' in Mappings, ed. Denis Cosgrove. Reaktion Books, 1999.

Optional Readings:

• Harley, J.B. Maps, Knowledge and Power. In The Iconography of Landscape. Ed. Denis Cosgrove and Stephan Daniels (p277-311).

Additional Books On Mapping + Visualization

• Tufte, Edward. The Visual Display of Quantitative Information. Graphics Press, 1992
• Hanna, Karen. GIS for Landscape Architects. ESRI Press, NY. 2002.
• Denis Cosgrove, ed. Mappings . Reaktion Books, 1999.
• Kate Ascher. The Works: Anatomy of a City. Penguin Books, 2005.

In Class Workshop: Vector GIS workshop: General introduction to GIS, map projections, where to find GIS data online, manipulating layers and properties, and exporting maps.

3/2 WEEK 3 – LANDSCAPE ECOLOGY : Matrix to patch

Required Readings:

• Forman, Richard. Landscape Mosaics. Part 1 Landscapes and Regions. Cambridge University Press. Cambridge, UK. 1996
• Way, Douglas. Terrain Analysis. Chapter 1 Landforms and Aerial Photographic Terrain Analysis. Dowden, Hutchinson & Ross Inc. Stroudsburg, Pennsylvania.

In Class Workshop: Using aerial photos and USGS maps to study landscape mosaic.

3/9 WEEK 4 – WATER : Watershed To Water Drop

Required Readings:

• Hill, Kristina. Urban Design and Urban Water Ecosystems. In The Water Environment of Cities edited by Lawrence A. Baker. Springer Science & Business Media, 2009.

In Class Workshop: Gather water samples from the Providence River to test water for temperature, salinity, dissolved Oxygen, nitrogen and phosphorous. Water Samples brought back to the Lab to look at plankton under the microscopes.

3/16 WEEK 5 – TERRAIN: Soil Suitability to Phytoremediation

Required Readings:

• Soil Taxonomy: A basic System of Soil Classification for Making and Interpreting Soil Surveys, USDA
• Urban Soil Primer, URCS
• Way, Douglas. Terrain Analysis, Chapters on Fluvial, Glacial and Glacial Fluvial Landforms

Visiting Lecture: Kate Keenan from Offshoots to present her work and research on Phytoremediation

3/23 WEEK 6 - SPRING BREAK

3/30 WEEK 7 – IN CLASS REVIEW OF PROGRESS ON CASE STUDY

4/6 WEEK 8 – CASE STUDY PRESENTATIONS

4/13 WEEK 9 – VISUALIZING SPATIAL DATA 2

In Class Workshop: Raster GIS workshop: General introduction to Raster data and DEM files, 3D analyst tools, Topo analysis including hillshade, slope and aspect, and basics of reclassifying data and map algebra.

4/20 WEEK 10 – BIODIVERSITY: Migration Corridors To Pollinators

Required Readings:

- Hill, Kristina. Biodiversity and Climate in Cities. In Designing Wildlife Habitats. Ed. John Beardsley. Dumbarton Oaks. 2013.
- Del Tredici, Peter. Spontaneous Urban Vegetation. Nature and Culture 5(3),Winter 2010: 299–315

4/27 WEEK 11 – IN CLASS REVIEW OF PROGRESS ON HABITAT STUDY

5/4 WEEK 12 - LANDSCAPE PERFORMANCE : Ecosystem Services to Site Metrics

Required Readings:

- Steven Windhager, Frederick Steiner, Mark T. Simmons and David Heymann, "Toward Ecosystem Services as a Basis for Design," Landscape Journal 29 (2010): 2-10.
- Renee Kaufman. "Uncertainty And Anxiety," in Scenario 2: Performance. http://scenariojournal.com/article/uncertainty-and-anxiety/. 2012

Optional Readings:

- Robert Costanza, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg et al., "The value of the world's ecosystem services and natural capital." Nature 387: 253-260. 1997
- Stephanie Carlisle and Nicholas Pevzner. " Introduction: Performance" in Scenario 2: Performance. http://scenariojournal.com/article/letter-from-editors. 2012

Visiting Lecture: Arianna Koudounas from the Landscape Architecture Foundation

5/11 WEEK 13 – SITE MONITORING: Measuring Change over Time

Required Readings:

- Carlisle, Bruce & Carullo, Marc. Rapid method for Assessing Estuarine Marshes in New England. Massachusetts Office of Coastal Zone Management. 2006

In Class Workshop:

- Site monitoring workshop at salt marsh near Providence. Introduction to vegetation transects to calculate percent cover of species.

CLASS POLICY
All RISD academic policy for this course is outlined in detail in the course catalogue for the 2014-15. Please review the catalogue carefully to understand the institutional policies. Students should refer to the policies defining academic standing, academic dishonesty and all academic conduct that are outlined in the Course Announcement Catalogue.

ATTENDANCE
A student who misses the first class meeting of the term may be removed from the course. A student who misses any two classes over the course of the term may be removed from the class. The student is dropped from the course and given a grade W or F depending on the circumstance. Each lateness and unexcused absence will result in a reduction in the overall GPA for the course. Scheduled appointments and professional interviews will not be accepted as excused absences. Students must notify faculty of any excused absences in advance or as soon as possible on the say of their absence. Faculty contact information is located at the top of the course syllabus. RISD affirms the right of students to observe significant religious holy days. Students should inform their instructor on the first day of class/studio of such circumstances if class attendance will be affected.

Students who are unable to fulfil the requirements of the course or course schedule should consult with the course instructor before or in the first week of class to develop alternative strategies for successfully moving through the class. If at any time in the semester, medical or personal problems arise that begin to affect a student's ability to attend class or complete work, they are encouraged to speak with their faculty as soon as possible to discuss their options for completing the course successfully.

CELL PHONE, SOCIAL MEDIA, AND INTERNET
Cell phones and PDA devices ***must be turned off or set to silence during class***. Students who use their cell phone for translation services must advise their faculty of that need at the beginning of class. Computers shall be utilized for course sanctioned research and requirements during class hours.

BASIS FOR EVALUATION OF STUDENT PERFORMANCE
Student performance will be evaluated on evidence of competency in the conceptual and technical content of the course. Midterm evaluations will assess progress. Any students performing below the requirements for a B in the course will be given a warning at that time and must meet with their faculty to discuss ways to improve their standing. Final evaluation is assessed on attendance, participation, weekly progress in the development of the craft and quality of the work, and timely completion of the work. Assignments must be turned in on schedule. Failure to meet deadline will result in a grade reduction. Each day the work misses a deadline will result in a .5 grade reduction.

GRADING CRITERIA
60% Assignments
20% Quizzes and Exams
20% Participation
Students who fulfil course requirements in a manner that displays competent conceptual and technical mastery of the course content as described above will receive a B. Work that exceeds or fall short of that standard will be graded accordingly. A grade of B- indicates need for improvement. A grade below B- is a probationary grade.

GRADING SCALE

A	Superior/Excellent performance; showing exceptional progress and effort, work quality, consistent experimentation, rigorous work process, significant contribution to others, and a mastery of the subject matter.
B	Satisfactory performance; showing progress and effort and general comprehension of the subject matter.
C	Probationary-Graduate students must have a B average by their final semester in order to graduate.
D	Minimal course requirements unmet. Failing Grade
F	Minimal course requirements unmet. Failing Grade

DOCUMENTATION
All original drawings must be retained and submitted at the end of the course. All work should be stored flat in a dedicated portfolio case. It is recommended that the scanning of drawings happen frequently during the semester rather than at one time. A CD of all course work must be submitted to the department office before 1pm on Friday, MAY 22, 2015. Failure to submit proper documentation of work will result in an incomplete grade for the course.

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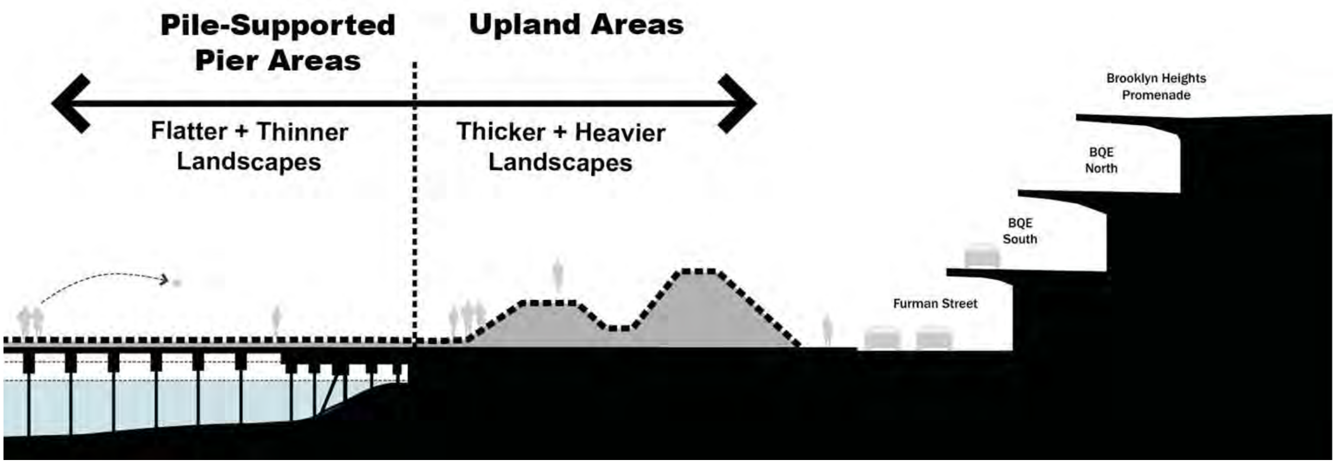


3/9 WEEK 4:
CASE STUDIES - DUE MARCH 30th

Case studies are an opportunity to look closely at a project and analyze designer's decisions to specific site conditions. For the next 3 weeks you will be working in small groups to analyze a project with the specific goal of understanding **how site analysis informed design decisions.** You will be presenting your research to the rest of the class on March 30th. The final presentation should be a mix of photos, project drawings, maps and drawings/diagrams that you make to analyze the design.

We expect everyone to cover the following topics:

- Water strategies (flooding, stormwater management, coastal)
- Planting strategies
- Grading / Soil strategies
- Circulation / Access
- Materials
- Views
- Spatial Organization
- Form

We will be looking at the following projects:
- Brooklyn Bridge Park : MVVA
- Fresh Kills : Field Operations
- Houston Arboretum and Nature Center : Reed Hildebrand + Design Workshop
- Novartis Campus : Vogt Landscape
- Orongo Station : Nelson Byrd Woltz
- Cardada : Paulo Burgi
- Cabecera Park, Valencia Spain : Eduardo de Miguel
- Phil Hardberger Park : Steve Stimson Associates
- Michel Desvigne : TBD
- Guadalupe River Park : Hargreaves

*For next week, use the watershed delineation techniques we discussed in class today to map the drainage area surrounding the site you are researching. Upload to Digication before class next week.

LIUPANSHUI MINGHU WETLAND PARK

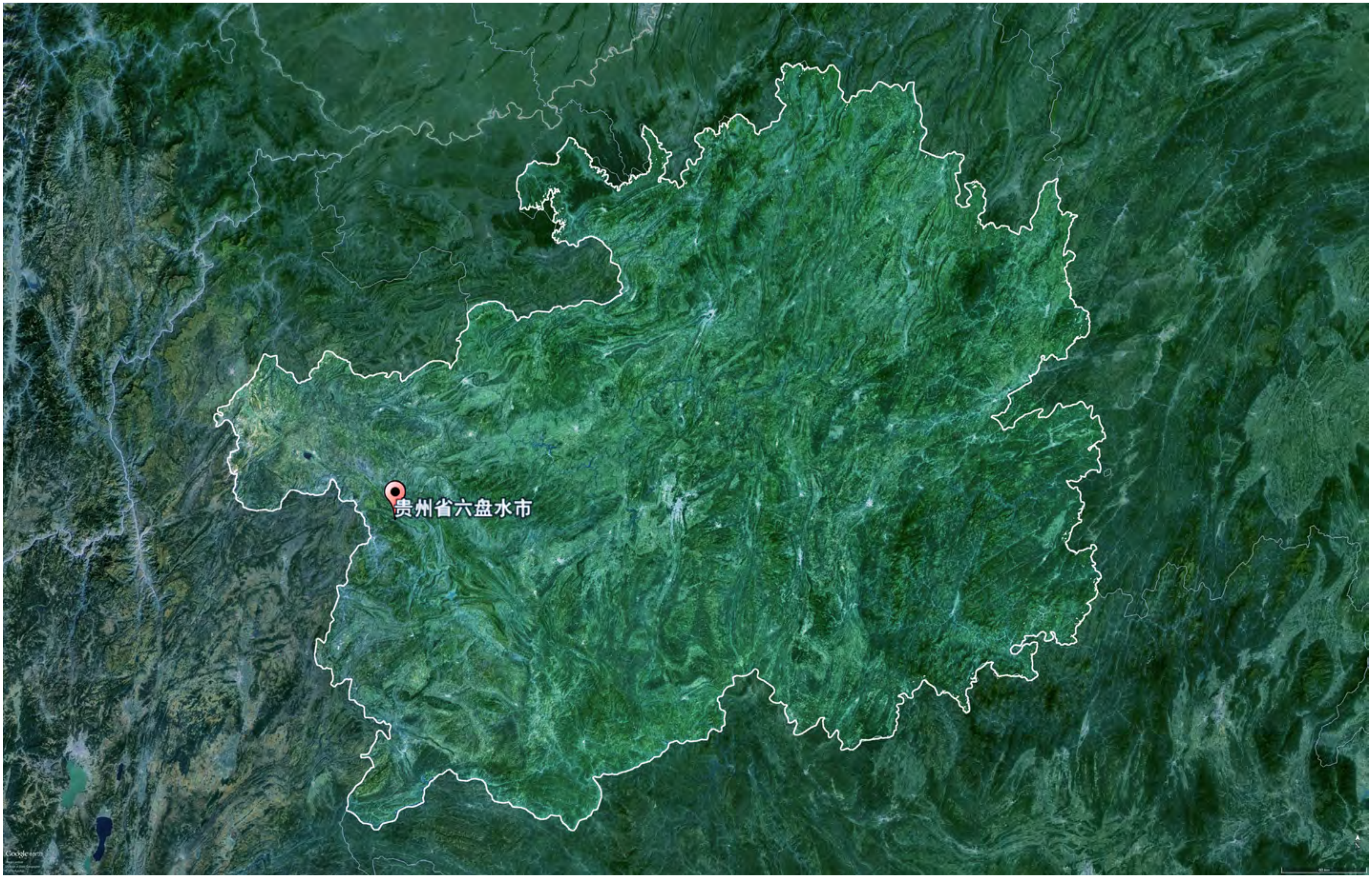
Liupanshui, Guizhou Province,China
By Turenscape
2012

LDAR 2257
04/06/2015
Patrick Beals
Yuan Zhang

GEOGRAPHIC LOCATION

Guizhou Province, China

GEOGRAPHIC LOCATION



Guizhou Province, China

GEOGRAPHIC LOCATION
Natural Landscape and Culture of Guizhou Province

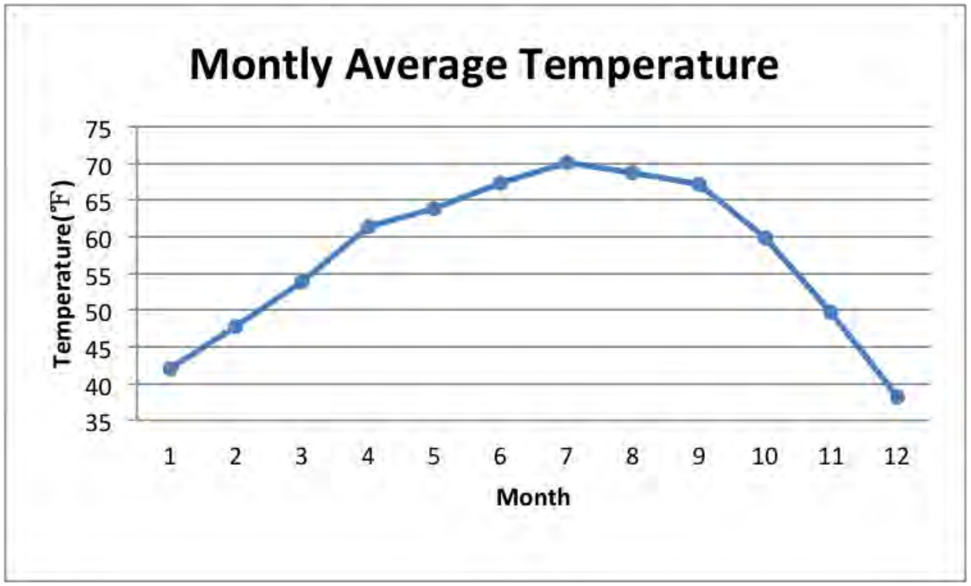
Terraced Fields

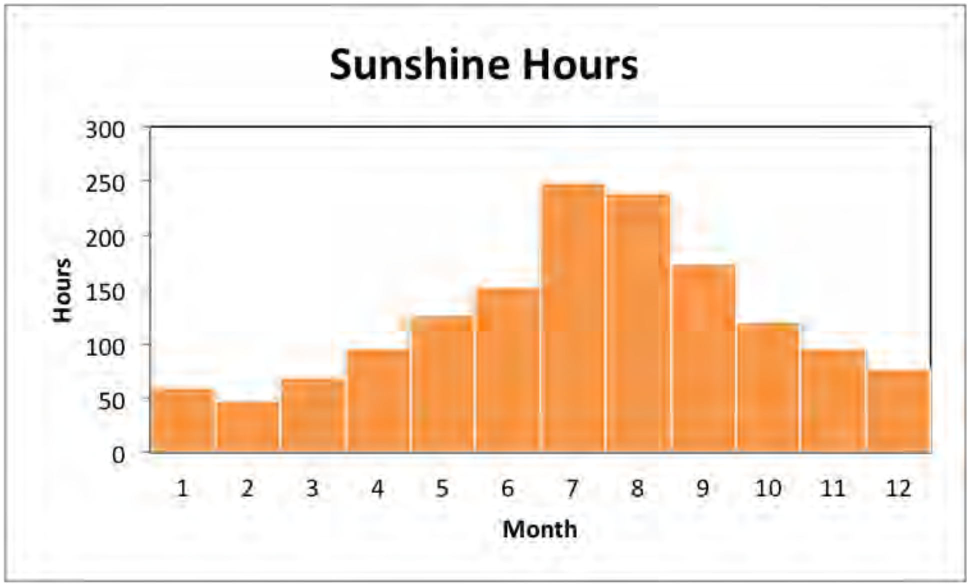
Ethnic Minority People: Buyi, Miao,...

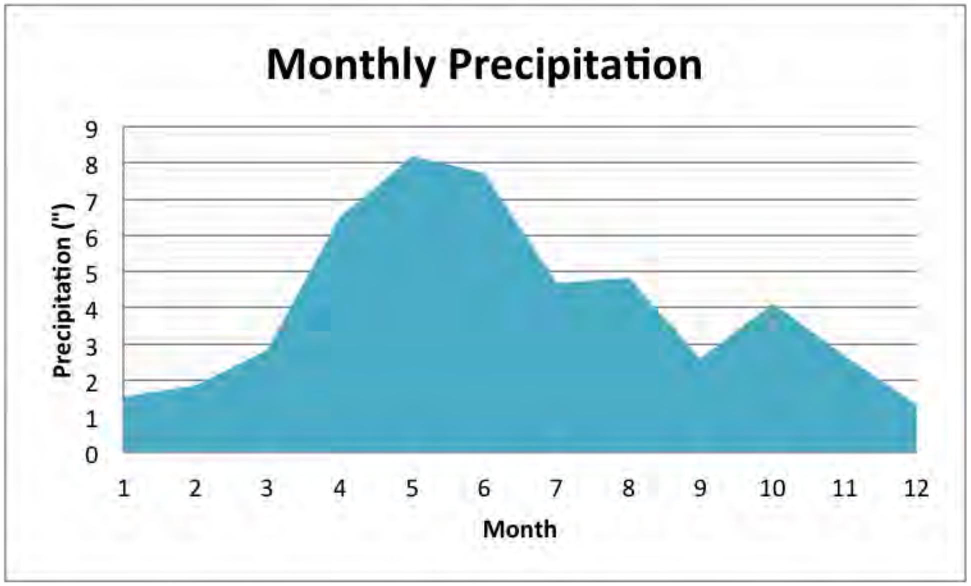
Karst Landforms

GEOGRAPHIC LOCATION
Climate

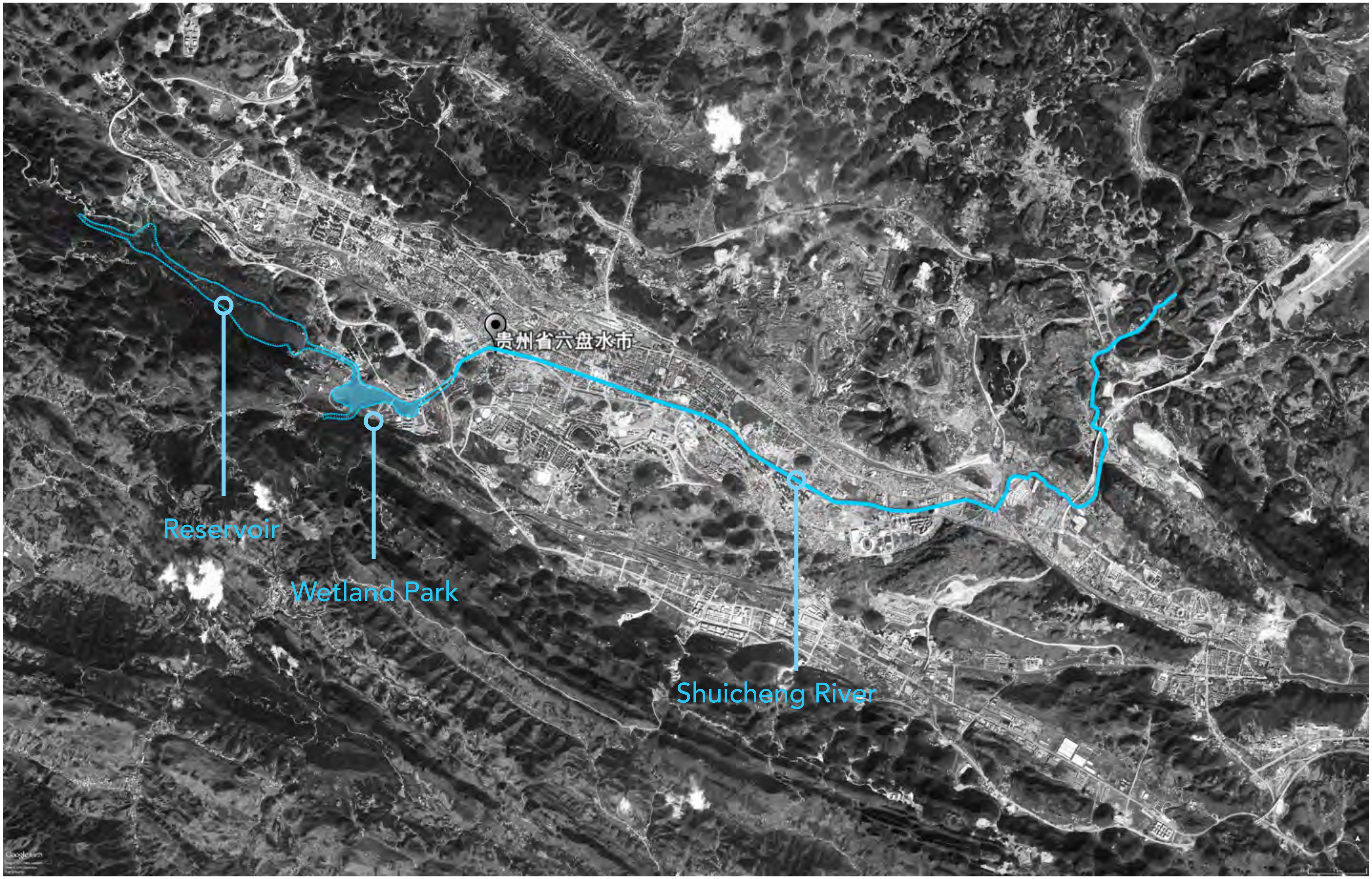
The climate in Liupanshui is warm and temperate. There is significant rainfall throughout the year in Liupanshui. Even the driest month still has a lot of rainfall.





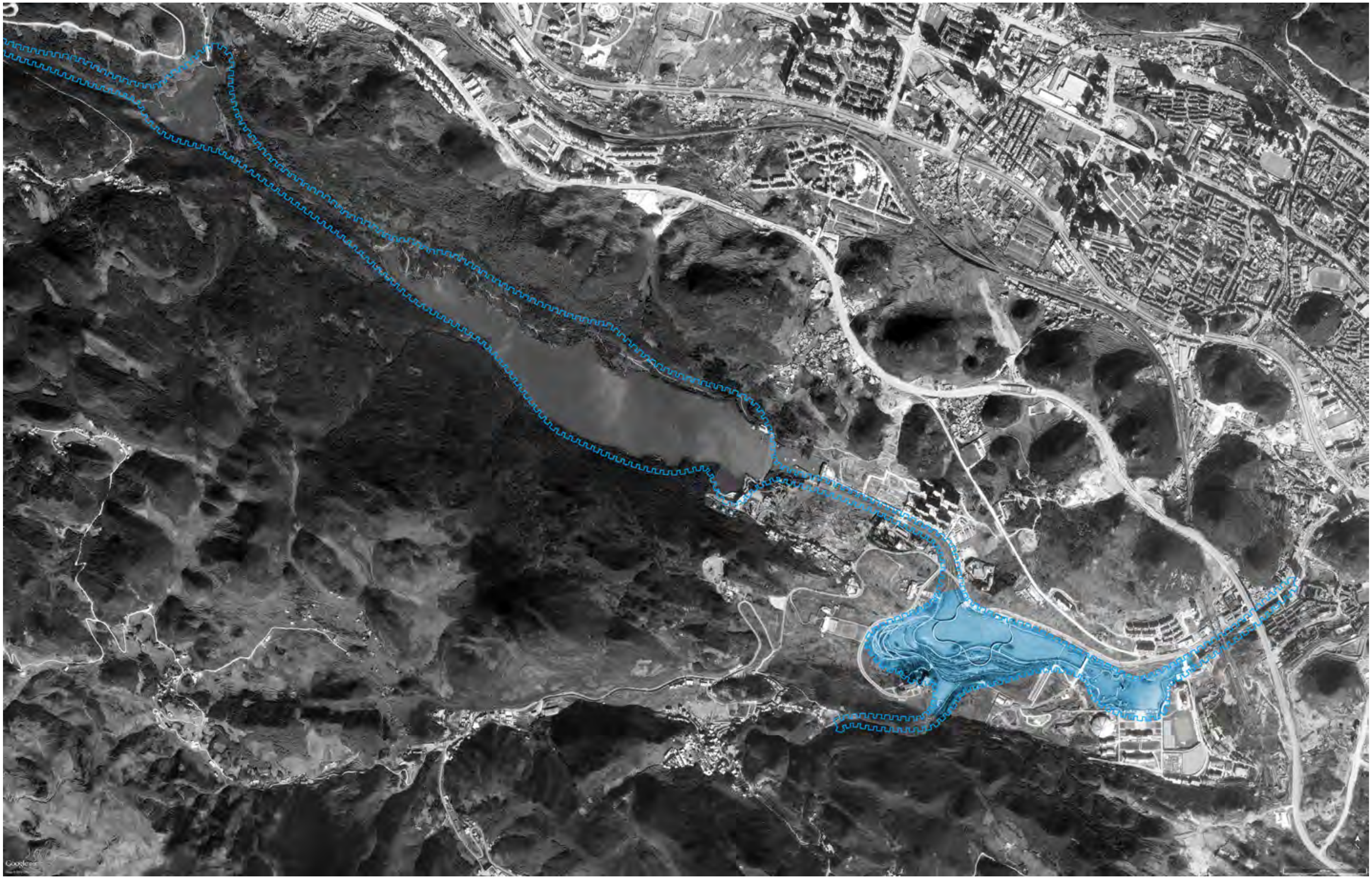


GEOGRAPHIC LOCATION



Liupanshui, Guizhou Province, China
Water System

GEOGRAPHIC LOCATION



Liupanshui Minghu Wetland Park

GEOGRAPHIC LOCATION

Liupanshui Minghu Wetland Park

HISTORY OF THE SITE

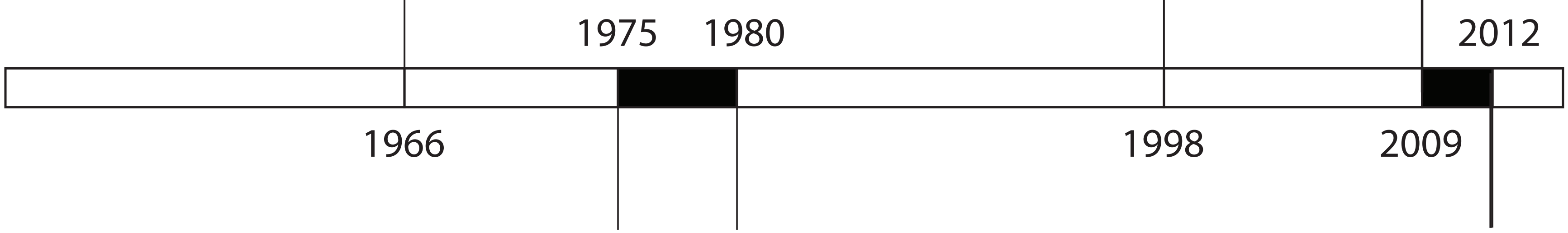
Left: 1980s -- fields
Lower Left: 2006 Villages with ponds and fields
Lower Right: 2013 Minghu Wetland Park

HISTORY OF THE SITE

Development Plan For the 3rd Tier Cities:
The starting point of urbanization of Liupanshui, Guizhou

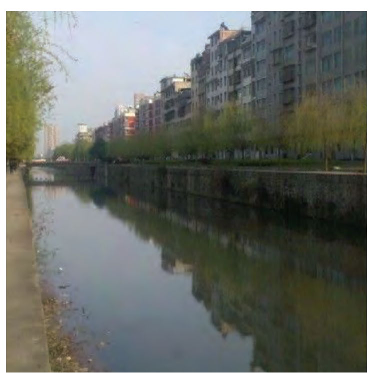
Long-term Flood and Stormwater Management Project started

