

When the Sea Rose 400 Feet

The Hudson Valley and the End of the Ice Age

*Lecture at the Center for the Urban River
at the Beczak Center, Yonkers NY*

*Bill Menke
Lamont-Doherty Earth Observatory
Columbia University*

Summary. The next time you take a hike, put aside your vision of a forest primeval, of woods stretching back through time to some dim era when dinosaurs walked the earth. The woods in this Hudson Valley are young! Run time backwards one hundred generations of oak and maple and you will find every living thing *gone*. No trees, no bushes, and no grass; no deer, no turkey, and no bear; no worms, no snakes, and no grasshoppers; just a blazing-white expanse of the great continental glacier of the Ice Age. All life began here when it melted. Everything around here is its legacy.

Part 1

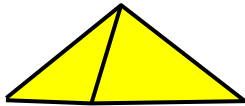
Everything Changes



Very Old



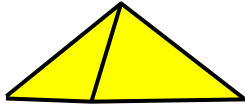
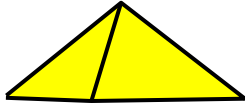
Great Pyramid at Giza
roughly 5000 years old



1 pyramid

5000 years

Imagine



what the
Hudson Valley
was like
4 Pyramids Ago ?

(20,000 years)



Whitetail
Deer



Whitetail
Deer

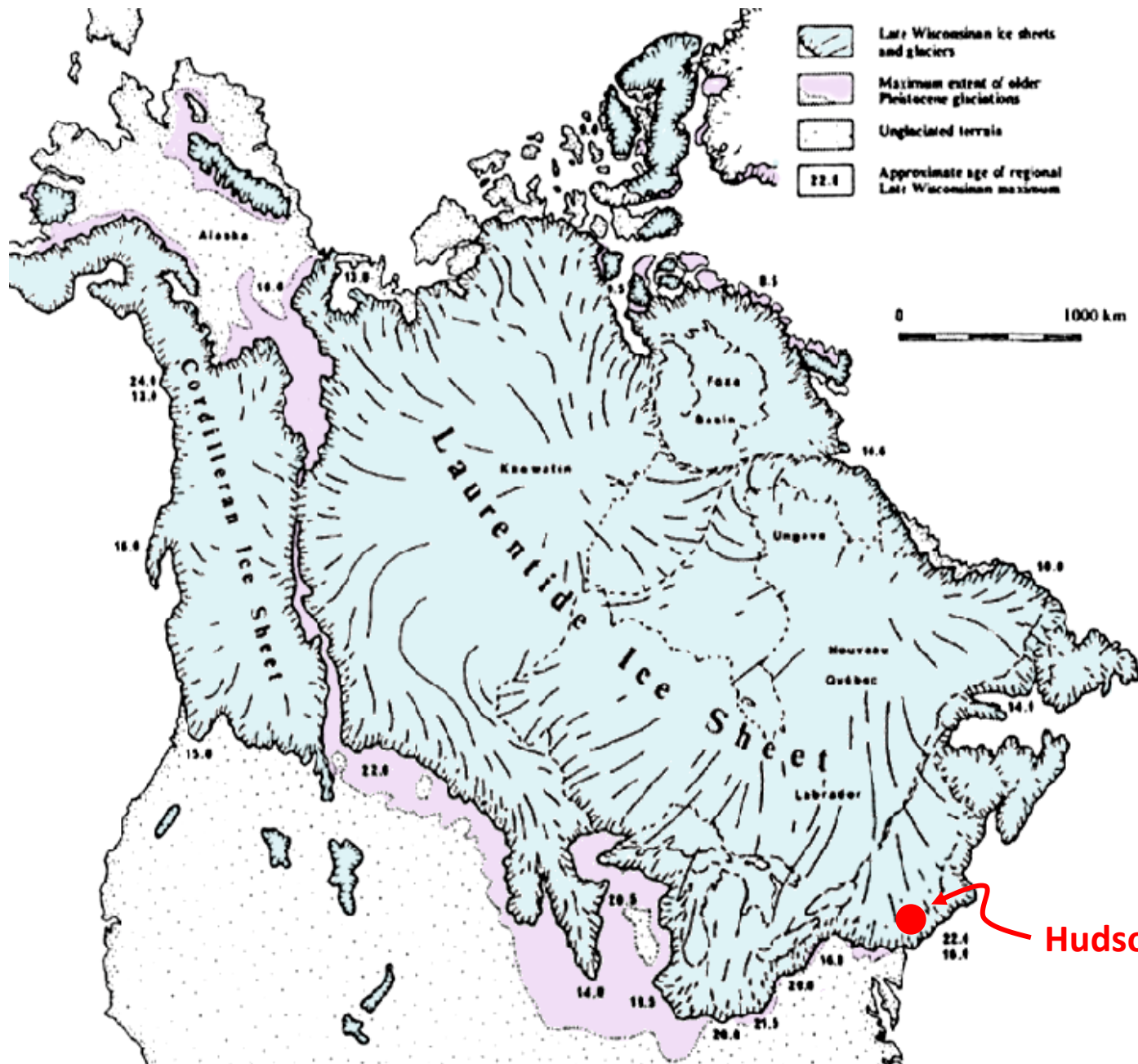






Greenland Ice Sheet

Absolutely nothing

lived in the Hudson Valley





-  Late Wisconsinan ice sheets and glaciers
-  Maximum extent of older Pleistocene glaciations
-  Unglaciated terrain
-  Approximate age of regional Late Wisconsinan maximum

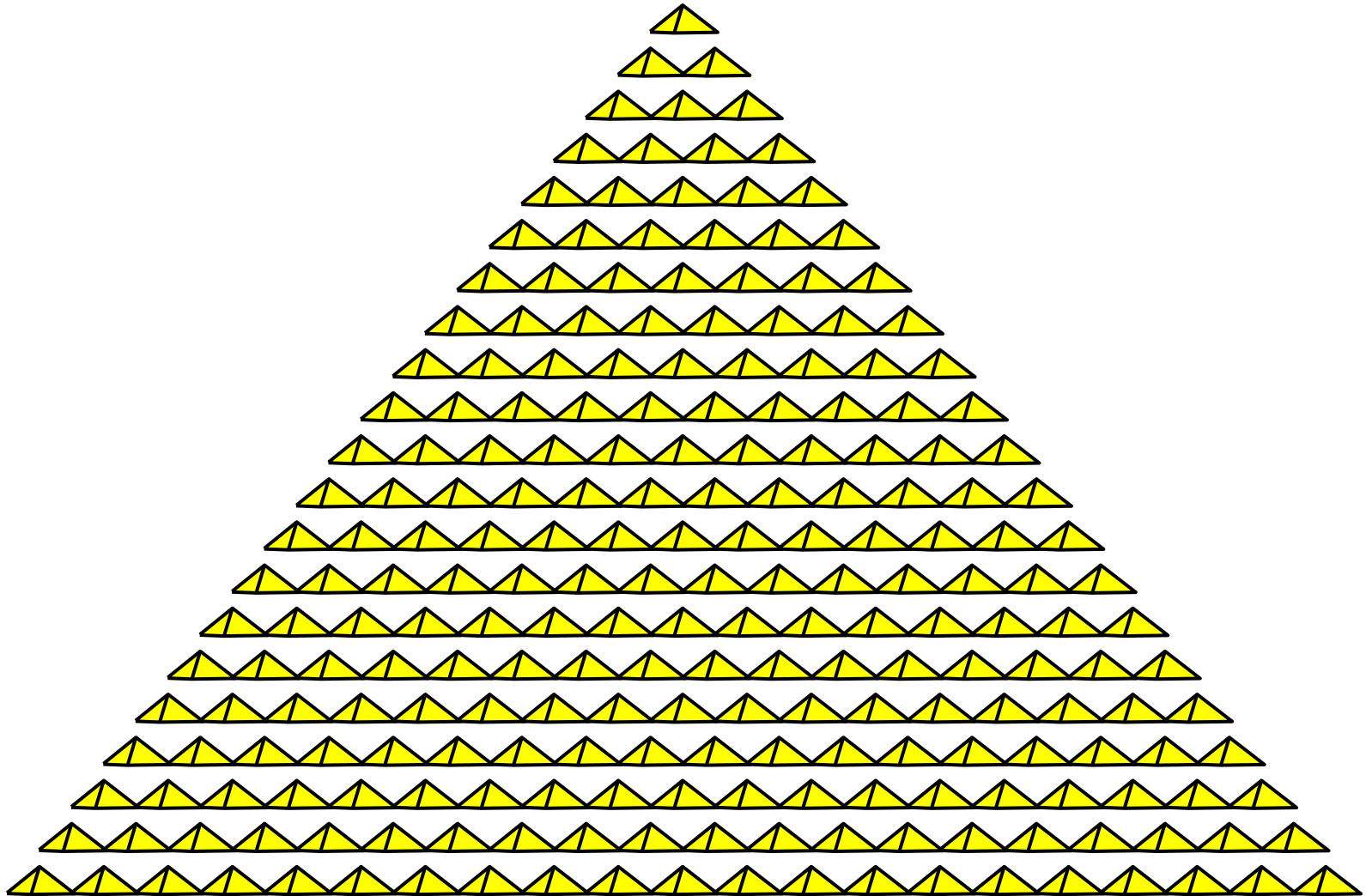
0 1000 km

Hudson Valley

Twenty Thousand Years

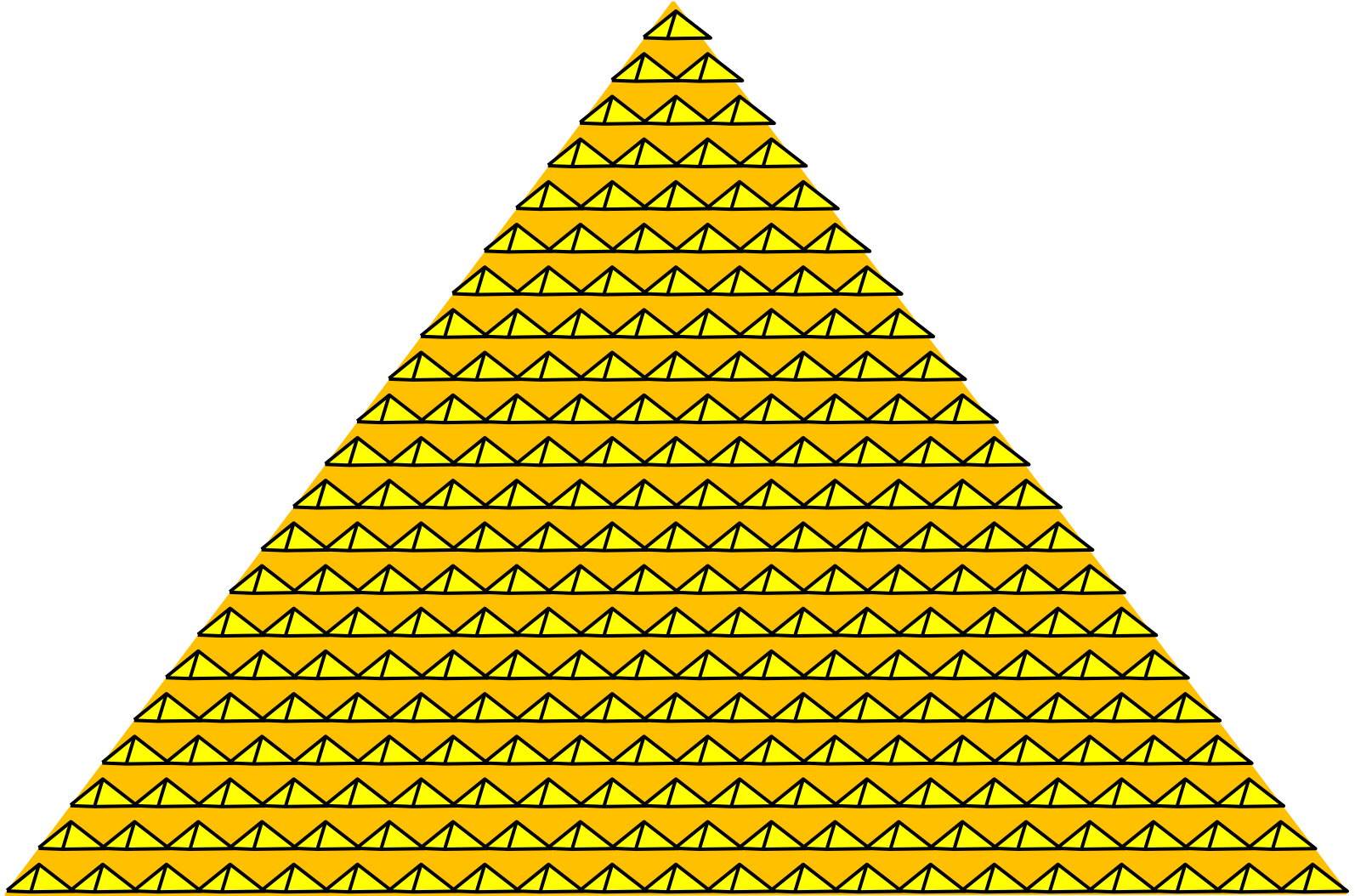
not all that long ago

Pyramid Of 200 Pyramids



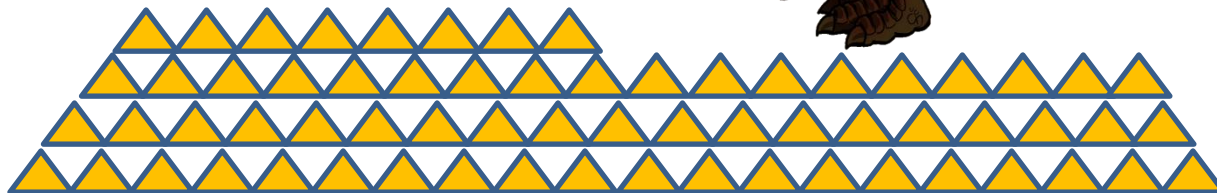
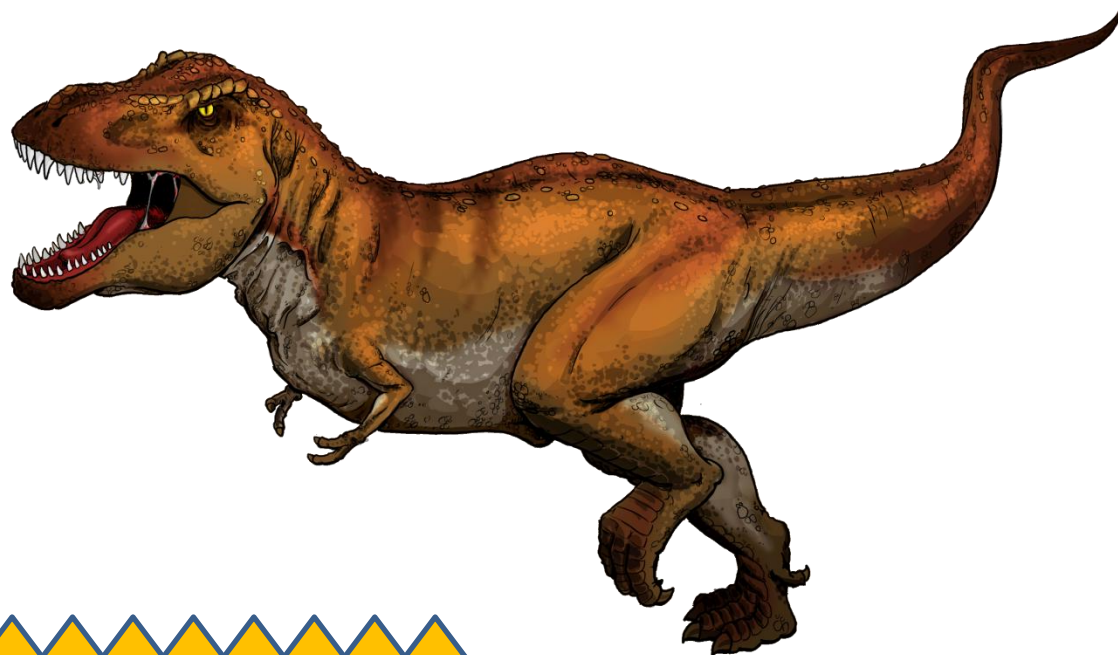
One Million Years

