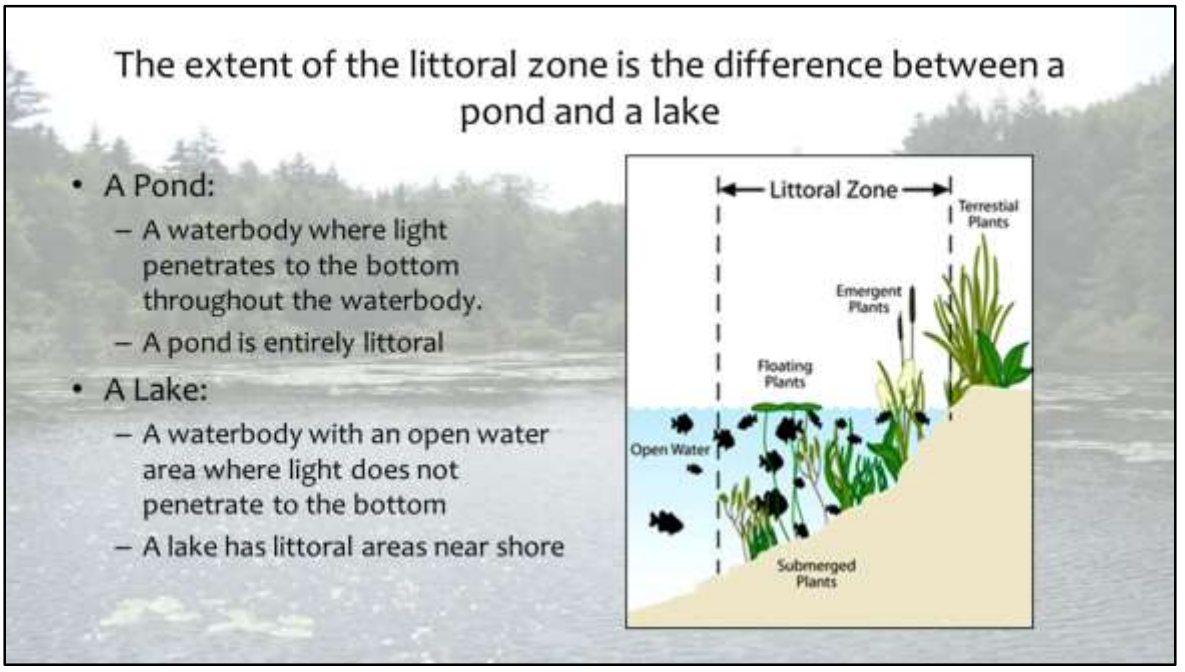
This presentation is one of two that were jointly prepared by Kellie Merrell and Angela Shambaugh for the Natural Shoreland Erosion Control Certification Trainings.

Lakes and Ponds are depressions in the land where water collects. They are permanent and they hold a large amount of water year-round. In Vermont, they range in size from Lake Champlain down to ponds 1 acre or less in size.

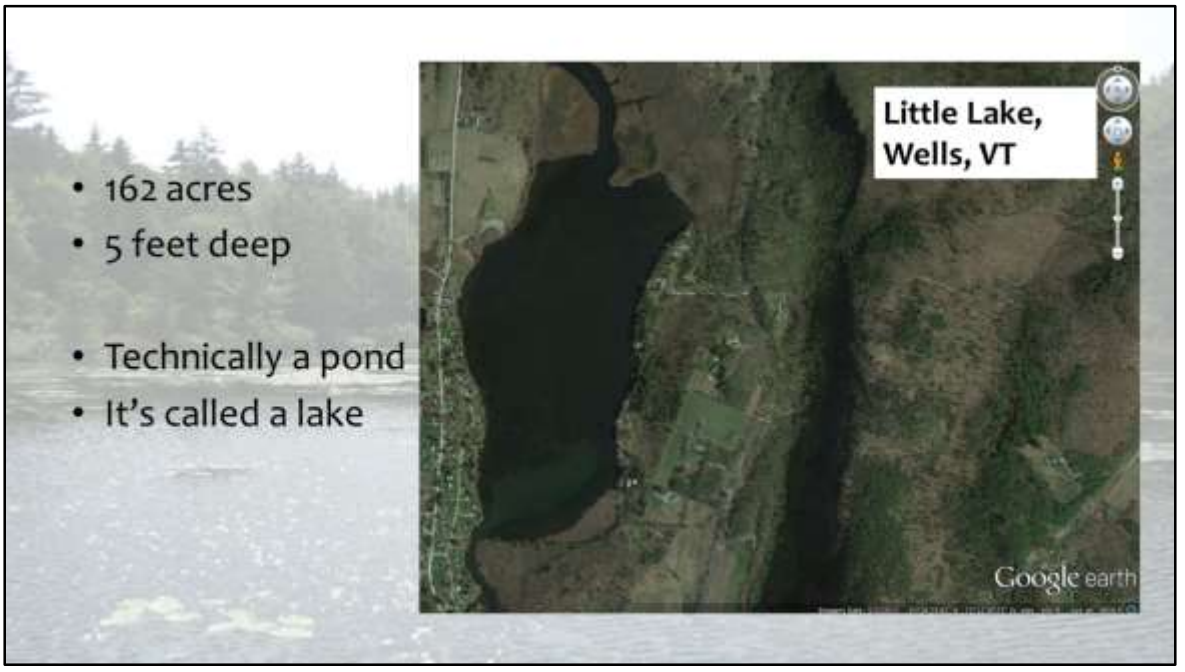


In the study of lakes, known as Limnology, lakes and ponds differ from each other in terms of depth. We call the area where light penetrates down to the bottom, the littoral zone.

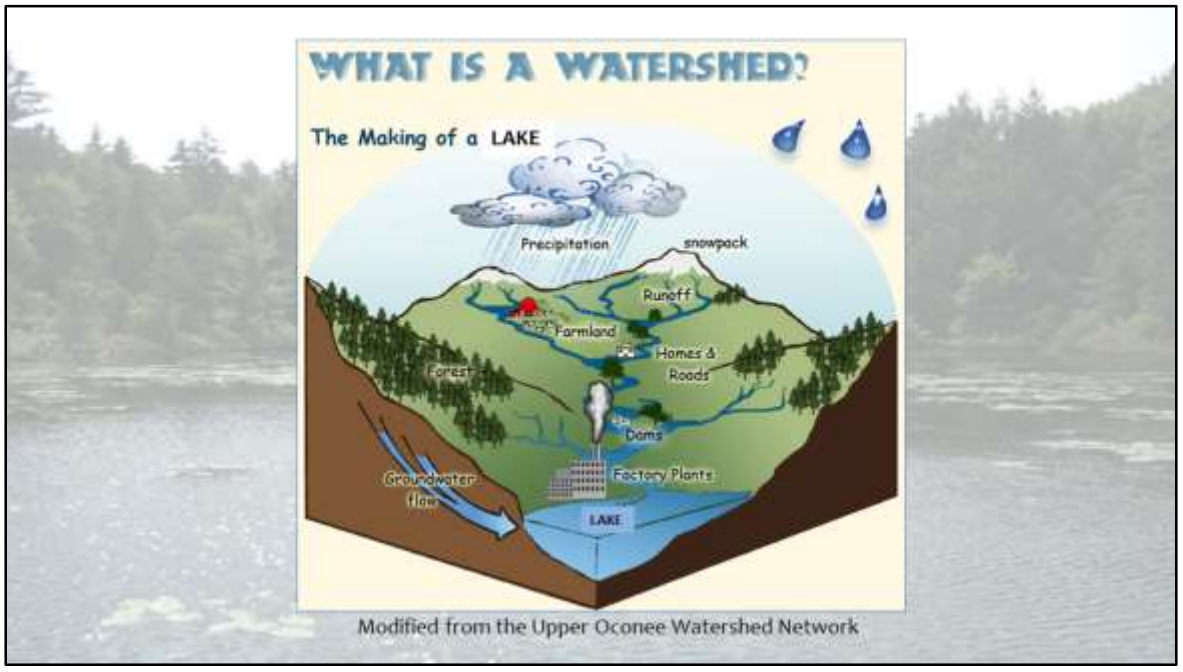
A pond is a waterbody where light penetrates to the bottom throughout the waterbody and hence aquatic plants can grow everywhere.

A lake is a waterbody with greater depths and open water areas where light does not penetrate to the bottom. This area tends to be cold and dark, and plants don't grow here

But we call lakes and ponds whatever we like. This is a lake that's called a pond.



And this is a pond that's called a lake

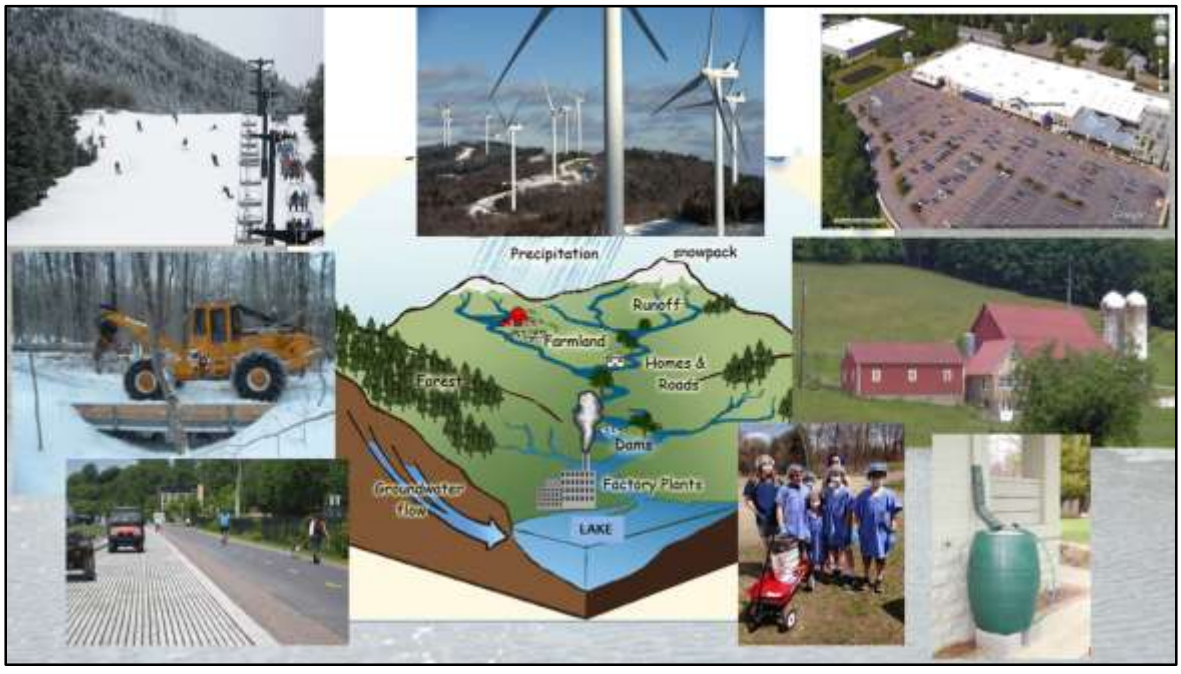


Lakes and ponds are the places where the water from the watershed ends up. Watersheds are the area of land funnel precipitation to a waterbody. The boundaries of watersheds are formed by the topography of the land. You may not be familiar with the term 'watershed' , but many of you were introduced to the concept in elementary school when you learned about the Continental Divide. The Rocky Mountains form the Divide and mark the boundary between two immense watersheds. Water falling to the east of the Divide eventually reaches the Atlantic. Water falling to the west eventually reaches the Pacific. Land to the east is the watershed of the Atlantic, to the west they are the watershed of the Pacific.

Watersheds nest within one another – within the immense watersheds of the Atlantic, for example, there are watersheds connected to every lake and pond. VT is divided into two large watersheds by the Green Mountains. Water falling to the east of the Greens does flow to the Atlantic, but gets there by way of the Connecticut River. Water falling to the west gets to the Atlantic by way of Lake Champlain and the St Lawrence Seaway. Every waterbody in VT has a watershed, right down to the puddles in your backyard.