Ecology & Environment Improvement Project



Water and River Management: Channelized

Construction Completed



PROBLEMS OF THE SITE

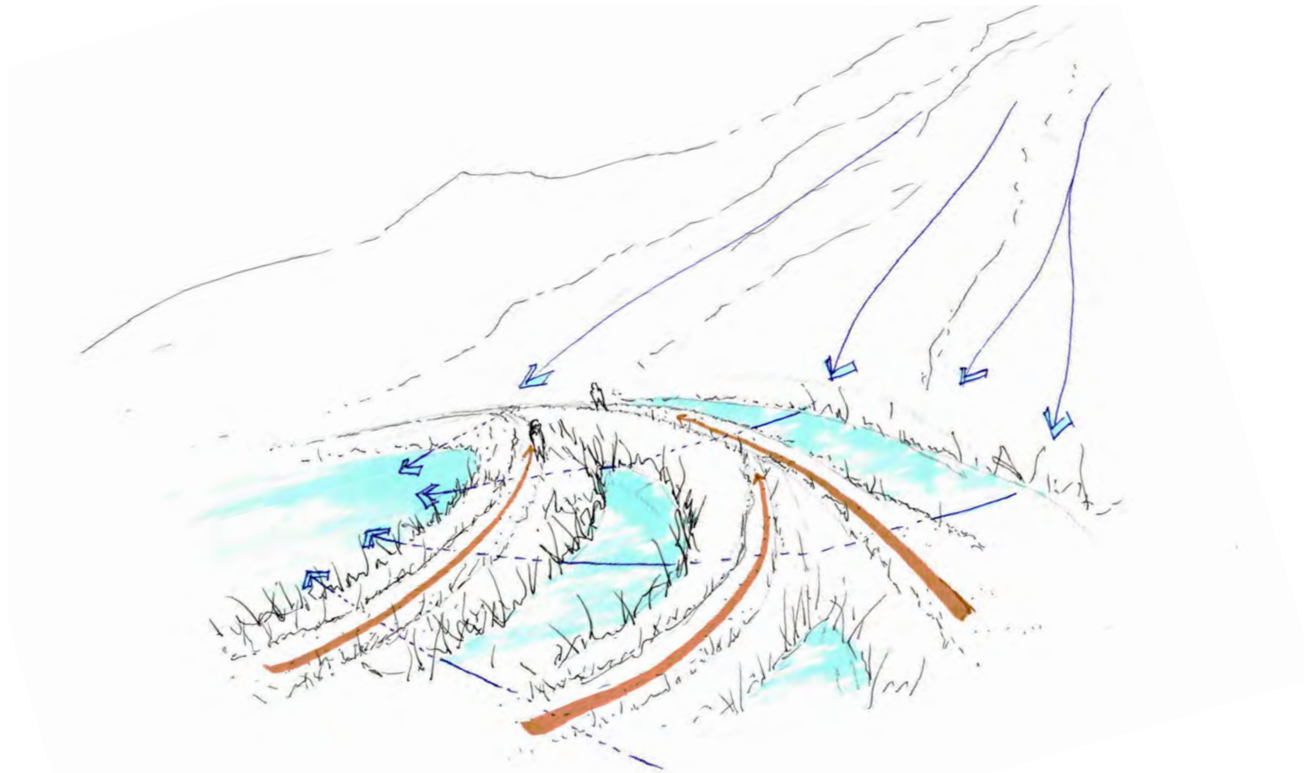
Trash and Water Contamination

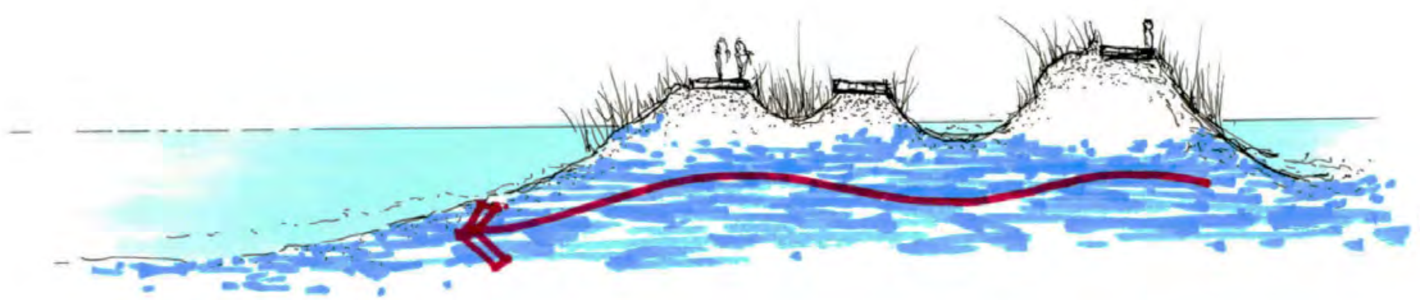
Stormwater Runoff

Waste Land

Channelized River

MAIN STRATEGY





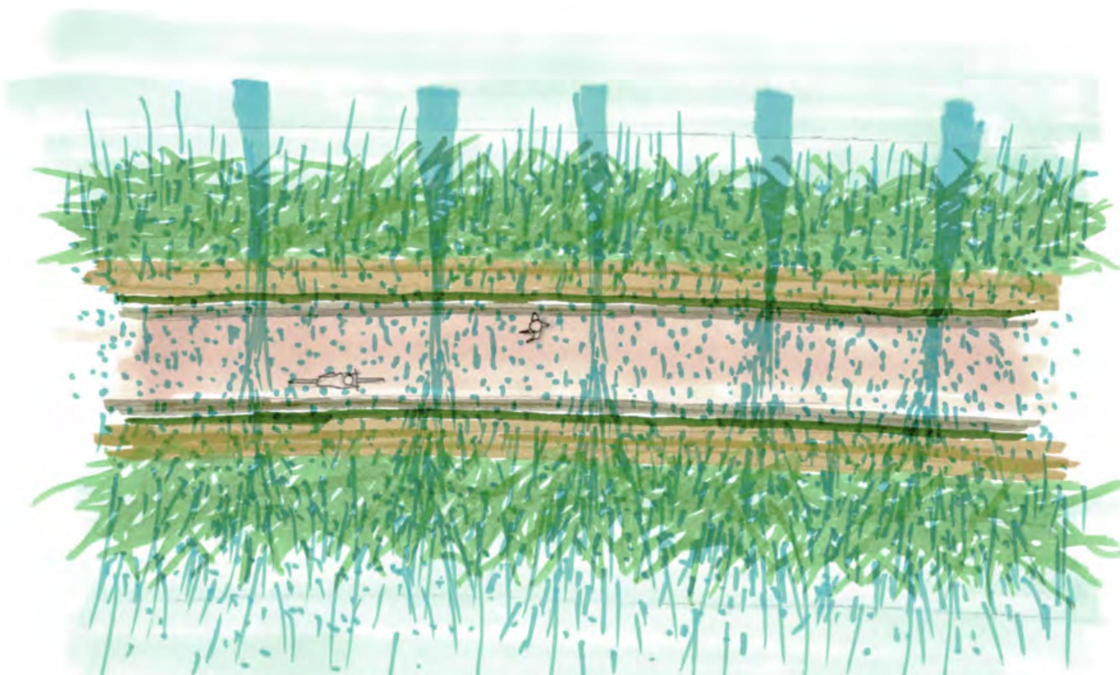
Filter-Circulation Terrace

1. WATER STRATEGY

1. 1 Channelized Riverbank → Soften the Edges

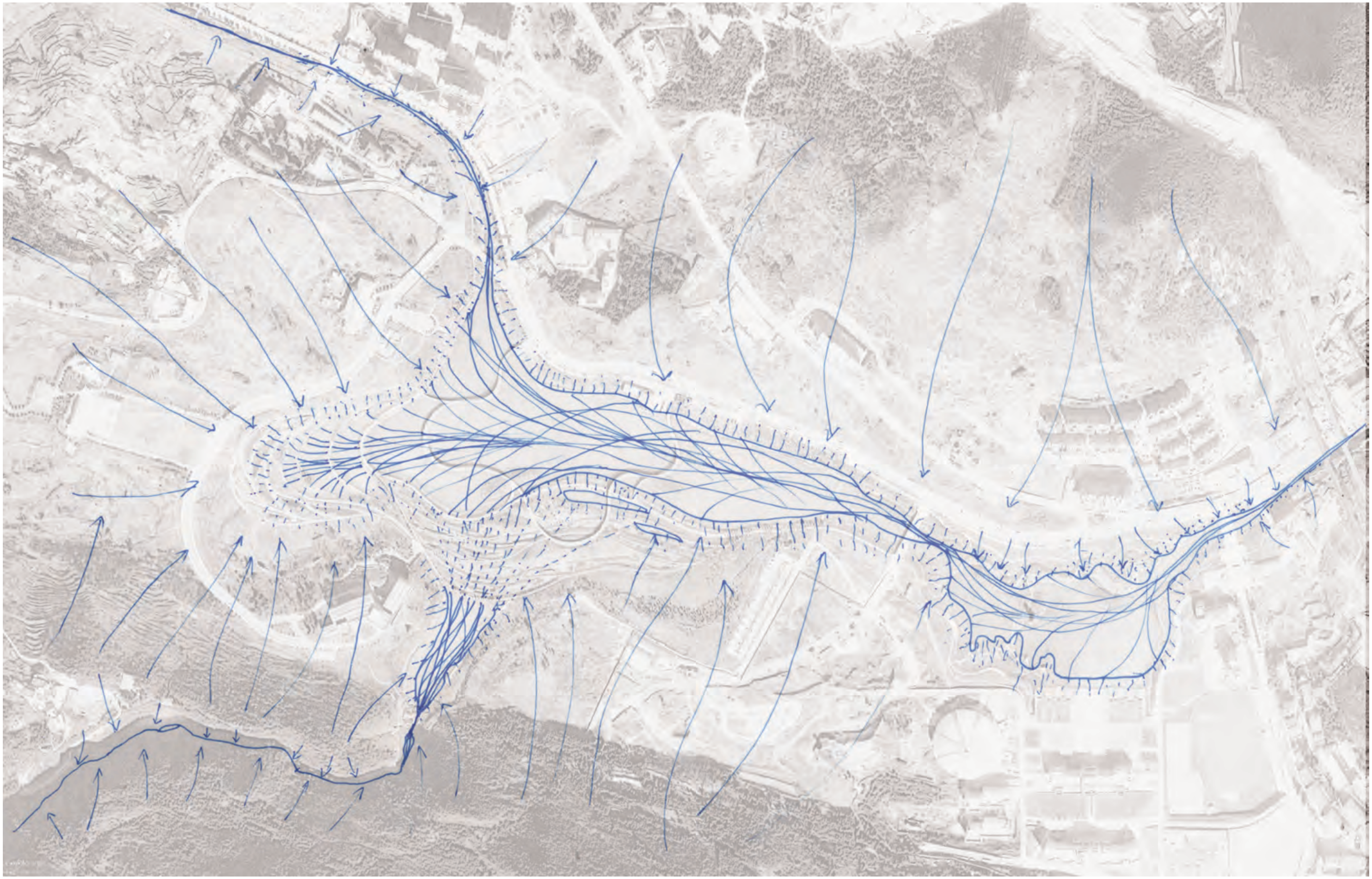
1. 2 Artificial Lake as Filtration and Habitat

1. 3 Terraced Ponds for Filtration



Filtration Diagram (Top View)

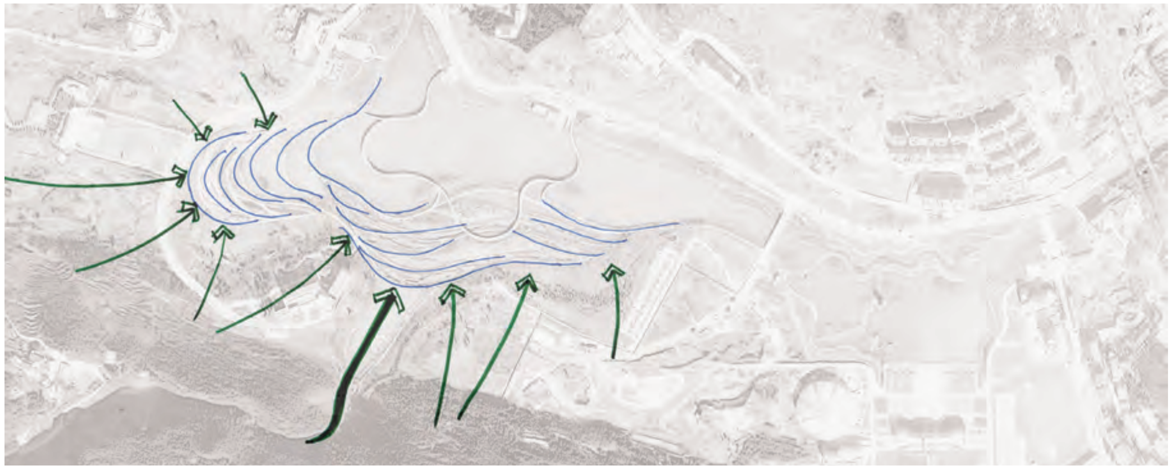
1. WATER STRATEGY



The Water flowing into the city is thus cleaner

2. FORM

2. 1 Crescent Shape to accept water from every direction



2. 2 Inaccessible Bio-Islands for Wild Life Habitats

3. PLANTING STRATEGY


Cattail


Cattail


Reed


Thalia


Machilus


Weeping Willow


BulRush


BulRush


Sassafras

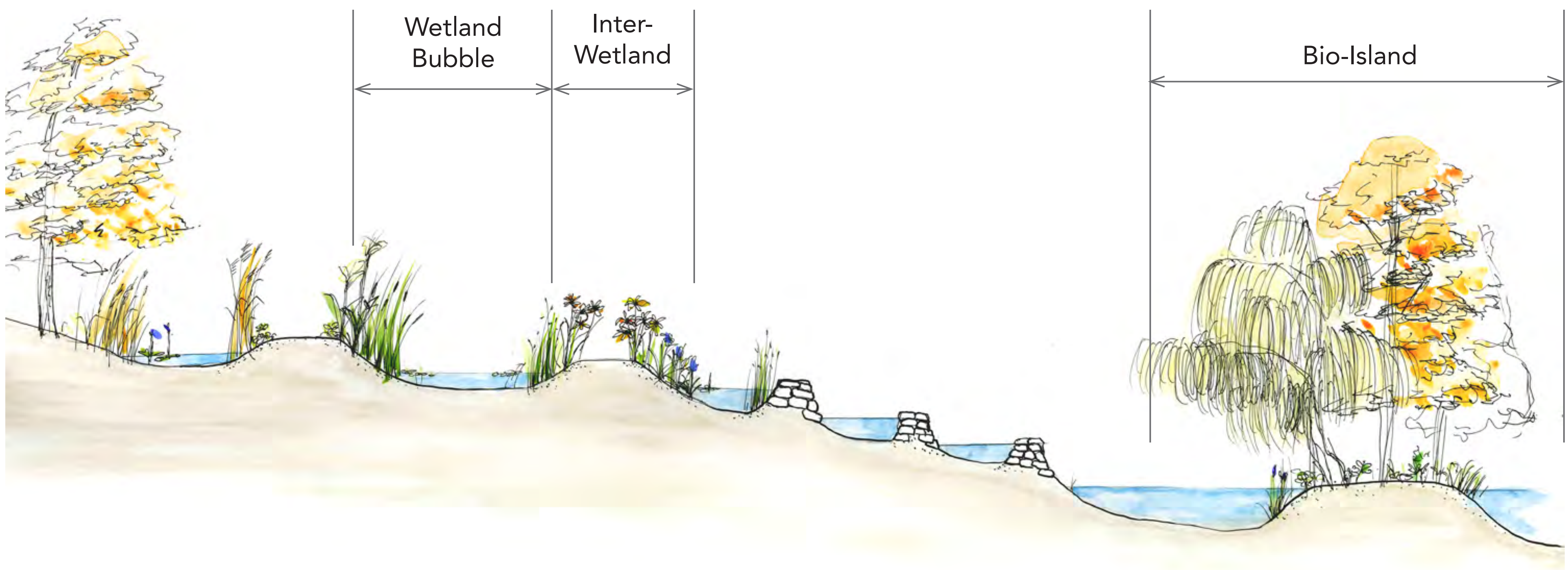

Populus yunnanensis


Arundo donax


Rudbeckia


White Clover


Reineckea

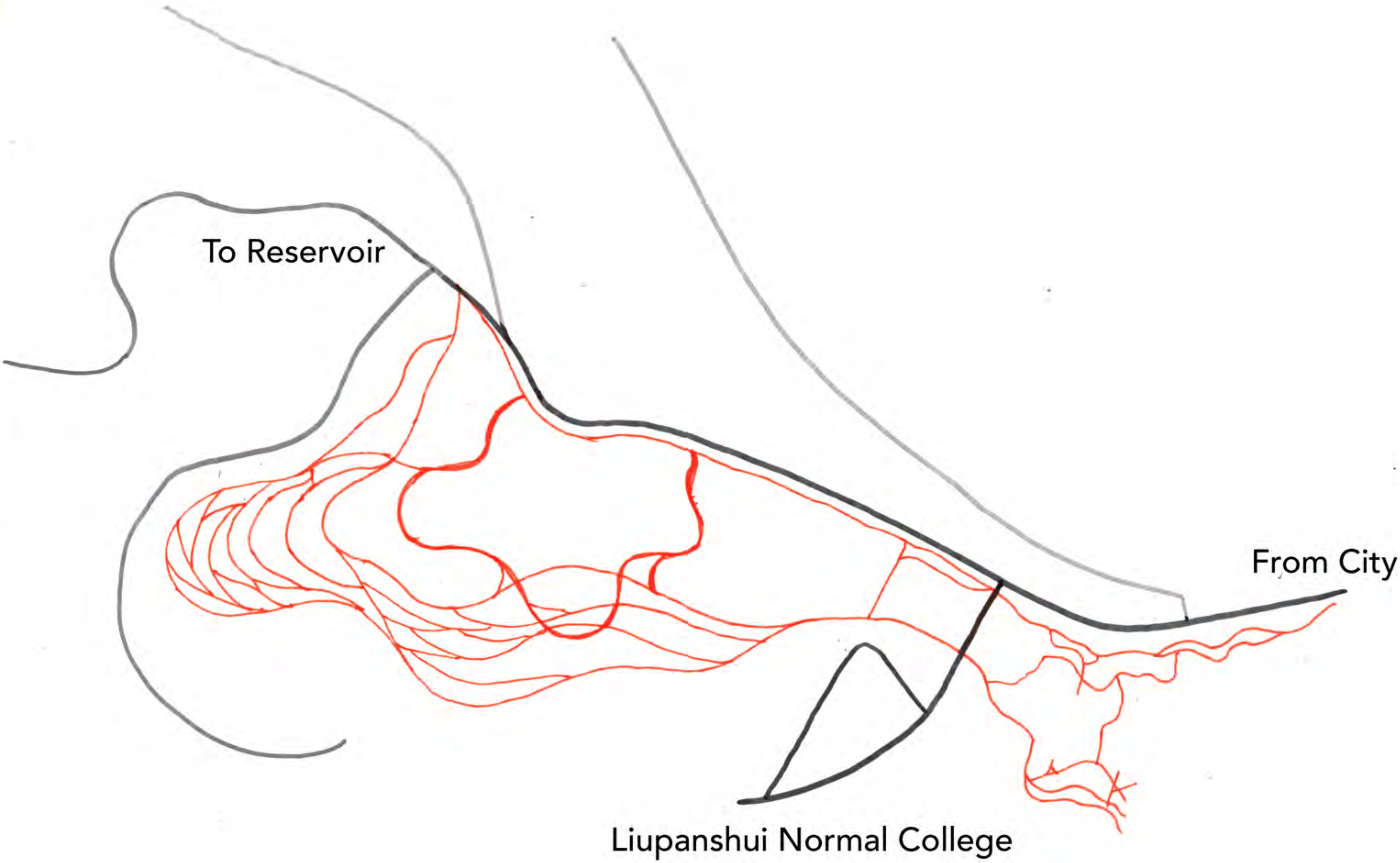


4. MATERIAL STRATEGY

4. 1 STEEL -- Industrial Memory

4. 2 LOW STONE WALL -- Agricultural Memory

5. CIRCULATION STRATEGY



6. VIEWS

Karst Landform as background

6. VIEWS

Topography Interaction

6. VIEWS

Bio-Islands during flooding

7.COMMENT & CRITICISM

评论人：丁海岳　　时间：2014-03-12 17:21:48

不足之处，没有结合当地的天气因素，就是这么大的湿地公园没有设置避雨措施，六盘水的天气风雨不定，雨一来基本上是没有课躲雨的地方

This is a large scale park but there is no shelter during rain, and Liupanshui rains a lot.

评论人：马欣　　时间：2013-09-29 09:46:46

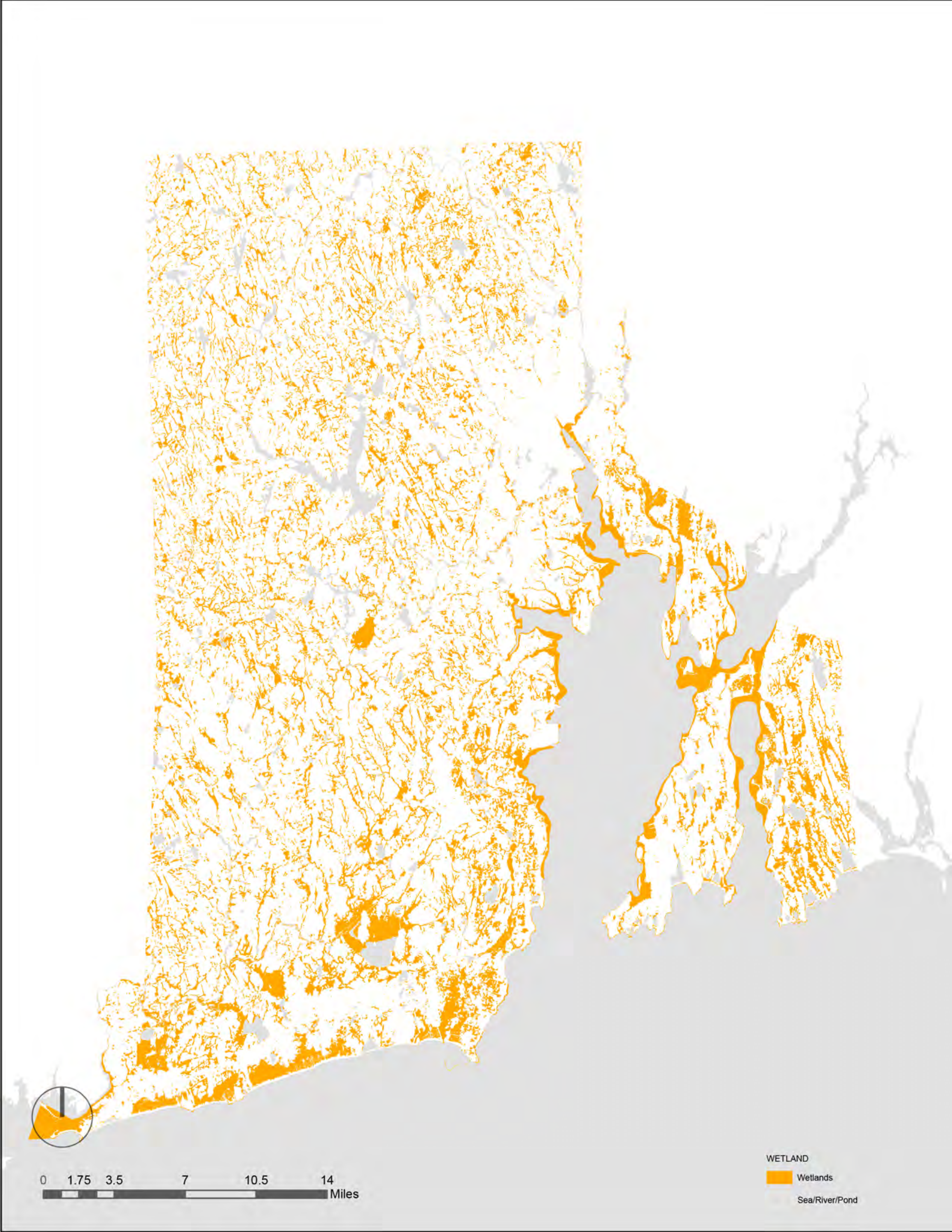
那是我的家乡，以前那里真的是脏乱差，亲自去看过很多次，人们在公园里都很开心，感觉真的回归大自然了，确实是富有人文关怀，又富有地方精神，只是木质铺装面积偏大，不知道能不能用其他的时间更长久一点的并且效果又比较好的景观的材料代替，这个过了不知道多少年以后换起来工程量还是比较大的。

People are really happy in the park. It really changed the bad situation. But the huge amount of wood deck may lead to maintenance problem after many years.

评论人：Yu Ma　　时间：2013-10-06 23:23:42

好奇这个项目的水什么时候能恢复到清亮，是不是有一个周期？那是我家乡，经常去。有时候看见鱼都会翻肚皮。

Curious about the water purification cycle. How long does it take to solve the problem? I used to see fish belly-up in the river.

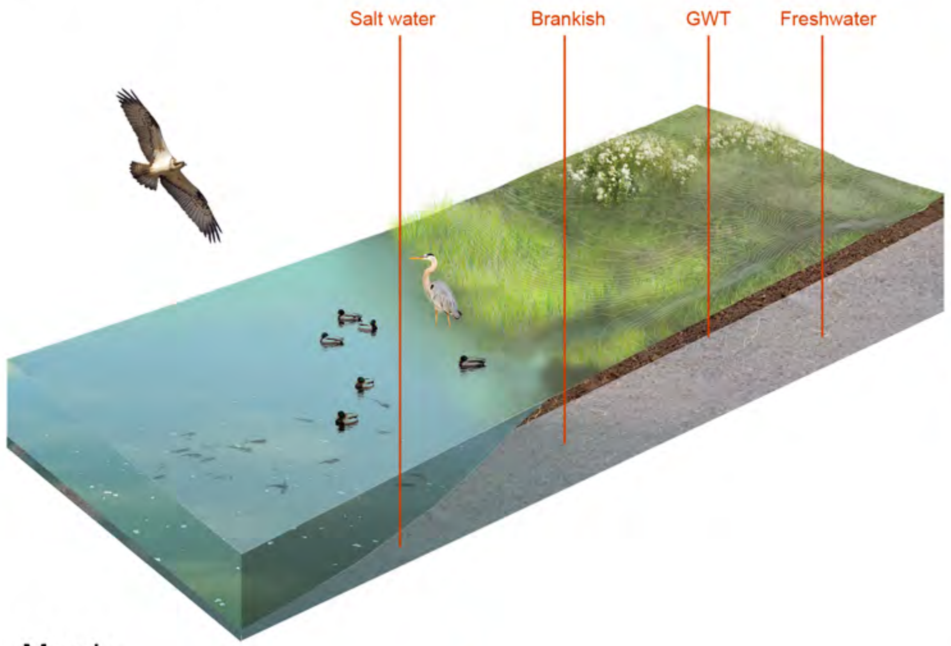

0
1.75
3.5
7
10.5
14
Miles
WETLAND
Wetlands
Sea/River/Pond

WETLAND

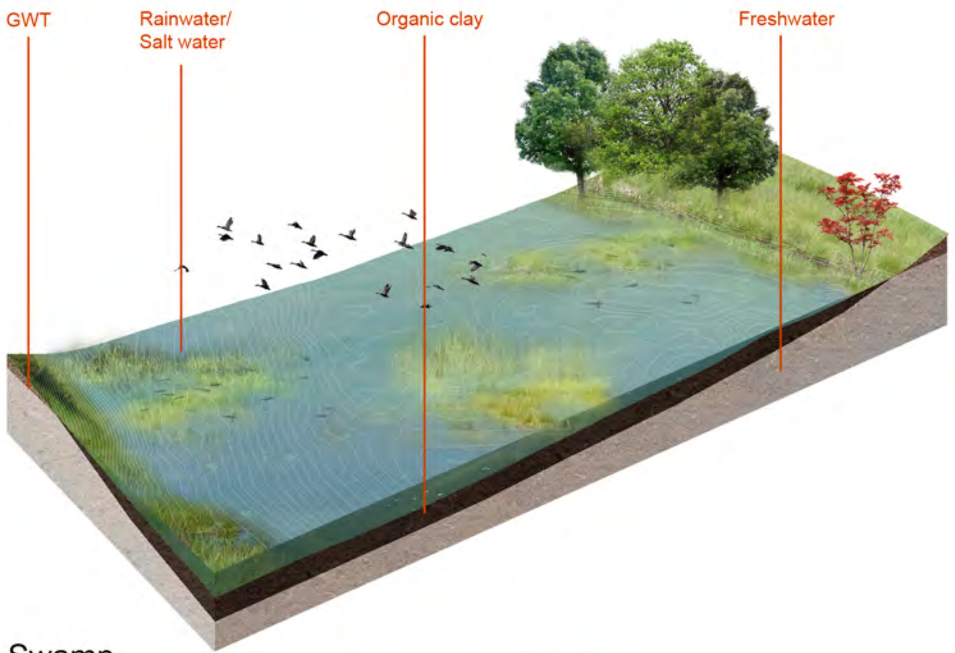
"Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetlands soils."
-- EPA, America's Wetlands: Our Vital Link Between Land and Water

Originators:
IEP inc
University of Rhode Island Environmental Data Center
Purpose:
Natural resource inventory and land use planning
How:
Wetlands as interpreted from 1988 aerial photography to one quarter acre polygon resolution by Cowardin 16 classification scheme.
Limitations:
The map was published in 1993, so the one problem is that the existing area of wetlands could be altered with time. And I found some wetland areas where near to the providence already dispeared from today's map. Therefore, it could be better if originators update the data information timely. On the other hand, the classification of the wetland is different to the sources I looked up online. Because the different ways to discribe a term, sometime it is not easy for us to find out the most positive content in the GIS.

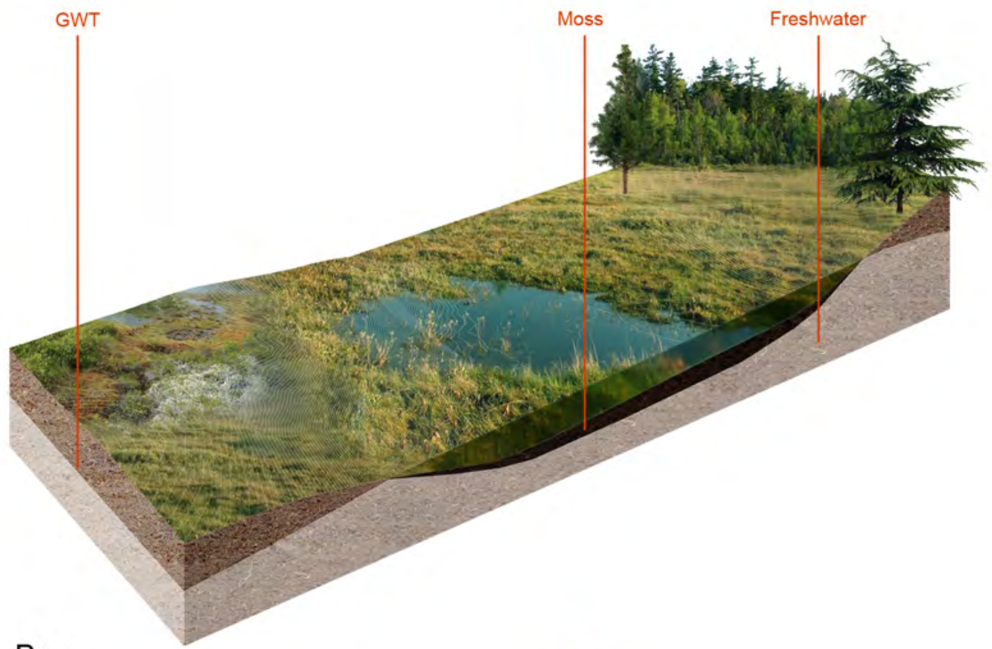
RI Wetland Main Type



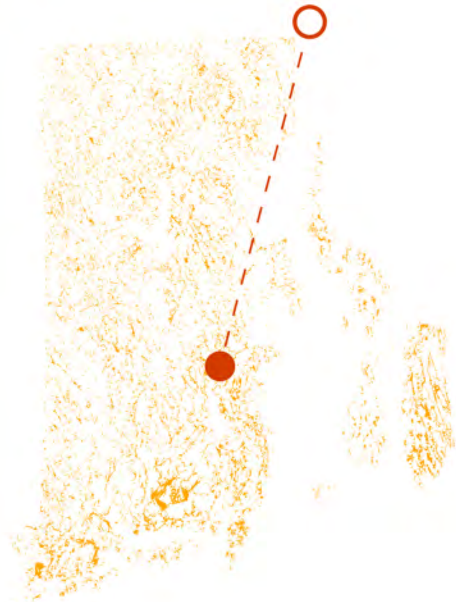
Marsh

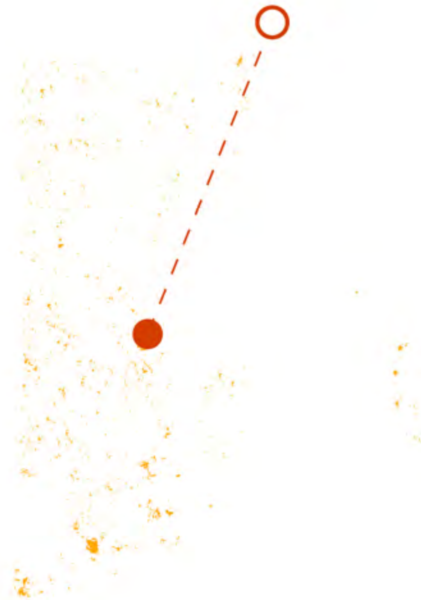


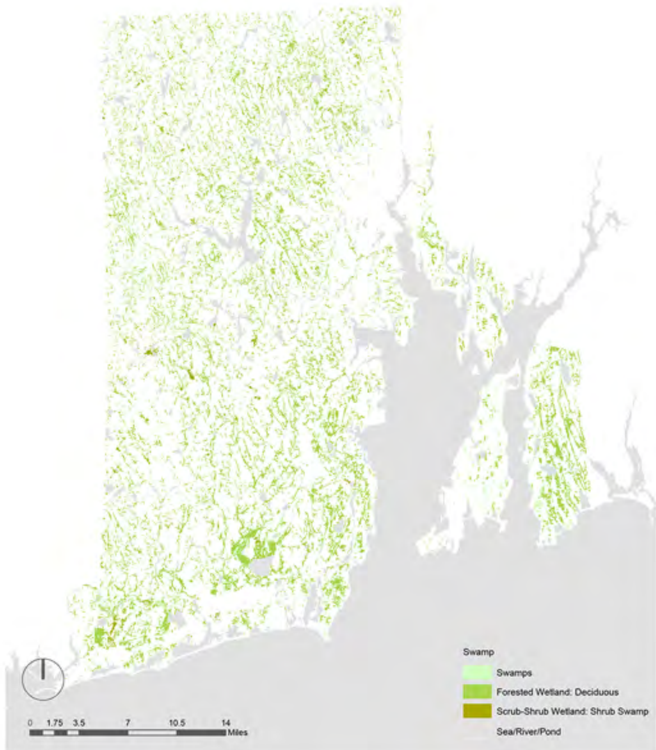
Swamp

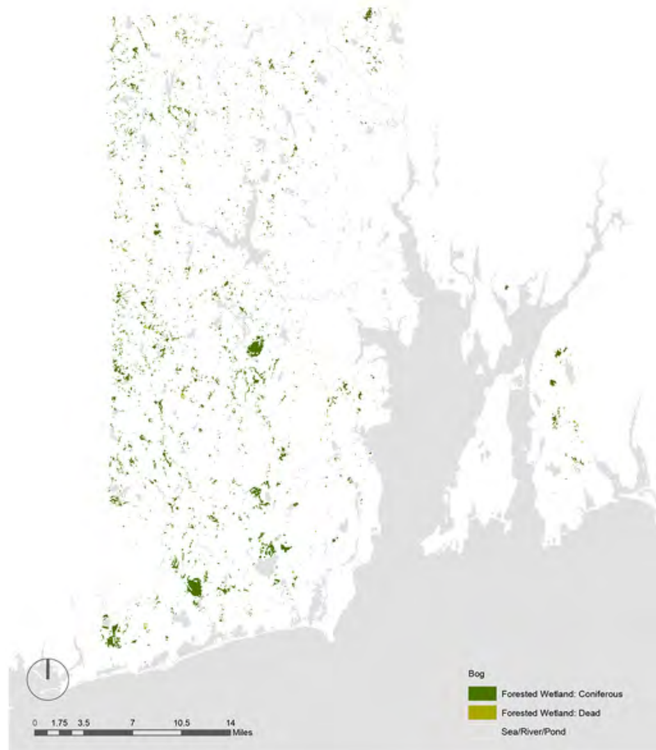


Bog









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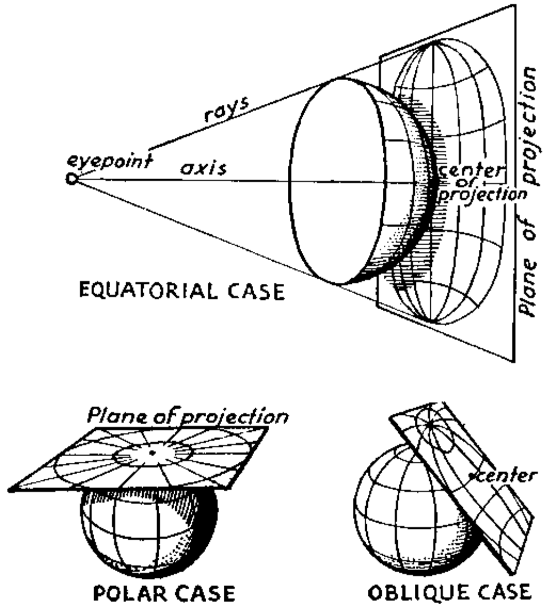
Emily Vogler + Jessica Leete
Spring 2015



2/23 WEEK 2:
VISUALIZING SPATIAL DATA 1 – GIS Vector Workshop
READINGS:
- James Corner. 'Agency of Mapping' in Mappings, ed. Denis Cosgrove. Reaktion Books 1999.

OPTIONAL:
- LaGro, James. Chapter 2 Visualization of Spatial Information
- Harley, J.B. Maps, Knowledge and Power. In The Iconography of Landscape. Ed. Denis Cosgrove and Stephan Daniels (p277-311).

ADDITIONAL BOOKS ON MAPPING + VISUALIZATION
- Tufte, Edward. The Visual Display of Quantitative Information. Graphics Press. 1992
- Hanna, Karen. GIS for Landscape Architects. ESRI Press, NY. 2002.
- Denis Cosgrove, ed. Mappings . Reaktion Books, 1999.
- Daniel Dorling and David Fairbairn. Mapping: Ways of Representing the World. Longman, 1997.
- Kate Ascher. The Works: Anatomy of a City. Penguin Books, 2005.

EXERCISE 2: MICRO | MACRO
For this exercise you will use GIS to map the topic that you are analyzing for studio. These drawings can and should overlap with the work you are doing for studio.

