FLOODING ON AMPHIBIANS

MPS 2022, Department of Landscape Architecture, Cornell University

Yiting WANG
Advisor: Jamie Vanucchi

ABSTRACT

This project starts with the irregular urban flooding in the city of Binghamton as a backdrop. In the process of studying the city, I gradually found out about the urban fragmentation situation caused by the construction of flood control facilities. At the same time amphibians, as travelers between inland and water bodies, are bound to bear the brunt of this. In my curiosity about this situation and the conservation mentality towards amphibians, I decided to choose the topic of the effects of urban flooding on amphibians as my research direction. And I also look forward to helping them create a more livable and friendly home by means of design.

This project is led by Assistant Professor Jamie Vanucchi in the College of Agricultural and Life Science in Landscape Architecture Department. We constructed a framework through rich field trips and interviews, and categorized the information obtained from the research during a year of study, which led to interesting design ideas. I hope this project outcome as a possibility could inspire more people to participate in amphibian conservation.

CONTENTS

PART 1: Site Context 4

PART 2: Amphibian Studies 10

PART 3: Habitat Fragmentation 16

PART 4: Design for Amphibians 20

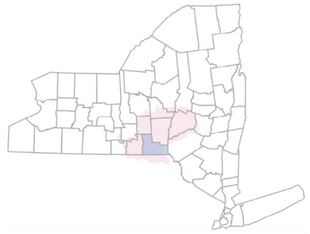
PART I

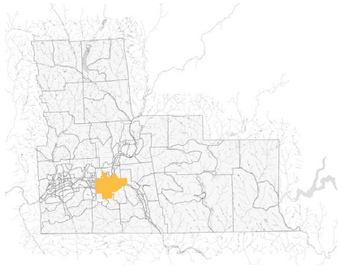
SITE CONTEXT

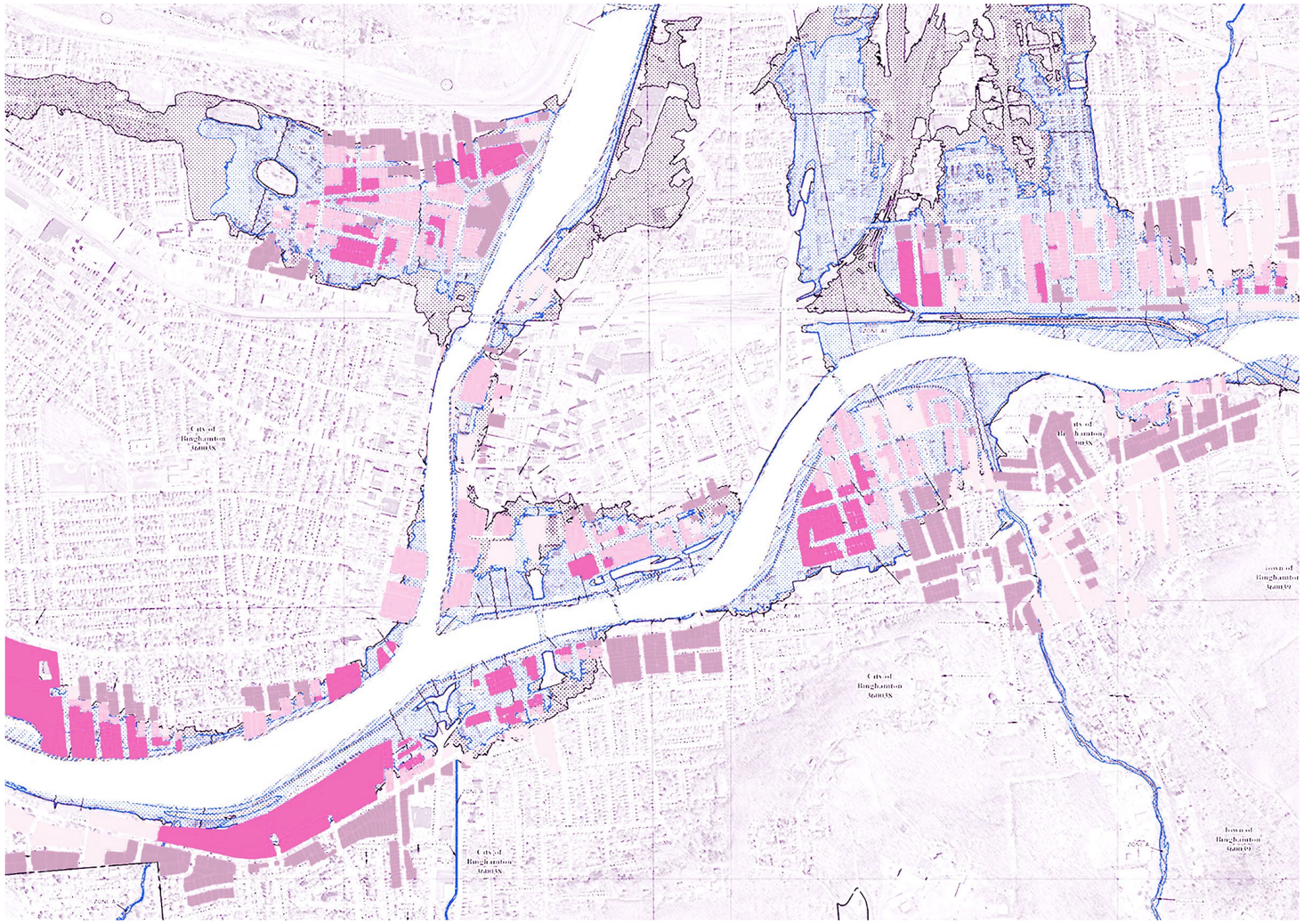
Founded in 1803, Binghamton grew at the junction of the Susquehanna and Chenango rivers. The town became a major transportation hub in 1837 when the Chenango Canal was completed and connected to the Erie Canal. By 1850, it had also become an important railroad nexus.

Like many old cities, waterways were a sustenance. But Binghamton was in a precarious spot along the Susquehanna River.

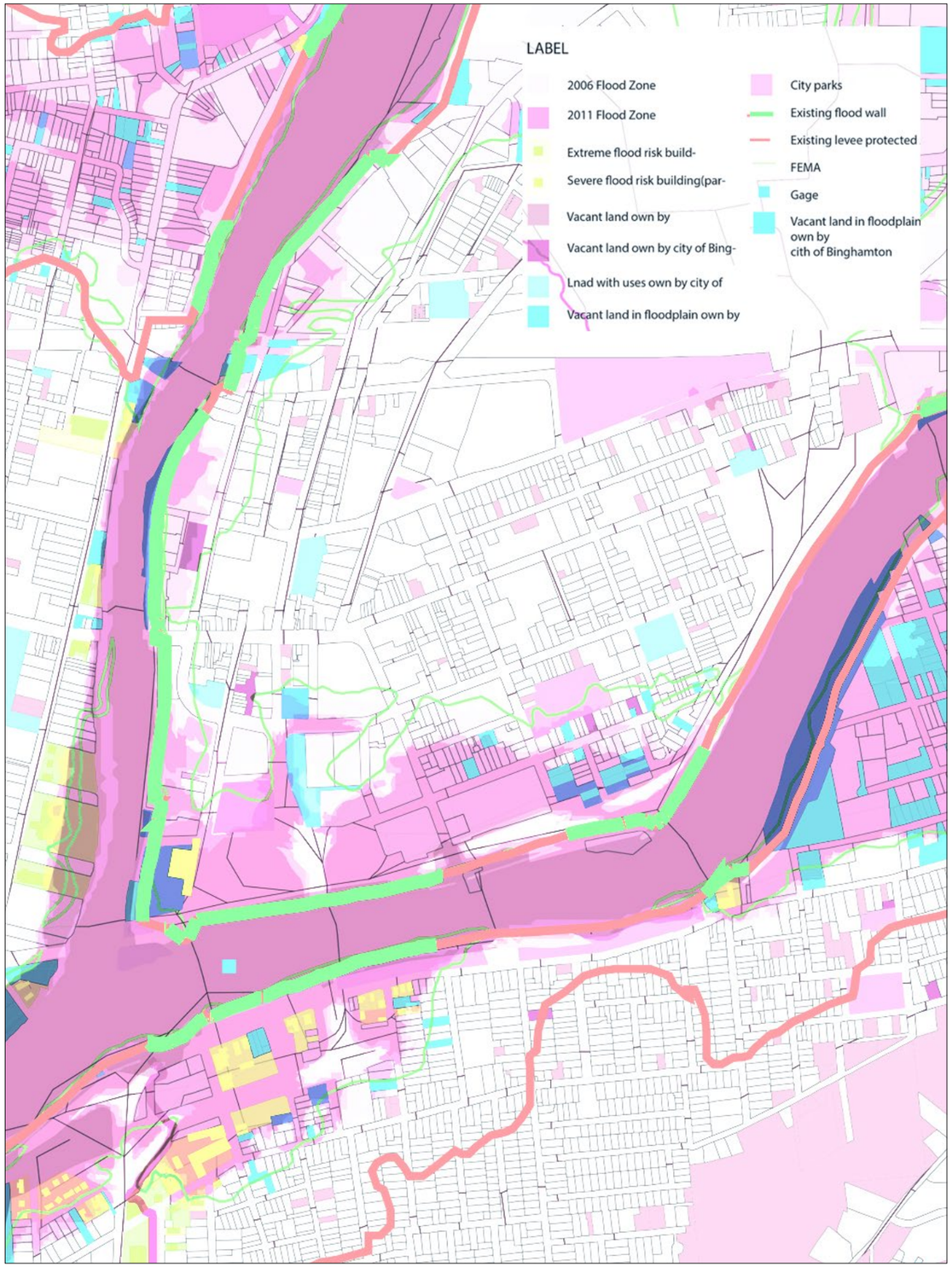
"The Susquehanna basin is so large, our location in the mid-Atlantic makes us susceptible to hurricanes and tropical storm systems, and in the summer there are a lot of west-to-east and Great Lakes thunderstorms," said Ben Pratt, a water resources engineer with the Susquehanna River Basin Commission. "It's all of those factors that stack up to make it a very flood-prone basin."







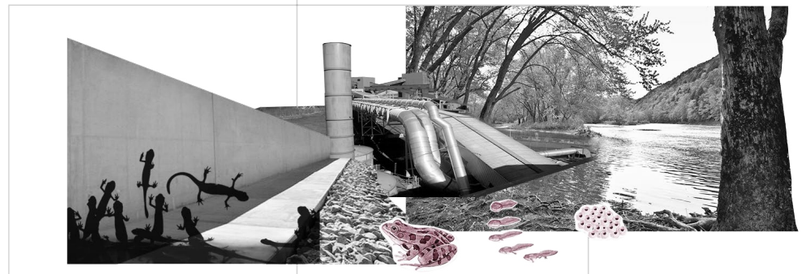
JOURNAL ENTRY



MONTAGE

River - Flood wall

To prevent flooding, flood walls surround the city and keep the river and the animals in it out as well.