Pyramid Of 200 Pyramids



One Million Years

Death of the Dinosaurs 65 Million Years ago



65 pyramids of 200 pyramids

The last 20,000 years

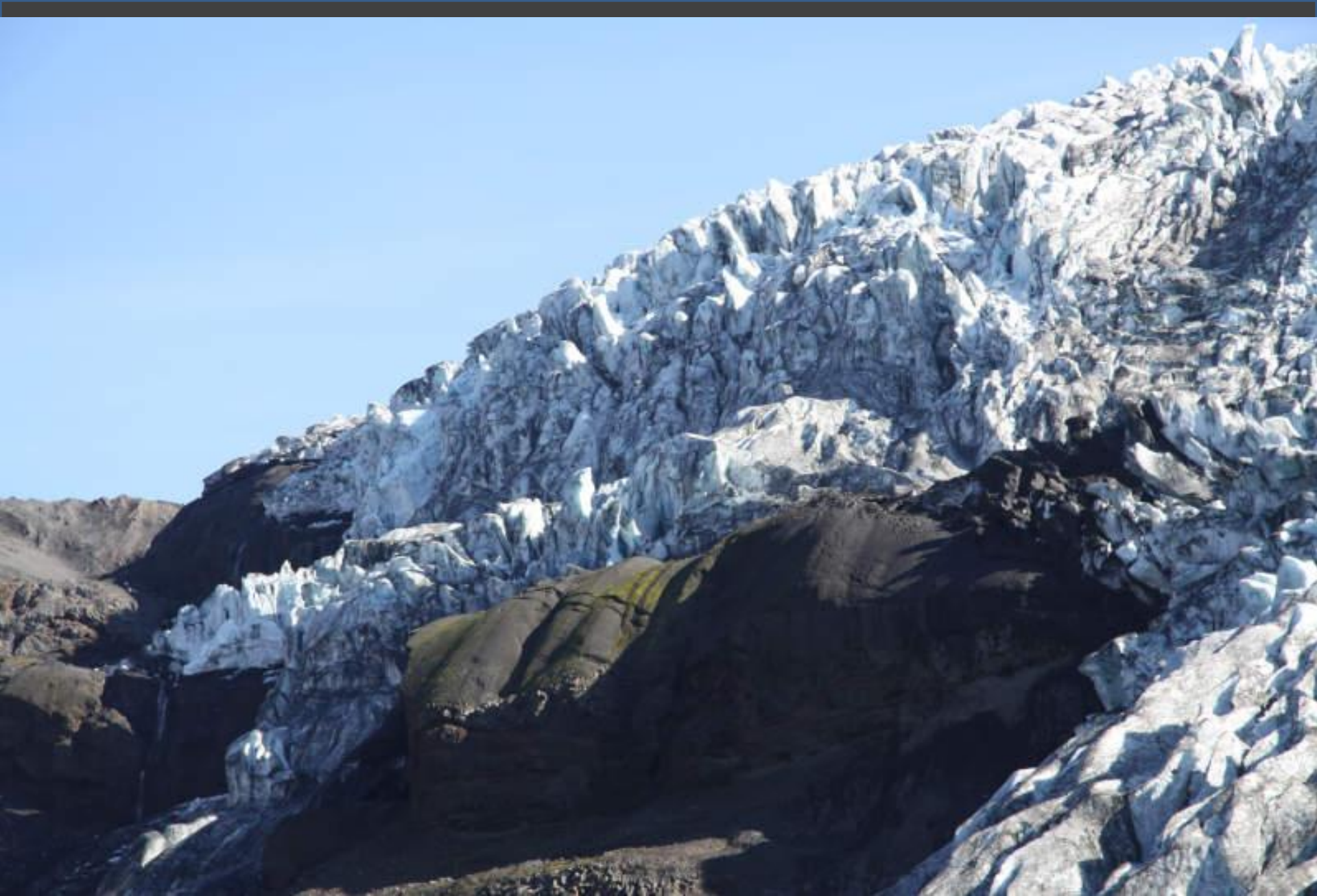
The end of the Ice Age

has been a era of tremendous
change in our area

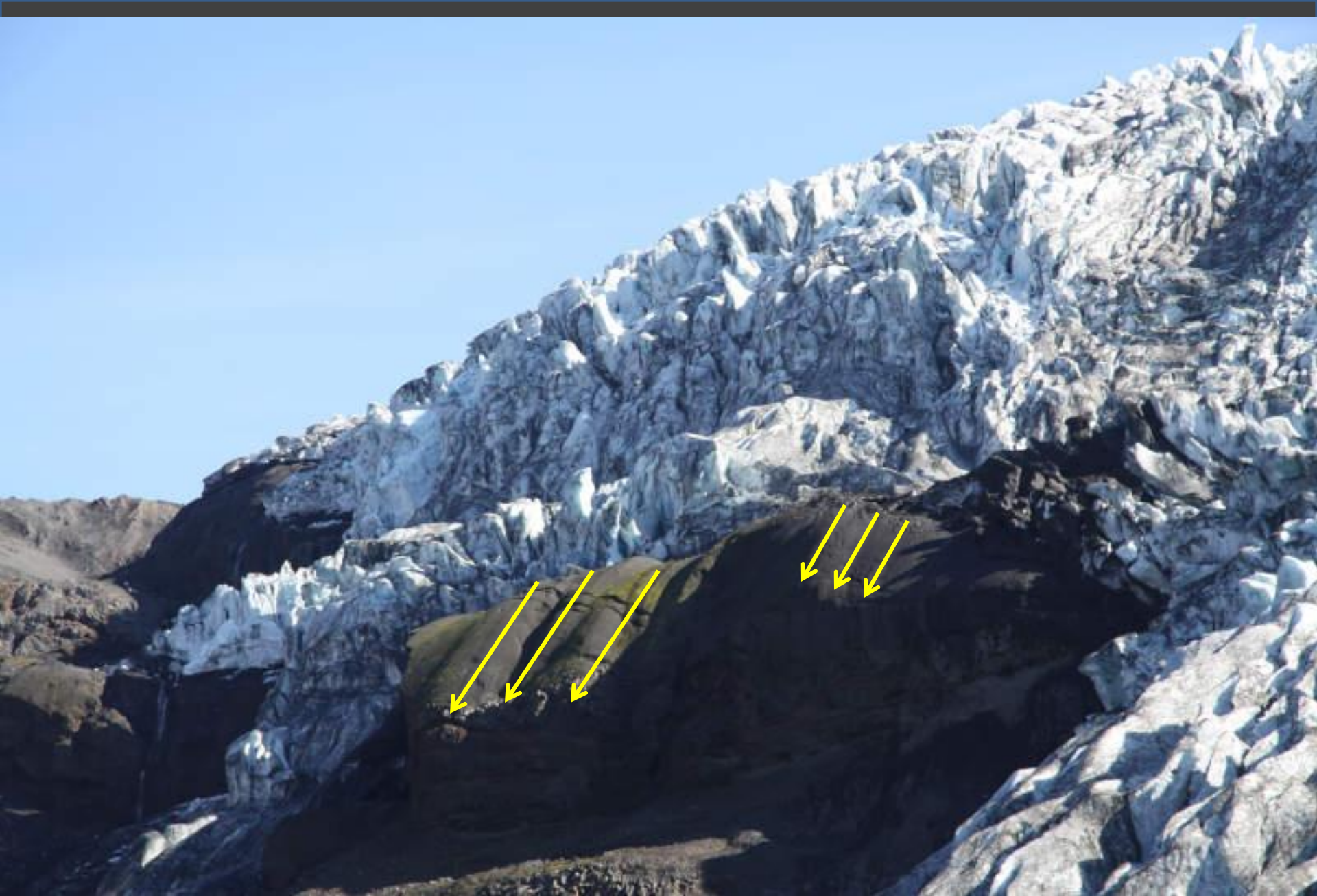
Part 2

Left-overs of the Ice Age
are everywhere

(if you know what to look for)