1. Make a graphically clear and compelling map or series of maps that cover the topic you are analyzing for studio. Include other layers that are needed to clearly communicate and locate the viewer (surrounding states, waterbodies, roads if appropriate, labels, etc). Map should include scale, north arrow, legend, etc.
2. Write a paragraph about the main layer you are using for your analysis work (ex. Land use, census, habitat). Reference the metadata and explain: Who created the layer? Why and how it was developed? What purpose is data supposed to be used for? And what are its limitations?
3. Take an element from the map and zoom into the micro scale and make a diagram (axon or section) or series of diagrams that provide spatial dimension or clarity to the data (section of different water edge conditions, axon of habitat types).

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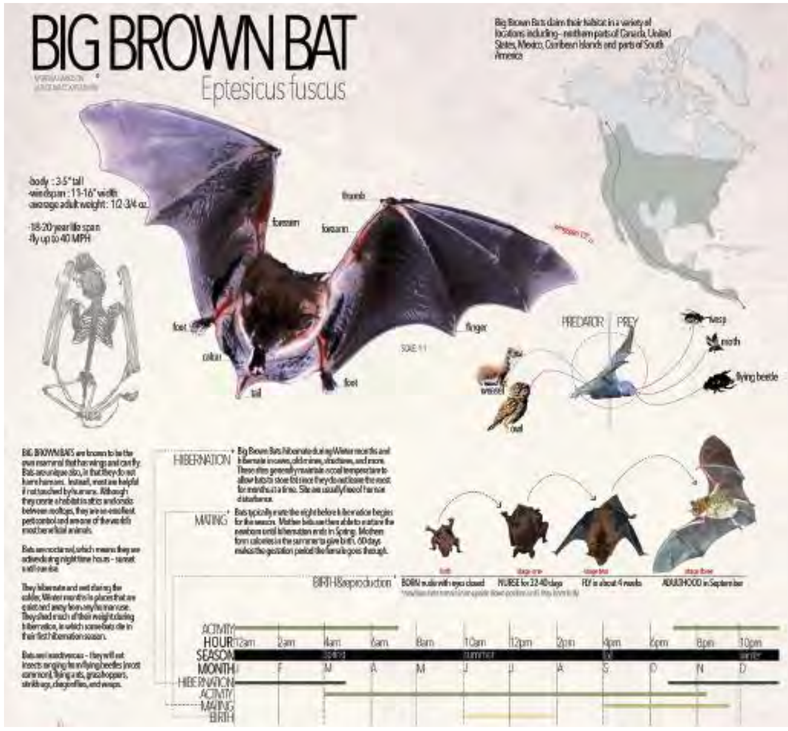


4/27 : HABITAT STUDY
DUE May 11th

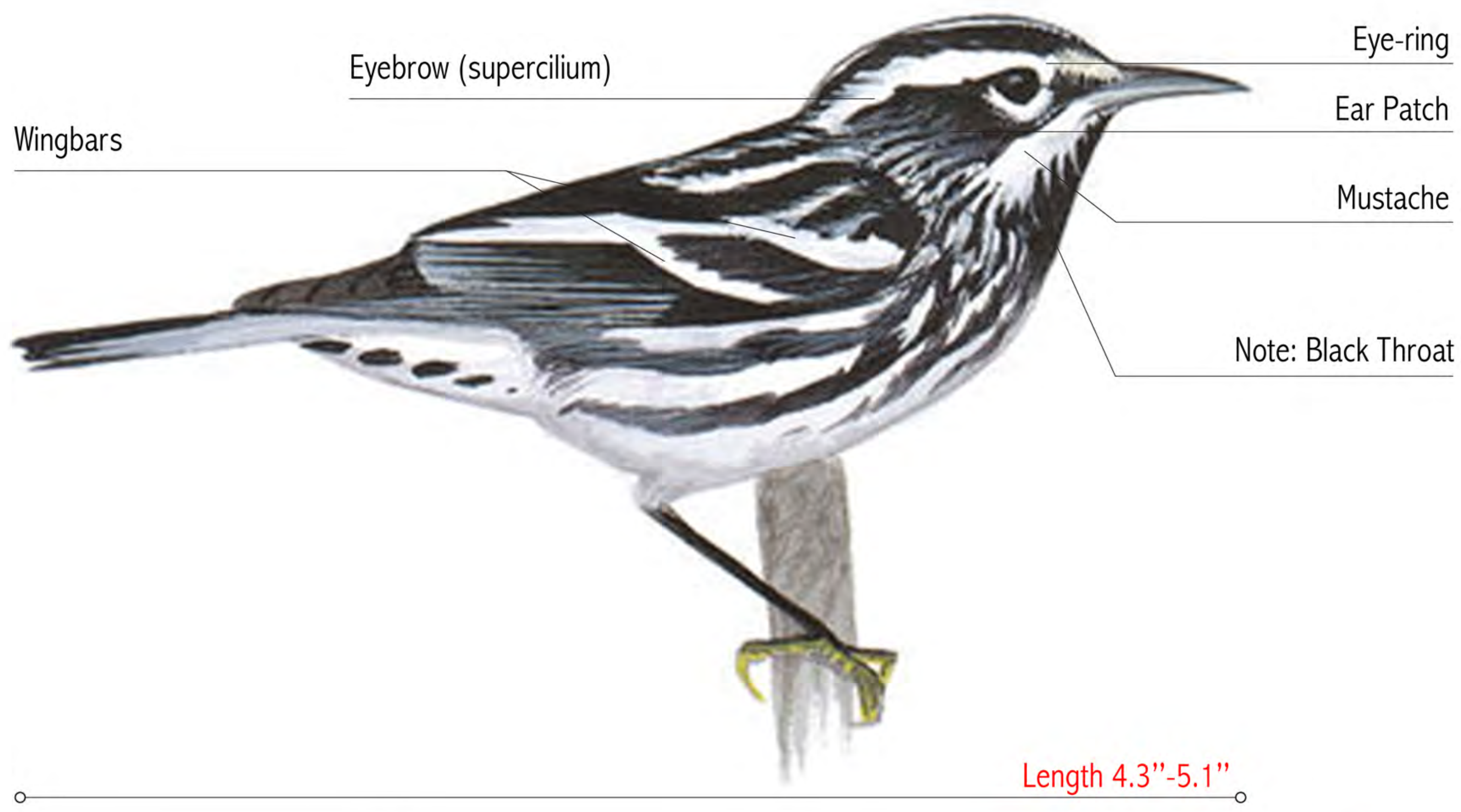
Your final assignment for this course is to apply what we have learned throughout the semester to your studio project:

1. Refine your species investigation to fully understand what it would take to create viable habitat for your species on your studio site. These should be represented in a graphically clear and compelling way. Consider including the following in your study:

- A diagram of the food chain that clearly communicates what plant/animal species are needed to support your species.
- A before and after section of the species habitat on the site. This should include accurate tide lines and accurate slope conditions.
- A diagram communicating the spatial dimensions of your species at multiple scales – dimensions of species, size of viable habitat requirements on the site (nest,etc), migratory dimensions
- A detail of the planting including what soils and additional stabilization are needed to support the establishment of the plants.
- An understanding of water quality needs (and impacts) of your species – salinity, turbidity, nutrients, etc.
- A drawing that communicates the potential for human interaction/education with species.
- What are the current threats and reasons you need to create habitat for this species.
- A drawing that communicates how you imagine the habitat will change over time
- Any additional drawings you think are necessary to communicate what it would actually take to create viable habitat on the site.

BLACK-AND-WHITE WARBLER

Mniotilta varia



Description:

B&W Warbler is entirely black and white in all plumages, except for a creamy wash on the face and flanks of many females. It has a white median crown stripe bordered by black on the head. Also a white supercilium separated by a broad black lateral crown-stripe. It has black-spotted undertail coverts.

B&W Warbler has an elongated hind toe and claws. This adaptation allows it to move securely on the surface of the bark. It has shortened tarsi, and a long thin bill with a slightly curved culmen, adapted for probing deeply into bark crevices.

In breeding plumage, male has black throat and cheeks. In winter, it has white chin. Female and immature have pale cheeks. Female has diffused streaks on buffy flanks. Buffy wash particularly bright on immature.

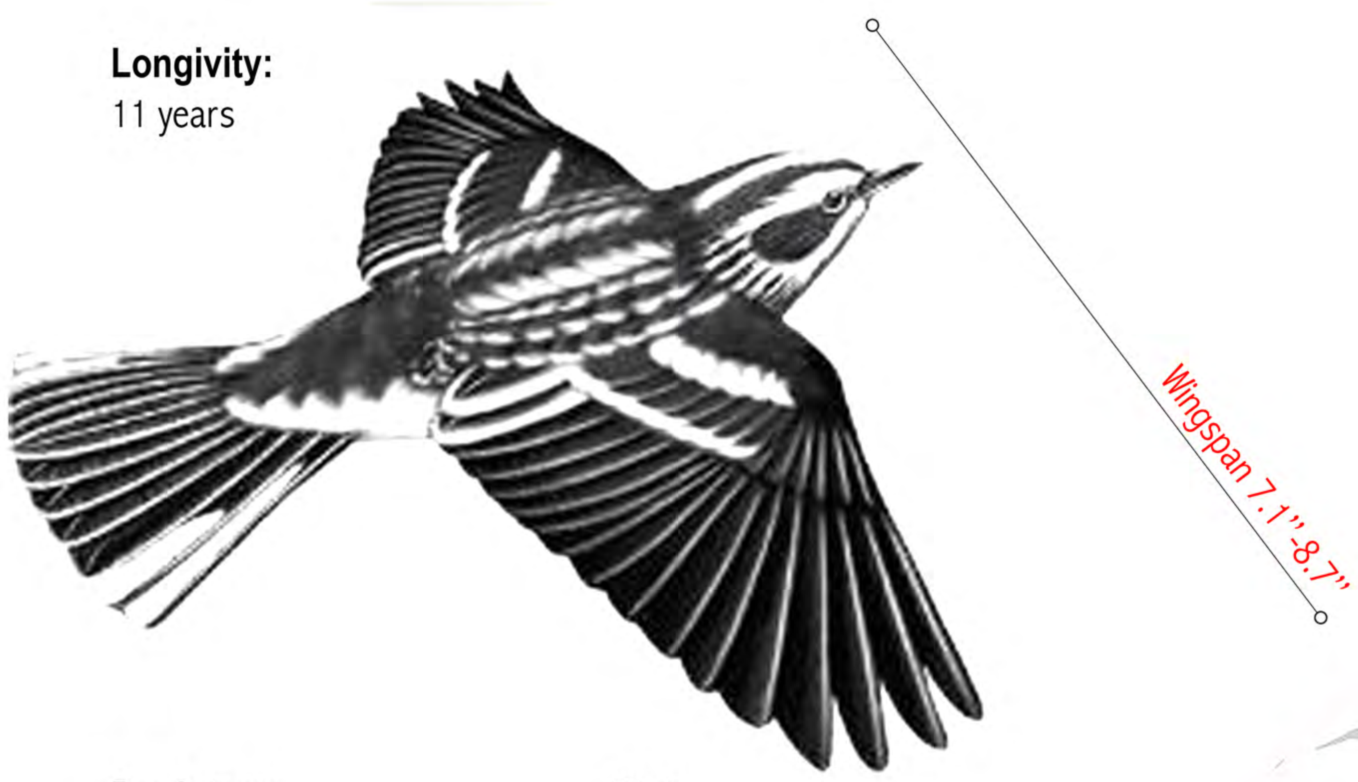
Biometrics:

Length
4.3–5.1 in

Wingspan
7.1–8.7 in

Weight
0.3–0.5 oz

Longivity:
11 years

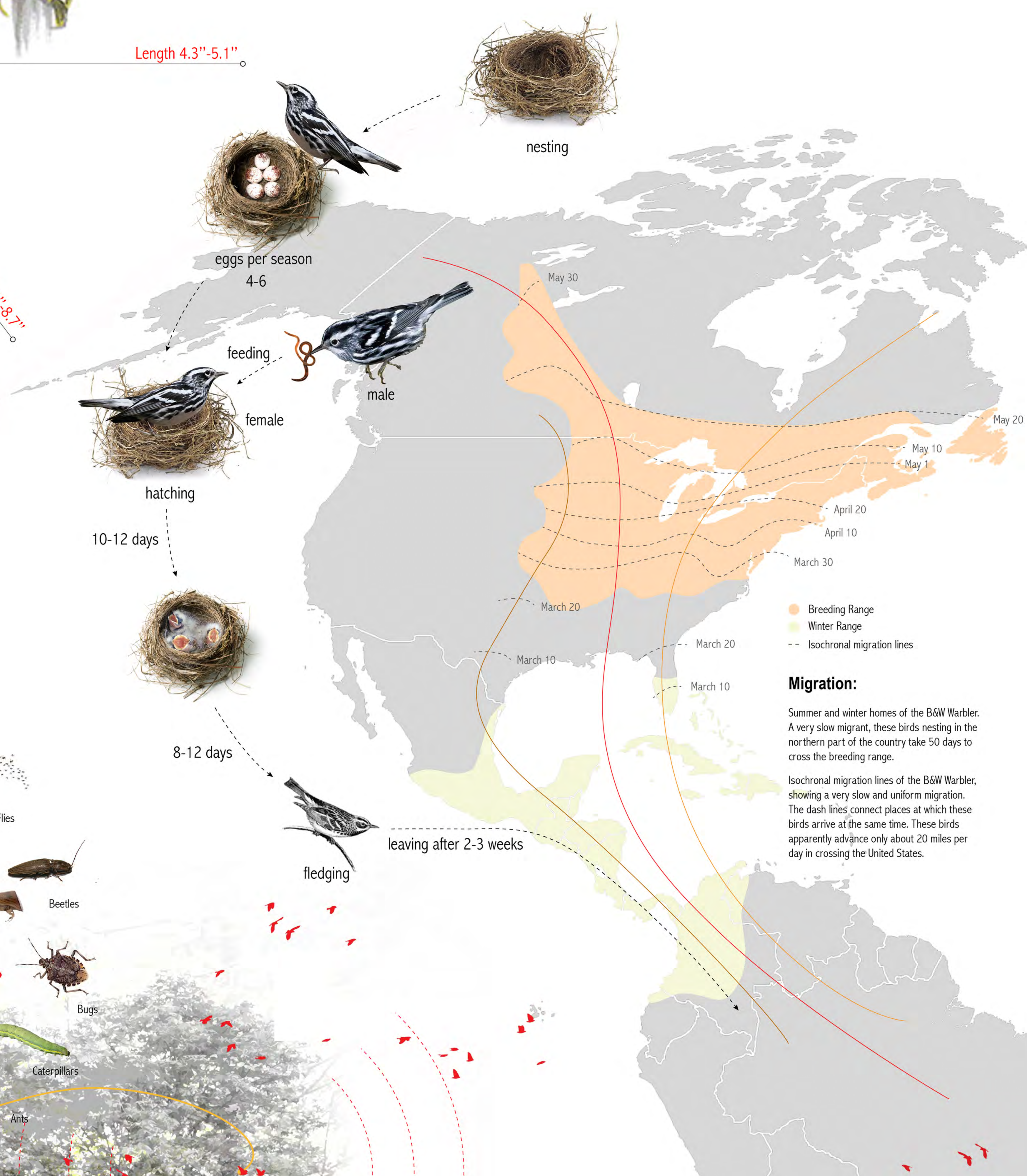


Predators:

As a ground nesting species, black-and-white warblers are probably vulnerable to many dif ferent predators, especially during the breeding season.

Diet:

B&W Warbler primarily eats insects such as caterpillars, flies, bugs, beetles, and also spiders, larvae and insect's egg. It is the only North American wood-warbler that regularly forages on bark.



Migration:

Summer and winter homes of the B&W Warbler. A very slow migrant, these birds nesting in the northern part of the country take 50 days to cross the breeding range.

Isochronal migration lines of the B&W Warbler, showing a very slow and uniform migration. The dash lines connect places at which these birds arrive at the same time. These birds apparently advance only about 20 miles per day in crossing the United States.

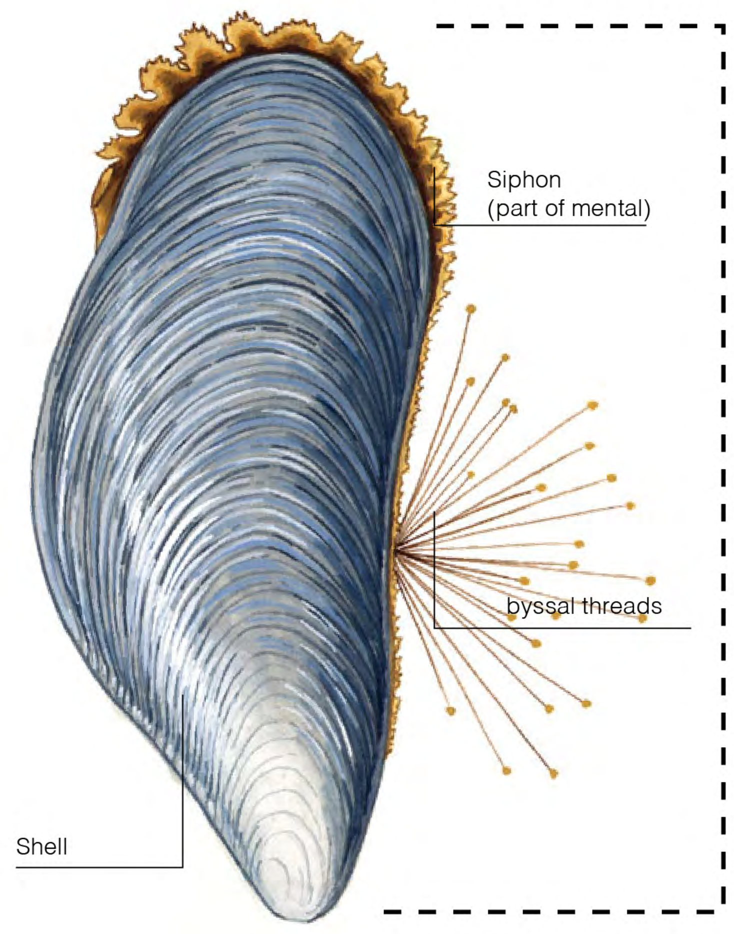
Nesting:

Black-and-white warblers breed in deciduous and mixed deciduous-conifer forests. They prefer forests with large trees and an understory of smaller trees and shrubs. In winter, black-and-white warblers can be found in a variety of forest types, as well as woodland borders, gardens, and coffee plantations.

*Black-and-white Warblers are quite vocal. Their song is thin, almost squeaky, but penetrating, so it's a good way to find them.

Blue Mussel and Surf scoter

Species research and structure design



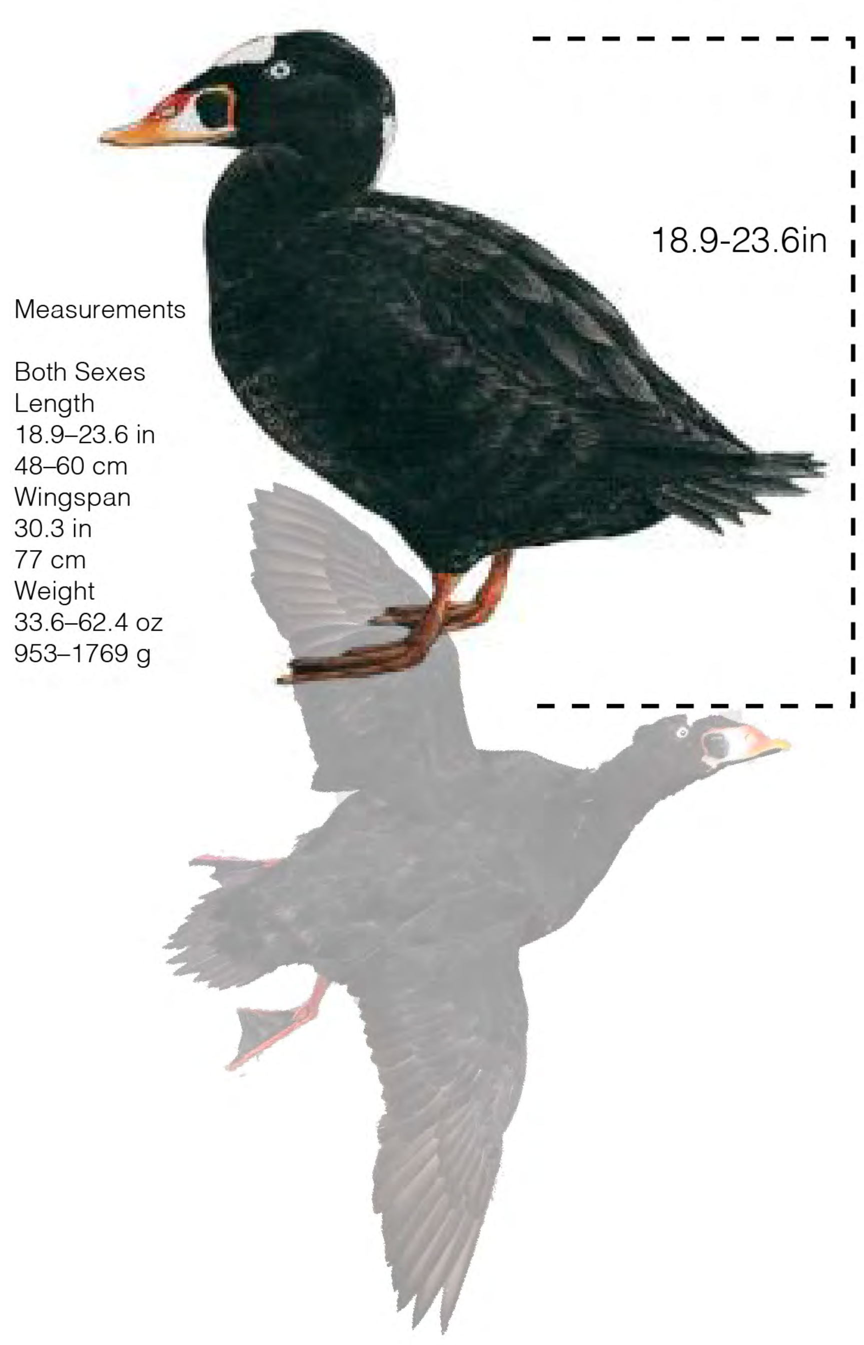
Blue Mussel:

Blue mussel is a key stone of the marsh land biosystem. It has a strong adaptive ability to live in the estuary environment. Once it catched the hard surface of the intertidal zone, it will stay there for years. Blue mussel is not only a kind of food to attract sea birds, but also it can act as a filter to clean the polluted water along the edge.

Habitat:

Blue mussels are boreo-temperate invertebrates that live in intertidal areas attached to rocks and other hard substrates by strong (and some-what elastic) thread-like structures called byssal threads, secreted by byssal glands located in the foot of the mussel.

Water codition:
Tempreture:15–20 °C
Salinities: between 15 and 35 ppt and 20 at 35 ppt at 20 °C (68 °F) ±10ppt, Although larvae from the high salinity populations can settle in estuaries, they die within a few months after settlement
pH level: 7.5 to 9.3



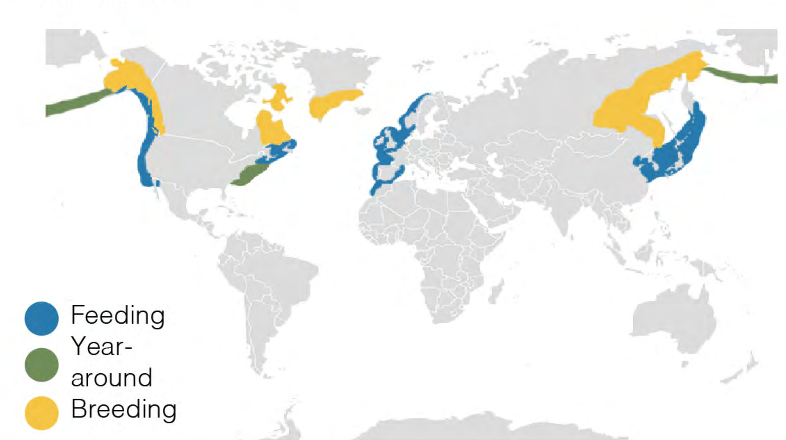
Measurements

Both Sexes
Length
18.9–23.6 in
48–60 cm
Wingspan
30.3 in
77 cm
Weight
33.6–62.4 oz
953–1769 g

Surf Scoter:

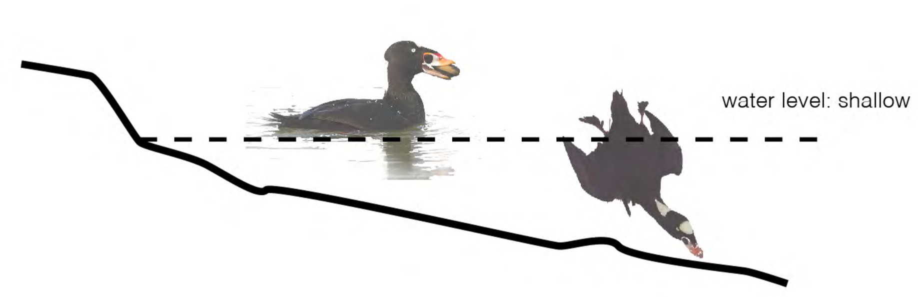
The surf scoter (Melanitta perspicillata) is a large sea duck, which breeds in Canada and Alaska. It is placed in the subgenus Melanitta, along with the velvet and white-winged scoters, distinct from the subgenus Oidemia, black and common scoters.

It winters farther south in temperate zones, on the coasts of the northern Unitetd States.



Breeds on shallow lakes in boreal forest and tundra. Winters in shallow marine coastal waters, usually over pebble and sand bottom.

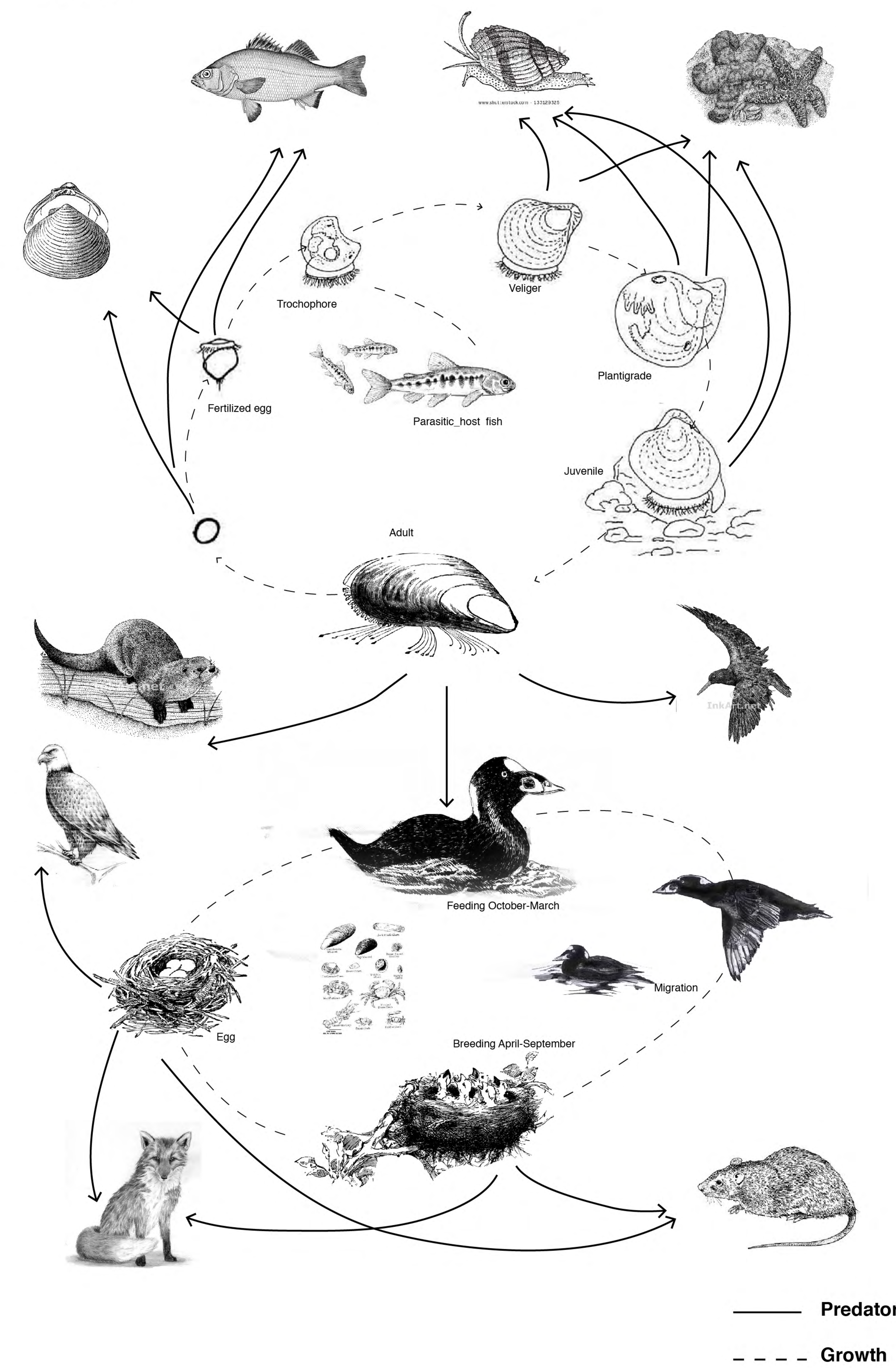
Name comes from their swimming habits. Always they can be found just beyond or in breaking waves.
Dives for prey on or near bottom.

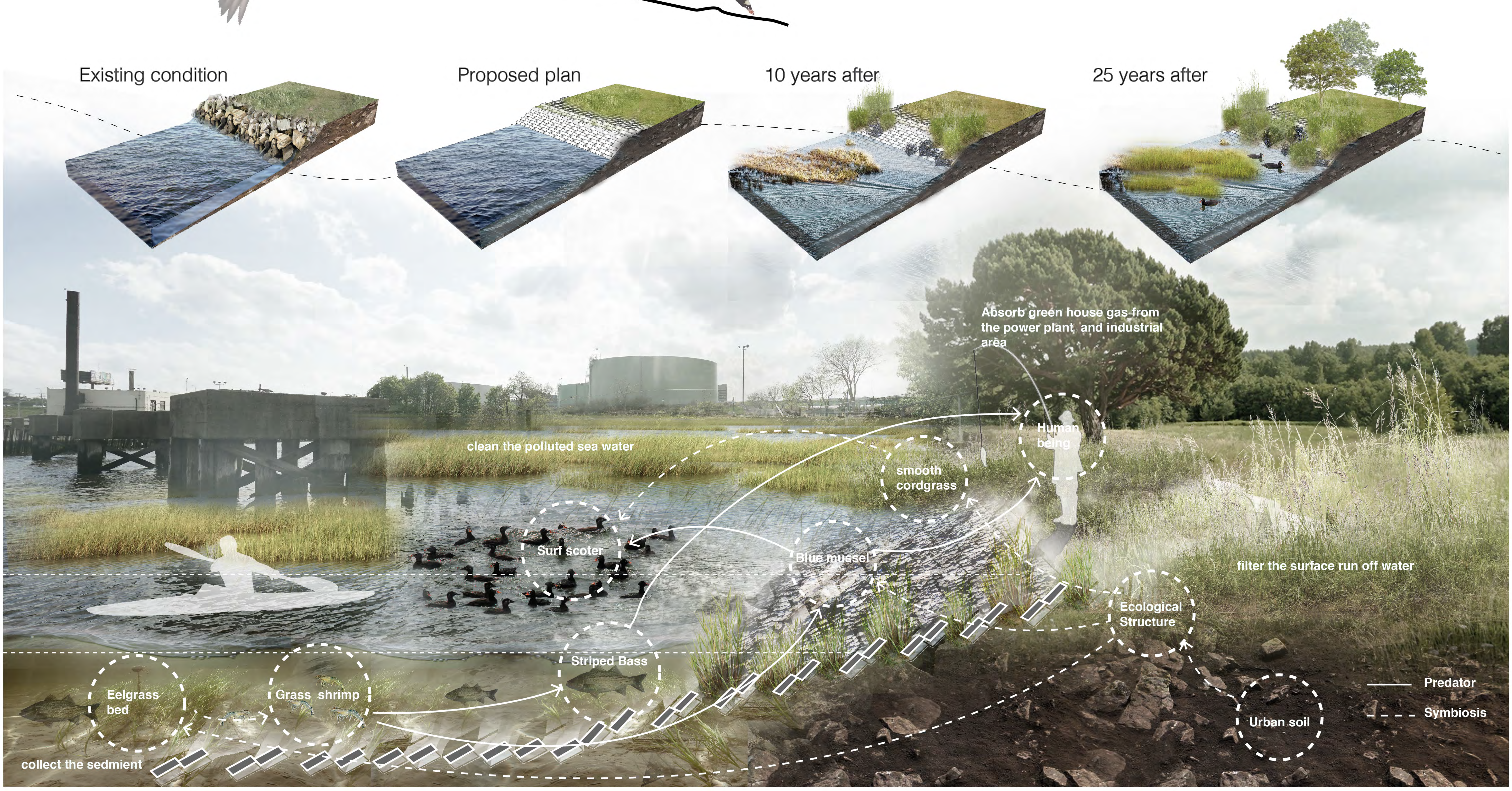


Food chain and life circle:

Mussels are bivalve mollusks, which means they have a hinged shell-like clams, oysters, and scallops. Blue mussels produce hundreds of thousands of eggs. Once hatched, larvae are highly mobile and drift around in the water column for 2-3 weeks before attaching to a substrate.