Flood wall/ levee - Highways

On the other side of the floodwall, the city is lined with motorized roads and viaducts that divide nature into a mosaic-like urban grid.

Parcels - Floodwall

Because the flood wall/ levee stands next to the river bank, the city residents can not enjoy the river view, and gradually wilderness buyouts can not be connected with the nature as a whole.

ECOLOGICAL IMPACTS OF URBAN FLOODING

Urban Fragmentation

Habitat Loss

Environmental Toxins

Ailien Invasives

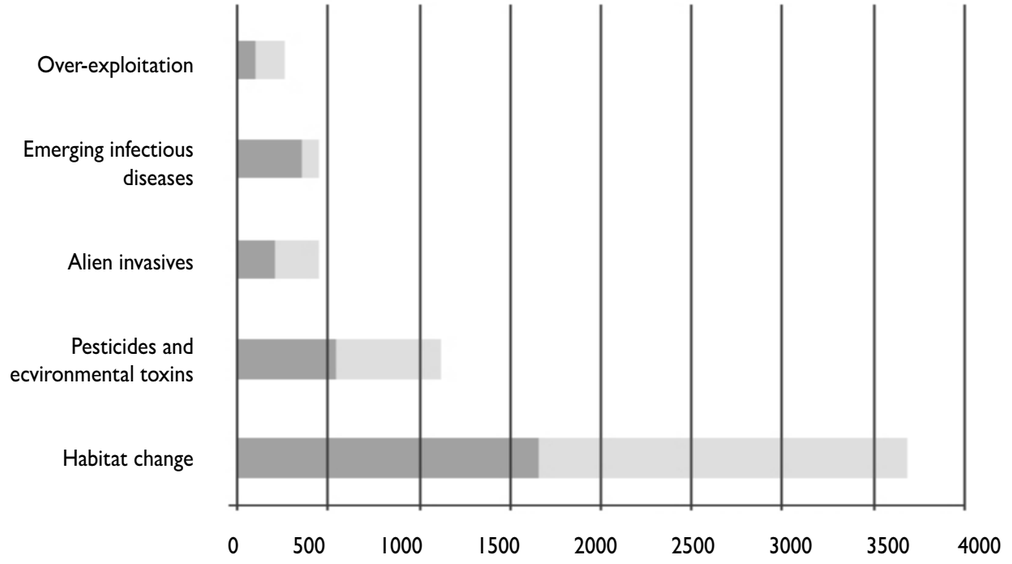
Infectious Diseases

and more...

Amphibians as a traveler between land and water, what kind of impact do floods have on them?

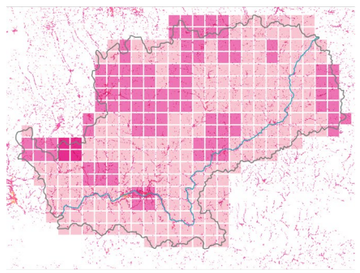
FLOODING ON AMPHIBIANS

The following five factors are the main causes of the decline in amphibian populations, in descending order of severity.

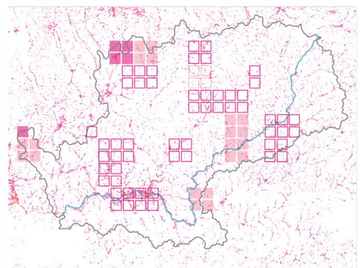


AMPHIBIAN DECLINE
in Upper Susquehanna River Basin

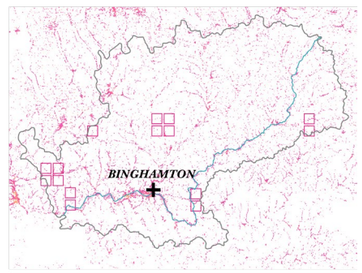
Amphibians Observation 1990 - 2000



Amphibians Observation 2000 - 2010



Amphibians Observation 2010 - 2020



AMPHIBIANS OBSERVATION
https://www.nyherps.org/explore

Low

High

FLOOD RISK
https://floodfactor.com/state/newyork/36_fsid

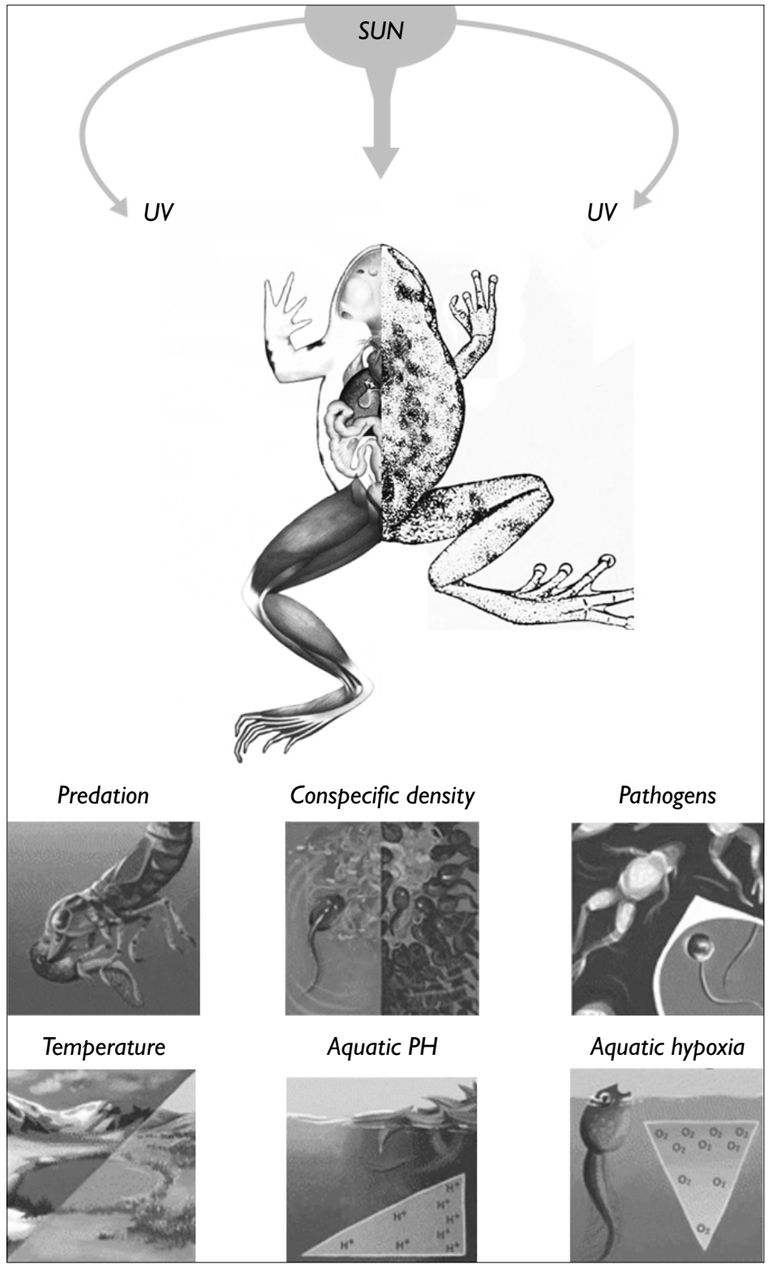
Minimal

Extreme

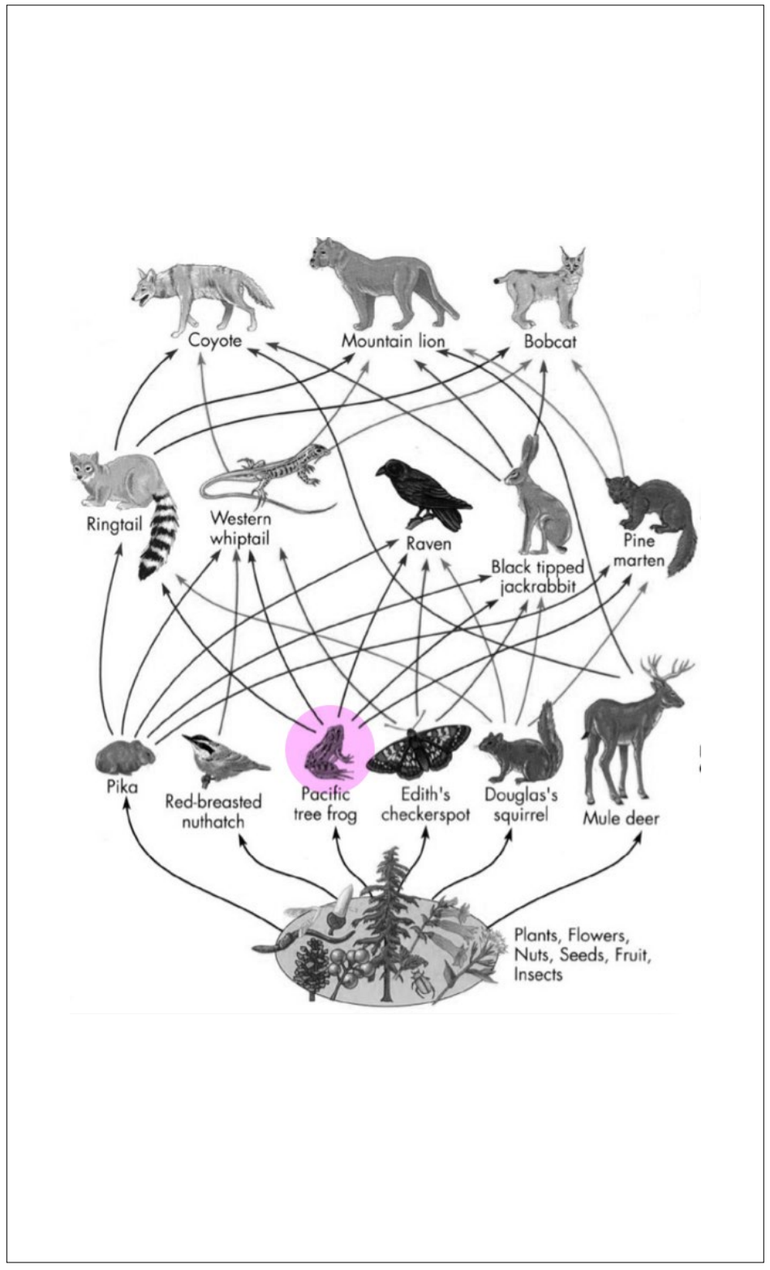
PART2 WHY SHOULD WE CARE ABOUT AMPHIBIANS?

Amphibians as Indicator species
provide early warning of ecosystem damage or environment issues.