Glacier in Iceland



Glacier in Iceland



Washington Heights



Washington Heights



Palisades Interstate Park





Above Ross Dock



Harriman State Park



Harriman State Park



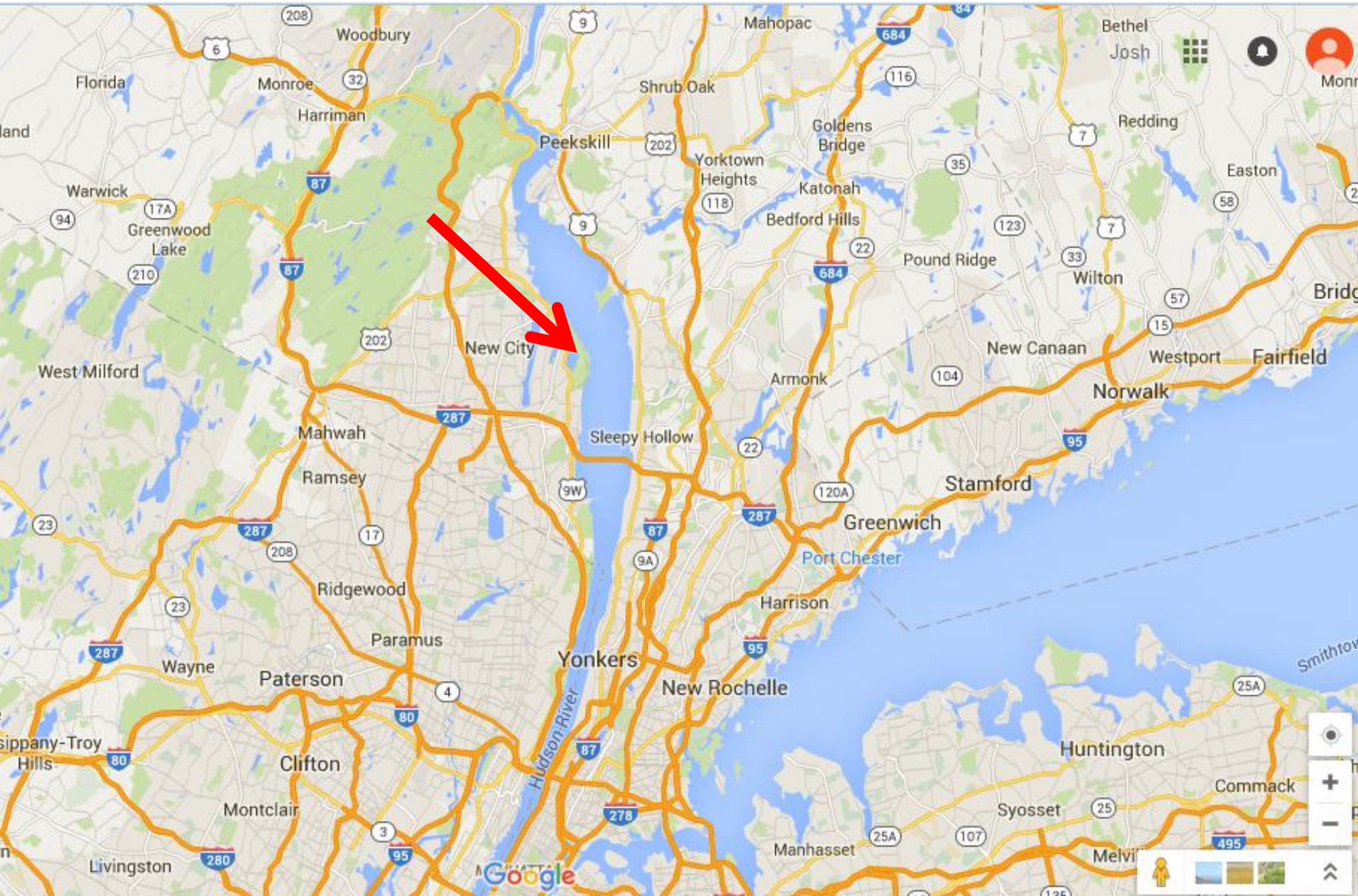
High Tor



High Tor



High Tor



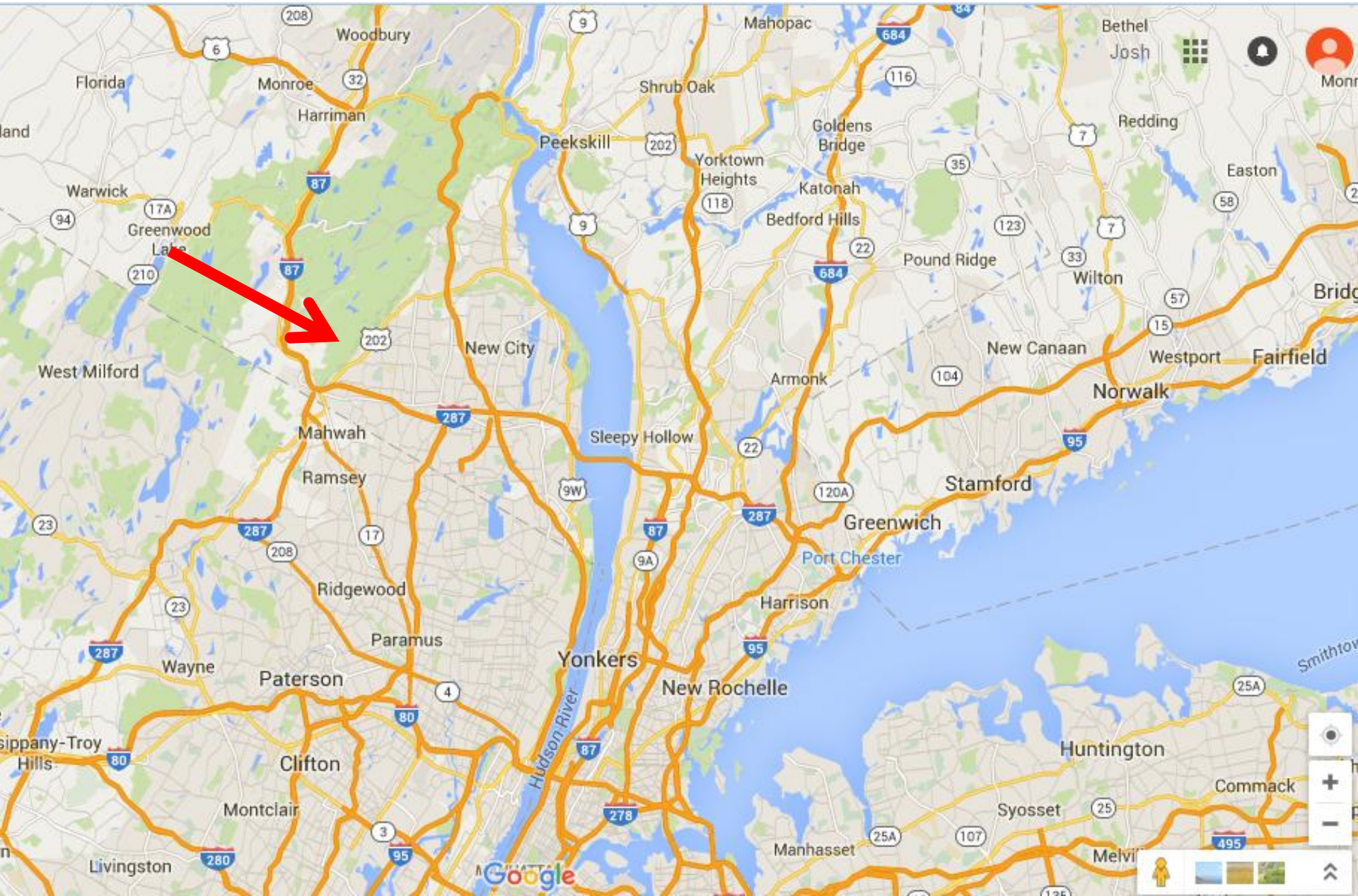


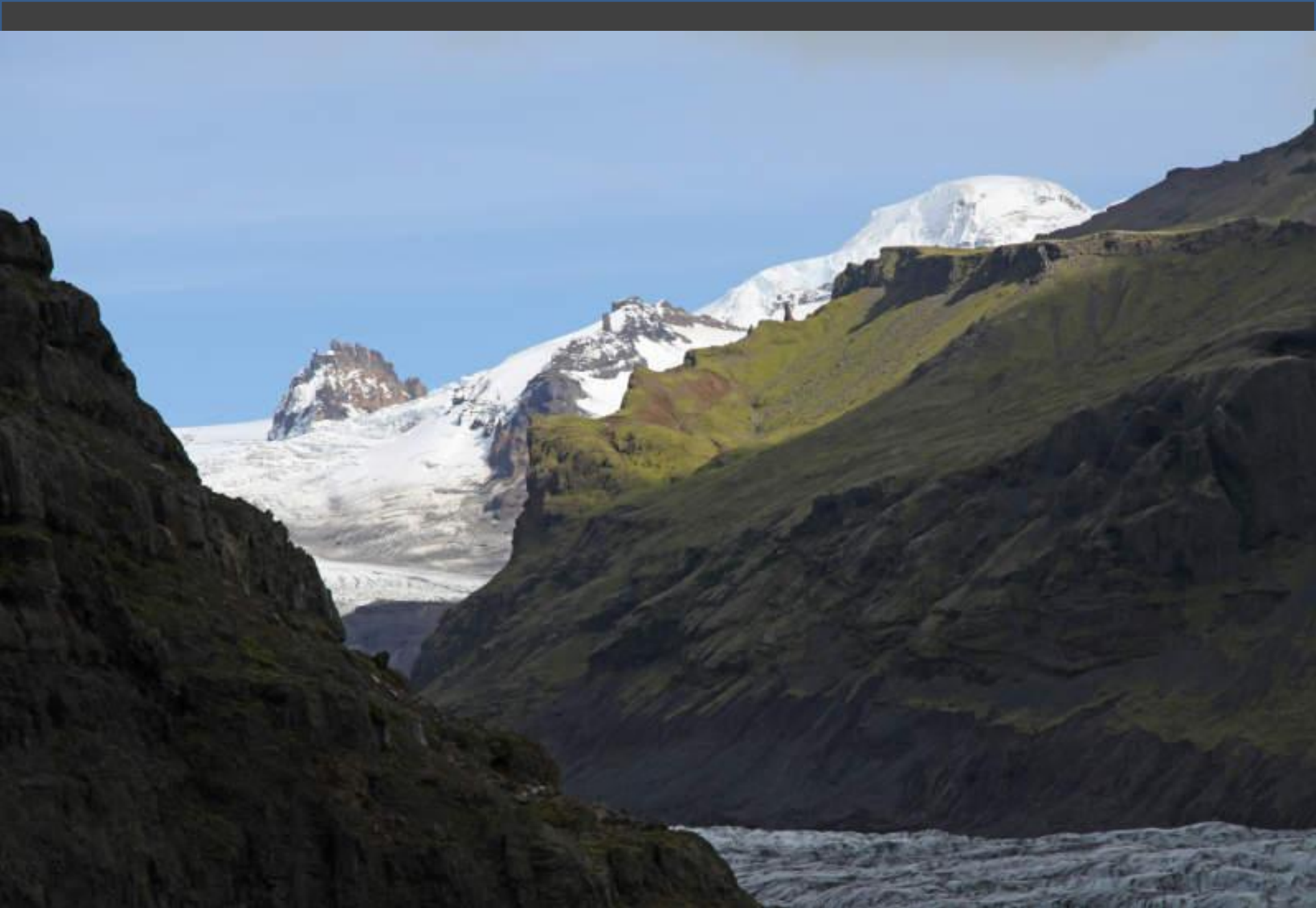
Bearford Mountain





Harriman State Park





Glacier in Iceland



Glacier in Iceland



Claudius Smith Den



Pine Meadow Lake



The Kitchen Stairs



Hudson Palisades Cliffs



Tension Crack near the Women's Federation Memorial



The Alpine Rockfall of 2012



Glacier in Iceland

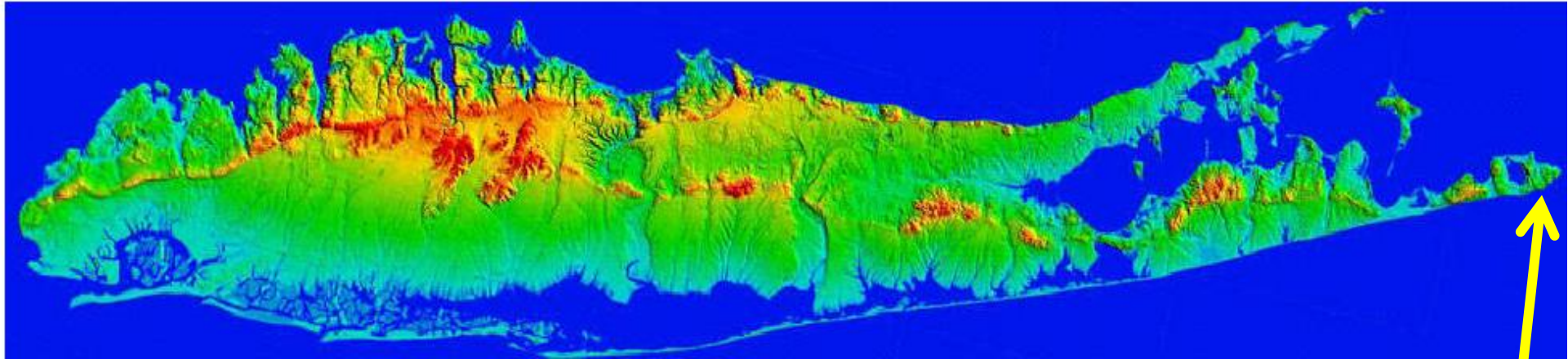


Glacial Lagoon in Iceland



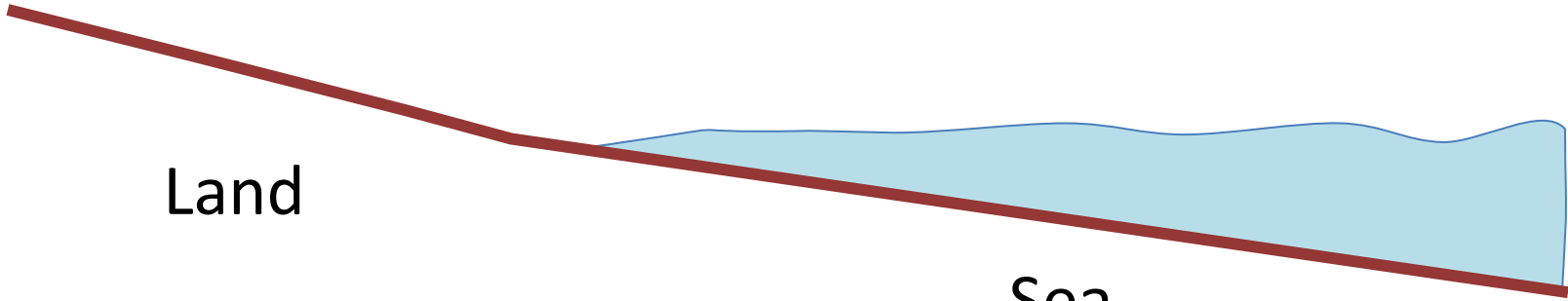
