





10/14/2016

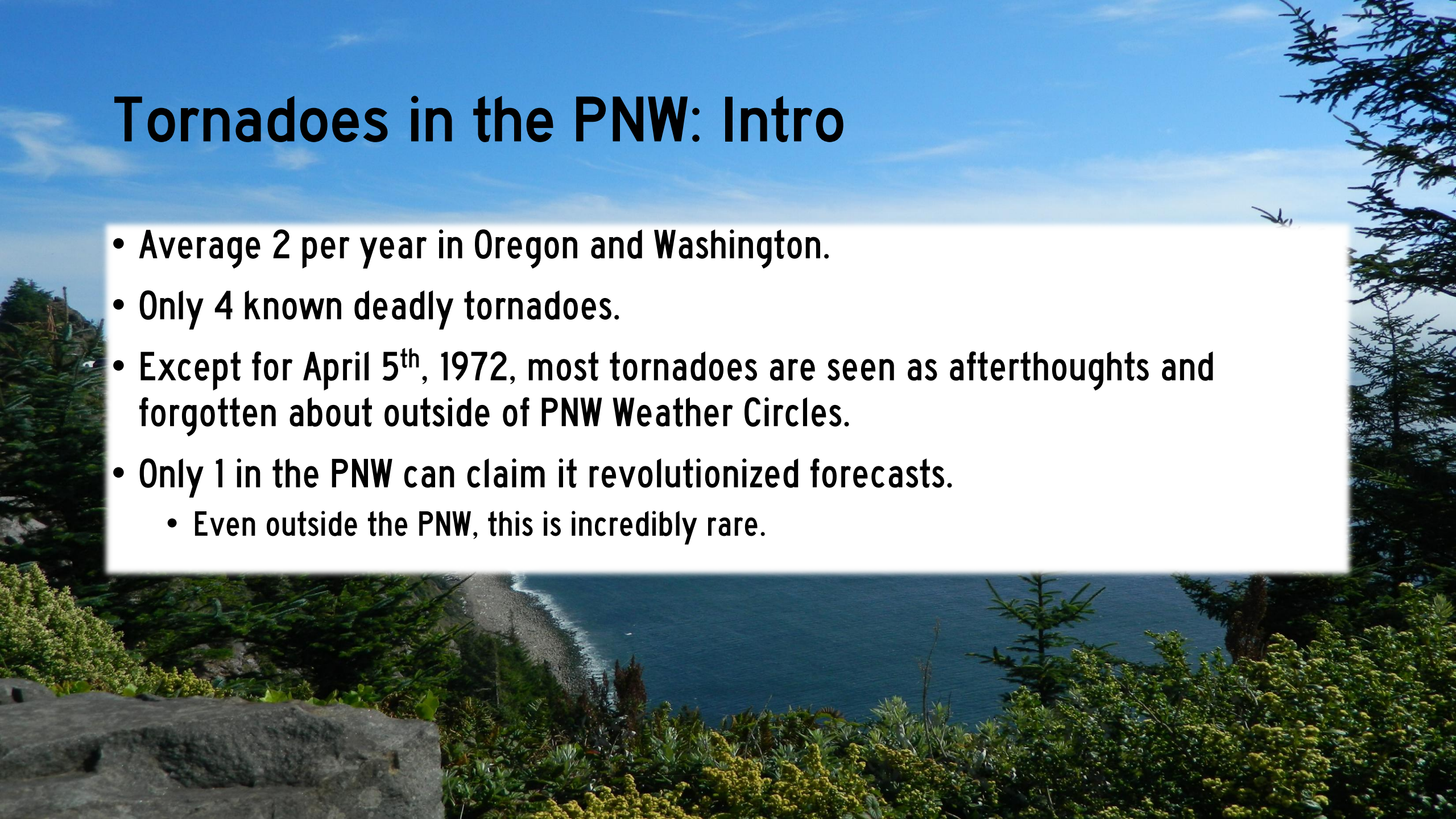
The Manzanita, Oregon EF2 Tornado

From Destruction to Determination

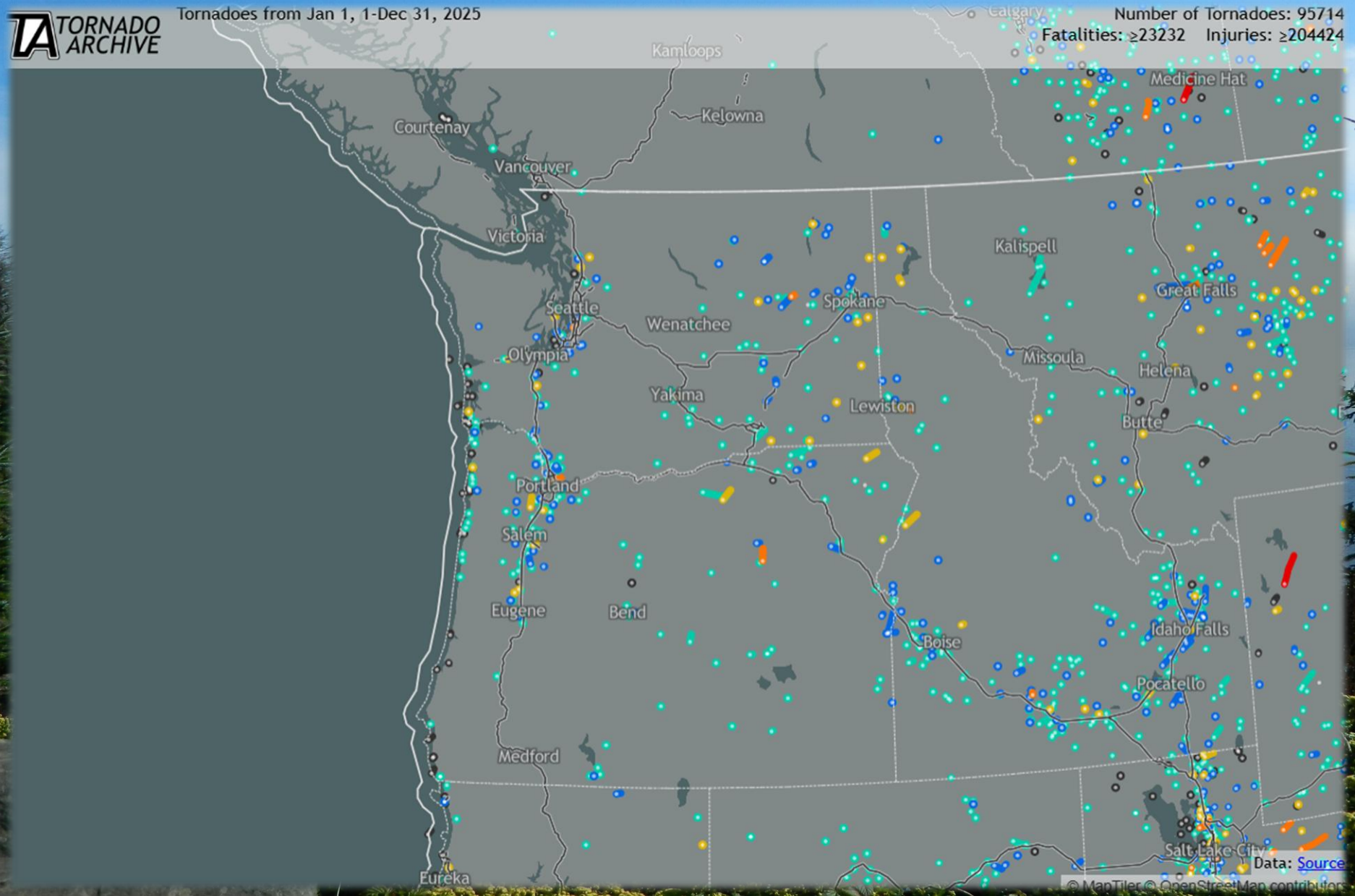
And Other PNW Tornado Items

Tornadoes in the PNW: Intro

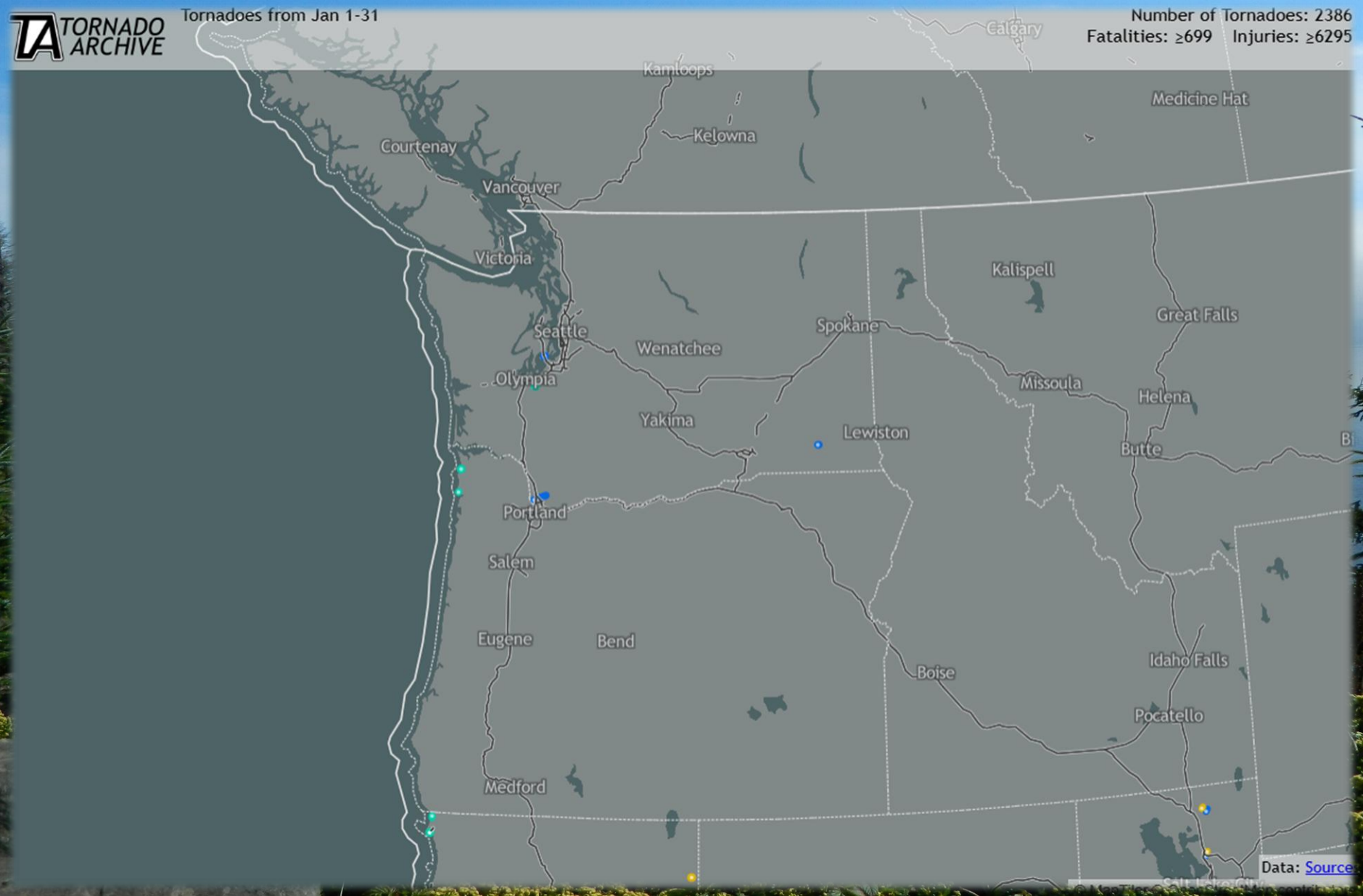
- Average 2 per year in Oregon and Washington.
- Only 4 known deadly tornadoes.
- Except for April 5th, 1972, most tornadoes are seen as afterthoughts and forgotten about outside of PNW Weather Circles.
- Only 1 in the PNW can claim it revolutionized forecasts.
  - Even outside the PNW, this is incredibly rare.