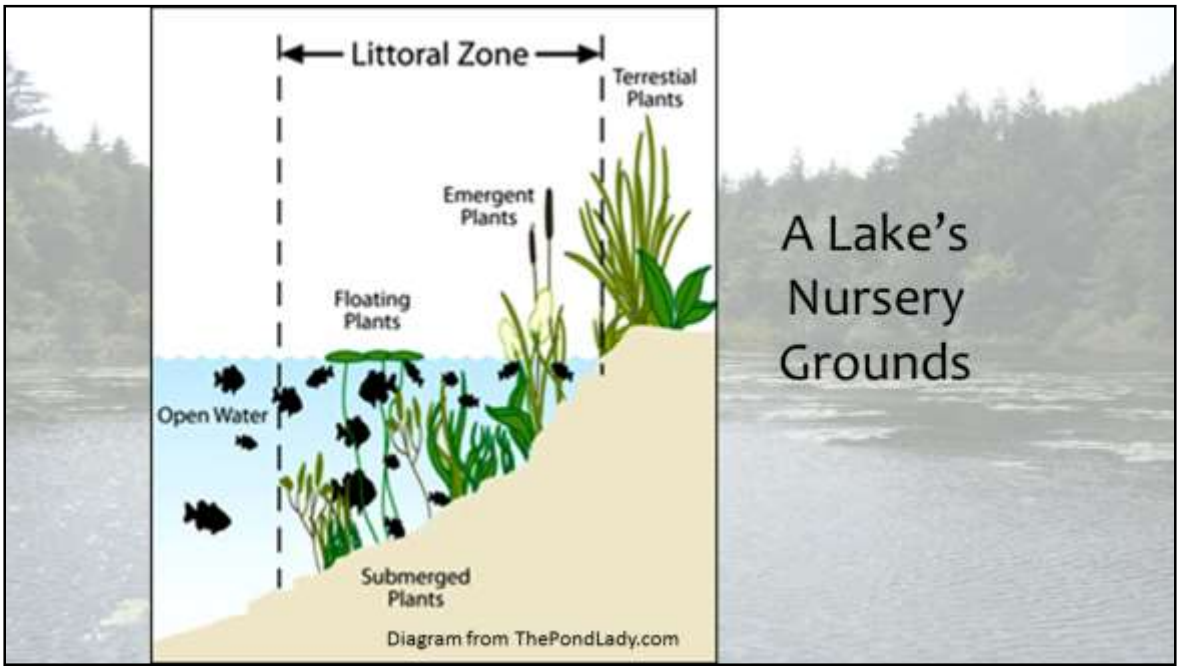
Water moving across the landscape picks up pollutants and other things as it flows. Eventually these reach the waterbodies at the foot of the watershed. We have known

for many years that activities on the land, far back up in the watersheds, will affect water quality in our lakes.



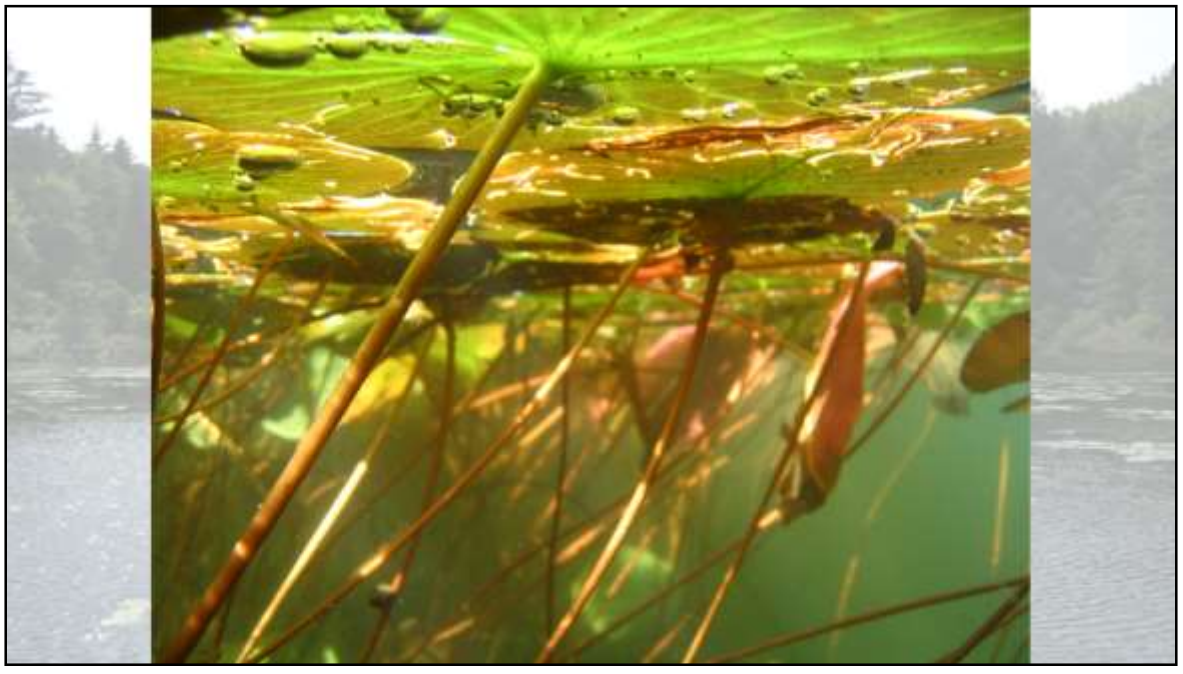
Hence, we have all kinds of regulations and voluntary activities geared toward protecting our lakes and ponds in the watershed miles from our lakes and ponds. All of these people and businesses are following regulations and implementing clean water practices to reduce the pollution traveling to our lakes and ponds.

But there is one area that was lagging behind in good management practices – the lake shore zone. We love our lakes and want to be close to them. Unfortunately, most of the changes made by property owners on the lake shore have a direct, and detrimental, impact on the lake they love.

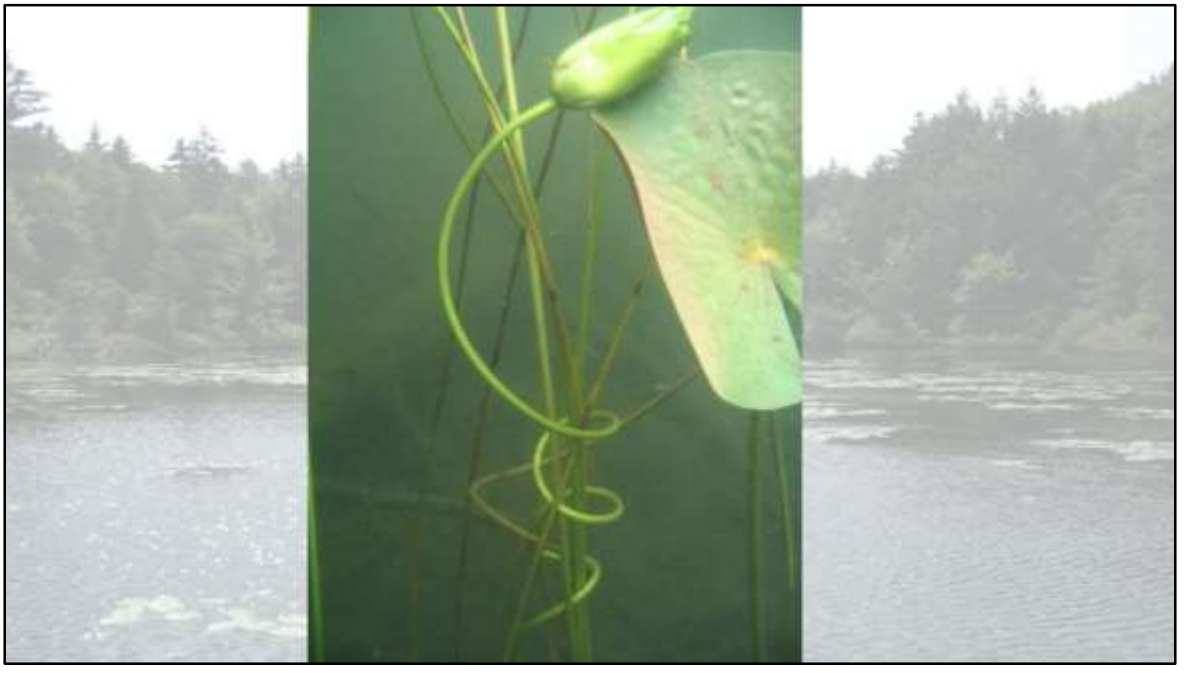


The littoral zone is a lake's nursery ground. It is full of a diverse array of plants, animals, insects and other invertebrates. It serves as their home, their food source, a place to raise their young and protection from predators. The diversity and complexity found in native littoral habitat is equal to that of coral reefs in the ocean.

Snorkeling or diving in these locations allows you to experience the diversity and abundance of fish, the variety of plants, and the character of each lake. Lake water chemistry is highly variable in VT and reflected in the diversity of plant or animal communities found in each lake. No two lakes are exactly alike.



Plants provide physical and vertical structure. This slows water movement, provides cover, provides food and protection. Aquatic plants have an amazing diversity in size and appearance..



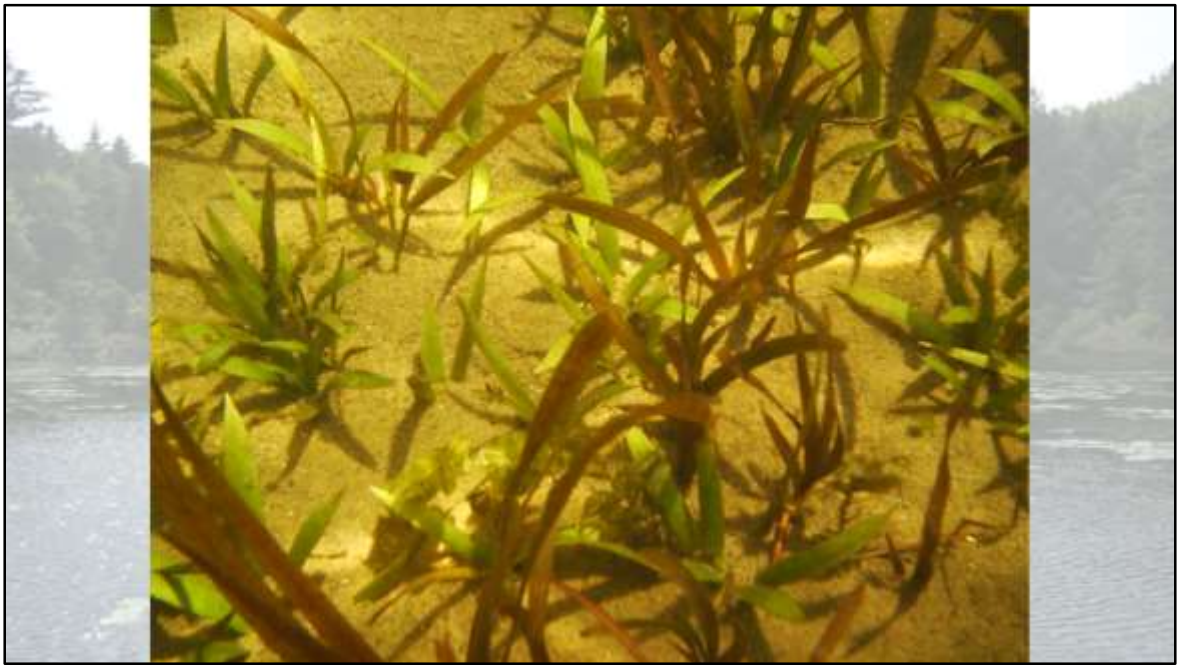
Habitat here is stable, changing little over the years in undisturbed lakes

The littoral zone provides a place for organisms of all sizes and kinds.