Long Island

Had this been New York and not Iceland



Part 3

The Ice and the Sea

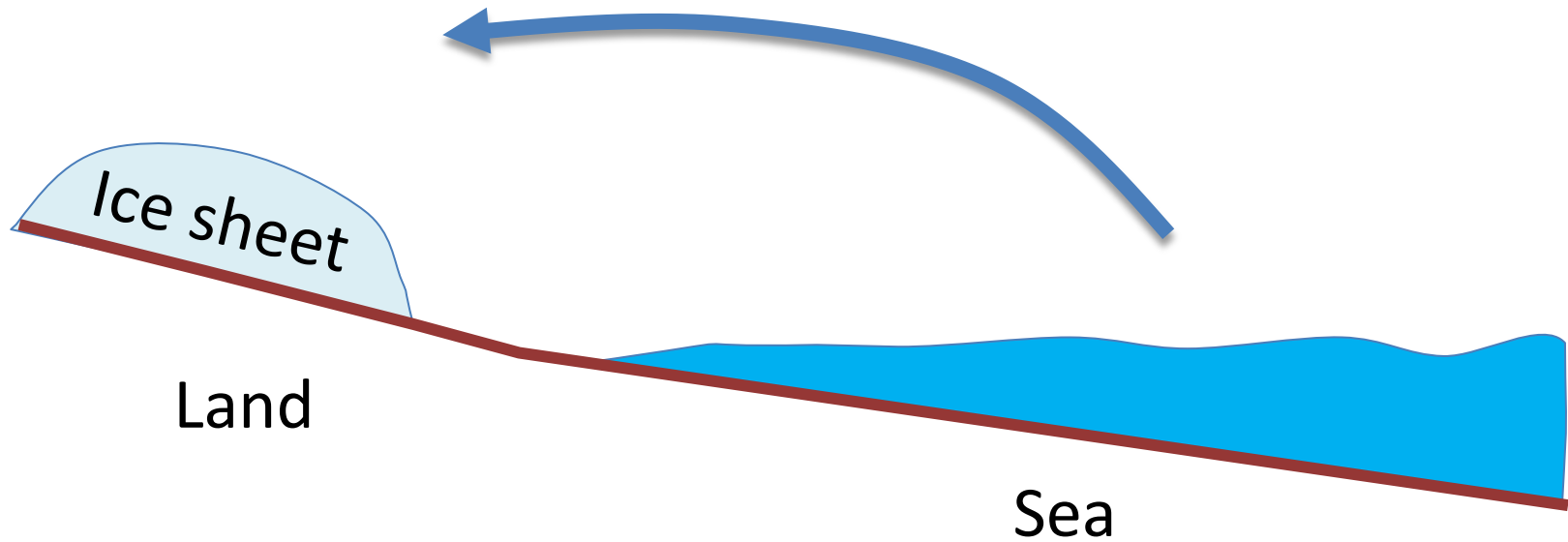


Land

Sea

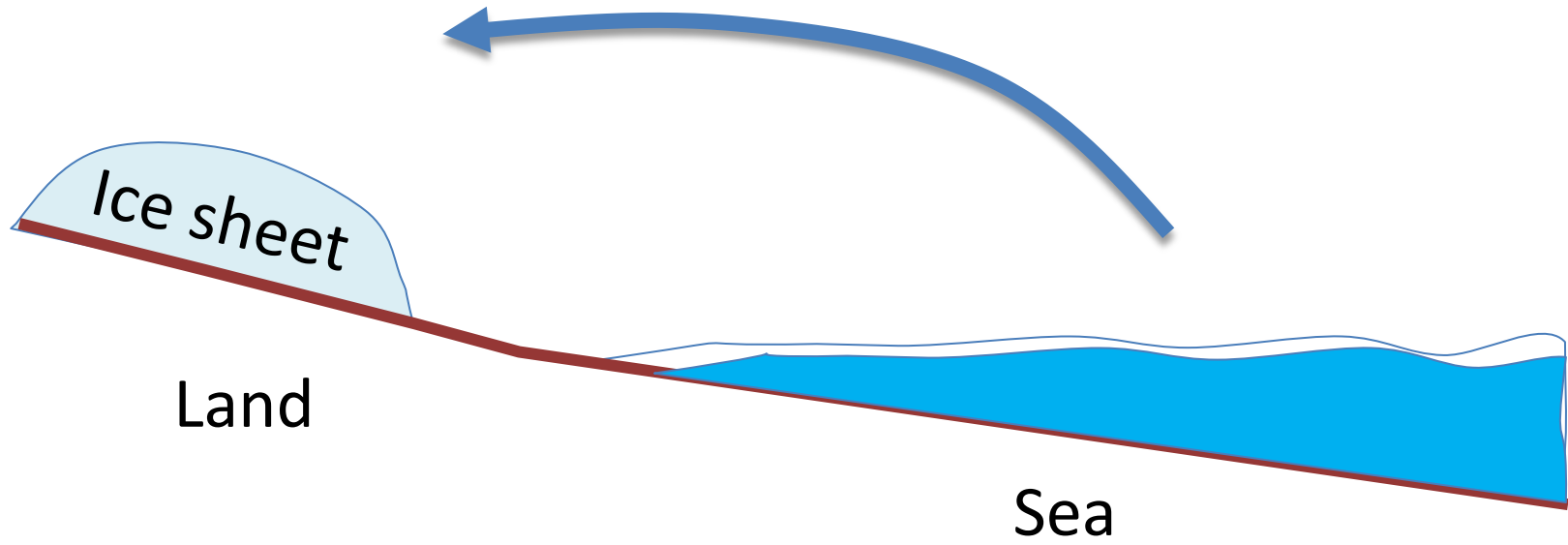
Make a glacier ...

from snow ... from water ... evaporated from the sea

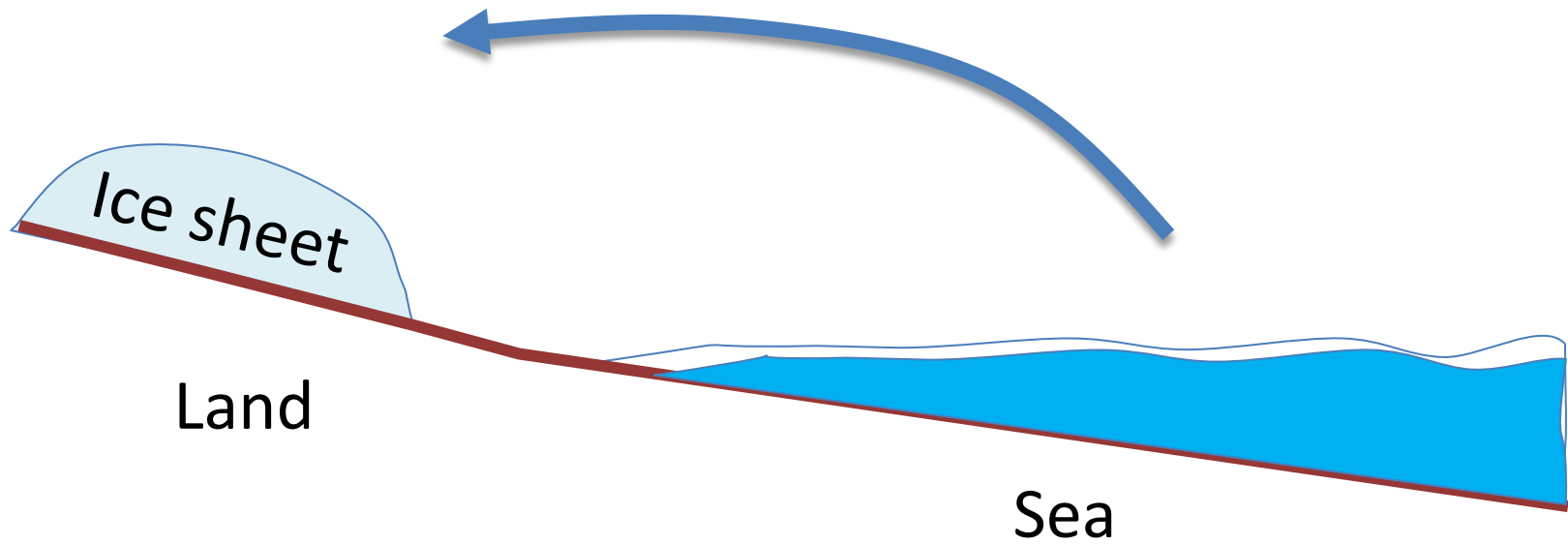


Make a glacier ...

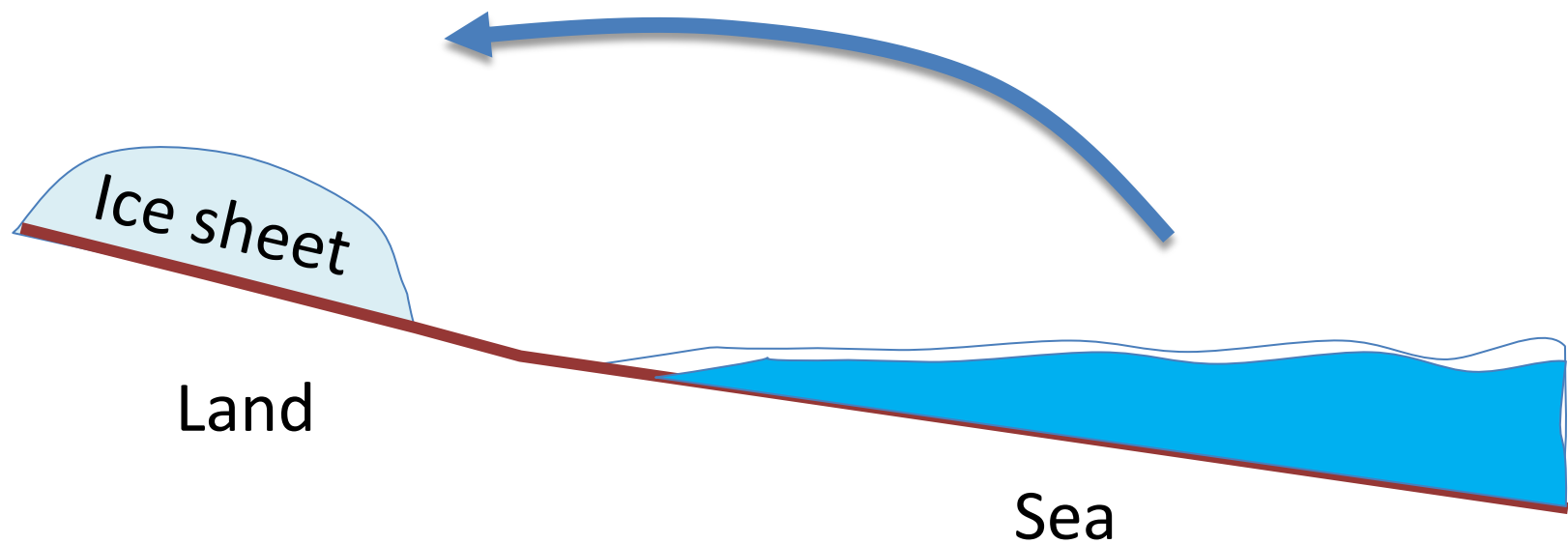
from snow ... from water ... evaporated from the sea



Make a glacier ...
Sea level goes down



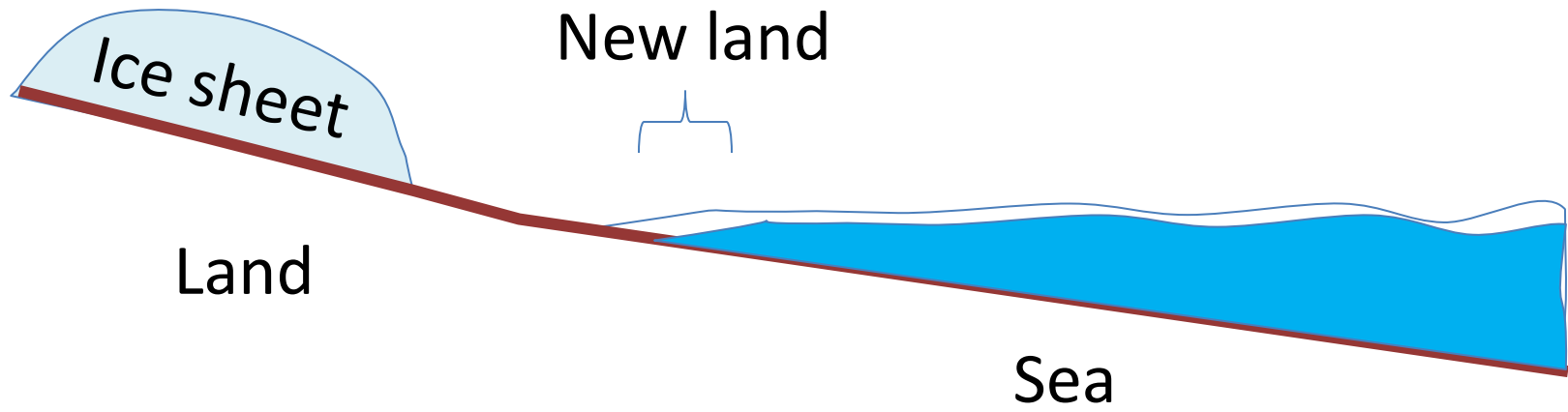
Make a glacier ...
Sea level goes down



400 Feet !

Make a glacier ...

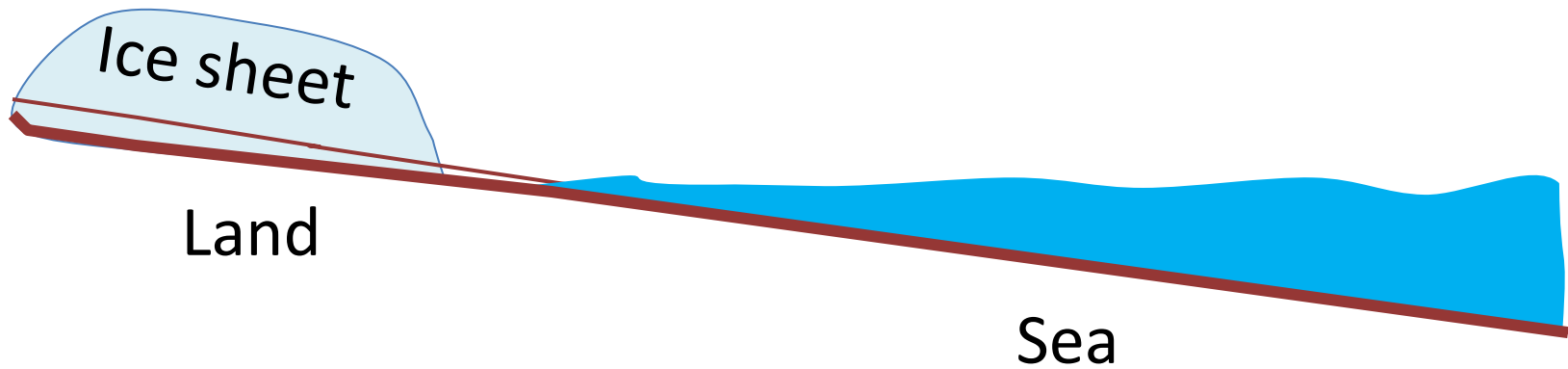
Sea level goes down ... coastline moves out

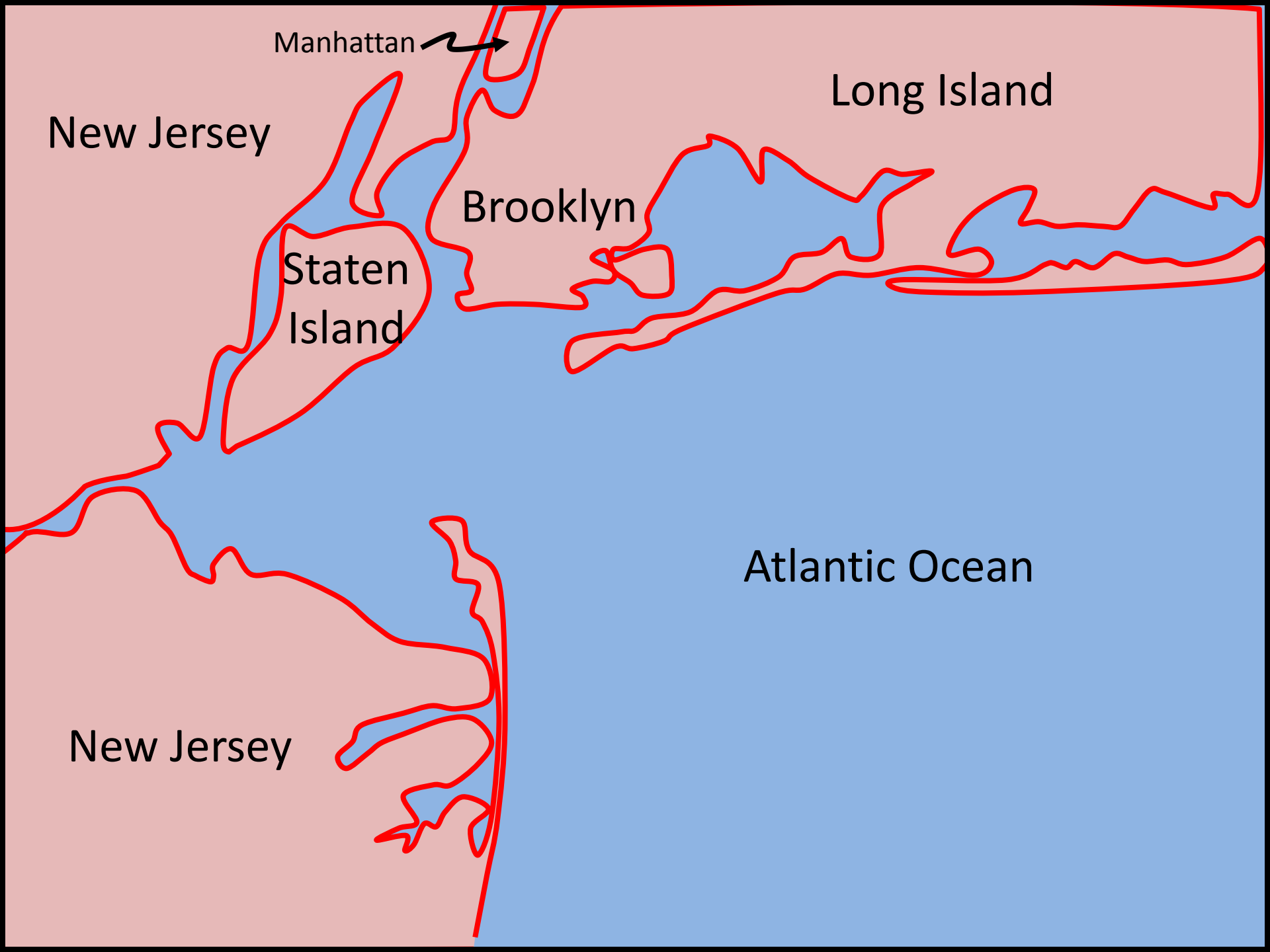


Make a glacier ...