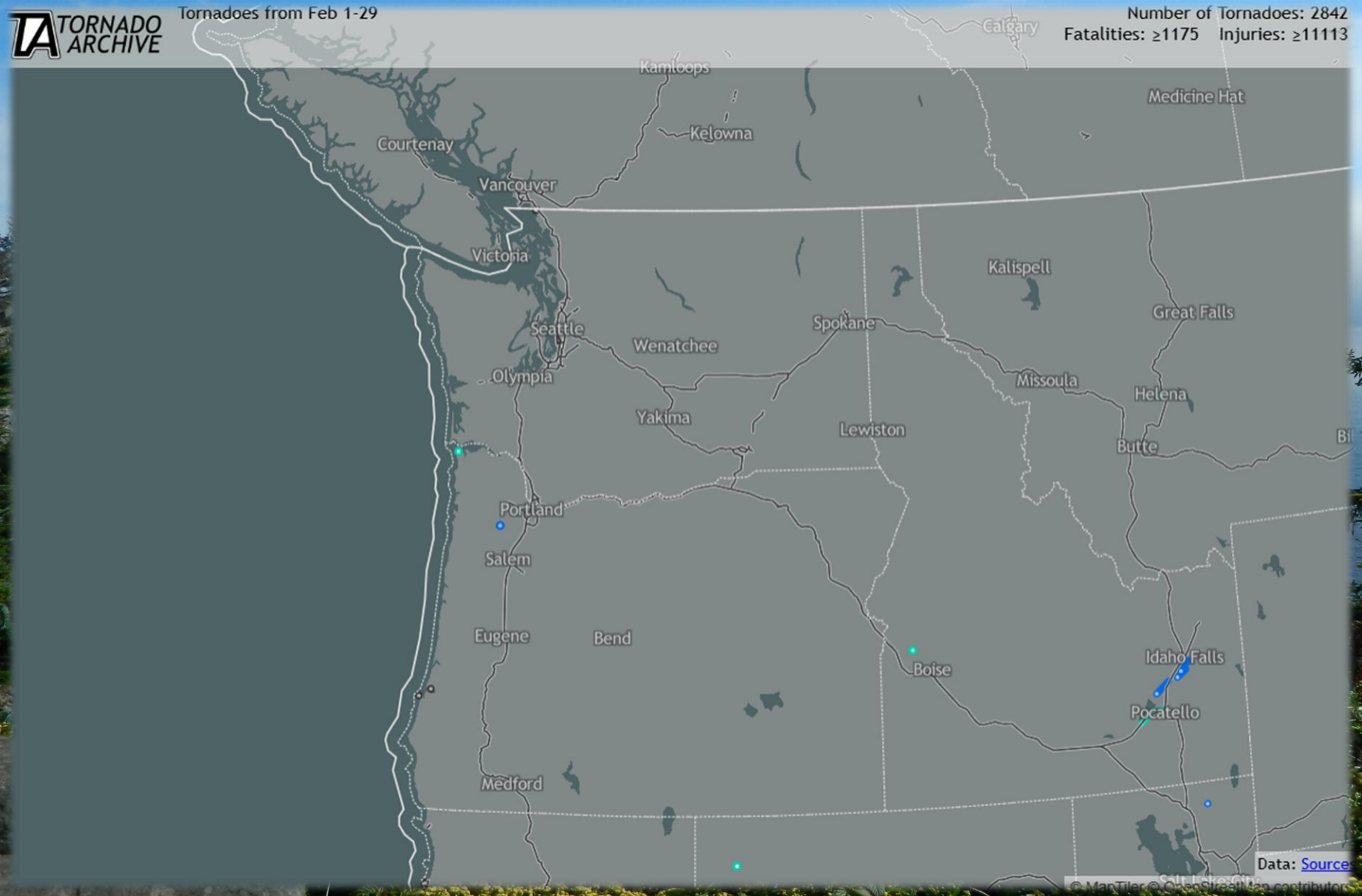
Tracks of the tornadoes



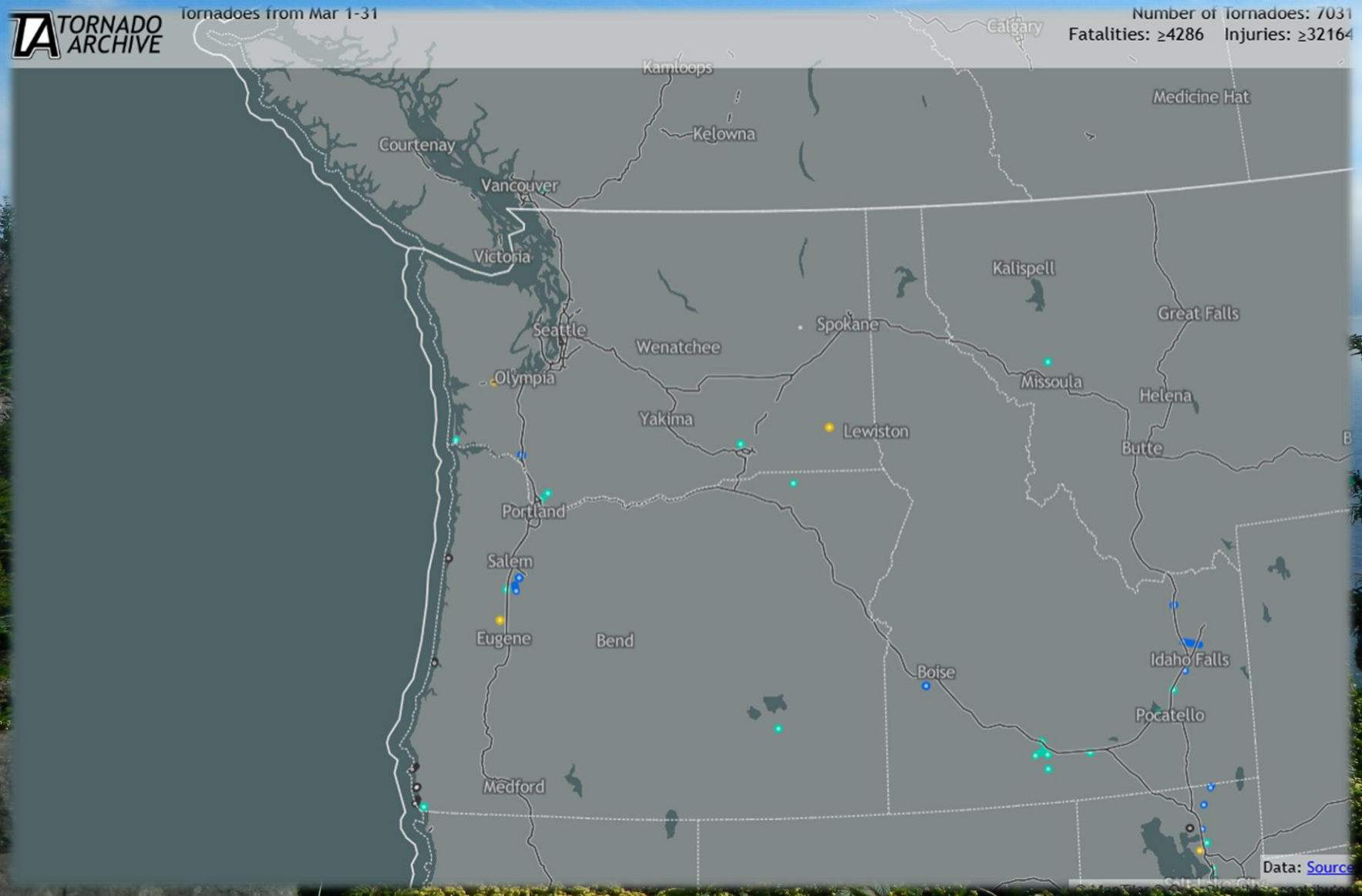
Tracks of the tornadoes in January



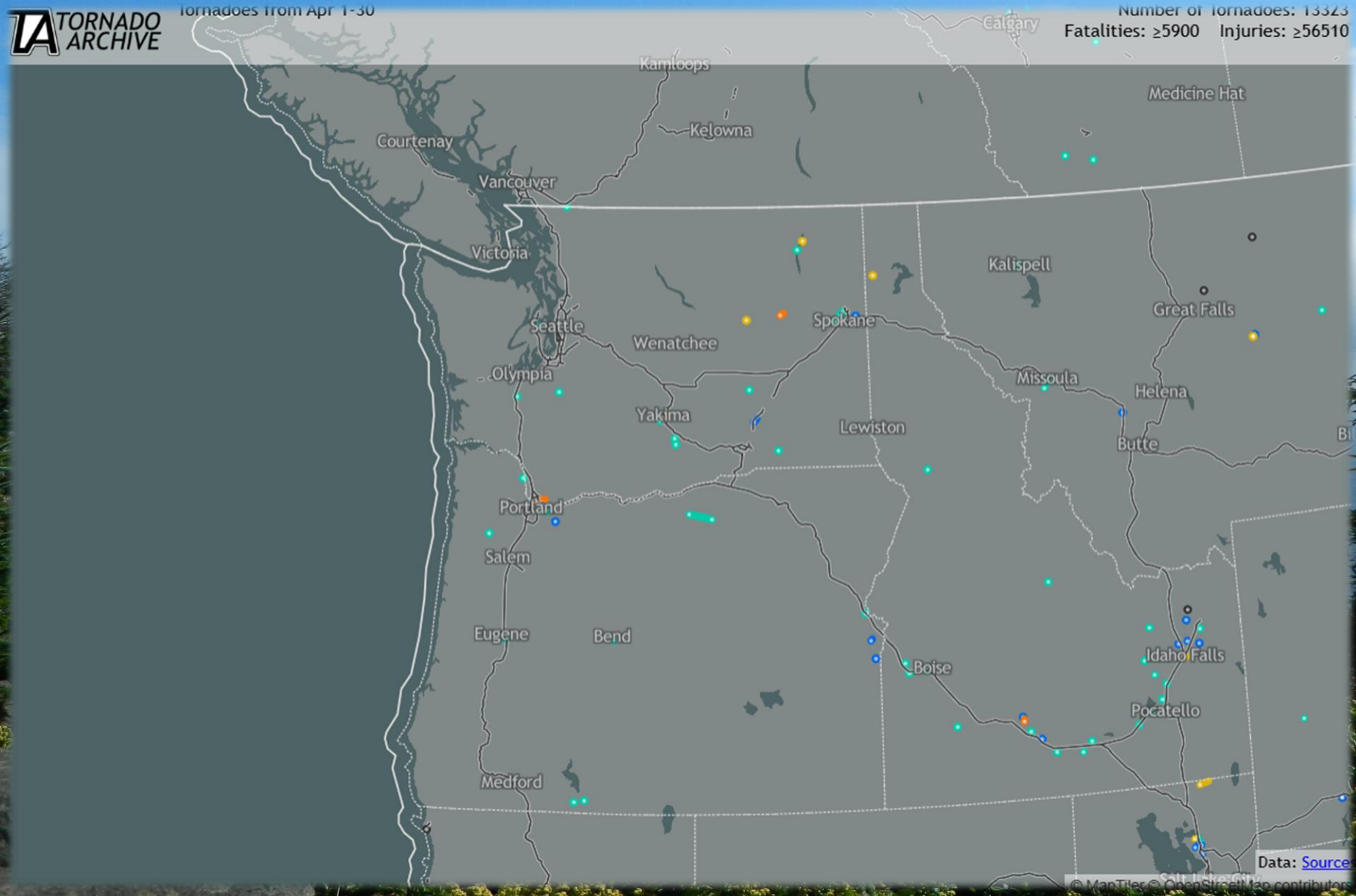
Tracks of the tornadoes in February



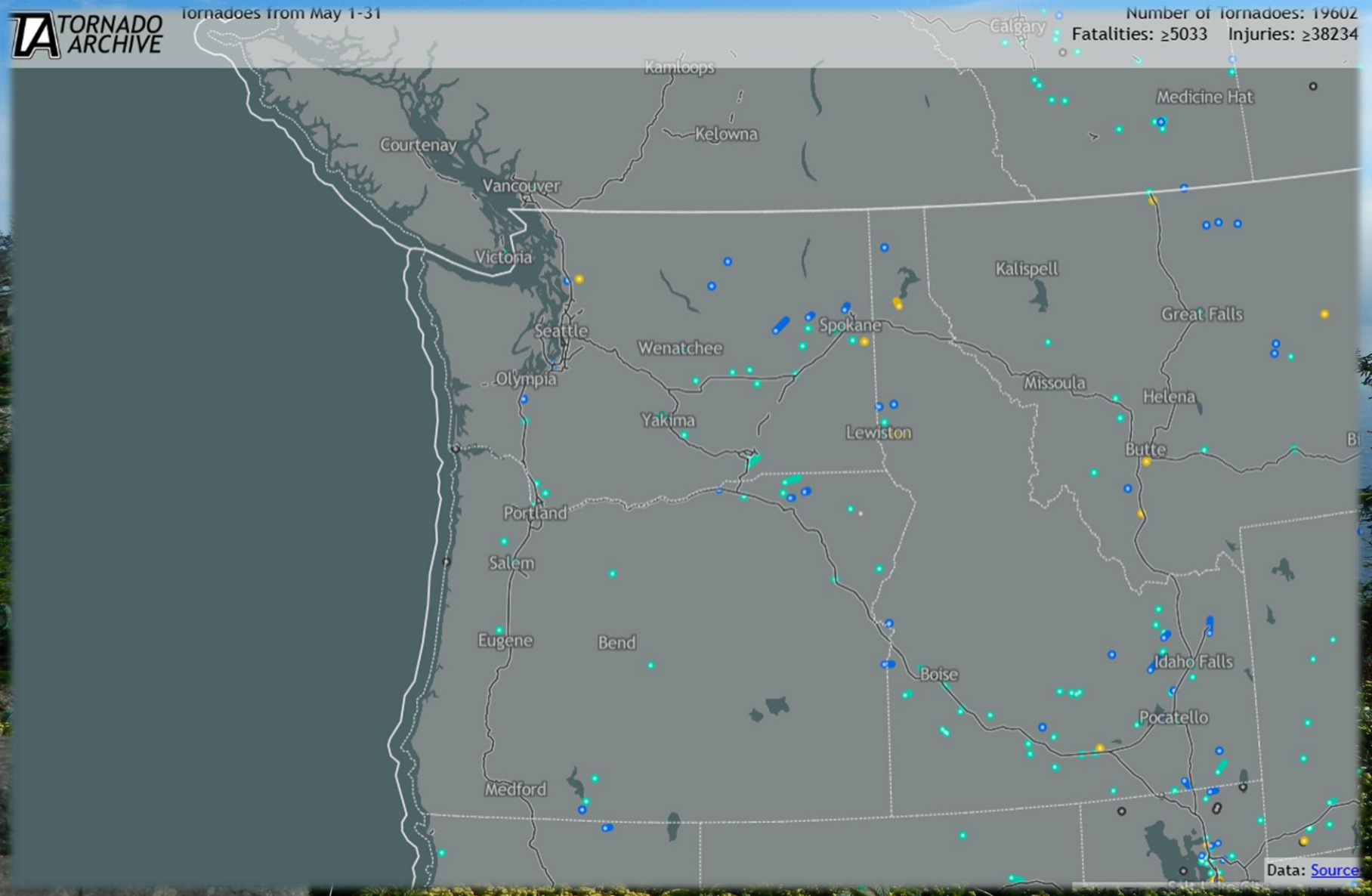
Tracks of the tornadoes in March



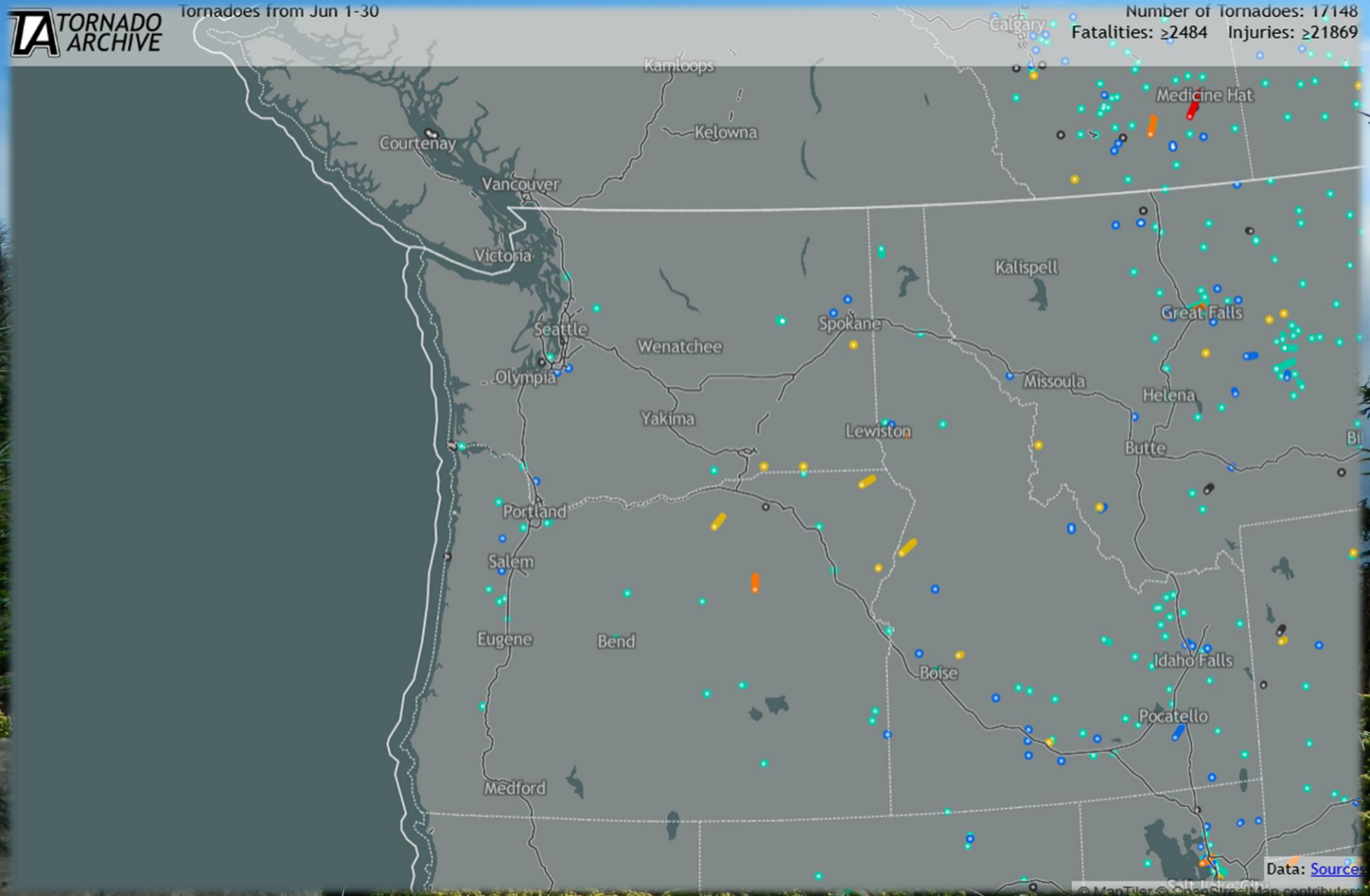
Tracks of the tornadoes in April



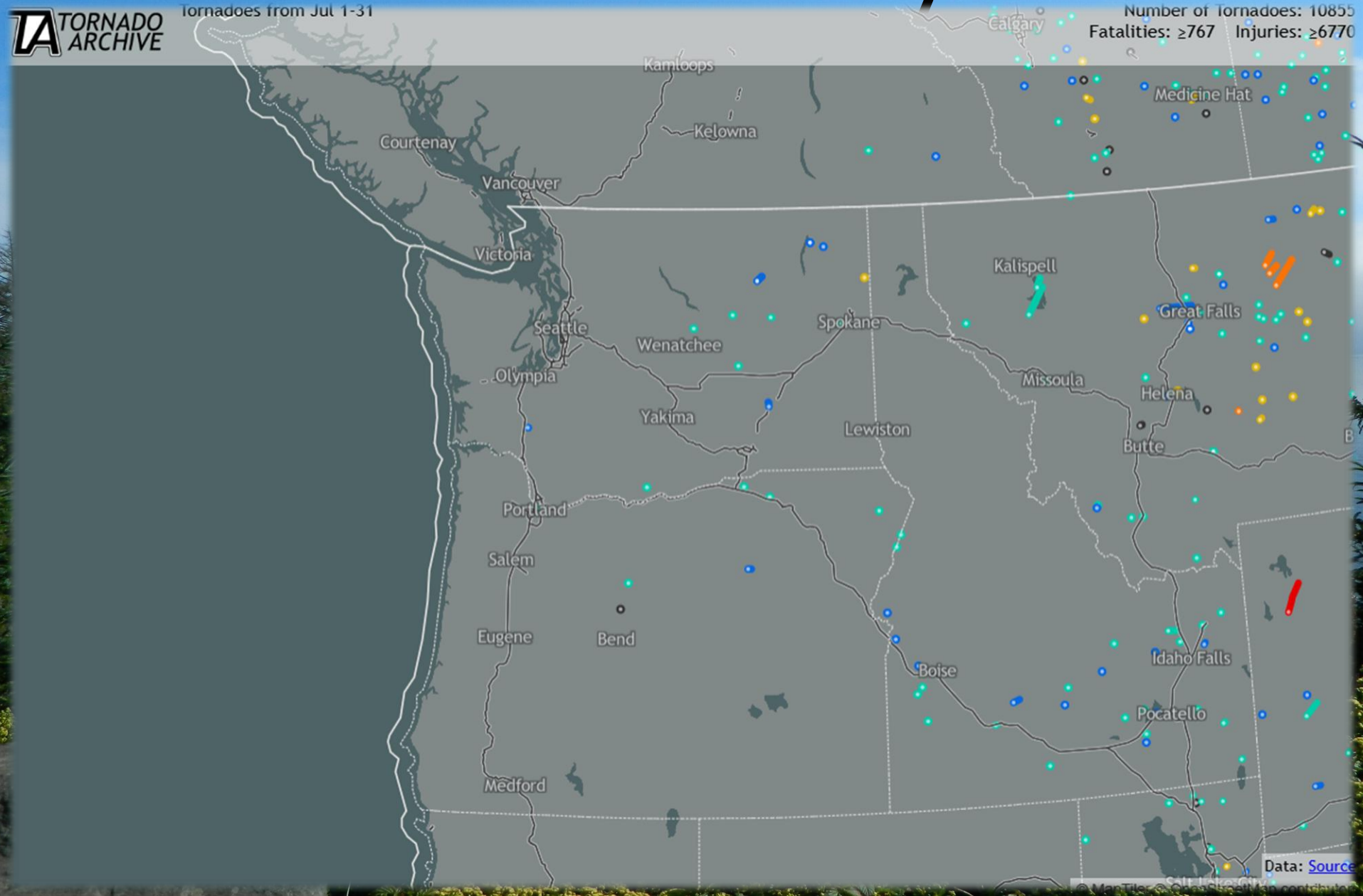
Tracks of the tornadoes in May



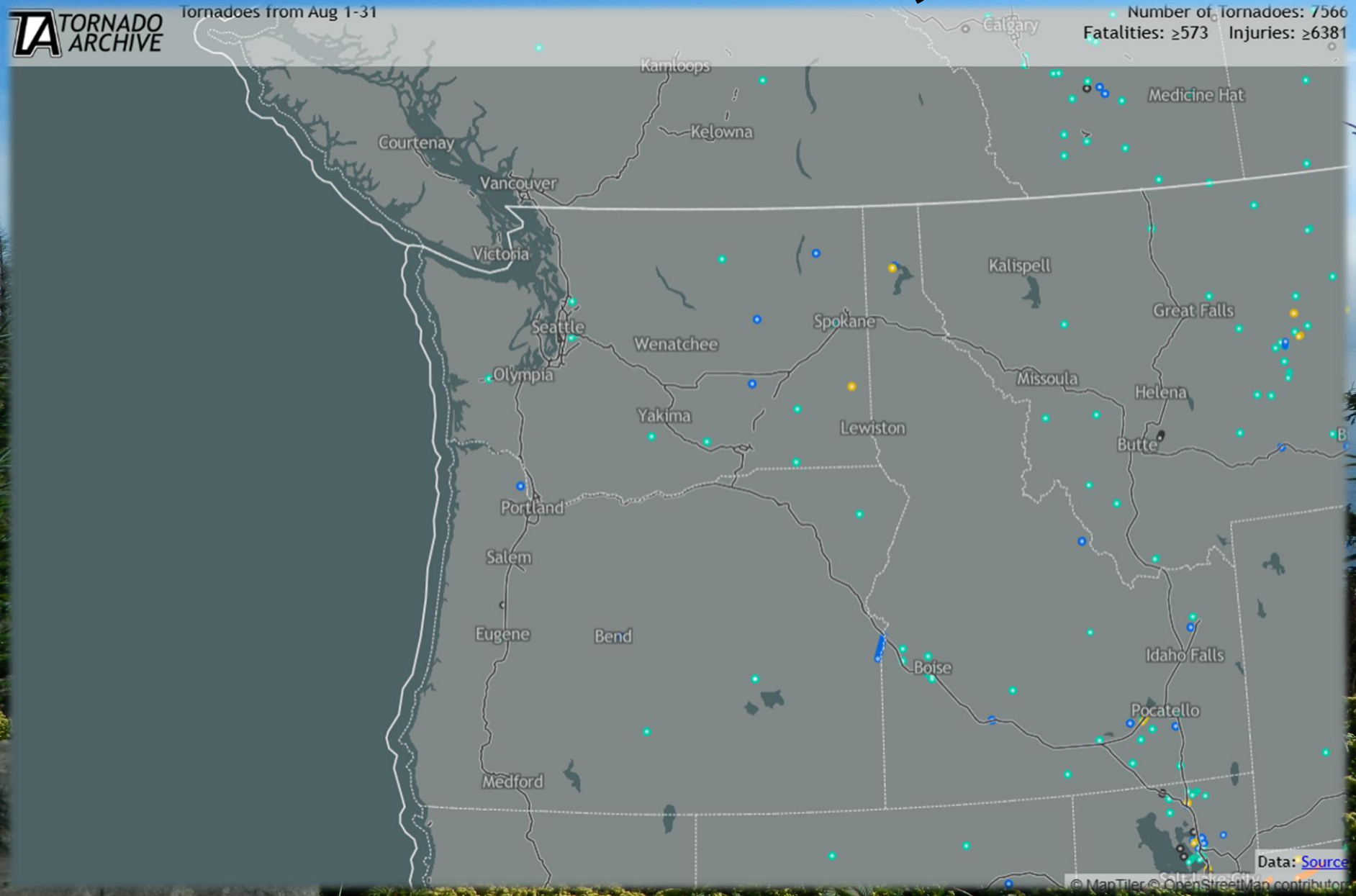
Tracks of the tornadoes in June



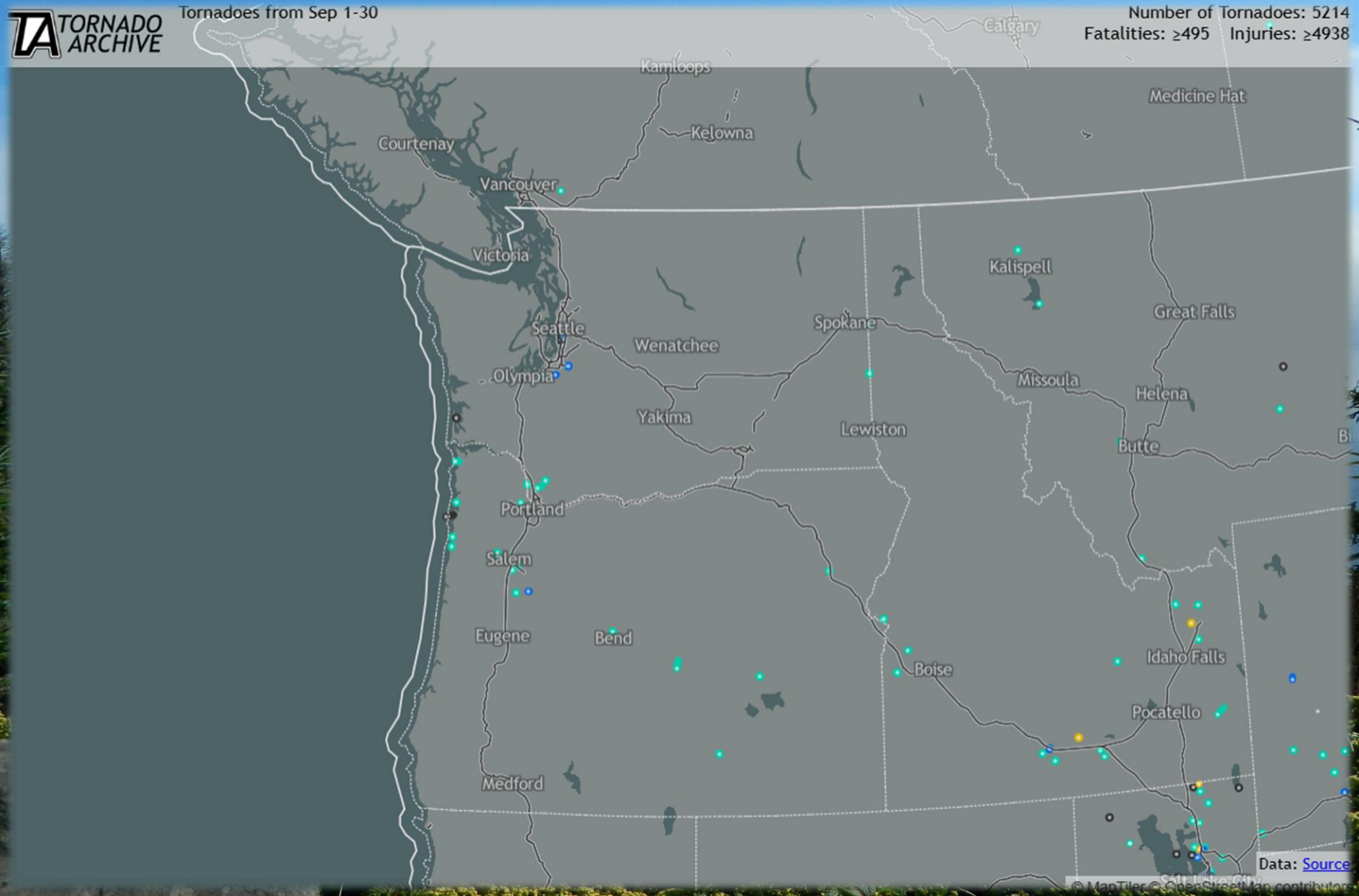
Tracks of the tornadoes in July



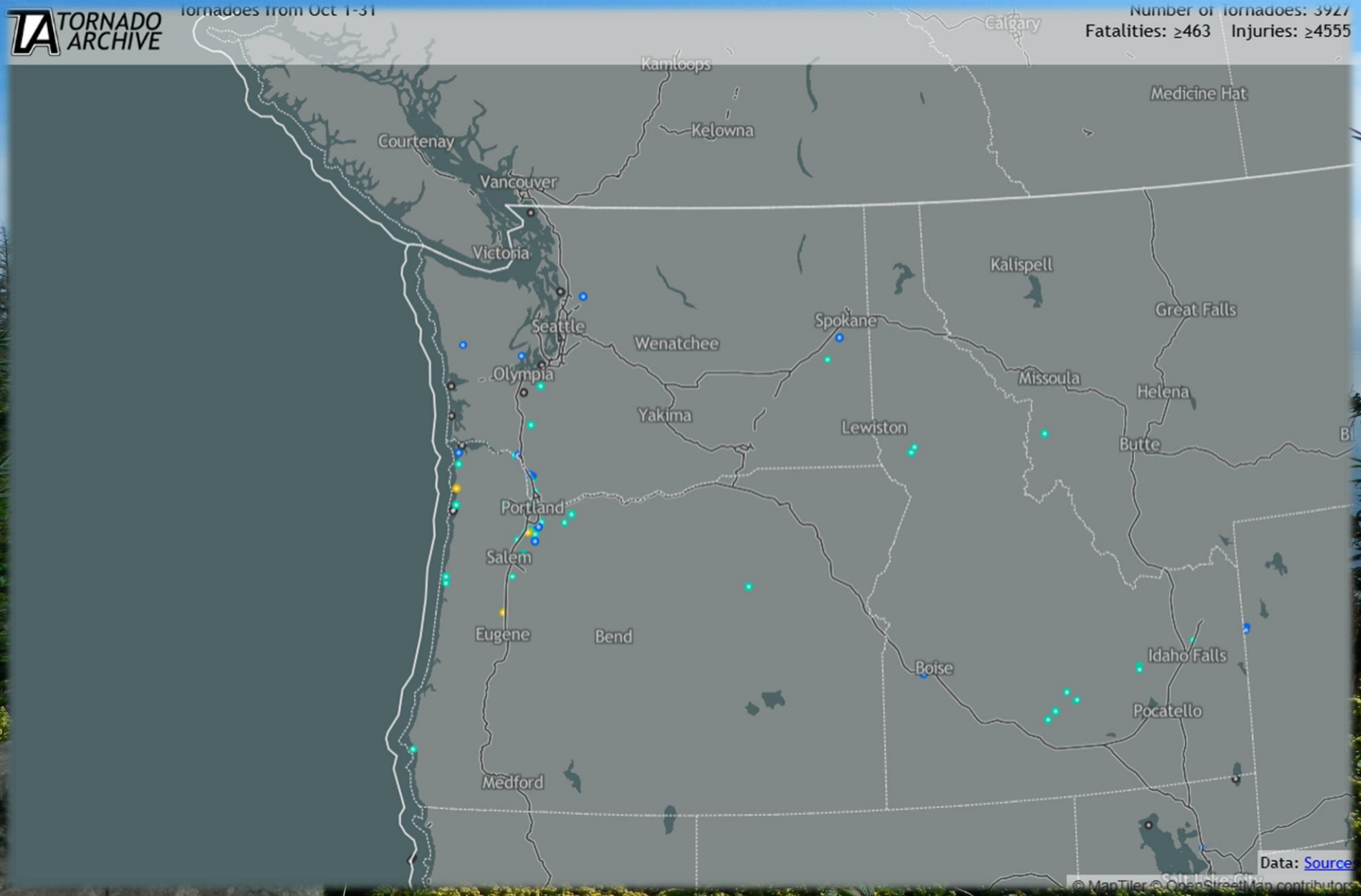
Tracks of the tornadoes in August



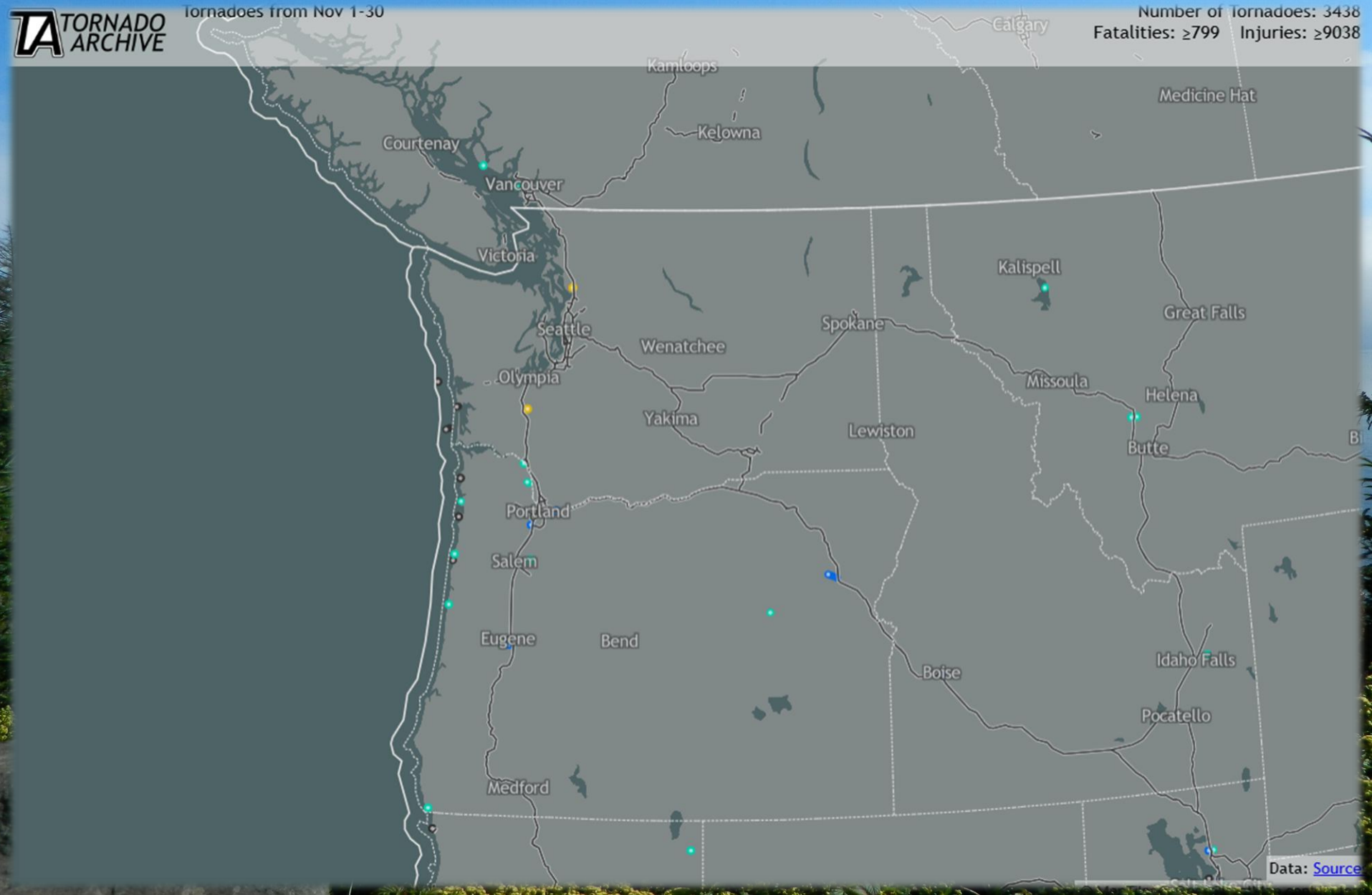
Tracks of the tornadoes in September



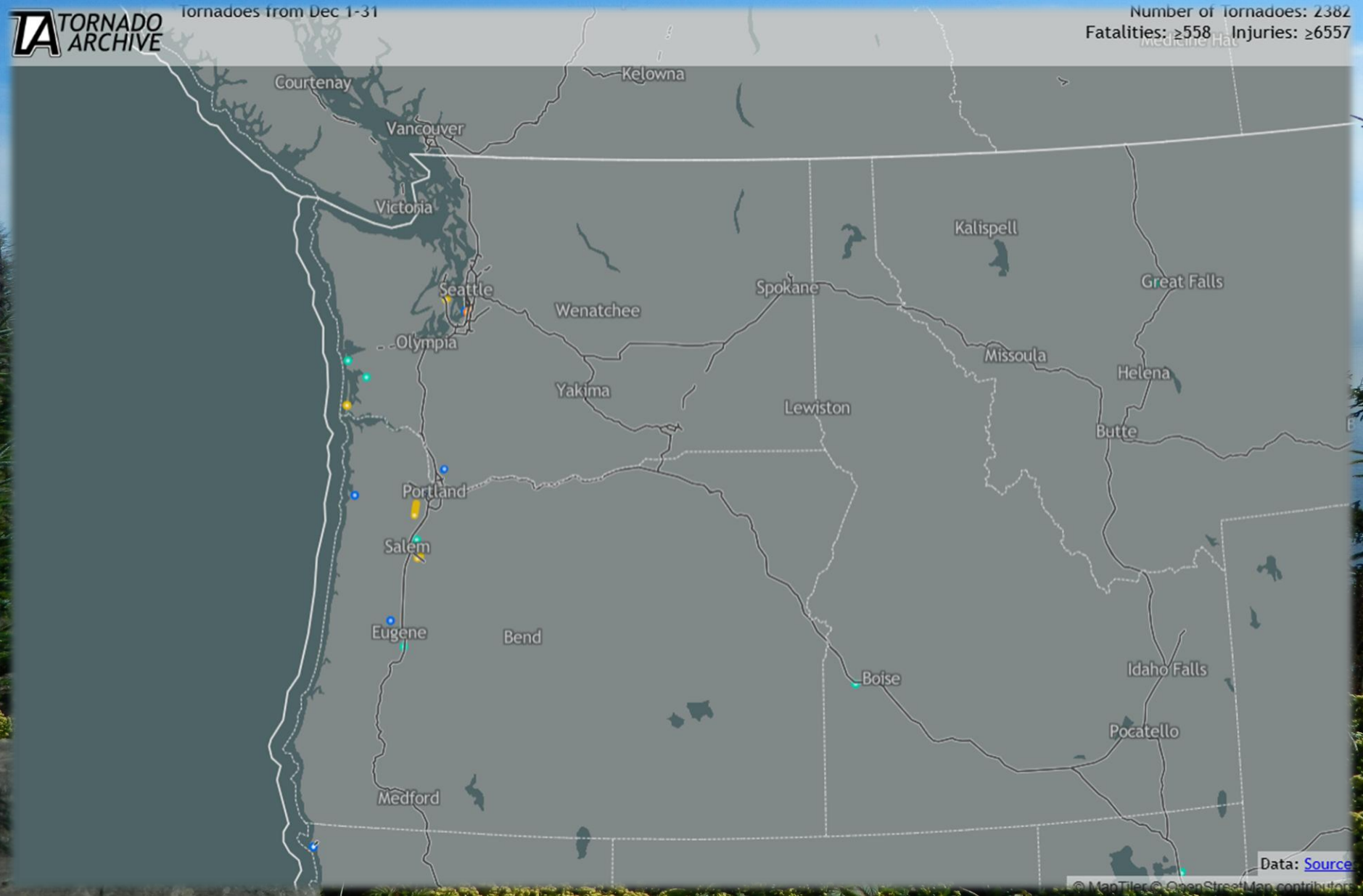
Tracks of the tornadoes in October



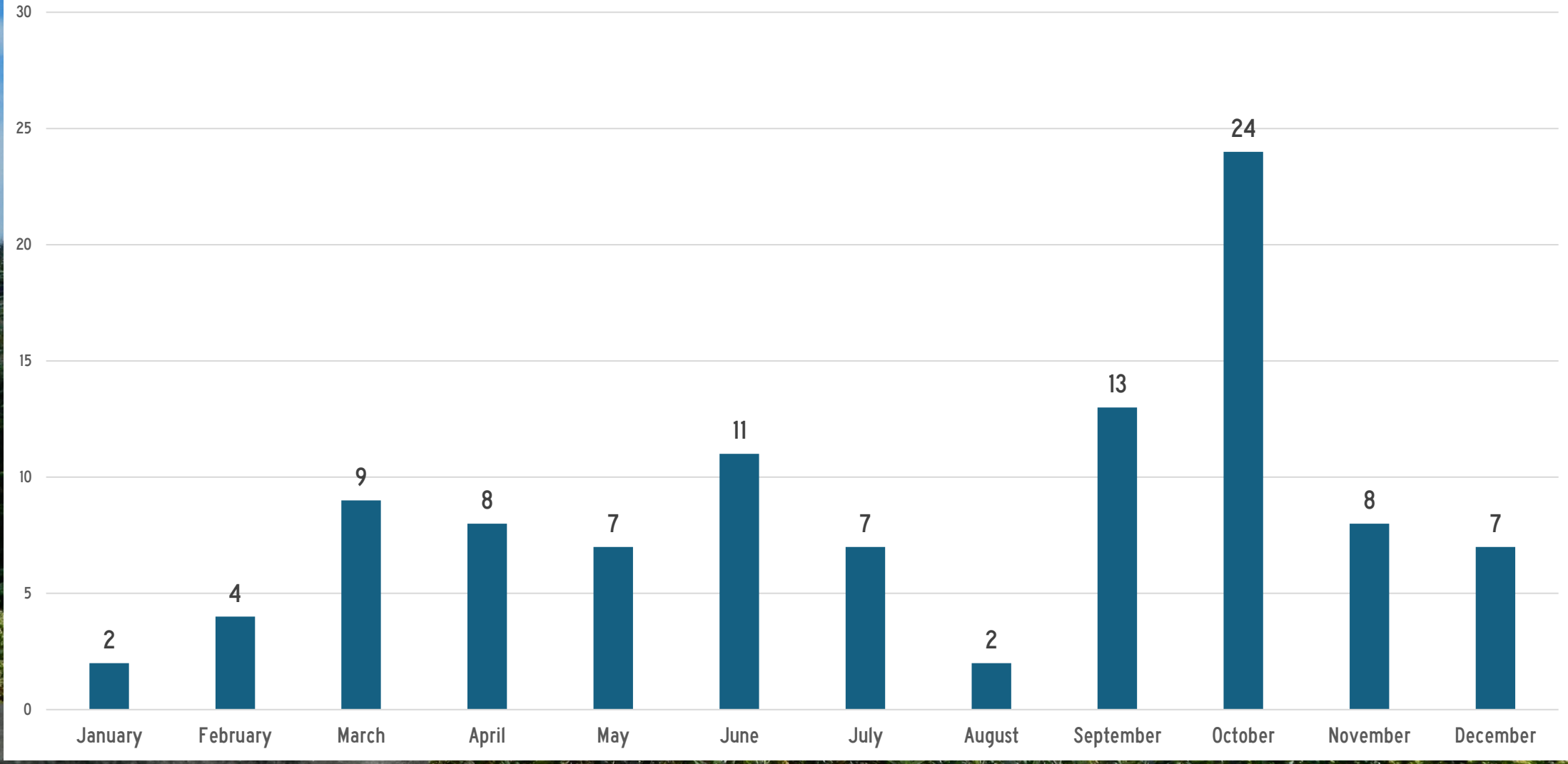
Tracks of the tornadoes in November



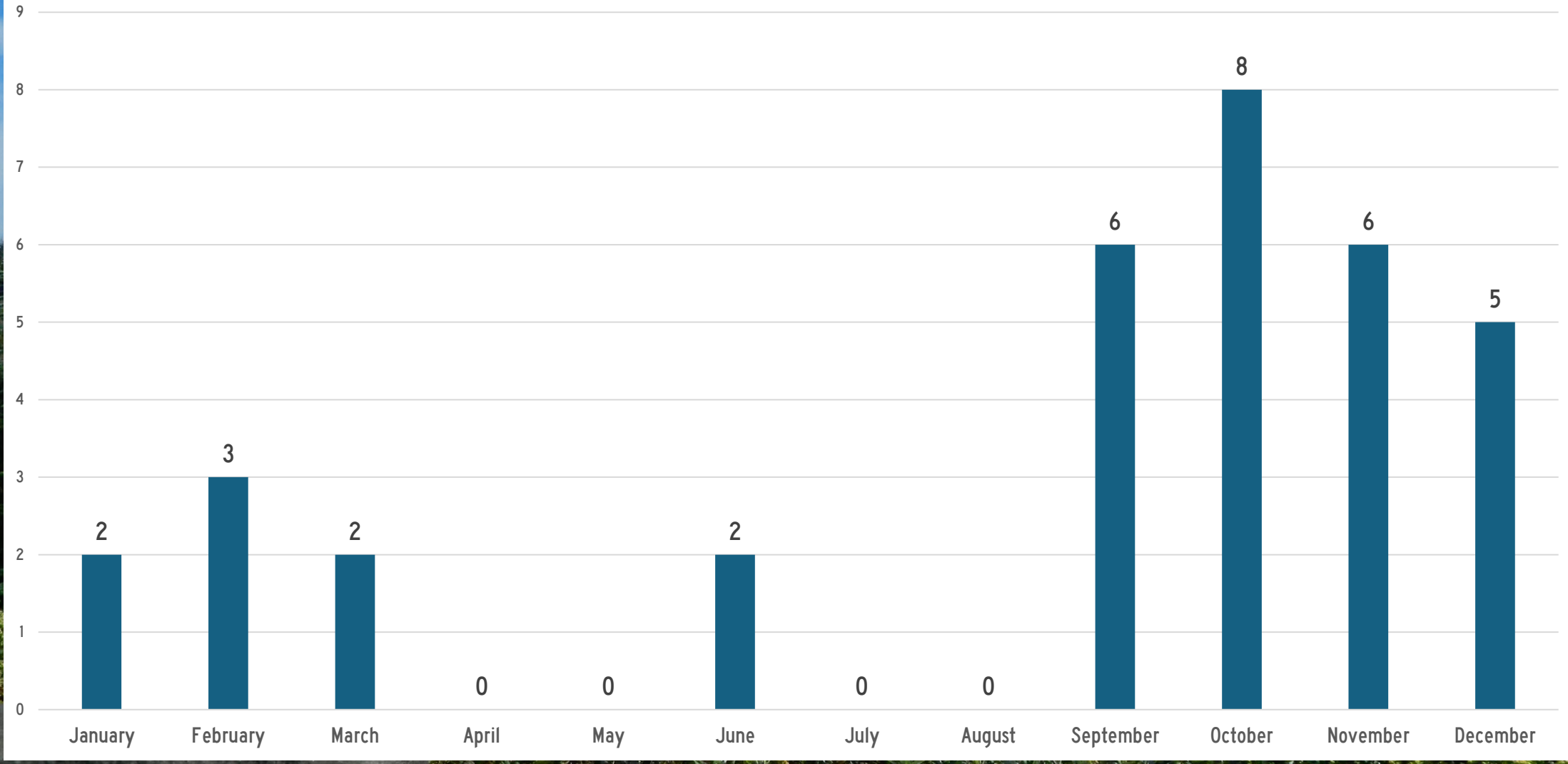
Tracks of the tornadoes in December



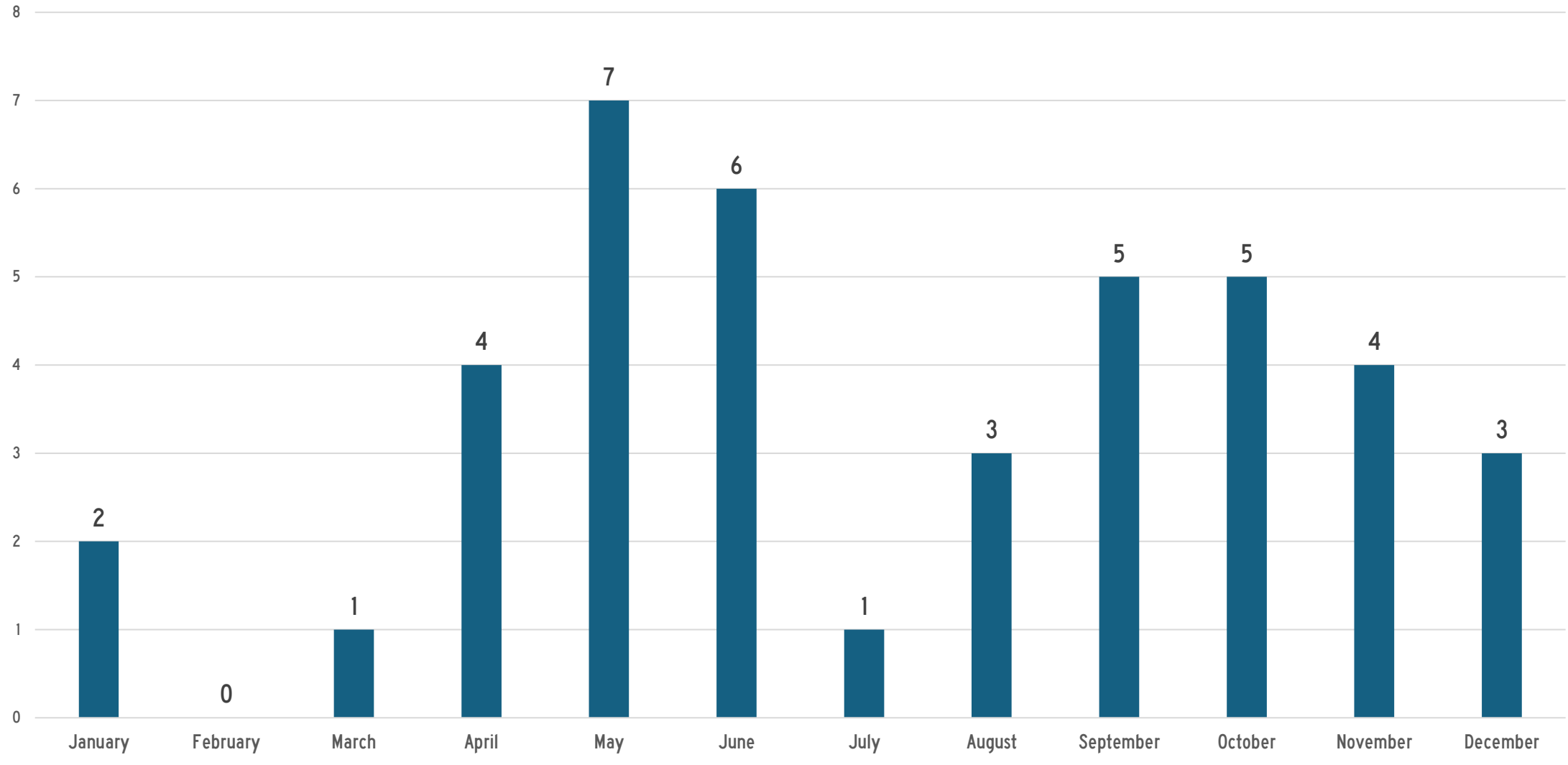
Willamette Valley Tornadoes



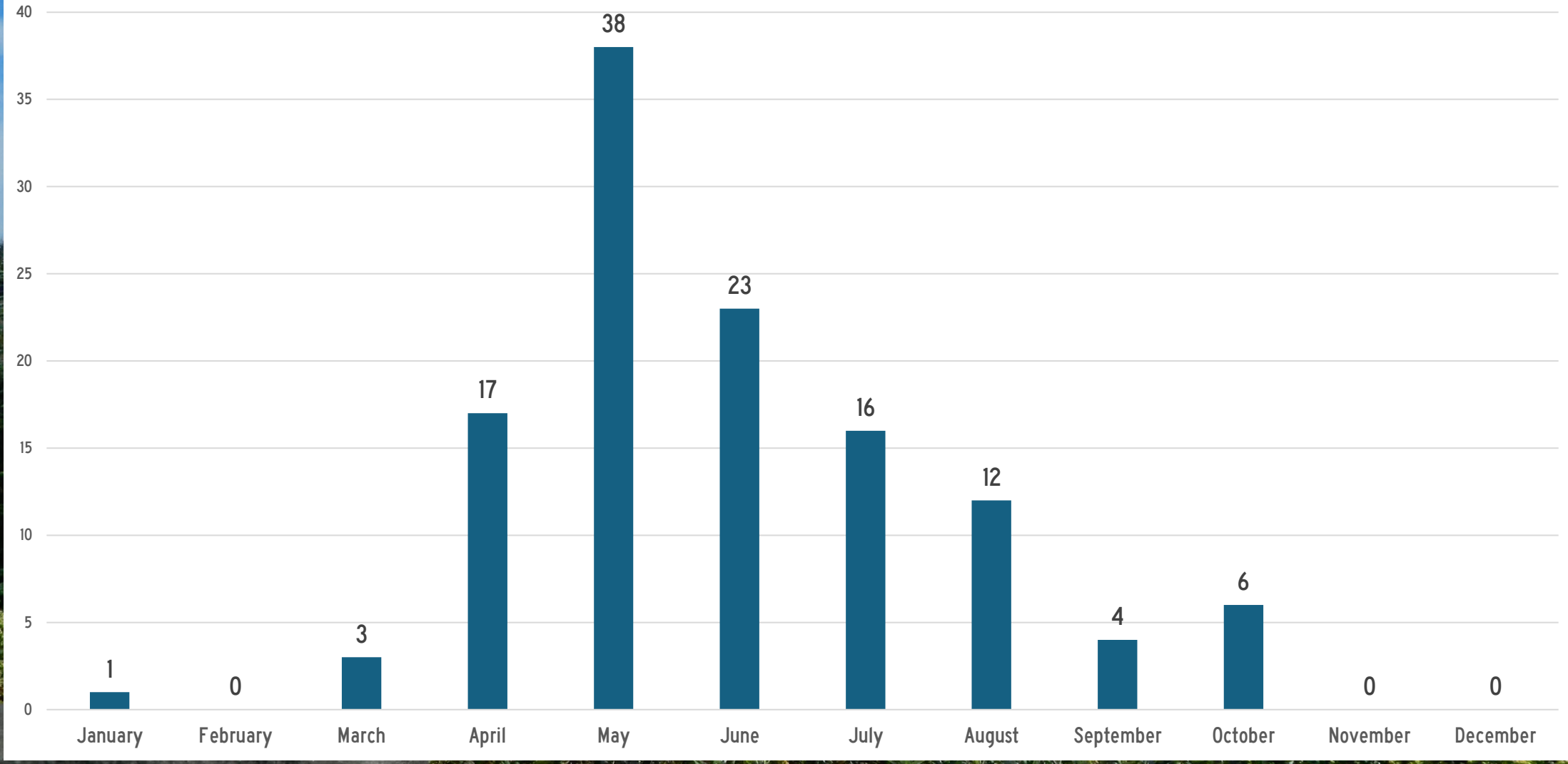
Coastal Tornadoes



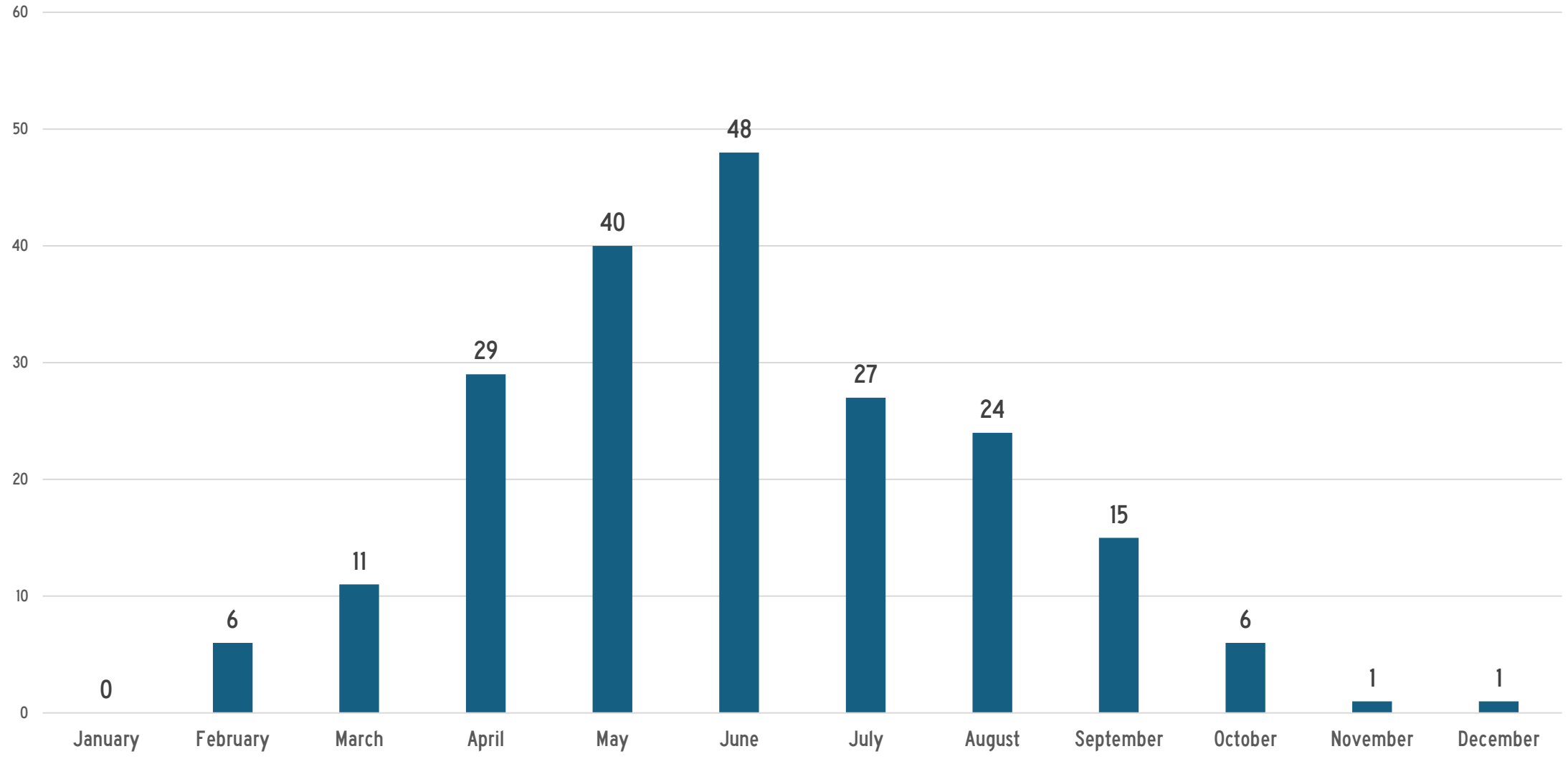
Salish Sea Tornadoes



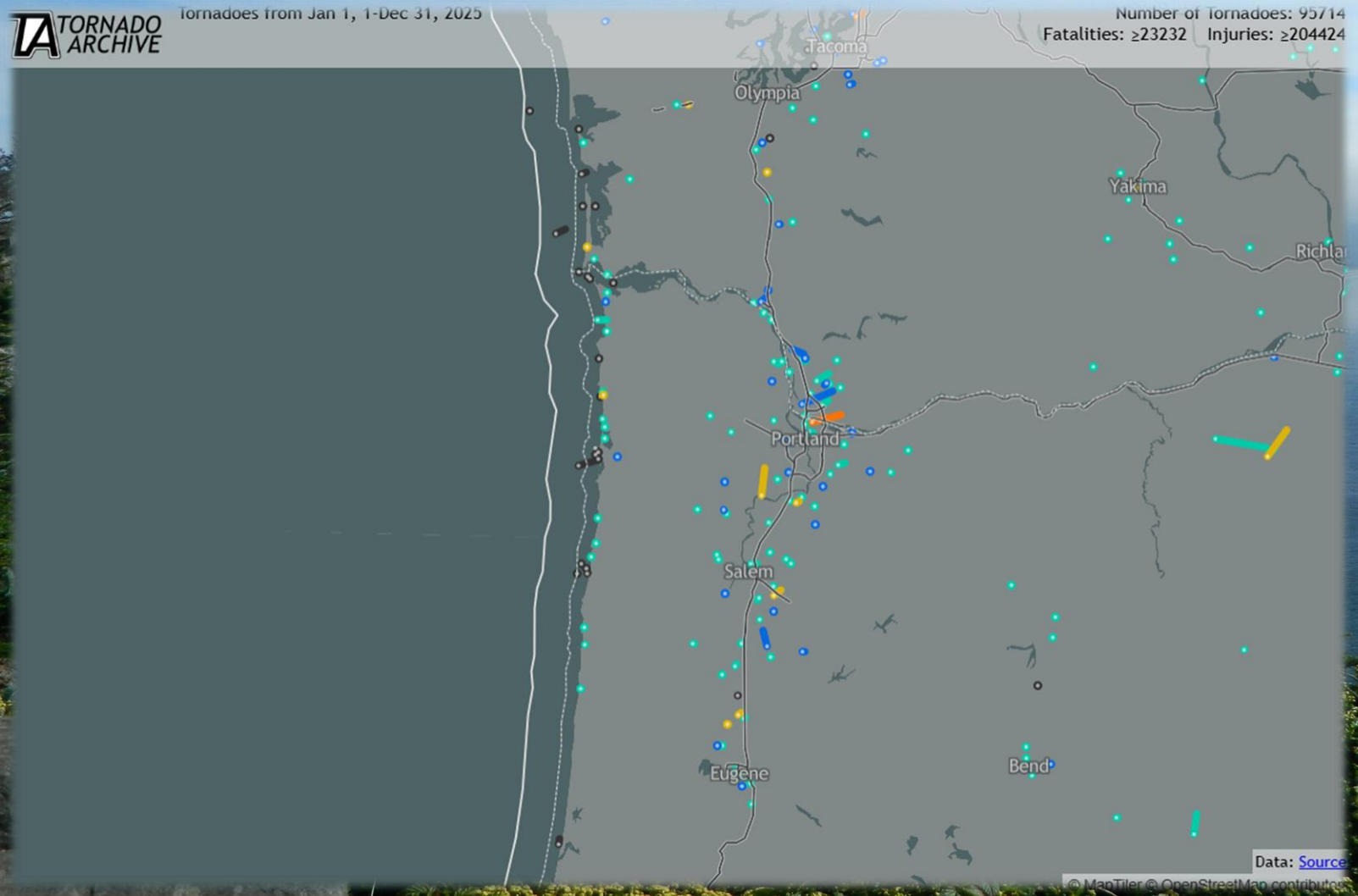
Columbia Basin Tornados



Snake River Plain Tornadoes



Is There a Hotspot West of the Cascades



NW Oregon/SW Washington Tornado Counts

County	Tornado Count
Clark	15
Marion	14
Clackamas	13
Linn	10
Lane	10
Multnomah	9
Washington	8
Columbia	7
Yamhill	6
Cowlitz	5
Polk	4
Benton	1