Environmentally ***sensitive life cycle***



Vulnerable eggs and skin *(susceptible to environment)*



Important ecological role *in ecosystem*

STUDY SPECIES

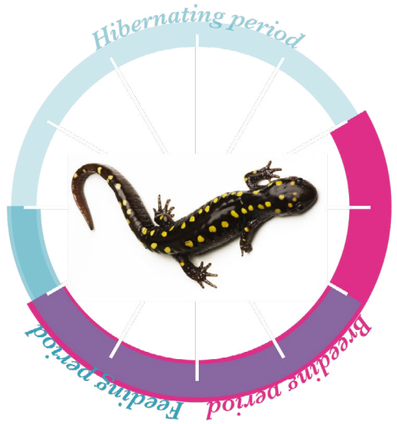
In this study, one species from each of the three major groups, salamander, frog and toad, was selected as the object of study to represent the amphibians of this group. The habitat and other characteristics of this species can better summarize the characteristics of most species in this group.

The following amphibian species live at the site:

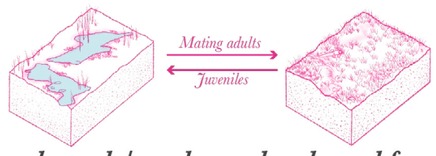
Salamander and Newt:
Red-backed Salamander (Plethodon cinereus)
Eastern Red-Spotted Newt (Notopthalmus viridescens)
Two-lined (Eurycea bislineata)
Dusky Salamander Northern (Desmognathus fuscus),
Dusky Salamander Mountain (Desmognathus ochrophaeus)
Slimy Salamander (Plethodon glutinosus)
Yellow Spotted Salamander (Ambystoma maculatum)
Four-toed Salamander (Hemidactylium scutatum),
Spring Salamander (Gyrinophilus porphyriticus)

Frogs and Toad:
Green Frog (Rana clamitans)
Wood Frog (Rana sylvatica)
Spring Peeper (Hyla crucifer now Pseudacris crucifer)
American Toad (Bufo americanus)
Pickerel Frog (Rana palustris)
Common Gray Tree Frog (Hyla versicolor)
Bullfrog (Rana catesbeiana)
Northern Leopard Frog (Rana pipiens)
Cope's Gray Tree Frog (Hyla chrysoscelis)

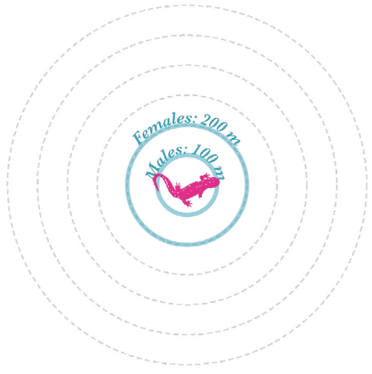
SPOTTED SALAMANDER (Ambystoma maculatum)



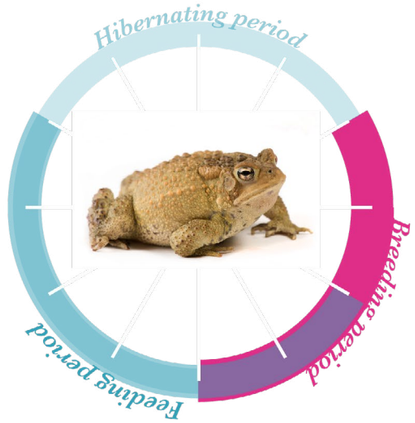
DIET: *insects, worms, slugs, spiders, and millipedes*
AVERAGE LIFE SPAN: *Up to 20 years*
SIZE: *5.9-9.8 in*
HABITATS:



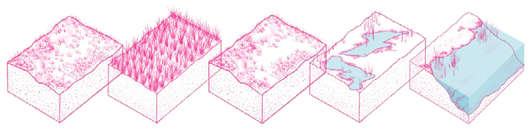
vernal ponds/ pool ***hardwood forest***
MIGRATION DISTANCE:



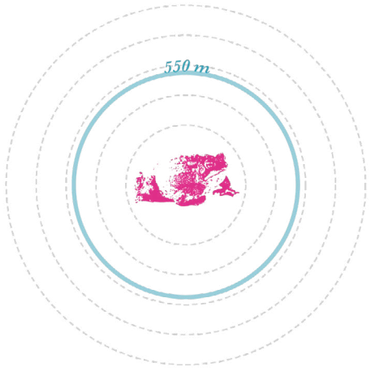
AMERICAN TOAD (Bufo americanus)



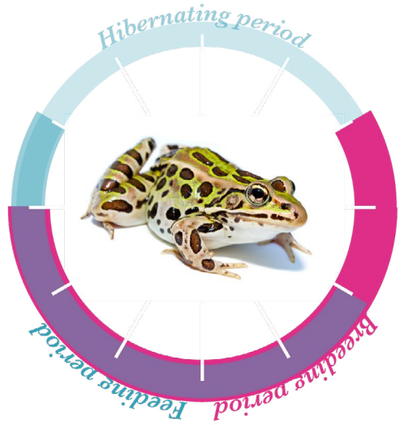
DIET: *woodlice, beetles, caterpillars, flies, earthworms*
AVERAGE LIFE SPAN: *Up to 12 years*
SIZE: *2-4.4 in*
HABITATS:



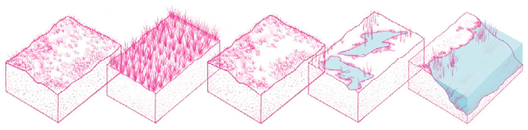
woodland, copses, fields, vernal ponds, permenent water
MIGRATION DISTANCE:



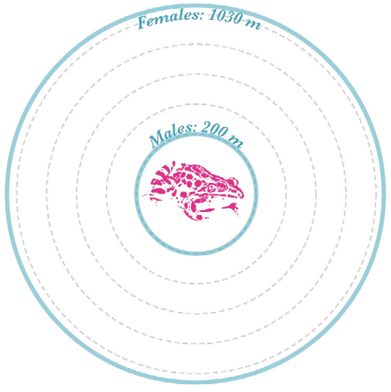
NORTHERN LEOPARD FROG (Rana pipiens)



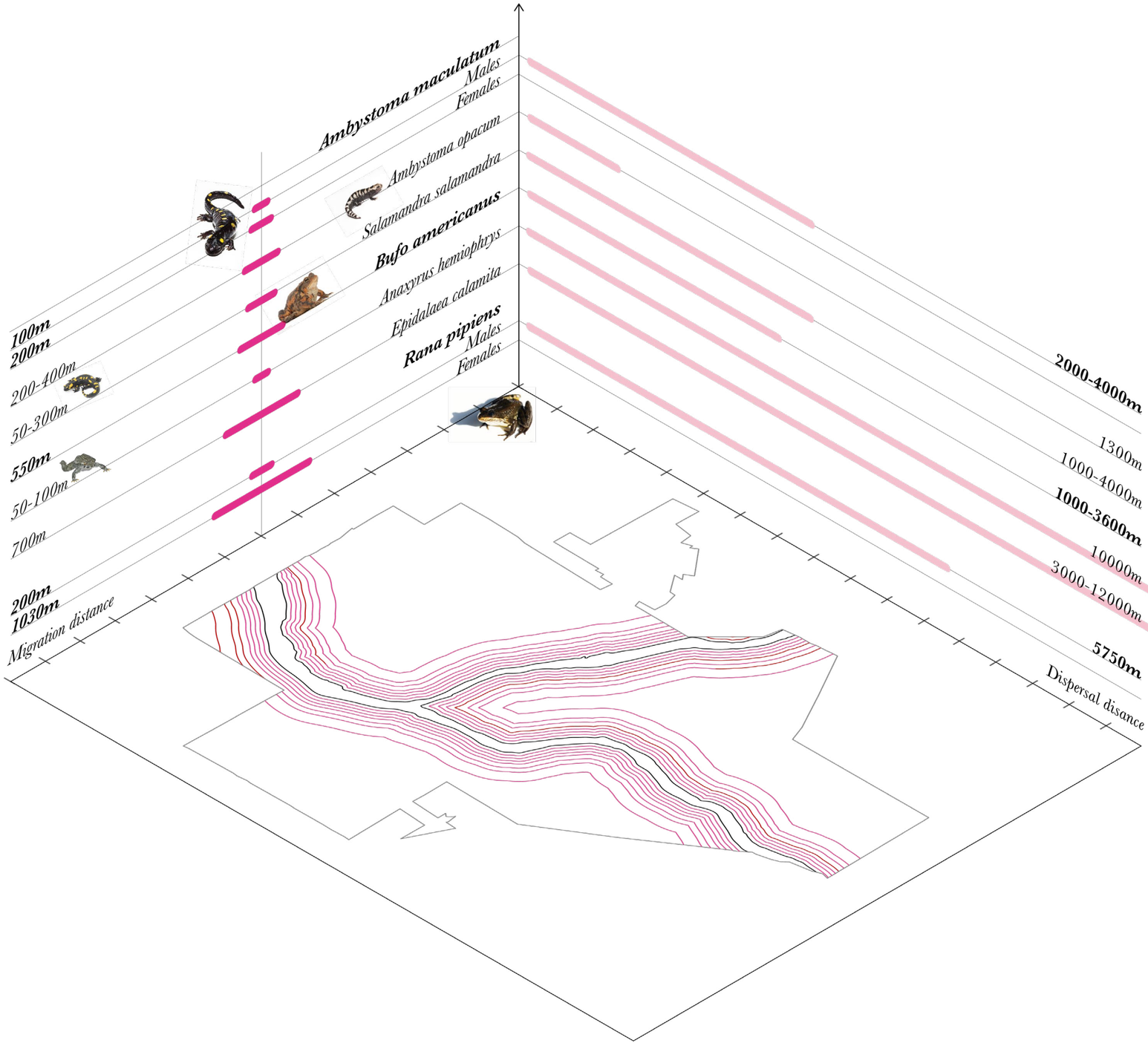
DIET: *beetles, ants, flies, worms, frogs, garter snakes*
AVERAGE LIFE SPAN: *2-4 years*
SIZE: *3-5 in*
HABITATS:

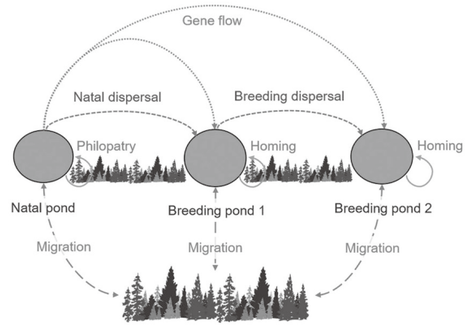


woodland,streams,grasslands,permanent ponds,marshes
MIGRATION DISTANCE:



MIGRATION DISTANCE AND MIGRATION BUFFER ZONE
in Selected Amphibians





Amphibian Migration:
Amphibian migration is movements primarily byresident adults, toward and away from aquatic breeding sites. During the breeding season, adults migrate across land from overwintering sites to ponds to mate and deposit eggs. After breeding, post reproductive males and females return to terrestrial habitats. Secondary migrations can occur between foraging habitat, summer refugia, and over-wintering sites. For the adult residents usinga breeding pond, migrations are reoccurring events (often,but not always annually), round-trip, and intrapopulational.