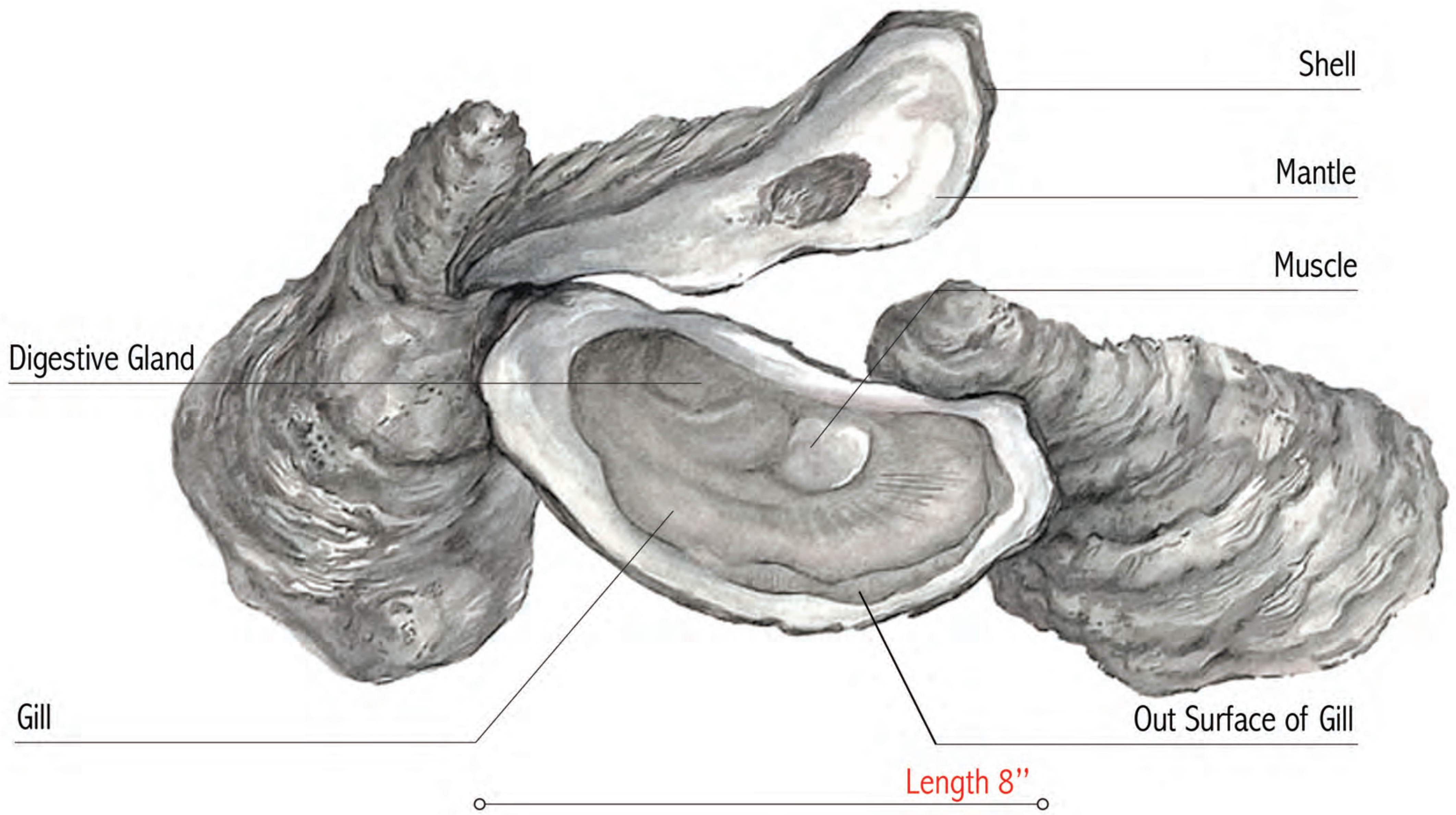
Surf scoter's nest is built on the ground close to the sea, lakes or rivers, in woodland or tundra. 5–9 eggs are laid. An egg may range from 55–79 g (1.9–2.8 oz) and average 43.9 mm (1.73 in) in breadth and 62.4 mm (2.46 in) in length. Occasional (and likely accidental) brood mixing between different females occurs in areas with high densities of nests. Growth is relatively rapid and the incubation period is about 28 to 30 days. The offspring will fledge independently at about 55 days.





EASTERN OYSTER

Crassostrea virginica



Description:

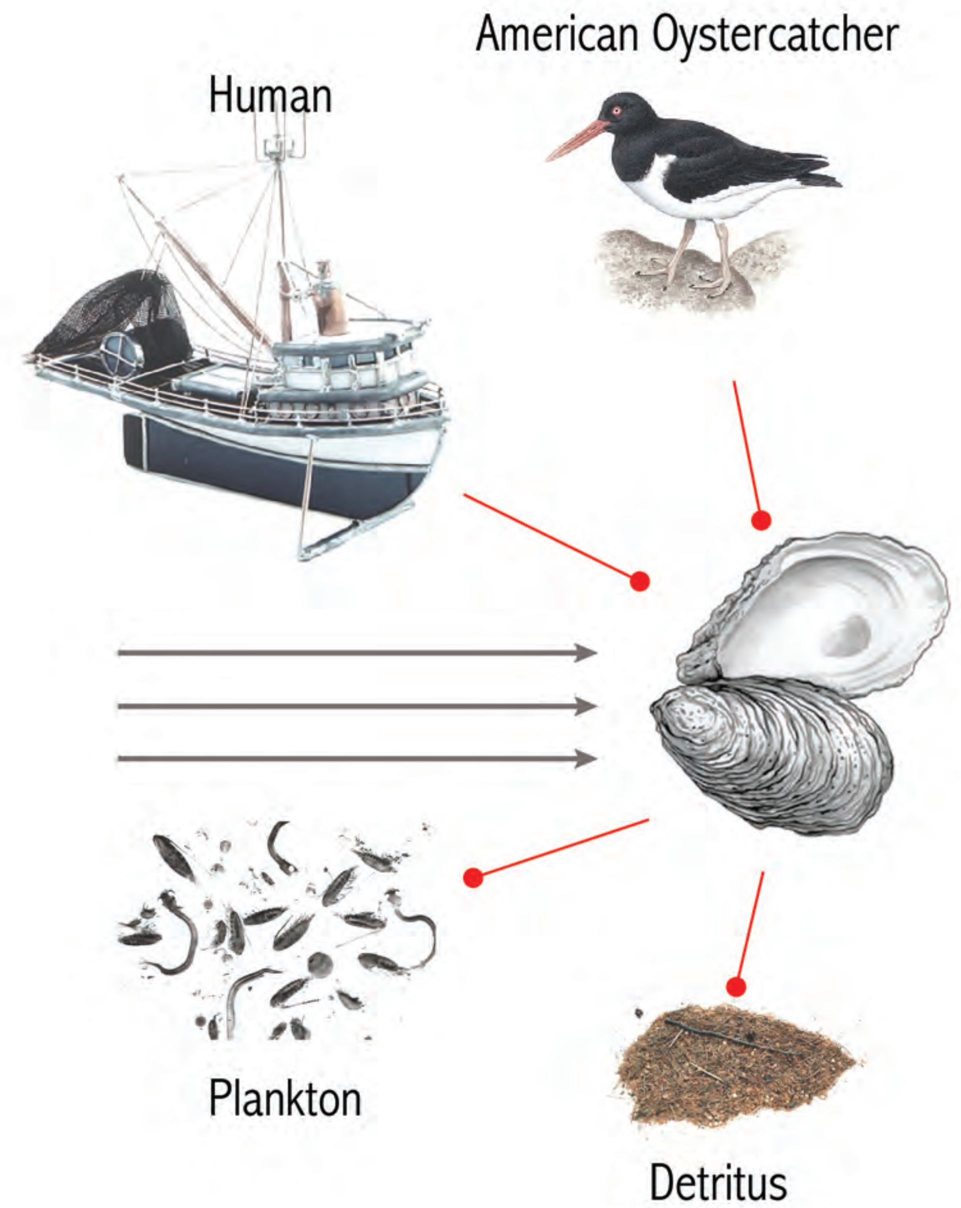
Valve (shell) length of the eastern oyster reaches up to 8 inches. Its two shells (called "valves," hence the name bivalve) attach together at one end by a natural hinge and by a single large muscle. The pale white to gray shell is rough with ridges or bumps.

Habitat:

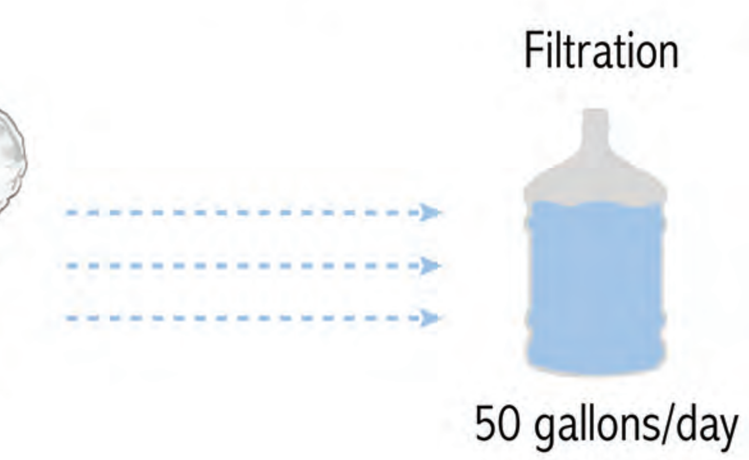
Eastern oysters are abundant in shallow saltwater bays, lagoons and estuaries, in water 8 to 25 feet deep

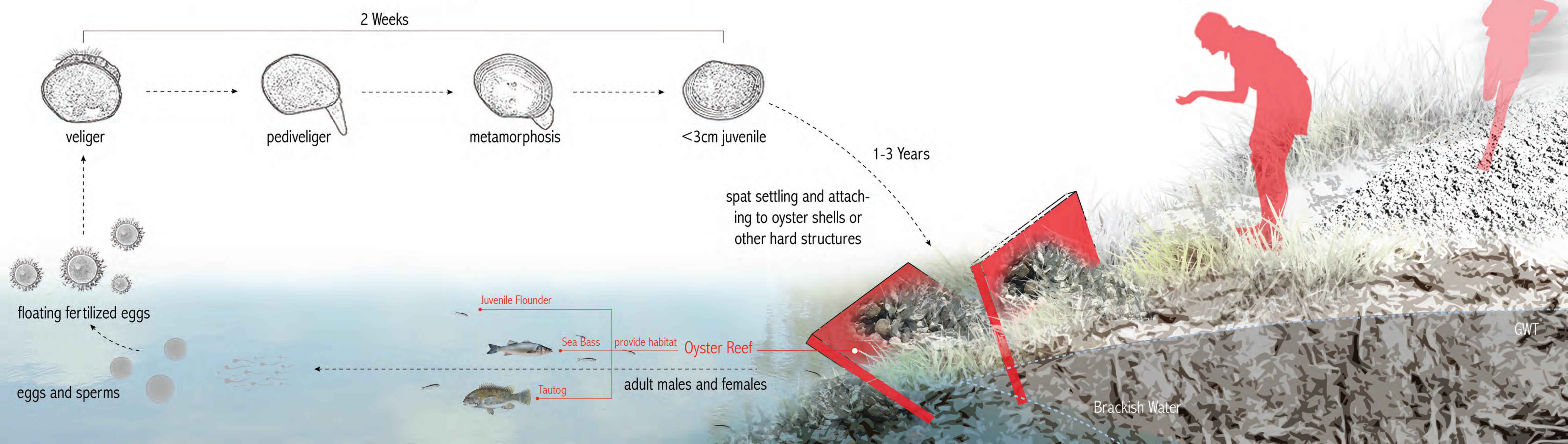
Predator & Prey:

The eastern oyster feeds on plankton and algae. It has numerous predators, including birds such as the American oystercatcher, ocean dwellers such as sea anemones, sea stars, sea nettles, some parasites, and humans.



*Oysters have an important impact on water quality. A large, adult oyster can filter up to 50 gallons of water per day, which not only clears the water, but also supplies vital nutrients to the reef. Oyster reefs also provide habitat for many species of marine life, including juvenile flounder, sea bass and tautog.





BIOTA

KELLIE KNIGHT
YIFAN KONG
MENGXUAN LIU

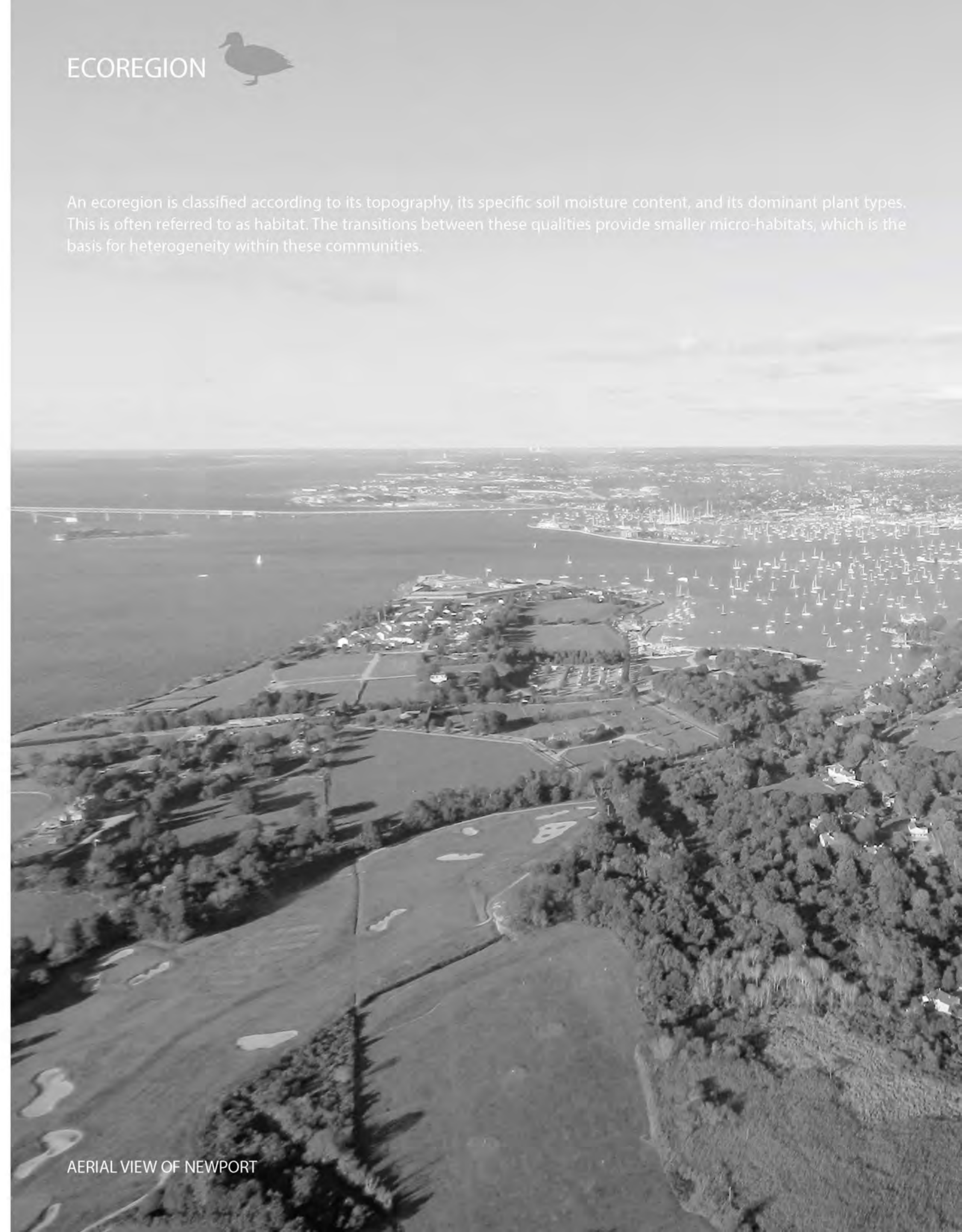
Overview

BIOTA is "the animal and plant life of a particular region." These regions are defined according to their physiogeography, climate, soil type, and hydrology, and they are termed ecoregions. The qualities that define them allow for the establishment of life. Their communities are first vegetative and micro-organismal, providing habitat for wildlife communities.

HABITAT : The location where a particular plant or animal lives and its surroundings (both living and nonliving) and includes the presence of a group of particular environmental conditions surrounding an organism including: air, water, soil, mineral elements, moisture, temperature, and topography.

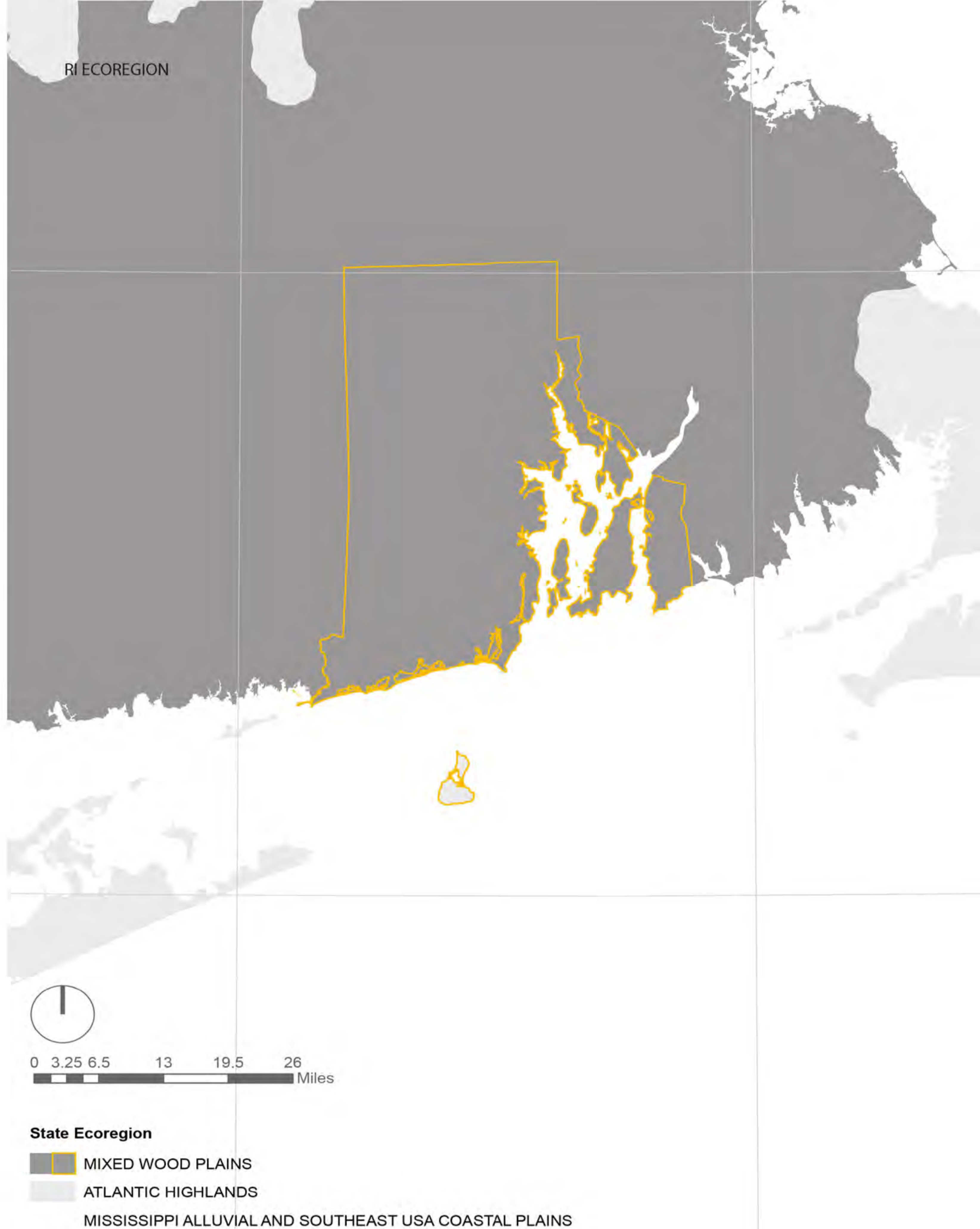
ECOREGION

An ecoregion is classified according to its topography, its specific soil moisture content, and its dominant plant types. This is often referred to as habitat. The transitions between these qualities provide smaller micro-habitats, which is the basis for heterogeneity within these communities.



AERIAL VIEW OF NEWPORT


US ECOREGION
0
270
540
1,080
1,620
Miles
US-Ecoregion
ALASKA BOREAL INTERIOR
ALASKA TUNDRA
ARCTIC CORDILLERA
ATLANTIC HIGHLANDS
BOREAL CORDILLERA
BOREAL PLAIN
BROOKS RANGE TUNDRA
CENTRAL AMERICAN SIERRA MADRE AND CHIAPAS HIGHLANDS
CENTRAL USA PLAINS
COASTAL PLAIN AND HILLS OF SOCONUSCO
COLD DESERTS
DRY GULF OF MEXICO COASTAL PLAINS AND HILLS
EASTERN SIERRA MADRE
EVERGLADES
HUDSON PLAIN
HUMID GULF OF MEXICO COASTAL PLAINS AND HILLS
INTERIOR DEPRESSIONS
MARINE WEST COAST FOREST
MEDITERRANEAN CALIFORNIA
MEXICAN HIGH PLATEAU
MISSISSIPPI ALLUVIAL AND SOUTHEAST USA COASTAL PLAINS
MIXED WOOD PLAINS
MIXED WOOD SHIELD
NORTHERN ARCTIC
NORTHWESTERN PLAIN OF THE YUCATAN PENINSULA
OZARK/OUACHITA-APPALACHIAN FORESTS
PLAIN AND HILLS OF THE YUCATAN PENINSULA
SIERRA AND PLAINS OF EL CABO
SIERRA LOS TUXTLAS
SOFTWOOD SHIELD
SOUTH CENTRAL SEMIARID PRAIRIES
SOUTHEASTERN USA PLAINS
SOUTHERN ARCTIC
SOUTHERN PACIFIC COASTAL PLAIN AND HILLS
SOUTHERN SIERRA MADRE
TAIGA CORDILLERA
TAIGA PLAIN
TAIGA SHIELD
TAMAULIPAS-TEXAS SEMIARID PLAIN
TEMPERATE PRAIRIES
TEXAS-LOUISIANA COASTAL PLAIN
TRANSVERSAL NEO-VOLCANIC SYSTEM
UPPER GILA MOUNTAINS
WARM DESERTS
WEST-CENTRAL SEMIARID PRAIRIES
WESTERN CORDILLERA
WESTERN PACIFIC COASTAL PLAIN, HILLS AND CANYONS
WESTERN PACIFIC PLAIN AND HILLS
WESTERN SIERRA MADRE
WESTERN SIERRA MADRE PIEDMONT

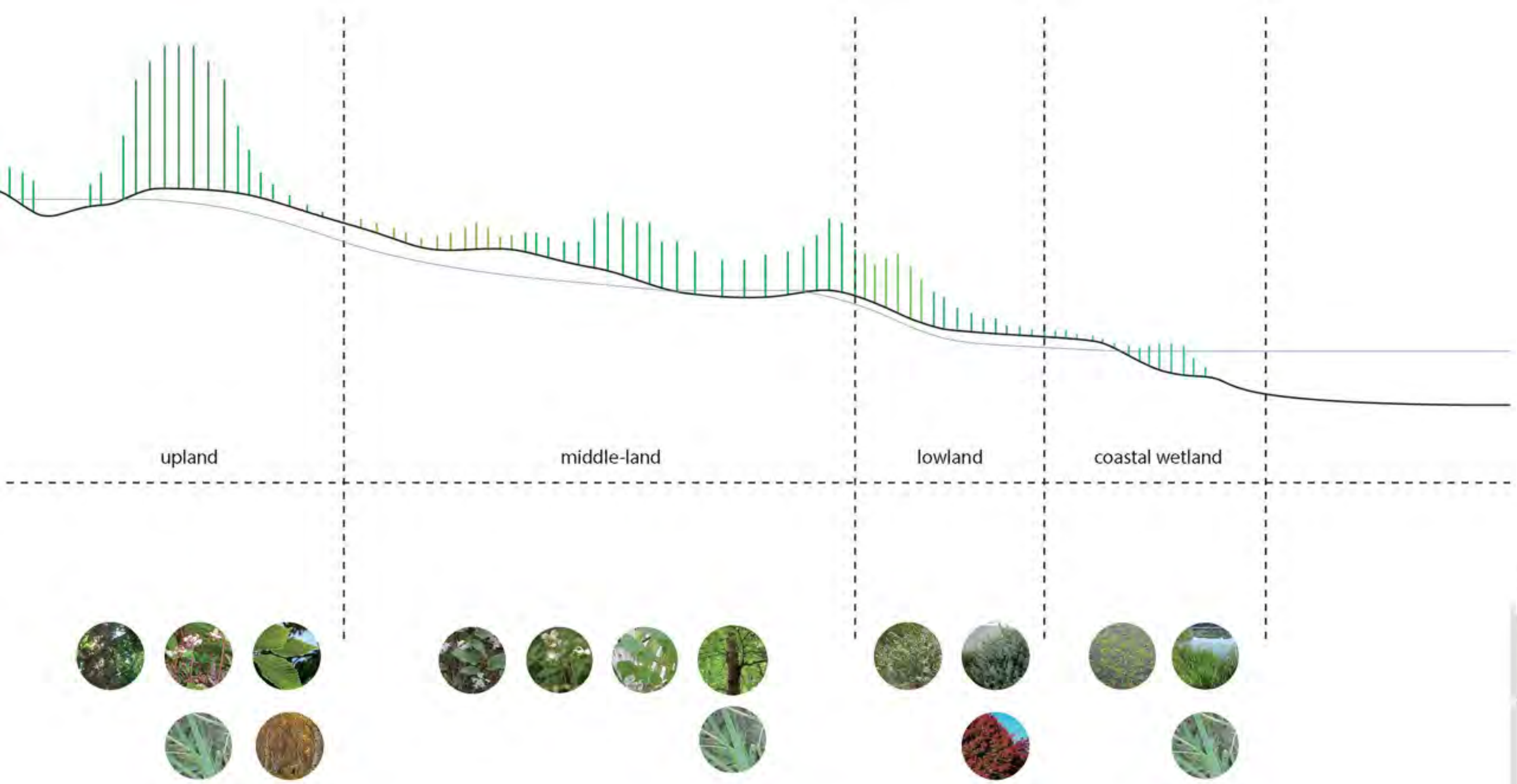

RI ECOREGION
0
3.25
6.5
13
19.5
26
Miles
State Ecoregion
MIXED WOOD PLAINS
ATLANTIC HIGHLANDS
MISSISSIPPI ALLUVIAL AND SOUTHEAST USA COASTAL PLAINS

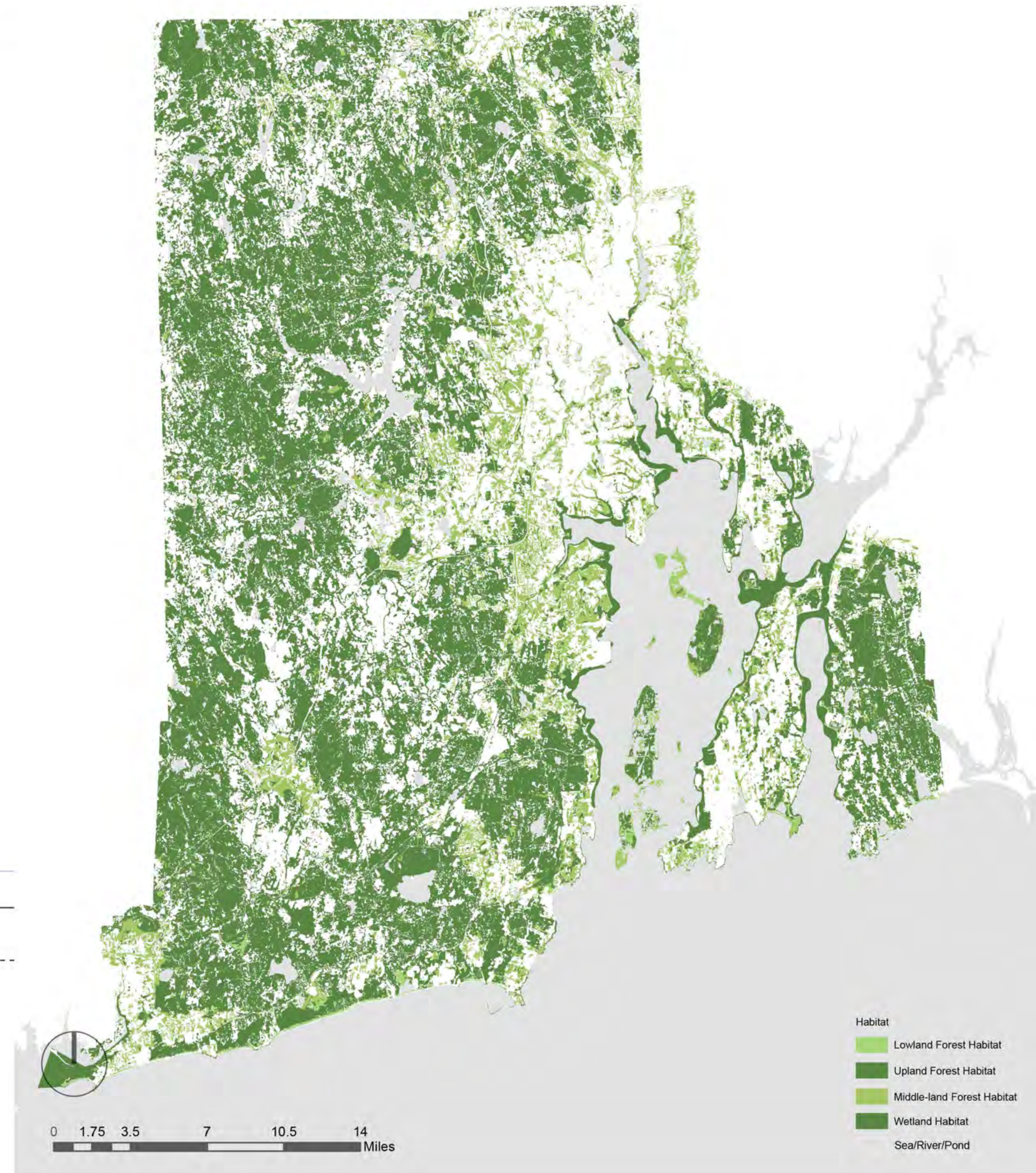
HABITAT CLASSIFICATION

Ecoregions are classified according to the change in topography and elevation, their specific soil moisture content and dominant plant type, often referred to as habitat. The transition between vegetation type and soil moisture content provide smaller micro-habitats for which allow for heterogeneity to develop within these communities.

-FOREST HABITAT

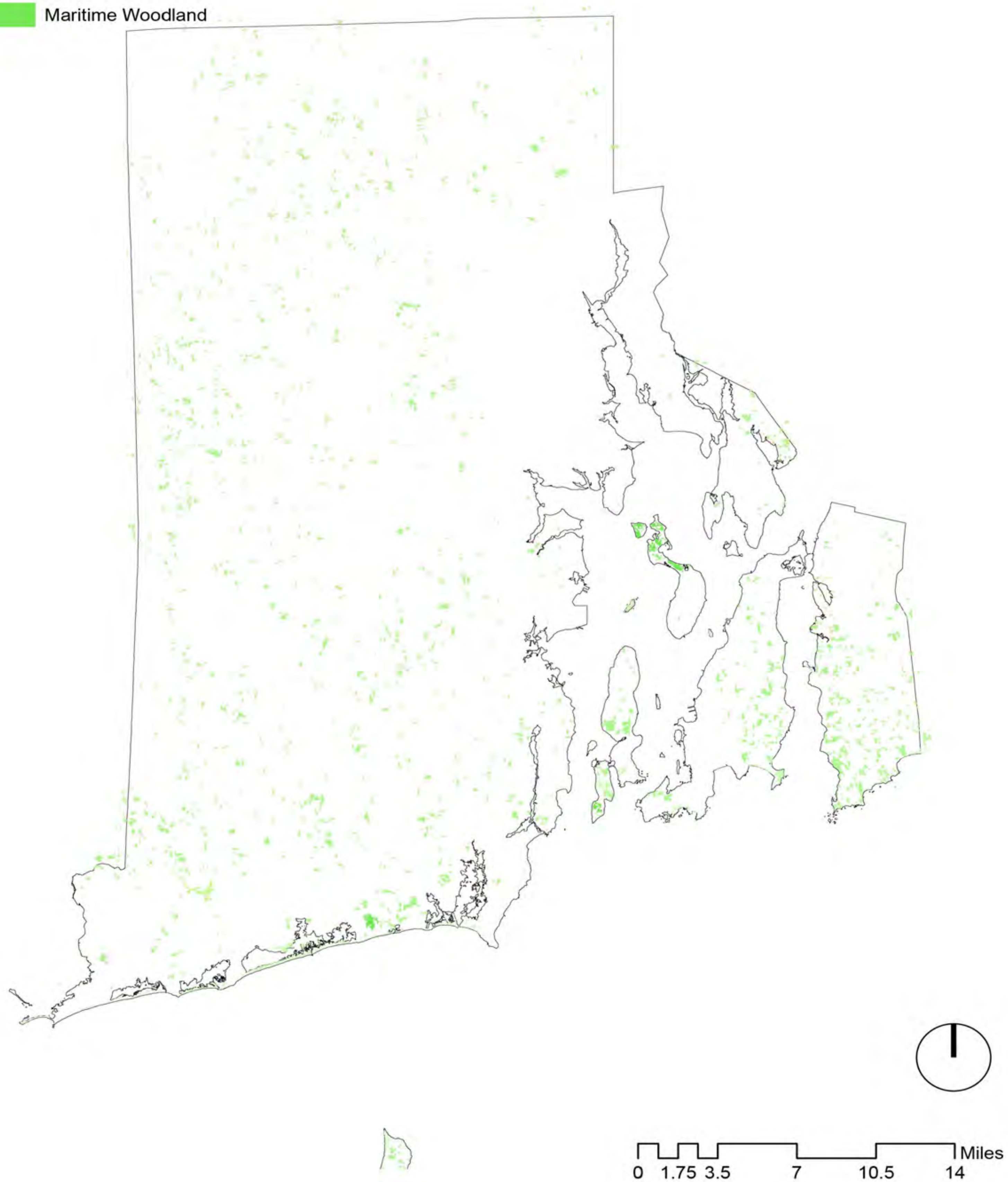
Forest habitat is an environmental condition characterized by woody vegetation, trees, and shrubs. The Rhode Island forest is diverse in its structure. It varies in composition from the dry upland forest down to the low wetland forest.