County	Tornado Count
Tillamook	10
Pacific	5
Lincoln	5
Clatsop	4
Grays Harbor	3

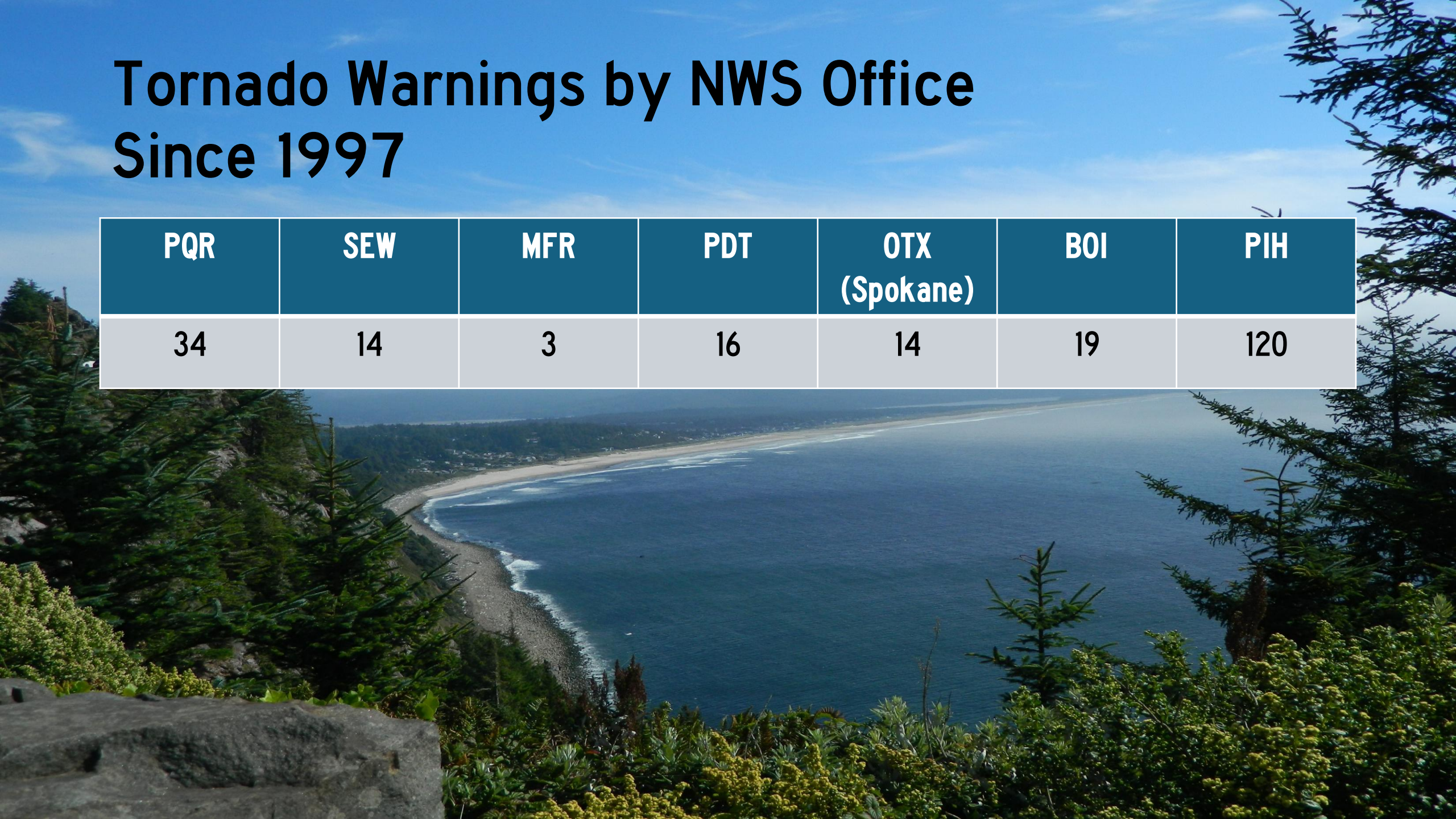
NW Oregon/SW Washington Tornado Warnings 1997-present

County	Warning Count
Clark	6
Marion	6
Clackamas	7
Linn	2
Lane	0
Multnomah	1
Washington	0
Columbia	1
Yamhill	0
Cowlitz	0
Polk	1
Benton	0

County	Warning Count
Pacific	9
Tillamook	5 (all on 10/14/2016)
Clatsop	3
Wahkiakum	2
Lincoln	0 (out of range)
Grays Harbor	8

Tornado Warnings by NWS Office Since 1997

PQR	SEW	MFR	PDT	OTX (Spokane)	BOI	PIH
34	14	3	16	14	19	120





Types of Tornadoes

Type 1: Cold Air Funnel

- Caused by cold temperatures aloft and the stretching of vorticity as the air parcel rises.
  - Clouds have a limited updraft, which limits the time of the storm.
  - Most successful if the system is tilted with height.
- Normally, no warnings are issued.
  - Harder to detect on radar.
- Rare for one to reach the ground. The strongest on record is the 2013 McMinnville EF1.

Type 2: Landspout

- Forms from the ground up, unlike every other type of tornado.
  - You still need some shear/rotation.
- Most common in strengthening thunderstorms, but is possible with just cumulus clouds.
- EF2 or less for these tornadoes.
- NWS cites this as the most common tornado in the Willamette Valley.



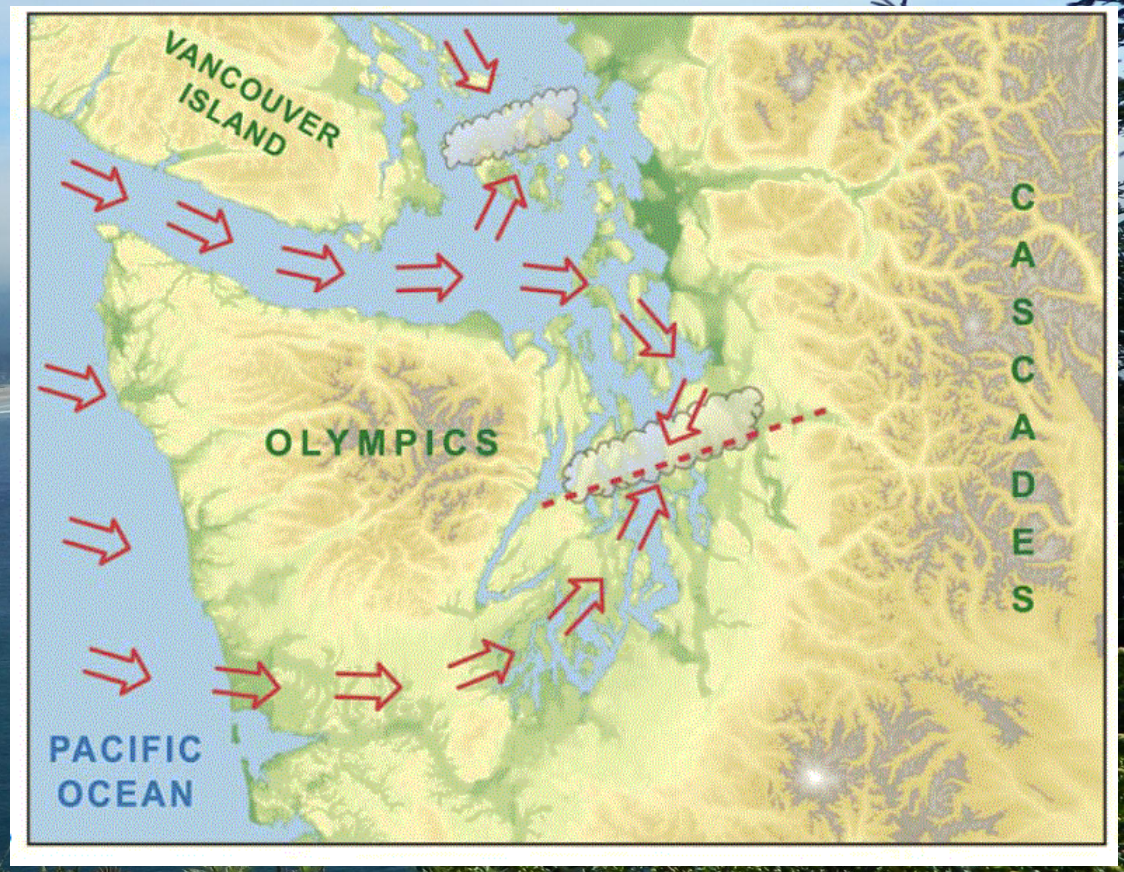
Photo: Wikipedia Commons

Type 3: Terrain Induced

- Localized areas of shear and rotation can be induced by local terrain or localized convergence zones.
  - Most common in Clark County or the East Valley.
  - Research is lacking to confirm or deny this.
- These can form in non-supercell thunderstorms.
- Typically, these are pulsing thunderstorms, quick hit and they die.

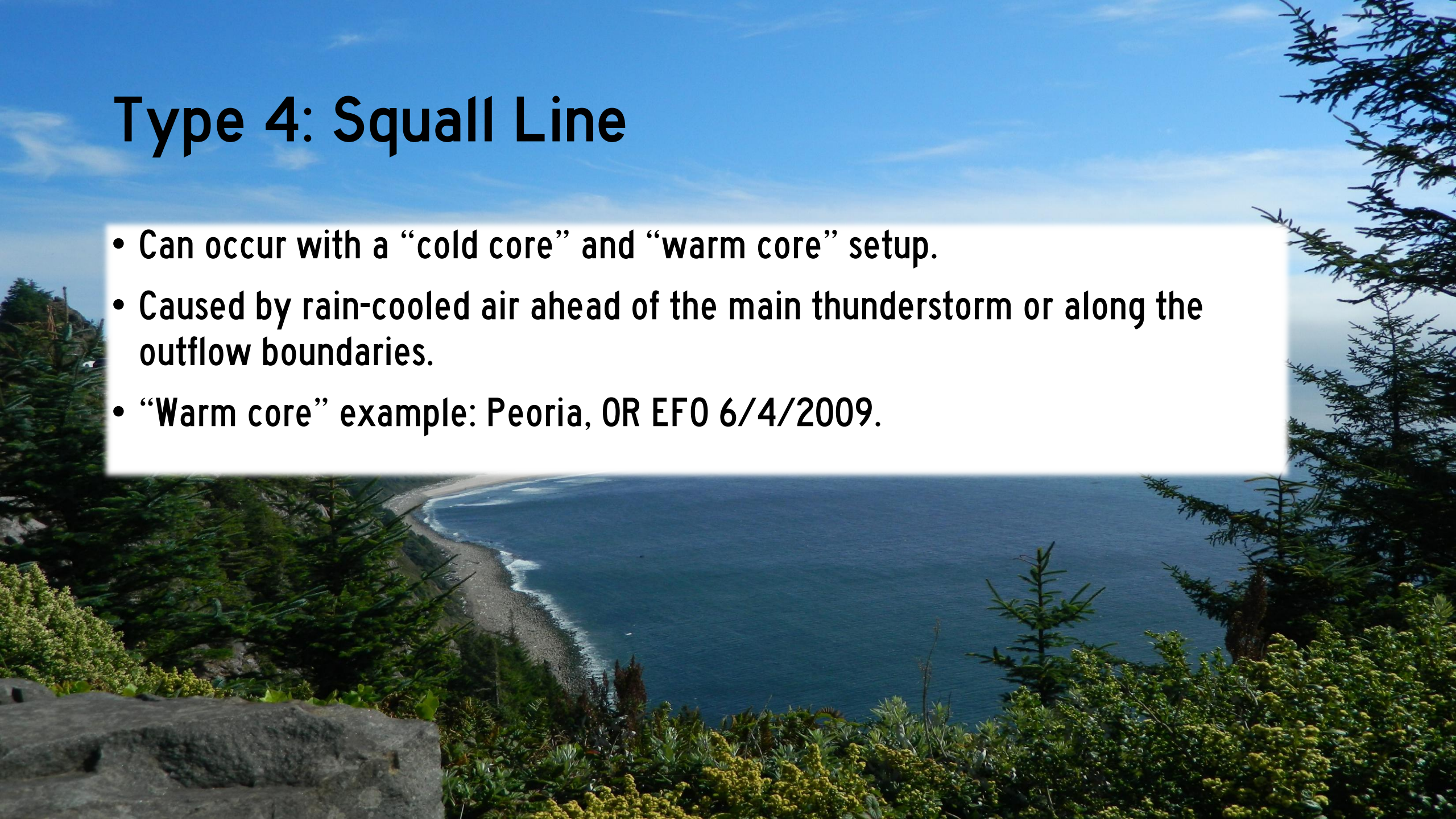
Type 3.5: Puget Sound Convergence Zone

- Formed by converging air on the east side of the Olympic Mountains.
- Creates localized areas of shear in optimal environments that can create quick tornadoes.
- Examples include 12/18/2018 Port Orchard EF2.



Type 4: Squall Line

- Can occur with a “cold core” and “warm core” setup.
- Caused by rain-cooled air ahead of the main thunderstorm or along the outflow boundaries.
- “Warm core” example: Peoria, OR EF0 6/4/2009.



Type 5: Mini-Supercell

- Smaller form of classic supercell (yes, they are possible west of the Cascades, but are far rarer), topping out at 20,000-40,000 feet.
  - May not have an anvil.
- Supercells are rotating thunderstorms, and have a strong updraft.
- Have been recorded producing EF4 tornadoes out in Tornado Alley.
- Most tornadoes on the Coast are caused by one.

Cold vs. Warm Setup Tornadoes

Cold

- Also known as low CAPE, high shear.
  - The higher shear compensates for the lower CAPE.
  - Normally 300-1000 J/kg.
- Nationwide 39% of EF2+ came from these setups, and EF5 potential have been noted.
- Hail is limited, but possible with this setup.

Warm

- Rare West of the Cascades. Have only been recorded from April to June, plus a candidate in September.
- Higher CAPE, normally helped by monsoonal moisture.
  - Most setups where we have good CAPE (1500 J/kg), we lack shear for tornadoes.
- Normally, other hazards.
  - Tornadoes aren't the primary hazard in PNW warm storm setups.

A Few Notable Tornadoes

This is NOT an all-encompassing list.

This goes over lesser-known significant tornadoes.

10/18/1876: 2 Candidate F2s

F2 Tornado | October 18, 1876

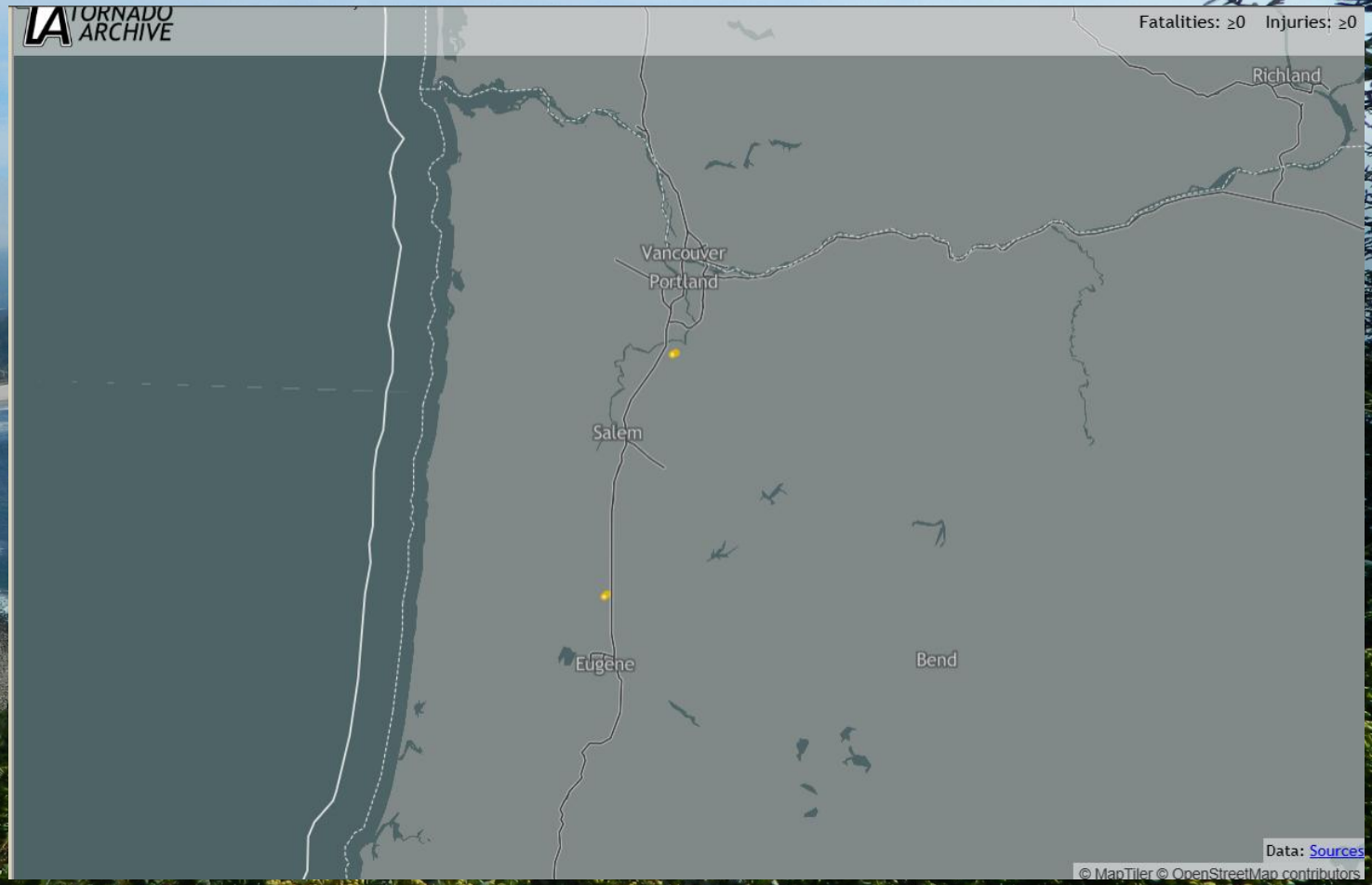
Date	Oct 19, 1876
Start Location	45.25° N, 122.73° W
End Location	45.25° N, 122.72° W
Rating	F2
Path Length	1 mi
Source	Blue Ayanami
Comments	A tornado struck Clackamas County, moving over Barlow, near Canby. It tore a large warehouse to pieces, uprooted or twisted off numerous trees, and scattered a large amount of fencing.

Report an issue

F2 Tornado | October 18, 1876

Path Length	1 mi
Path Width	13 yds
Source	Blue Ayanami
Comments	A tornado damaged the residence of Samuel Estick, located five miles northeast of Harrisburg, Linn County. Continuing northeast, the tornado then tore through J. Tregoning's orchard, where it uprooted large apple trees and carried them between one-half and three-quarters of a mile. It also unroofed M. Tregoning's barn, carrying three of the rafters a distance of over three-quarters of a mile. Finally, the tornado cut a path through the oak timber on Little Muddy, mowing a swath 35 to 40 feet wide, as cleanly as if an ax had cut it, bearing off the trees as if they were mere shrubs.

Report an issue



6/14/1888: Lexington, OR

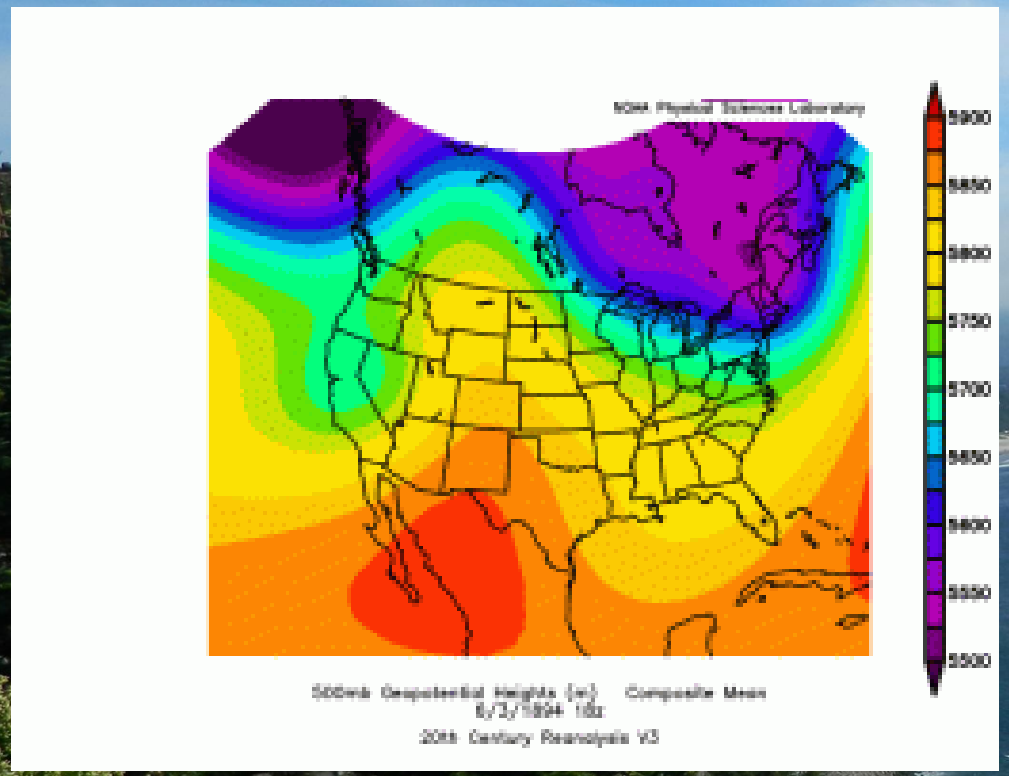
F2 Tornado | June 13, 1888	
Date	Jun 14, 1888
Start Location	45.39° N, 119.75° W
End Location	45.5° N, 119.62° W
Rating	F2
Path Length	10 mi
Fatalities	3
Injuries	5
Source	TPG
Comments	Per Grazulis, "A woman and two children were killed in three separate homes as a tornado moved NE across the town of Lexington. One of the deaths was in a schoolhouse. Another child in that school building may have died. At least a half-dozen homes were destroyed."

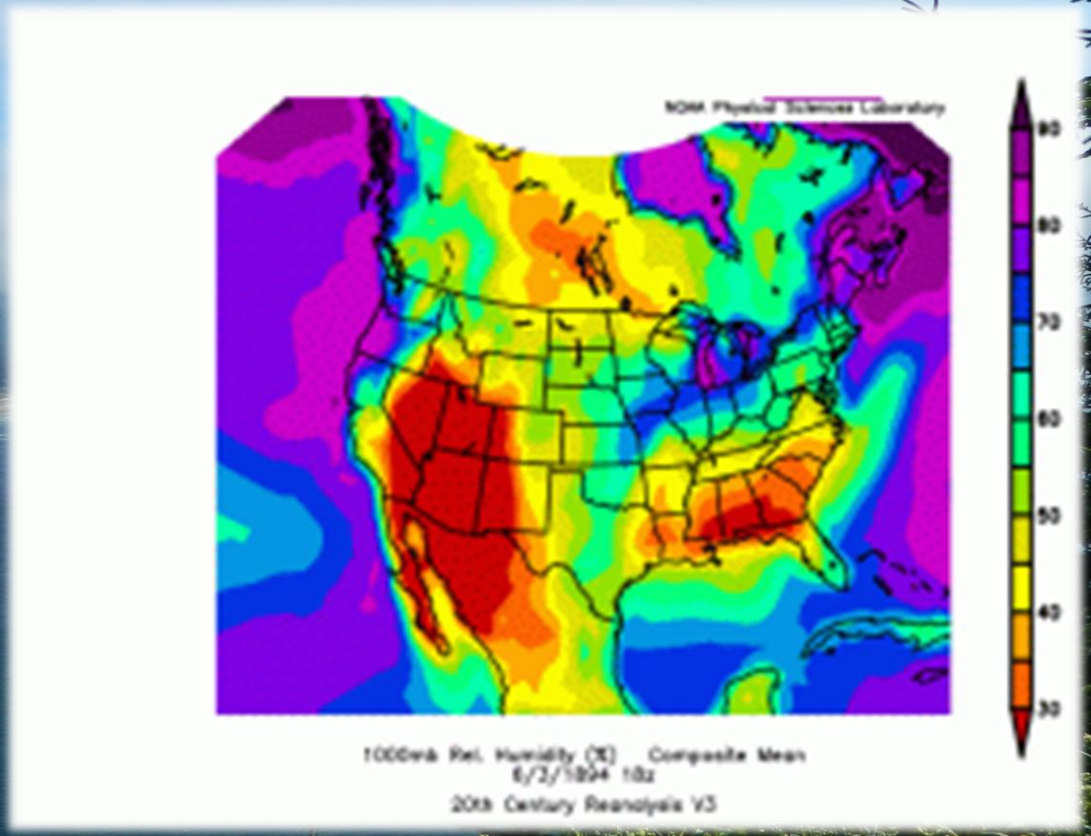
Report an issue

6/14/1894 Long Creek, OR F3

- Rated F3 by tornado historian Thomas Grazulis.
- Killed 3.
  - A newborn
  - A couple escaping tornado country from Kansas.
- Traveled 10 miles.
- Was 0.5 miles wide.
- $25,000 in damage (1894 dollars)
- Only hit the SE part of town.
- Hail reported at 4-5 inch squares.
- Severe Thunderstorm Outbreak both West and East of the Cascades, with possibly more tornadoes.

500 mb and Humidity





Blurbs from "An Illustrated History of Baker County"

In June of this year the northern part of Grant county was swept by a cyclone, which destroyed many thousands of dollars worth of property and resulted in the death of three people and the wounding of several on Long creek. This cyclone entered Grant county from the western portion of Baker county, breaking and twisting off large trees and piling them up like straws, and crossing the mountains struck the edge of the town of Long Creek with tremendous force. Of the buildings which stood in its path not a single trace remained after the storm had passed. An old resident and his wife, Mr. and Mrs. David J. Parrish, were killed in their home, and in the demolition of Dr. and Mrs. Nichol's house their little baby, Blanche, met death. The other members of the family who were in the building at the time miraculously escaped with their lives, though injured to a greater or less extent. C. H. Lee's house was in the path of the storm. All the inmates escaped serious injury, although one of Mrs. Lee's arms was shattered and nearly wrenched off. Several others were slightly injured. L. W. Solawn was picked up by the wind and carried over the top of Woodall's store. Fortunately he alighted safely on a pile of hay, where N. B. Oliver's barn once stood. In Long Creek eight buildings were swept away, the school house, which cost $5,000, was wrecked, the roller mills of C. L. Williams were badly damaged, making a total loss in property estimated at $25,000. Several families were left homeless and penniless. The people of the town cared tenderly for the injured and loving hands prepared the dead for their long rest. The news was at once communicated to the outside world, and a considerable amount of relief money was raised and forwarded to the sufferers.

The cyclone, after leaving Long Creek, continued its course northward, unroofing two or three dwellings before reaching the middle fork of the John Day river, at which point it seems to have spent its force. Much loss was reported on east Long creek, at the Flood Meadows, on Beach creek, and also in Fox valley, but no further loss of life.



Damage shown from the school

There is a Credible Case Long Creek was an F4

- The schoolhouse was NOT one of the buildings described as swept away.
  - 8 buildings were swept away.
- Grazulis's analysis left out some buildings and had damage quoted as 1/5 of the actual amount.
- Contextual to modern images would place this at a high end EF3/low end EF4.
- Would need to see another photo for confirmation. One is not enough to justify a violent tornado.

Taholah 2/21/1904 Tornado

- The tornado started as a waterspout and made landfall at midnight.
  - One of only 2 known tornadoes west of the Cascades to occur at midnight.
- Killed 2 (a newlywed couple) and injured multiple others.
- Likely would've been an EF2+ based on the damage descriptions, but no photos to back this up.

Poster: Treena Jensen

From the 2016 AMS Local Storms Conference

Taholah, Washington - February 21, 1904

Recent Discovery of First Known Fatal Tornado in Washington State

Tragedy Struck the Quinault Agency

Around midnight a tornado moved across the Quinault Indian village presently known as **Taholah.**



1920 Map

The storm resulted in extensive damage to several buildings, including the flattening of the community spiritual gathering place.

Tornado Killed Guests of Quinault Hotel

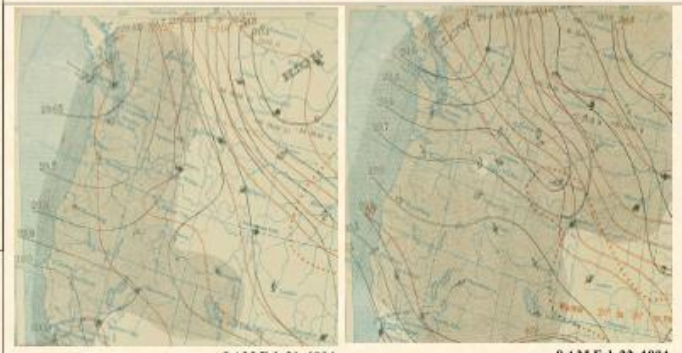
A hotel on the reservation owned by Harry Shale was badly damaged. A newly married couple who was traveling from Hoquiam to their homestead in Clearwater was killed by the tornado. Another guest of the hotel broke his collarbone.

A witness described three nearby houses were blown on top of the hotel, and building debris was liberally scattered amongst the town.



Quinault Hotel before 1904

A 995 mb Low Moved Over NW Washington



8 AM Feb 21, 1904 | 8 AM Feb 22, 1904



Johnny Shale (date unknown)

The house of Johnny Shale was moved 50 yards by the storm.

The father of the Shale boys was also severely injured by the tornado.

SCIENTIFIC STORYTELLING

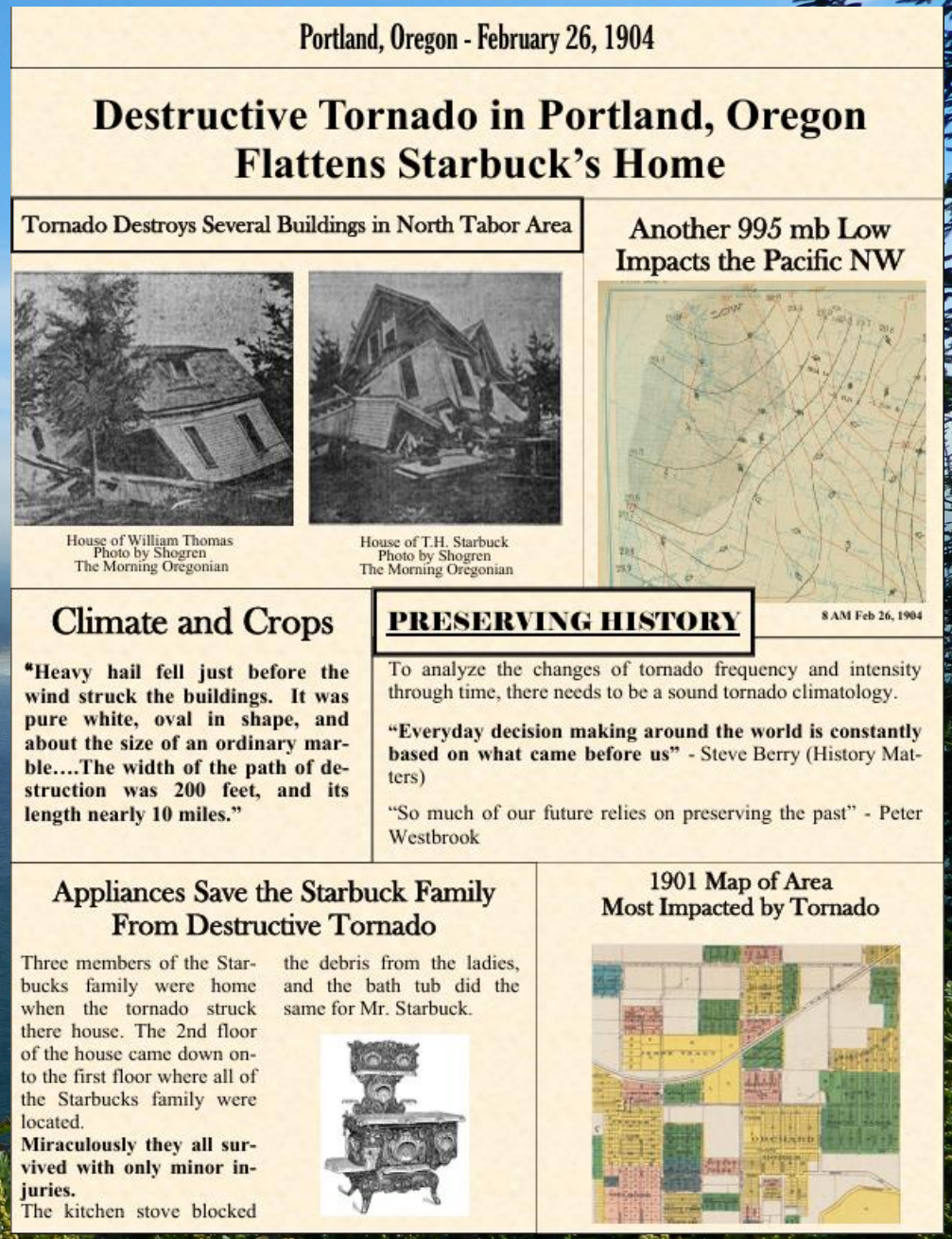
Stories are powerful tools to connect people to circumstances, and can be used by Meteorologists to persuade community response to warnings.

Portland 2/26/1904 Tornado

- Tracked for 10 miles from Montivello to Fairview
  - Longest known tornado west of the Cascades.
  - Most damage in a 1-mile area.
- No deaths.
  - Starbuck family saved by their appliances blocking debris.
  - Only minor injuries.
- Likely would've been an EF2+ based on the photos shown in The Oregonian.

Poster: Treena Jensen

From the 2016 AMS Local Storms Conference



Portland, Oregon - February 26, 1904

Destructive Tornado in Portland, Oregon Flattens Starbuck's Home

Tornado Destroys Several Buildings in North Tabor Area

House of William Thomas
Photo by Shogren
The Morning Oregonian

House of T.H. Starbuck
Photo by Shogren
The Morning Oregonian

Another 995 mb Low Impacts the Pacific NW

8 AM Feb 26, 1904

Climate and Crops

"Heavy hail fell just before the wind struck the buildings. It was pure white, oval in shape, and about the size of an ordinary marble....The width of the path of destruction was 200 feet, and its length nearly 10 miles."

PRESERVING HISTORY

To analyze the changes of tornado frequency and intensity through time, there needs to be a sound tornado climatology.

"Everyday decision making around the world is constantly based on what came before us" - Steve Berry (History Matters)

"So much of our future relies on preserving the past" - Peter Westbrook

Appliances Save the Starbuck Family From Destructive Tornado

Three members of the Starbucks family were home when the tornado struck there house. The 2nd floor of the house came down onto the first floor where all of the Starbucks family were located.

Miraculously they all survived with only minor injuries.

The kitchen stove blocked the debris from the ladies, and the bath tub did the same for Mr. Starbuck.