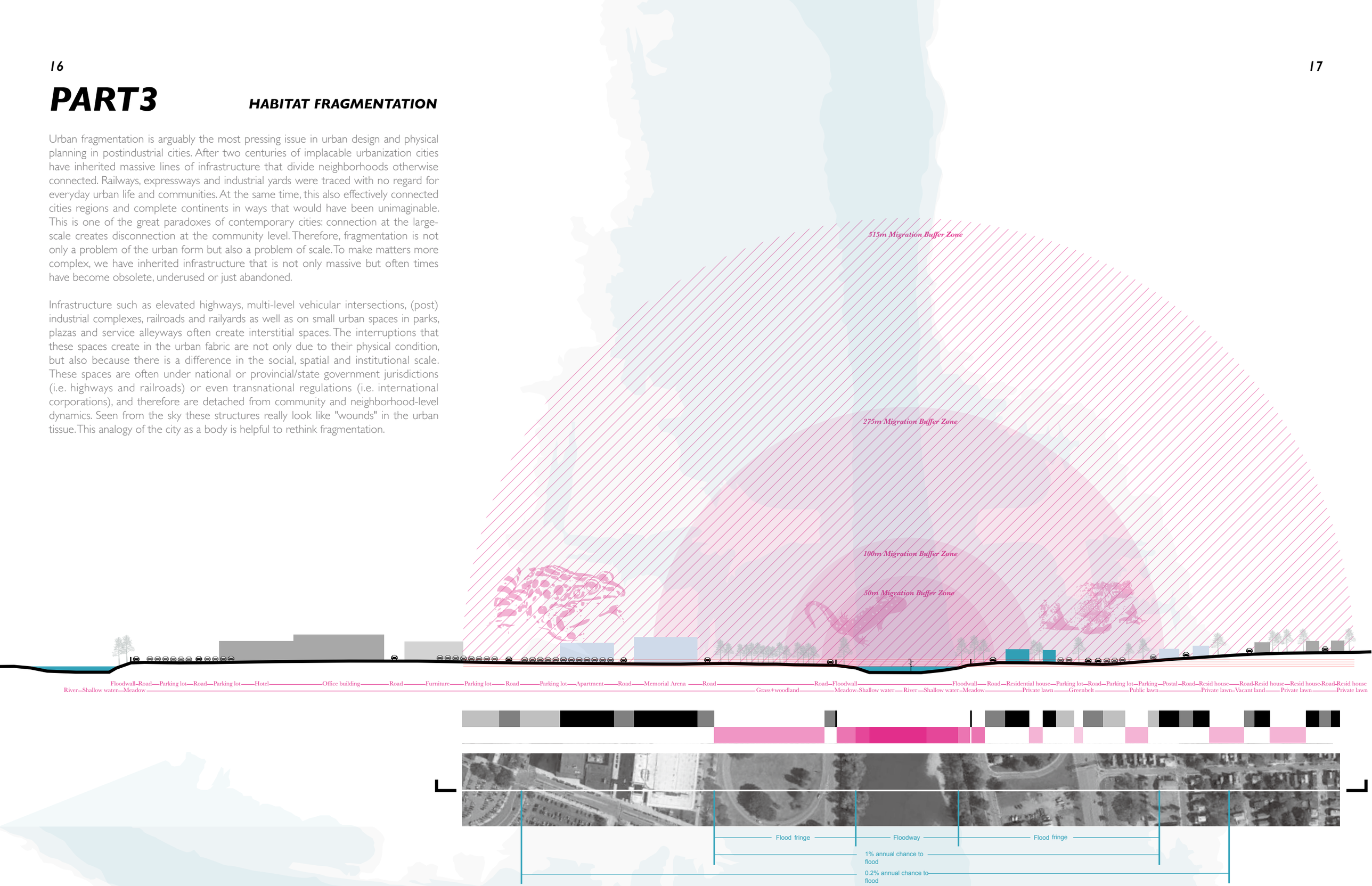
Amphibian Dispersal:
Amphibian dispersal is unidirectional movements from natal sites to breeding sites that are not the pond of birth and not part of the local population. For dispersing juveniles, movements are ultimately greater indistance than for migrating adults, probably occur only oncein a lifetime, and are interpopulational in scale. Sometime after adults leave the breeding pond, dependingon species, larvae metamorphose and move onto land away from the pond. A portion of the juveniles will remain nearthe breeding site, reach sexual maturity, and return to breedin their natal pond, thereby joining the local breeding adultpopulation. The remaining portion of surviving juvenileswill disperse into the terrestrial habitat and presumably colonize nonnatal ponds.

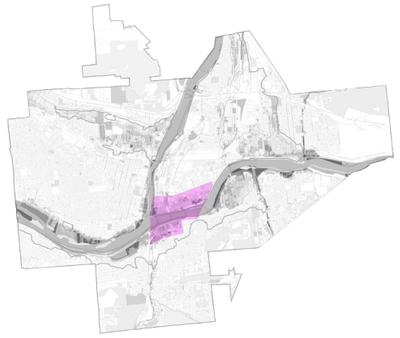
PART3

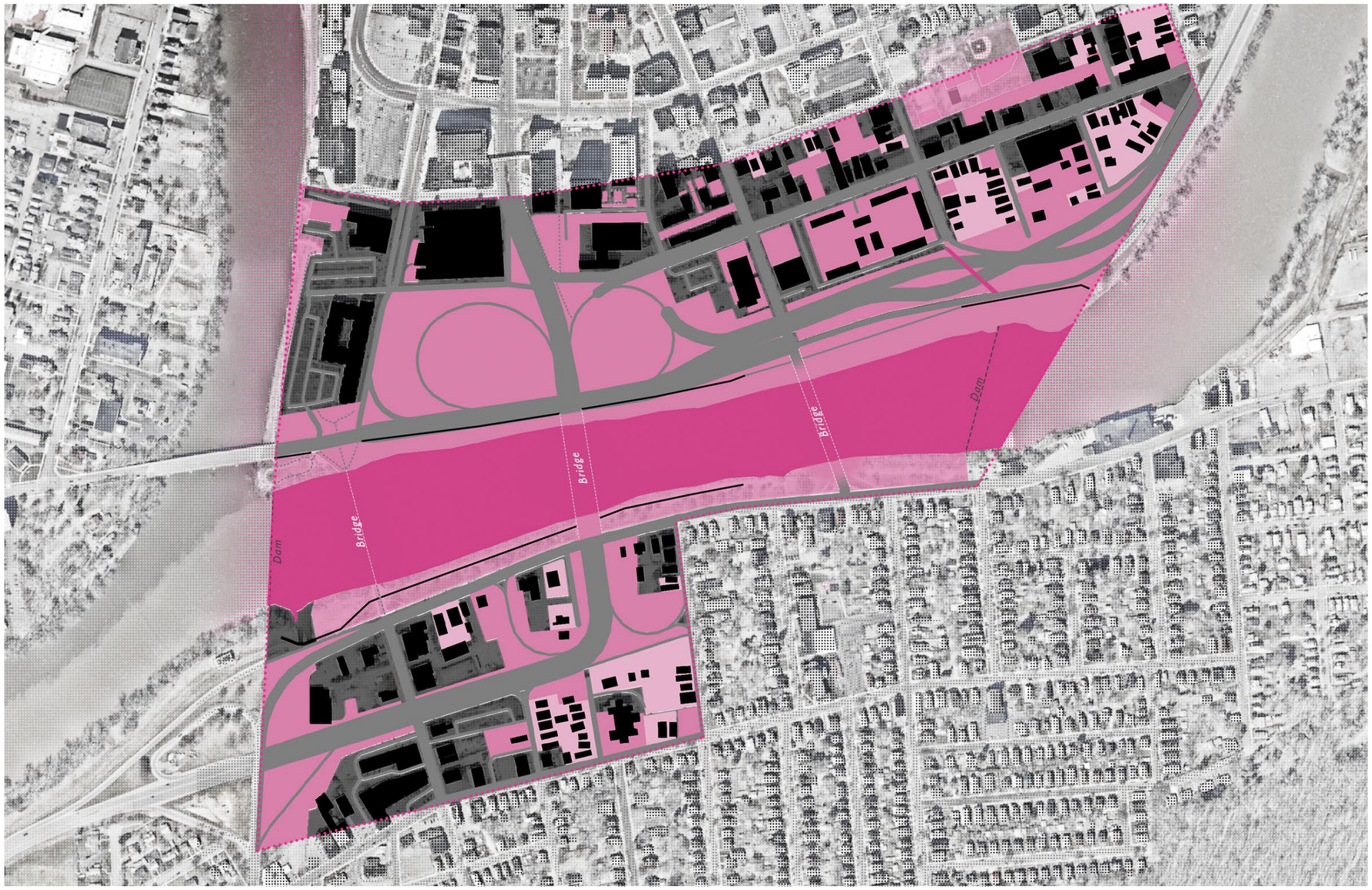
HABITAT FRAGMENTATION

Urban fragmentation is arguably the most pressing issue in urban design and physical planning in postindustrial cities. After two centuries of implacable urbanization cities have inherited massive lines of infrastructure that divide neighborhoods otherwise connected. Railways, expressways and industrial yards were traced with no regard for everyday urban life and communities. At the same time, this also effectively connected cities regions and complete continents in ways that would have been unimaginable. This is one of the great paradoxes of contemporary cities: connection at the large-scale creates disconnection at the community level. Therefore, fragmentation is not only a problem of the urban form but also a problem of scale. To make matters more complex, we have inherited infrastructure that is not only massive but often times have become obsolete, underused or just abandoned.

Infrastructure such as elevated highways, multi-level vehicular intersections, (post) industrial complexes, railroads and railyards as well as on small urban spaces in parks, plazas and service alleyways often create interstitial spaces. The interruptions that these spaces create in the urban fabric are not only due to their physical condition, but also because there is a difference in the social, spatial and institutional scale. These spaces are often under national or provincial/state government jurisdictions (i.e. highways and railroads) or even transnational regulations (i.e. international corporations), and therefore are detached from community and neighborhood-level dynamics. Seen from the sky these structures really look like "wounds" in the urban tissue. This analogy of the city as a body is helpful to rethink fragmentation.







HABITAT FRAGMENTATION MAP

PATCH DEFINITION: The study area is divided into several patches, and the patches can be classified and graded according to artificial or natural as well as the patch states: potential, active, or degraded.