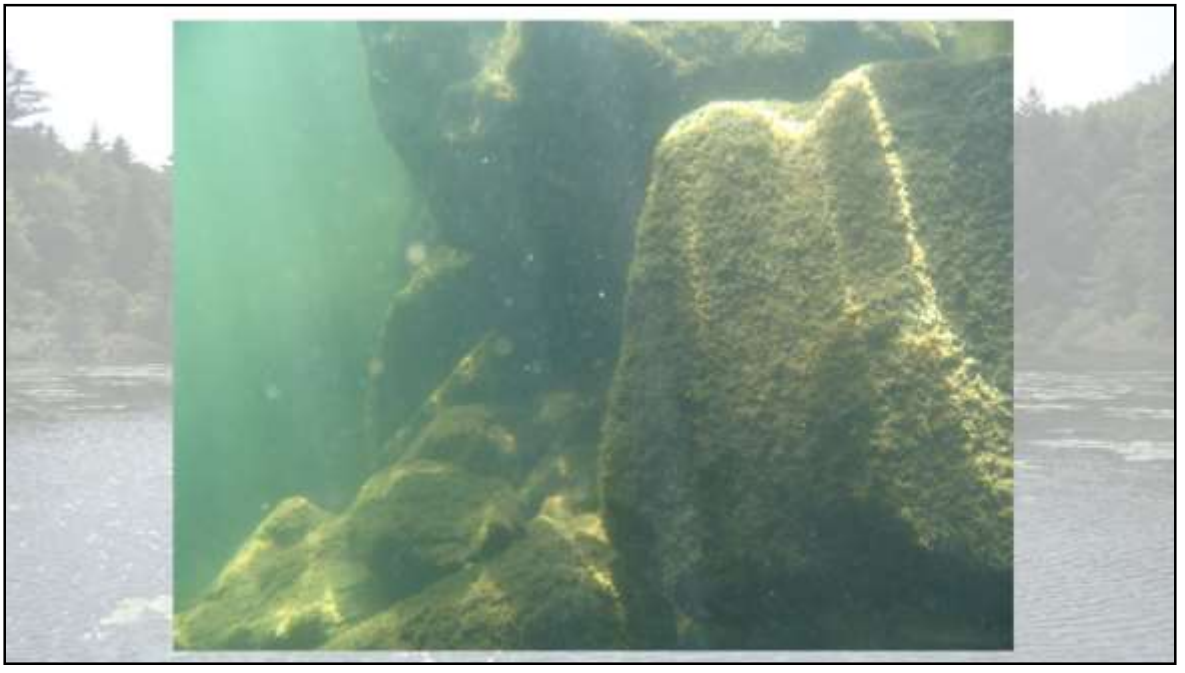
It provides food and nesting sites for fish

For insects

For amphibians



Plants provide lots of physical structure, but plants do die back at the end of the summer. That's when other more permanent natural structure like rocks becomes especially important.



Boulders and large rocks provide nooks and crannies to hide in. The fuzzy material seen here is a layer formed of algae, fungi and bacteria known as 'aufwuchs' or 'biofilm'. It serves a food source for many insects, snails, and small fish. So rocks provide not only cover, but also food.

Trees falling into the lake or pond are also providing another source of physical structure. The tangle of branches provides hiding and nesting places.

All sizes from full trees to smaller branches are important.

Here a freshwater sponge grows on a small branch that has fallen into the lake.

Leaves falling into the lake are an important source of food and cover. Many fisherfolk know about the group of aquatic insects found in streams that eat leaves, the 'shredders'. Insect larvae found in lakes also rely on leaf litter.

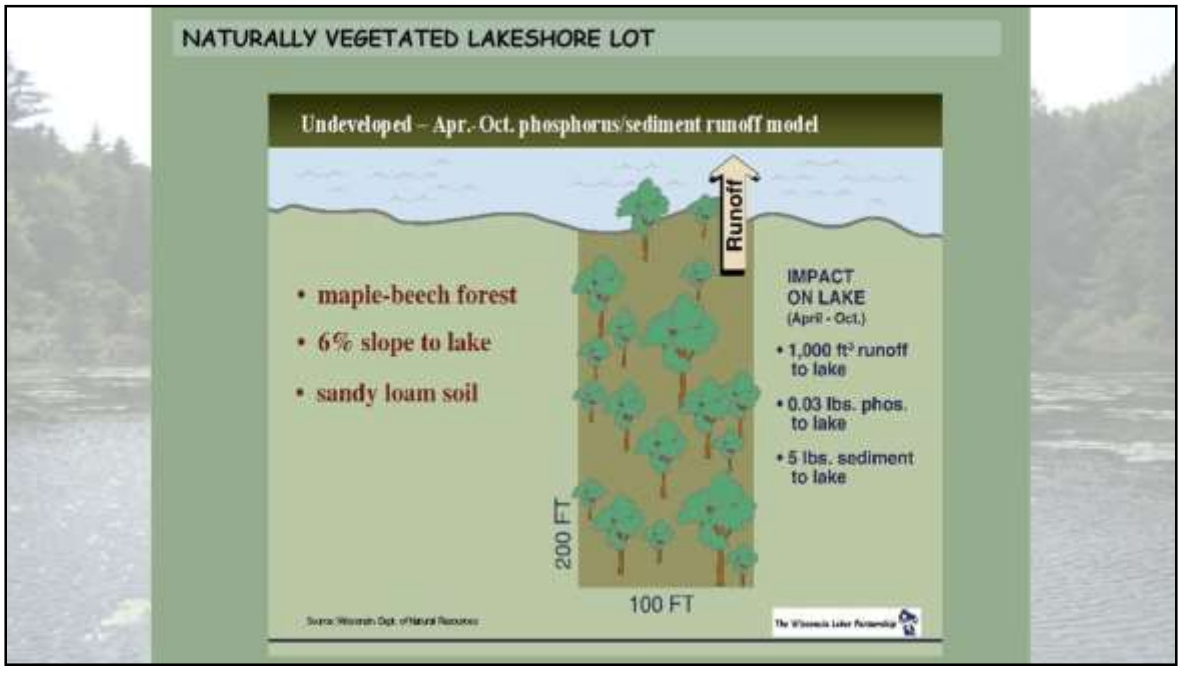
The range of sizes found in woody debris and in the rocky bottom is important.. Even the smaller cobble, pebbles and sand provide cover, a place for aufwuchs to grow

and a place for fish to nest

The diversity of life in the littoral zone is high

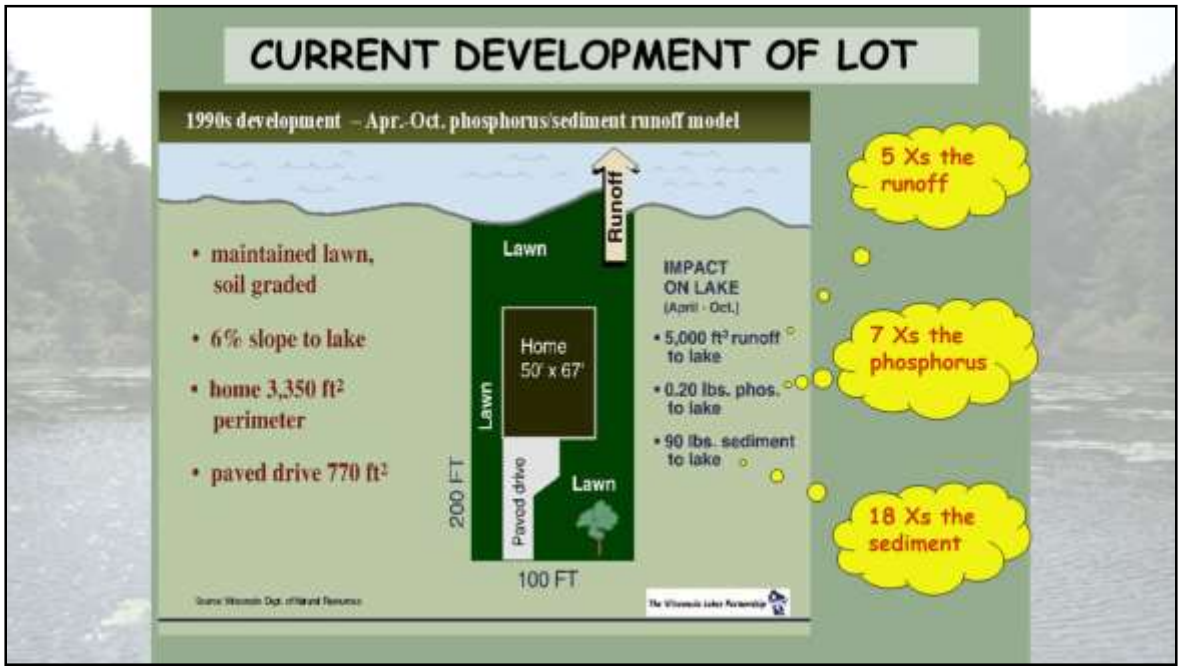
Shorelines in Vermont are primarily of two types – wetlands or marshy shores like this one

Or forested right down to the water's edge like we see here. Rocky and sandy shorelines can be found in Vermont, usually on the larger lakes, but are not common. Most shoreline on our inland lakes is (or was) wooded or marshy. Sandy shorelines on inland lakes are mostly locations where someone has trucked in sand and covered the original native littoral zone.



We spoke earlier of precipitation carrying pollutants across the land in a watershed. Even a fully forested, protected watershed allows water, phosphorus and sediment to reach the lake in small amounts. Lakes are adapted to, and need, those small inputs of phosphorus and sediment.

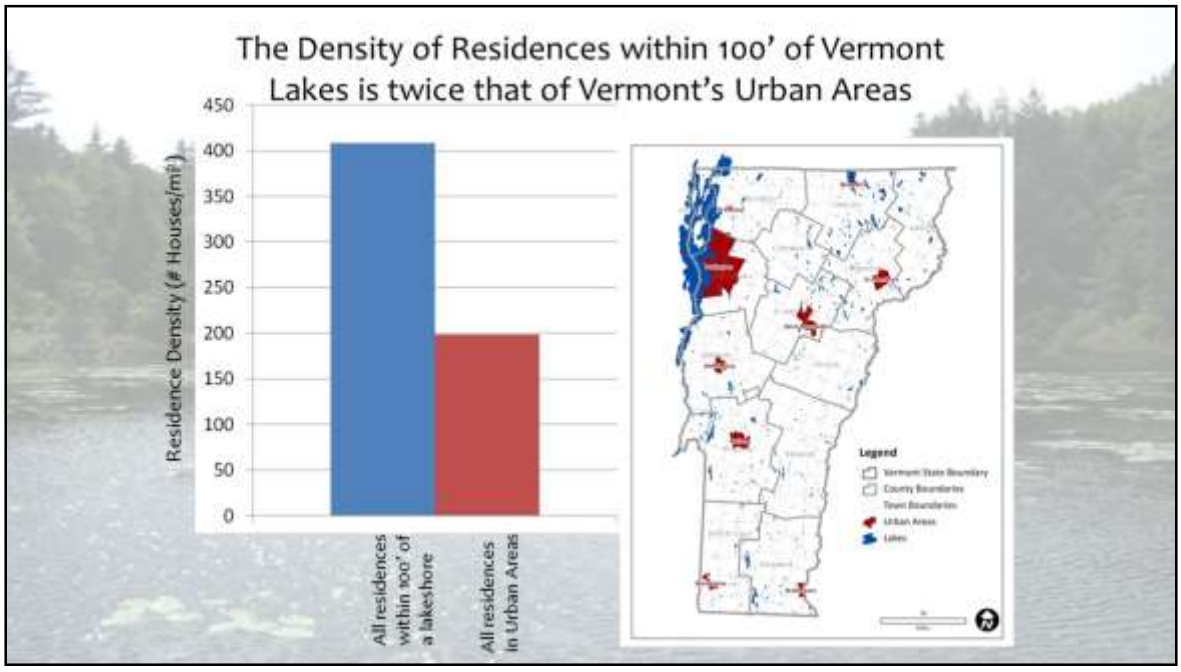
Wisconsin compared the natural amount of run-off, shown in this slide, to what occurs when a shoreline is developed.