1901 Map of Area Most Impacted by Tornado

Blurbs from the Oregonian on 2/27/1904

TORNADO HERE

Wrecks Many Houses at Mount Tabor.

SPENDS ITS FURY QUICKLY

Black Funnel-Shaped Cloud Appears Without Warning.

PICKS MAN UP INTO THE AIR

Big Trees Are Torn From Their Roots, Four Buildings Demolished, Others Moved Off Foundations--Damage $5000.

Picked Up a Man.

While he escaped practically unhurt, no one had a more harrowing encounter with the tornado than George Bidgood, a nurse employed at the Portland Sanitarium. Bidgood was near Central station waiting for a car and was standing right in the path of the tornado when it swept down upon him. He tried to keep his feet, but the terrific force of the disturbance literally took him into the air and swept him out into the muddy road and half way across the street. He looked up an instant later to see the Starbuck residence totter and fall with a crash.

Fortunately there were no occupants in any of the other houses. Had there been any occupants of a small shack a dozen rods from the Sheen residence and owned by Mrs. Woodcock they could barely have escaped injury. The tornado threw its full force on this frail structure and scattered it for a distance of a hundred feet. It scattered none of the other structures, merely pushing them over in chaotic heaps.

The tornado is known to have sprung up about a mile south and west of Montavilla. Its period of destructiveness was limited to about a minute and a half. The first seen of it was half a mile west of Central Station. It had the appearance of an ominous black cloud, fluffed in bar and carrying a murky trail behind it. Those who saw it say it looked not al together unlike a gigantic express trai under full speed and blurred by smok Owing to the short period of its duratio comparatively few people saw the phe nomenon. Those who did estimate it width at from 50 to 100 feet and its heigh at several times that figure.

It did its first effective work at a smal cottage owned by E. A. Fehrung. I picked this structure, which fortunatel was unoccupied, from its foundation an dropped it with a crash into an excava tion. A factional part of a second late it struck the Sheen home, passed on t the Woodcock shack and destroyed tha with one disdainful sweep, caved in on end of Mrs. Lena Bergh's house, a fe yards away, battered in an end of Henr Rosenthal's home, a few yards furthe along, passed around several house shook several more on their foundation demolished the home of Rev. Mr. Starbuc and an unoccupied house belonging t William Thomas, crashed in the front o the Henton grocery-store, and then disap peared as mysteriously as it appeared apparently subsiding once more into goo breathable atmosphere.

12/23/1949: Long Beach, WA

WA DEC 23, 1949 1100 0k 0inj 20y m F2
PACIFIC--One home was unroofed and a garage was destroyed as a waterspout moved onshore at Long Beach.

- An F2 tornado rolled into the outskirts of Long Beach, WA, at 11:00 am.
- Only one home was noted to have significant damage.
- No injuries.
- No media reports that I could find.
- Rating and damage report from Tornado Historian Thomas Grazulis.

6/11/1968 Wallowa, OR

- Destroyed 1800 acers of prime timber.
- Damaged some homes, but primarily farm barns.
- No known pictures.
- Rated F2 by NWS and Grazulis.
- Damage $25 million
  - Costliest tornado in PNW history.

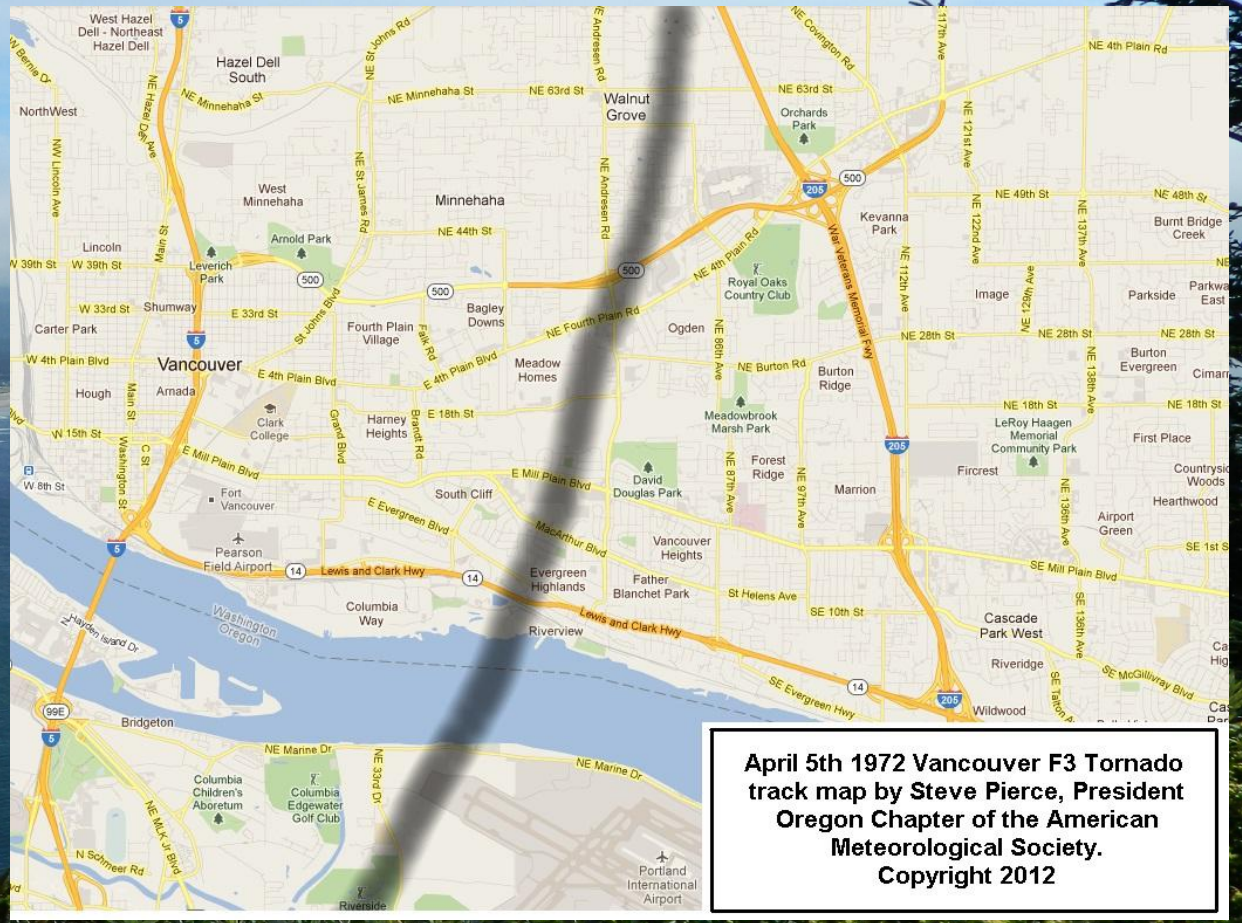
12/12/1969 Kent, WA

- Only one significant injury.
- Sources vary on the number of buildings damaged.
- Started as a waterspout and made landfall.
- Convergence Zone tornado.
- Reports of twin funnels over the water.
- Indirectly caused accidents on I-5 from people looking at the tornado.
- Photo from Boeing Space Center.



4/5/1972: Portland-Vancouver F3

- Rated F3 officially.
- Killed 6, injured 300+.
- Damage of $25 million.
- Most notable buildings damaged:
  - Wearmart Store
  - Bowling Alley
  - Elementary School
- Supercell of some sort.
  - Golf ball-sized hail reported.
- Would qualify for a Tornado Emergency if it happened today.



NWS/Local News Pictures of the Damage

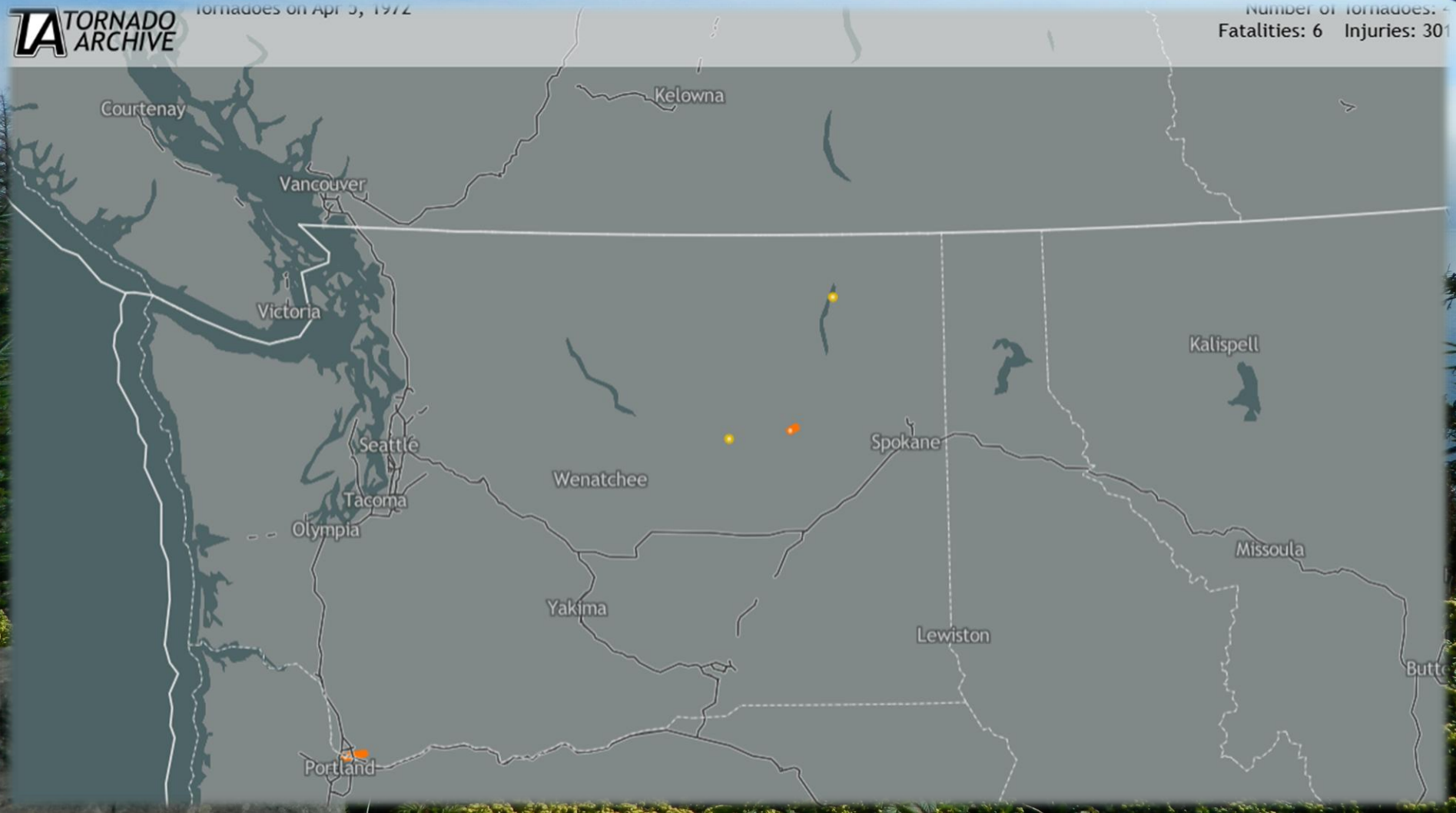
Peter S. Ogden Elementary School



Bowling Alley



4 Tornadoes, All F2+ on 4/5/1972



7/21/1987 Teton-Yellowstone F4

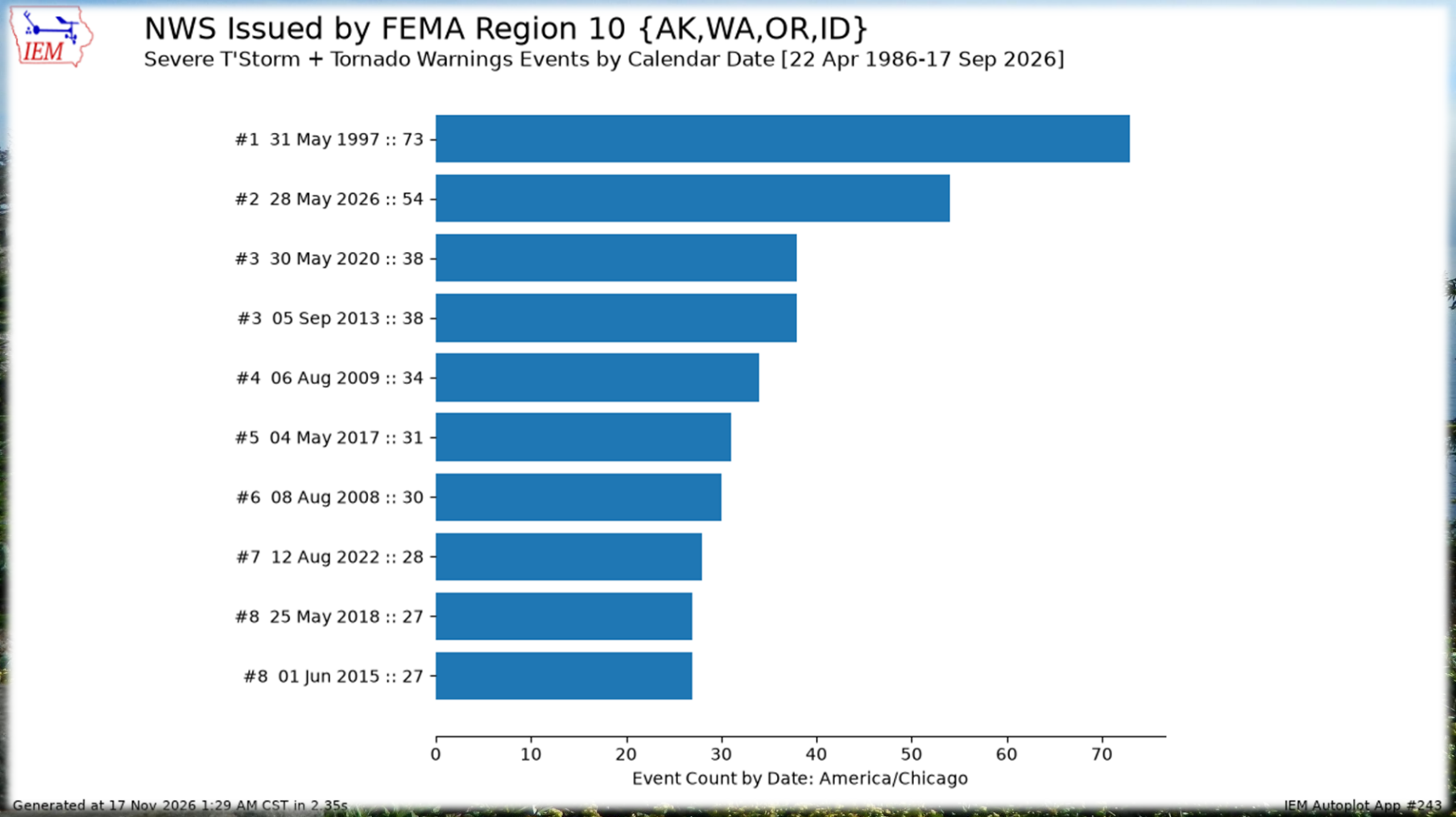
- Rated F4 by Ted Fujita, who led the damage survey, and was 25 miles long.
  - This tornado in particular fascinated him, and said it was some of the worst tree damage he's ever seen from a tornado.
  - Compared the damage to the 1974 Super Outbreak
  - 2.4 miles wide
- Only F4 west of the Continental Divide.
  - Crossed the continental divide.
- Poster child of "tornadoes can't form in mountains."
- Mostly tree damage (1 million trees) in wilderness or national parks.



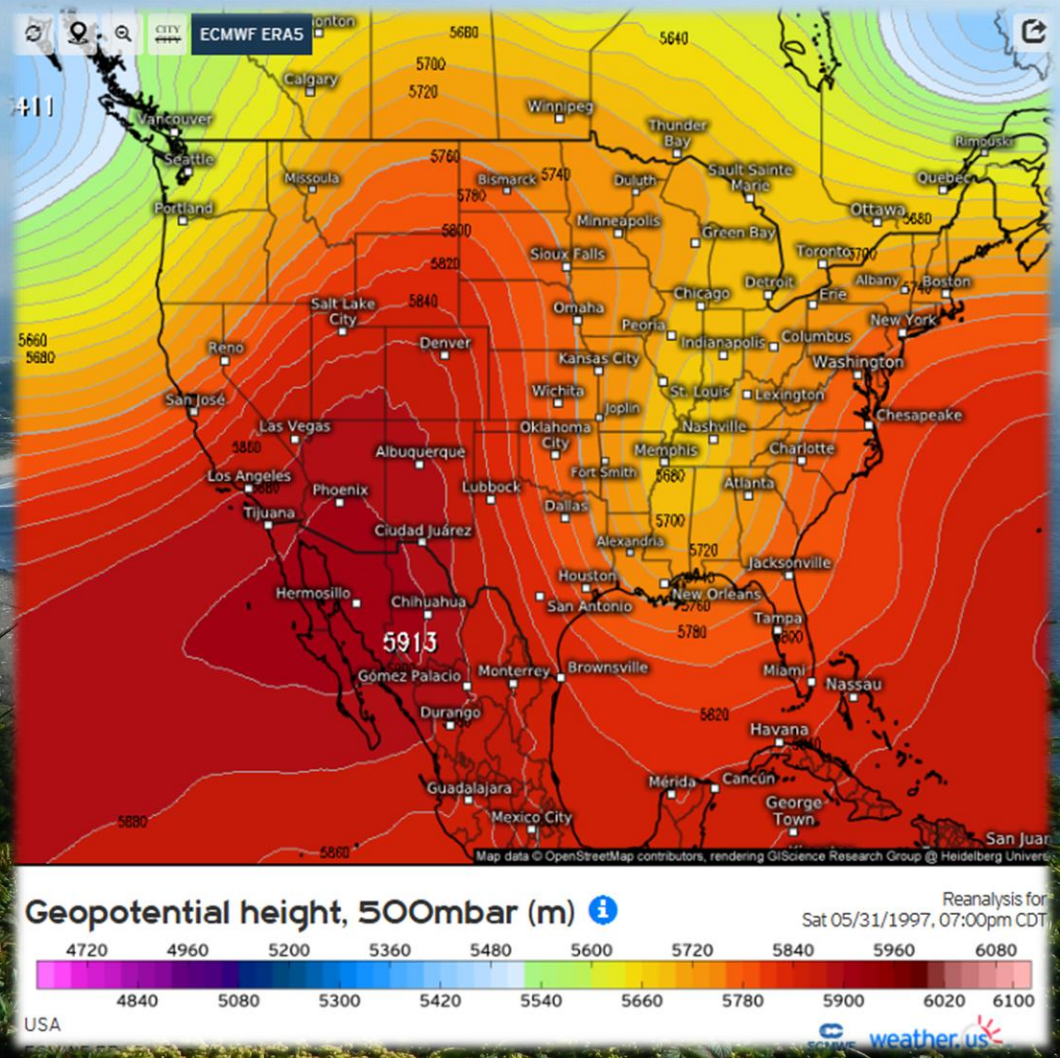
5/31/1997: 9-11 tornadoes

- The number is disputed. NWS Spokane cited 6 tornadoes in Washington. SPC cites 4.
- 3 tornadoes west of the Cascades (Salem, Vancouver, Tacoma). Tacoma was an F1.
- The strongest was an F2
- Only known tornado watch in the PNW.

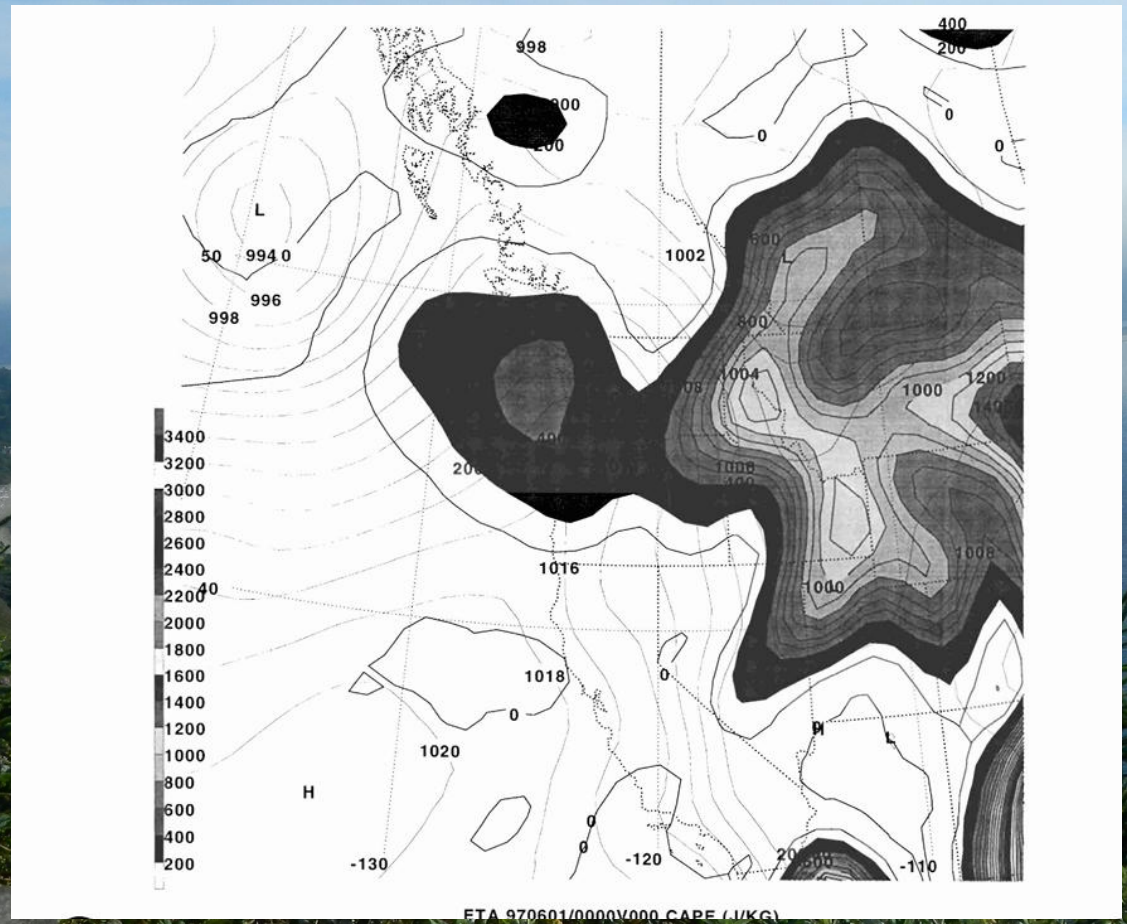
Most Warnings Issued in 1 Day in the PNW



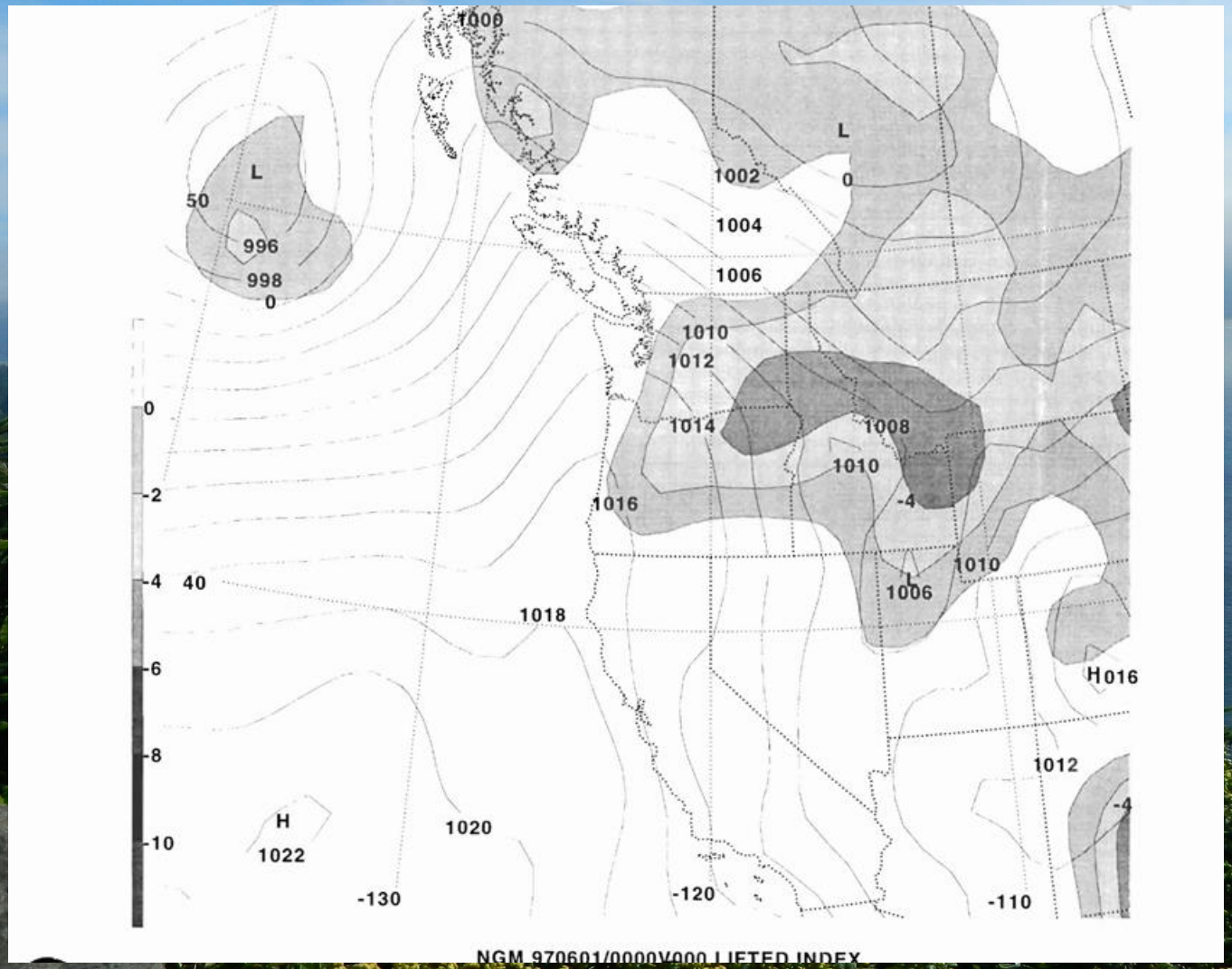
500 mb map (ECMWF Reanalysis)



CAPE (NWS Boise Map)



Lifted Index

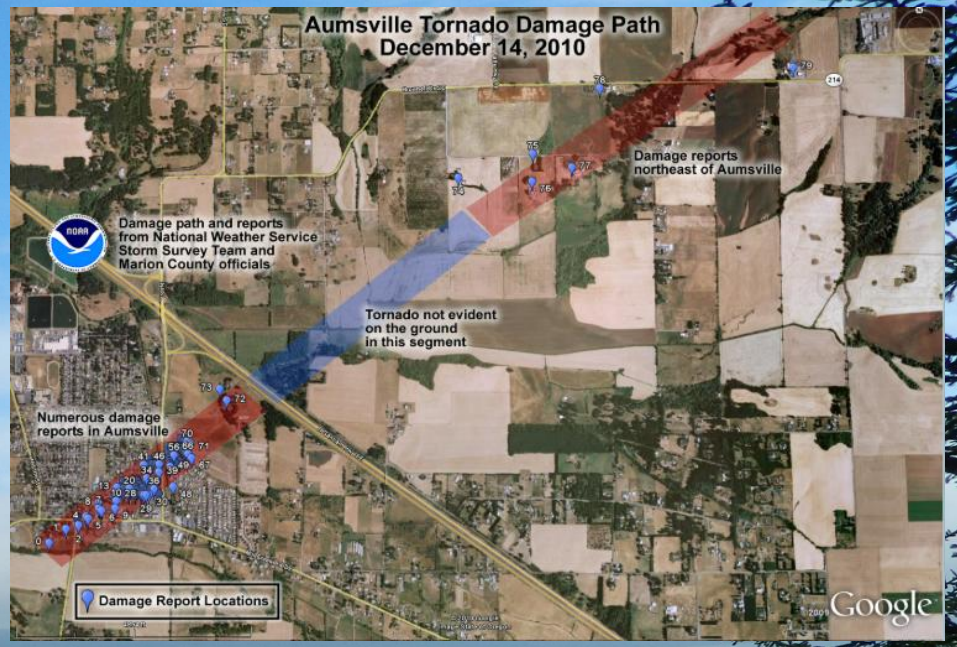


Tornado Archive uses the SPC Data:
9 Tornadoes.



12/14/2010: Aumsville EF2

- Hit the main part of town around mid-day.
- $1 million in damage.
- On the ground for 6 miles.
- 2 injuries.

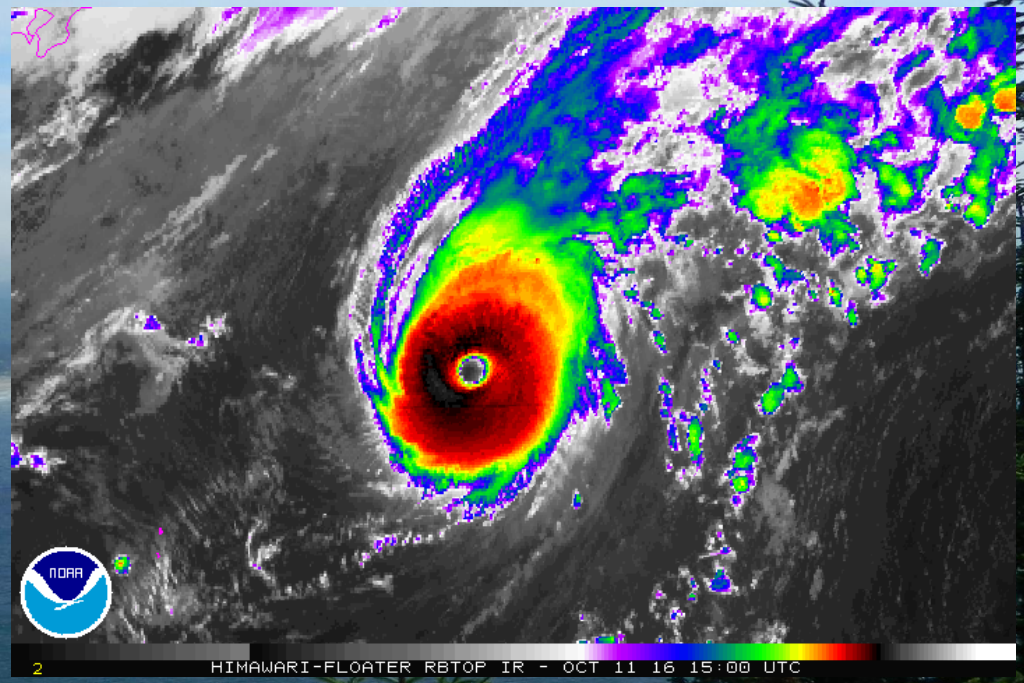





Now, Onto Manzanita

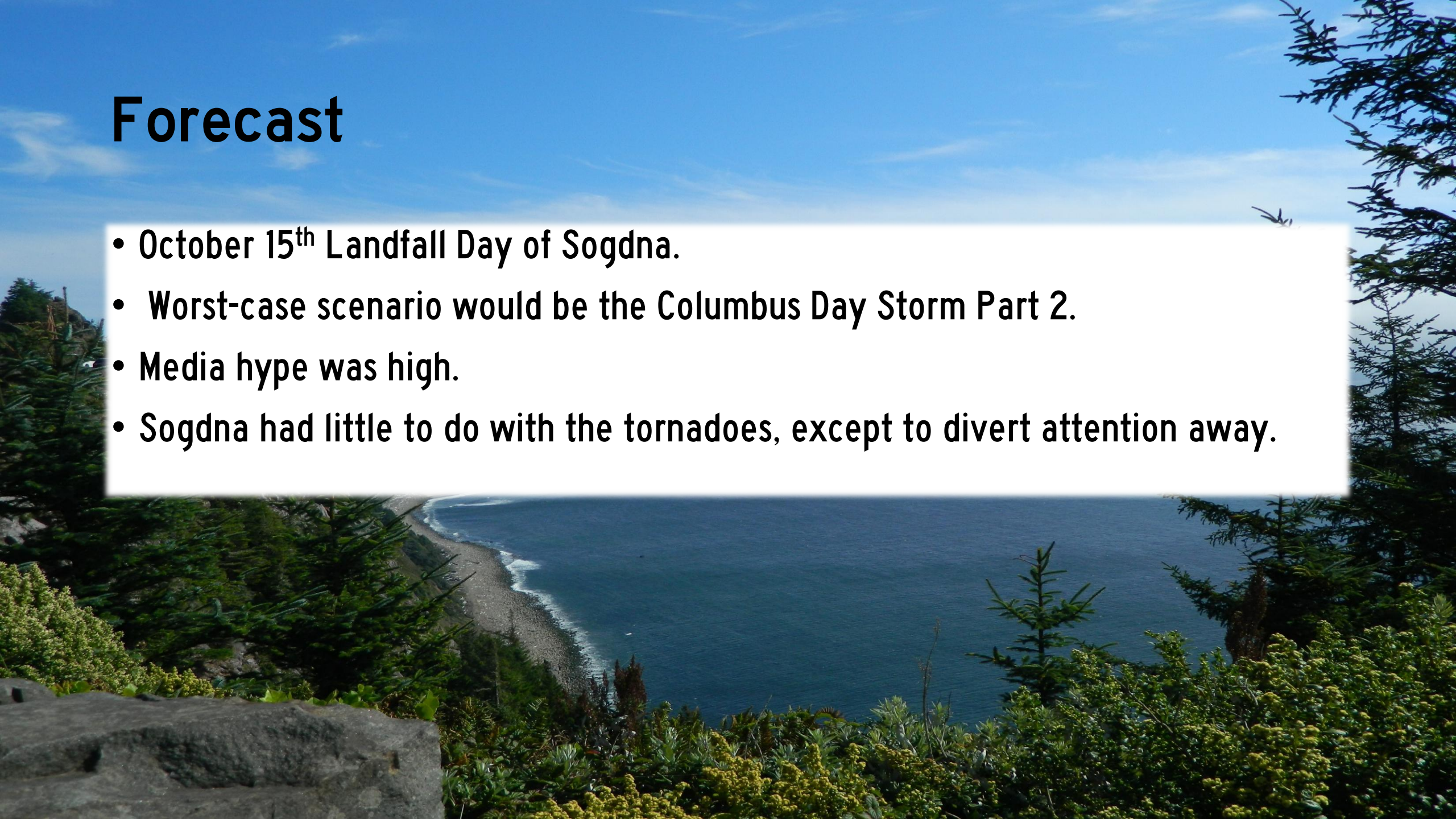
Setup: Typhoon Songda

- Typhoon Sogdna in the Pacific: 150 mph winds.
  - Aiming directly for the PNW.
- "Pre-Event" Typical windstorm forecasted on October 13th.
- October 14th, 2016 was supposed to be the break day.
- Tornadoes weren't forecast, but an isolated thunderstorm couldn't be ruled out.



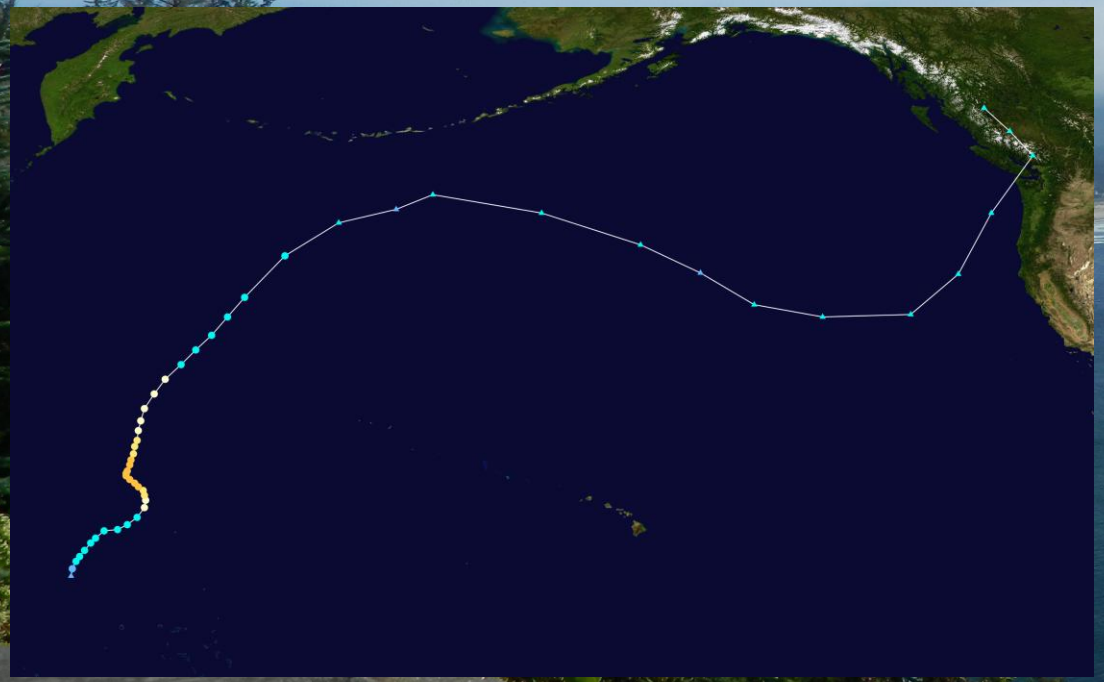
Forecast

- October 15th Landfall Day of Sogdna.
- Worst-case scenario would be the Columbus Day Storm Part 2.
- Media hype was high.
- Sogdna had little to do with the tornadoes, except to divert attention away.