LOWLAND FOREST HABITAT

- Coastal Grassland
- Coastal Shrubland
- Floodplain Forests
- Hayfields/Pasture
- Inland Sand Barren
- Maritime Woodland



Orach Sea-rocket

Beach plum Bayberry

Tupelo

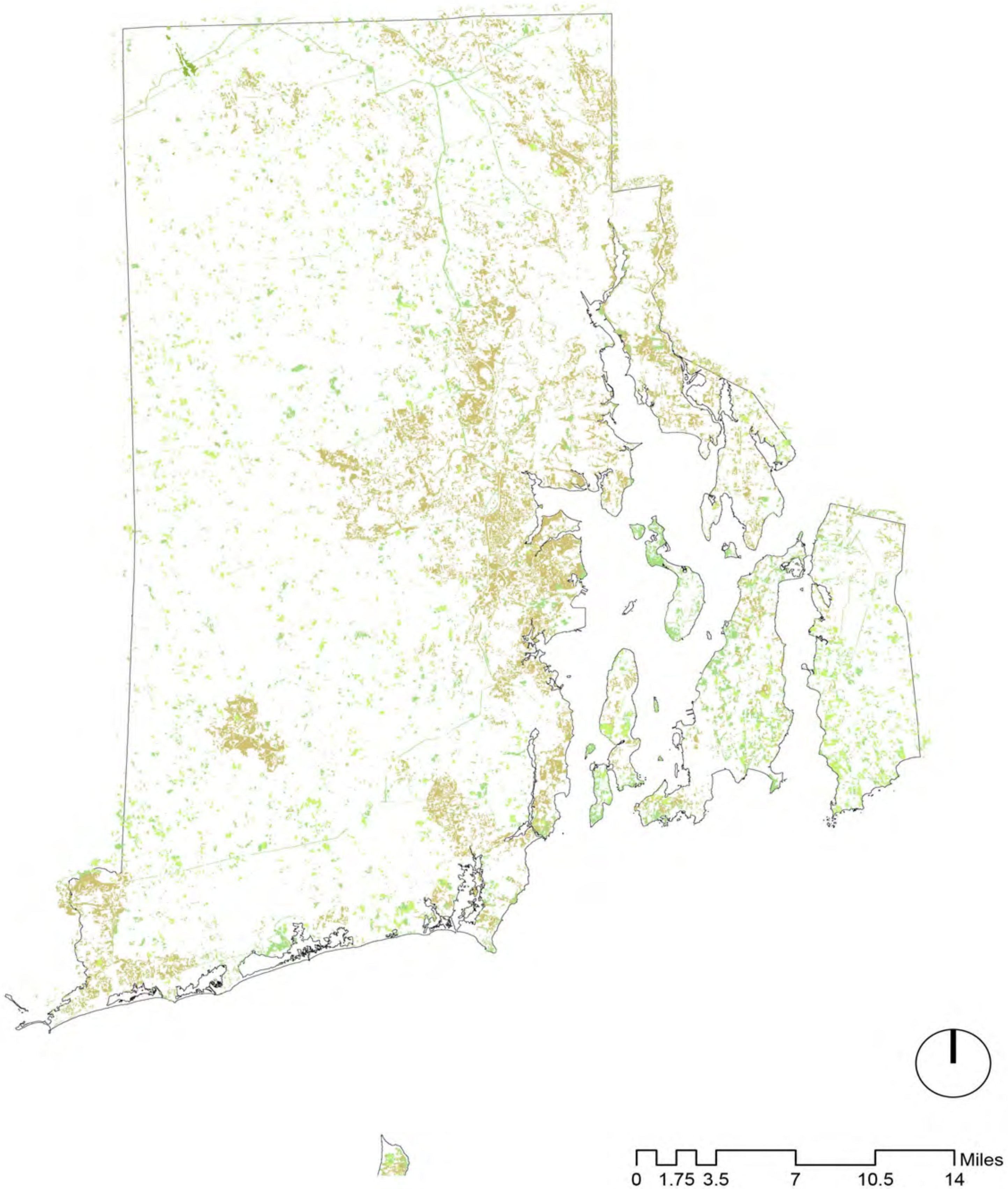
Witch hazel Shinleaf

Beach plum Bayberry

Black cherry White ash Red oak

MIDDLE-LAND FOREST HABITAT

- Hayfields/Pasture
- Ruderal Grassland/Shrubland
- Ruderal Forest
- Hemlock/Hardwood Forest



Hayfields/Pasture

Spotted pipsissewa

Ruderal Grassland/Shrubland

Trailing arbutus

Winter green

Ruderal Forest

Gray birch

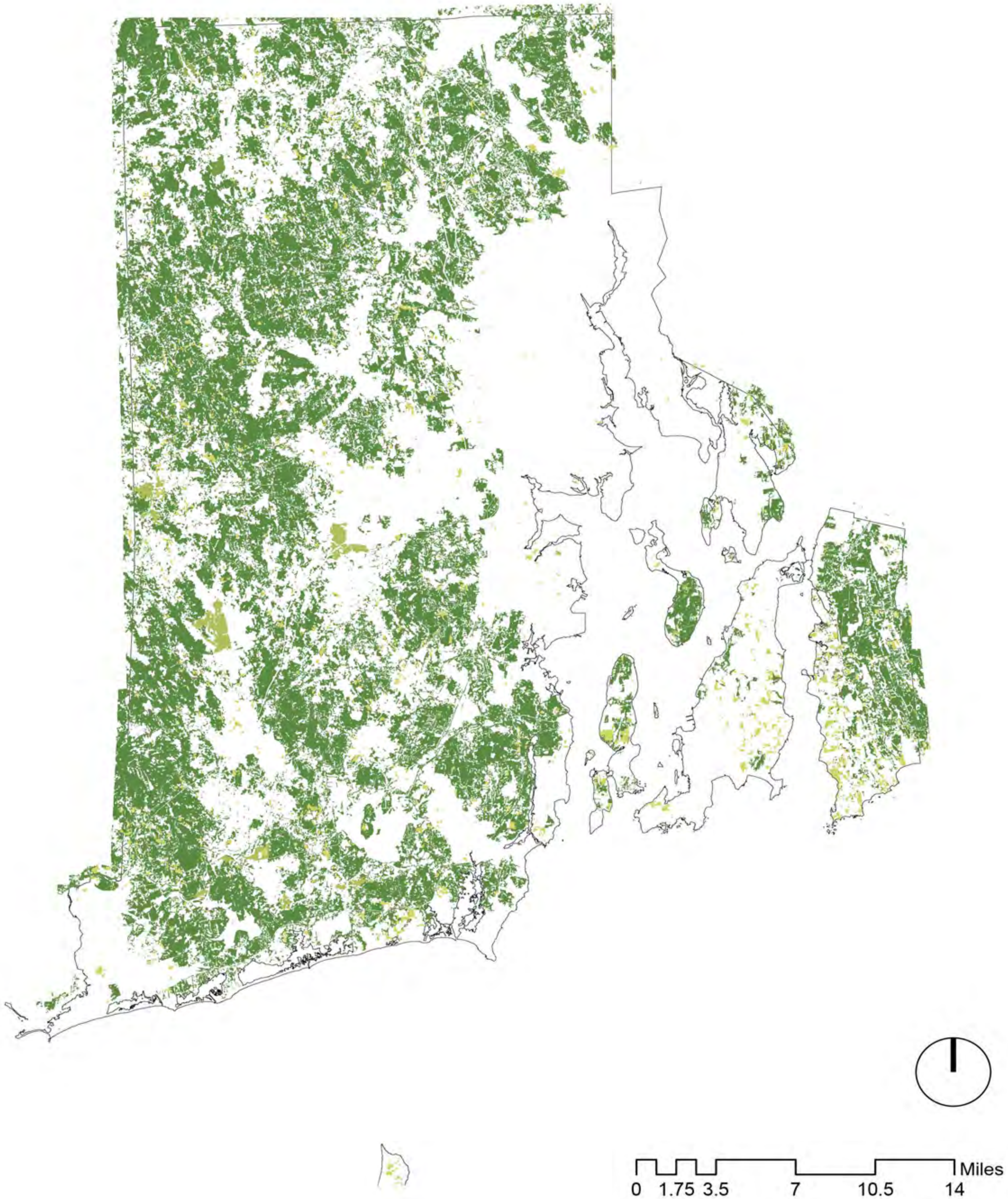
Hemlock/Hardwood Forest

Canadian hemlock

Black birch

UPLAND FOREST HABITAT

- Hayfields/Pasture
- Pitch Pine Woodland/Barrens
- Hemlock/Hardwood Forest
- Northern Hardwood Forest
- Oak Forest



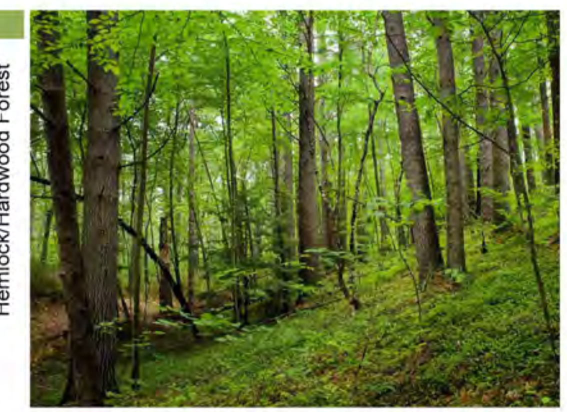
Hayfields/Pasture

Pipsissewa

Pitch Pine Woodland/Barrens

Pitch pine

Hemlock/Hardwood Forest



American beech

Newengland beech

Northern Hardwood Forest

Sugar maple

Yellow birch

Oak Forest

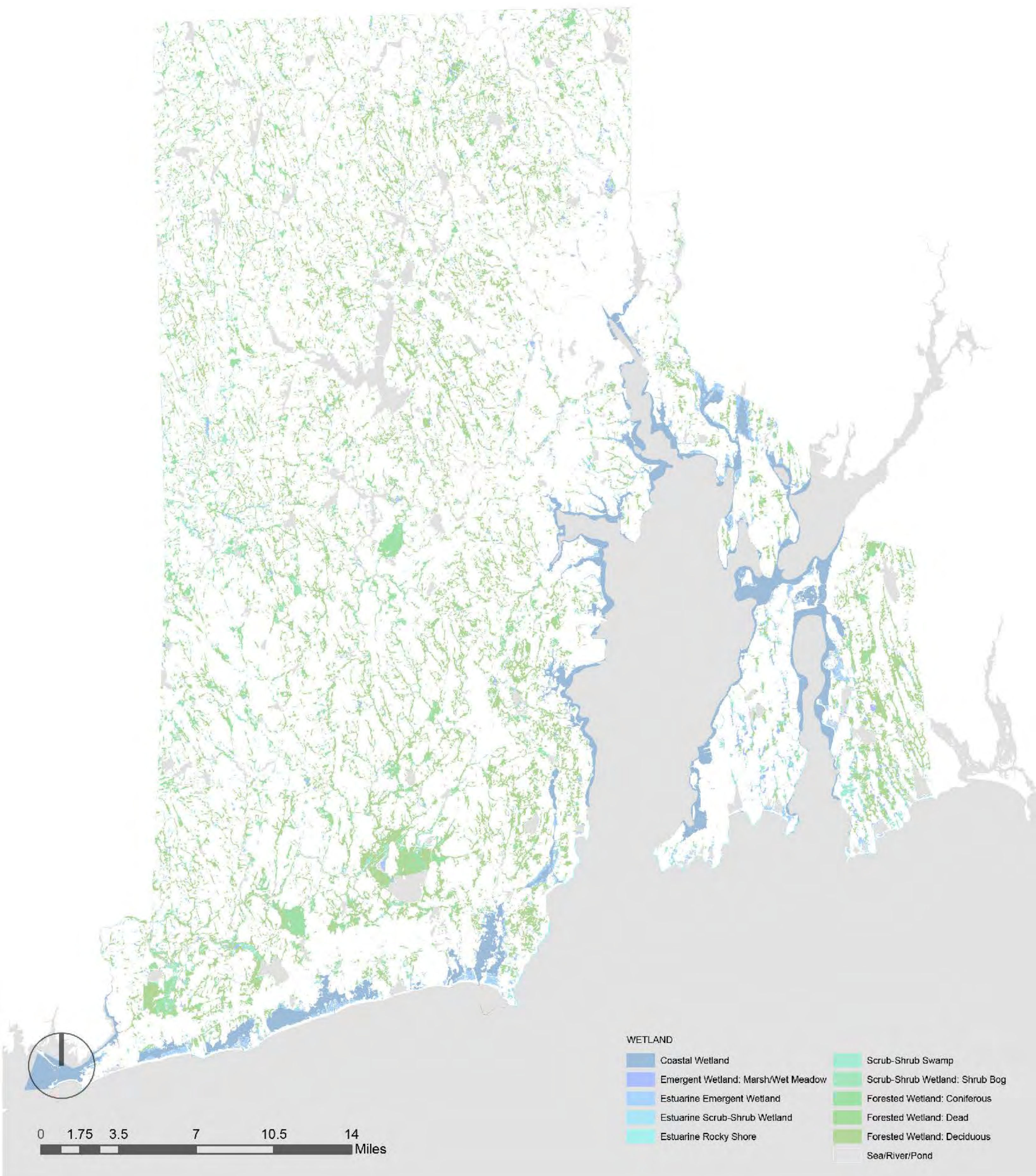
Chestnut oak

Scarlet oak

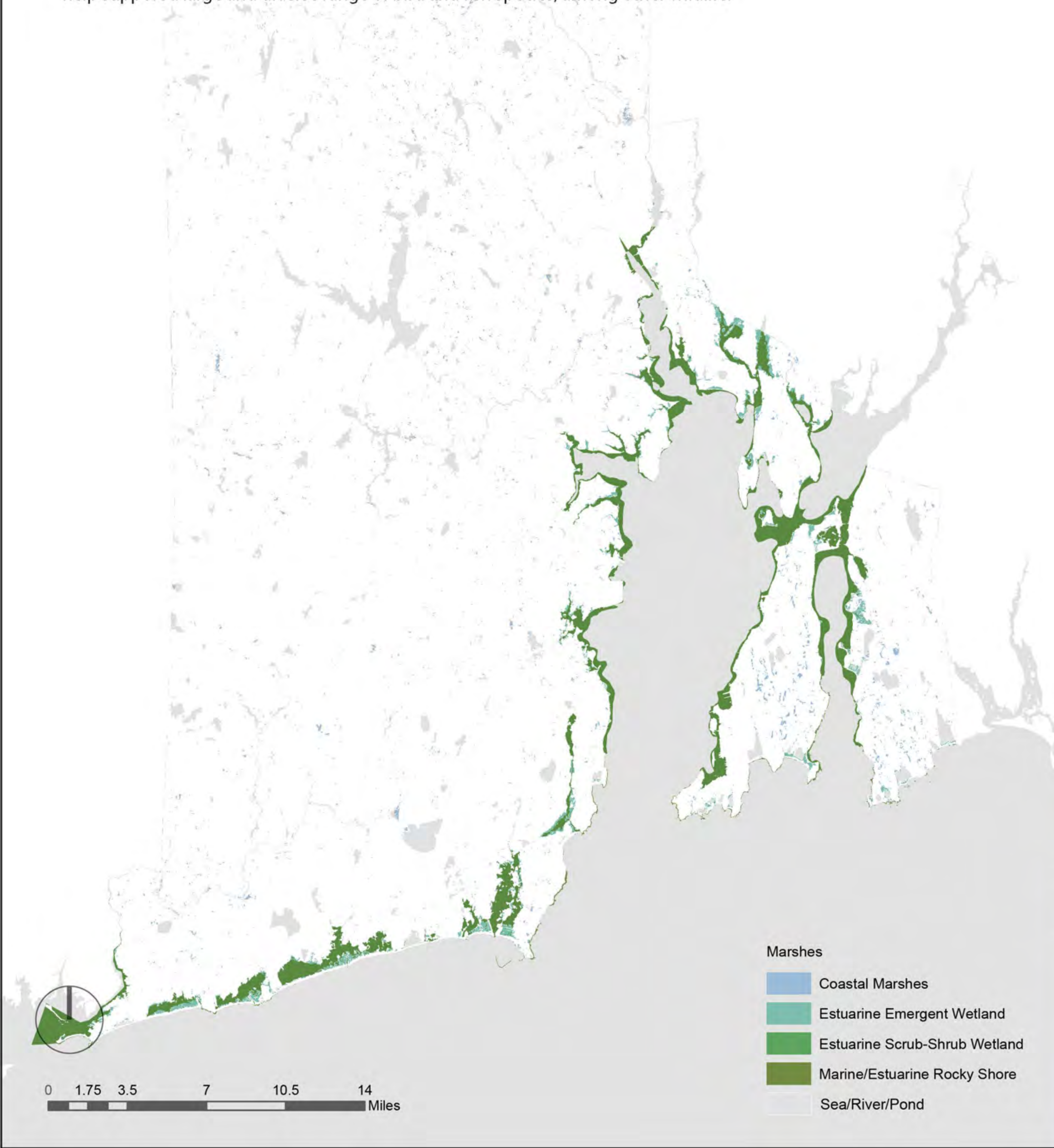
-WETLAND HABITAT

“Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promotes the development of characteristic wetlands soils.”

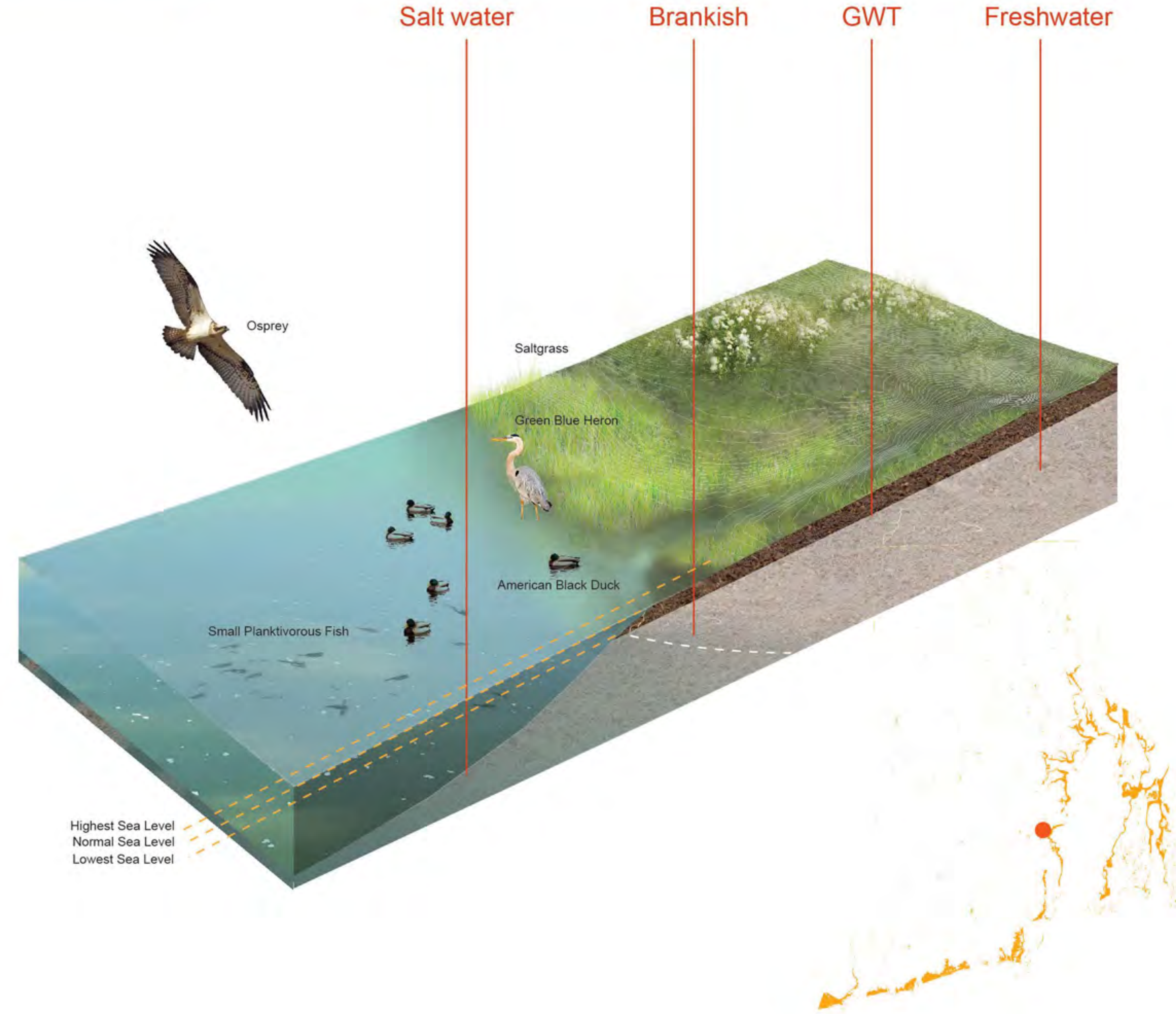
-- EPA, America’s Wetlands: Our Vital Link Between Land and Water



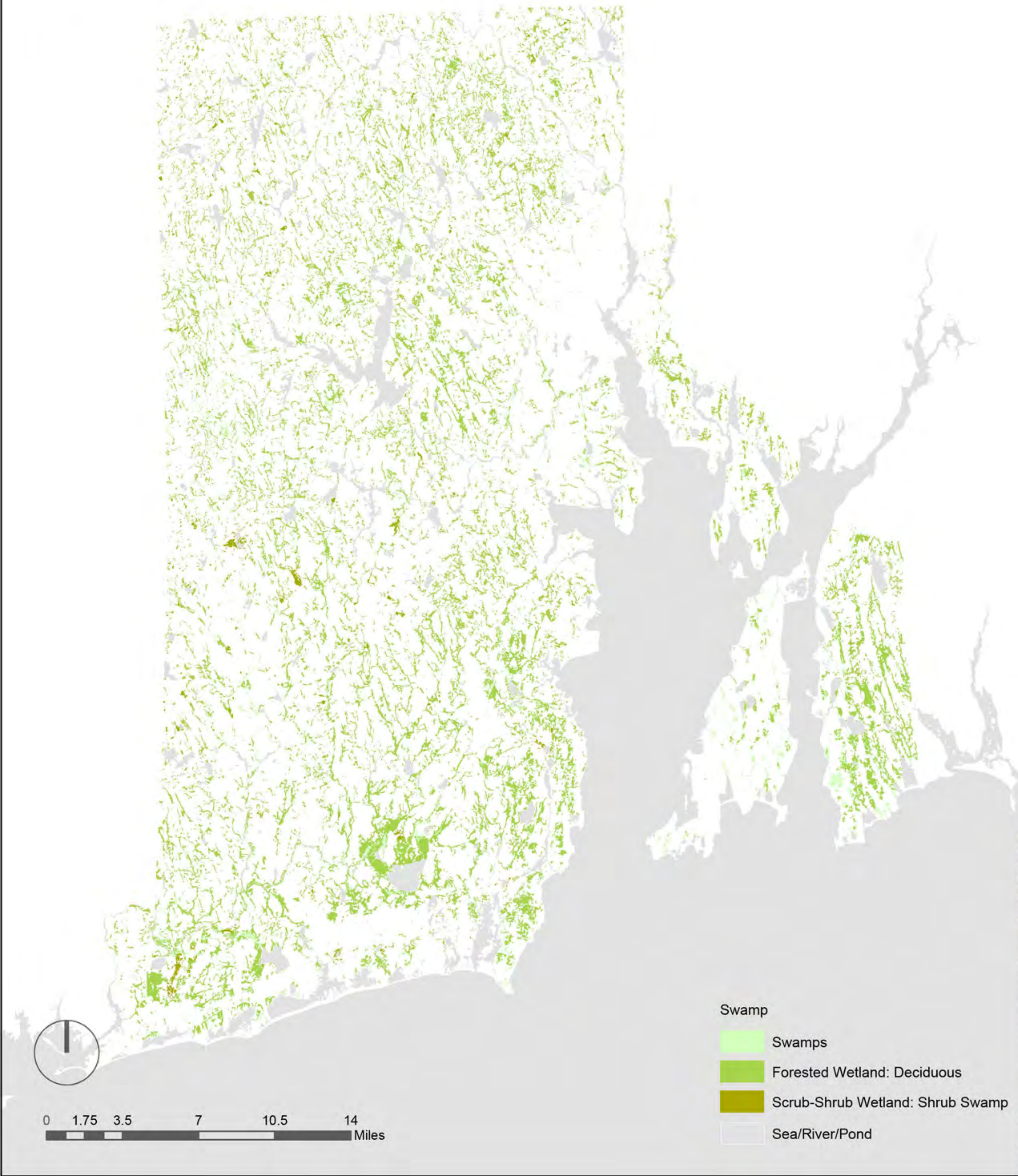
Coastal salt marshes occur along coastlines and are influenced by tides and often by freshwater runoff, rivers, or ground water. Salt marshes are the most prevalent types of tidal marshes and are characterized by salt-tolerant plants such as smooth cordgrass, saltgrass, and glasswort. Salt marshes have one of the highest rates of primary productivity associated with wetland ecosystems because of the inflow of nutrients and organics from surface and/or tidal water. Tidal freshwater marshes are located upstream of estuaries. Tides influence water levels but the water is fresh. The lack of salt stress allows a greater diversity of plants to thrive. Cattail, wild rice, pickerelweed, and arrowhead are common and help support a large and diverse range of bird and fish species, among other wildlife.



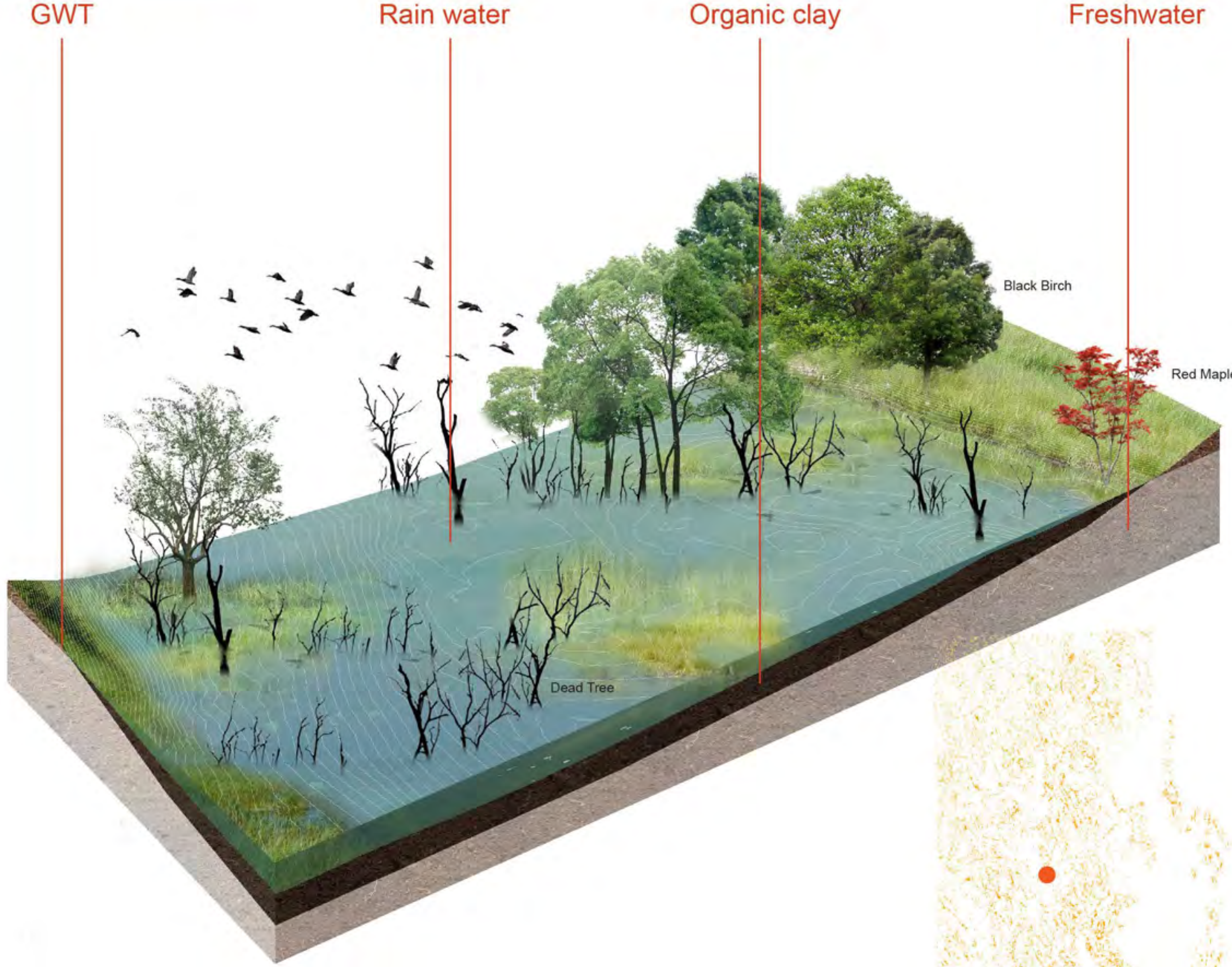
Salt Coastal Marsh



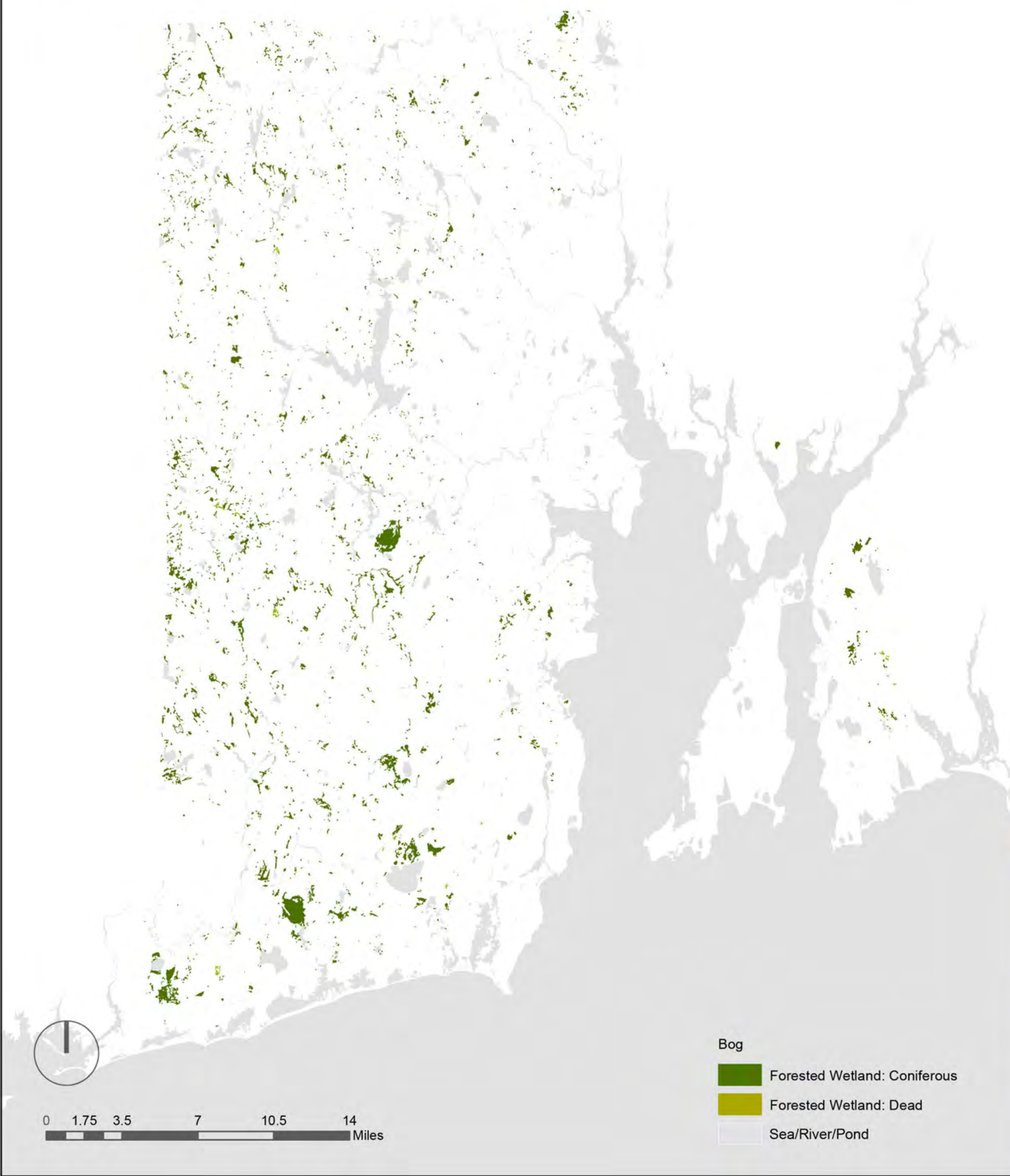
Swamps are fed primarily by surface water inputs and are dominated by trees and shrubs. Swamps occur in either freshwater or saltwater floodplains. They are characterized by very wet soils during the growing season and standing water during certain times of the year.