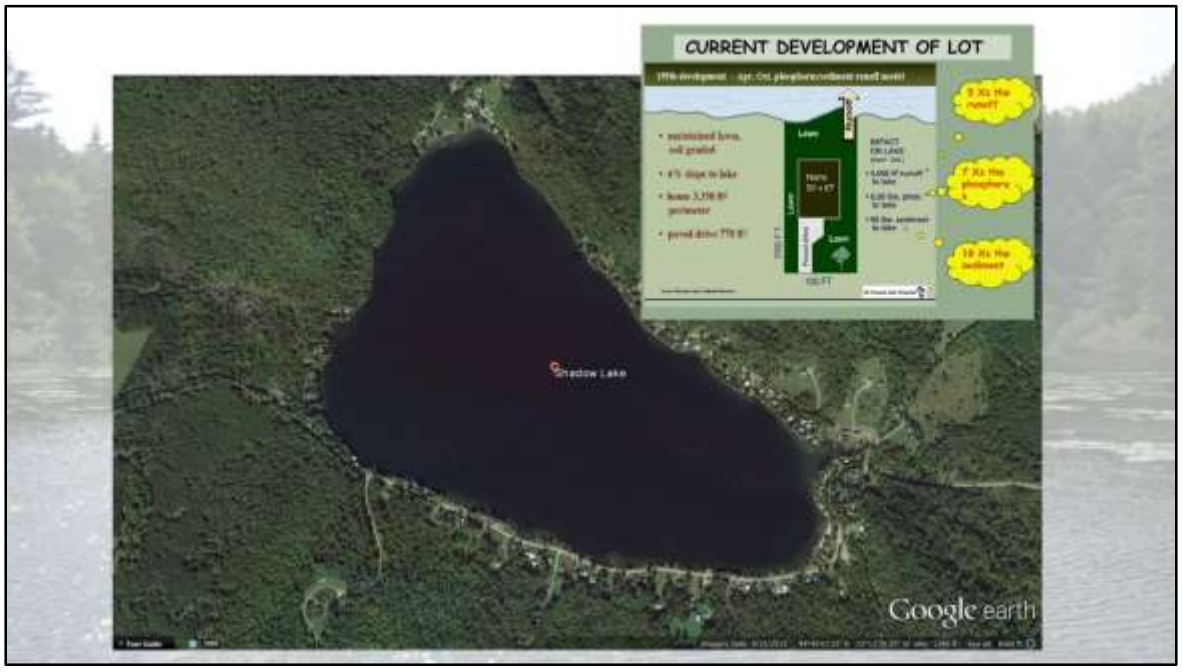
When we move to the lake, we tend to cut down all the trees and vegetation, put in a lawn all the way to the shore, and create impervious surface (where water can't seep into the ground) by building houses, garage and driveways. When we make those changes, we change what is running off the land and into the lake: there is 5x more runoff, 7x more phosphorus and 18x more sediment.

All that sediment runoff washes into the lake and buries the smaller rocks and the important small spaces they provide. It buries the eggs laid in these nursery grounds and keeps them from getting enough oxygen to survive. This is a rock that was pulled from the sediment off a developed site. The reddish line represents how far it was embedded into the sediment, how much of it had been covered by silt.

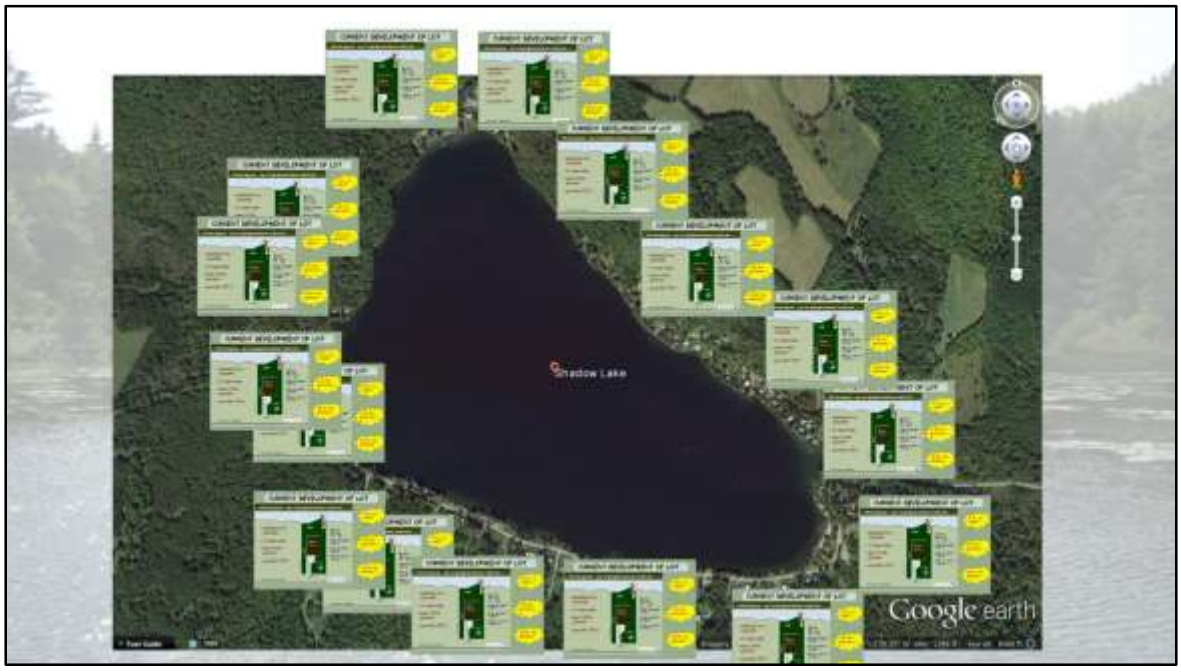
Eventually, the physical structure provided by the small rocks, the plants and woody structure found offshore disappears near developed sites. We create a desert where fish and other aquatic life don't want to spend much time because they don't feel safe and can't find food.



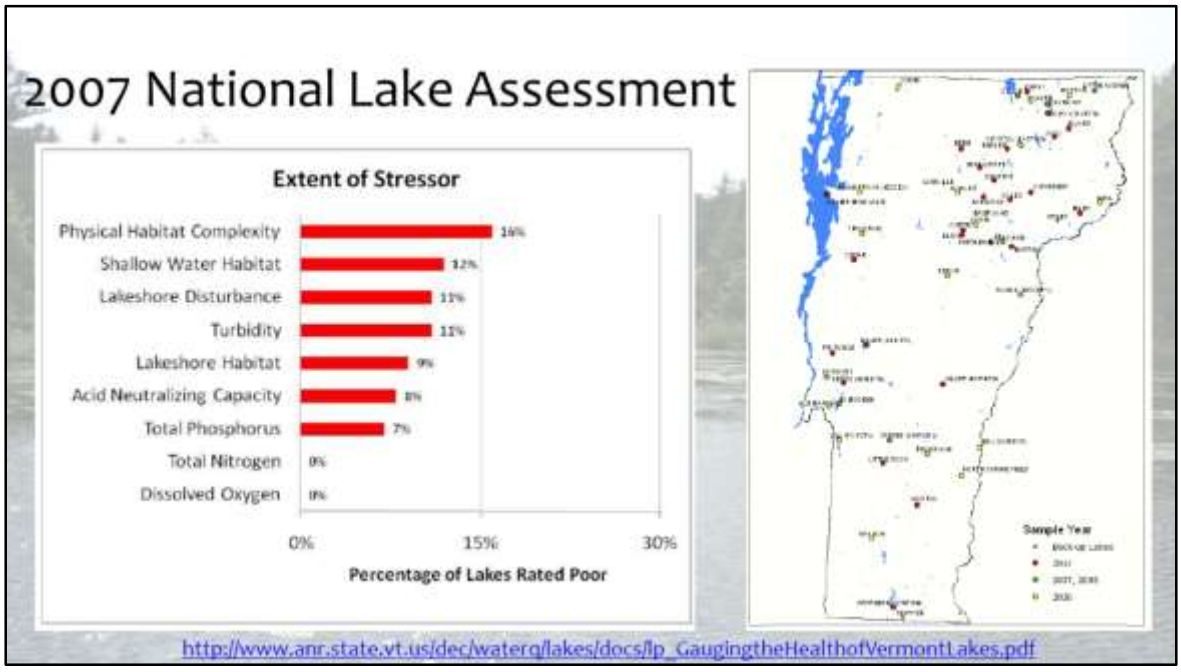
In Vermont, we love to live on our lakes. In fact, the density of residences within 100 feet of the water's edge is twice that found in our towns and villages. Roughly 400 home/mile are found in the shoreland zone, compared to 200 in our urban areas. For more information, see http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_residencedensity.pdf



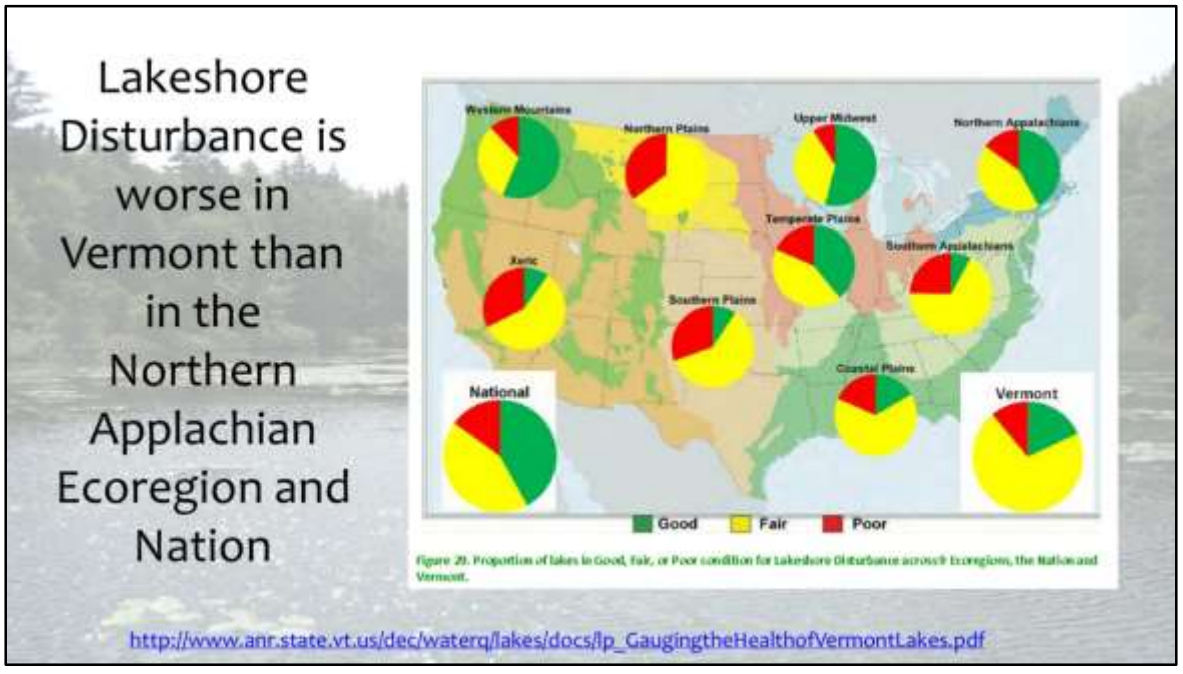
Lakes are resilient and can accommodate a few shoreline developments that add some additional phosphorus and sediment.
Shadow Lake in Concord, VT



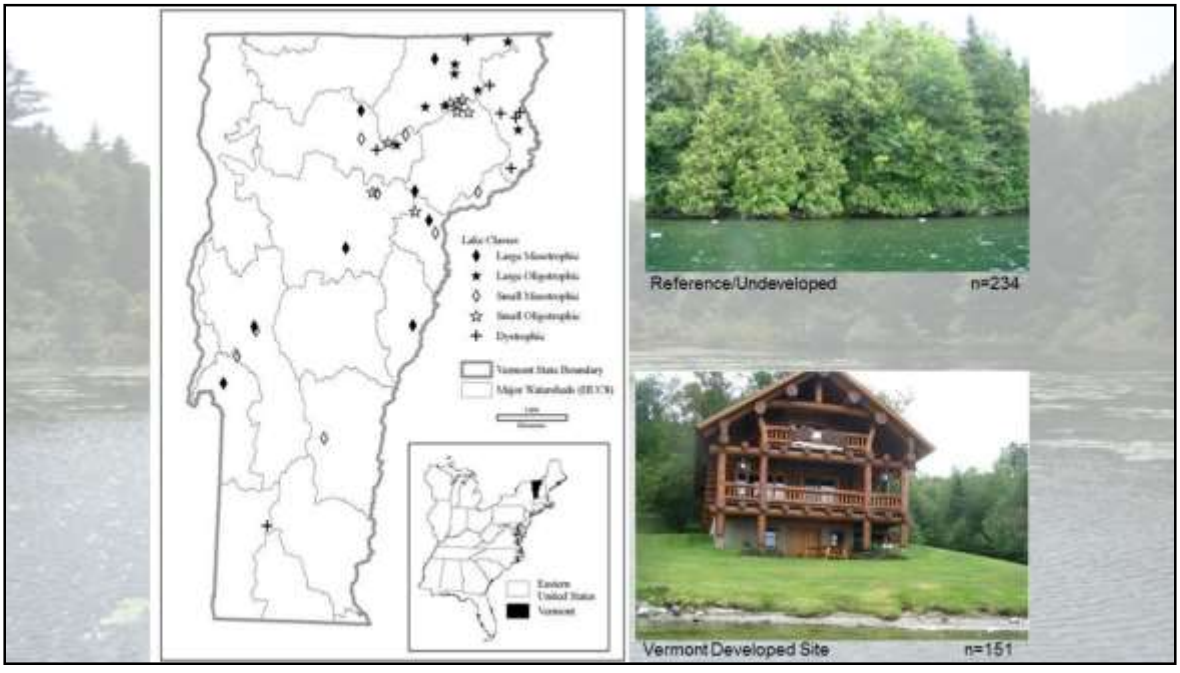
But no matter how resilient, a lake can only accommodate so much of the increased silt and phosphorus. As the amount of development increases, the lake will begin to change in many ways, starting in the littoral zone but eventually affecting the overall water quality.