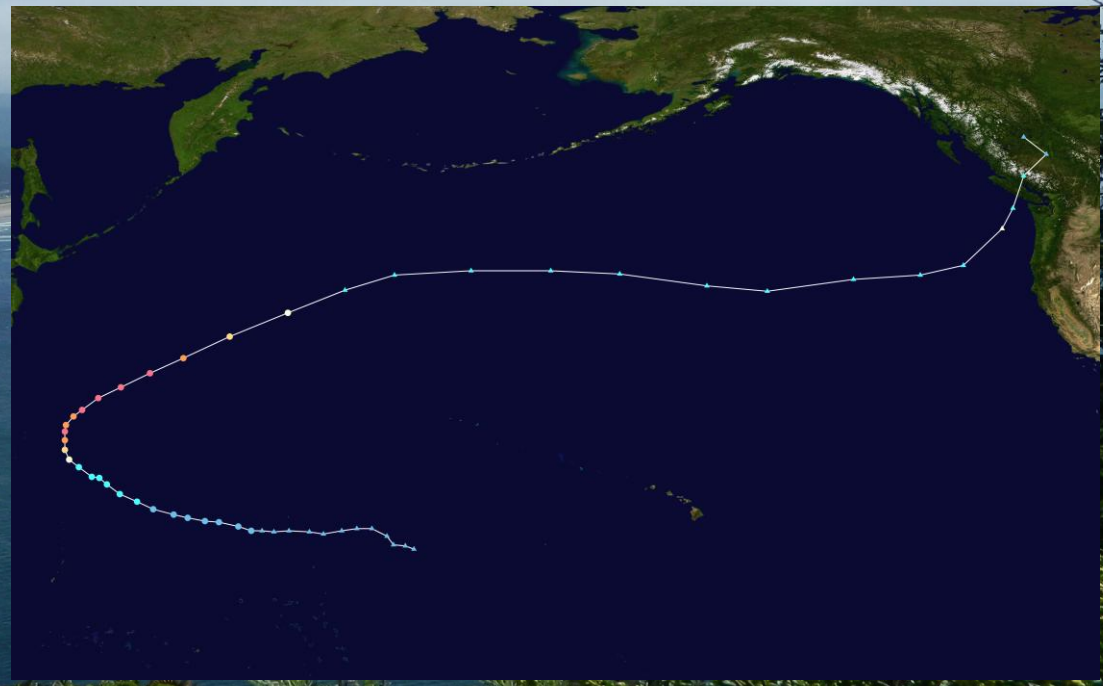


Track Comparison

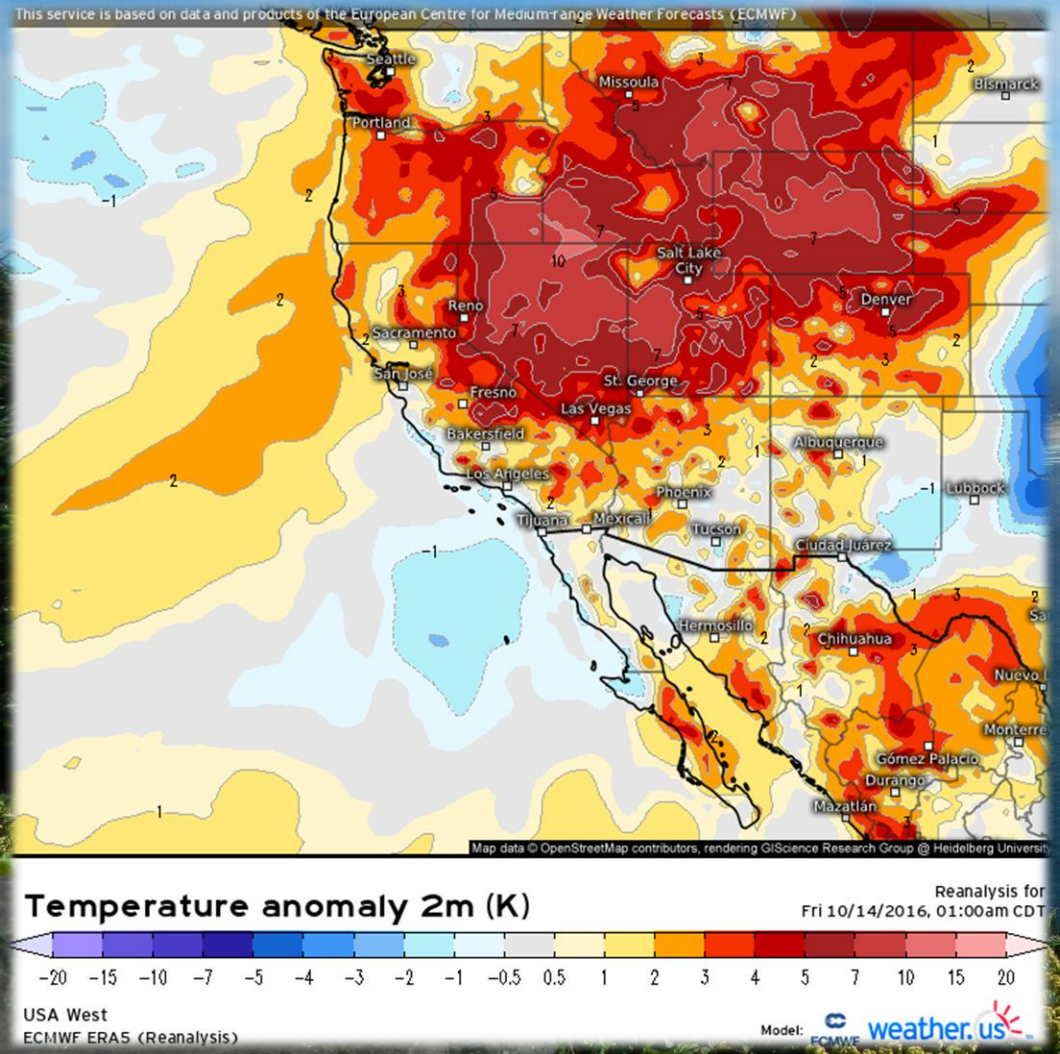
Freda (AKA Columbus Day Storm)

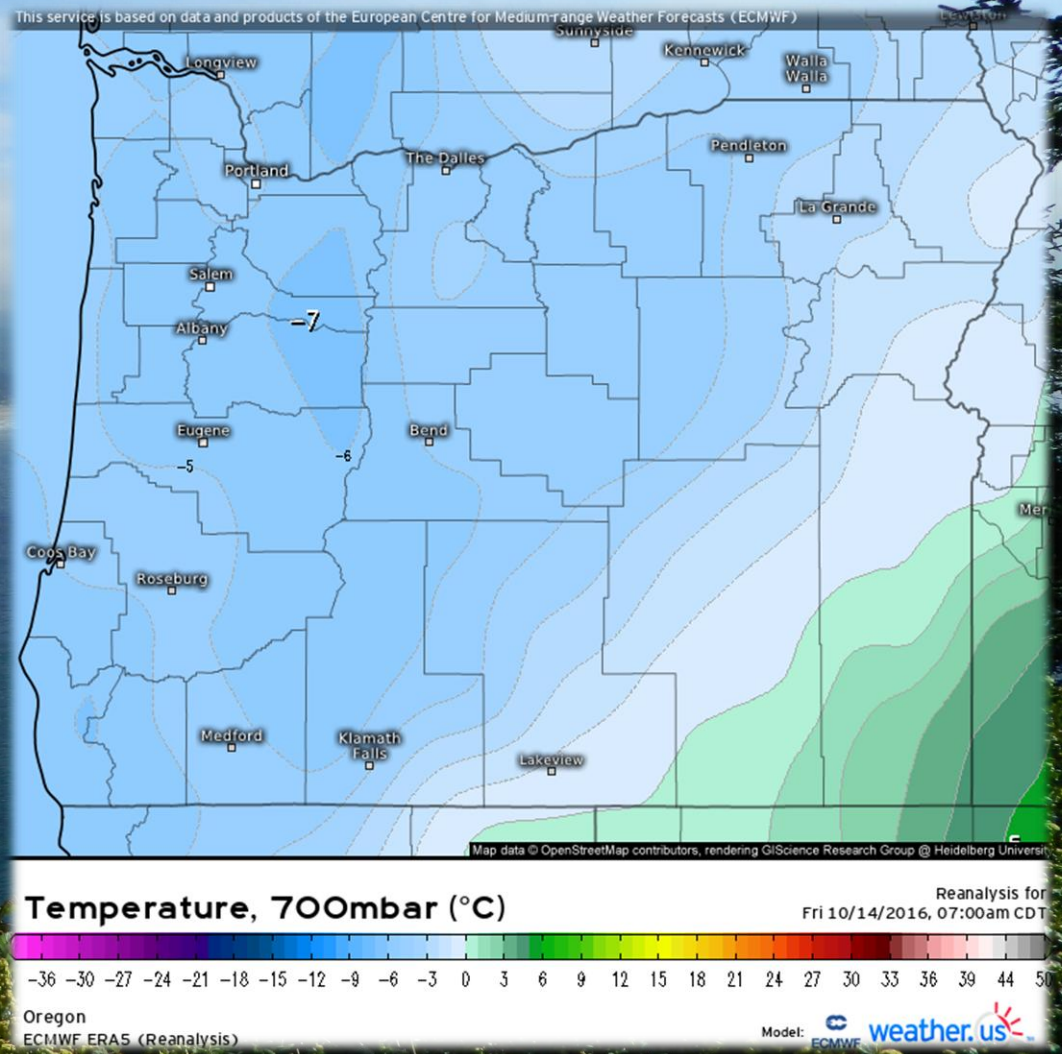


Songda (AKA Ides of October)

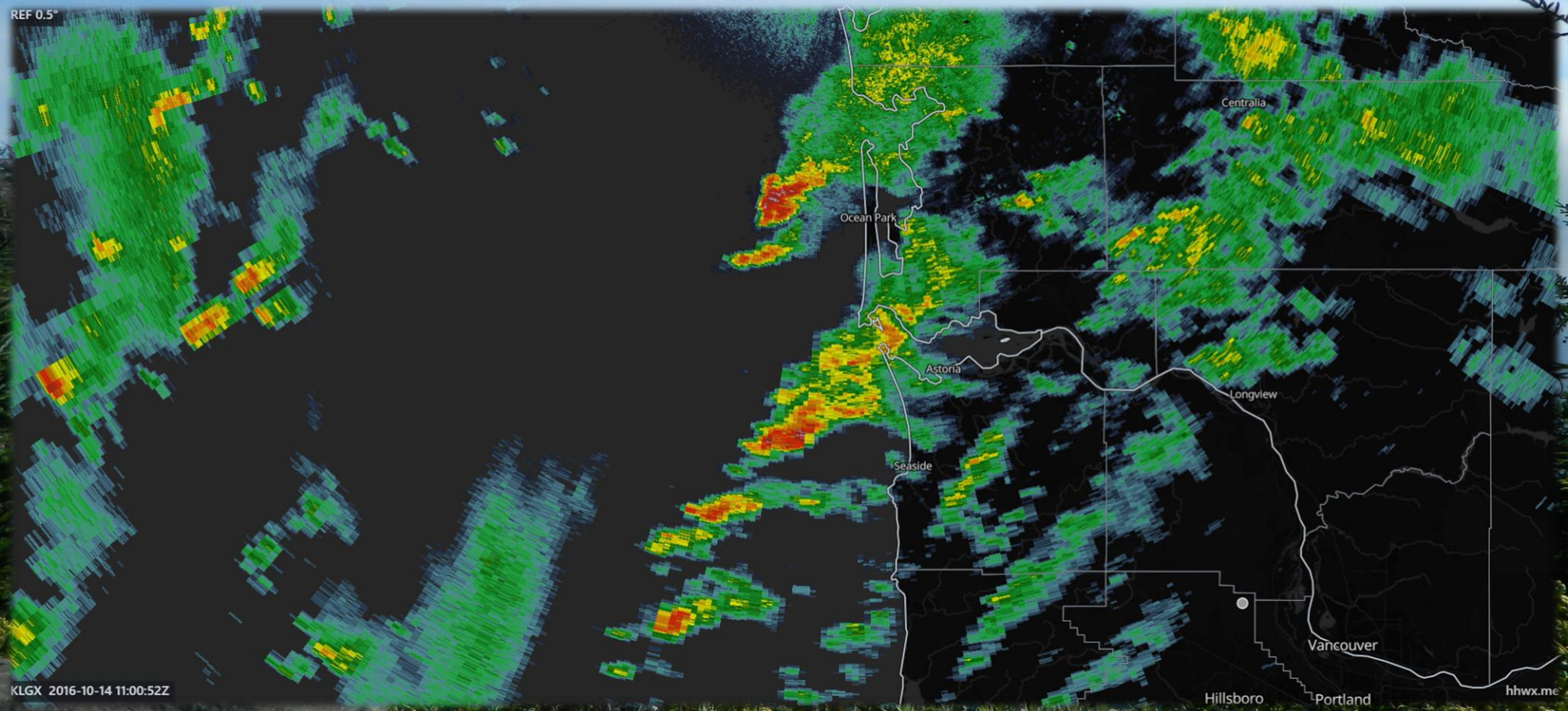


Above Average SST's and Cool air Aloft After Storm 1





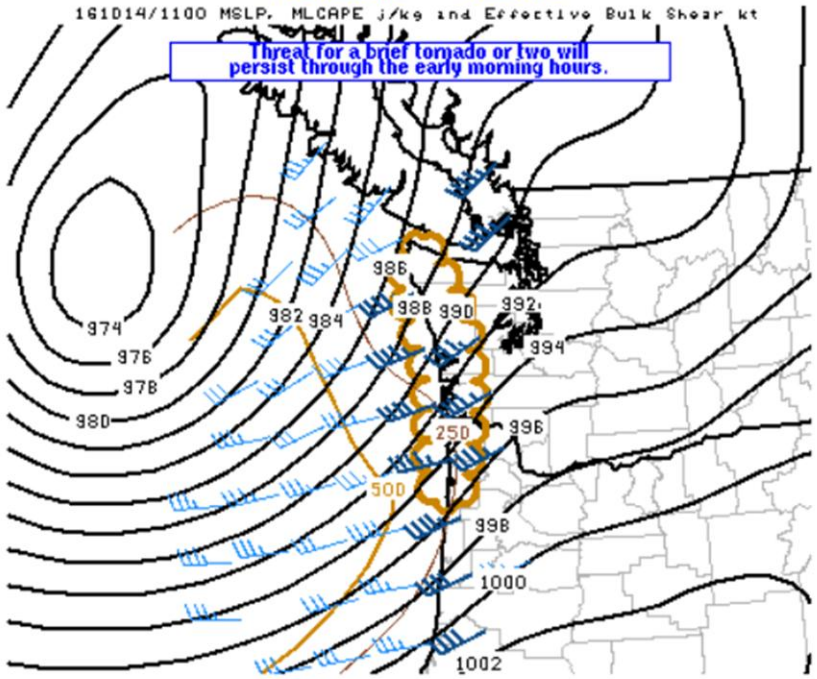
4:30 am: First Tornado Warning



5:05 am: MD Issued

Mesoscale Discussion 1786

< Previous MD Next MD >



SPC MCD #1786

MESOSCALE DISCUSSION 1786
NWS STORM PREDICTION CENTER NORMAN OK
0705 AM CDT FRI OCT 14 2016

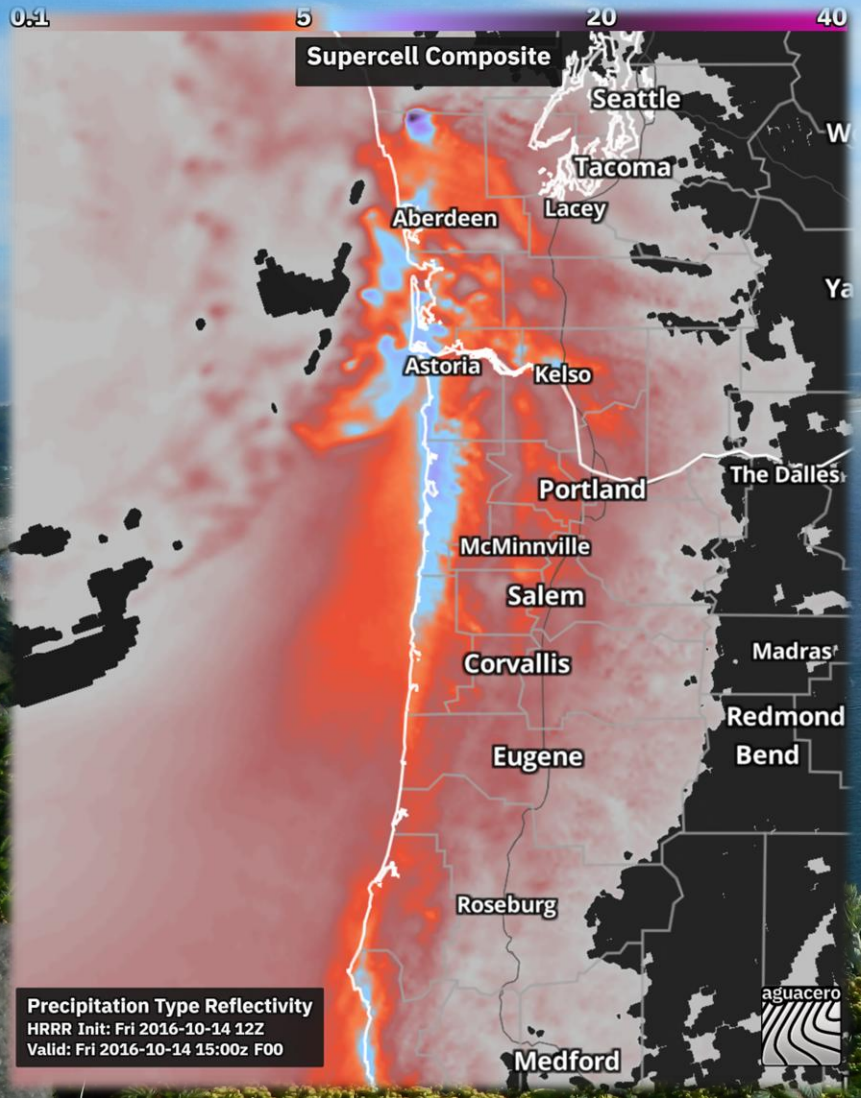
AREAS AFFECTED...NWRN OREGON THROUGH WRN WA

CONCERNING...SEVERE POTENTIAL...WATCH UNLIKELY

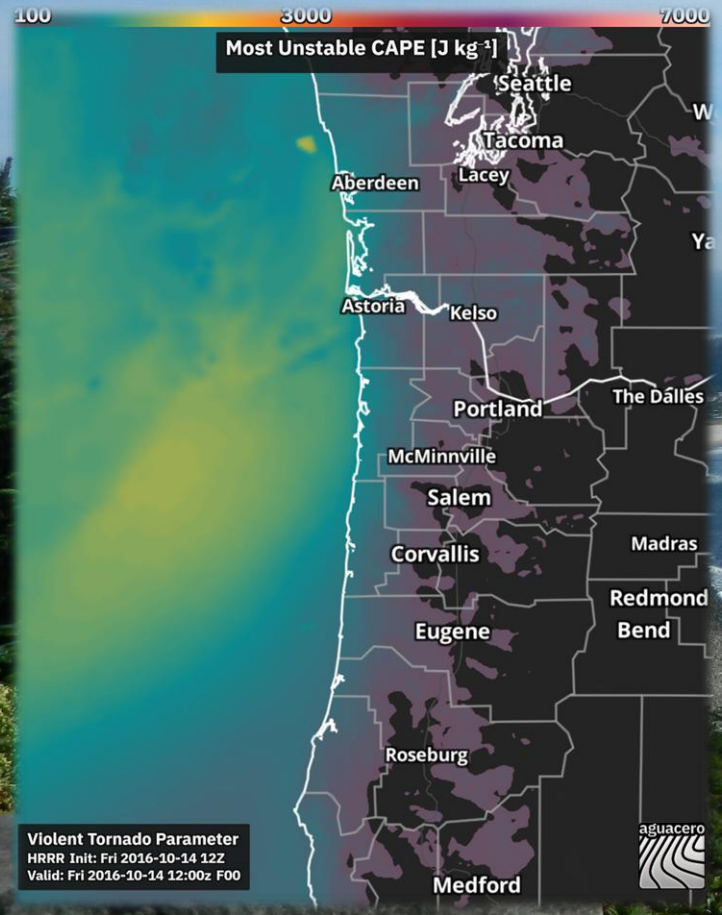
VALID 141205Z - 141430Z

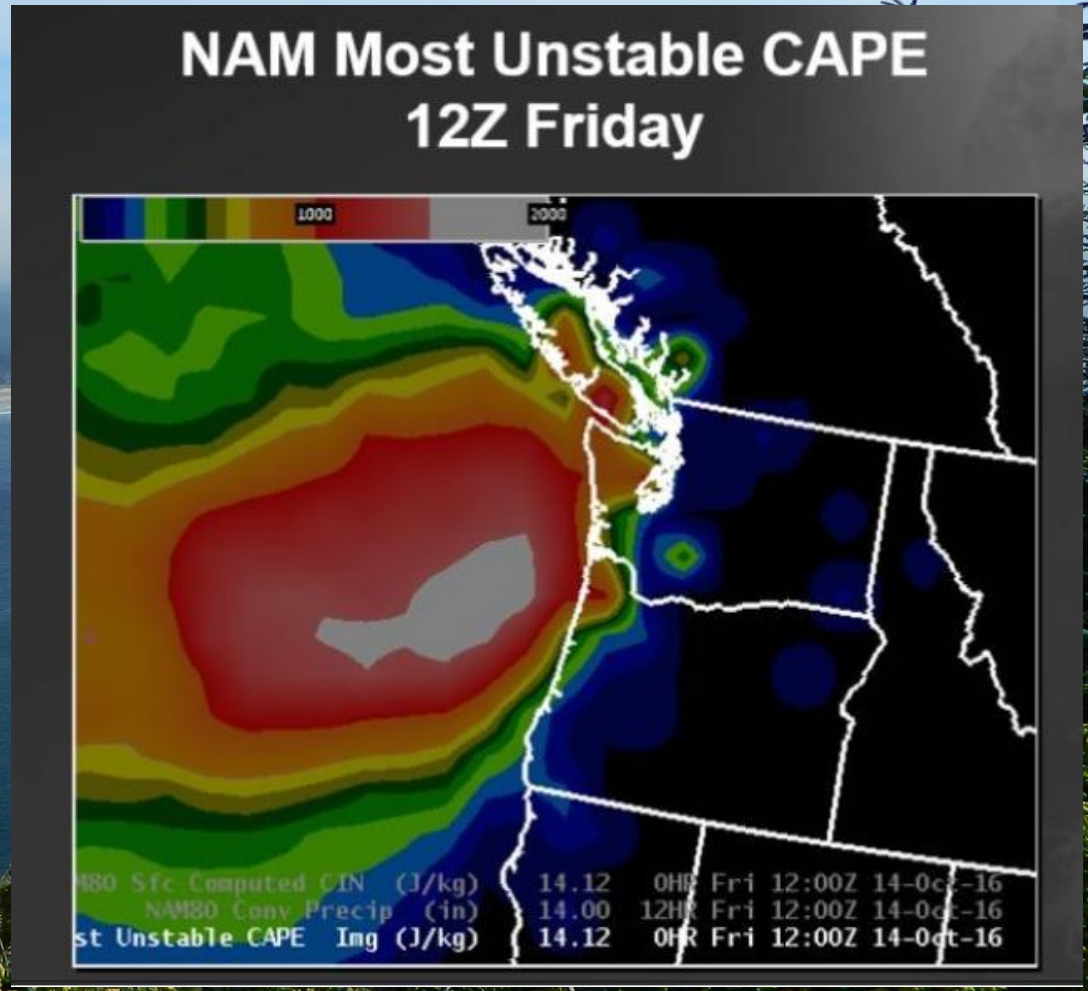
PROBABILITY OF WATCH ISSUANCE...20 PERCENT

12z HRRR Supercell Composite



12z HRRR and NAM CAPE

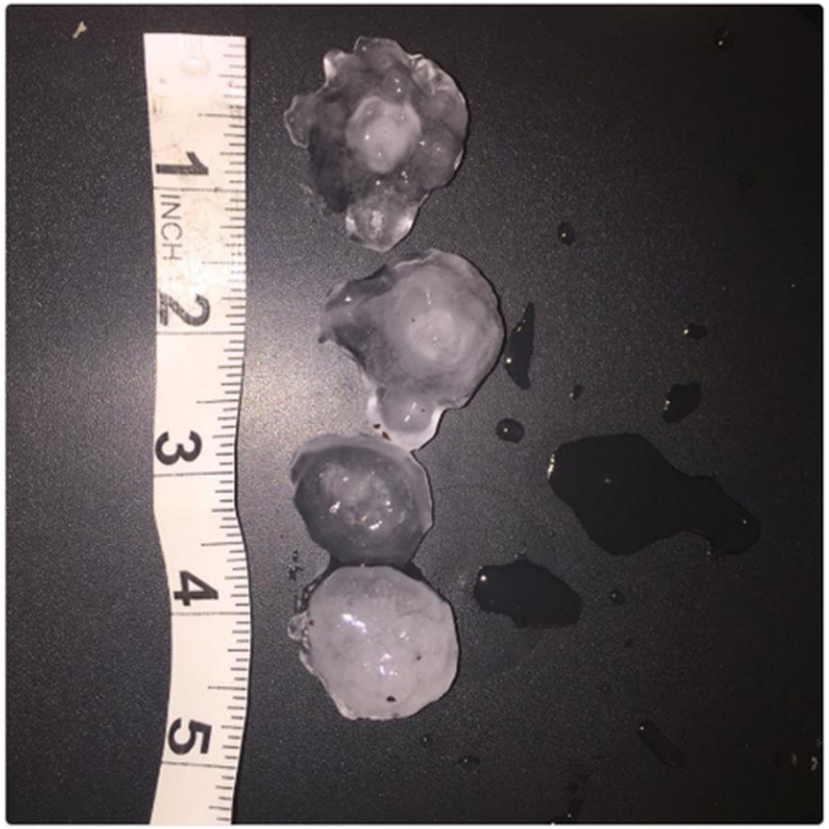




5:30 am: Unwarned Hail in Hammond, OR

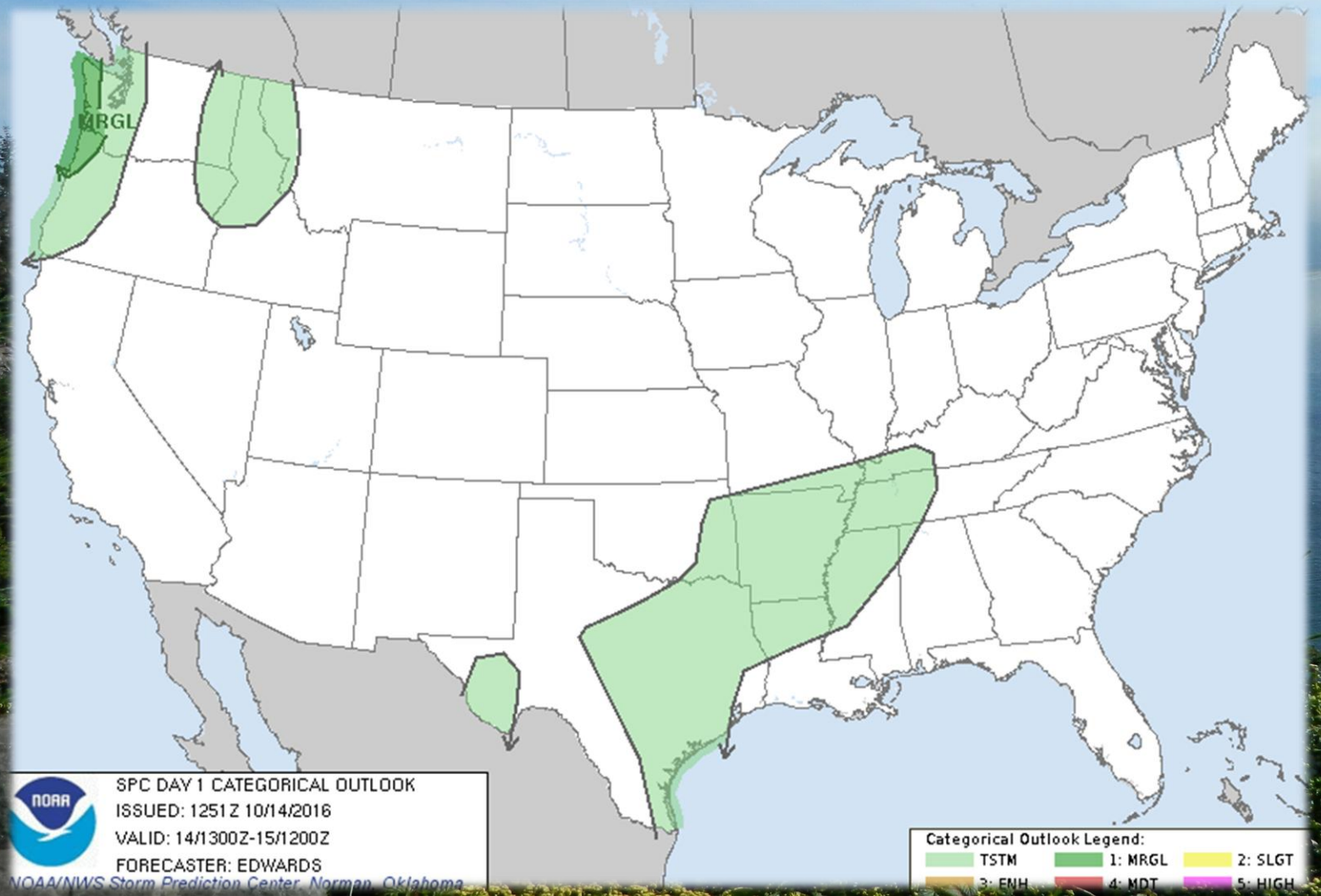
Warrenton Police @WarrentonPD · Oct 14

Hail stones at 5:30am this morning in Hammond, Oregon.

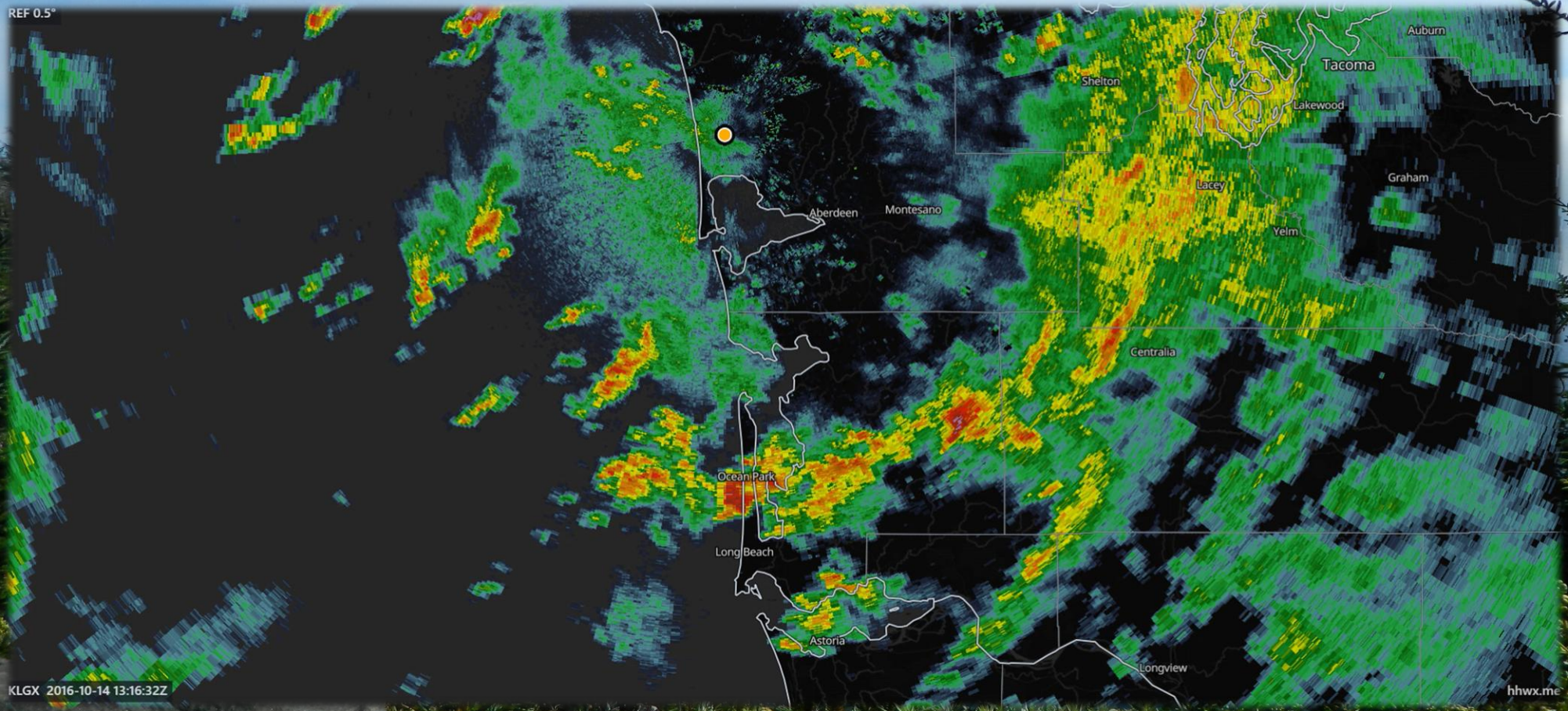


1 1 1 •••

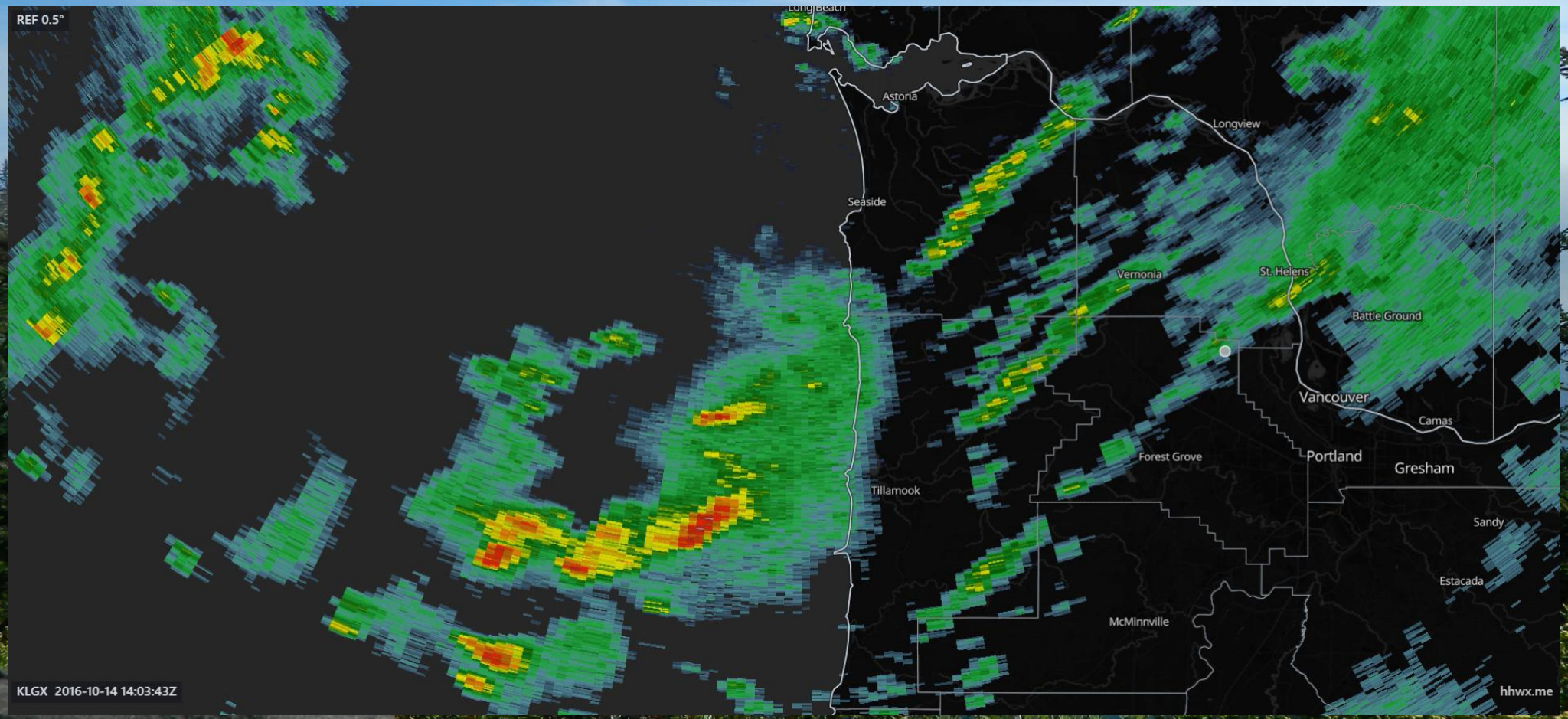
6:00 am MRGL Risk Introduced



6:27 am: 2nd Tornado Warning

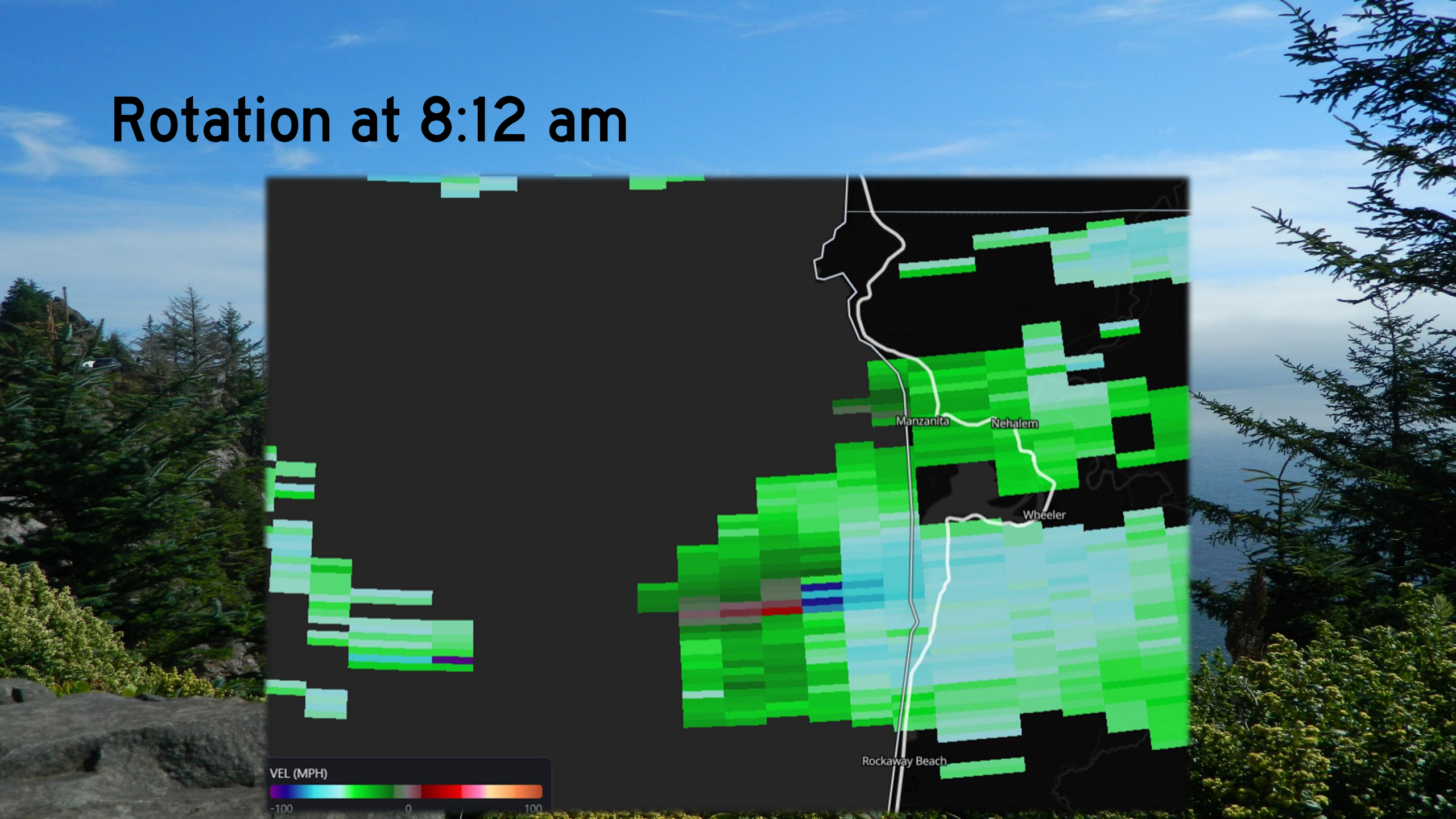


7:45 am: Severe Thunderstorm Warning into Tornado Warning over Manzanita



- Would trigger a destructive tag in the modern criteria (this was warned to 80 mph).