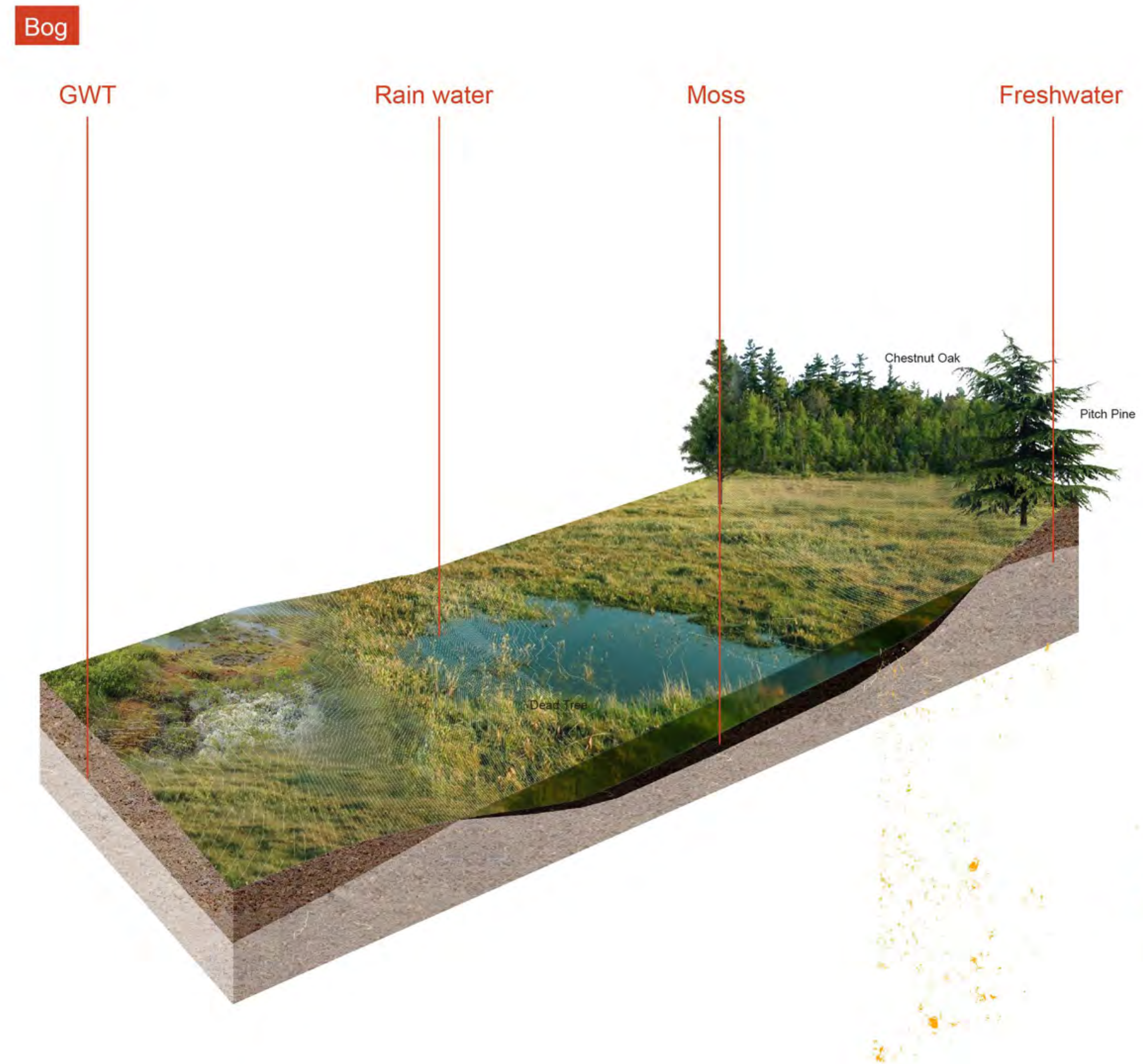


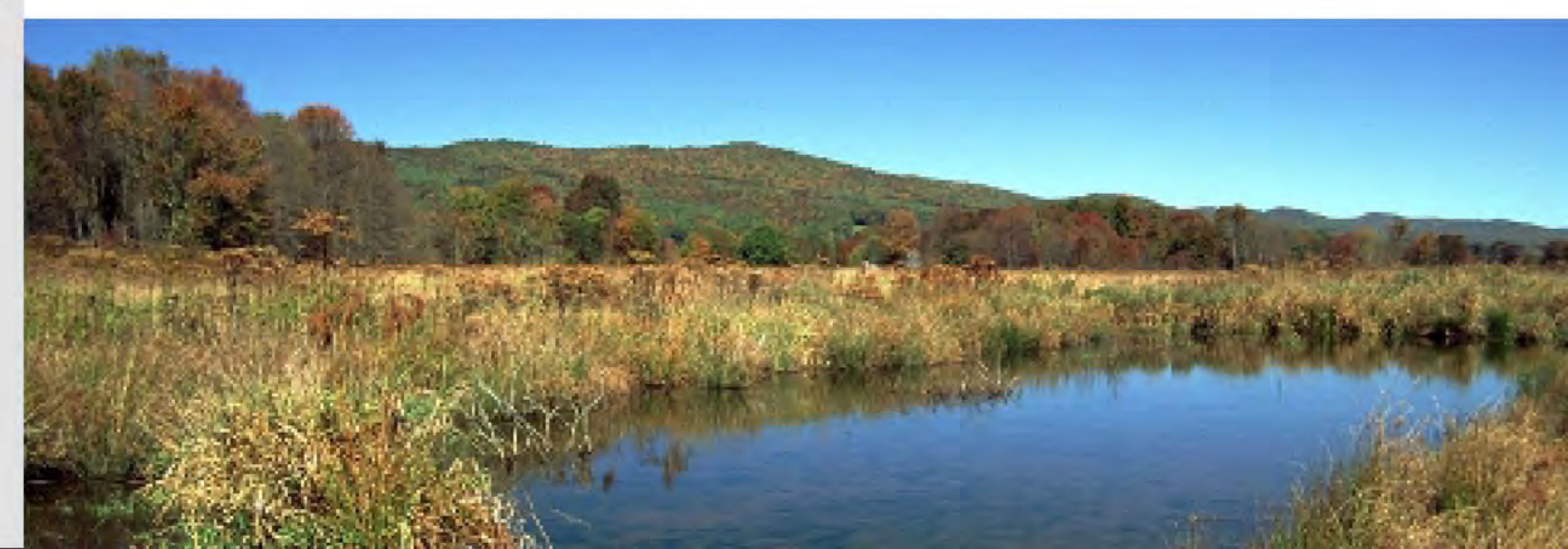
Freshwater Swamp



BOGS are freshwater wetlands characterized by spongy peat deposits, a growth of evergreen trees and shrubs, and a floor covered by a thick carpet of sphagnum moss. These systems, whose only water source is rainwater, are usually found in glaciated areas of the northern United States.

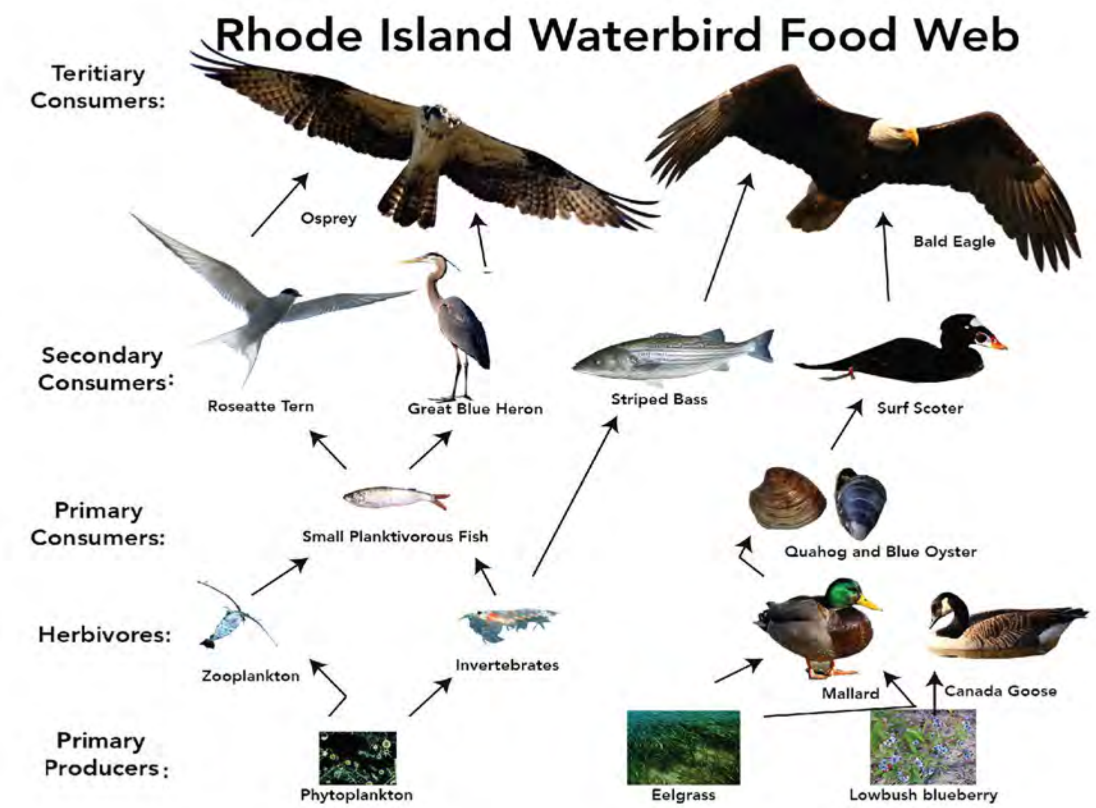


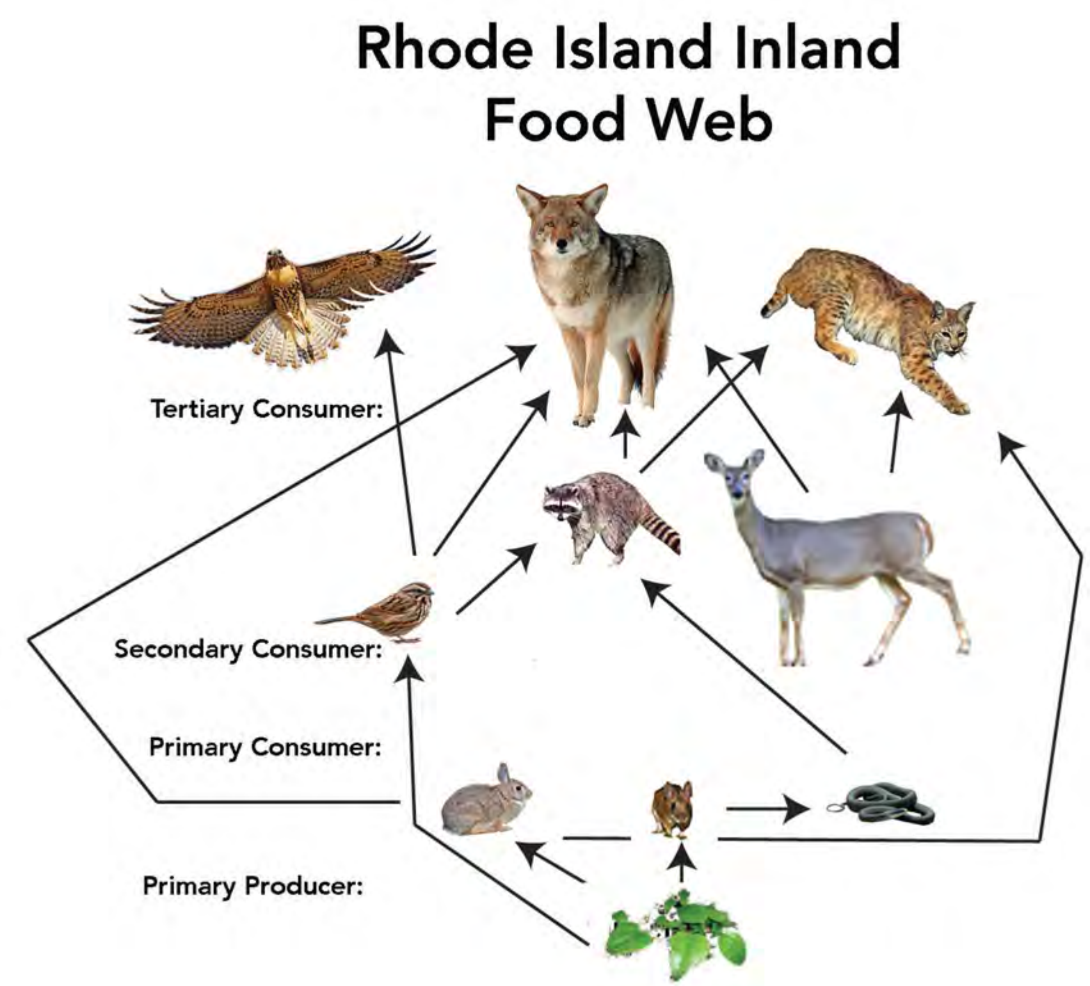




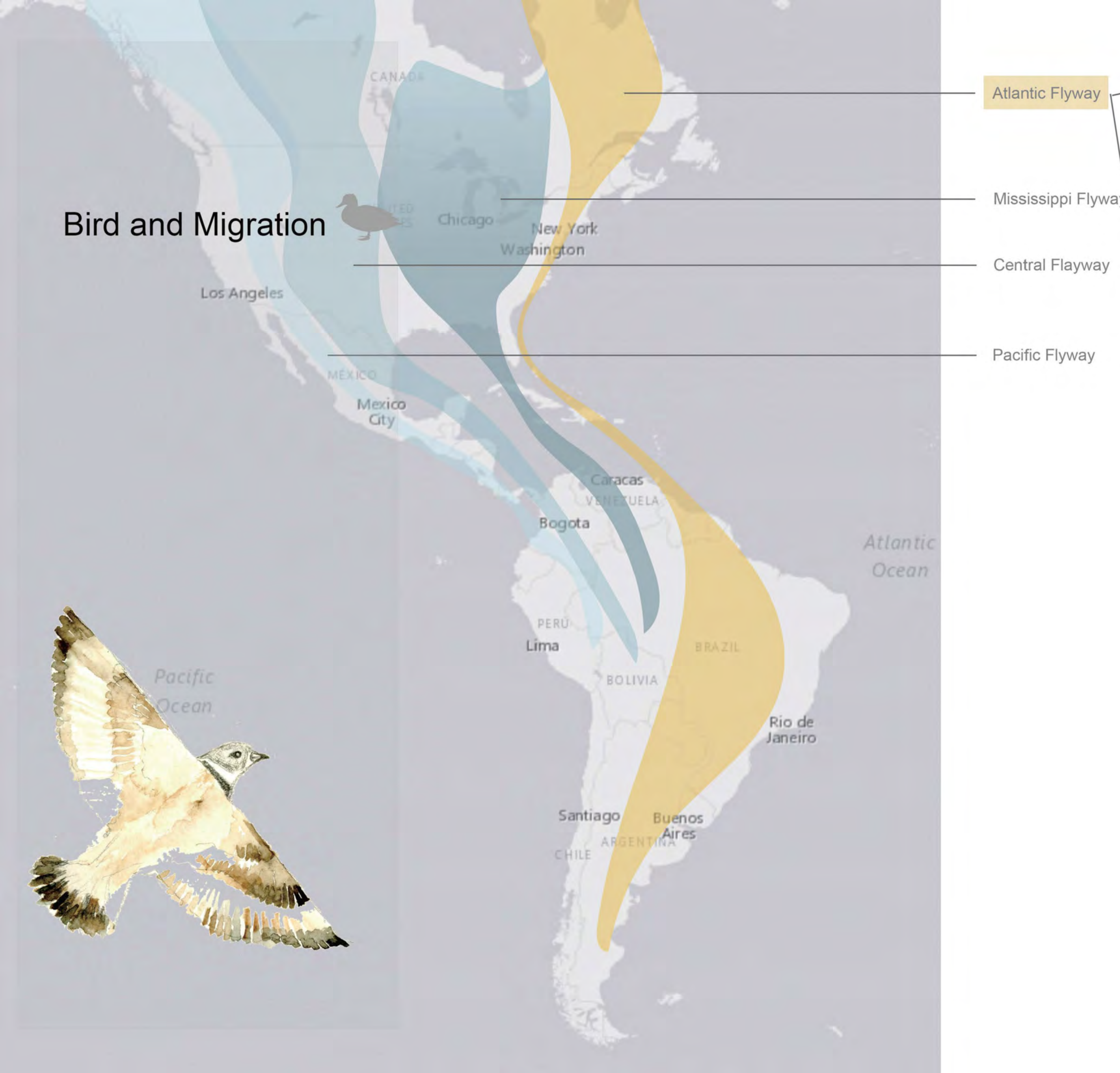
FOOD WEB

The linking of species in an ecosystem based on energy exchange, through consumption of either plant or animal matter, or the absorption of sunlight and nutrients. The food web is important because it determines habitat success, the ability of a habitat to sustain life, beyond the provision of shelter.





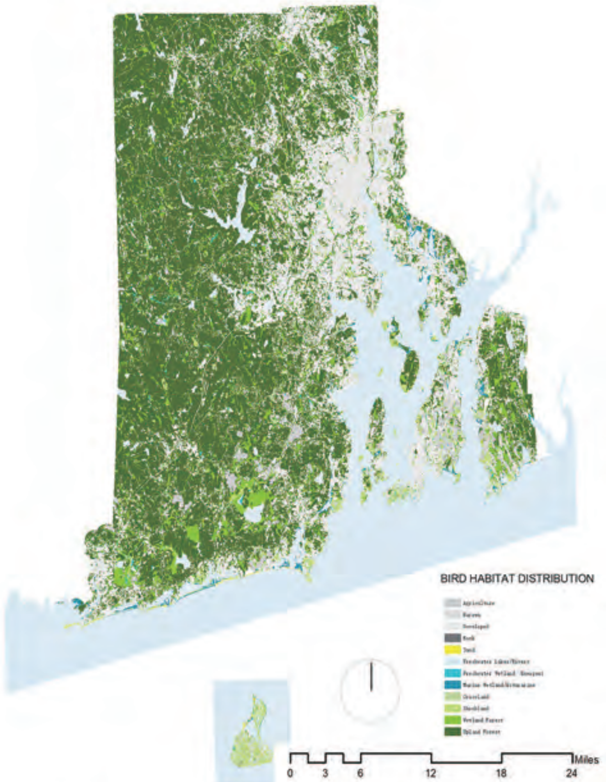
Bird and Migration



There are four (4) major North American flyways that have been named the Atlantic, the Mississippi, the Central and the Pacific Flyways.

Except along the coasts, the flyway boundaries are not always sharply defined and both in the northern breeding, and the southern wintering, grounds there is more or less overlapping.

Rhode Island locates in the Altantic Flyway Area. Many bird Species' migration routes pass the state. Also, there are a huge amout of all-year round bird species in Rhode Island.



Habitat and Birds

Birds need habitat to survive. Exactly what type and how much depends on a species' food preferences, foraging strategies, and nest site requirements.[1]

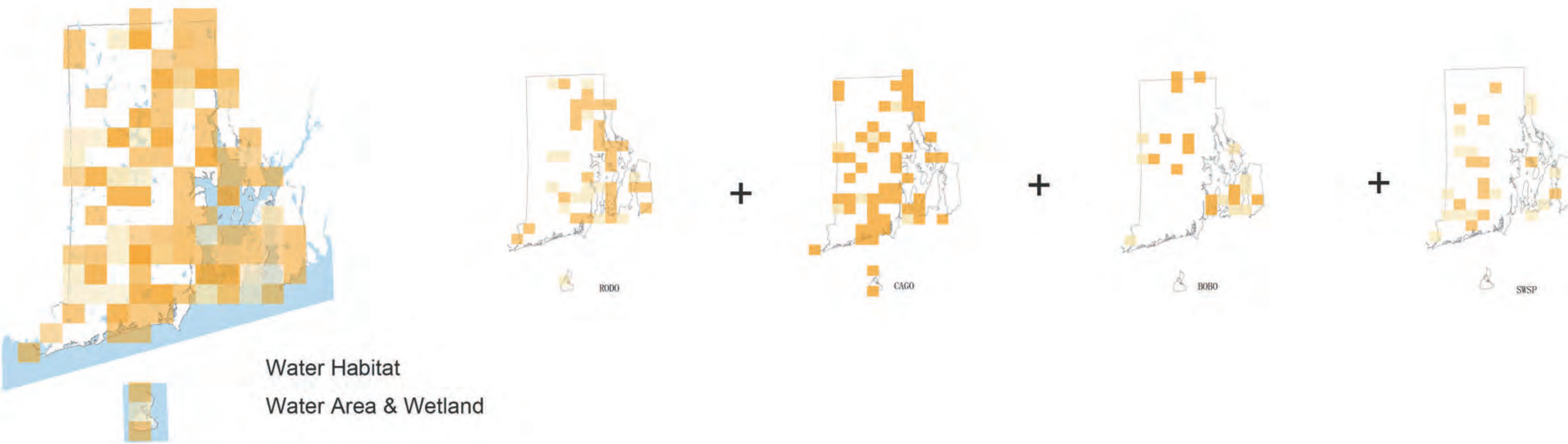
Bird species respond to changes in habitat management scenarios, landscape patterns, and the dynamic ecosystems in which they persist.

Bird populations naturally fluctuate over time in response to changing habitat conditions and other factors present at their breeding, migration and wintering grounds

Most species use more than one habitat type to complete their annual and/or life cycles.

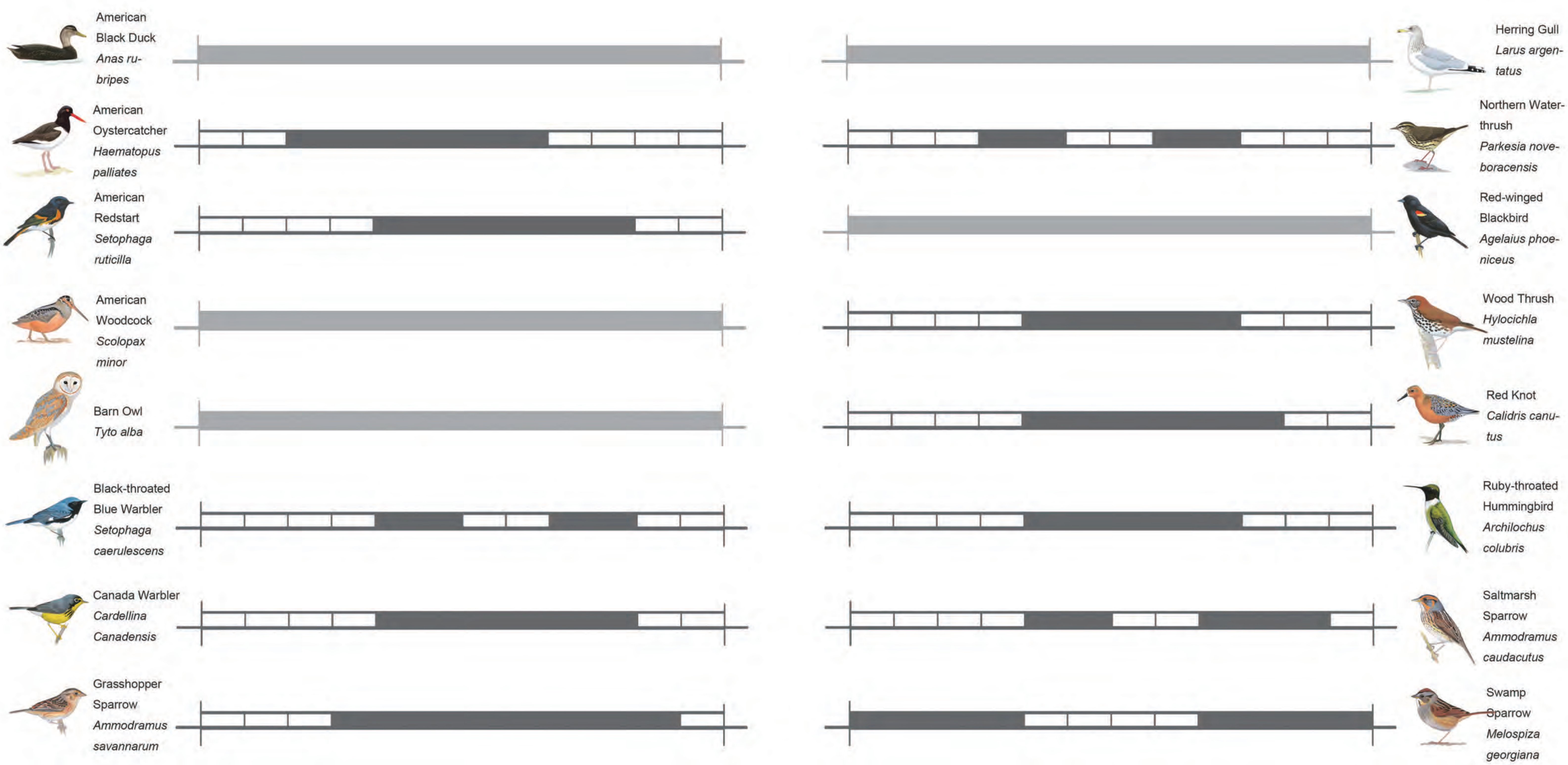
1.http://www.birds.cornell.edu/AllAboutBirds/conservation/habitat/

Land Habitat
Forest & Shrublands



Water Habitat
Water Area & Wetland

Shore Habitat
Bay, Sand & Rock Coast Area



Priority bird species in Providence

Year-round Bird (Light Grey)

In the area of Providence, some species do not migrate.

They are able to find adequate supplies of food throughout the winter.

Migration Bird (Dark Grey)

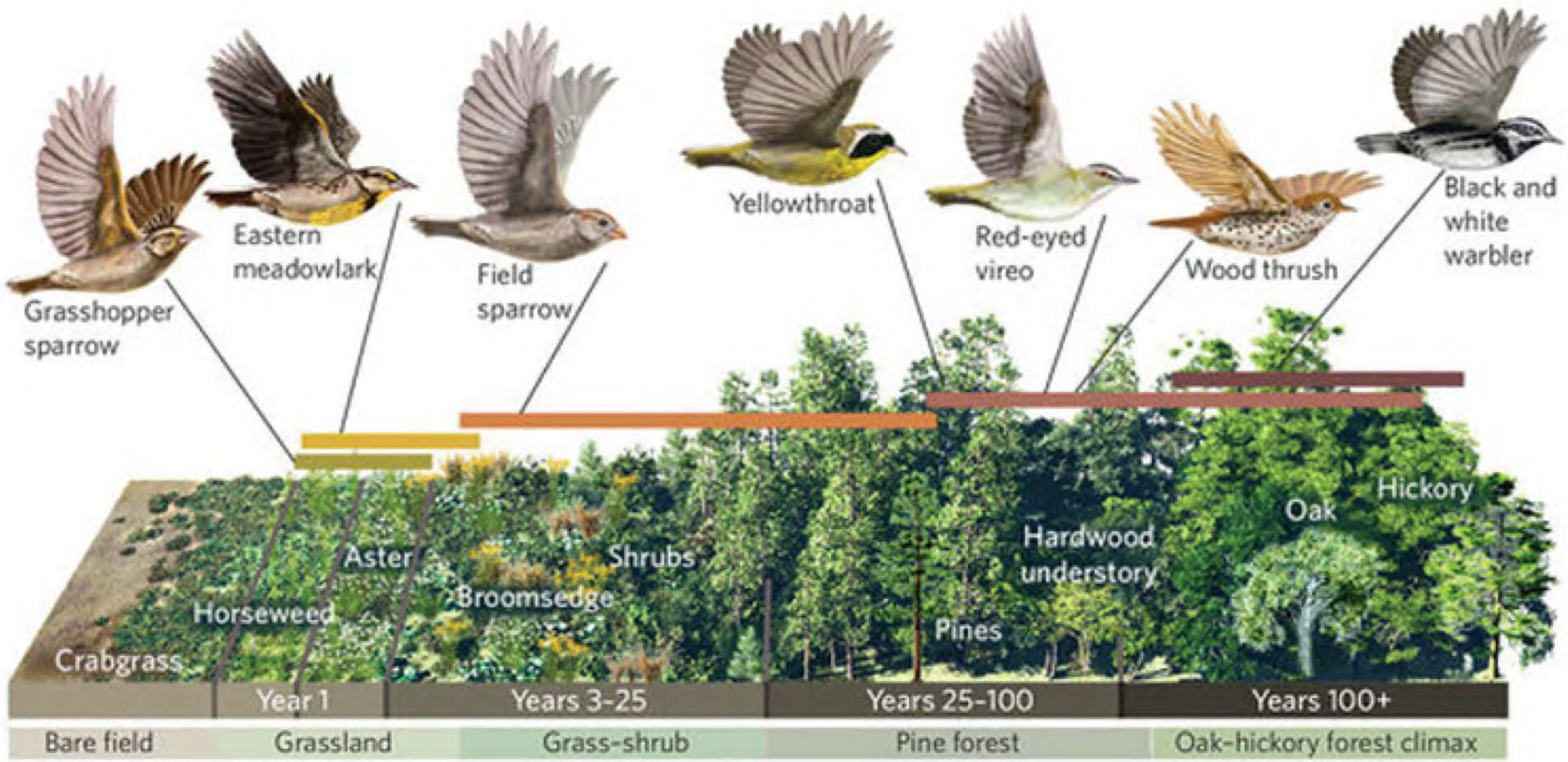
Birds that nest in the northern hemisphere (like in Providence) tend to migrate northward in the spring to take advantage of burgeoning insect populations, budding plants and an abundance of nesting locations. As winter approaches, and the availability of insects and other food resources drops,the birds move south again.

SUCCESSION

These plant and animal communities within these individual topographic classes are apt to change due to the natural processes of ecological succession. This process of evolution alters the resource distribution and habitat availability of biological communities.

PRIMARY SUCCESSION: "occurs in essentially lifeless areas—regions in which the soil is incapable of sustaining life as a result of such factors as lava flows, newly formed sand dunes, or rocks left from a retreating glacier."

SECONDARY SUCCESSION: "occurs in areas where a community that previously existed has been removed; it is typified by smaller-scale disturbances that do not clear the environment of life but only make the environment more heterogenous."



Biodiversity 

Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrerstrial, marine, and aquatic ecosystems and the ecological complex of which they are a part; this includes diversity within species, between species, and of ecosystems."

Why is Biodiversity important?

It important to our well-being, establishes our economy.

Could be the answer to future medical advances.

Provides us with valuable ecosystem services, such as clean water and air.

Allows for adaptation within communities against disturbance.

Allows for an increase in genetic variation, which is important for survival.

—Invasive Species

INVASIVE SPECIES: Invasive alien species - are animals, plants or other organisms introduced by man into places out of their natural range of distribution, where they become established and disperse, generating a negative impact on the local ecosystem and species.

Plants

Widespread and Invasive

Fanwort
Cabomba caroliniana

Asiatic Bittersweet
Celastrus orbiculatus

Autumn Olive
Elaeagnus umbellata

Japanese Honeysuckle
Lonicera japonica

Purple Loosestrife
Lythrum salicaria

Japanese Knotweed
Polygonum cuspidatum

Curly Pondweed
Potamogeton crispus

Restricted and Invasive

Tree of Heaven
Ailanthus altissima

Garlic Mustard
Alliaria petiolata

Porcelain-berry
Ampelopsis brevipedunculata

Wineberry
Rubus phoenicolasius

White Swallowwort
Vincetoxicum rossicum

Agreed are invasive but need more information

norway Maple
Acer platanoides

Japenese Barberry
Berberis thunbergii

Burning Bush
Euonymus alatus

Morrow and Bella Honeysuckle
Lonicera morrowii and Lonicera x Bella

Animals

Mute Swan
Cygnus olor

Asian clam
Corbicula fluminea

– Endangered Species

ENDANGERED SPECIES: The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Plants

Sandplain gerardia
Agalinis acuta

Small Whorled pogonia
Isotria medeoloides

Swamp Cottonwood
Populus heterophylla

Canadian Burnet
Sanguisorba canadensis

Purple Clematis
Clematis occidentalis

Animals

Piping Plover
Charadrius melodus

Green sea turtle
Chelonia mydas

Leatherback sea turtle
Dermochelys coriacea

Shortnose sturgeon
Acipenser brevirostrum

Roseate tern
Sterna dougallii dougallii

Finback whale
Balaenoptera physalus

Humpback whale
Megaptera novaeangliae

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CLIMATE:

from Greek *klima*, inclination

the composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine,cloudiness, and winds, throughout the year, averaged over a series of years.

Brianna Cato
Jil Sanchez
Yuan Zhang

Overview

The main determinant of our planet's climate is its distance from the sun. As the Earth orbits around the sun, the axial tilt of its rotation changes, creating the seasons. From December to March the Northern Hemisphere is tilted away from the sun, causing winter in the Northern and summer in the Southern Hemisphere. This tilt inverts every six months: when the North is tilted towards the sun during northern summer, it is winter in the South.

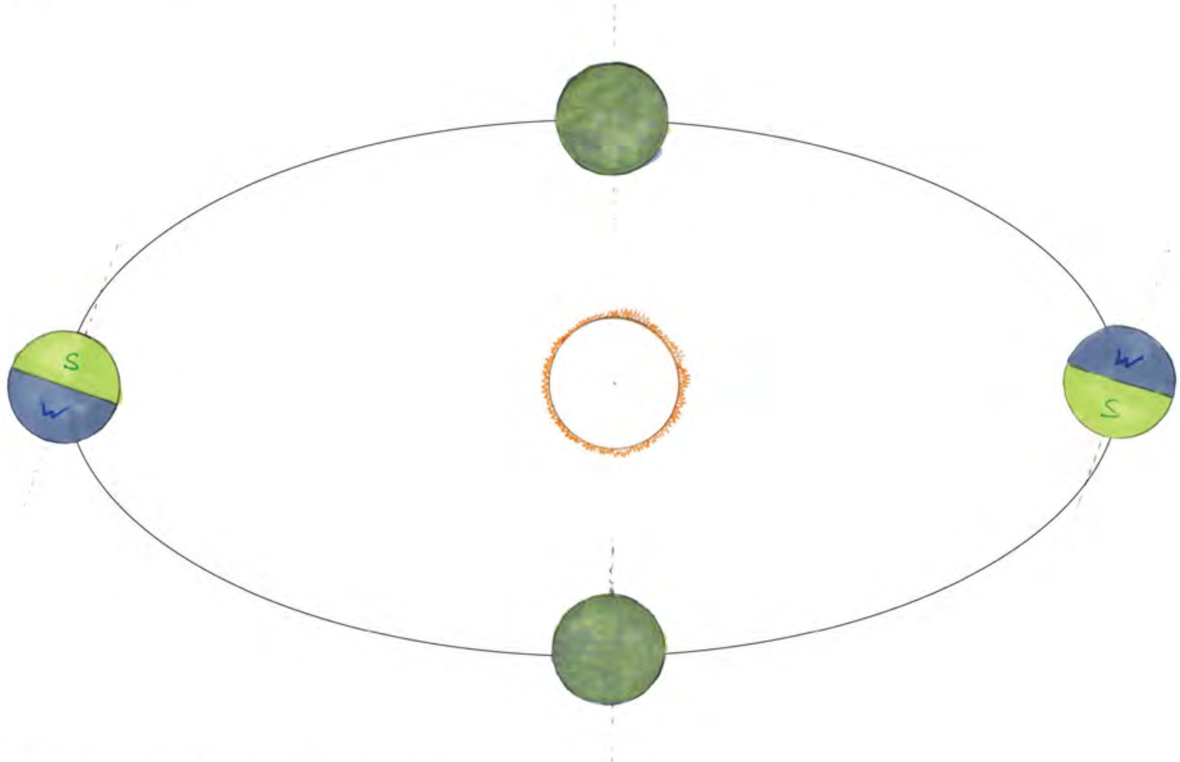
Since the Earth is round, latitude and longitude of a given place will affect its climate. As one moves from the equator towards the poles, the climate continues to become colder. Climates on Earth range from equatorial (hot and humid), subtropical (warm and seasonal), and temperate (cooler and seasonal) to polar (cold and dry).

LATITUDE : The angular distance north or south from the equator of a point on the earth's surface, measured on the meridian of the point.

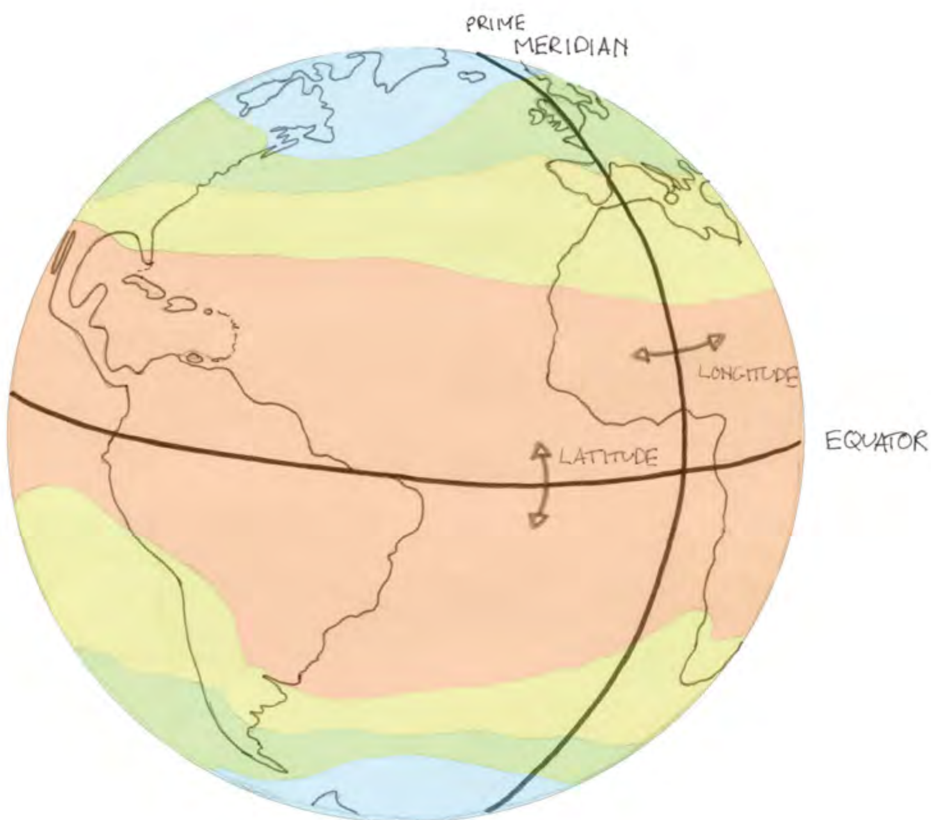
LONGITUDE: The angular distance east or west on the earth's surface, measured by the angle contained between the meridian of a particular place and some prime meridian, as that of Greenwich, England, and expressed either in degrees or by some corresponding difference in time.