Vermont participated in the 2007 National Lakes Assessment, where lakes and ponds across the entire country were evaluated using identical measurements and testing protocols. When results were compiled, the most common stressors affecting Vermont lakes were connected to the development along our lakeshores – loss of physical habitat complexity, loss of shallow water habitat, increasing lakeshore disturbance, increasing turbidity and loss of lakeshore habitat. Increasing phosphorus concentrations is also a concern, but changes in the littoral habitat are affecting more of our inland lakes.

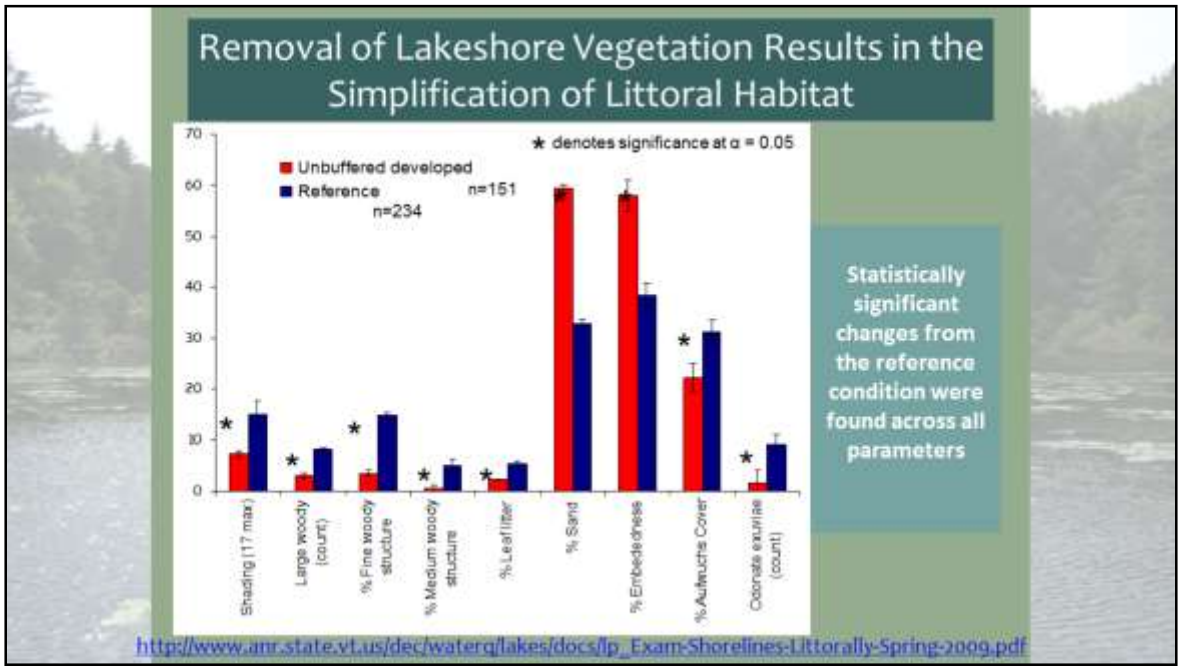


That same study measured the presence of human activity on the lakeshore and in the nearshore area as Lakeshore Disturbance, which can be thought of as how intensively we use our lakeshores and the likelihood that evidence of human activities will be visibly present on or near the lakeshore. Lakeshore disturbance levels in Vermont are considered fair or poor in more than 80% of lakes, notably worse than both the Nation and Northern Appalachian Ecoregion

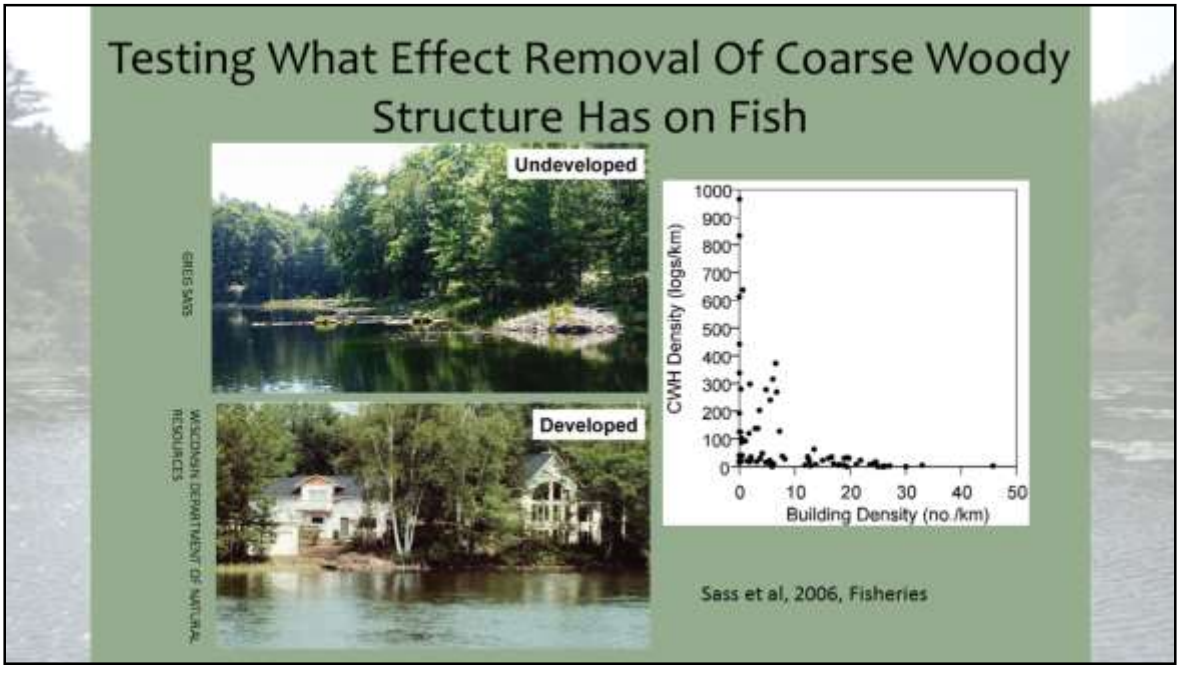


Kellie Merrell led a team of biologists in a project to understand how development affects the littoral habitat on Vermont's inland lakes. They selected 40 lakes where it was possible to find enough natural wooded shoreline to compare to physically similar developed sites on each lake.

Using standardized methods in the littoral zone and the lakeshore area, they collected habitat and biological data at each of the sites.

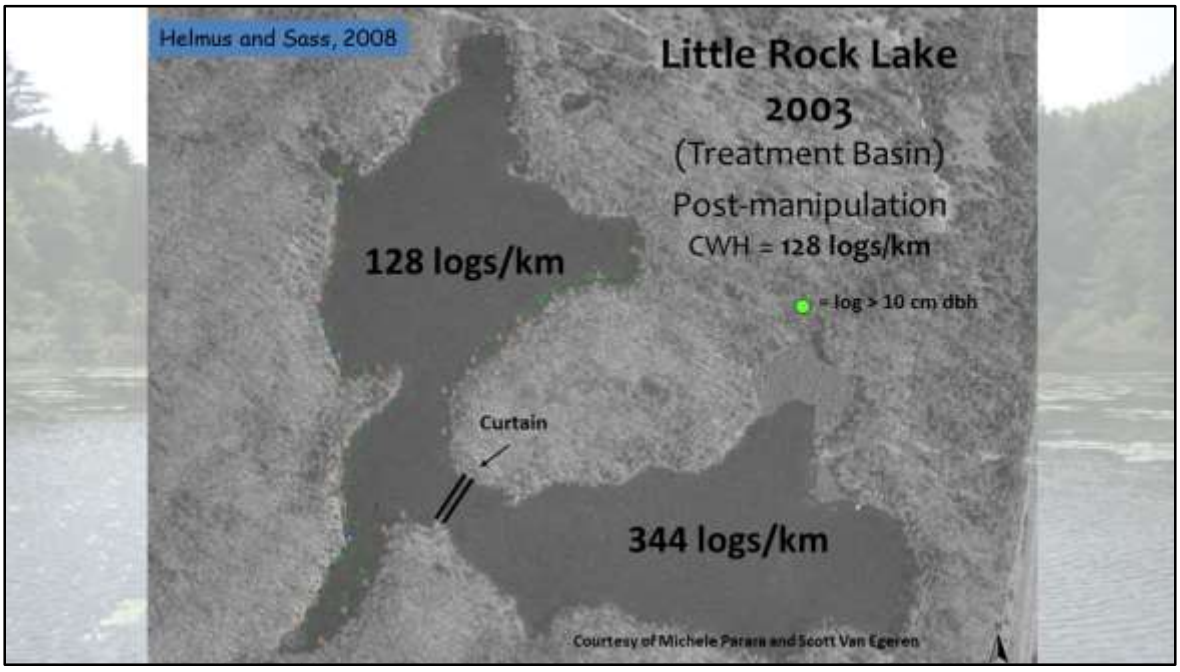


Here blue bars represent conditions at the undisturbed natural shoreline (reference condition), the red represents the disturbed shoreline. What they found was that across the board, for every habitat and biological parameter measured, there was a statistically significant difference from the reference condition. Along developed shores, there was significantly less woody debris of all sizes, less leaf litter and less shading – all connected to the loss of trees along the shoreline. The amount of sand increased, as did the embeddedness of the smaller rocks. There was less aufwuchs and evidence that Odonates (dragonflies and damselflies) were less abundant.

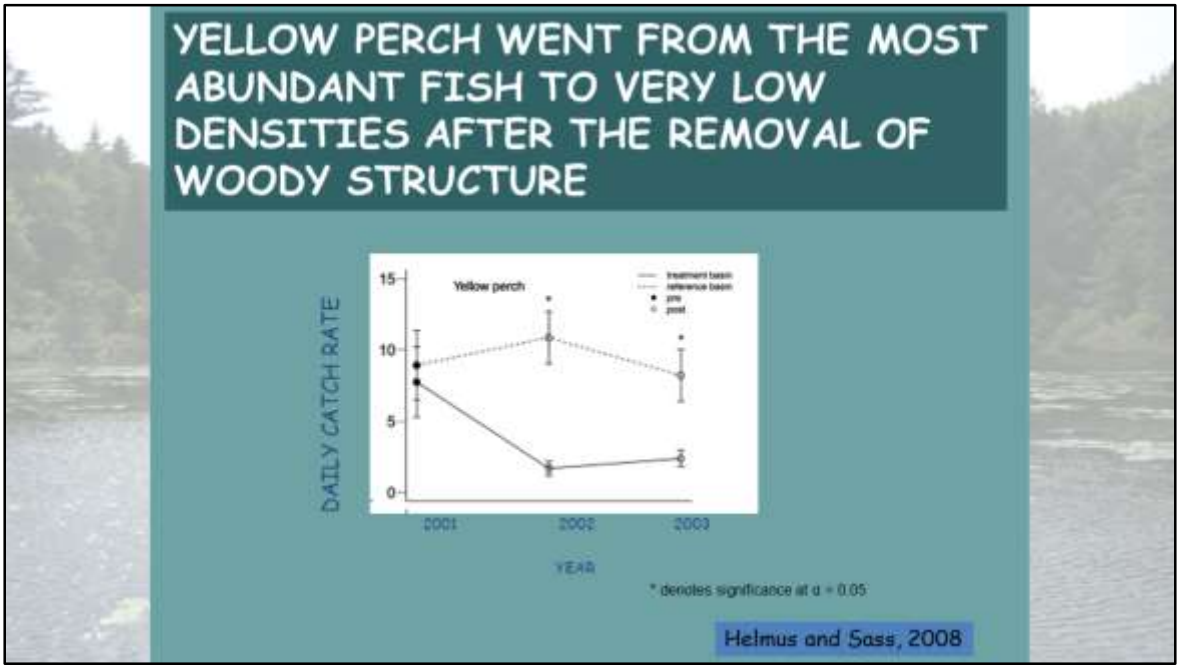


Vermont is not the only state to document changes that occur as development increases on lakeshores. This study in Wisconsin showed the amount of large wood debris (logs) decreased rapidly as building intensity increased.

