## Narration from the animation, Ghost Forests—Evidence for a Giant earthquake & tsunami in the Pacific Northwest. (<https://www.iris.edu/hq/inclass/animation/740>)

"Ghost forests" along the coast are part of the evidence that a great tsunami-generating megathrust earthquake occurred off the Cascadia, or Pacific Northwest, coast on January 26, 1700 at about 9 PM local time. How do we know, with such precision, the time of this event that occurred over 100 years before the Lewis and Clark expedition? To unravel the mystery, we will:

1. show the geologic process that makes a ghost forest;
2. share Native American oral history that recalls a great earthquake and tsunami;
3. examine the geology beneath ghost forests; then
4. add the final piece of the puzzle from Japanese Samurai written records.

In this simplified model, the North American Plate in Cascadia is locked by immense friction to the subducting Juan de Fuca Plate along a vast sloping fault called a megathrust. As the subducting oceanic plate pushes the leading edge of the continental plate backwards, the land is compressed and coastal areas rise.  When the stress *between* the plates overcomes friction, the continental plate slides rapidly up the megathrust in a process called elastic rebound that drops coastal forests below sea level.  The offshore leading edge of the continental plate lifts the ocean sending a tsunami out to the open ocean and onto shore carrying sand and debris inland. The drowned forest dies in the salty marsh while the process begins anew eventually raising the dead tree trunks above sea level, creating what is known as a ghost forest.

Let's look at a close-up view for more detail. The forest, represented by this single tree, grows in fertile soil upslope of the shoreline. During the great earthquake, land drops below sea level and sand washed in by the tsunami covers the forest soil.  Trees die from exposure to salt water and intertidal mud accumulates to build a salty marsh. Over decades and centuries, the land gradually rises again.

How do we know this really happened in the Pacific Northwest?

The first evidence came from interviews in the mid 1800s with Native Americans. Their oral history, art, and ceremonies tell of a great earthquake that shook the ground violently and huge ocean waves that swept away villages in the night and lifted canoes high into the trees.La`bid, interviewed in1930 spoke.*“This is not a myth...my tale is seven generations old...there was a great earthquake and all the houses of the Kwakiutl collapsed*” The interviewer wrote: “There is no doubt in my mind of the truth of this tradition.” Similar interviews throughout Pacific Northwest tribes, placed the event in the early 1700s.

U.S. Geological Survey geologist Brian Atwater, who had studied ghost forests and tsunami deposits in Chile and Alaska, began to explore coastal marshes and ghost forests in Oregon and Washington in the 1980s.  When he dug into cut-banks along coastal rivers, he found what is now known as classic 3-layer cake tsunami geology. The*lower layer* is an organic-rich topsoil with plants and occasional charcoal from Native American fire pits. Sand and silt of the middle layer was swept ashore by the onrushing tsunami while intertidal mud and clays of the top layer were slowly deposited in the centuries since the great earthquake. Using Carbon-14 dating of charcoal, marsh grass, and tree wood, University of Washington researcher Minze Stuiver narrowed the date of ghost forest formation, and the great earthquake, to between 1695 and 1710. David Yamaguchi, a dendrochronologist or tree-ring analyst, compared the rings of “victim trees” in the ghost forests to “witness trees” on higher ground nearby that experienced, but survived, the earthquake. Ultimately by dating the final ring from bark-covered roots, Yamaguchi determined that the last tree ring recorded the 1699 growing season so the trees died between the fall of 1699 and the spring of 1700.

The final piece of the puzzle came from Japan, over 4,000 miles away. Japanese geophysicists, who knew about research on the Cascadia great earthquake, thought Samurai may have recorded the tsunami from that earthquake as it swept along the Pacific Coast of Japan. Indeed, abundant written records tell of a tsunami that flooded the coast in Japan from north to south on January 26th 1700. Samurai called it an “Orphan Tsunami” because it arrived without a “parent” earthquake, meaning that no ground shaking was felt in Japan. Now knowing the arrival time of the Orphan Tsunami and the time required for a tsunami to cross the ocean from the Pacific Northwest of North America to Japan, the origin time of the Cascadia great earthquake was determined to be around 9 PM on January 26, 1700.

Further geologic evidence from the Pacific Northwest includes repeated cycles of coastal tsunami deposits over thousands of years and offshore marine deposits that record great Cascadia earthquakes back to 10,000 years ago. When coupled with current GPS observations that the Cascadia continental margin is being compressed by the offshore Juan de Fuca Plate, it is clear that the Pacific Northwest will experience great megathrust earthquakes in the future.