Additionally, climate is governed by a planet's proportion of land to ocean, atmospheric composition, ocean currents, and vegetation. These last two factors together with altitude and distance from the ocean also play a role in determing a specific area's climate.

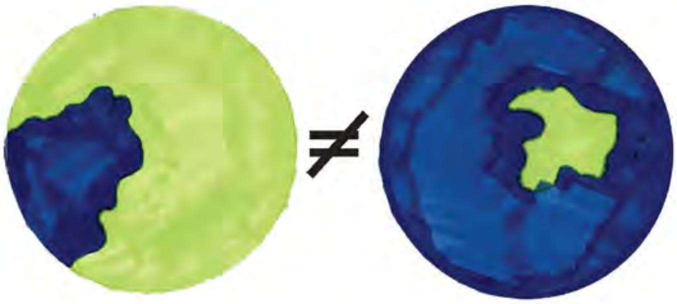
Global Climate

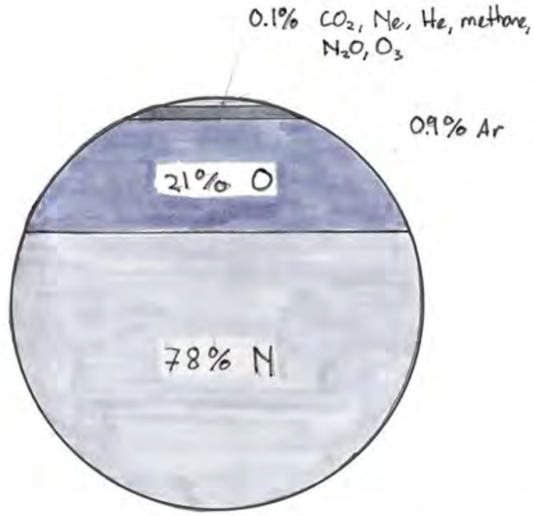


INCLINATION : Earth's changing inclination causes the seasons



LATITUDE AND LONGITUDE: create climate zones



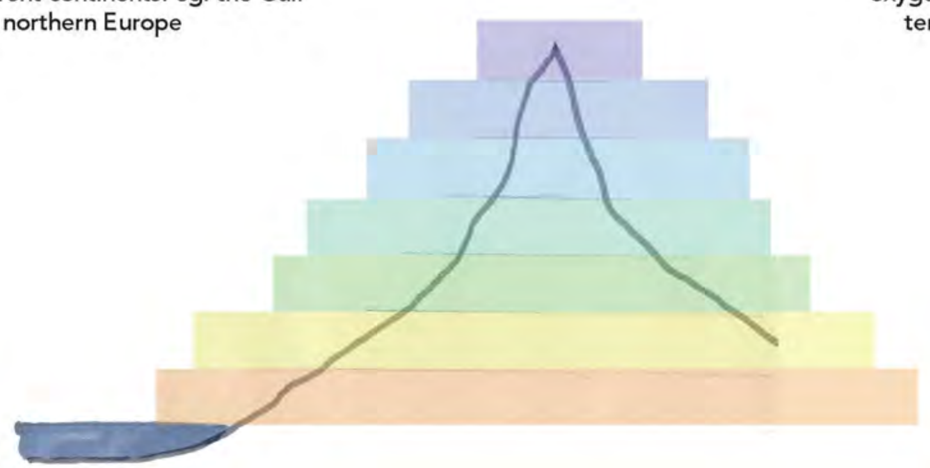


PROPORTION OF LAND TO OCEAN:
affects amount of reflected solar radiation

COMPOSITION OF ATMOSPHERE:
amount of green house gasses affects temperature

OCEAN CURRENTS:
movement of warm and cool streams affect climates on different continents. eg: the Gulf Stream warming northern Europe

VEGETATION:
converts carbon dioxide to oxygen, playing a role in regulating temperature; evapotranspiration affects air humidity

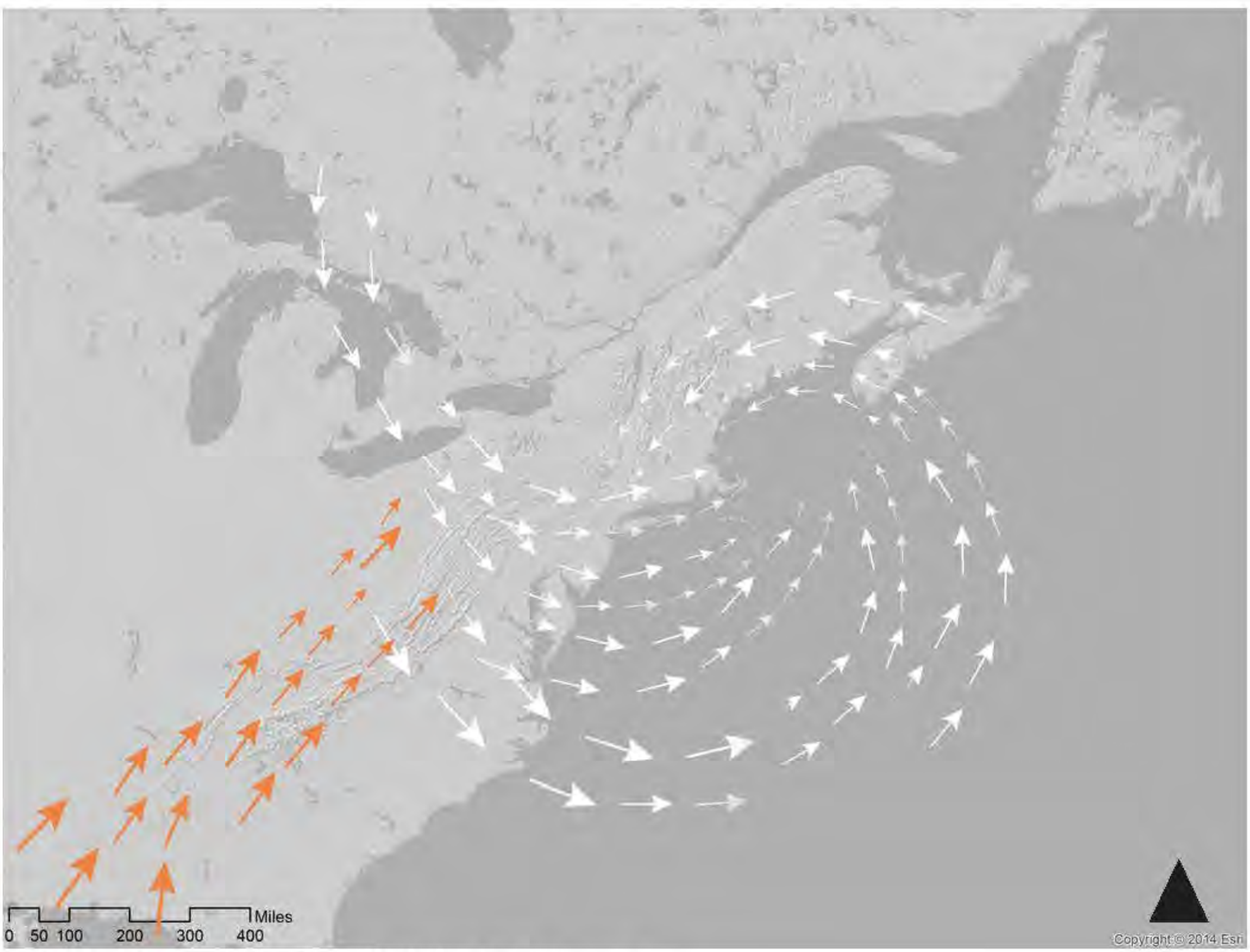


ELEVATION: temperature decreases between 5 and 10 °C every kilometer of altitude

New England Climate

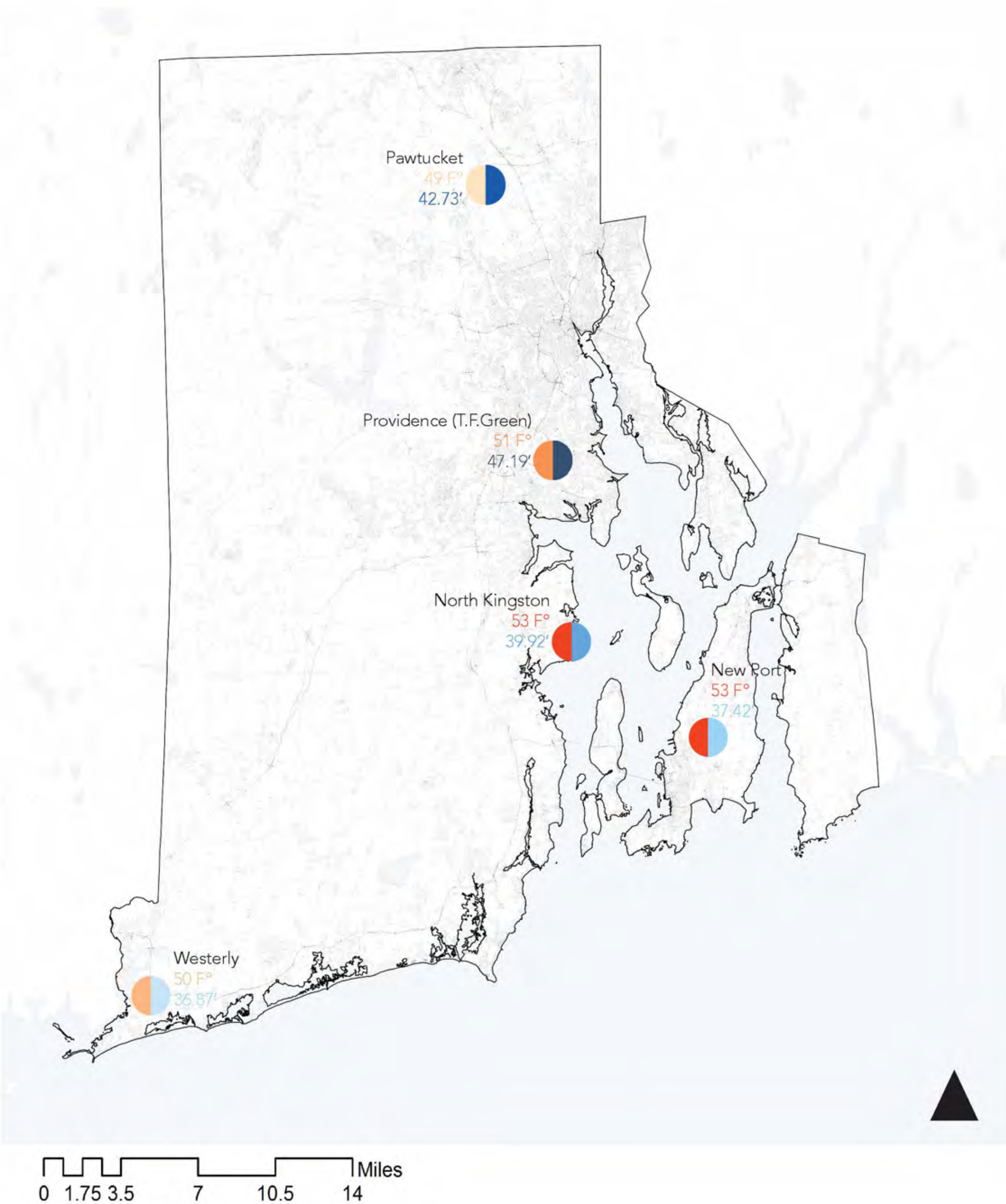
New England has multiple climates which differ according to location, altitude, and distance from the coast. Northern and Western New England is characterized by highlands and mountains, with climates between humid-continental and alpine. Here, winters are long and cold with short warm summers and precipitations spread throughout the year. Low lying coastal areas tend to be hotter than inland areas in the summer, and generally receive less snow in winter. However, these places are more exposed to strong coastal winter winds than the hilly hinterlands.

A common type of storm affecting the area during the winter months is the nor'easter, when winds blow from the north-east and rotate along the coast. In summer, the dominant winds come from the south-west.

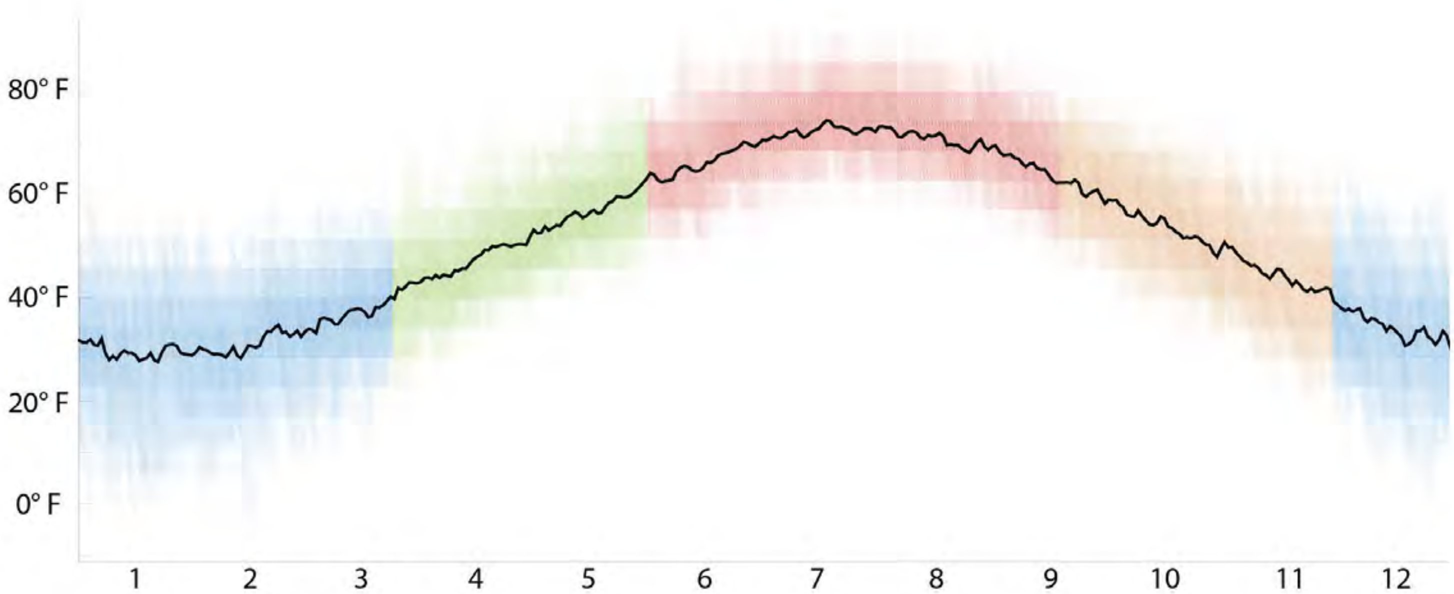


NOREASTERS (white) AND SOUTHWESTERS (orange)

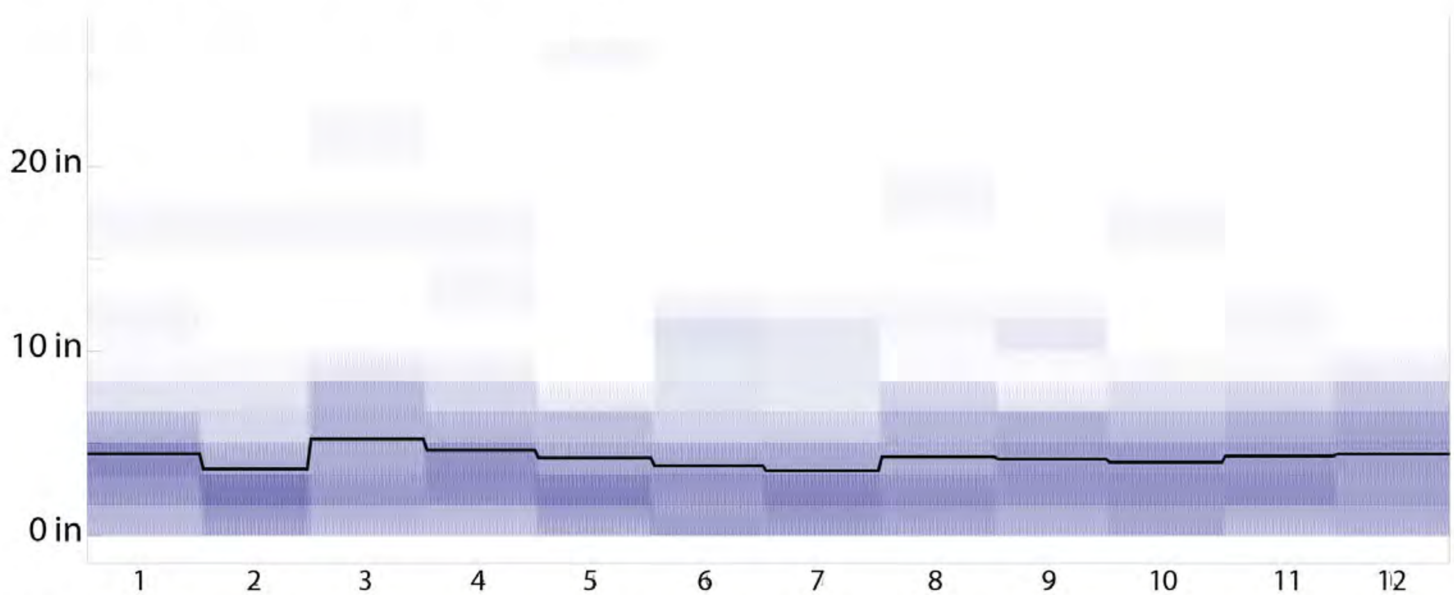
Rhode Island and Narragansett Bay Climate



ANNUAL AVERAGE TEMPERATURE AND TOTAL PRECIPITATION IN 2014

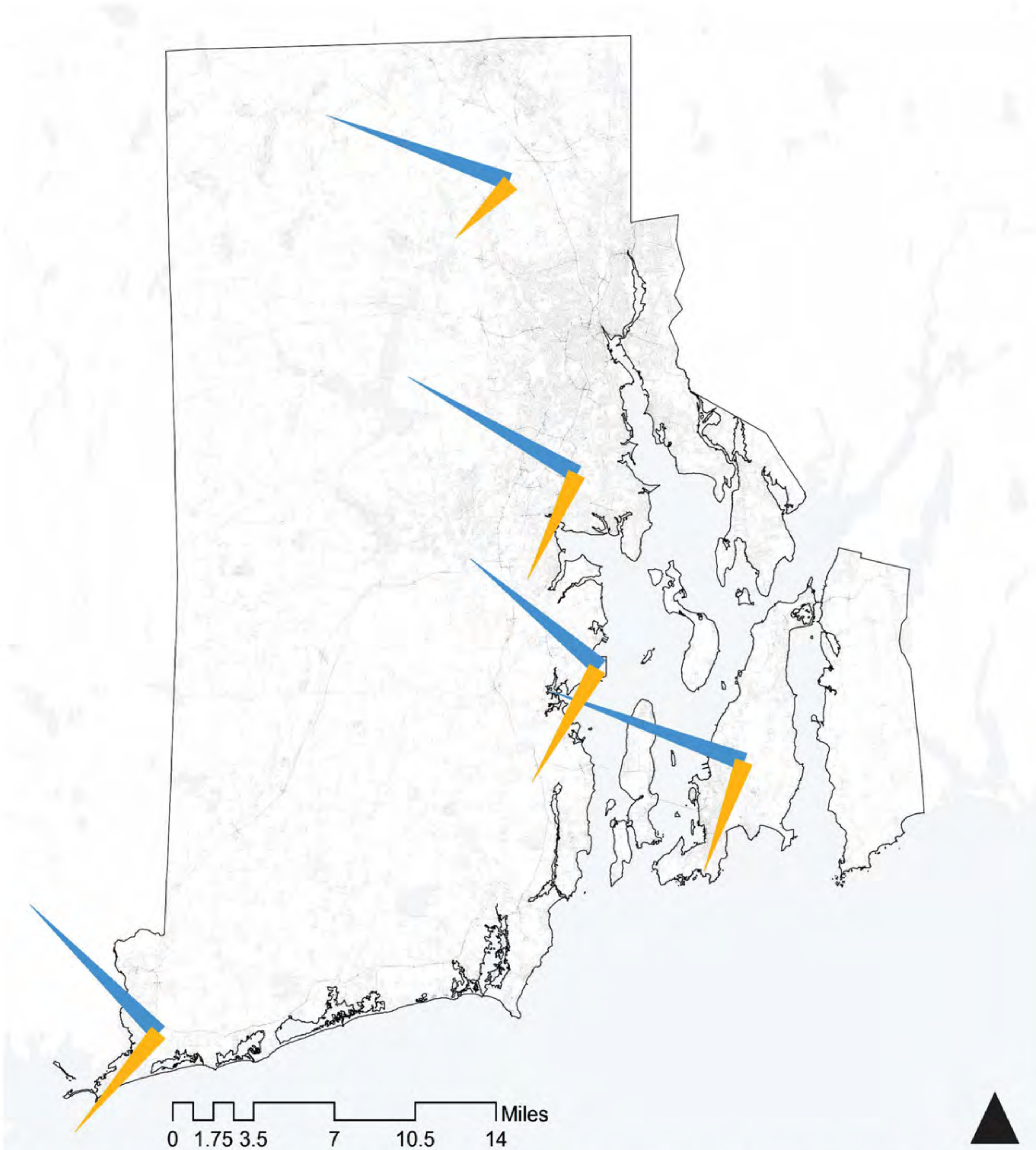


TEMPERATURE OF RHODE ISLAND 1942-2015

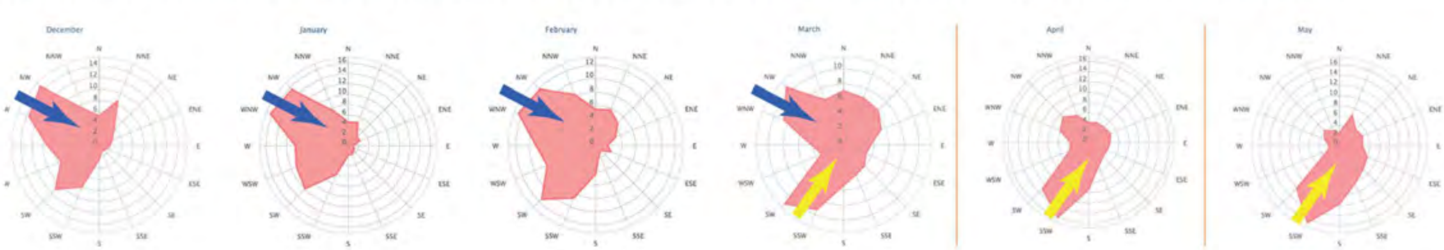


PRECIPITATIONS IN RHODE ISLAND 1973-2015

Rhode Island has four distinct seasons, with warm summers and cold winters. Precipitations are spread year round as for the rest of New England, ranging from rain in the spring, summer, and fall to snow and sleet in the winter.



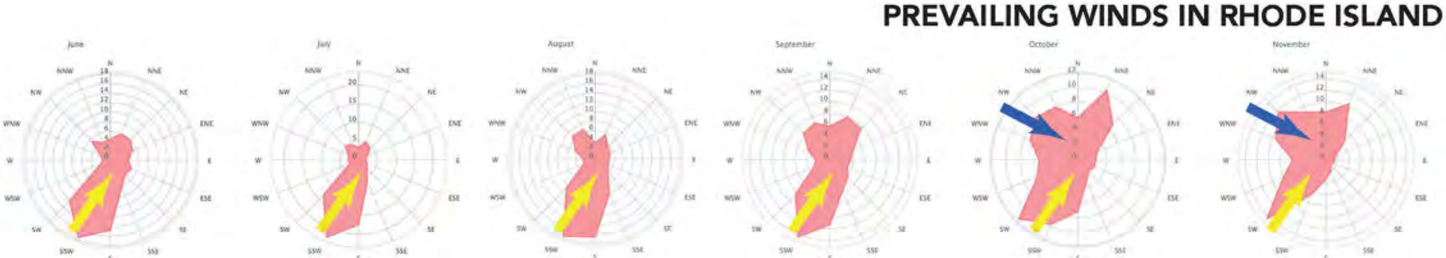
AVERAGE WIND DIRECTION AND RELATIVE SPEED IN FEBRUARY (BLUE) AND JULY (ORANGE)



NARRAGANSETT BAY WIND TUNNEL EFFECT

Not all parts of the New England coast are affected equally by coastal winds, since they are not equally exposed. Long Island acts as a barrier to the Connecticut coast, while Martha's Vineyard and Cape Cod protect southern Massachusett's coast. Narragansett Bay, on the other hand, is left fully exposed to winds blowing from the Altantic. The Bay acts as a wind tunnel, funnelling winds northward to Providence.

PREVAILING WINDS IN RHODE ISLAND

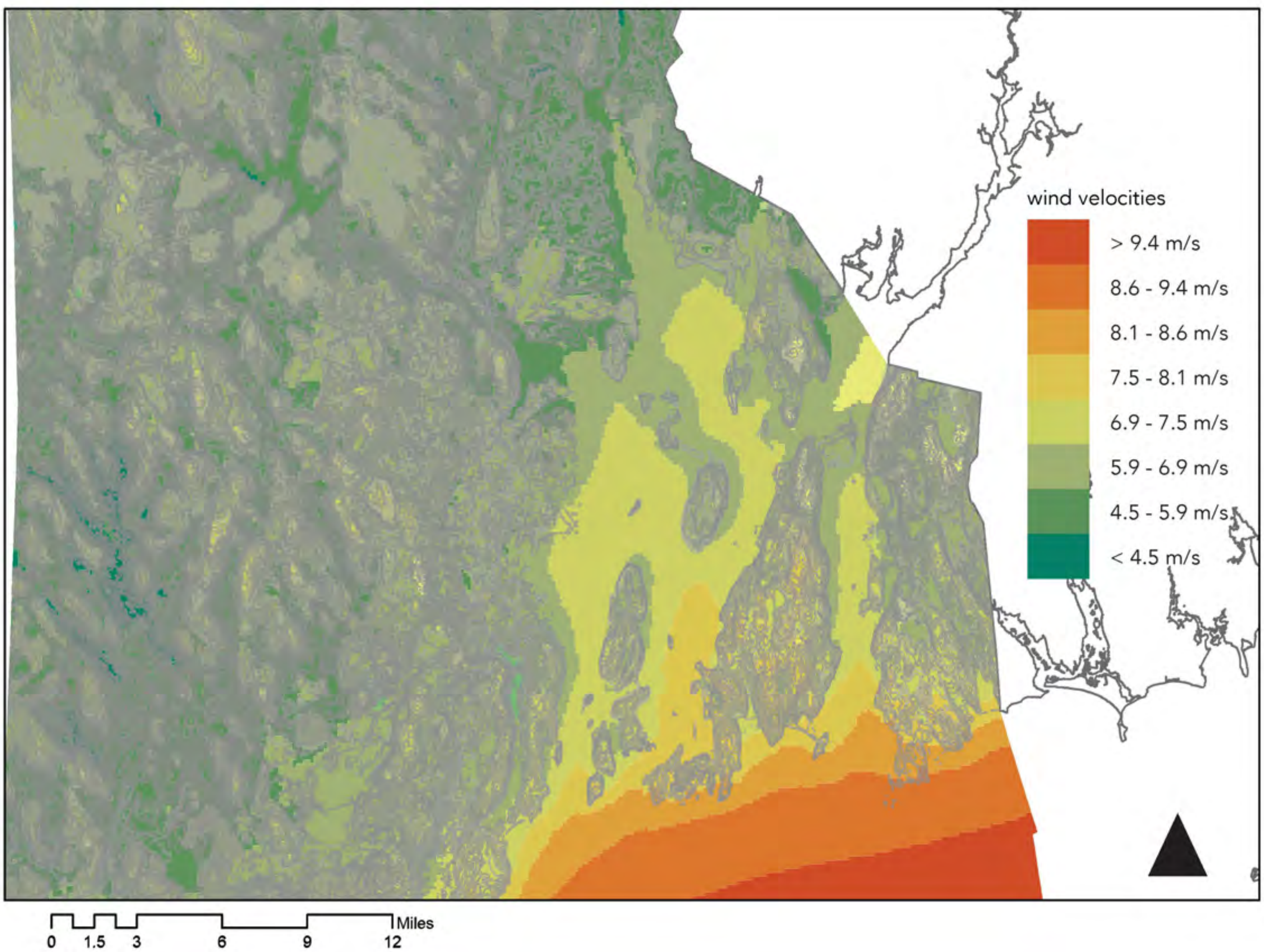


Microclimates

MICROCLIMATE : the climate of a small area, as of confined spaces such as caves orhouses (cryptoclimate) of plant communities, wooded areas, etc.(phytoclimate) or of urban communities, which may be different from that in the general region.

Microclimates occur in many places at many scales around Narragansett Bay, ranging from an island's leeward wind shadow to the conditions under a single rock. They are nested and combined, cumulatively yielding the Bay's general climate.

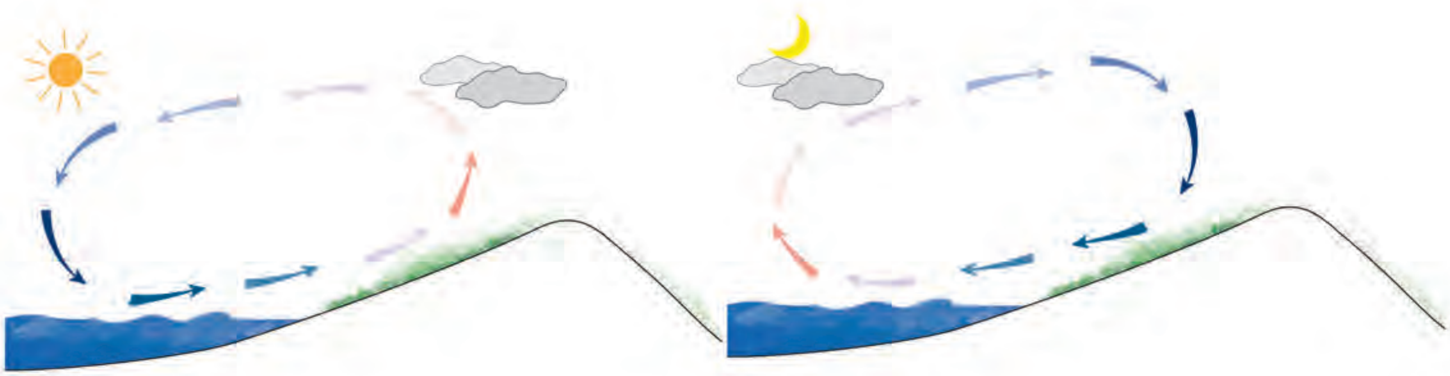
Humans also have a hand in shaping microclimates. For example, areas with a greater amont of impervious surfaces will reflect a higher proportion of solar radiation, creating the urban heat island effect. Additionally, individual buildings can cause microclimates.



NARRAGANSETT BAY WIND SHADOWS

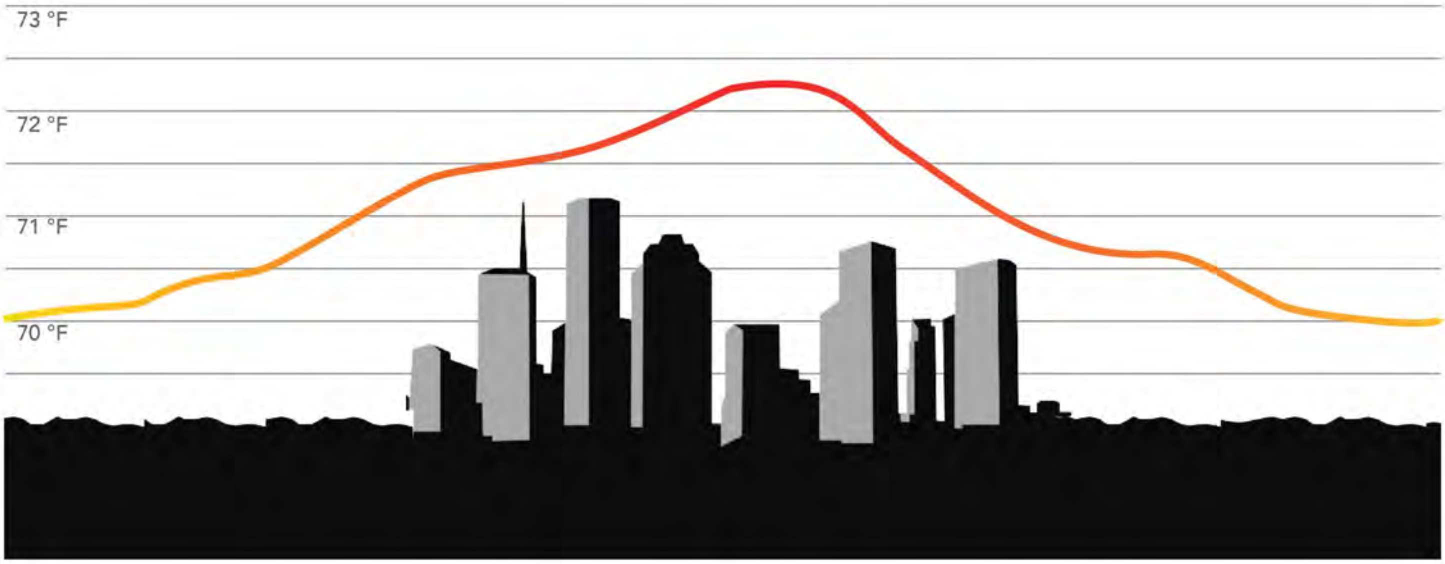
TOPOGRAPHY

In the daytime, wind blows from valley to the hill, because the hill receives more sunlight and is warmer than the valley. In another word, the air in the valley is cooler and has higher pressure than that on the hill. In the night time, the wind blows from the hill to the valley due to a similar reason. Sometimes the cold air moving to warmer area will create clouds and rainfall.