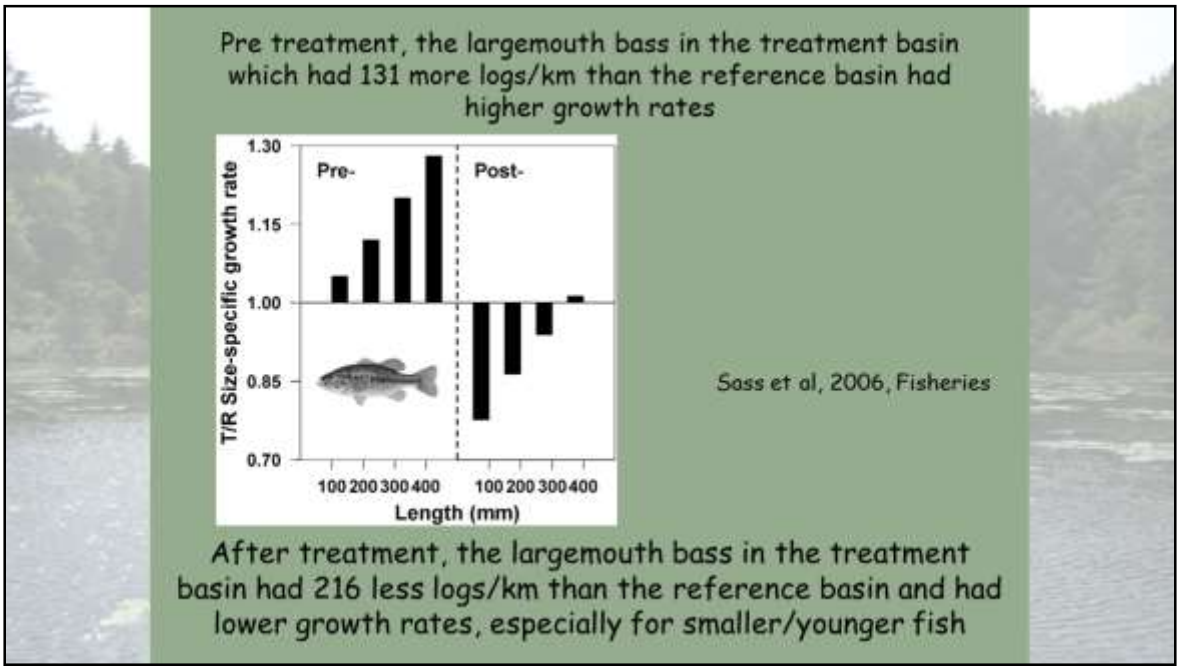
Those same scientists investigated what that change means for fish. They selected a lake with 2 distinct basins and then removed roughly half of the logs found in one of the basins.



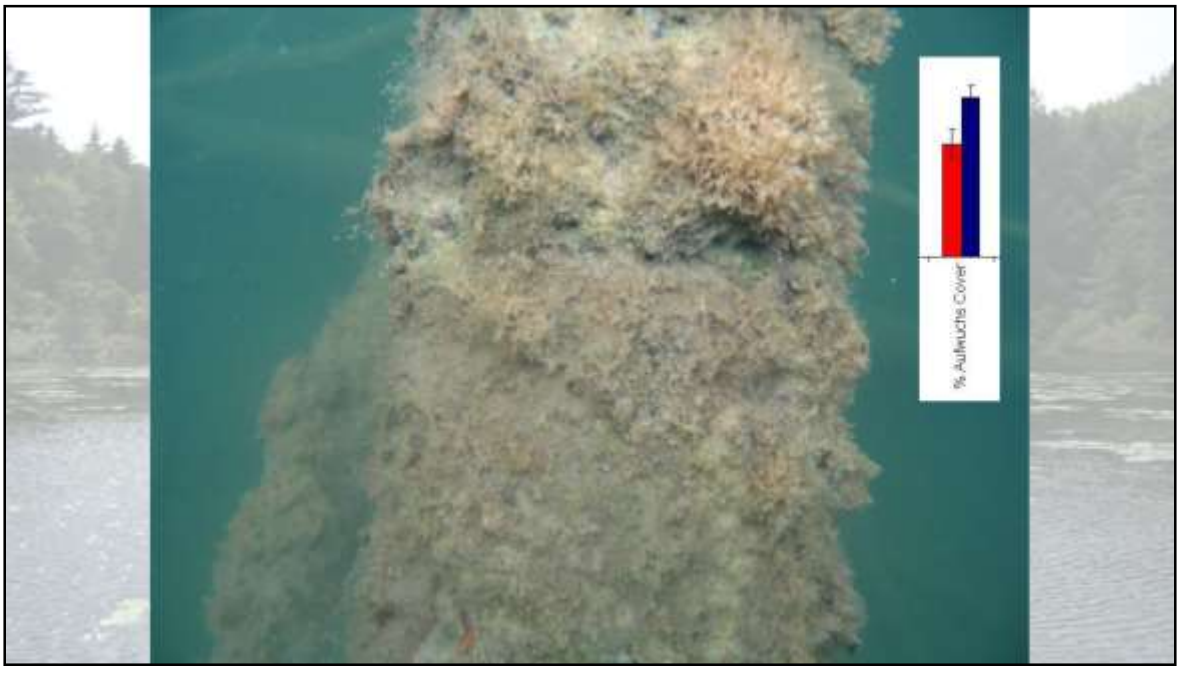
A barrier installed between the two basins prevented fish from moving between them. Log density was decreased all around the shoreline in one basin but left at the natural density in the other.



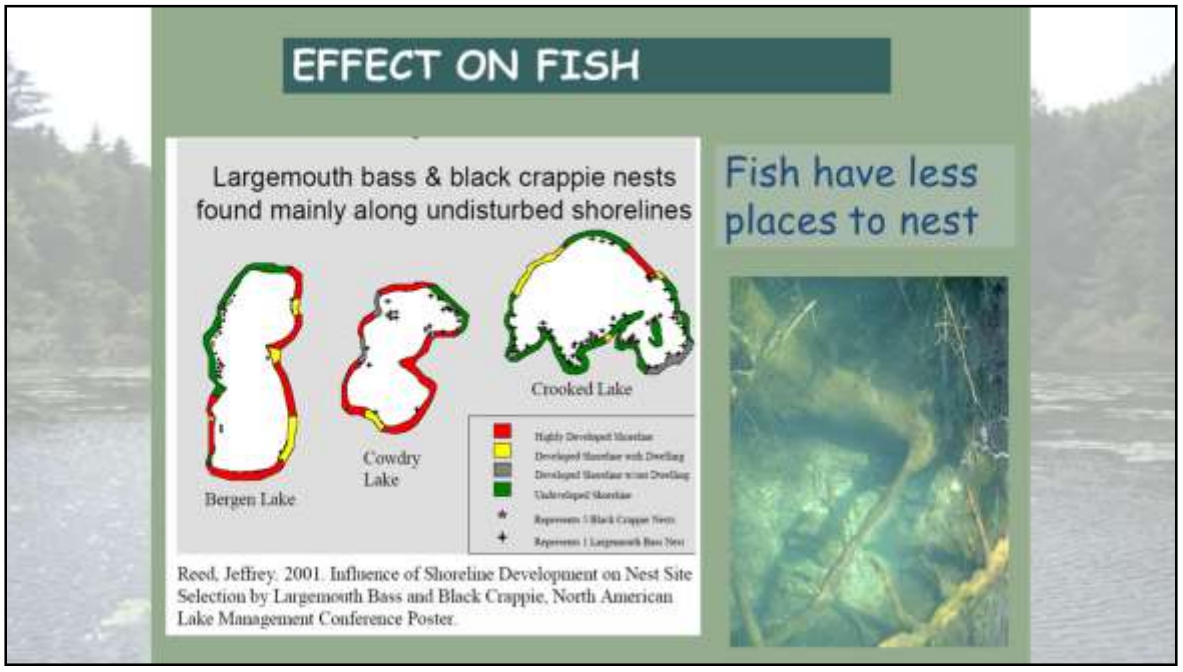
What they found was that the yellow perch population crashed in the treatment lake, the one with all the woody structure removed.



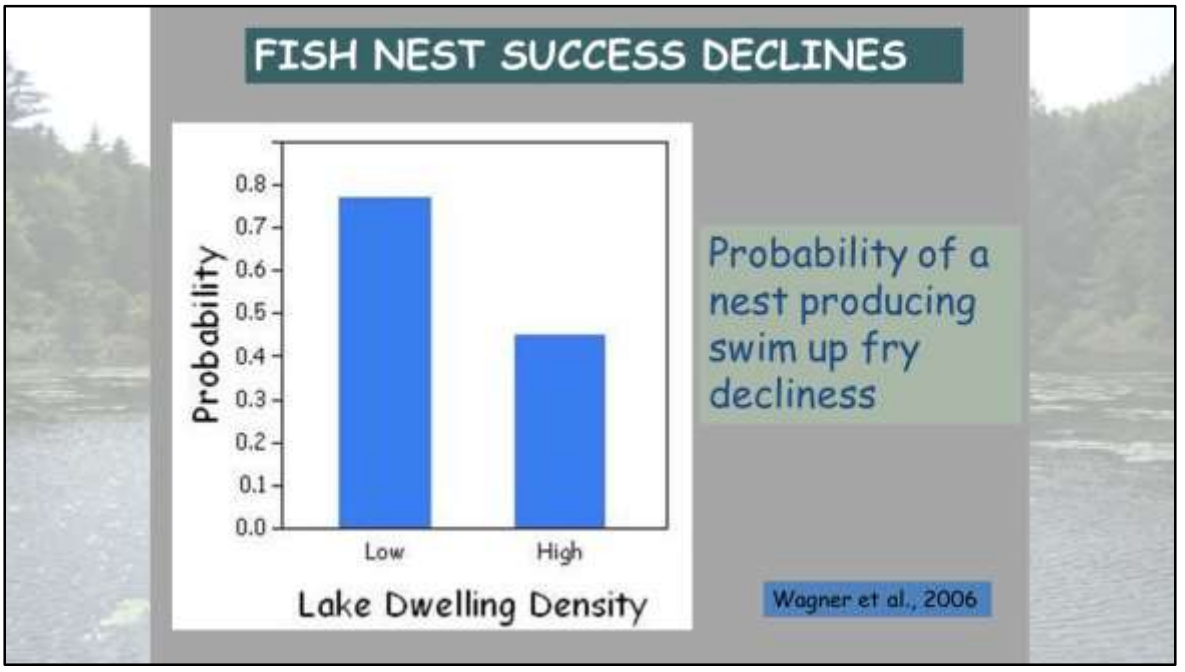
Removal of logs directly impacted largemouth bass as well. Their growth rate decreases significantly compared to the time frame before logs were removed, particularly for the smaller fish. They had fewer places to hide and less prey available.