As shown in the section, the gray squares represent artificial/ degraded patches and the pink squares represent natural/ active patches, and the shades of color represent different degrees of the attribute.

0% Passability: buildings, walls

<50% Passability: roads, passages

>50% Passability: hard surfacing, parking lot

Active Patches: Habitats like river, ponds

Potential Patches: parks, public green zone, lawn

Private Patches: private backyards

PART4

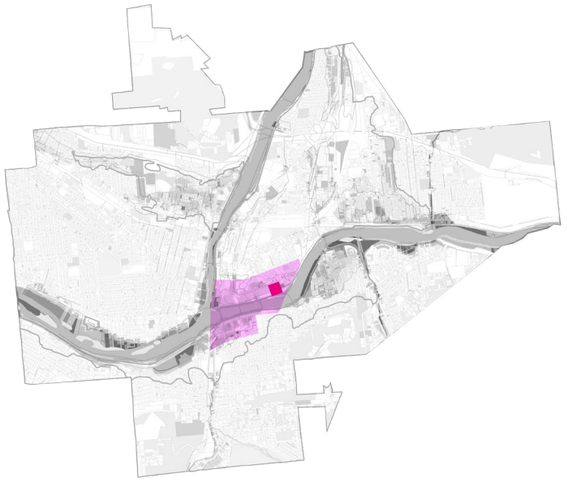
RESEARCH OBJECTIVES AND DESIGN GOAL

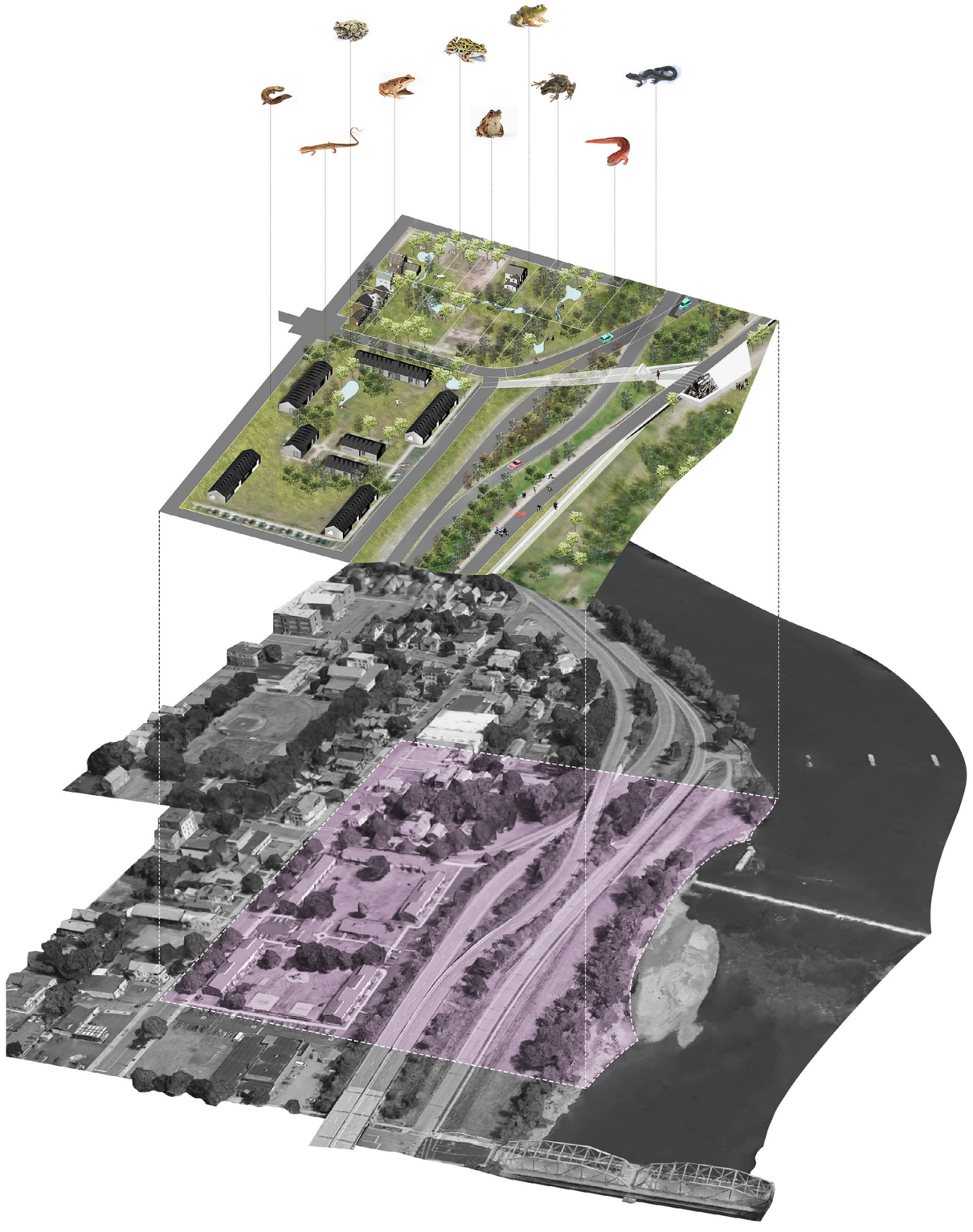
Upgrade Floodplain Parcel Connectivity To Help Create A More Amphibian-Friendly Urban Environment

LANDSCAPE CONNECTIVITY
The success of amphibian's migrations depends on interactions between movement capacity (e.g., locomotion performance, orientation mechanisms, and stress management) and the harshness (e.g., aridity, toxicity, danger) of the landscape to be crossed. These interactions determine landscape connectivity.

PATCH DYNAMICS:
Ecosystems are spatially and temporally heterogeneous—that is, they contain a diverse and unevenly distributed mixture of organisms and resources.
Ecological disturbances, such as floods, are responsible for much of the dynamics of spatial heterogeneity. As a result, ecosystems can be thought of as mosaics of patches. Flux, rather than balance, is a major emphasis in patch dynamics research.
In patch dynamics a habitat patch can exist in three states: potential, active, and degraded. Potential patches have yet to become active through the dispersal of a species in that area. Degraded patches are abandoned, but they can become potential patches again through recovery.

So the goal of this project is to target improvements to the frequently flooded urban environment to make it a much more amphibian-friendly environment by studying how amphibians survive and the difficulties they encounter in different kinds of urban patches.





DESIGN STRATEGIES

PHASE 1

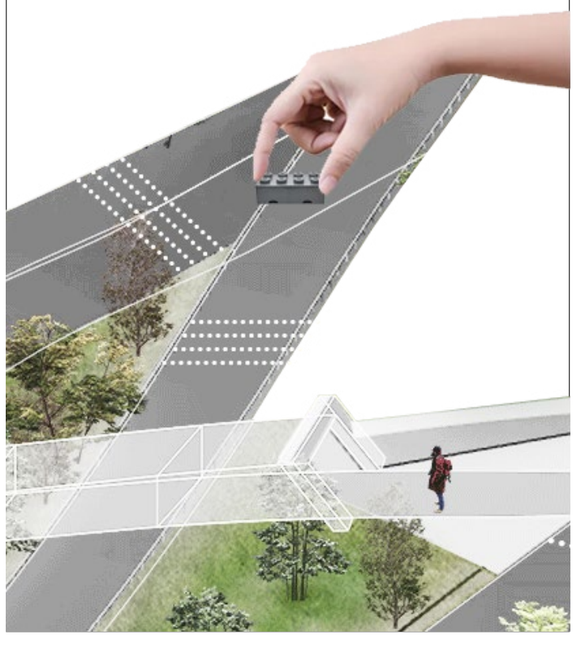
Breaking Barriers -
Facility Renovations for Amphibians

1. OVERPASS

2. ADAPTIVE GATE

3. ECOTUNNEL

4. UNDERPASS:
Install culverts or tunnels as road crossings



PHASE 2

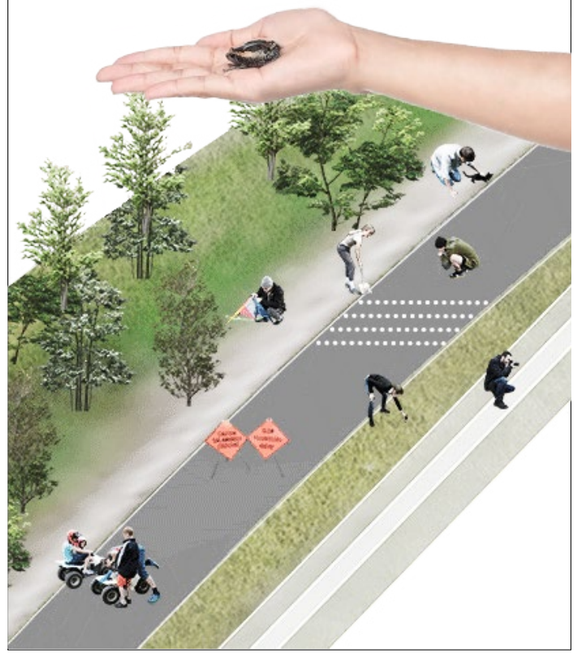
Migration Guidance

1. Install barrier fencing along roads

2. Modify gully pots and kerbs

3. Use humans to assist migrating amphibians across roads

4. Use signage to warn motorists
or close roads during seasonal migration



PHASE 3

New Inland Habitat -
Convert potential patches into habitats

1. VEGETATION:
clear vegetation and control invasive plants

2. HIBERNACULA:
Create artificial hibernacula or aestivation sites

3. PONDS/ WETLAND:
Create ponds/wetland, regulate water level and remove or control fish

4. CREATE "BACKYARD" HABITAT:
Engage landowners and other volunteers to manage land for amphibians

5. The Wetlands Reserve Program:
Pay landowners to cover the costs of conservation measures

PHASE 4

Human animal coexistence
and Educational facilities

1. Provide education programmes about amphibians

2. Raise awareness amongst the general public through educational games, campaigns or other forms of public information

MASTER PLAN

Phase 1 - Breaking barriers

Phase 2 - Migration guidance

Phase 3 - New inland habitats

Phase 4 - Human amphibian coexistence

GREEN BLOCKS - Optimized Habitats:

Grassland

Highway woods (not habitat)