glacier is heavy ... weighs down the land ...

land sinks near the glacier ... becomes lowlying





Manhattan



New Jersey

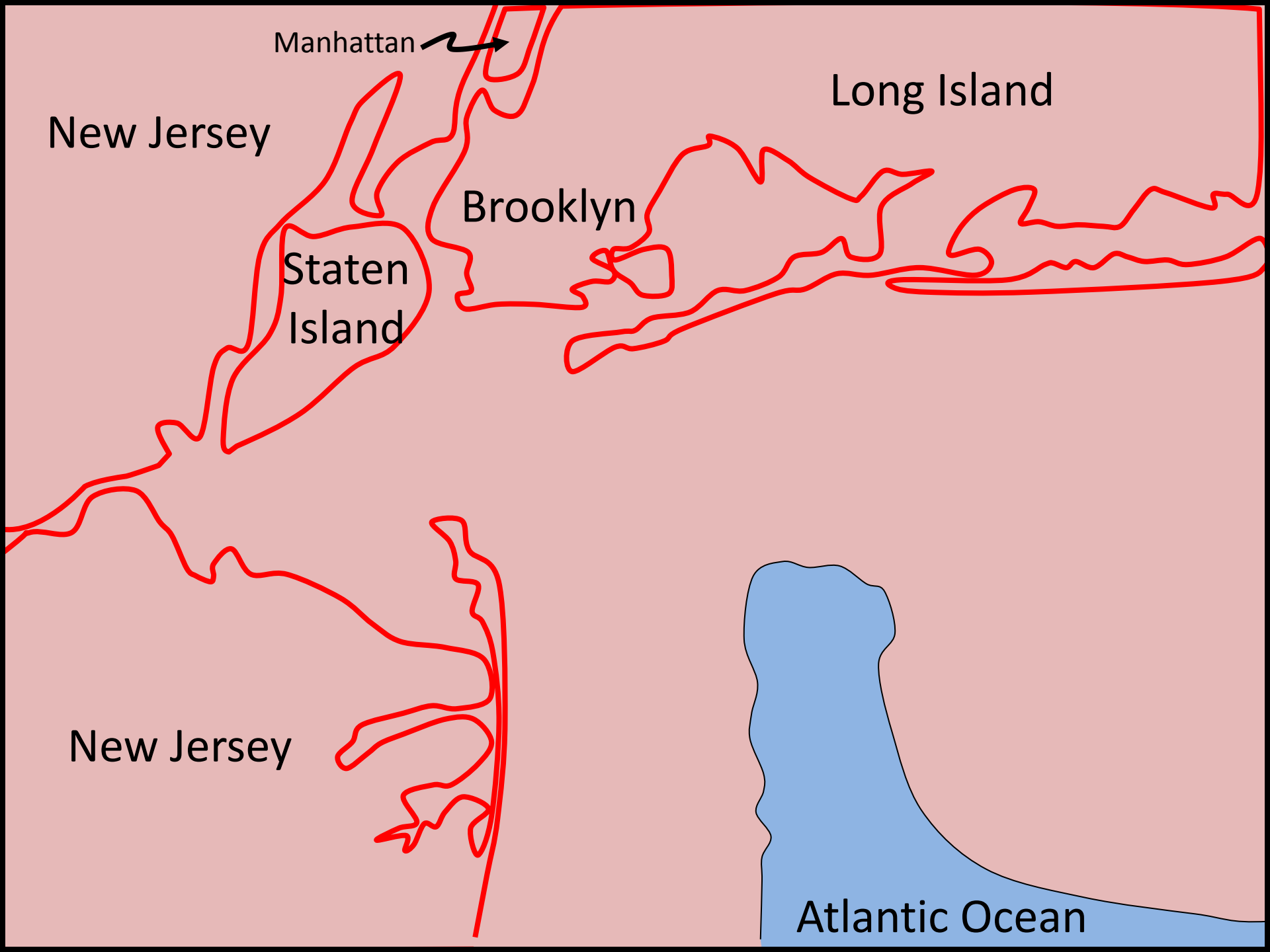
Long Island

Brooklyn

Staten
Island

Atlantic Ocean

New Jersey



Manhattan

New Jersey

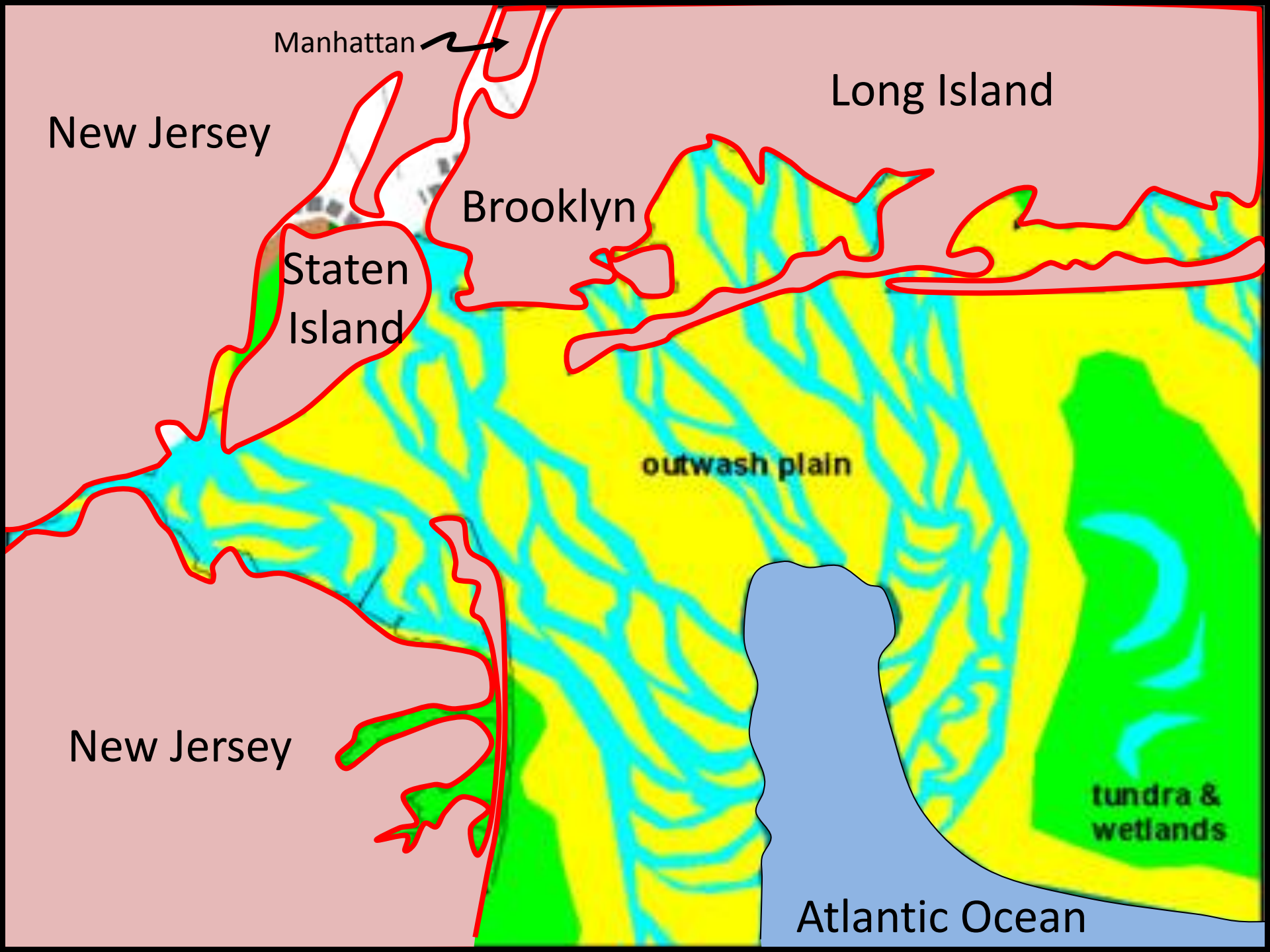
Long Island

Brooklyn

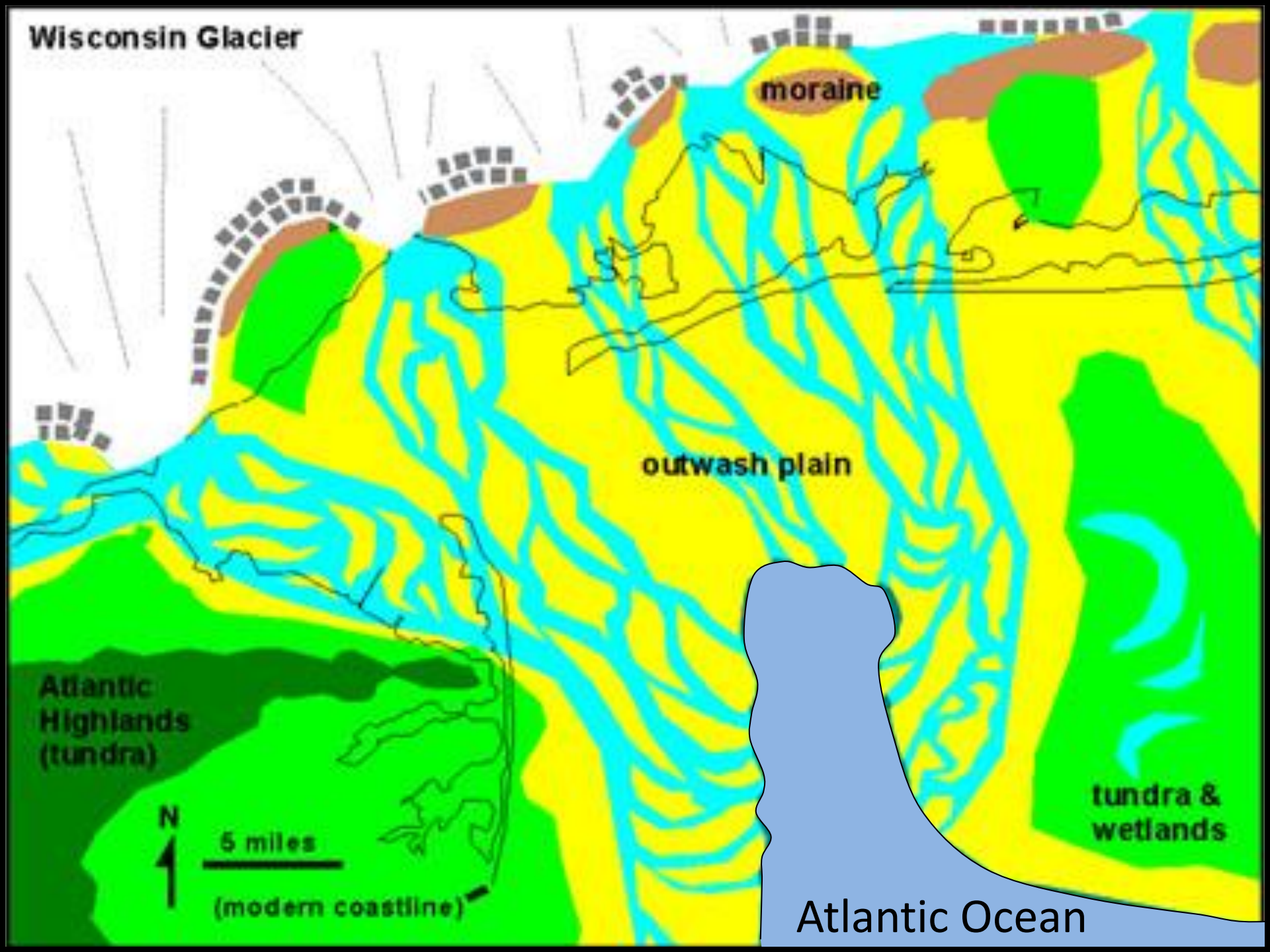
Staten
Island

New Jersey

Atlantic Ocean



Wisconsin Glacier





Outwash plain, Iceland

Part 4