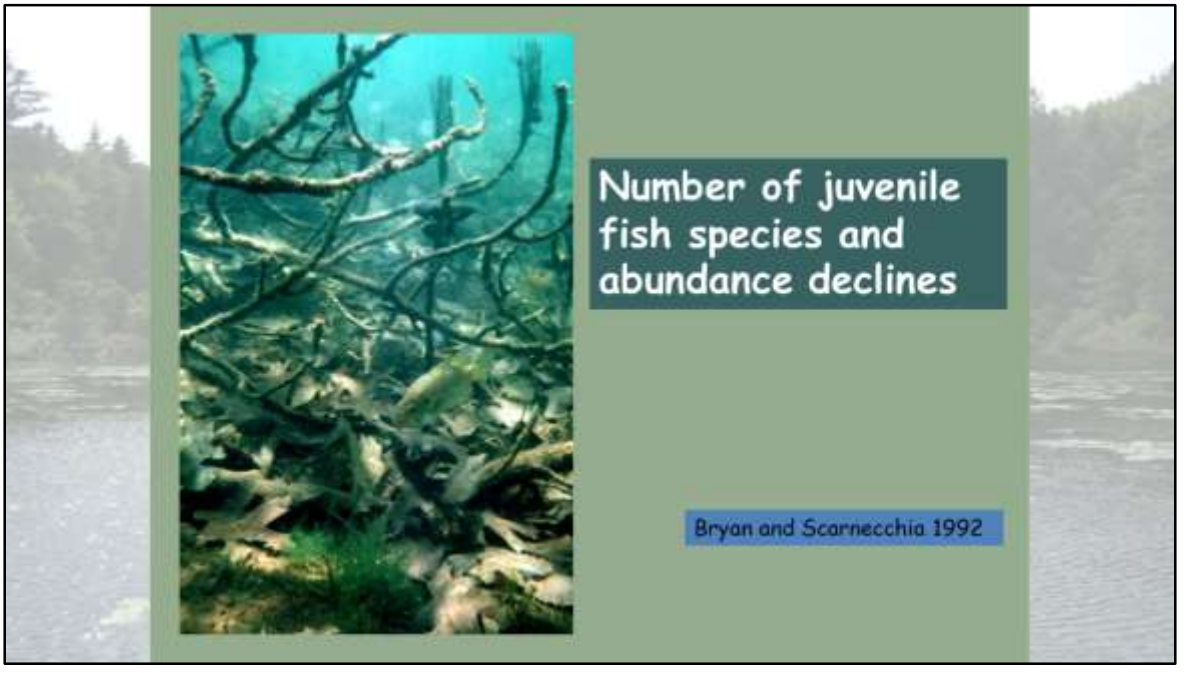
The removal of woody structure, also removes the substrate that a whole community of organisms lives on. This community is made up of microscopic animals, plants and bacteria that is an important food source for fish and macroinvertebrates. We found statistically significantly less of this community, what is called Aufwuchs off the developed sites vs undeveloped sites in our study on Vermont lakes.



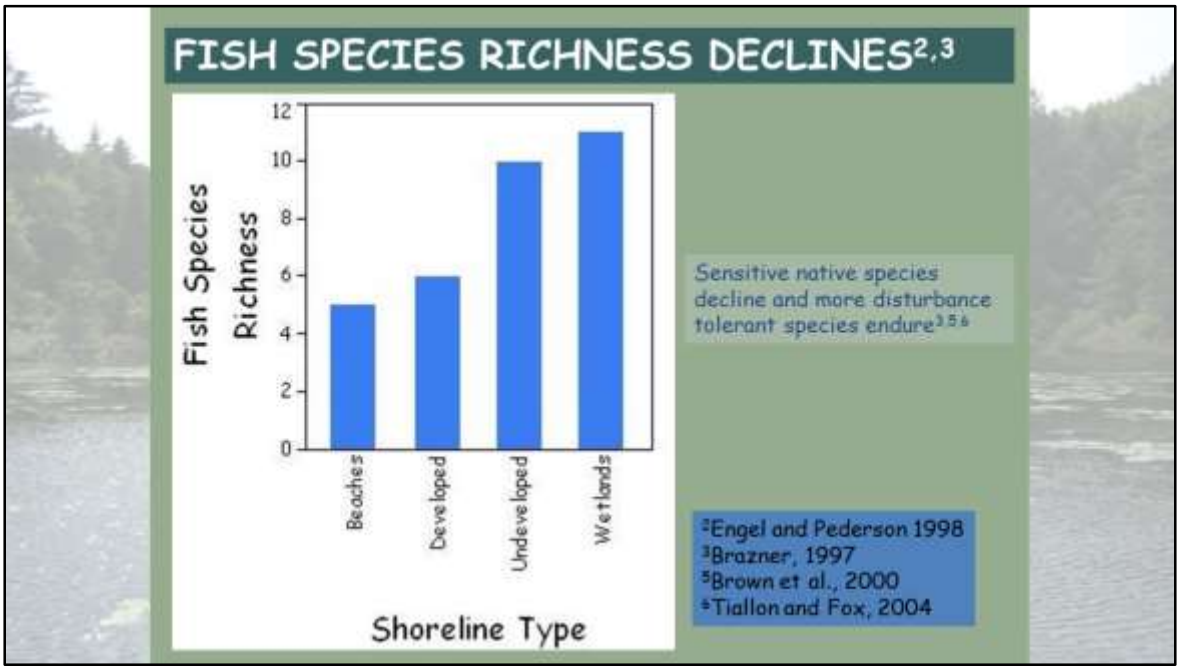
Another study looked at where bass choose to nest. Red and yellow on these lake silhouettes notes where development occurs, with red being most highly developed. Green marks natural shoreline. The black marks inside the boundaries shows where fish chose to nest. They look for sites providing the right substrate to protect and keep their eggs aerated. When given the choice, most of them don't nest off of developed shores.



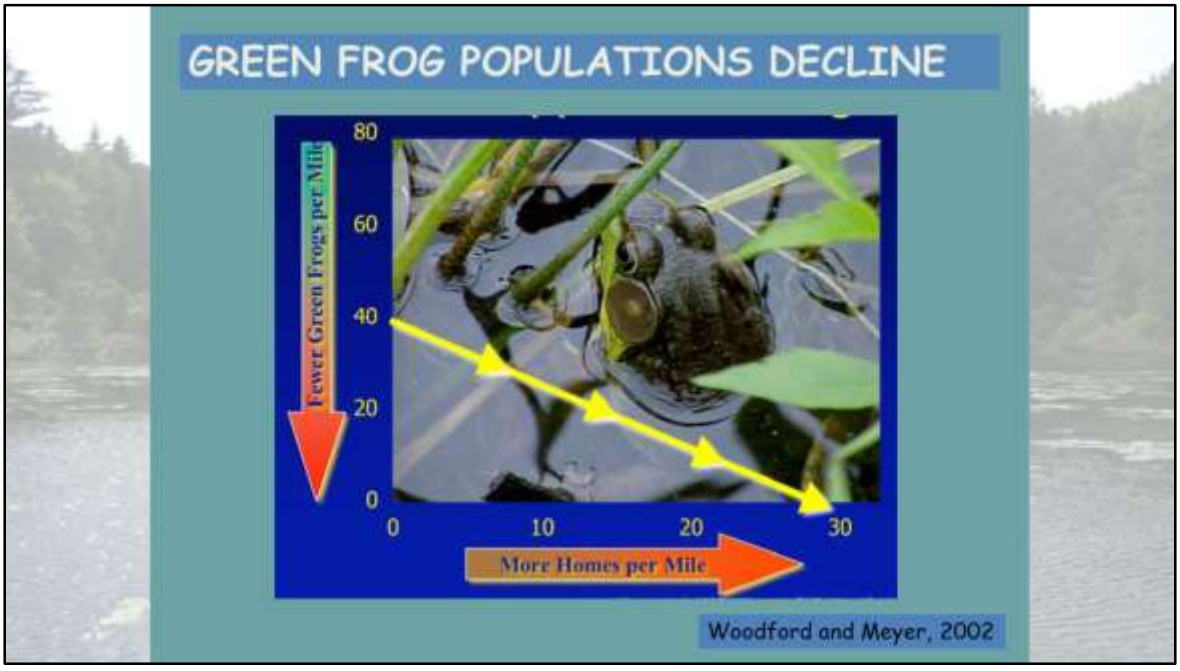
Another study found fish nests on lakes with denser development were less likely to produce swim up fry – those young fish that survive to leave the nest and begin life in the open water.



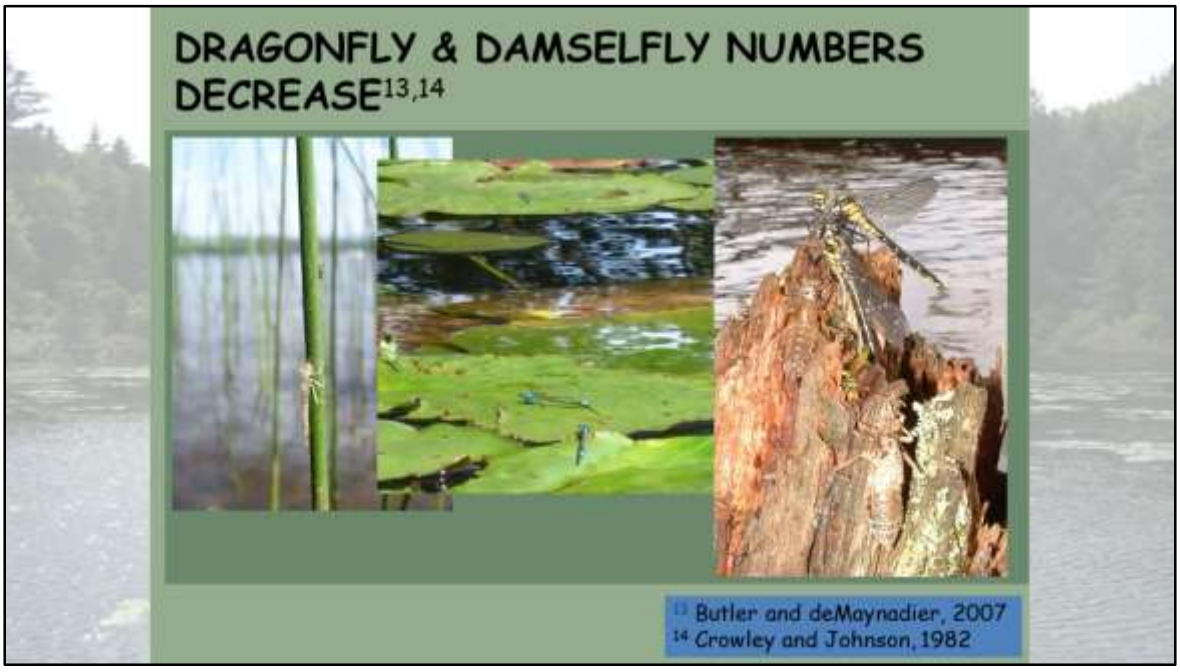
Another study found that the diversity and abundance of fish decline.



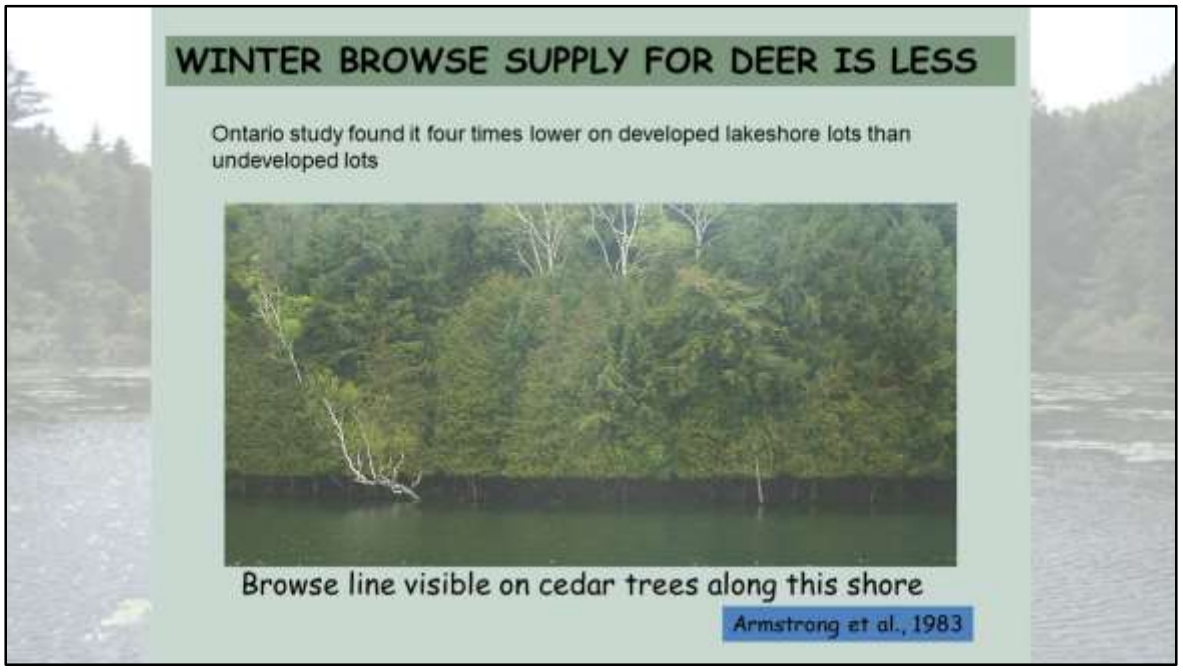
And another study found that the diversity of fish, the number of different species found within a lake, associated with developed lakeshore was less than undeveloped shores. Note that beaches have the least diversity of all shoreline types. Beaches have no protective cover, no food, no physical structure – they are not places fish and other aquatic creatures want to be.