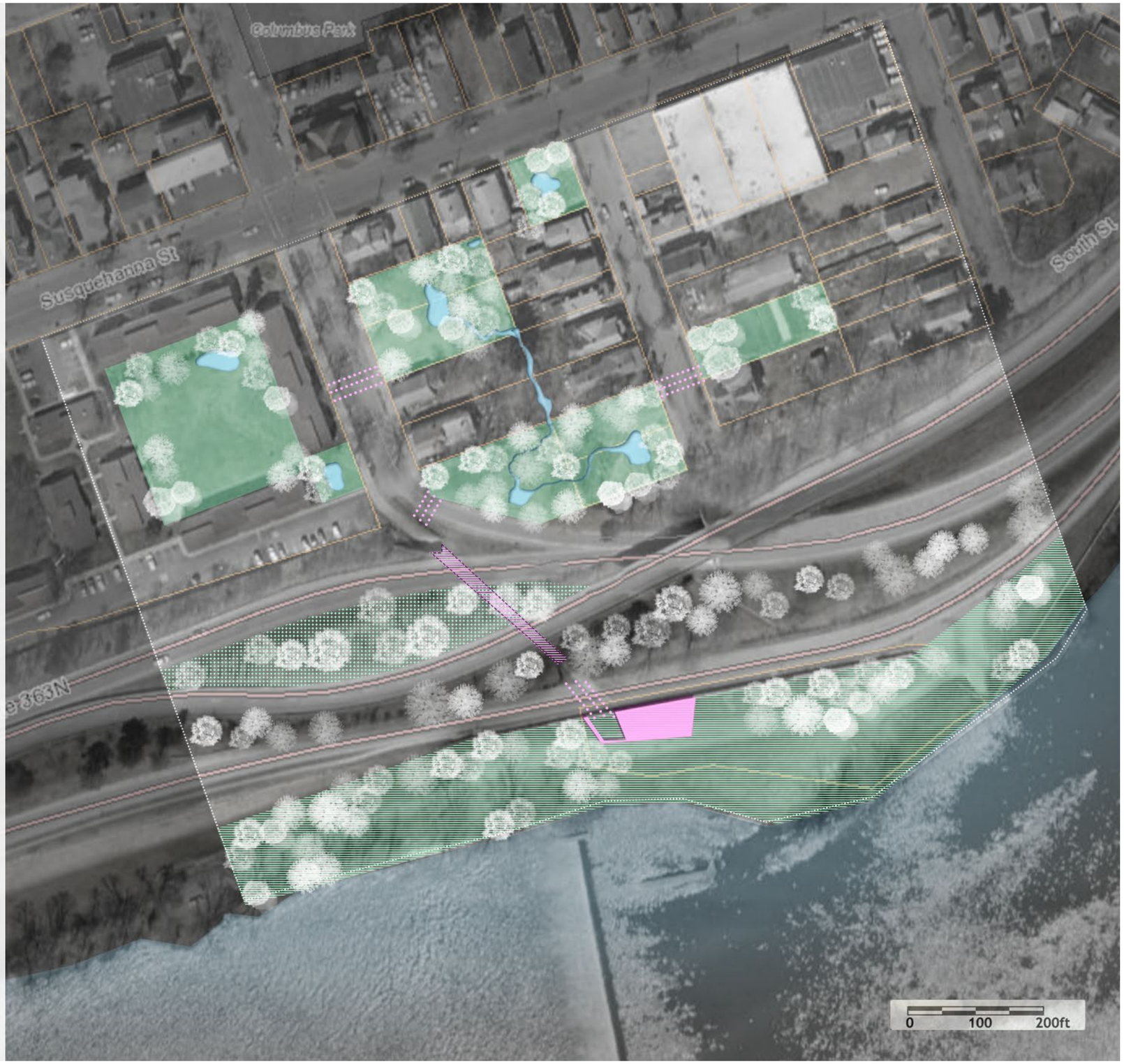
Marsh

PINK BLOCKS - Connections:

Underpass

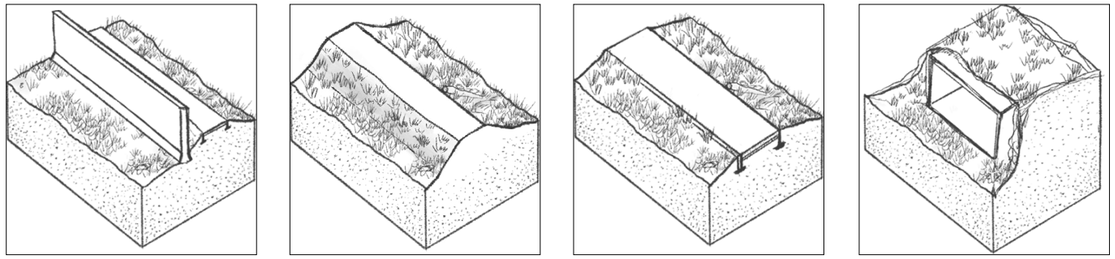
Eco-tunnel

Transparent viewing deck+ educational center



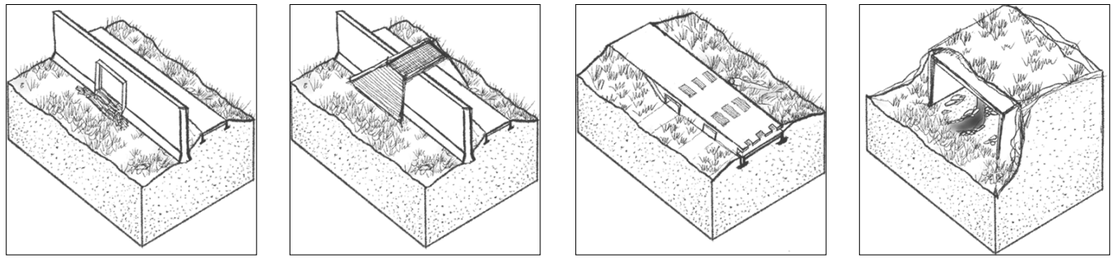
PHASE 1:
Breaking Barriers -
Facility Renovations for Amphibians

BARRIERS



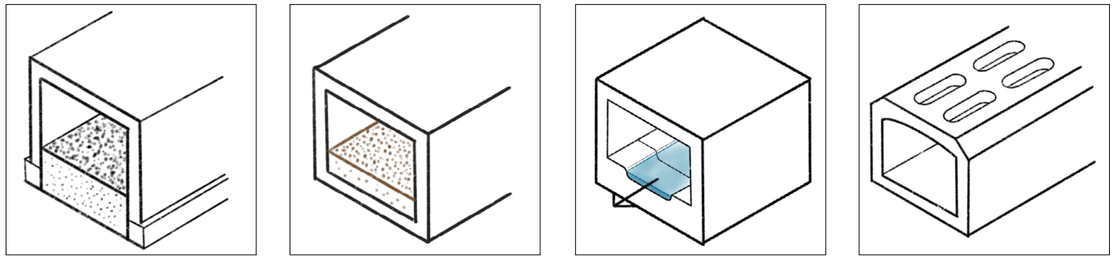
Flood wall | Levee | Road | Hill

CONNECTIONS



Adaptive Floodwall | Overpass | Underpass | Eco-tunnel

DESIGN DETAILS OF UNDERPASSES/ TUNNEL

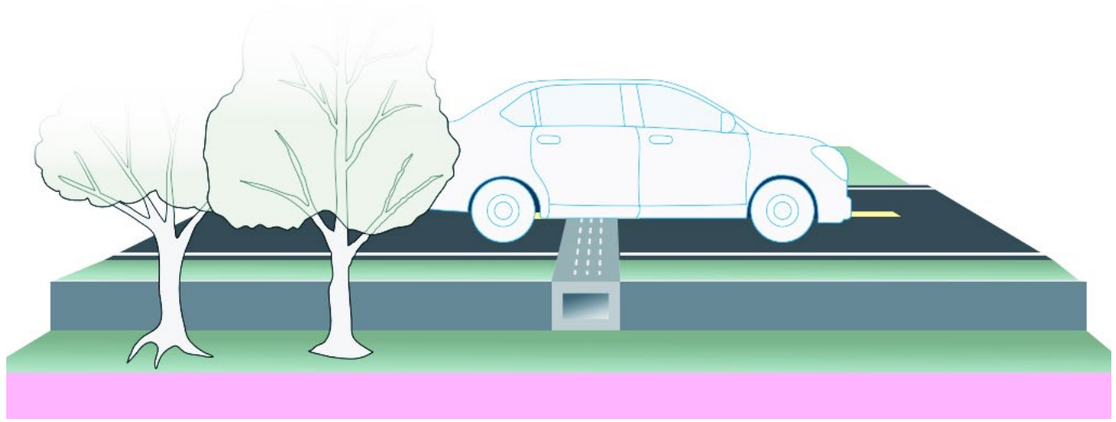


Passages built on foundations are sometimes referred to as 'bottomless' or 'stilt' passages due to the open natural soil base and support on both sides.

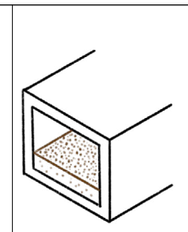
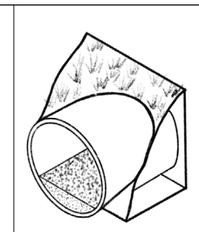
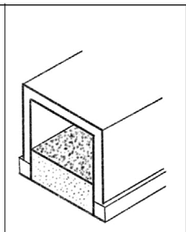
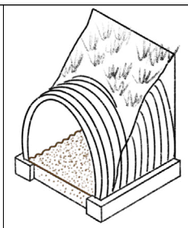
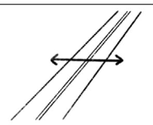
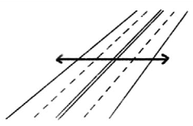
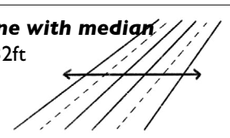
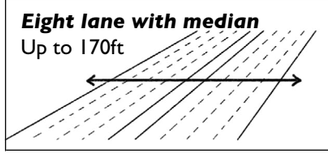
Simulation of passages that can be designed with substrate placed at the base during construction.

Water flow or a drainage system may be incorporated into the design of a culvert passage to provide a wet channel or moist passage base.