The Ice Melts

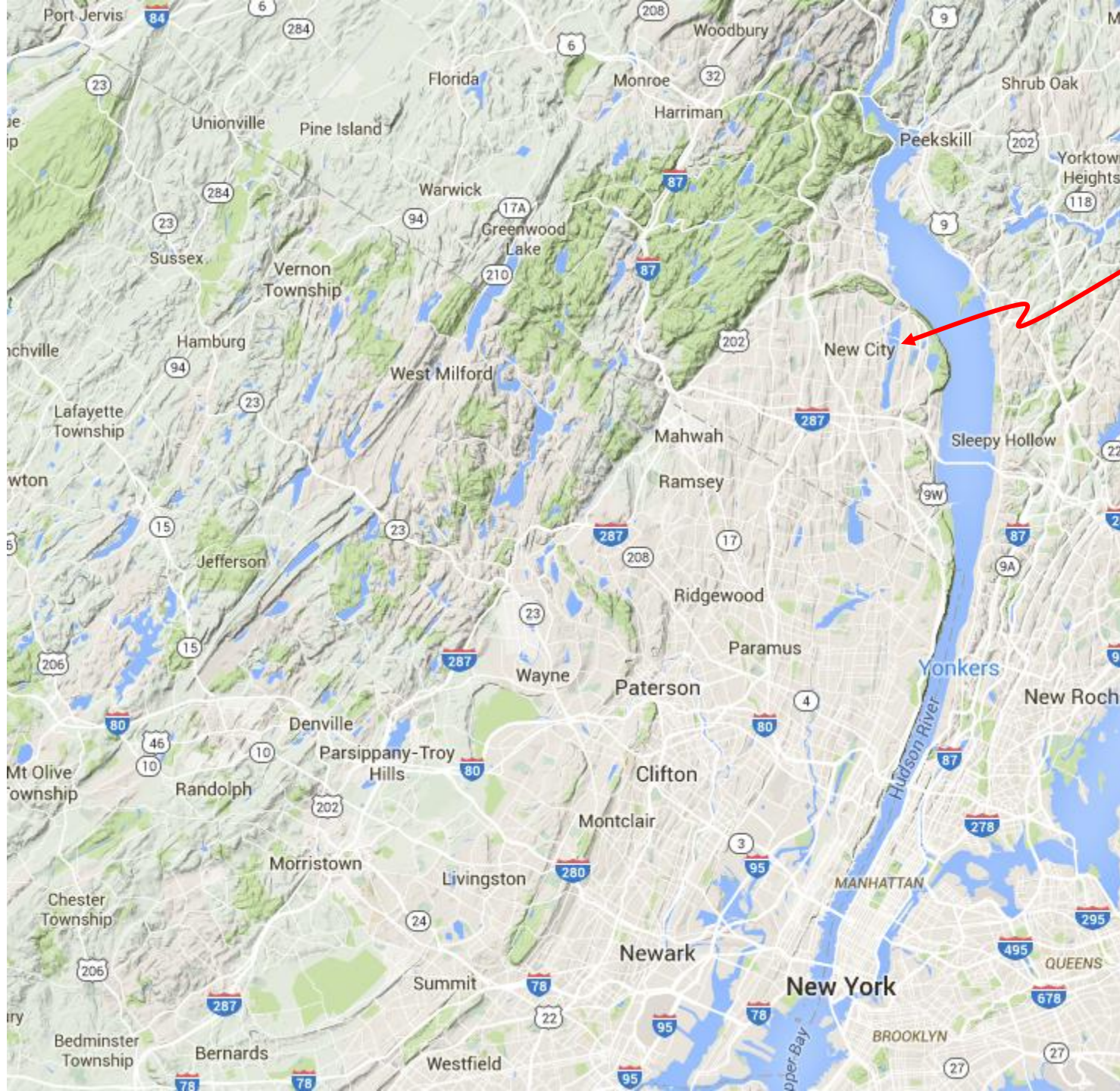
That's a lot of water



Glacial lake in Iceland



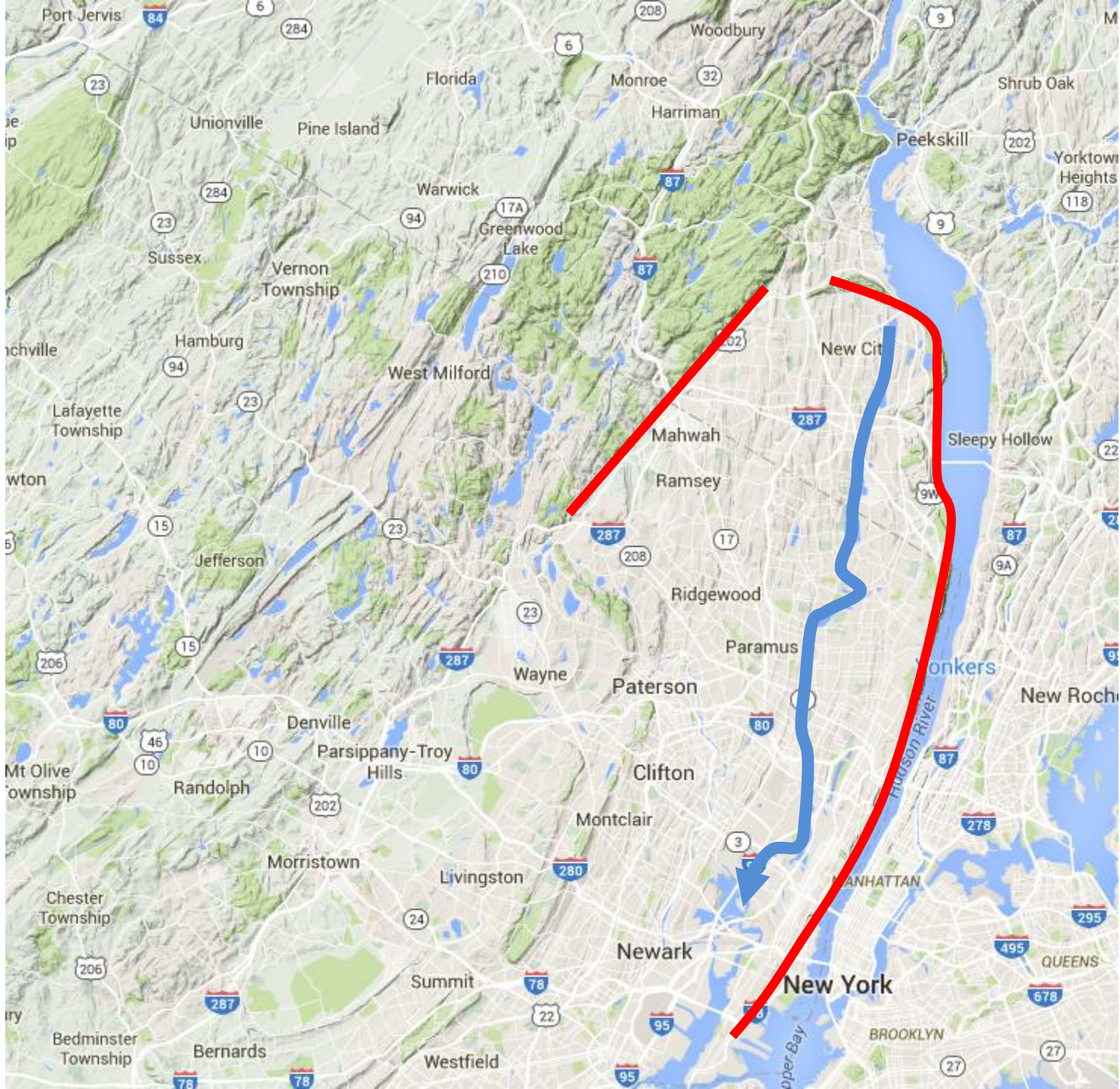
Lake Deforest

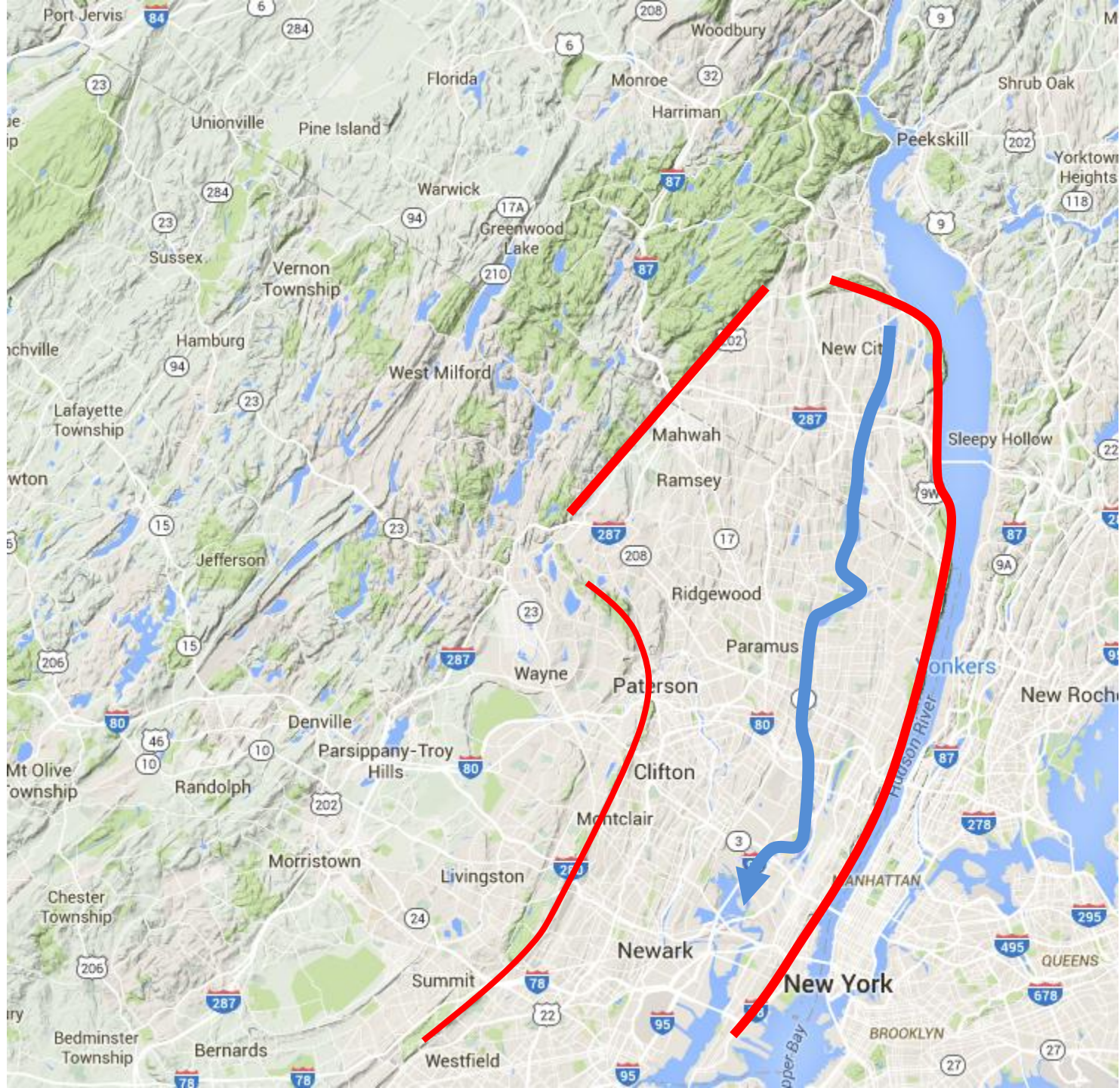


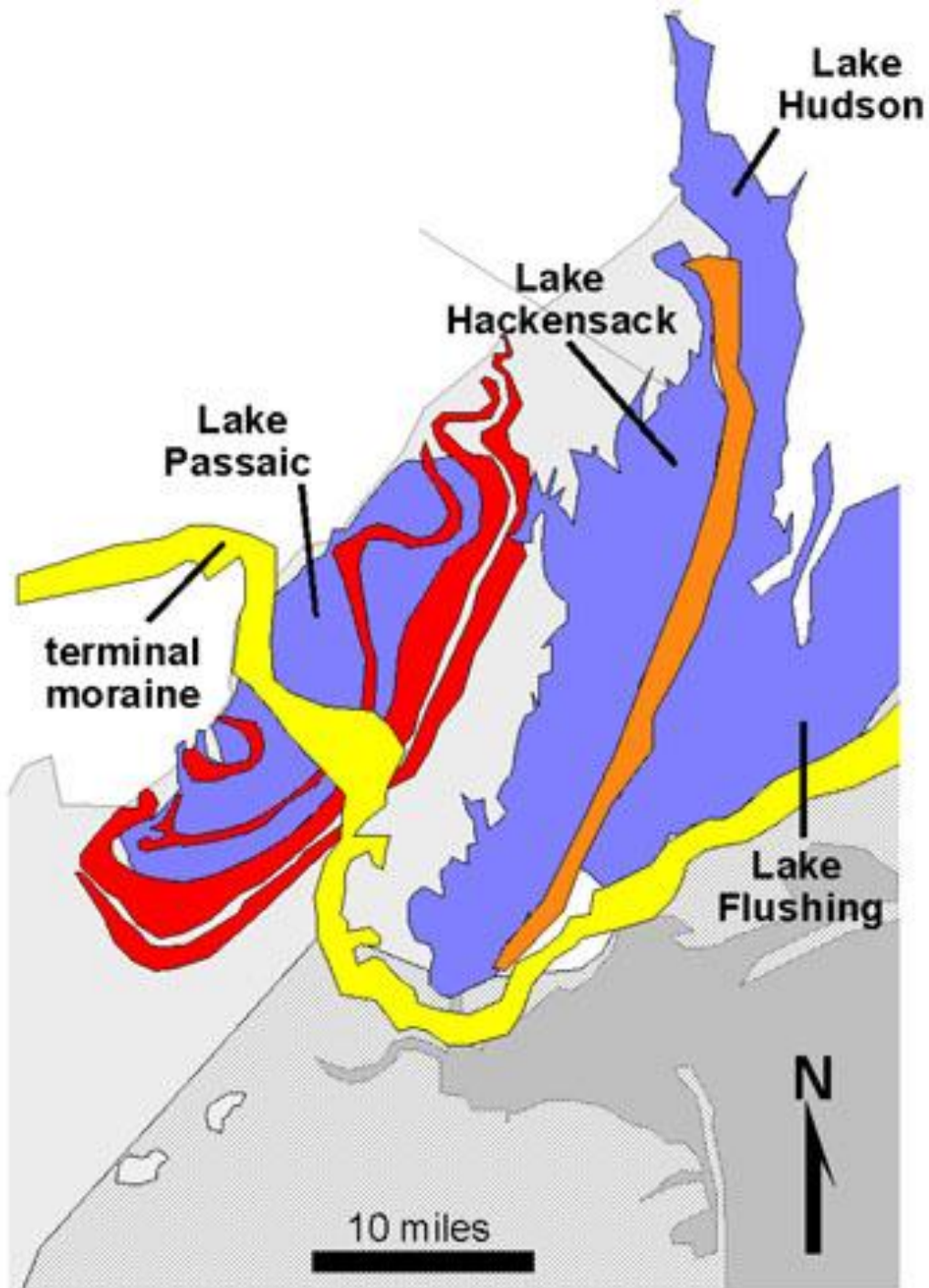
Lake
Deforest



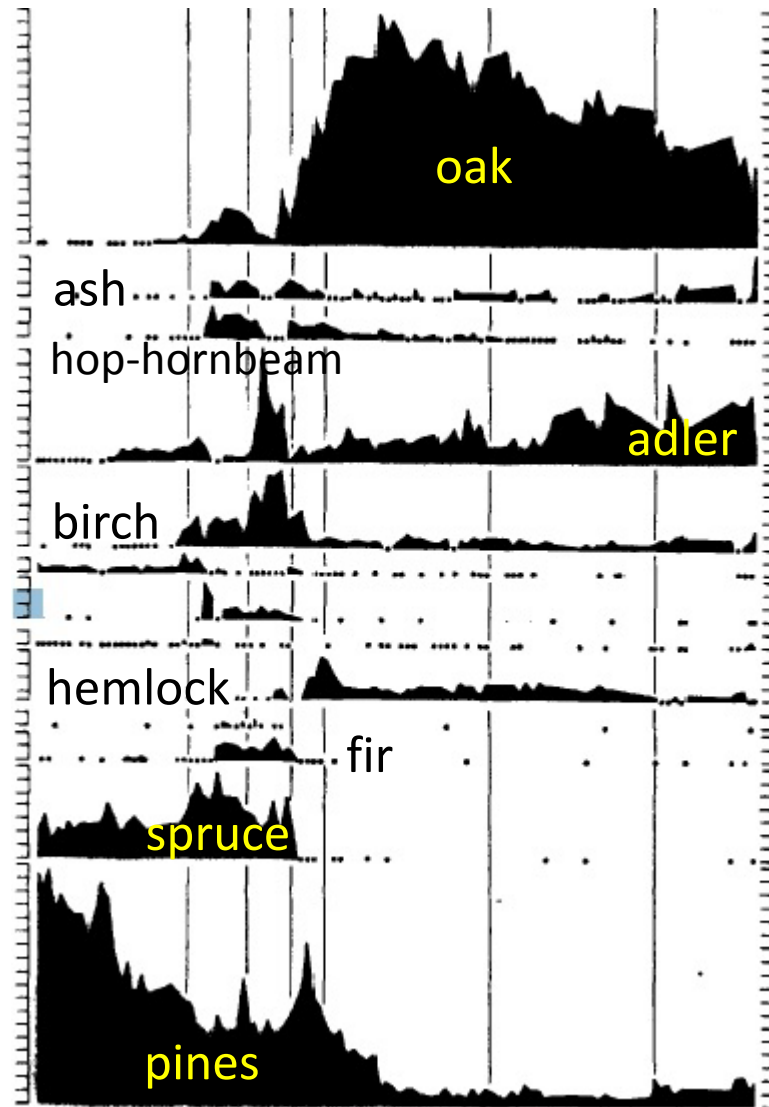
Hackensack River







The return of life



Tree pollen at Alpine Swamp



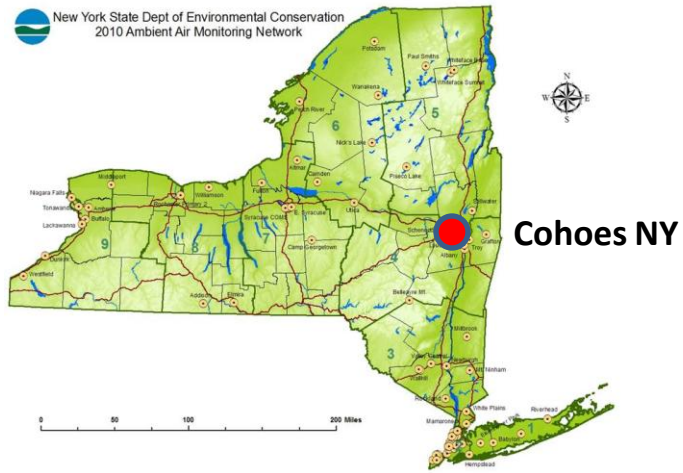
14000



today



Dr Peteet