Rotation at 8:12 am



8:18 am Tornadic Waterspout Makes Landfall





Landfall Site, Treasure Cove Lane Beach Access

Minor Damage to Homes to Start, Major Tree Damage



Photo: KATU

Tornado hit Peak Strength: 8:19 am

- Crossing Laneda Avenue between 3rd and 4th Street, commercial businesses would be affected, along with 3 homes I want to highlight
- Things not shown in upcoming images:
  - Apartment above what was then known as Vino Manzanita was deemed uninhabitable for an unknown period of time but was salvageable.
  - Manzanita Sweets was damaged and lost its door.
  - Red Slipper House (last home shown) was slated for demolition but was still structurally sound.
- Building Damage shown will progress from SW to NE

View from Tyler Ryals as it hit Laneda Avenue

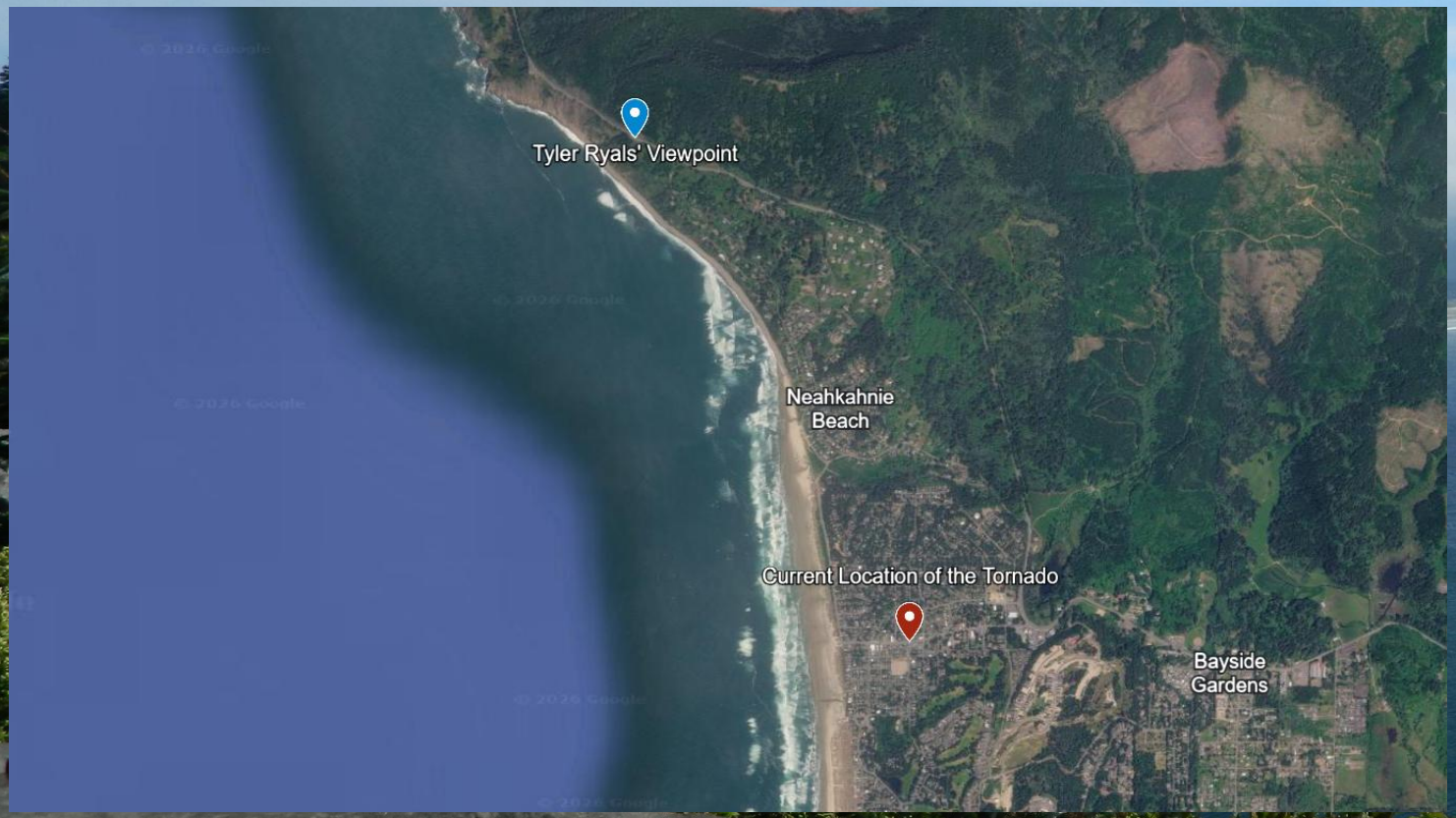




Photo: SPC Damage Survey

Siren's Salon





Photos: KATU

Longevity Massage and Yoga Roots Studio



Moxie's Fair Trade, Westeria Chic, and Manzanita Cones and Coffee





Photos: KATU

Same Site as the Deadliest Shipwreck in Oregon: HMS Francis H. Legett

- Load of 62 crew and passengers going from Aberdeen to San Francisco.
- September 18th, 1914:
  - 60 mph winds caused its cargo (railroad ties) to shift to one side of the boat.
  - Water filled the ship and distress signals were sent out.
  - Received by Japanese ships, who thought it was a German trap (they were enemies in WW1), so it was ignored.
  - The lifeboats launched were capsized almost immediately.
- Only 2 survivors, clinging to wood and ties before a rescue ship finally heard the distress signal.

Aftermath of the Shipwreck



Photo: University of Houston

One Home was Built From the Ties and Some of the Wood (Taken in 2014)



Photo: University of Houston

The Same Home, 10/14/2016



Photo: KATU

Some Wood Got Sold to Someone After the House was Demolished



What became known as the “Red Slipper House” Shifted off Foundation



Photo: EVCNB

Why this is Called the Red Slipper House



Photo: EVCNB

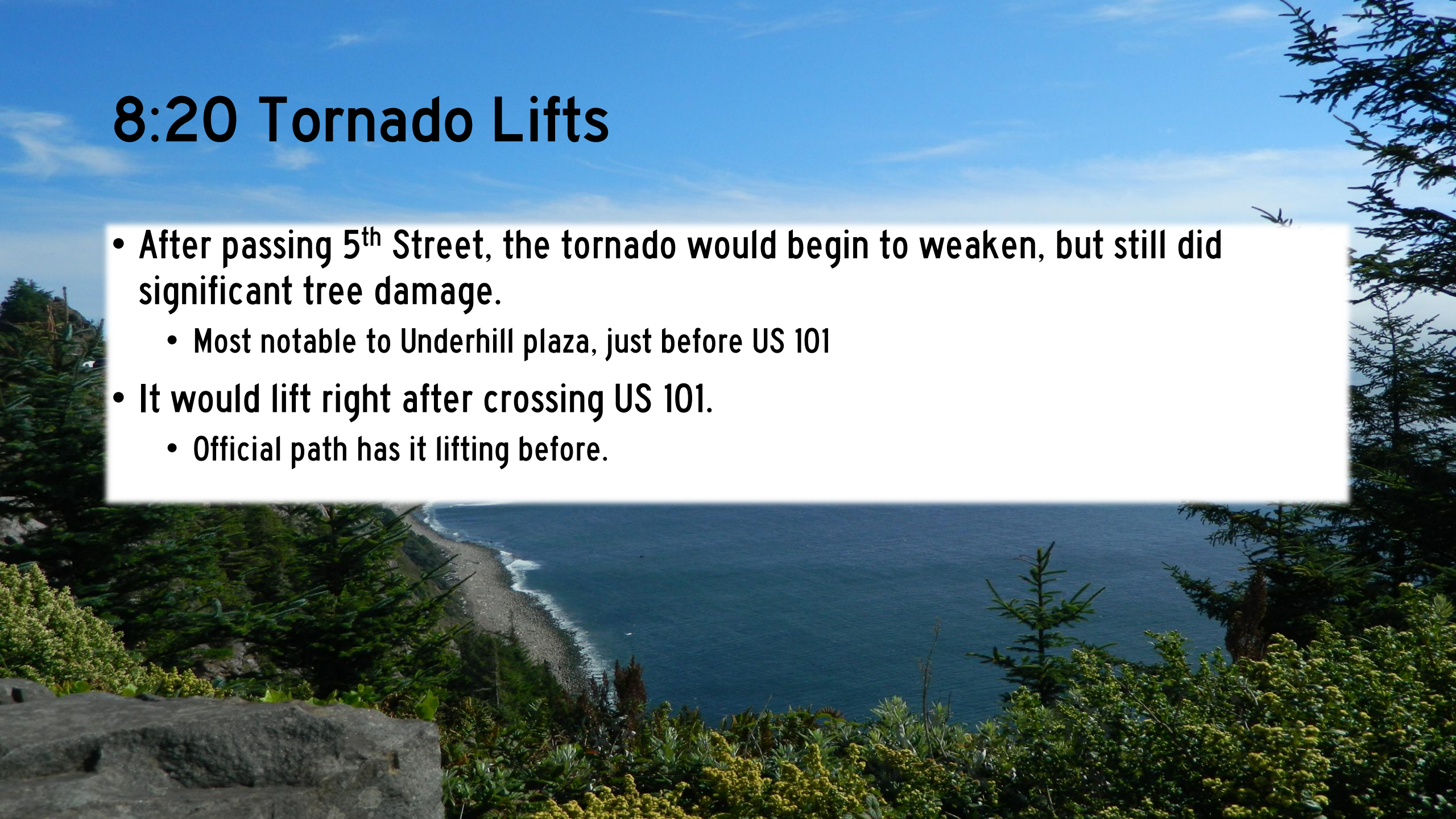
Red Slipper Zoomed Out Reveals Something Else



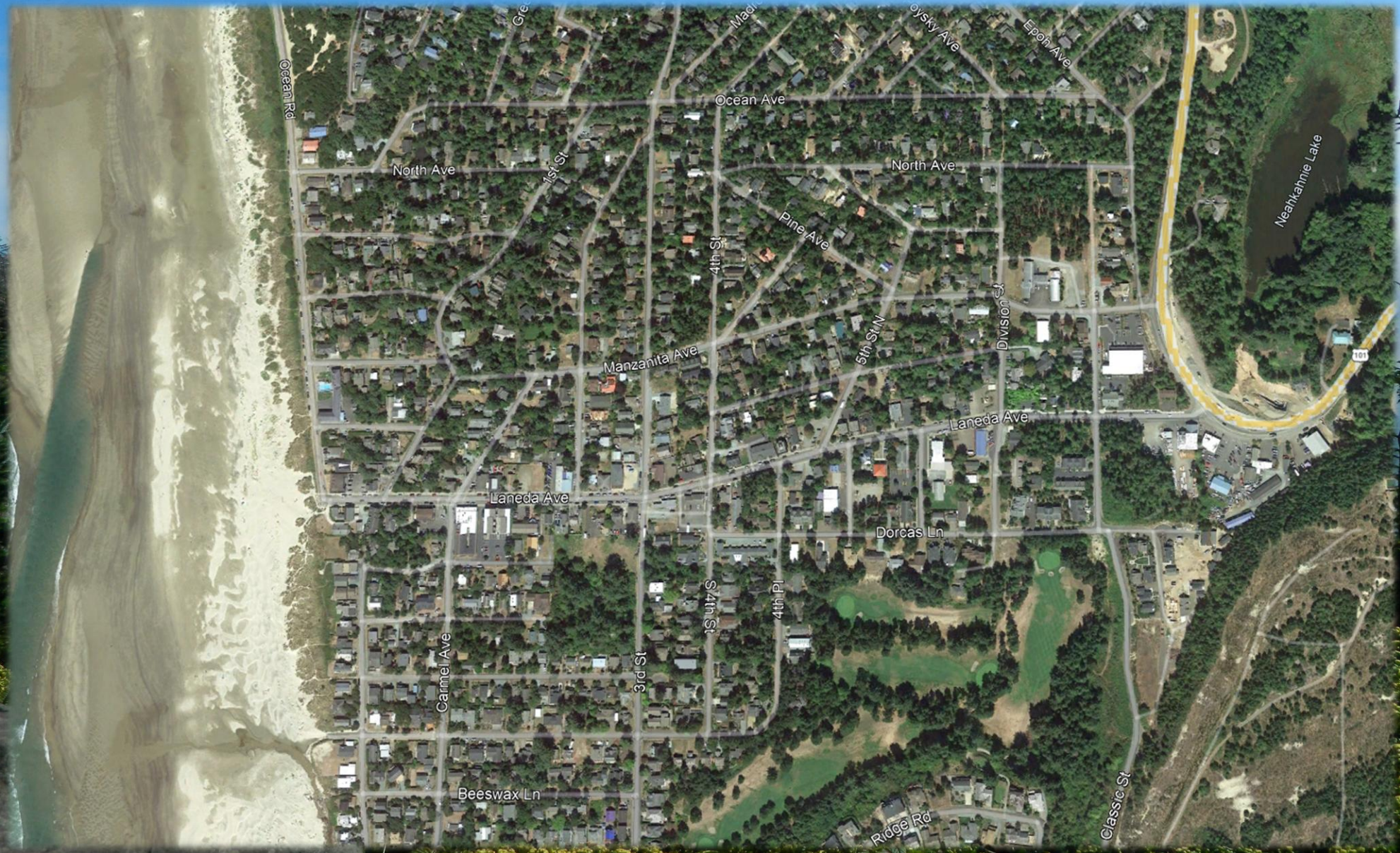
Photo: EVCNB

8:20 Tornado Lifts

- After passing 5th Street, the tornado would begin to weaken, but still did significant tree damage.
  - Most notable to Underhill plaza, just before US 101
- It would lift right after crossing US 101.
  - Official path has it lifting before.



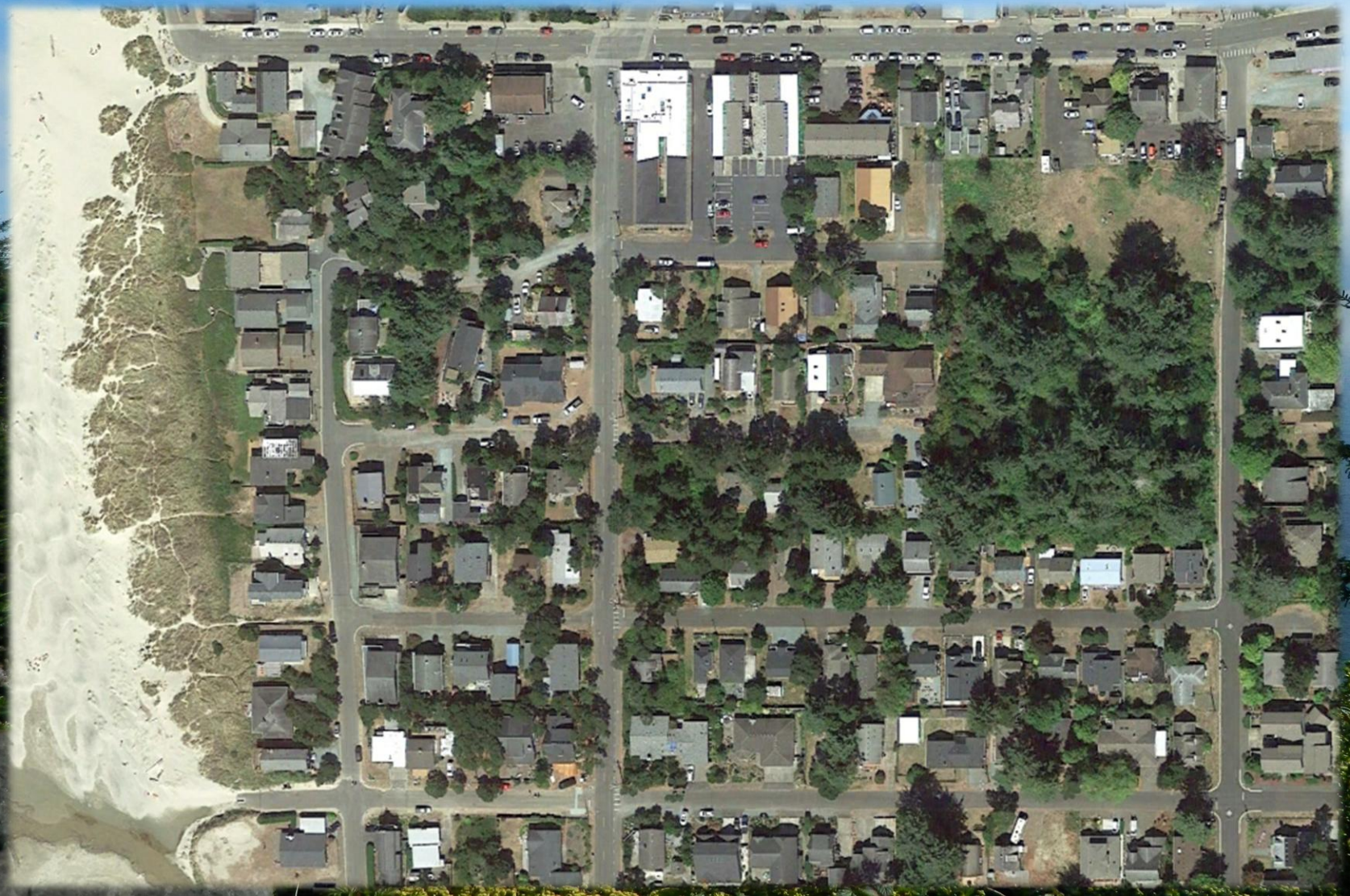
Before (August 2016) and After (June 2017)



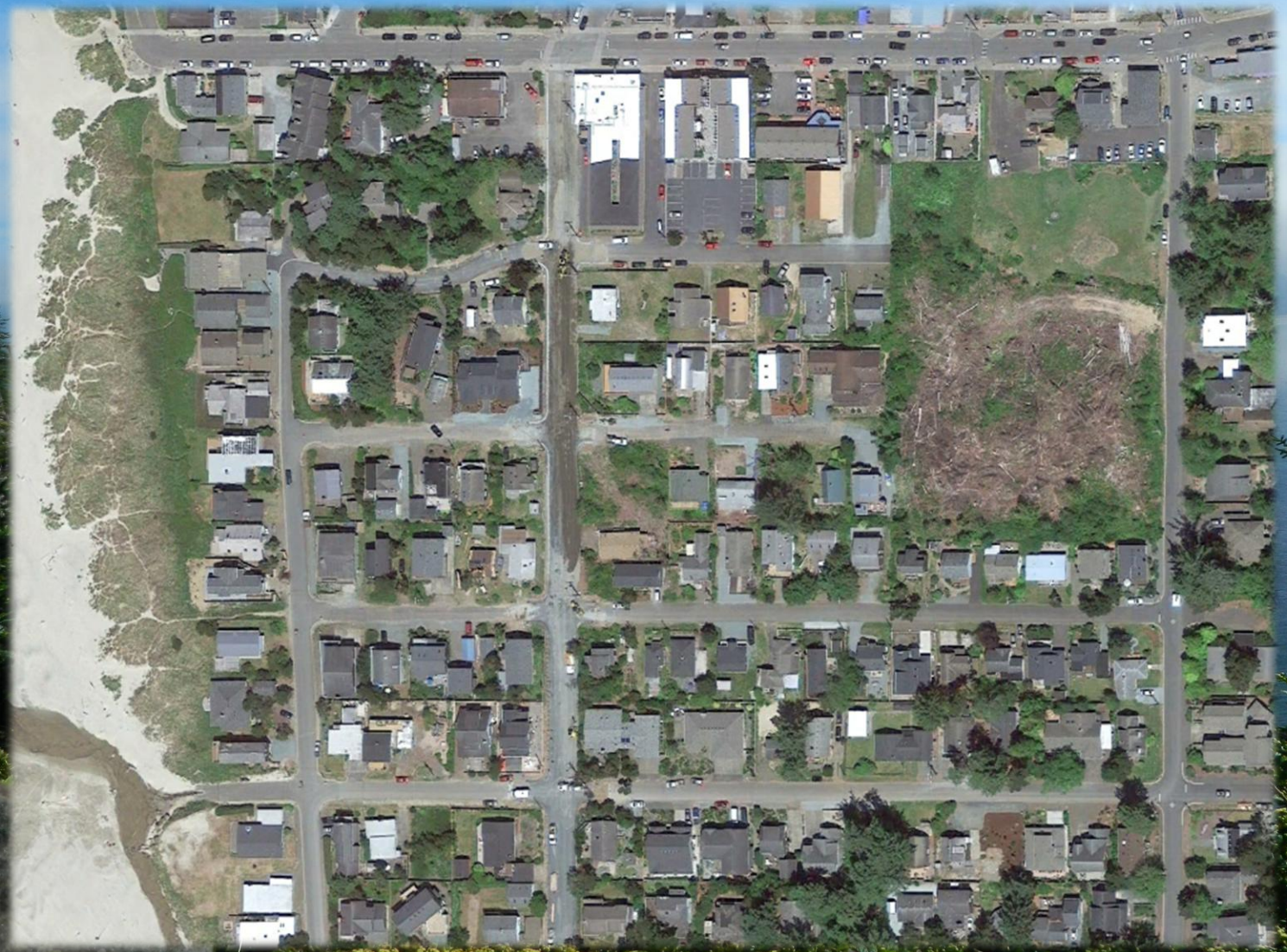
Before (August 2016) and After (June 2017)



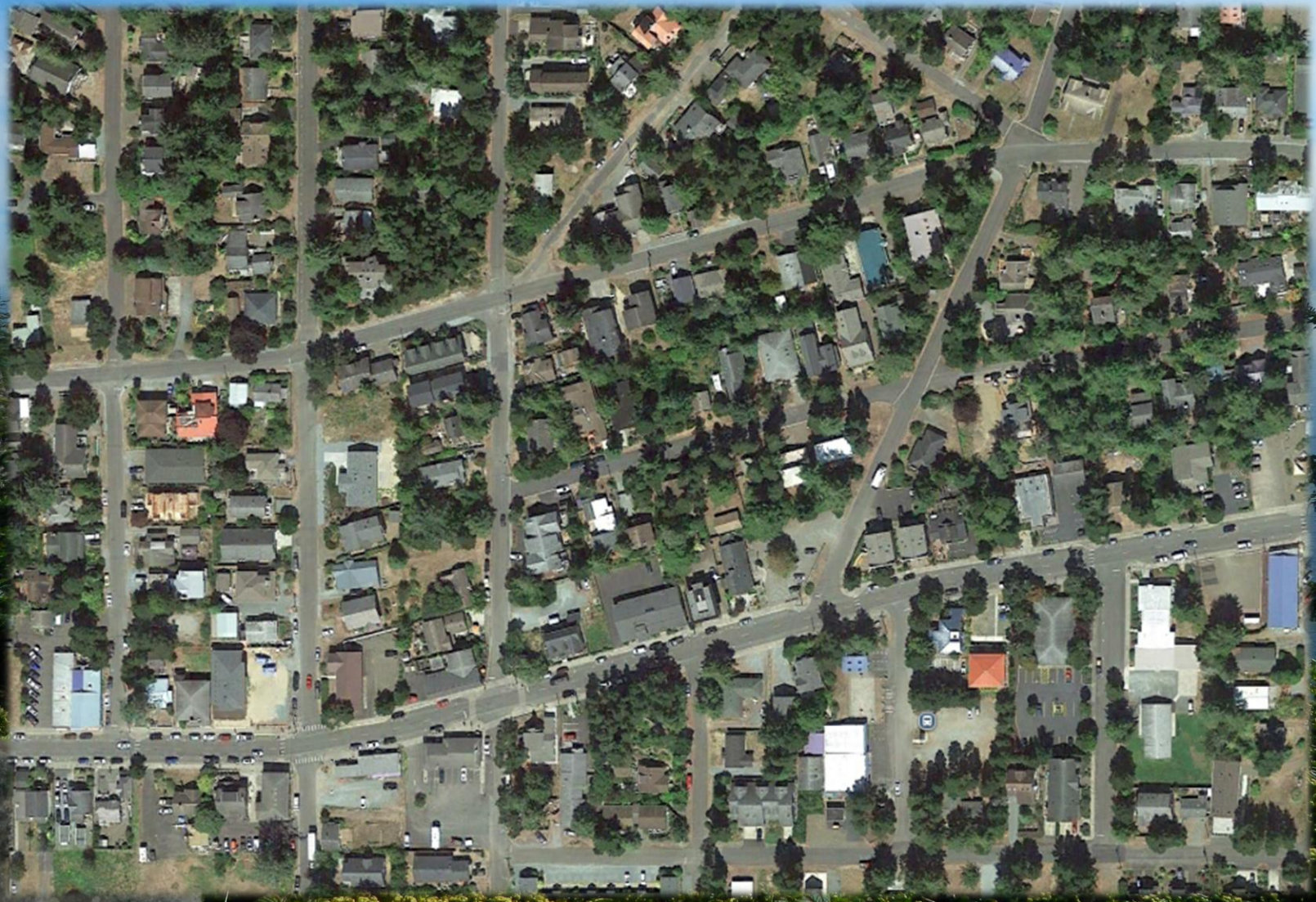
Before (August 2016) and After (June 2017) Southwest Manzanita



Before (August 2016) and After (June 2017) Southwest Manzanita



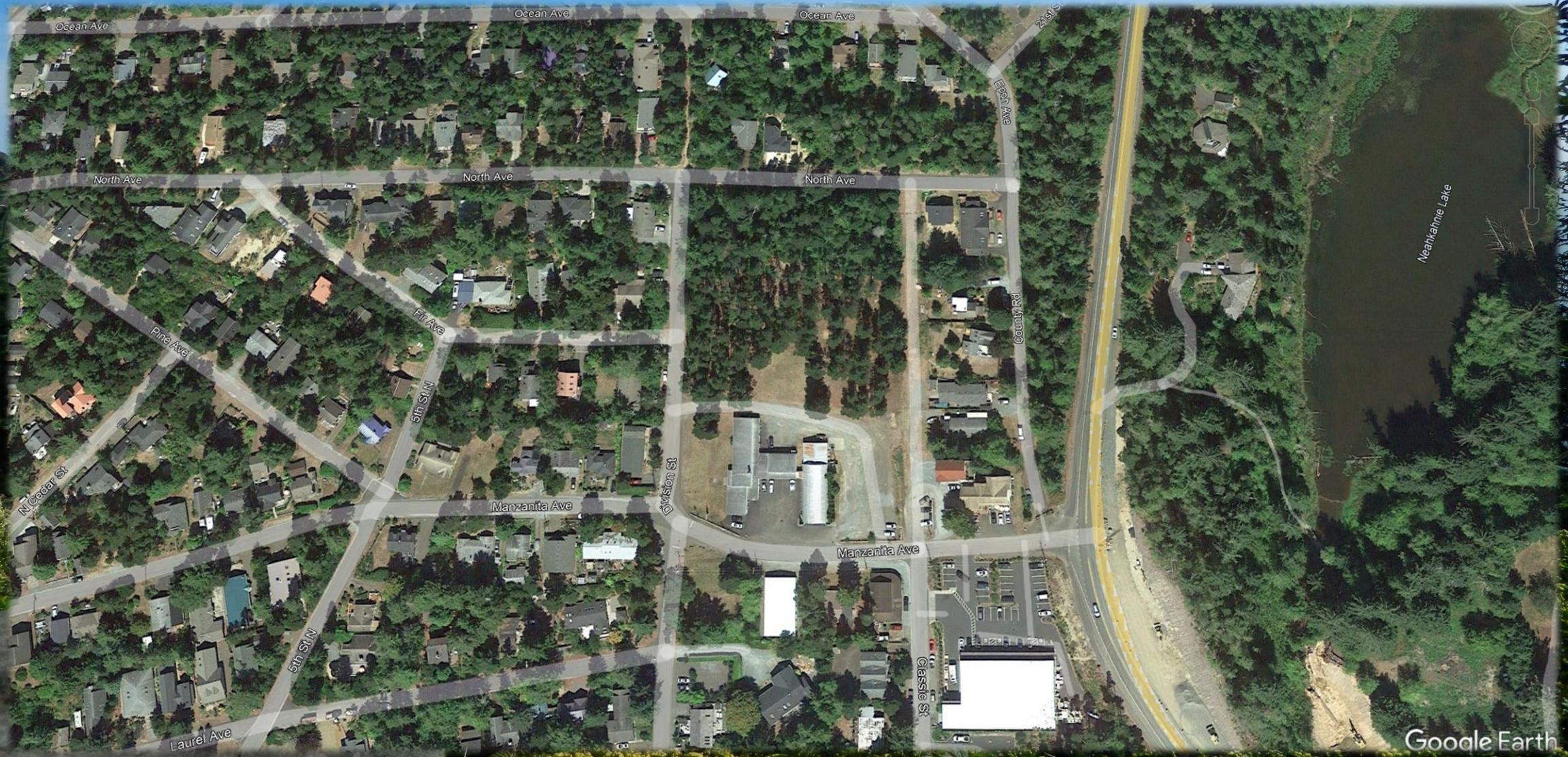
Before (August 2016) and After (June 2017) Central Manzanita



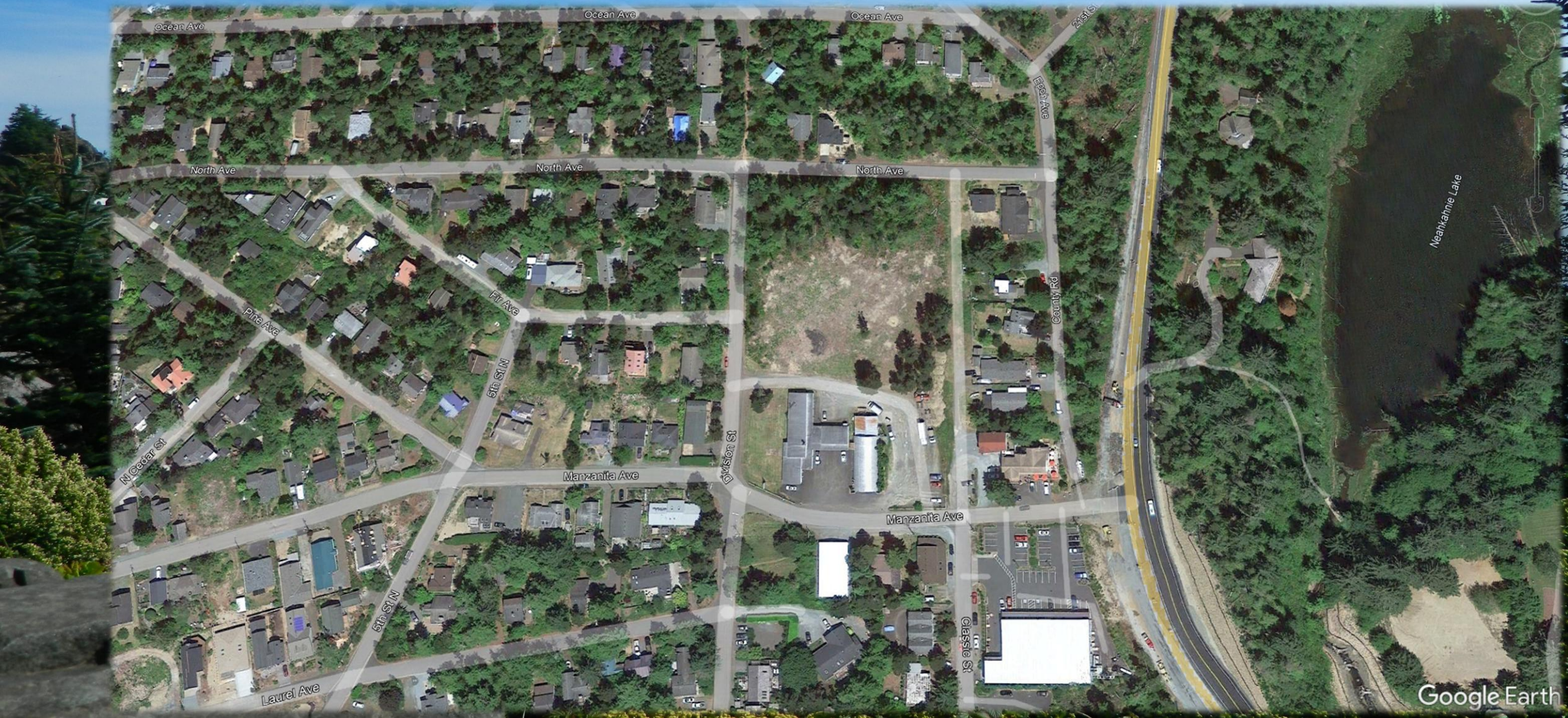
Before (August 2016) and After (June 2017)
Central Manzanita