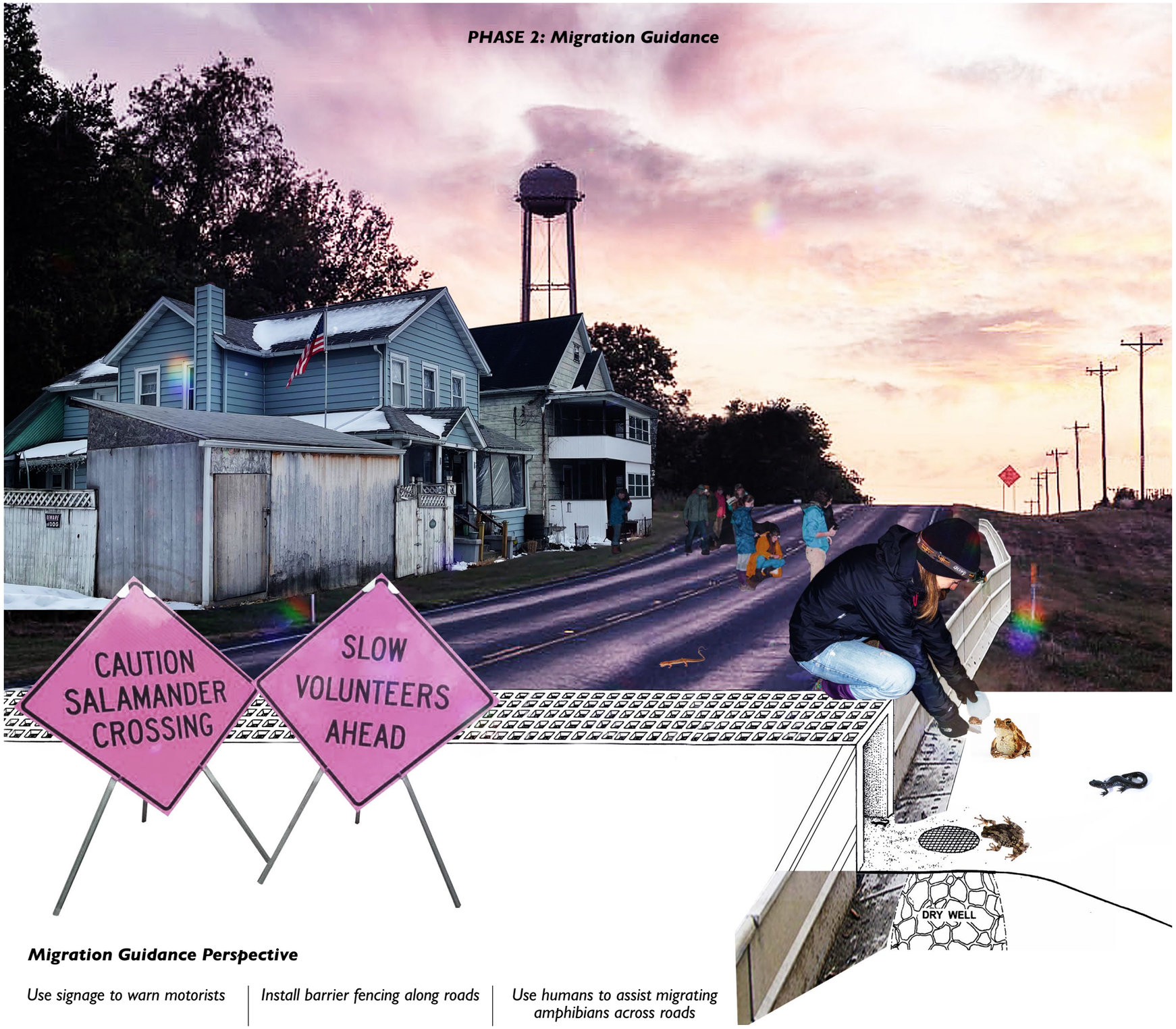
Micro-surface passages flush with the road surface maximize exposure to ambient environmental conditions and weather.



Recommended minimum width and height (W/H) dimensions for different types, according to passage length and the size (width) of a road.

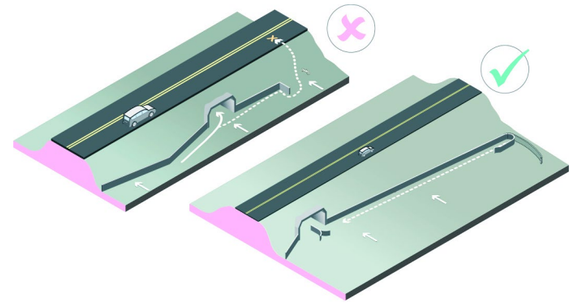
	 ***Rectangular***	 ***Circular***	 ***Rectangular Bottomless***	 ***Arch Bottomless***
Two lane Up to 66ft 	3 ft 3"/ 2 ft 6" 1000/750mm	3 ft 4" 1000mm	3 ft 7" / 2 ft 1100/600mm	3 ft 3" / 2 ft 4" 1000/700mm
Four lane Up to 100ft 	5 ft/ 3 ft 4" 1500/1000mm	4 ft 5" 1400mm	4 ft 11" / 2 ft 8" 1450/800mm	4 ft 5" / 2 ft 4" 1400/700mm
Four lane with median Up to 132ft 	5 ft 9"/ 4 ft 1" 1750/1250mm	5 ft 4" 1600mm	5 ft 11" / 3 ft 3" 1800/1000mm	5 ft 4" / 3 ft 7" 1600/1100mm
Eight lane with median Up to 170ft 	6 ft 6"/ 4 ft 11" 2000/1500mm	6 ft 8" 2000mm	6 ft 8" / 3 ft 7" 2000/1100mm	

PHASE 2: Migration Guidance



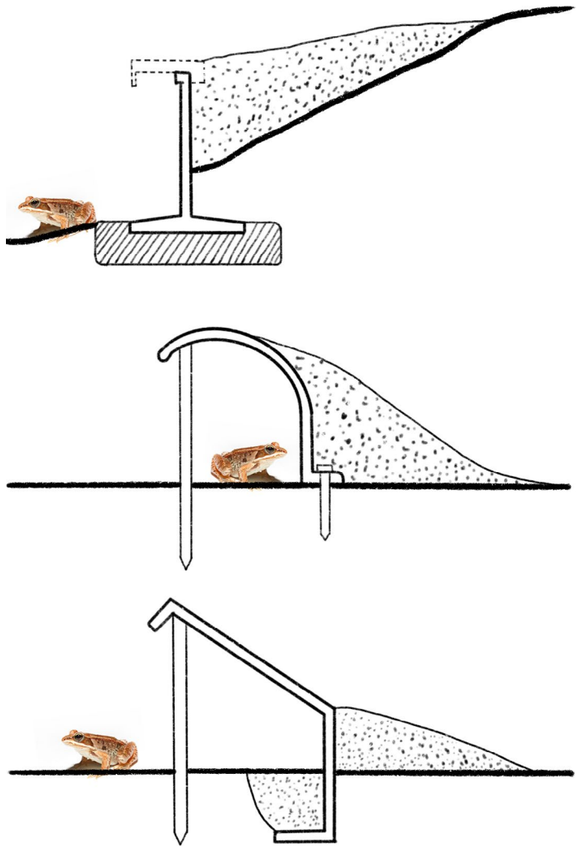
Migration Guidance Perspective

Use signage to warn motorists | *Install barrier fencing along roads* | *Use humans to assist migrating amphibians across roads*



When barriers are not long enough and the associated turn-arounds are inadequate, a proportion of a population may find its way on to the road.
A curved turn-around and a secondary curved turn-around to catch wanderers, will also help minimize these risks.

MIGRATION GUIDANCE BARRIER SECTION



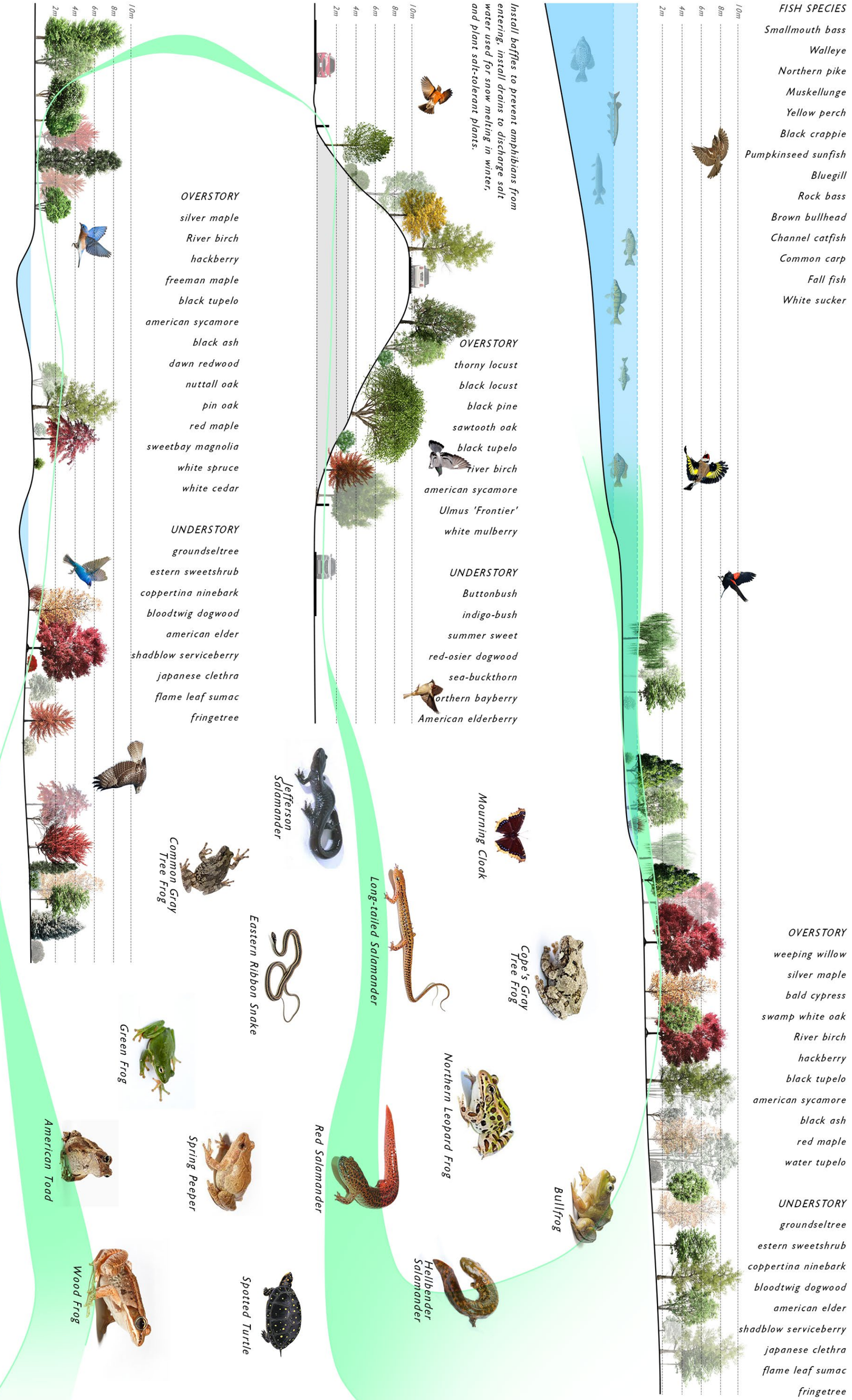
PHASE 3:
New Inland Habitat -
Convert potential patches into habitats

The Wetlands Reserve Program (WRP) was a voluntary program that offered landowners the opportunity to protect, restore, and enhance wetlands on their property, especially Certain lands that had the potential to become a wetland as a result of flooding! There are different kinds of Enrollment Options, mostly the USDA will pay most of the restoration costs.