The Cohoes Mastodon discovered 1866

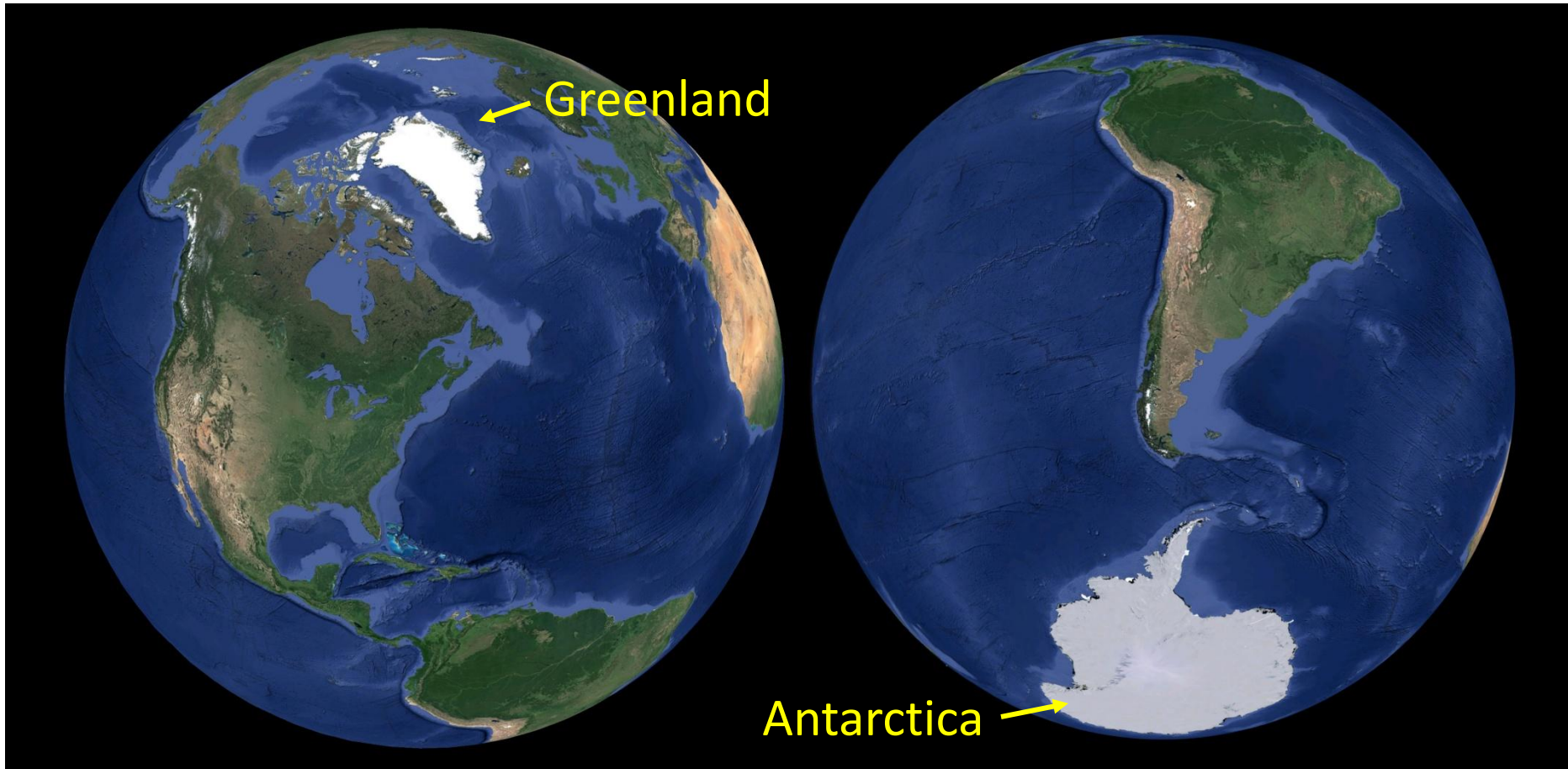
Died 11,070 year ago



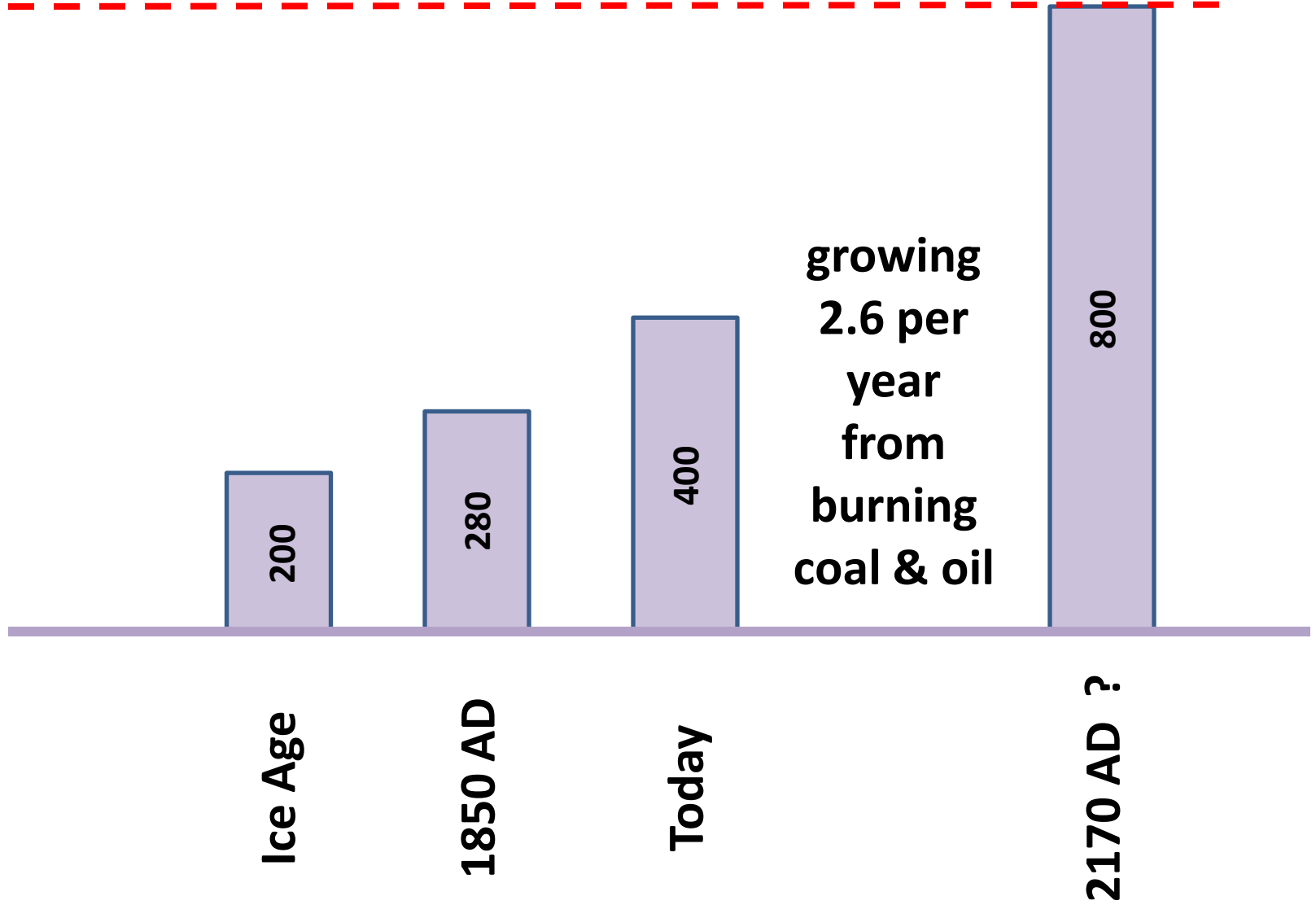
Part 5

The future

Could we melt the ice that's left?



CO₂ Level needed to melt Greenland and Antarctica

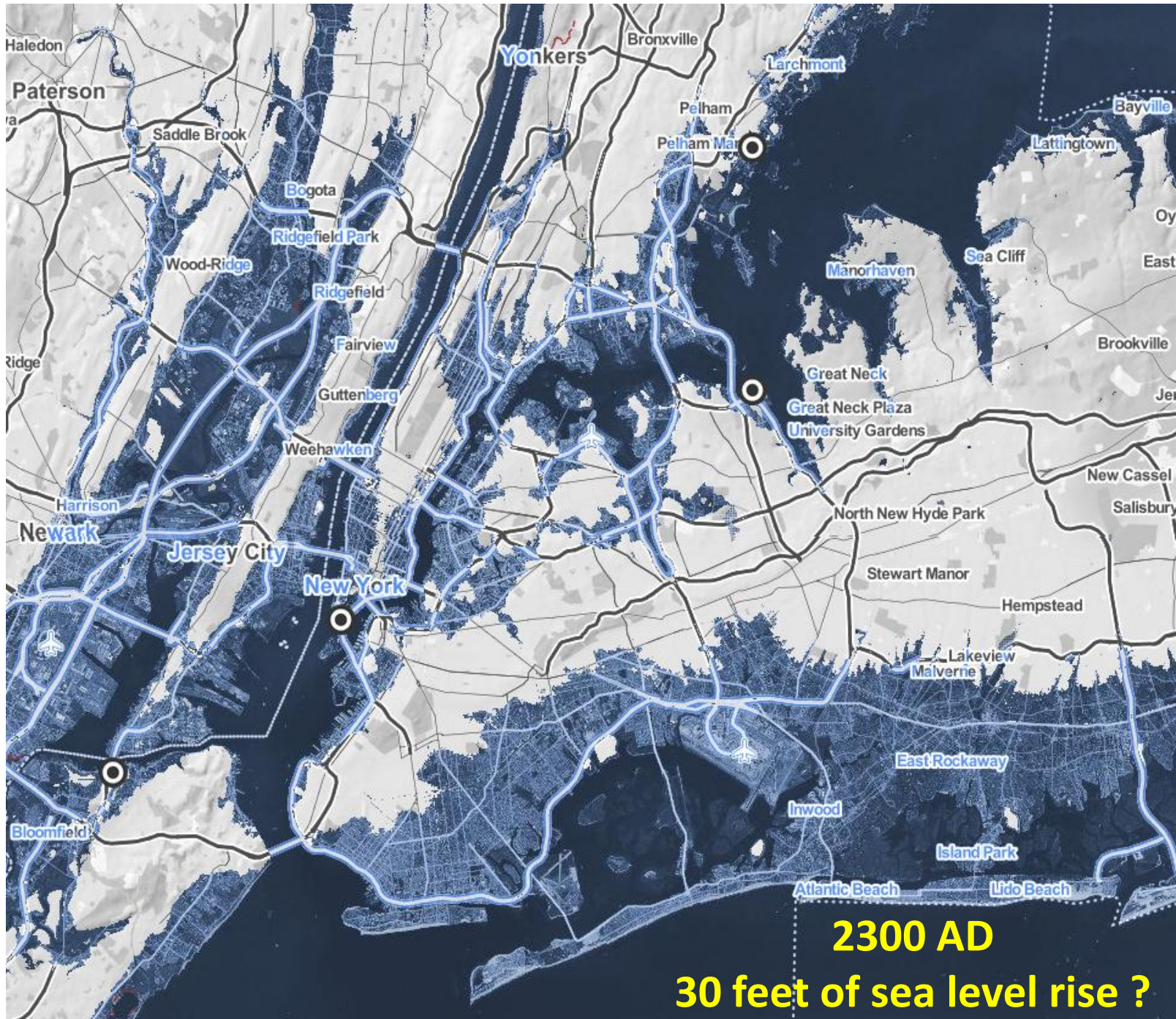


We could melt the ice that's left

and if we did

Sea level would rise 200 feet

(not all at once, but at the rate of a few inches per year)



Big changes are in store!