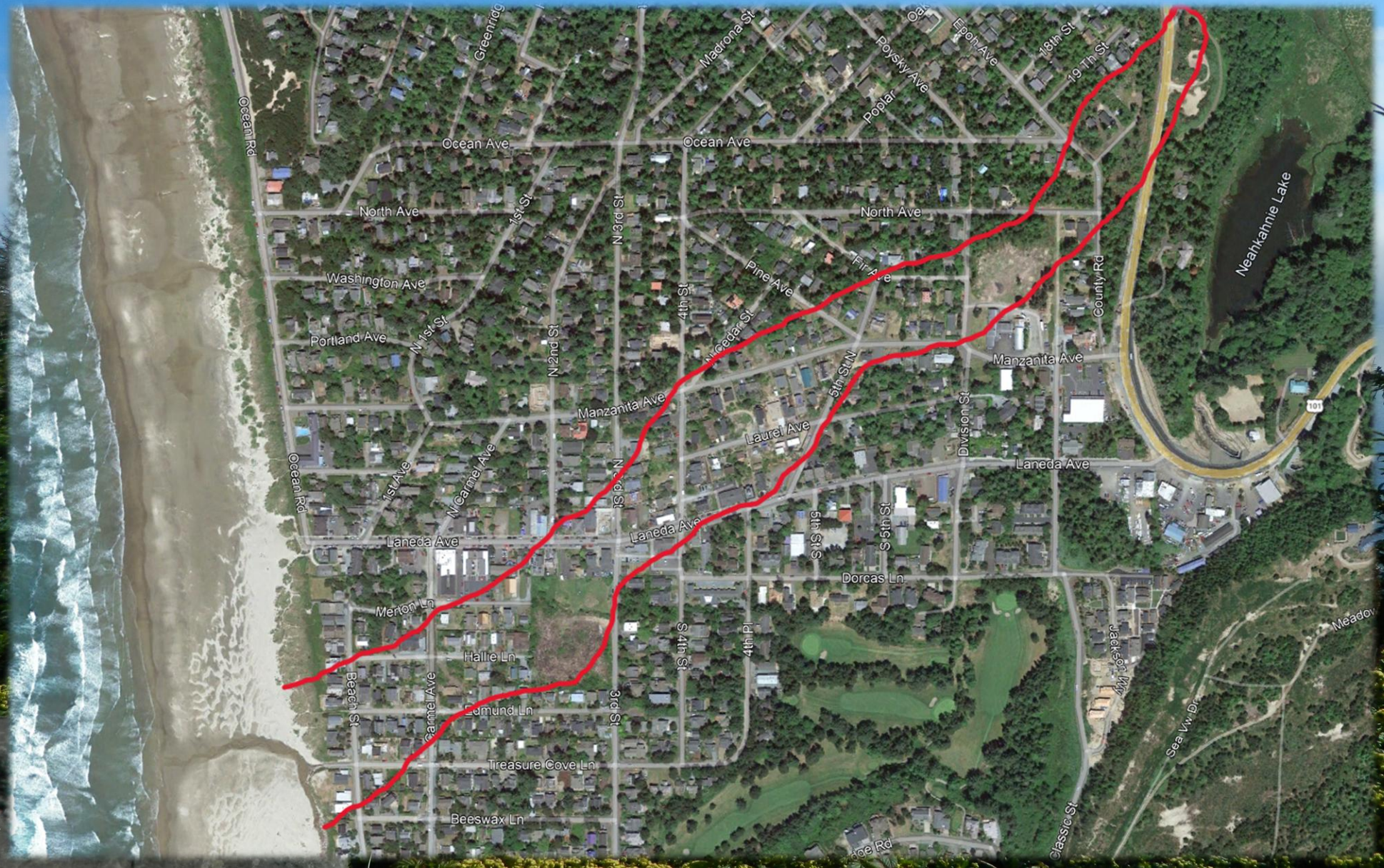
Before (August 2016) and After (June 2017) Northeast Manzanita



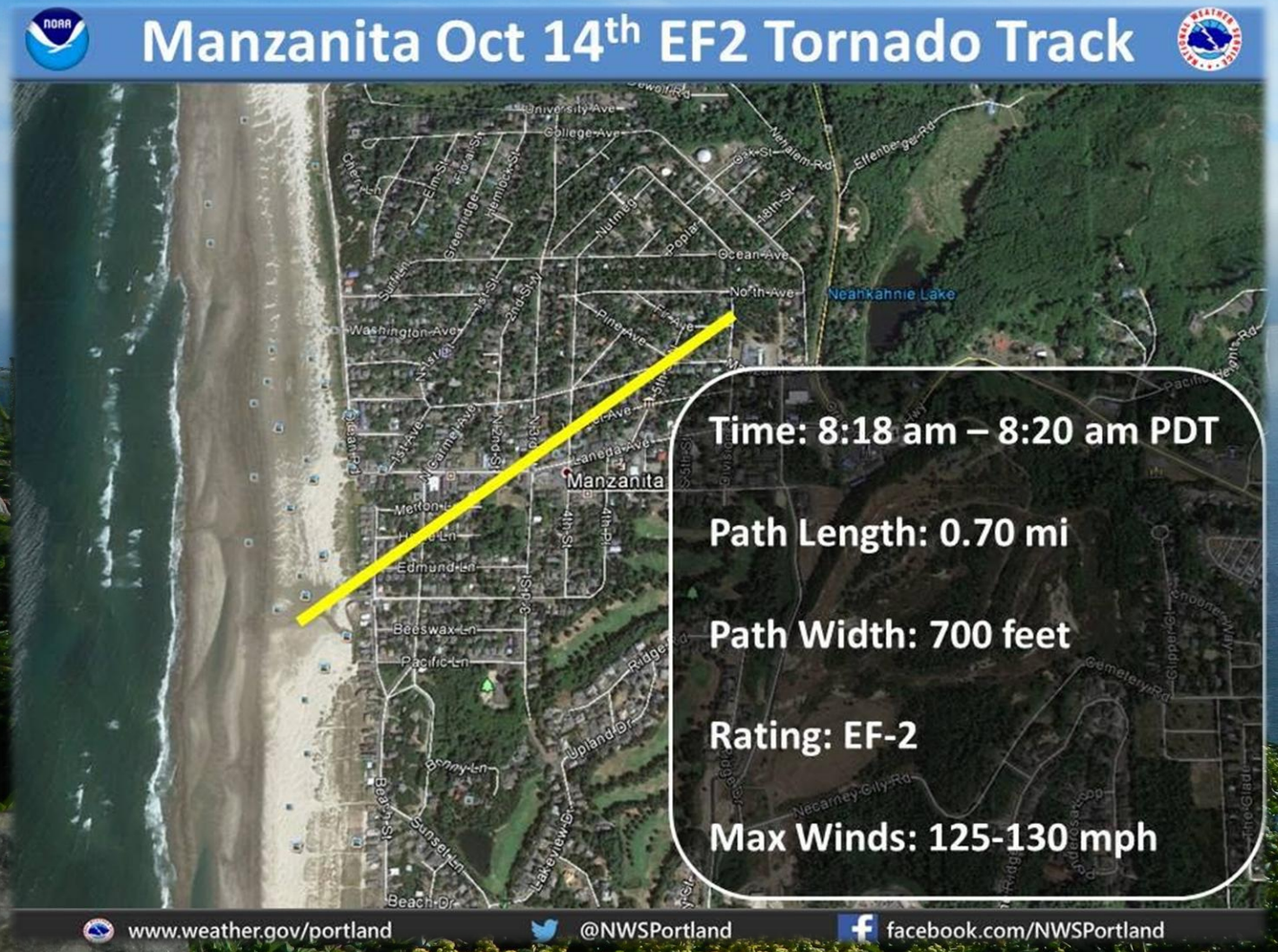
Before (August 2016) and After (June 2017) Northeast Manzanita



Damage Outline (Path would be 1.0 miles)



Official Path

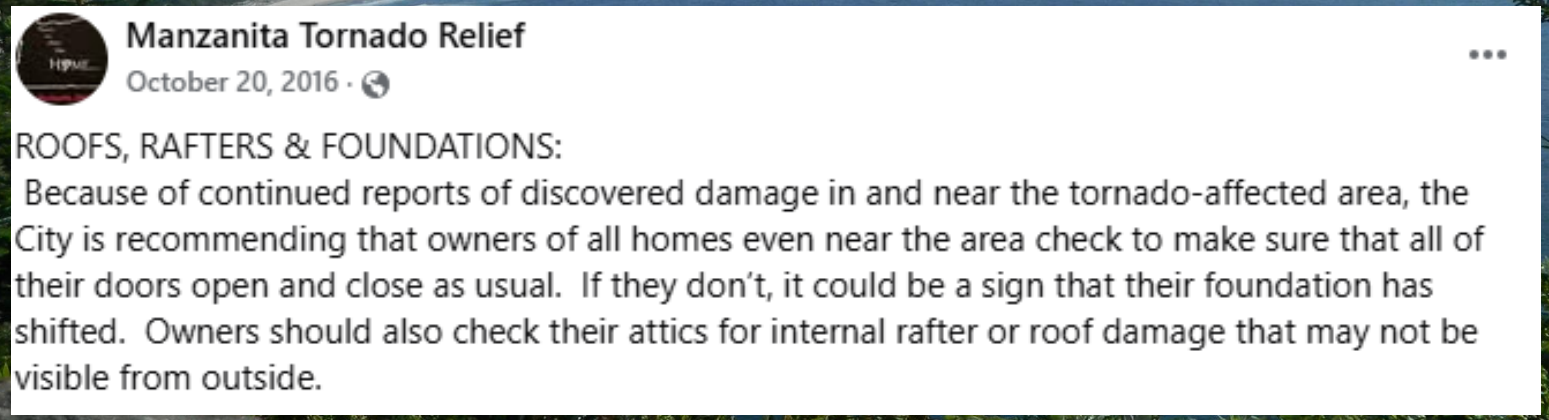


Damage Map from City of Manzanita



A note on the damage

- Some damage would not be discovered until days later.
  - This damage can be as subtle as deformed door frames and windows.
- This is what caused the discrepancy between the official path and damage map.
  - Damage survey was done the same day.



Manzanita Tornado Relief
October 20, 2016 ·

ROOFS, RAFTERS & FOUNDATIONS:
Because of continued reports of discovered damage in and near the tornado-affected area, the City is recommending that owners of all homes even near the area check to make sure that all of their doors open and close as usual. If they don't, it could be a sign that their foundation has shifted. Owners should also check their attics for internal rafter or roof damage that may not be visible from outside.

Keen Observers can View the Tree Damage 10 Years Later

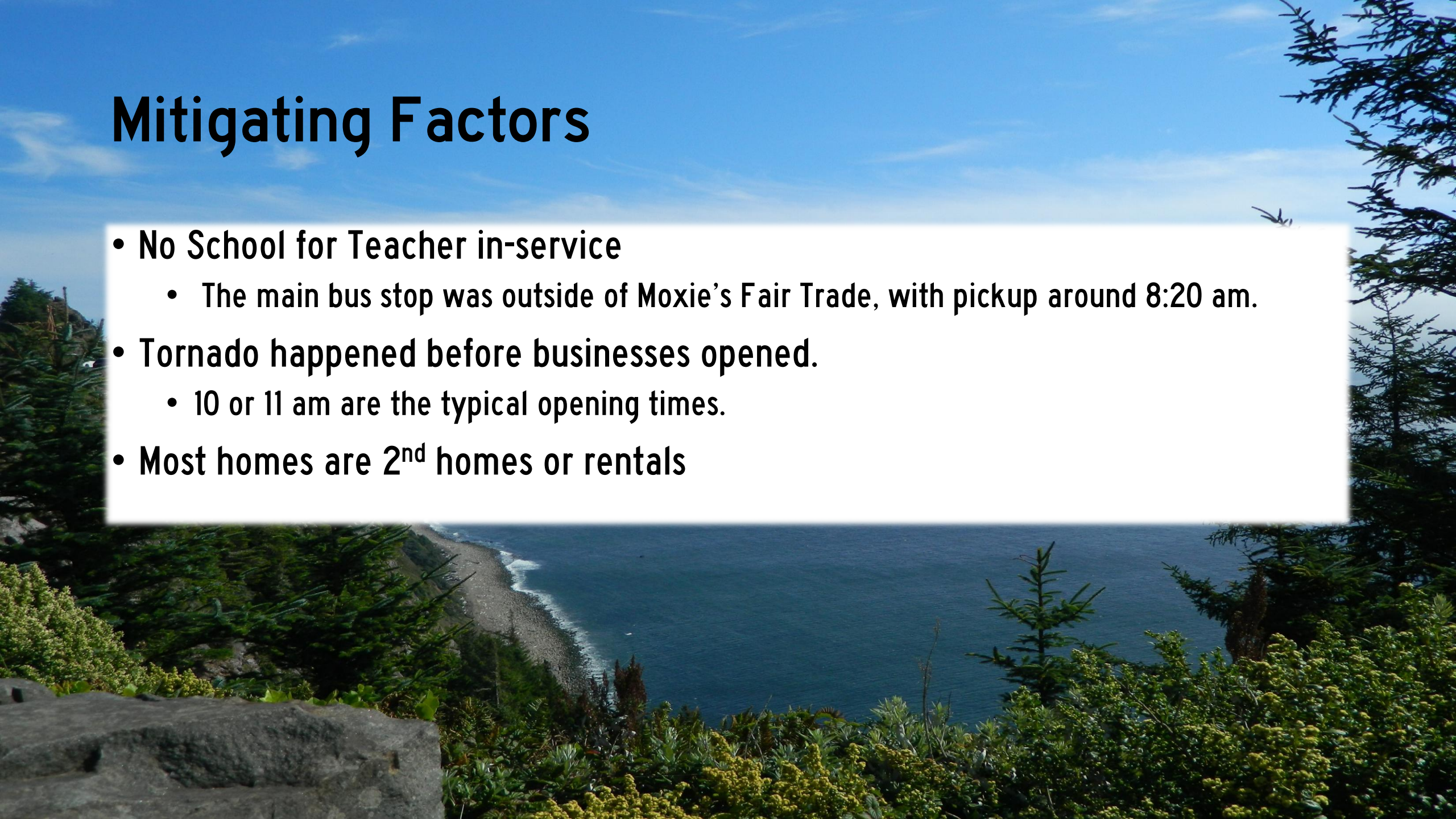


Tornado Facts

- Official path 0.7 miles
  - Might be short: Damage occurred after the path ended.
- On the ground for 2 minutes
- 700 feet wide at the widest point
- Estimated 128-189 Structures damaged
  - Varies depending on source
- 1/3 of trees snapped in the city
- No reported injuries.
  - EVCNB said a few people got scrapes from the tornado.
- $1 million in damages reported.

Mitigating Factors

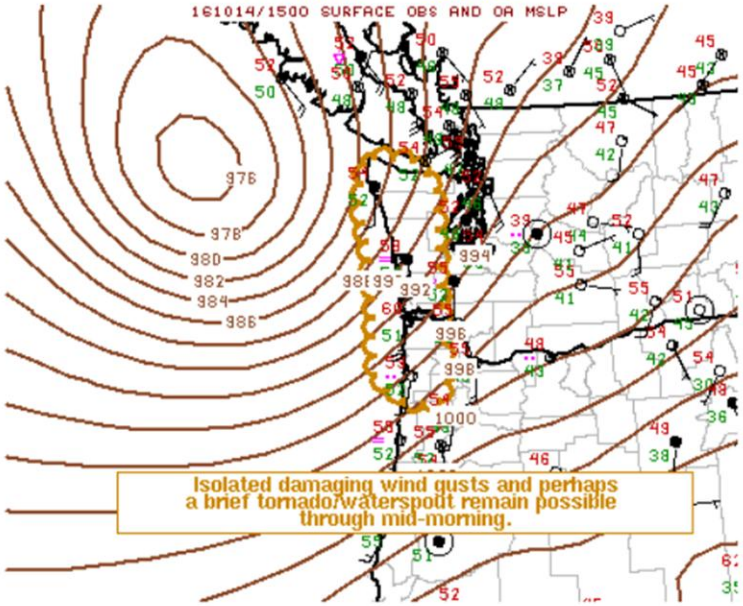
- No School for Teacher in-service
  - The main bus stop was outside of Moxie's Fair Trade, with pickup around 8:20 am.
- Tornado happened before businesses opened.
  - 10 or 11 am are the typical opening times.
- Most homes are 2nd homes or rentals



New MD 9 Minutes After Landfall

Mesoscale Discussion 1787

< Previous MD Next MD >



SPC MCD #1787

MESOSCALE DISCUSSION 1787
NWS STORM PREDICTION CENTER NORMAN OK
1029 AM CDT FRI OCT 14 2016

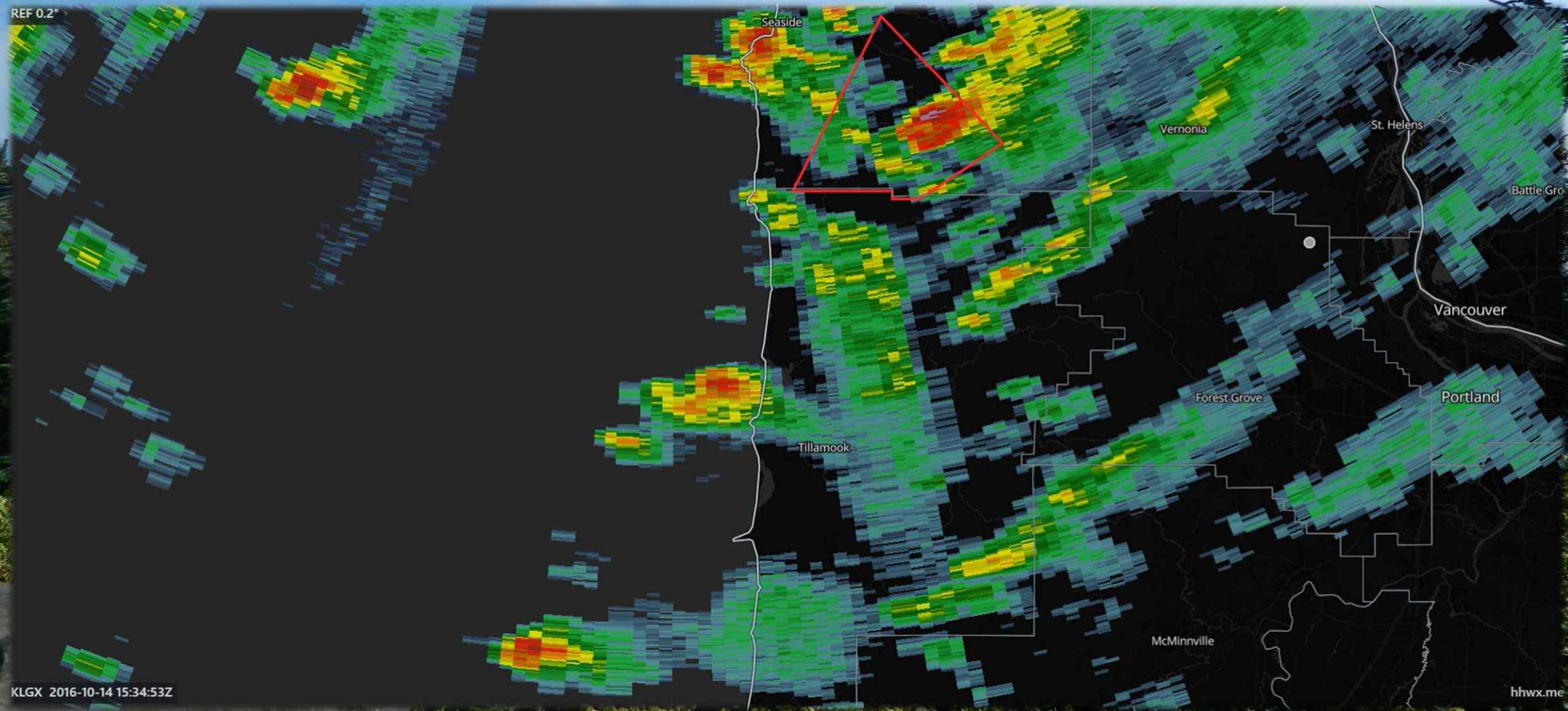
AREAS AFFECTED...COASTAL REGIONS OF WRN WASHINGTON/NWRN OREGON

CONCERNING...SEVERE POTENTIAL...WATCH UNLIKELY

VALID 141529Z - 141730Z

PROBABILITY OF WATCH ISSUANCE...5 PERCENT

4th-6th Tornado Warnings on the Day All Within an Hour



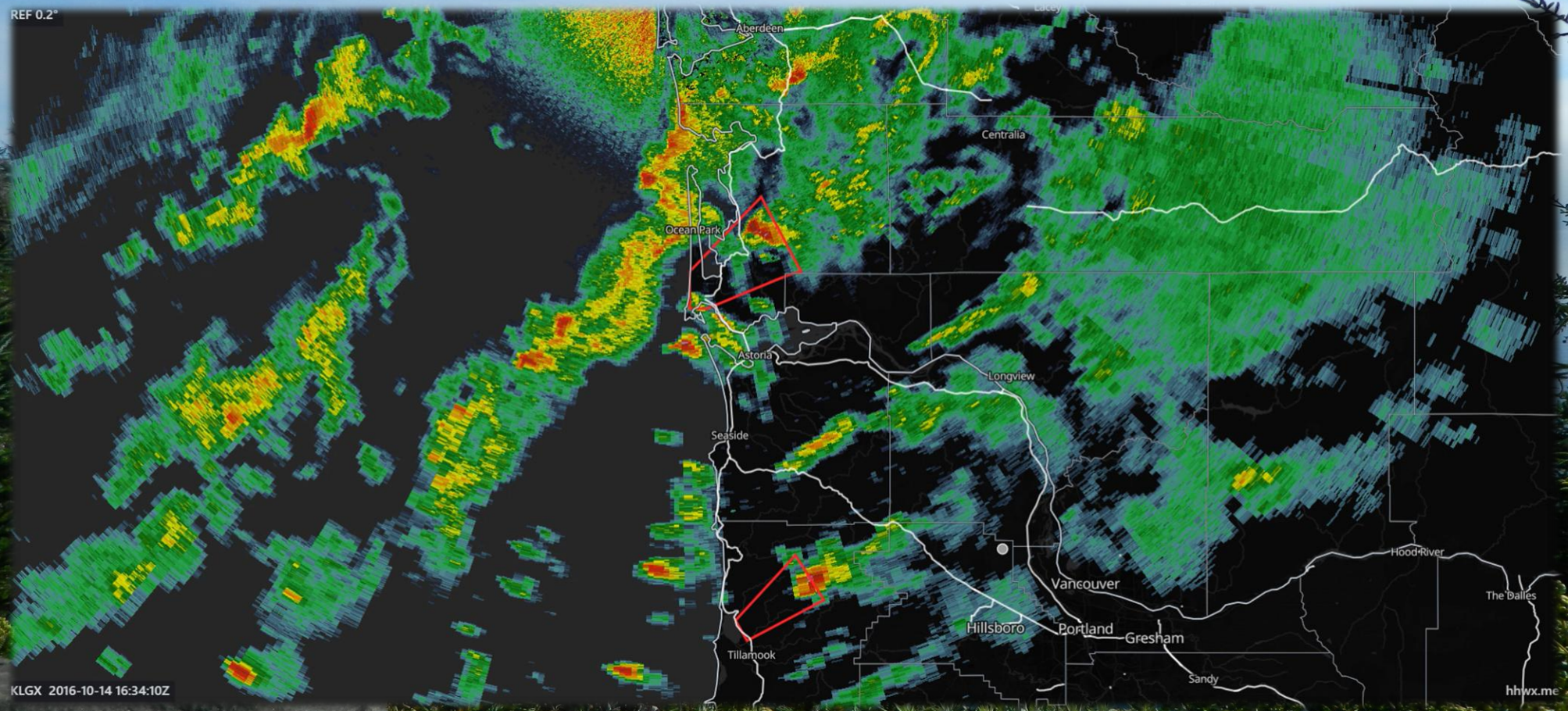
Oceanside Tornado: 9:05 am

- No damage
- No injuries
- Can barely see the funnel in an image.
- Rated EFU.

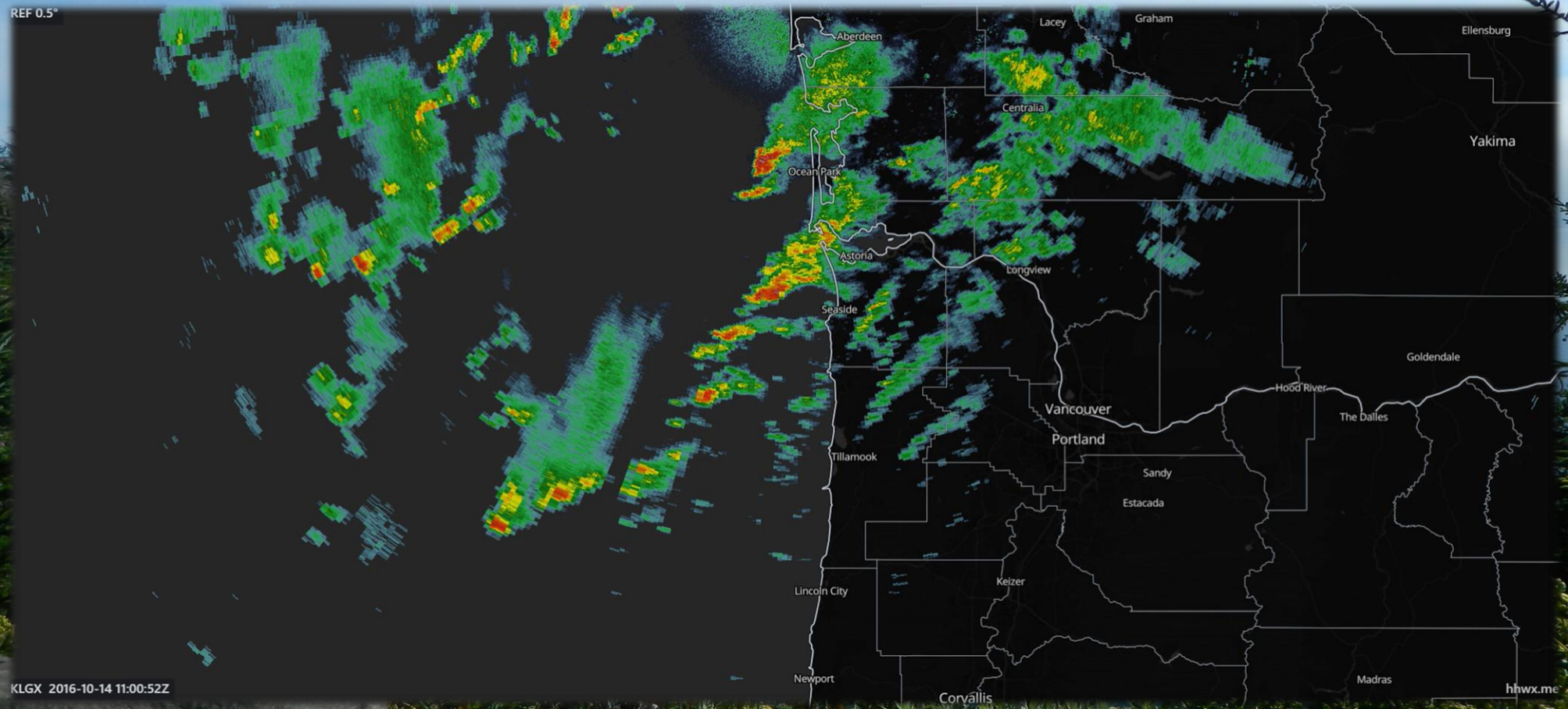


Photo: SPC Damage Analysis (cropped to fit)

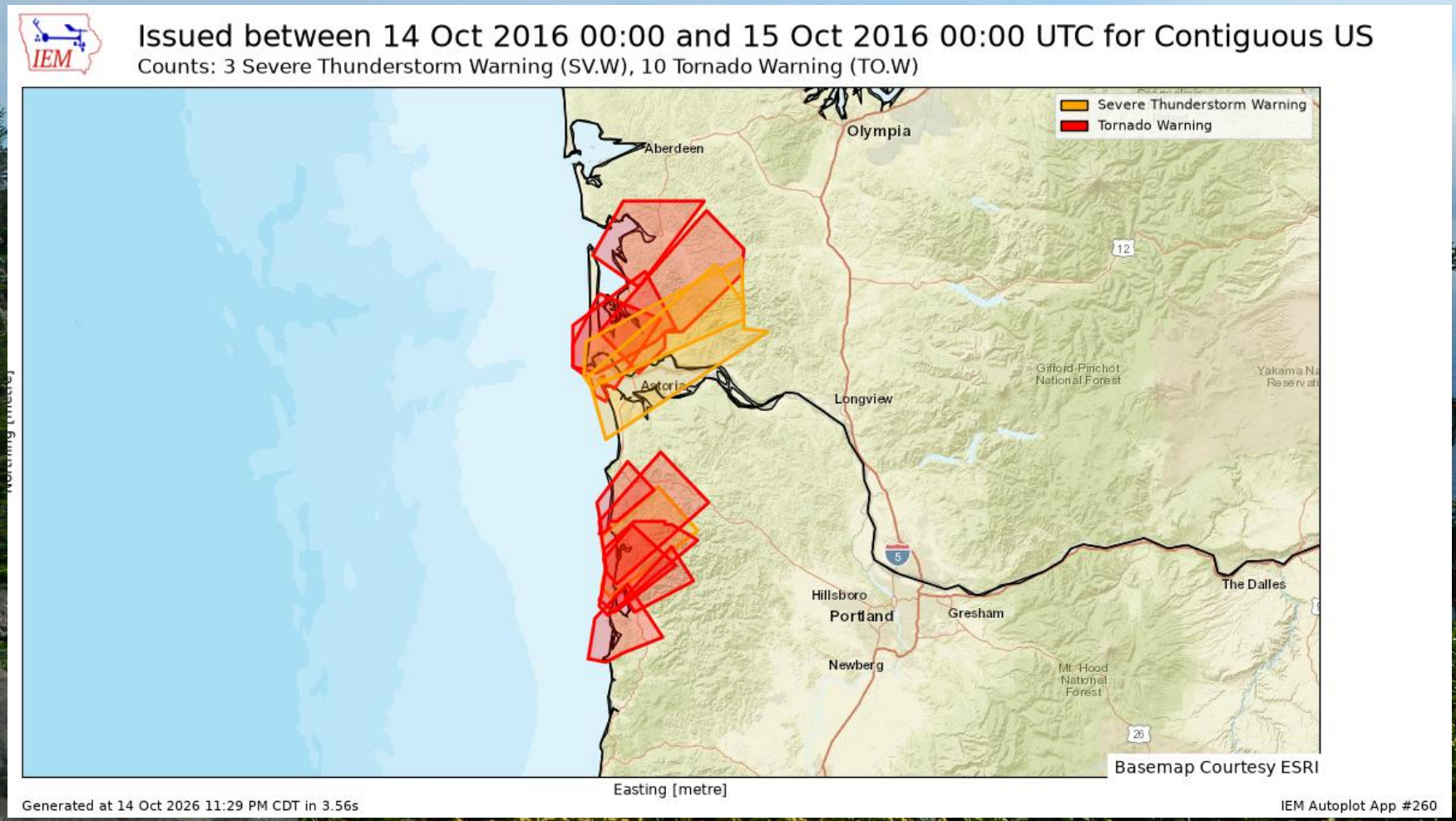
Warnings 8-10 Happened Simultaneously
No Tornadoes



Full Loop of the Event: 4 am – 1 pm



- 10 tornado warnings (record high for PNW, 3rd for West of Rockies)
- 13 land-based total severe warnings (Portland NWS record)



Severe Reports (from S. to N.)

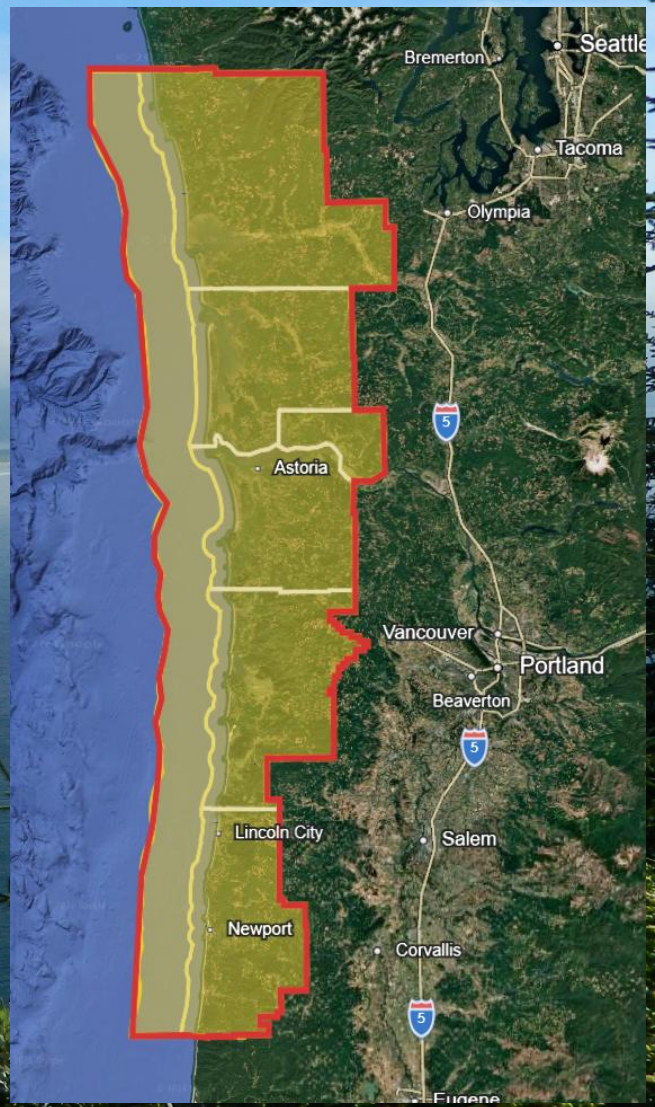
Town/Place Name	Report
Gleneden Beach, OR	59 mph (unwarned)
Oceanside, OR	EFU Tornado
Cape Meares, OR	79 mph
Garibaldi, OR	60 mph
Manzanita, OR	EF2 Tornado
Cannon Beach, OR	59 mph
Warrenton (Astoria Airport)	59 mph
Astoria (near downtown)	65 mph
Hammond, OR	1-1.5-inch hail (unwarned)
Ilwaco, WA	63 mph

6 reports (or 2 tornadoes) verifies a watch.

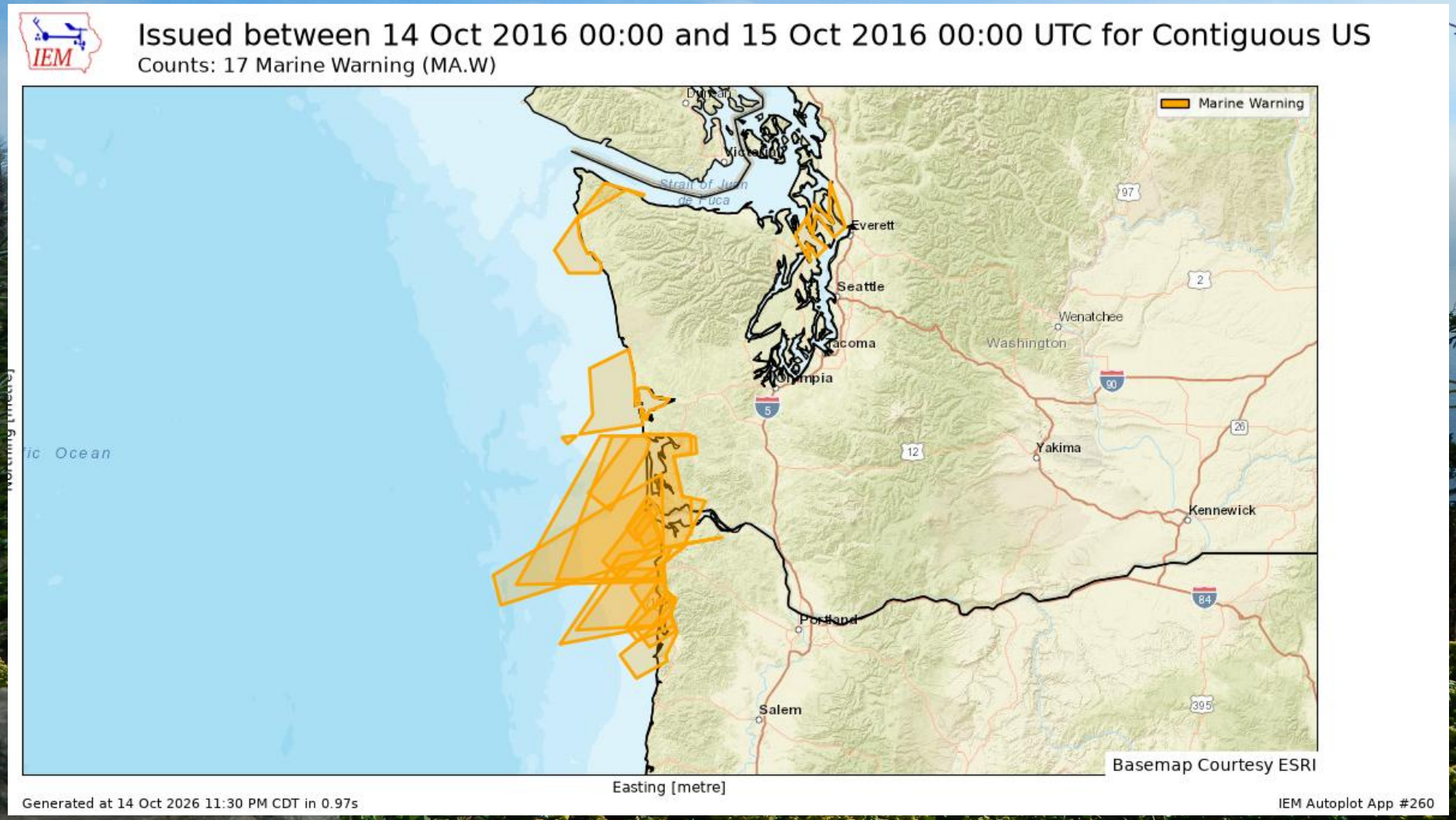
A tornado watch should've been Issued

Criteria Used:

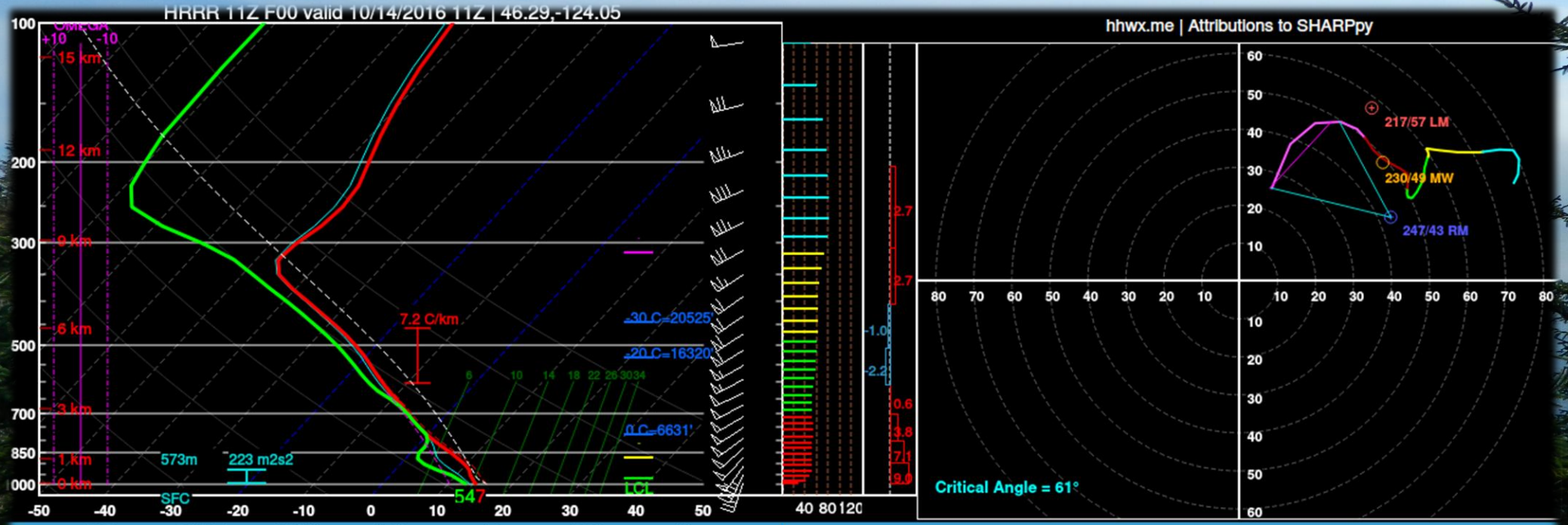
- MD 1786 area
- Historical tornadoes on the Coast.
  - None have been recorded north of Gray's Harbor County, or south of Lincoln until Curry County.
- Where the modeled Supercell Composite was the highest (Lincoln to Clatsop Counties).