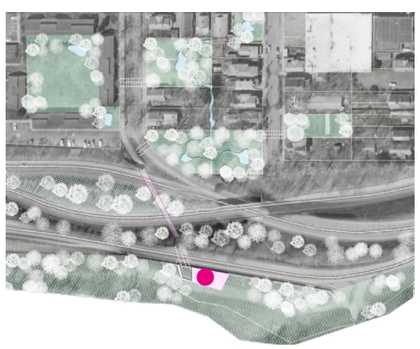
GRASSLAND

HIGHWAY WOOD

MARSH



PHASE 4:
Human animal coexistence
and Educational facilities

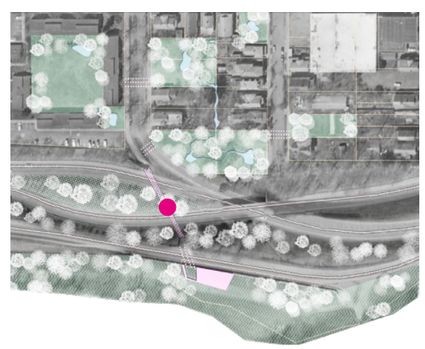


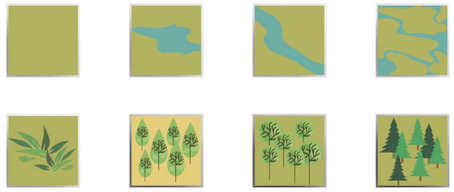
Educational Center over Flood Wall Perspective

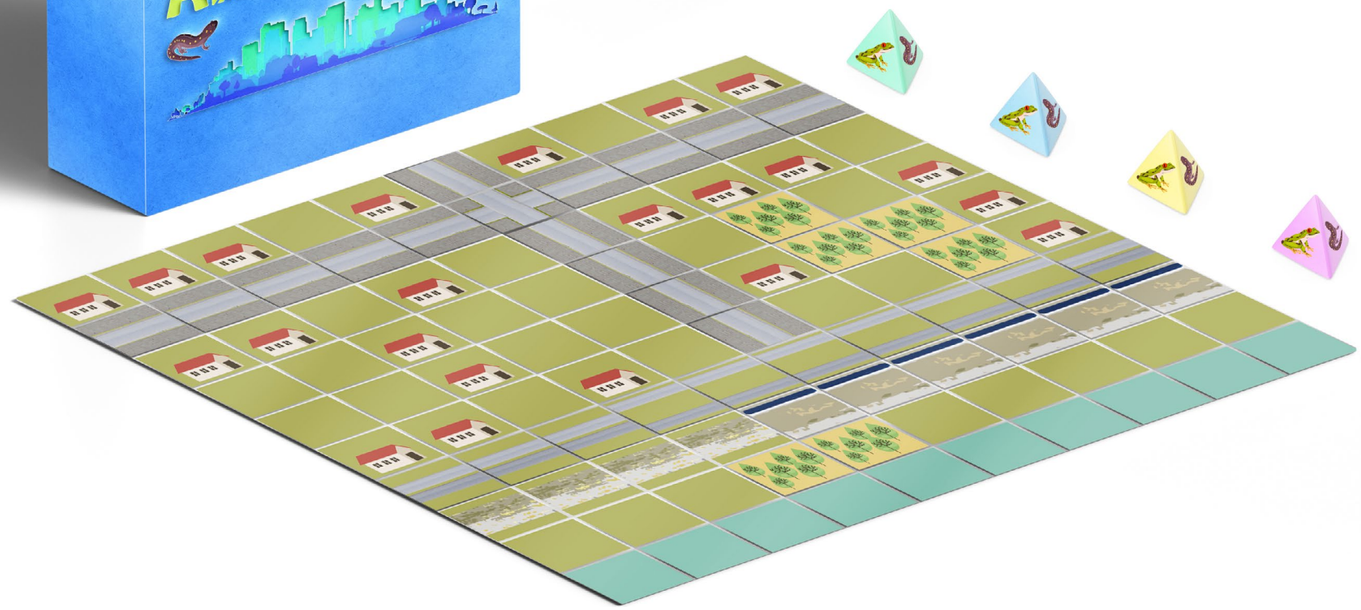
The Education Center is an adaptable building built on a flood wall: under normal conditions, there is a slight height difference between the building floor and the road for amphibians to cross; and when flooding comes, that height difference closes automatically.
The floor of the building is made of glass, which allows visitors to observe amphibian activity up close from inside.

Human and Amphibians in Eco-tunnel Perspective

The tunnel passes through the knoll under the viaduct where it originally existed for pedestrians to cross. However, the tunnel was too long and dry for amphibians to cross safely. Transforming this tunnel into an ecological corridor opens a convenient door for amphibians to migrate inland.







Save Amphibians!

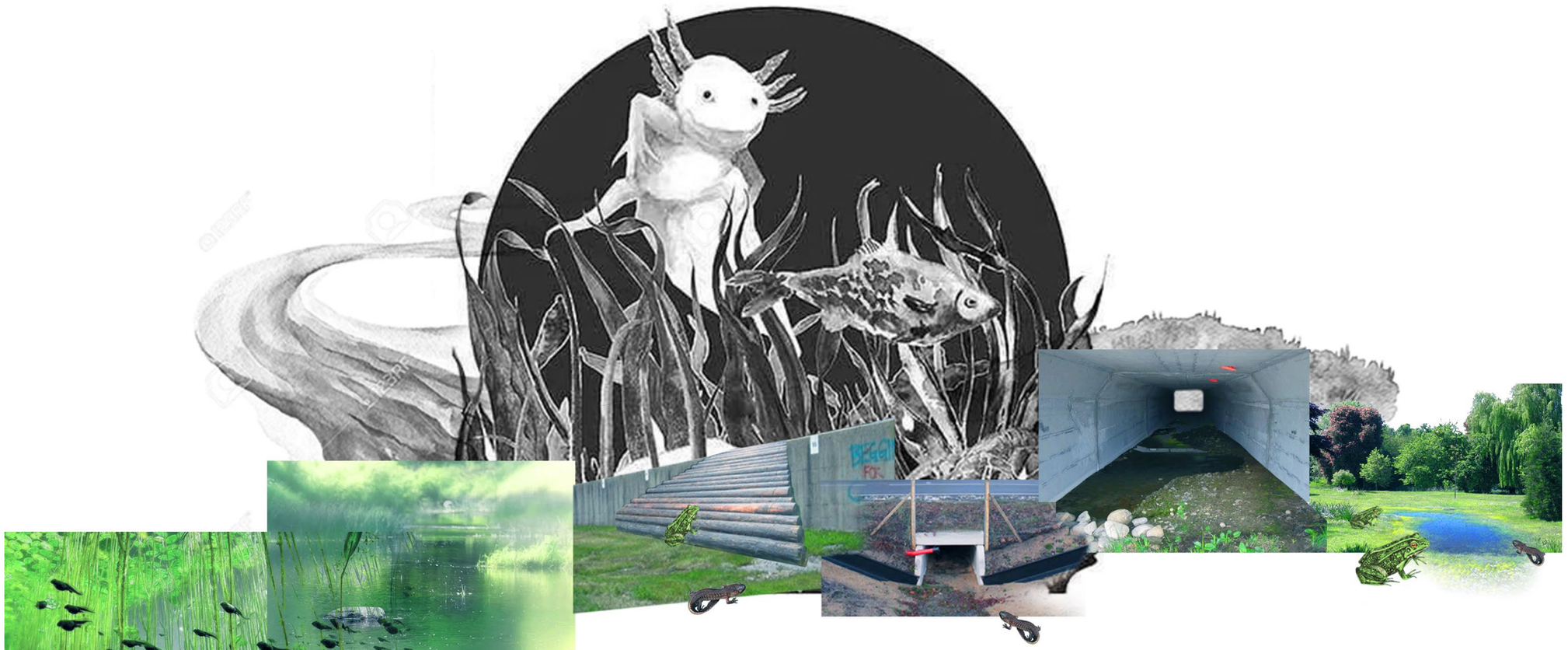
Game Design for Amphibians

To awaken the awareness to protect declining amphibians among city dwellers, I decided to design a board game that would help bring players into the perspective of amphibians and understand their hardships of surviving in urban environment. So the rules of the game are established according to the real situation of amphibian survival and also improved on the basis of gamification. For the accessibility of the game, the board game can also be adapted into a mobile version. Hope this game could really make a difference to amphibians someday in the future.

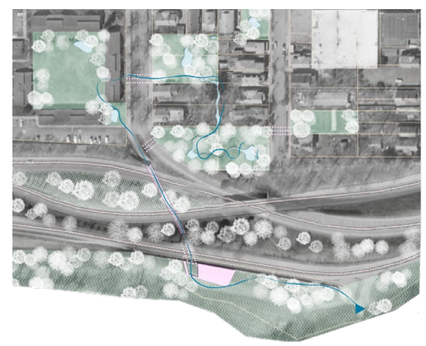
Scan this QR code to visit the detailed game website.

Mobile version coming soon...

SEQUENCE OF AMPHIBIAN PERSPECTIVES



Water — Log ramp under the educational center — Underpass under the roads — Eco tunnel — Habitats



REFERENCE

Lesley A. Alton and Craig E. Franklin (2017) '*Drivers of amphibian declines: effects of ultraviolet radiation and interactions with other environmental factors',* Alton and Franklin Climate Change Responses (2017).

Pierre Joly (2019) *'Behavior in a Changing Landscape: Using Movement Ecology to Inform the Conservation of Pond-Breeding Amphibians'*, Frontiers in Ecology and Evolution.

Donald Watson, FAIA, and Michele Adams, P.E. (2011) *'DESIGN FOR FLOODING'*, John Wiley & Sons, Inc.

Julian, A.J. & Hand, N.K. (2018). '*ARG UK Advice Note 11. Managing Habitat for Adders: Advice for Land Managers'*, Amphibian and Reptile Groups of the UK.

Langton, T.E.S. and A.P. Clevenger. (2021) *'Measures to Reduce Road Impacts on Amphibians and Reptiles in California. Best Management Practices and Technical Guidance'*, Prepared by Western Transportation Institute for California Department of Transportation, Division of Research, Innovation and System Information.

Binghamton University (2022) '*Reptiles & Amphibians (Herpetofauna)*', Availabe at:
https://www.binghamton.edu/nature-preserve/flora-funa/reptiles/index.html (Accessed: 8/8/18).

New York Amphibian & Reptile Survey (NYARS) 'Amphibian& Reptile Survey', Available at:
https://www.nyherps.org/explore.

U.S. Geological Survey (USGS) 'USGS Current Conditions for the Nation', Available at:
https://nwis.waterdata.usgs.gov/nwis/uv? (Accessed: 2022-05-20 20:56:32 EDT).