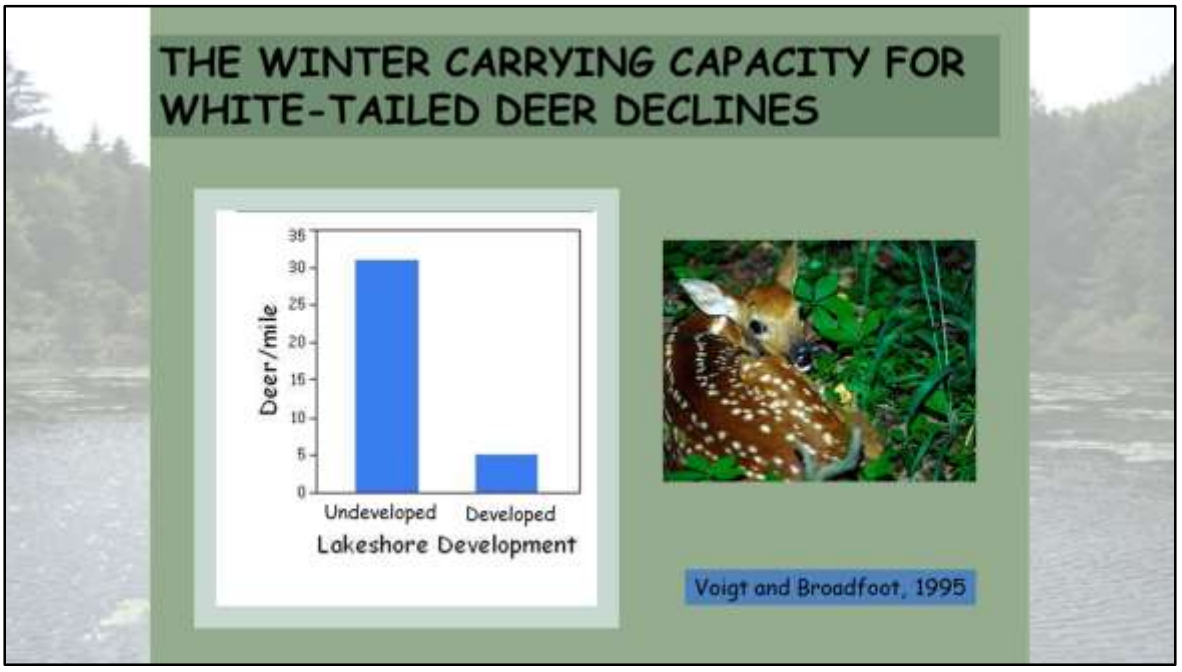
A study from Wisconsin showed that green frog abundance declines with increased homes per mile



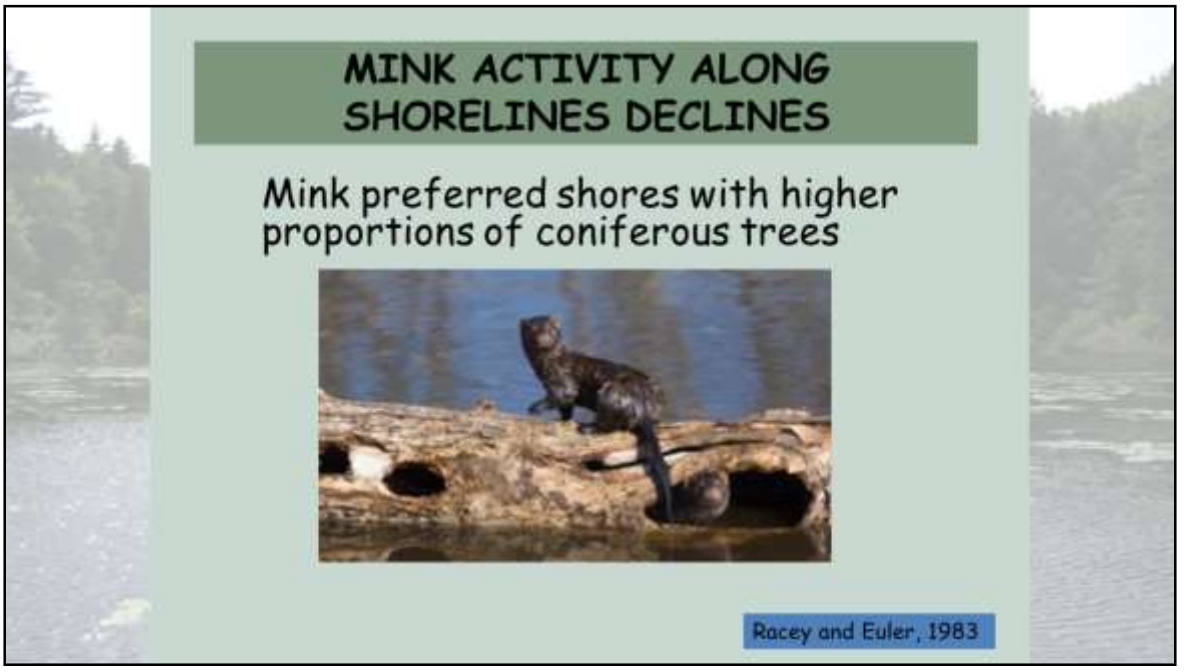
Dragonflies decrease with as natural habitat disappears and houses move in. Dragonflies eat mosquitos as adults and are food for fish when living in the lake.



Ontario study found the winter browse supply for deer was four times lower on developed lakeshore lots than undeveloped lots



This other study found that the winter carrying capacity of white tailed deer decline without that winter browse.

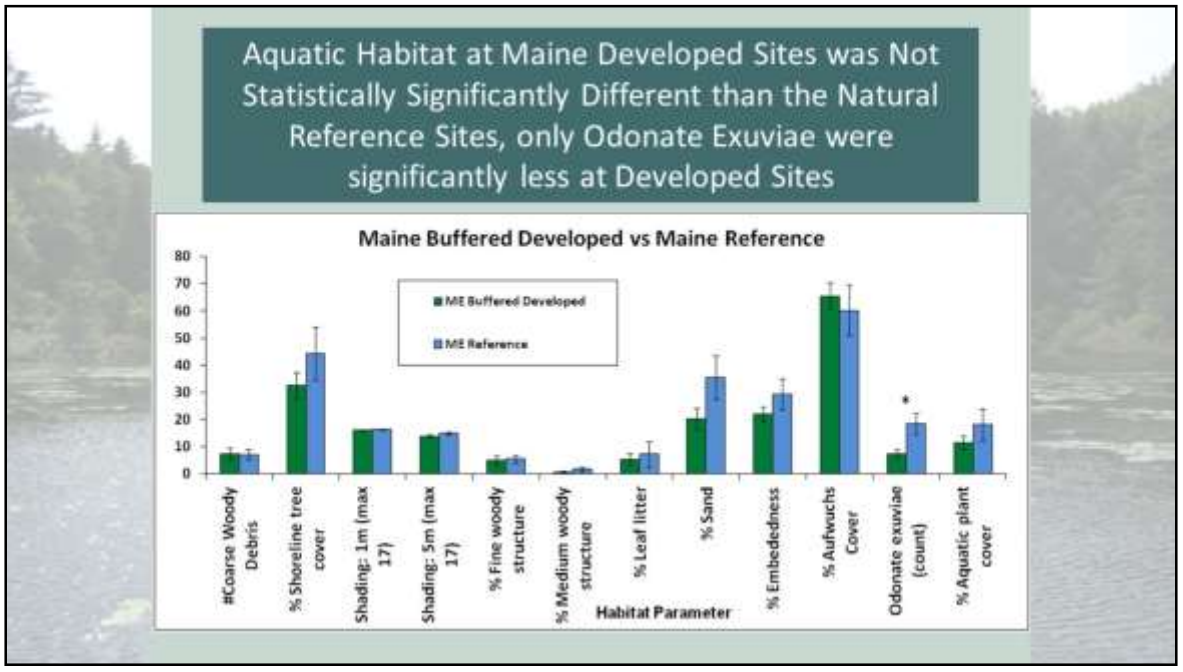


A study in central Ontario found that mink activity decreased as a function of the level of lakeshore development. Along buffered shores, mink activity varied depending on tree types. Shores dominated by decidous trees were not used much by mink. As the proportion of coniferous trees along the lakeshore increased, so did mink activity. The clearing of vegetation from developed lots was responsible for the decline in mink activity along developed shores.

So data from Vermont shows that development along our lakeshores has a direct, measurable effect on the littoral habitat. When we move to the lakes we love, we change them in ways that cause harm to the very things we cherish.

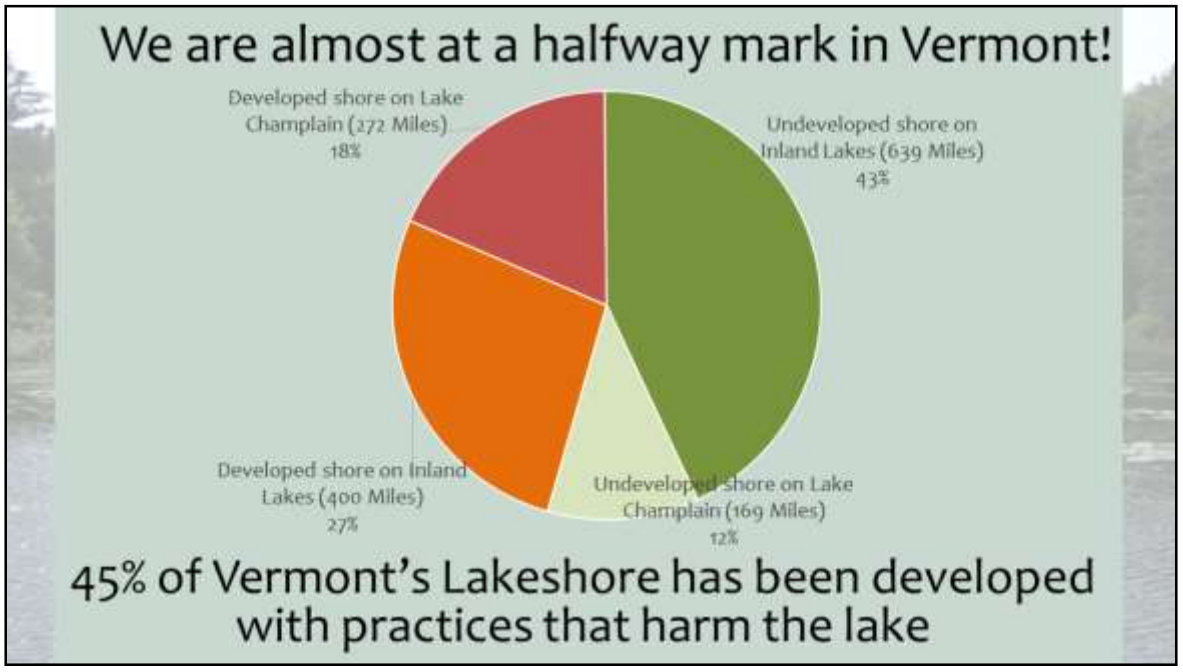
So, what can we do? In the 1970s, both Maine and Vermont enacted shoreline protection laws. Vermont repealed theirs within a year. Maine did not and has been increasing shoreline protection since that time. Kellie took her team on the road to Maine and evaluated littoral habitat conditions there, using the same methods she used to evaluate Vermont's lakes.

THE QUESTION IS CAN YOU DEVELOP AND PROTECT THE LAKE?? ANSWER WAS YES!! Because Maine has done just this!



Here the green bars represent lakeshores developed following the Maine standards and blue represents sites that were wooded down to the water's edge. The team found that there was no difference between developed and undeveloped shores in all but one measurement. Thoughtful development – leaving trees and vegetation along the shoreline following Maine's guidelines – safeguarded life in the littoral zone. It is possible to live along the shores of the lakes we love and preserve the very things that brought us to them in the first place.

YOU CAN DEVELOP AND PROTECT THE LAKE!! FOLLOWING BMPS IS THE KEY!



We are at the halfway mark in Vermont. We've got roughly 1,500 miles of lakeshore on all our lakes 10 acres in size or greater. 45% of it has been developed in ways that have a direct measurable impact on the littoral zone and the habitat it provides for aquatic life. We know that changing how we build and live on lakeshores makes a difference. That's why we are here today – to share the BMPs and techniques that will allow us to live near the lakes we love with minimal change to the aquatic life that live there too.

http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_undevelopedlakeshore.pdf