Question: I understand that the Palisades Cliffs were heavily quarried. Is that why they are so steep?

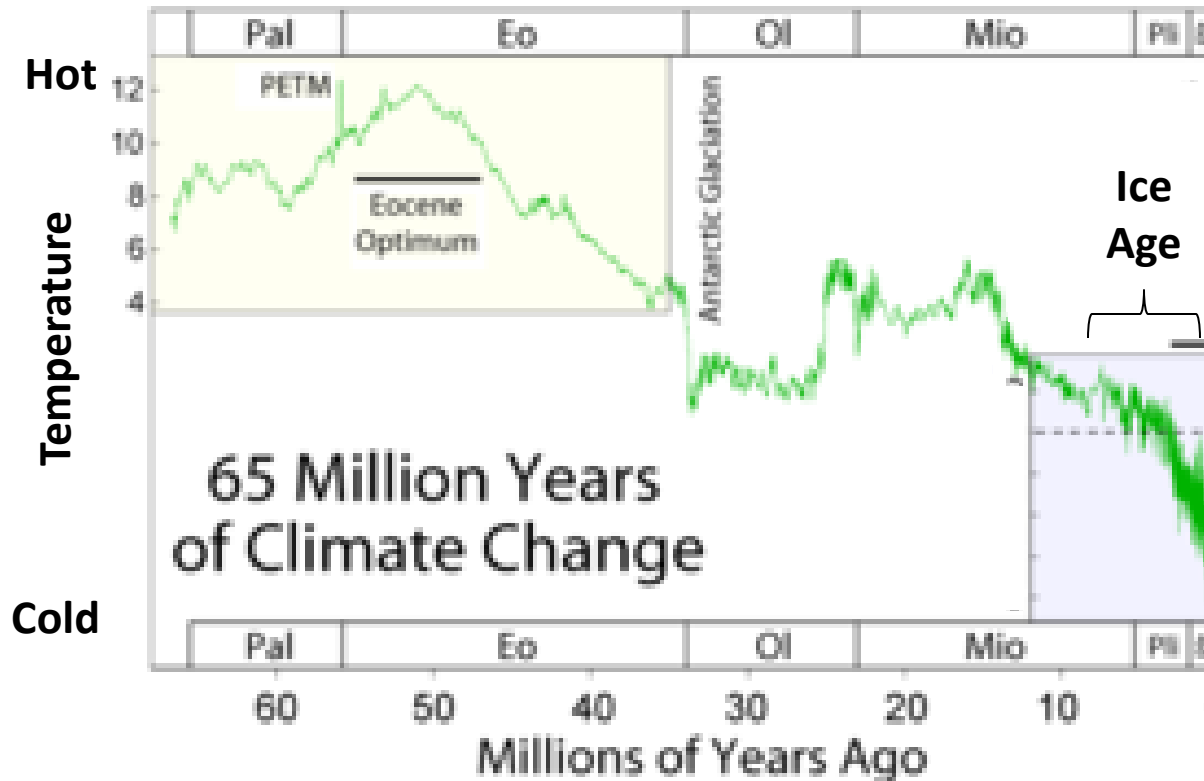


Back in the 1800's, some parts of the cliffs were heavily quarried, leaving very steep quarry faces. The quarry (left) at the end of Landing Road behind Rockland Lake is an example. Other quarries are by the Pool in Tallman Mountain State Park, The Upper Picnic Area at Nyack Beach State Park and several more along the Haverstraw Trail north of Landing Road. Still, they influence only a small part of the Palisades Cliff. The rest of the cliff is natural. But irrespective of being natural or artificial, the cliff will eventually collapse, heaving a more rounded hill. The natural part of the Palisades are so sharp because they were sharpened recently by the glaciers, and all the rubble at their base was swept away.

(If you are ever offered the opportunity to live in this little house below the quarry, I recommend you decline!)

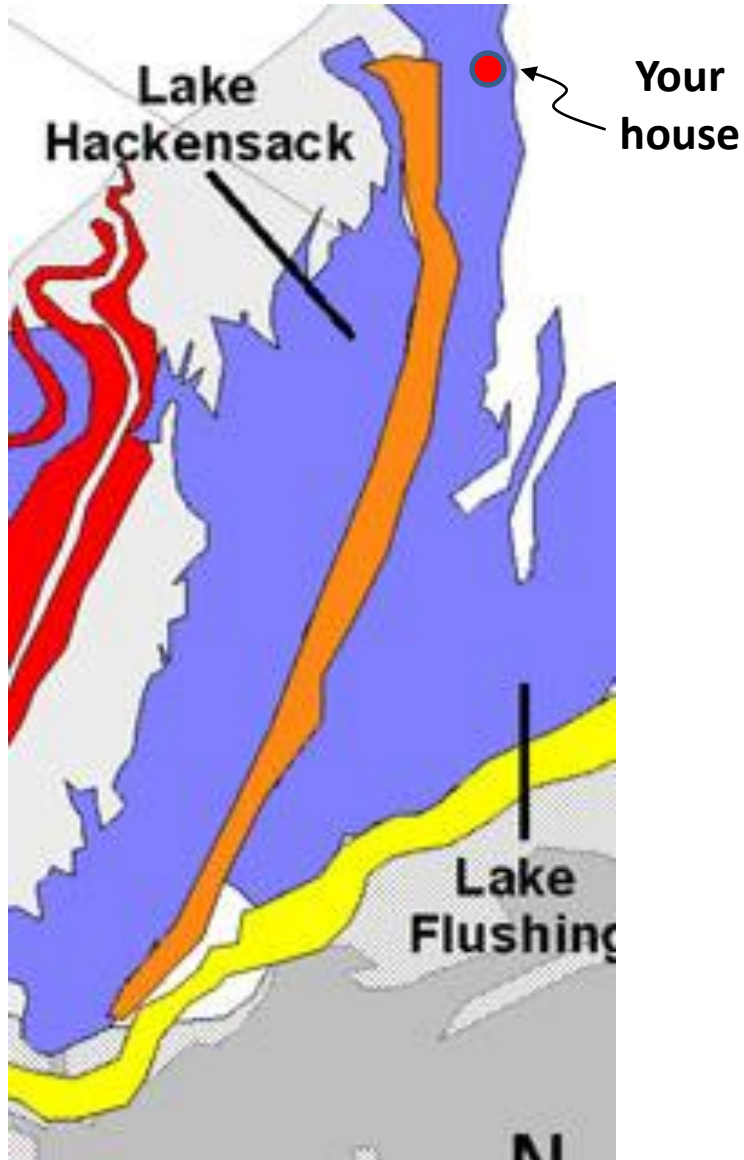
Question: What caused the Ice Age?

We do not fully understand its cause. Over the last 50 million years, the earth has slowly been getting colder. Back then, there was no ice in Antarctica and palm trees grew in the Arctic. It's believed that the amount of CO₂ in the atmosphere began to decrease, due to erosion of rock in the newly-formed Himalayas and deposition of limestone in the ocean, both of which such CO₂ out of the atmosphere. About 30 million years ago, the earth cooled enough that glaciers began to form in Antarctica. However, 4 million years ago the Earth's temperature started to take wild swings –



the cold part of each swing was an Ice Age and the warm part was an interglacial (like we're living in today). We don't understand why these wild swings occur. But they seem to be paced – though not caused – by very small changes in the Earth's orbit that affects the amount of sunlight reaching the Earth.

Question: My backyard above the Hudson River in Scarborough (Westchester County) has thick layers of sand, not coarse gravel like one might get in a glacial moraine. Where did it come from?



I don't know that region well enough to be sure. Your house may be built on sediments from the bottom of Lake Hudson or a deltaic deposit coming from rivers that were coming off the edge of the glacier as it melted. The fact that its sand and not gravel means that it was transported far enough to be sorted by flowing water. Keep in mind that the elevation of both your house and the bottom of the Hudson River was lower, owing to the weight of the ice.

Question: So Long Island wouldn't be there except for the glaciers.



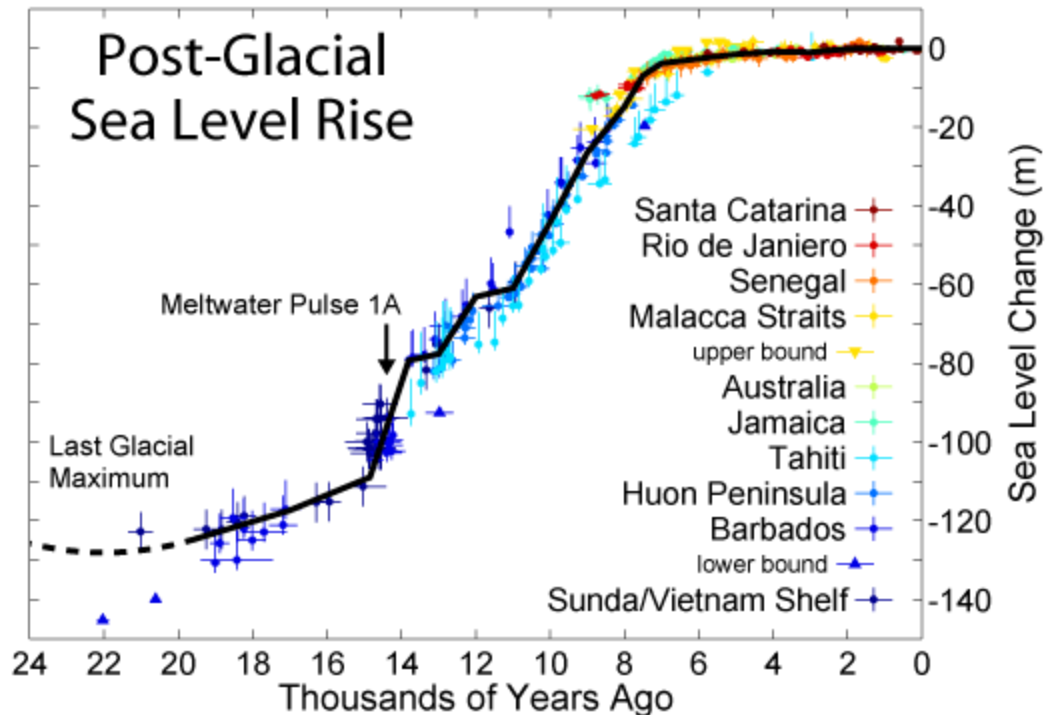
**pre-Ice Age
clay**

That's right, the island is almost entirely made of moraines (gravel heaped up by the glaciers) and outwash (sandy sediment deposited by glacial rivers). Of course, if you dig down deep enough, you will get to rock that pre-dates the Ice Age. And there are a few spots – Garvies Point in Glen Cove, for example – where knobs of older material stick up through the outwash and moraines.

Question: Have you included feedbacks in your models of sea level rise?

Actually, my ideas are not so much based on model results but on analogies to past conditions. But you are right that feedbacks, such as cloud feedback, are important in controlling the Earth's temperature. I am using two analogies:

First, thirty million years ago Antarctica was ice free. Sure, climate feedbacks were operating then, but they were insufficient to keep the Earth cold enough to sustain glaciers. My reasoning is that if we alter the composition of the Earth's atmosphere to match its composition during that era, Antarctica will melt.



Second, at the end of the Ice Age, even though the temperature rose to a point where the North American Ice sheet started to melt, it did not melt at once but rather took several thousand years. During this time, sea level rose a few inches per year. My reasoning is that a few inches a year is what we might expect if we boost temperatures high enough that Antarctica starts to melt.

Neither analogy is perfect, for the world today is not exactly the same as the world of these past eras. Nevertheless, I think that, overall, the argument is strong.

Bill Menke's Bio: I am a naturalist with a great love of the outdoors and a deep appreciation of the natural beauty the Hudson Valley. Raised on the south shore of Long Island, I spent every childhood summer poking around its bays, salt marshes, tidal pools and beaches, catching fish and crabs, watching birds and collecting minerals and shells. Later in life, I studied earth and environmental science at MIT and Columbia University, and learned the importance of precise measurement and sound logical deduction to scientific discovery. My doctoral degree, completed in 1982, was on earthquake waves. Since then, I have taught students and pursued research projects as a professor at Lamont-Doherty Earth Observatory, whose campus is built atop the Palisades Cliffs. In my spare time, I've hiked almost every trail and kayaked almost every stretch of water that's nearby. My studies have taken me to geologic faults, volcanoes, glaciers, and rock formations around the world, but I have always returned to New York, because, to me, it is the most fascinating place of all. I am currently studying the deep roots of the continent beneath our feet.