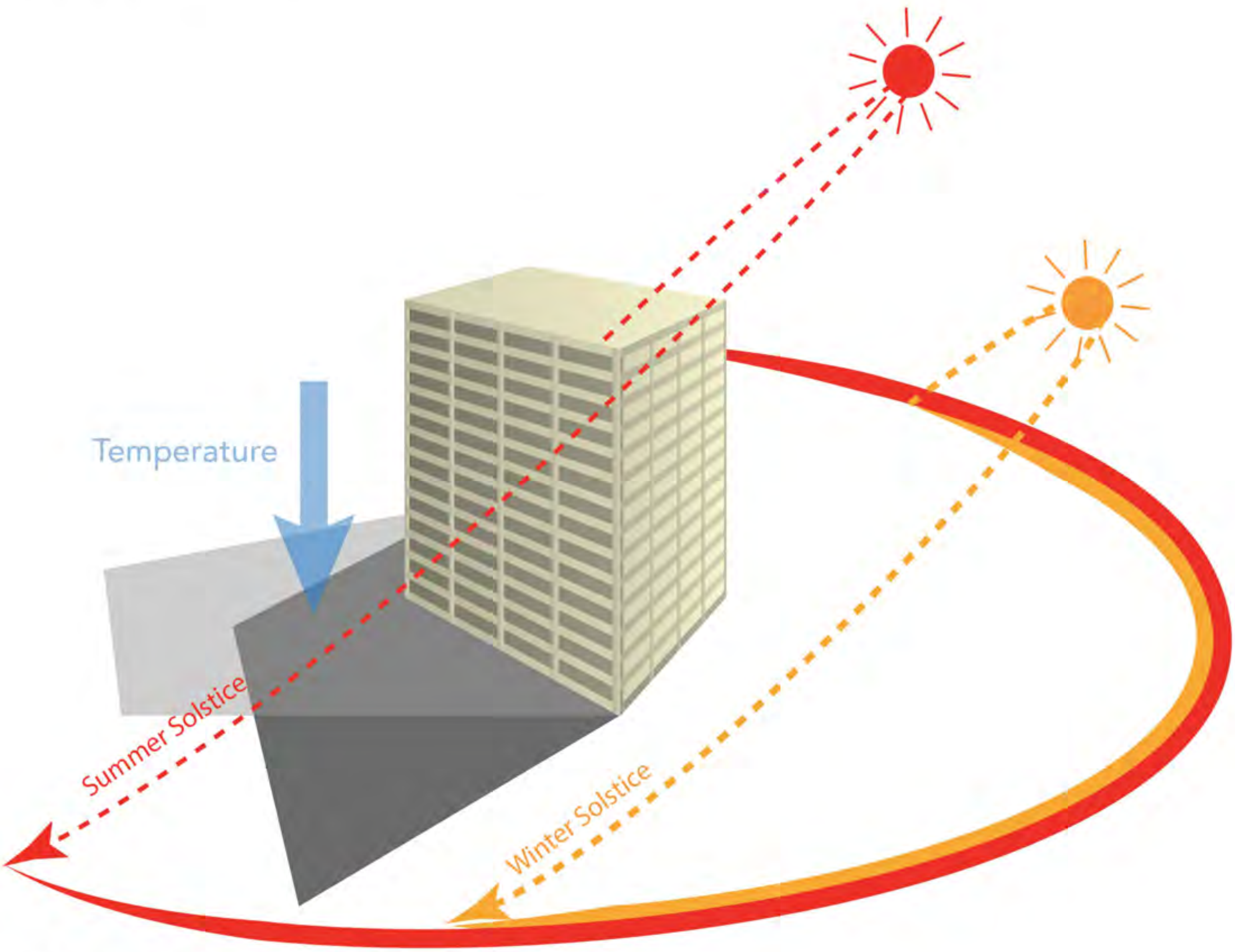


OCEAN

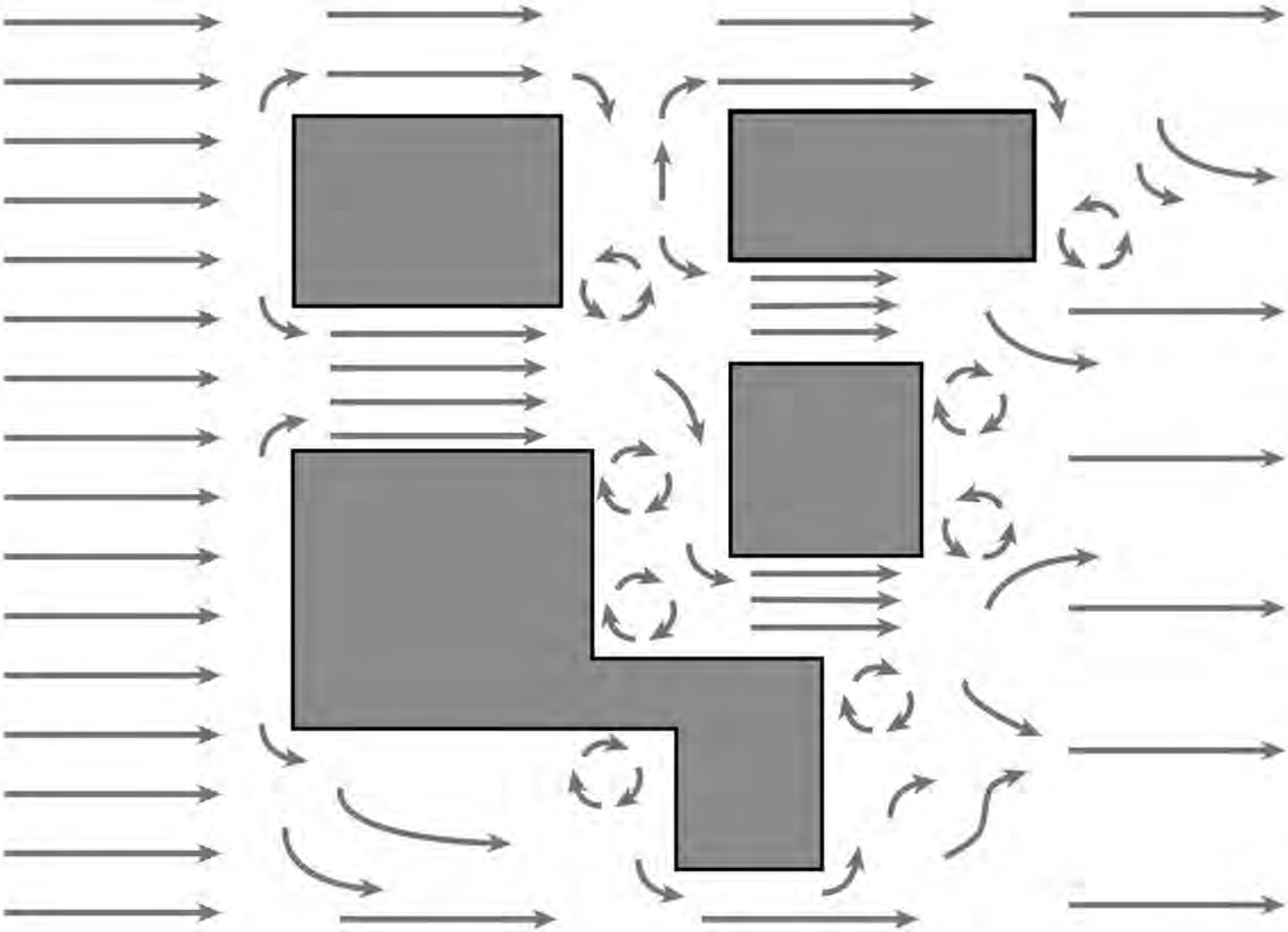
In the daytime, wind blows from the ocean to the land, because the land is better at absorbing heat and thus warmer than the ocean. In the night time, the wind blows from the land to the ocean due to that the land is also worse at keeping the heat from going and thus cooler.



URBAN HEAT ISLAND



BUILDING SHADE



VORTICES AND WIND TUNNELS

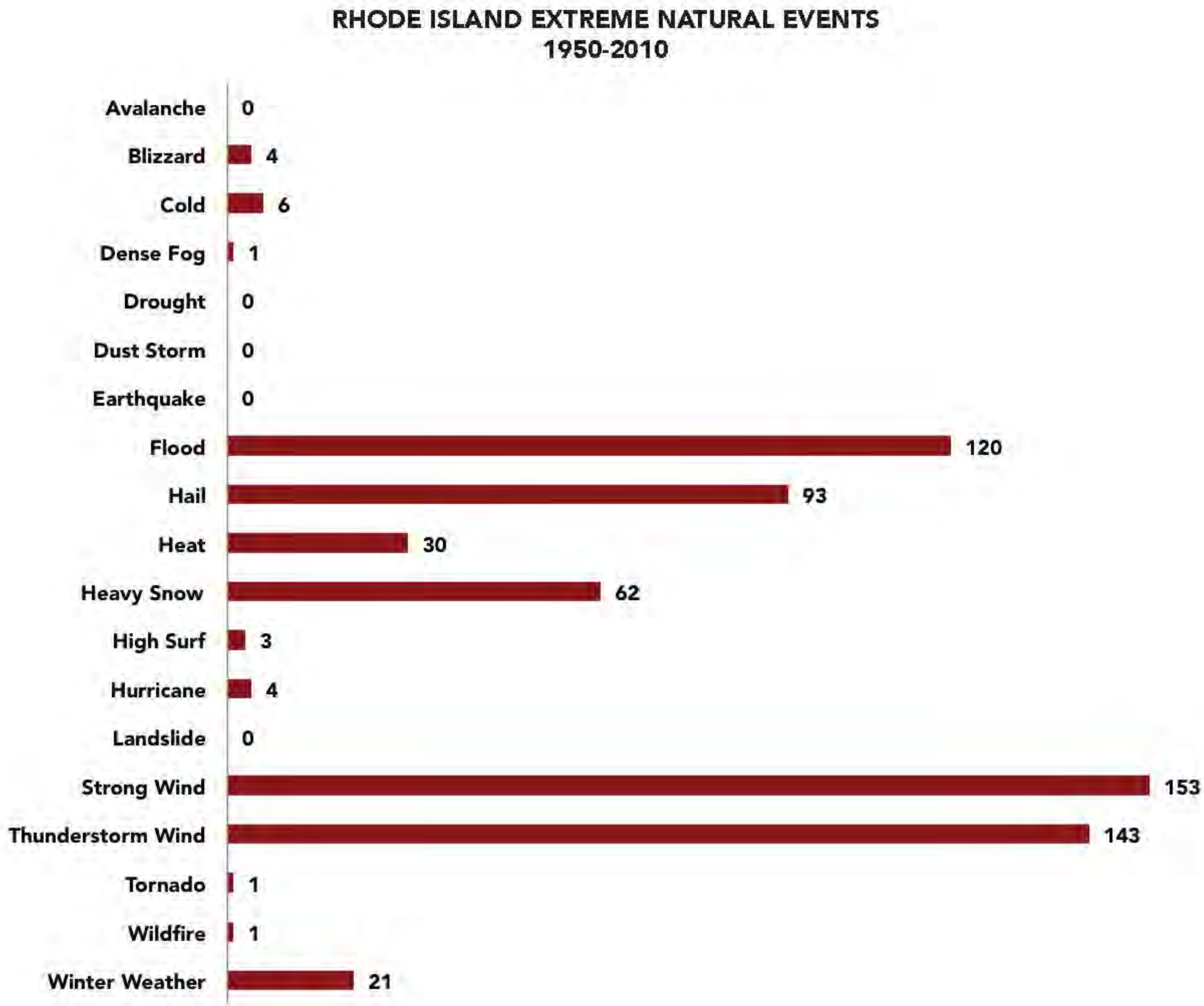
Due to impervious surfaces, reflective building materials, and heavy traffi, urban areas are usually warmer than suburban and rural areas.

At different time of a year, the sun angle is different and the size of the shade cast by a building is different too. Note that it is always cooler in the shade.

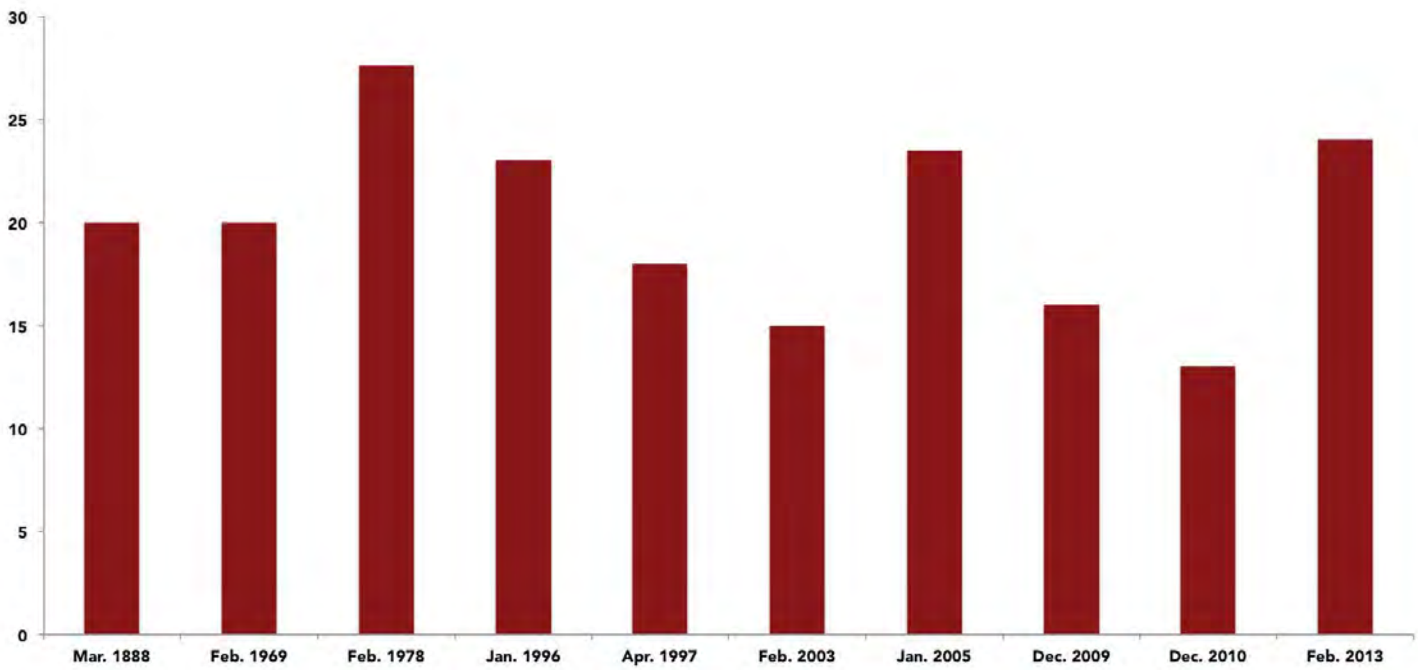
Wind tunnels and vortices are very common phenomena in urban areas. When the wind speed is too high it could cause danger to pedestrians and cars moving through dense building areas.

Extreme Weather

Compared to other states, Rhode Island has a rather calm existence. Its most frequently occurring extreme natural events tend to be weather-related rather than geological disasters. Most of these occur during winter, when strong winds sweeping through Narragansett Bay from the north-east combine with low temperatures, leading to heavy ice and snow accumulation.



EXTREME WINTER STORMS SNOW ACCUMULATION (INCHES)



HIGH SNOWS: though usually inconvenient, snow banks sometimes offer opportunities for play

Hurricane Timeline

1804 - Snow Hurricane

1806 - Great Coastal Hurricane

1815 - The Great September Gale

1938 - New England Hurricane

The New England Hurricane caused unprecedented damage in Providence, flooding the city's downtown and causing $120 million of damage.

1999 - Hurricane Floyd

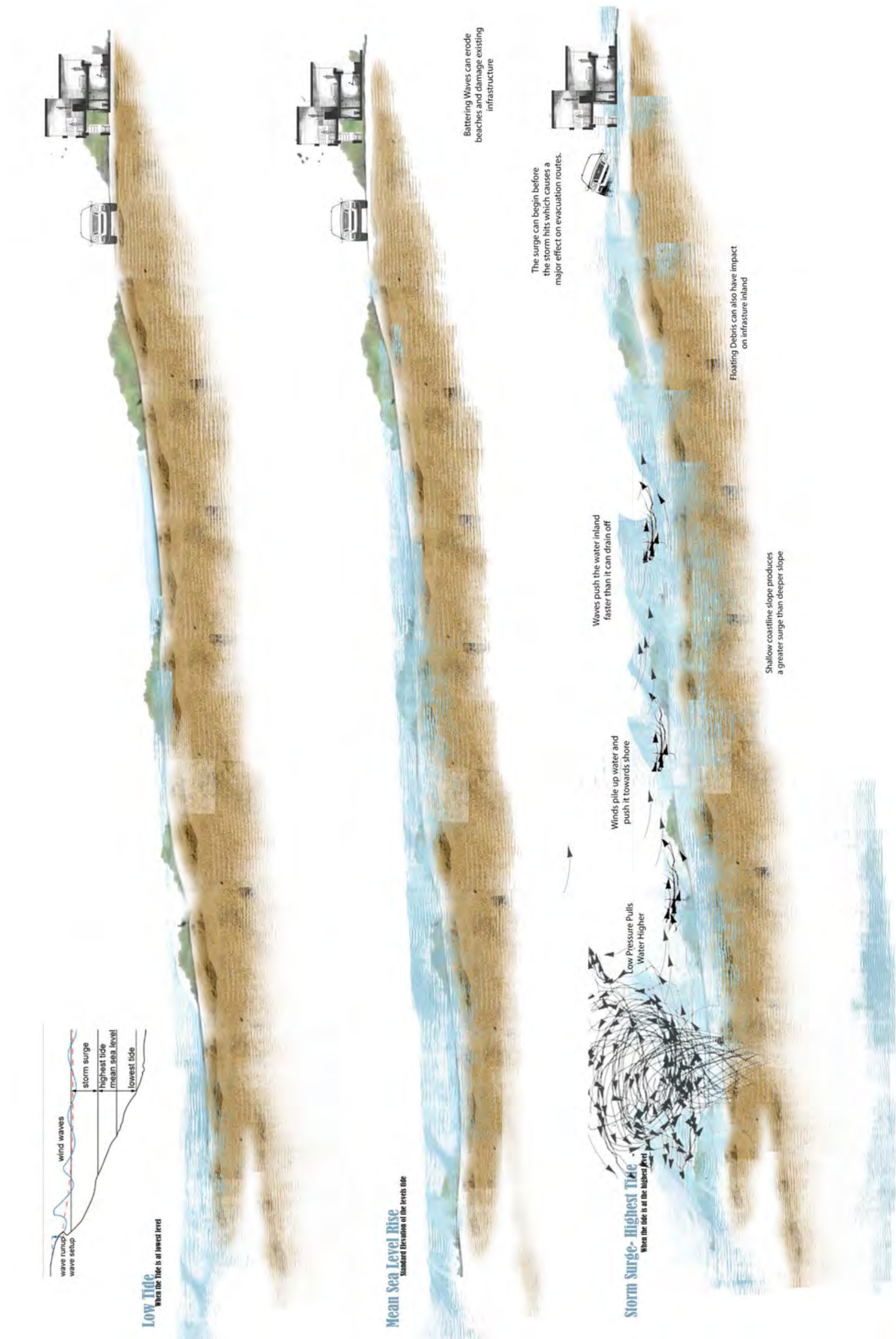
2012 - Hurricane Sandy

1954 - Hurricane Carol

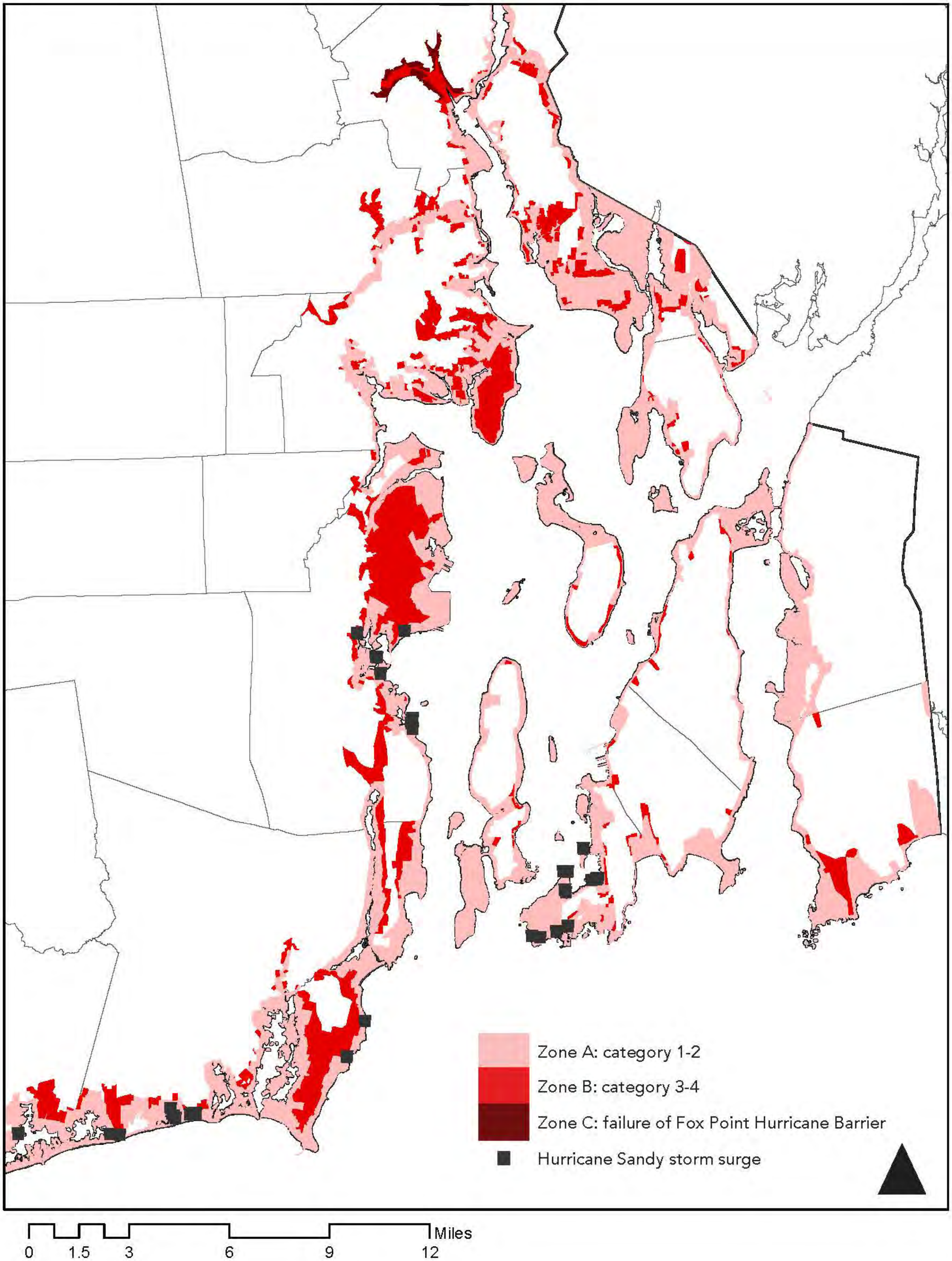
2011 - Hurricane Irene

After Hurricane Carol struck Providence costing $41 million in damage, the city decided to build the Fox Point Hurricane Barrier to protect the Providence River's banks from strom surges.

2010 - Hurricane Earl



STORM SURGES: storms can cause more damage when they hit at high tide



NARRAGANSETT BAY HURRICANE EVACUATION MAP

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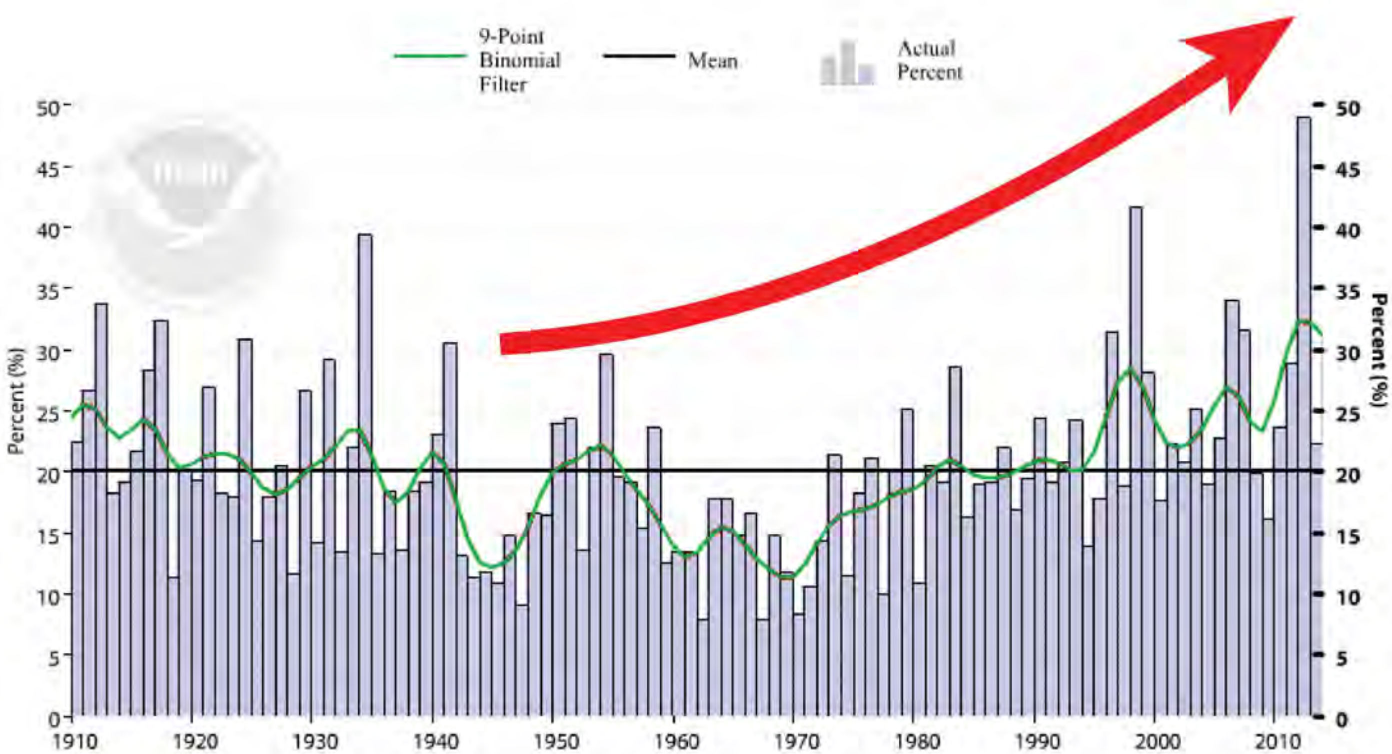
Climate Change

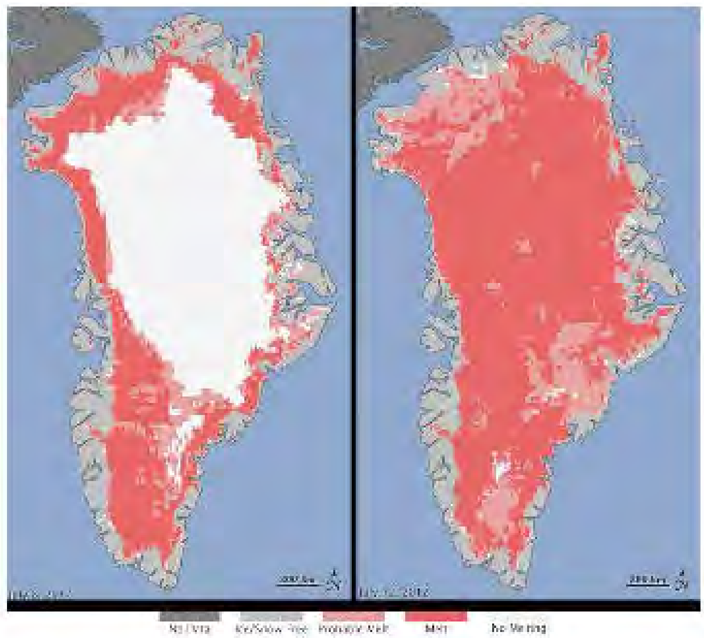
It is common knowledge that the Earth's climate is warming. This has strong effects on various meteorological phenomena, which affect humans, animals, and plants on many scales.

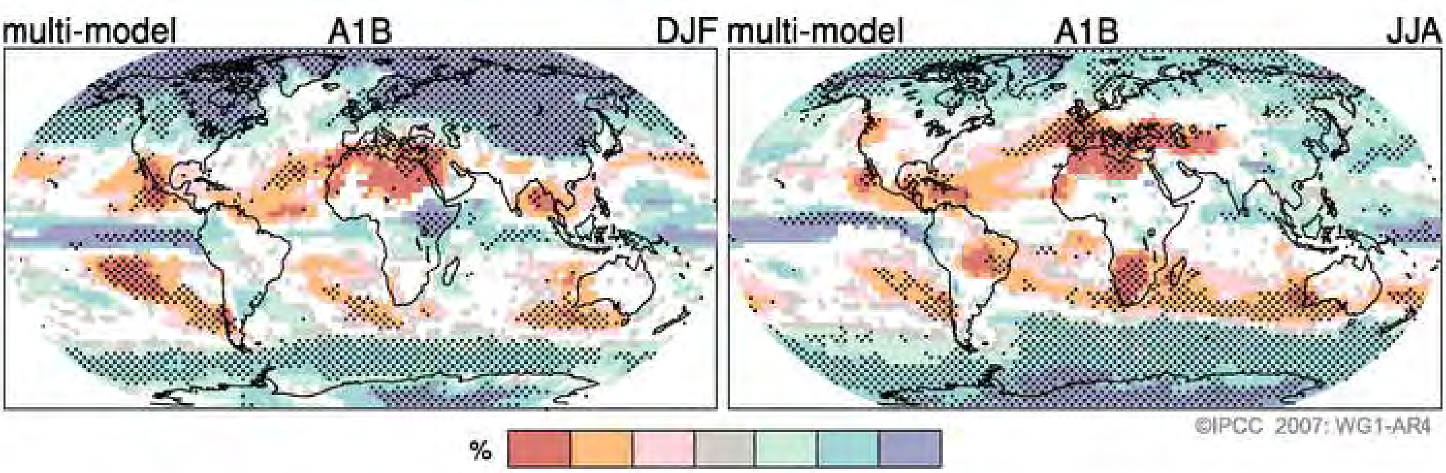
The recent increase in extreme weather events hints at the fact that the future's climate will feature more dramatic storms and hurricanes. However, this does not mean that the planet will become more humid: many areas will be faced with increasingly severe drought, perhaps leading to famine. Generally, regions near the equator are projected to become drier, while regions approaching the poles are expected to receive more precipitation than in the past.

Rising temperatures and ever stronger heatwaves are causing the polar ice sheets to melt, leading to sea level rise, which has major ramifications for all coastal areas.

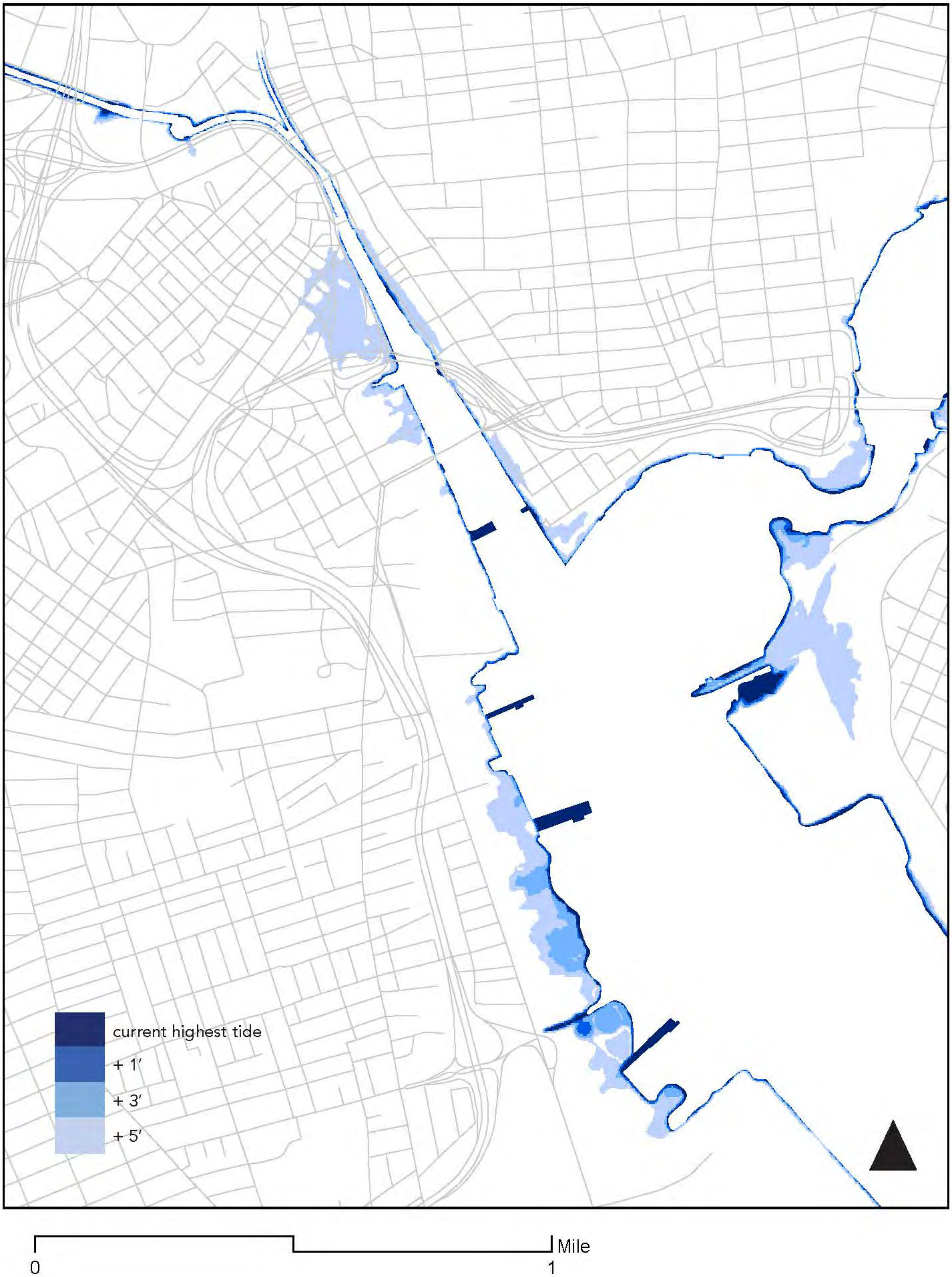


EXTREME WEATHER EVENTS INDEX FOR THE CONTINENTAL UNITED STATES





CLIMATE CHANGE PROJECTIONS



SEA LEVEL RISE IN PROVIDENCE

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