- 15 Special Marine Warnings (Portland NWS record)
- 28 total severe warnings (Portland NWS record)



Long Beach 11z



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	927	-14	202	-3	1034	8574
ML	332	-32	950	-1	1565	8165
FCST	1014	0	1405	-4	1405	8574
MU	927	-14	202	-3	1034	8574

PW = 0.84in
MeanW = 7.2g/kg
LowRH = 78%
MidRH = 95%
DCAPE = 258
DownT = 50F

K = 30
TT = 53
ConvT = 64F
maxT = 68F
ESP = 0.5
MMP = 0.94

WNDG = 0.1
TEI = 9
3CAPE = 66
MBURST = 0

SigSvr = 7162 m3/s3

Sfc-3km AGL LR = 7.4 C/km
3-6km AGL LR = 7.2 C/km
850-500mb LR = 7.3 C/km
700-500mb LR = 6.9 C/km

Supercell = 4.1
STP (cin) = 0.3
STP (fix) = 1.1
SHIP = 0.5

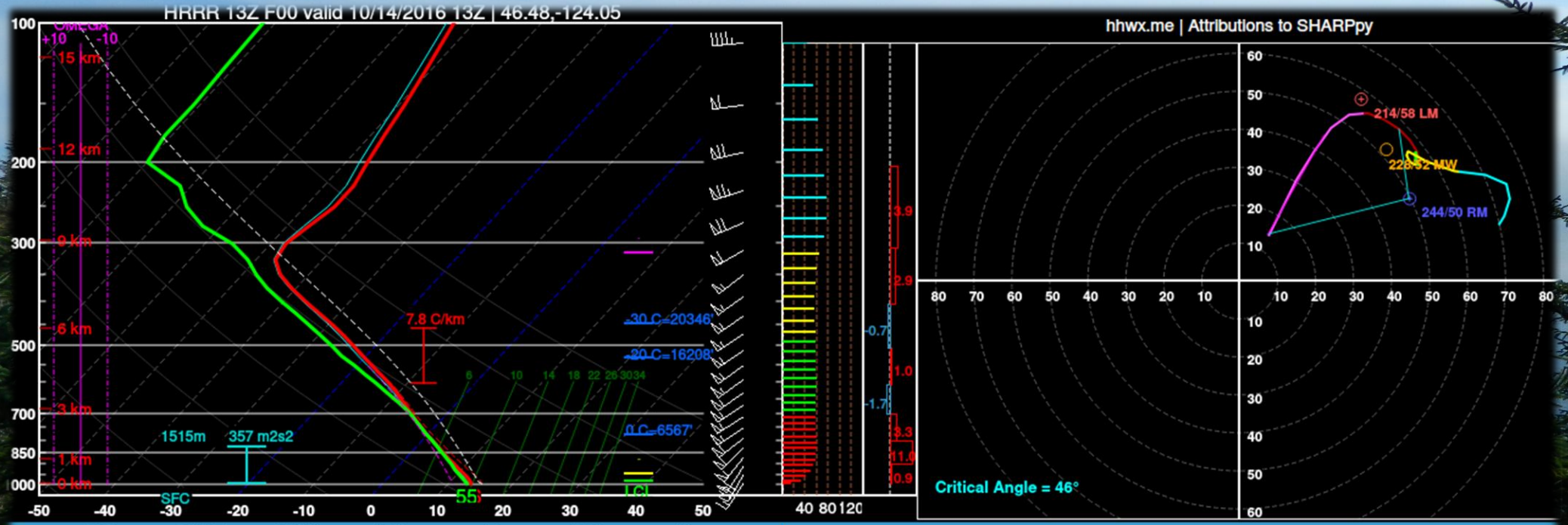
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	253	28	210/45	142/28
SFC-3km	298	36	224/47	158/18
Eff Inflow Layer	223	25	205/42	134/30
SFC-6km		42	230/49	172/15
SFC-8km		46	231/50	177/15
LCL-EL (Cloud Layer)		44	232/52	184/15
Eff Shear (EBWD)		39	228/48	164/15

BRN Shear = 63 m2/s2
4-6km SR Wind = 220/13 kt

...Storm Motion Vectors...
Bunkers Right = 247/43 kt
Bunkers Left = 217/57 kt
0-6km Mean Wind = 230/49 kt

1km & 6km AGL Wind Barbs

13z Long Beach



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	879	-3	79	-3	397	8575
ML	650	0	538	-3	665	8471
FCST	1297	0	944	-5	944	8897
MU	879	-3	79	-3	397	8575

PW = 0.93in
MeanW = 8.3g/kg
LowRH = 95%
MidRH = 98%
DCAPE = 168
DownT = 51F

K = 33
TT = 56
ConvT = 60F
maxT = 65F
ESP = 0
MMP = 0.94

WNDG = 0.0
TEI = 6
3CAPE = 128
MBURST = 0

SigSvr = 14284 m3/s3

Sfc-3km AGL LR = 6.9 C/km
3-6km AGL LR = 7.5 C/km
850-500mb LR = 7.1 C/km
700-500mb LR = 7.3 C/km

Supercell = 6.3
STP (cin) = 1.2
STP (fix) = 1.3
SHIP = 0.5

	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	313	41	212/42	121/27
SFC-3km	379	43	224/50	145/17
Eff Inflow Layer	357	44	215/46	131/24
SFC-6km		43	228/52	155/14
SFC-8km		43	229/52	157/14
LCL-EL (Cloud Layer)		41	229/53	160/14
Eff Shear (EBWD)		44	227/51	151/15

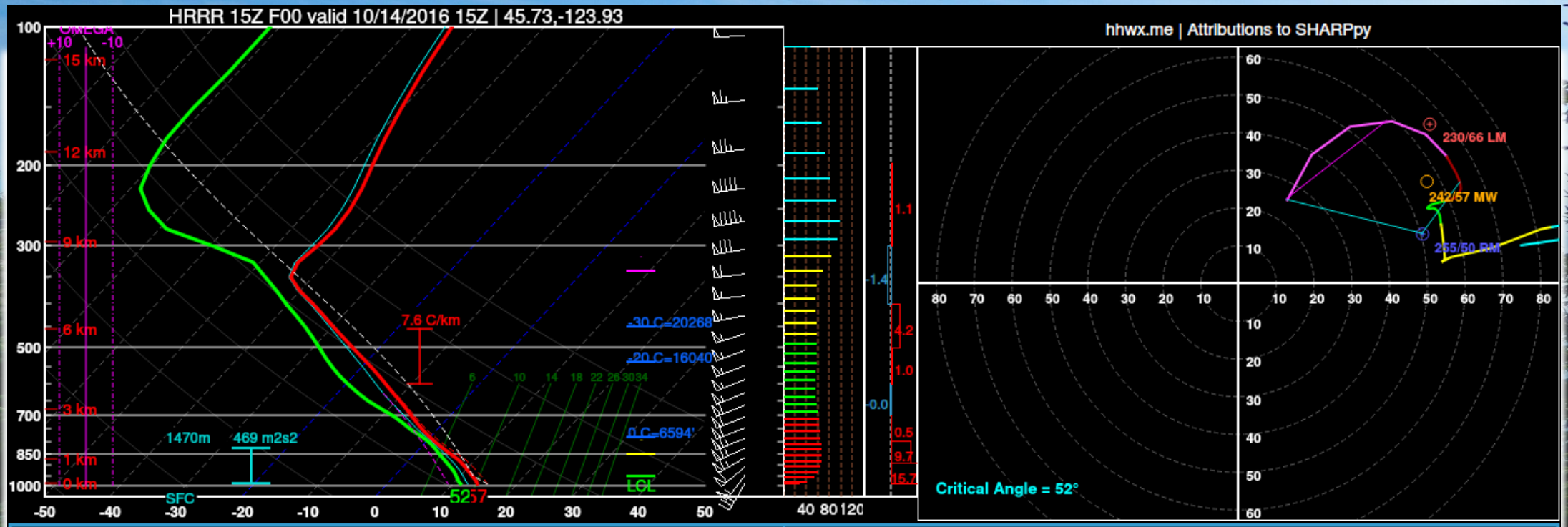
BRN Shear = 67 m2/s2
4-6km SR Wind = 187/12 kt

...Storm Motion Vectors...

Bunkers Right =	244/50 kt
Bunkers Left =	214/58 kt
0-6km Mean Wind =	228/52 kt

1km & 6km AGL Wind Barbs

15z Manzanita



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	659	-27	326	-3	1226	8016
ML	600	-14	720	-3	1226	8016
FCST	1261	0	1169	-5	1169	8422
MU	659	-27	326	-3	1226	8016

PW = 0.8in
MeanW = 7.6g/kg
LowRH = 85%
MidRH = 84%
DCAPE = 323
DownT = 49F

K = 31
TT = 57
ConvT = 63F
maxT = 66F
ESP = 0.8
MMP = 0.91

WNDG = 0.5
TEI = 8
3CAPE = 123
MBURST = 0

SigSvr = 12735 m3/s3

Sfc-3km AGL LR = 7.3 C/km
3-6km AGL LR = 7.4 C/km
850-500mb LR = 7.4 C/km
700-500mb LR = 7.3 C/km

Supercell = 5.9
STP (cin) = 1.2
STP (fix) = 1.4
SHIP = 0.3

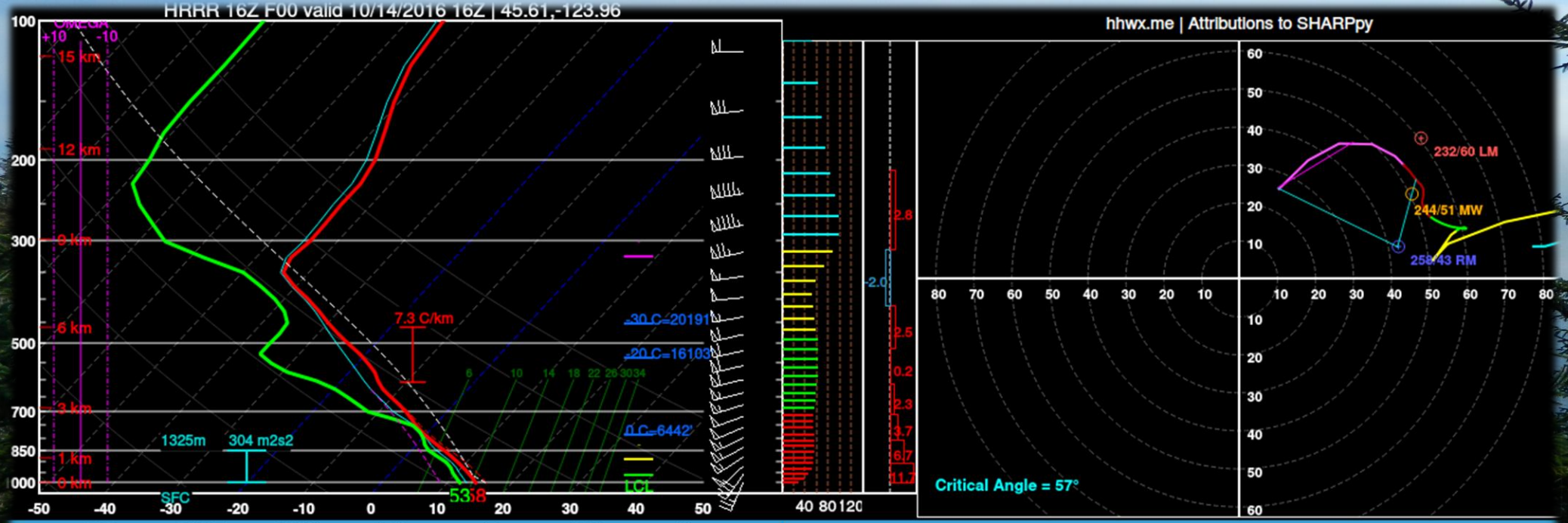
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	437	44	224/53	155/28
SFC-3km	470	41	238/58	181/17
Eff Inflow Layer	469	46	230/56	165/23
SFC-6km		41	242/57	185/14
SFC-8km		49	244/56	188/12
LCL-EL (Cloud Layer)		45	245/58	201/12
Eff Shear (EBWD)		37	240/57	183/16

BRN Shear = 85 m2/s2
4-6km SR Wind = 195/7 kt

...Storm Motion Vectors...
Bunkers Right = 255/50 kt
Bunkers Left = 230/66 kt
0-6km Mean Wind = 242/57 kt

1km & 6km AGL Wind Barbs

Rockaway 15z



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	815	-17	305	-4	947	8408
ML	664	-8	761	-3	1088	8106
FCST	1249	0	1151	-5	1151	8511
MU	815	-17	305	-4	947	8408

PW = 0.79in
MeanW = 7.9g/kg
LowRH = 87%
MidRH = 82%
DCAPE = 428
DownT = 48F

K = 26
TT = 56
ConvT = 63F
maxT = 67F
ESP = 1.3
MMP = 0.94

WNDG = 0.5
TEI = 11
3CAPE = 136
MBURST = 0

SigSvr = 16299 m3/s3

Sfc-3km AGL LR = 7.5 C/km
3-6km AGL LR = 7.4 C/km
850-500mb LR = 7.4 C/km
700-500mb LR = 7.2 C/km

Supercell = 5.0
STP (cin) = 1.1
STP (fix) = 1.3
SHIP = 0.5

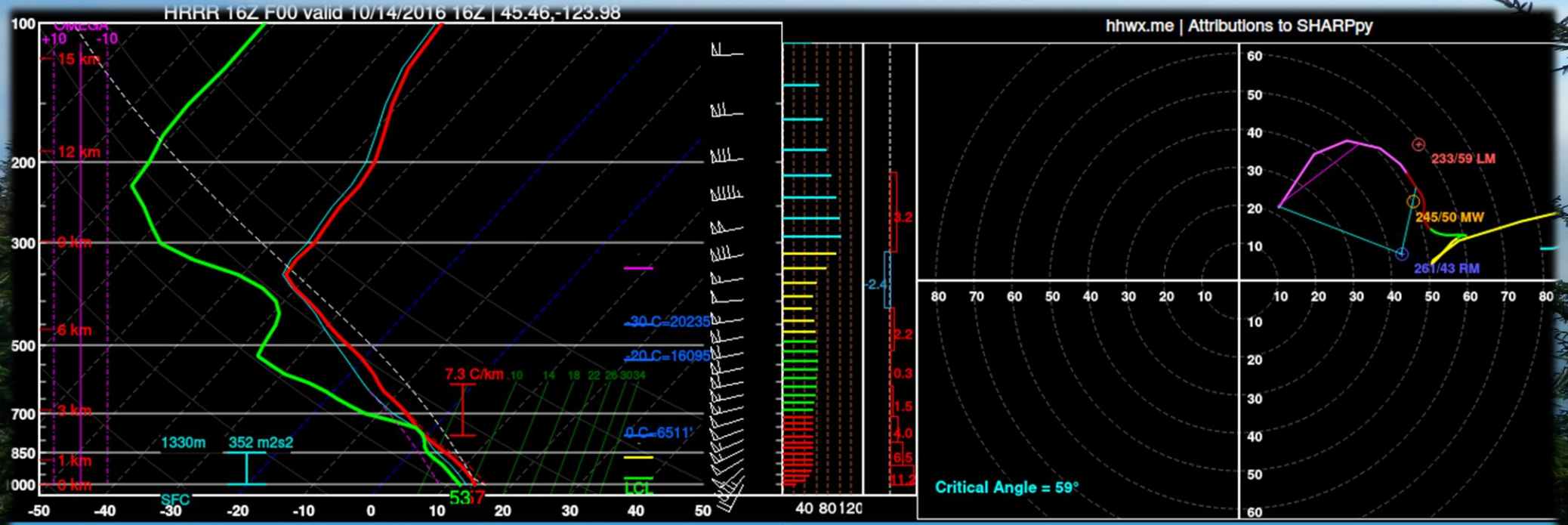
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	283	33	221/43	151/27
SFC-3km	333	41	236/48	174/18
Eff Inflow Layer	304	36	226/45	157/25
SFC-6km		48	244/51	194/14
SFC-8km		49	246/51	200/13
LCL-EL (Cloud Layer)		51	248/53	212/14
Eff Shear (EBWD)		48	240/49	183/16

BRN Shear = 95 m2/s2
4-6km SR Wind = 253/17 kt

...Storm Motion Vectors...
Bunkers Right = 258/43 kt
Bunkers Left = 232/60 kt
0-6km Mean Wind = 244/51 kt

1km & 6km AGL Wind Barbs

Oceanside 16z



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	772	-23	282	-3	1092	8113
ML	582	-12	828	-3	1330	8015
FCST	1167	0	1231	-5	1231	8415
MU	772	-23	282	-3	1092	8113

PW = 0.77in
MeanW = 7.7g/kg
LowRH = 84%
MidRH = 81%
DCAPE = 471
DownT = 48F

K = 26
TT = 56
ConvT = 64F
maxT = 67F
ESP = 0.9
MMP = 1.0

WNDG = 0.4
TEI = 11
3CAPE = 113
MBURST = 0

SigSvr = 14181 m3/s3

Sfc-3km AGL LR = 7.4 C/km
3-6km AGL LR = 7.4 C/km
850-500mb LR = 7.4 C/km
700-500mb LR = 7.2 C/km

Supercell = 5.4
STP (cin) = 1.1
STP (fix) = 1.4
SHIP = 0.4

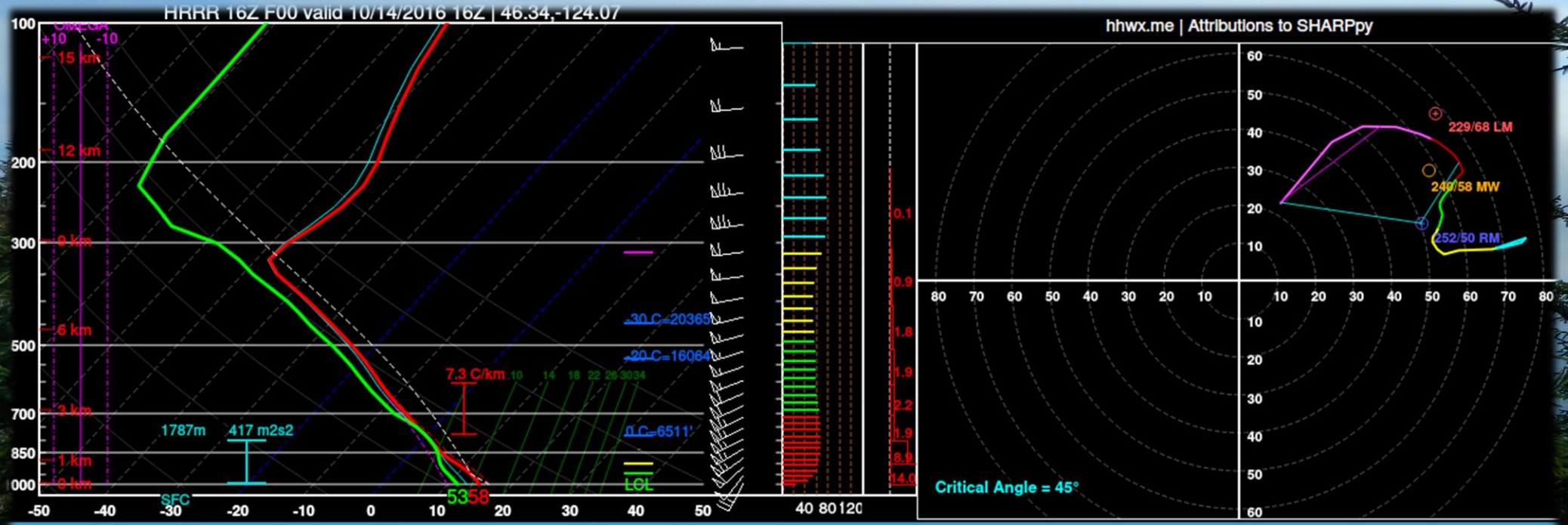
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	337	35	223/44	153/28
SFC-3km	381	41	238/48	173/18
Eff Inflow Layer	352	37	227/45	158/26
SFC-6km		47	245/50	192/14
SFC-8km		51	247/50	197/13
LCL-EL (Cloud Layer)		47	249/52	208/13
Eff Shear (EBWD)		46	242/49	180/16

BRN Shear = 93 m2/s2
4-6km SR Wind = 252/16 kt

...Storm Motion Vectors...
Bunkers Right = 261/43 kt
Bunkers Left = 233/59 kt
0-6km Mean Wind = 245/50 kt

1km & 6km AGL Wind Barbs

Long Beach 16z



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	829	-19	408	-3	825	8585
ML	535	-7	865	-2	1058	8481
FCST	1051	0	1203	-4	1203	8906
MU	829	-19	408	-3	825	8585

PW = 0.86in
MeanW = 7.5g/kg
LowRH = 81%
MidRH = 95%
DCAPE = 255
DownT = 50F

K = 31
TT = 56
ConvT = 62F
maxT = 66F
ESP = 1.4
MMP = 1.0

WNDG = 0.5
TEI = 8
3CAPE = 112
MBURST = 0

SigSvr = 11512 m3/s3

Sfc-3km AGL LR = 7.6 C/km
3-6km AGL LR = 7.2 C/km
850-500mb LR = 7.1 C/km
700-500mb LR = 7.0 C/km

Supercell = 6.9
STP (cin) = 1.1
STP (fix) = 1.5
SHIP = 0.4

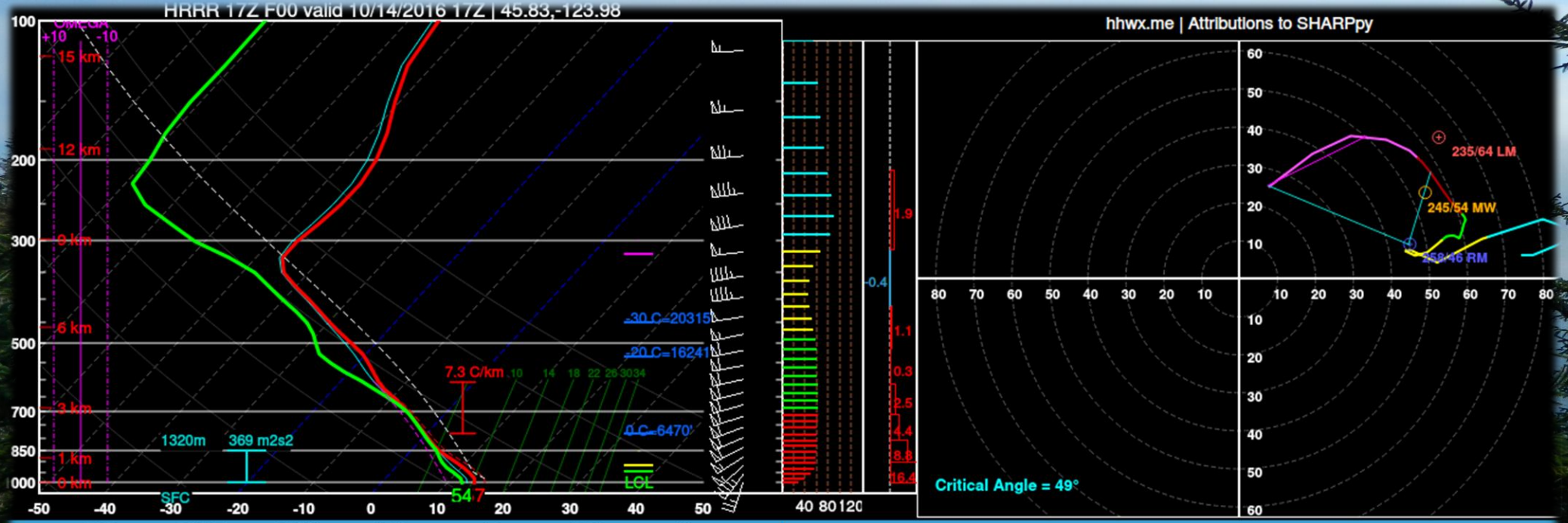
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	367	43	223/51	150/26
SFC-3km	425	46	235/59	180/18
Eff Inflow Layer	417	48	230/56	167/22
SFC-6km		42	240/58	188/14
SFC-8km		46	242/57	190/12
LCL-EL (Cloud Layer)		43	244/59	206/12
Eff Shear (EBWD)		42	237/58	185/16

BRN Shear = 78 m2/s2
4-6km SR Wind = 230/6 kt

...Storm Motion Vectors...
Bunkers Right = 252/50 kt
Bunkers Left = 229/68 kt
0-6km Mean Wind = 240/58 kt

1km & 6km AGL Wind Barbs

Arch Cape 16z



PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	838	-18	237	-3	851	8407
ML	590	-5	770	-2	943	8407
FCST	1128	0	1122	-4	1122	8615
MU	934	-6	444	-4	714	8510

PW = 0.88in
MeanW = 7.9g/kg
LowRH = 86%
MidRH = 98%
DCAPE = 267
DownT = 50F

K = 32
TT = 55
ConvT = 62F
maxT = 66F
ESP = 0.8
MMP = 1.0

WNDG = 0.5
TEI = 9
3CAPE = 131
MBURST = 0

SigSvr = 14414 m3/s3

Sfc-3km AGL LR = 7.3 C/km
3-6km AGL LR = 7.4 C/km
850-500mb LR = 7.0 C/km
700-500mb LR = 7.2 C/km

Supercell = 6.9
STP (cin) = 1.3
STP (fix) = 1.6
SHIP = 0.6

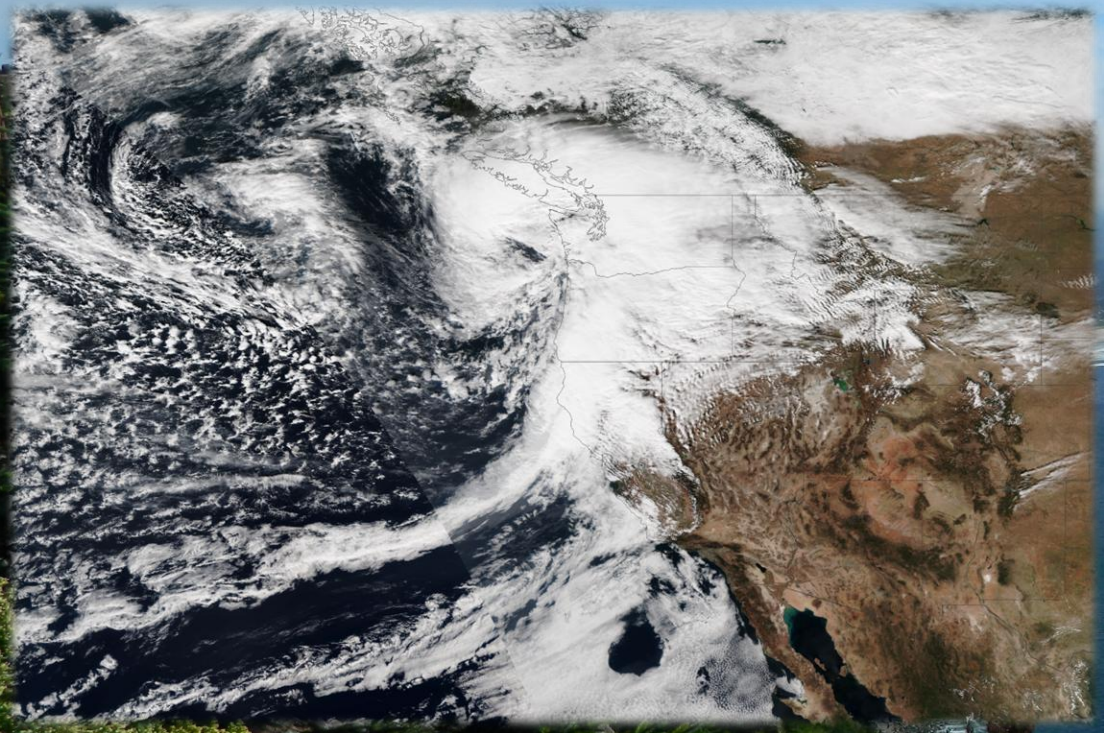
	SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	345	40	222/46	151/28
SFC-3km	424	51	238/52	179/19
Eff Inflow Layer	369	43	227/48	157/26
SFC-6km		48	245/54	197/14
SFC-8km		42	247/53	198/13
LCL-EL (Cloud Layer)		39	250/56	216/13
Eff Shear (EBWD)		52	242/54	189/16

BRN Shear = 112 m2/s2
4-6km SR Wind = 260/13 kt

...Storm Motion Vectors...
Bunkers Right = 258/46 kt
Bunkers Left = 235/64 kt
0-6km Mean Wind = 245/54 kt

1km & 6km AGL Wind Barbs

Songda Ended up as a Typical Storm



In the end, the storm tracked slightly farther northwest and offshore than expected, while maintaining roughly the same expected strength – a storm pressure of 969mb. Instead of moving directly inland over Washington, as forecasters initially feared, the storm ended up 30 to 40 miles off the coast. This deviation in track did not mean that the Pacific Northwest was spared completely; it meant that the worst of the storm was offshore.


The Recovery

Emergency Response Led By:

EVCNB

EMERGENCY VOLUNTEER CORPS OF NEHALEM BAY

NEHALEM BAY FIRE RESCUE

American Red Cross

EVCNB Details

- Created in 2008 after another storm brought hurricane-force winds.
- This is the first time it was activated

EVCNB

EMERGENCY VOLUNTEER CORPS OF NEHALEM BAY

General Responsibilities

- EVCNB: Direct to community and main organizers.
- Facebook Page called Maznanita Tornado Relief: Monetary/Fundraisers for outsiders.
- American Red Cross: Setting up a Shelter
- Fire Department: Safety management, blocking roads as needed for access to cut trees.
- Loggers: Cutting hazardous trees and branches.

Day 0: Tree Cleanup

- Outside of the loggers used for the trees, additional help was used from snowplows to clear the tree debris that fell onto roads.
- For safety and efficiency, those not helping were asked to stay away, excluding residents.
- Most debris was put on an empty, city owned lot.

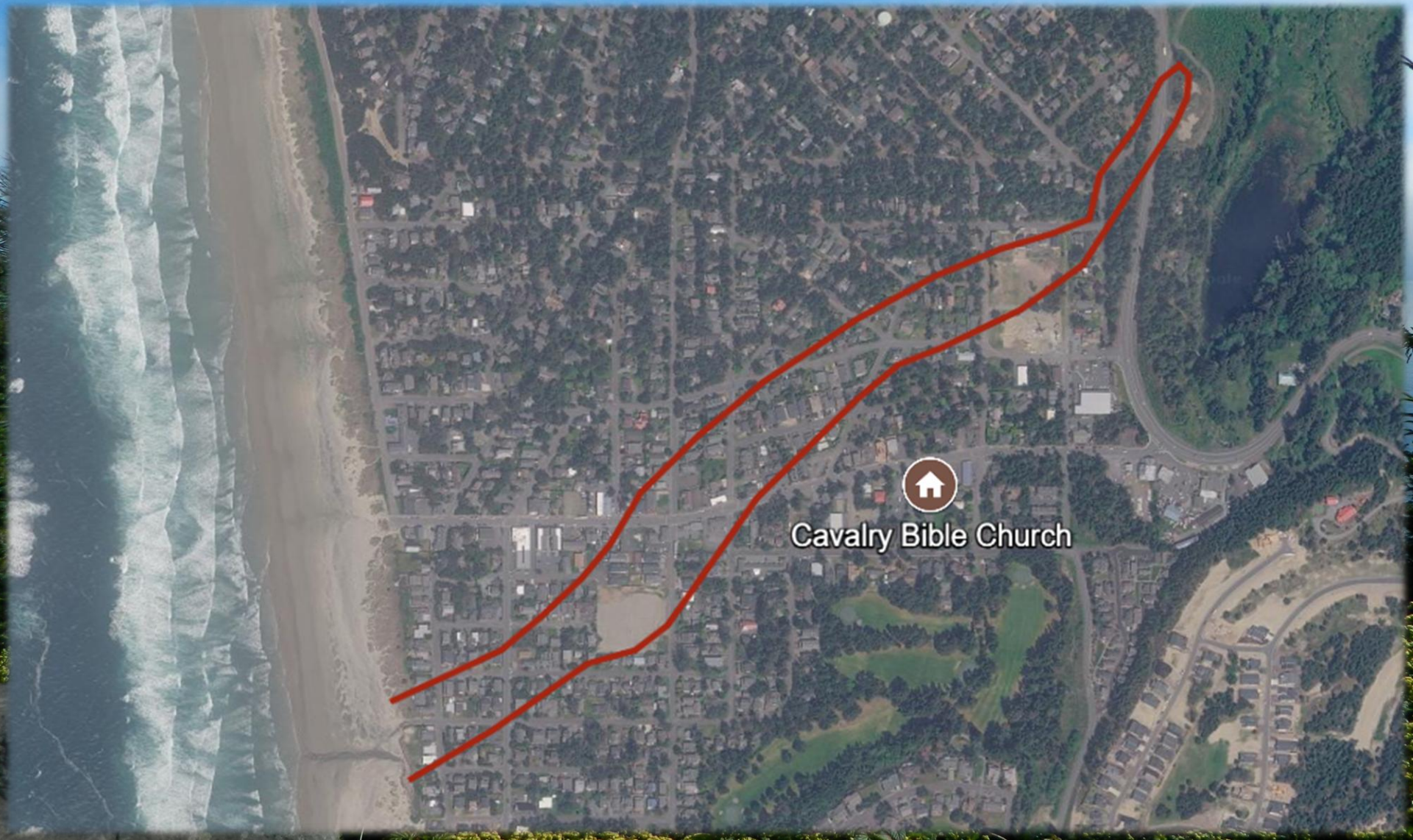


Photo: Wikipedia Commons

The Shelter

- Set up at the Cavalry Bible Church.
- In addition to providing a place for people to stay it did the following:
  - Central Point of the emergency response.
  - General Information.
  - Free food for volunteers and emergency responders.
- Shelter was not used as a shelter, as only 4 homes were deemed uninhabitable (2 beyond salvageable), and community members

Location



The All-in-One Shop to, or Receive Help



Manzanita Tornado Relief

775 followers • 0 following

Created to coordinate relief efforts for victims of October 14, 2016 tornado in Manzanita, OR

Community

Message Follow Search

Items Included

- Updates in recovery.
- Where those affected can receive help.
- Where those outside can go to help.
- Local workshops (ex: DIY repairs, managing stress)
- Heartwarming Stories.
- Any community fundraisers
  - More on the main one later.
- And more.

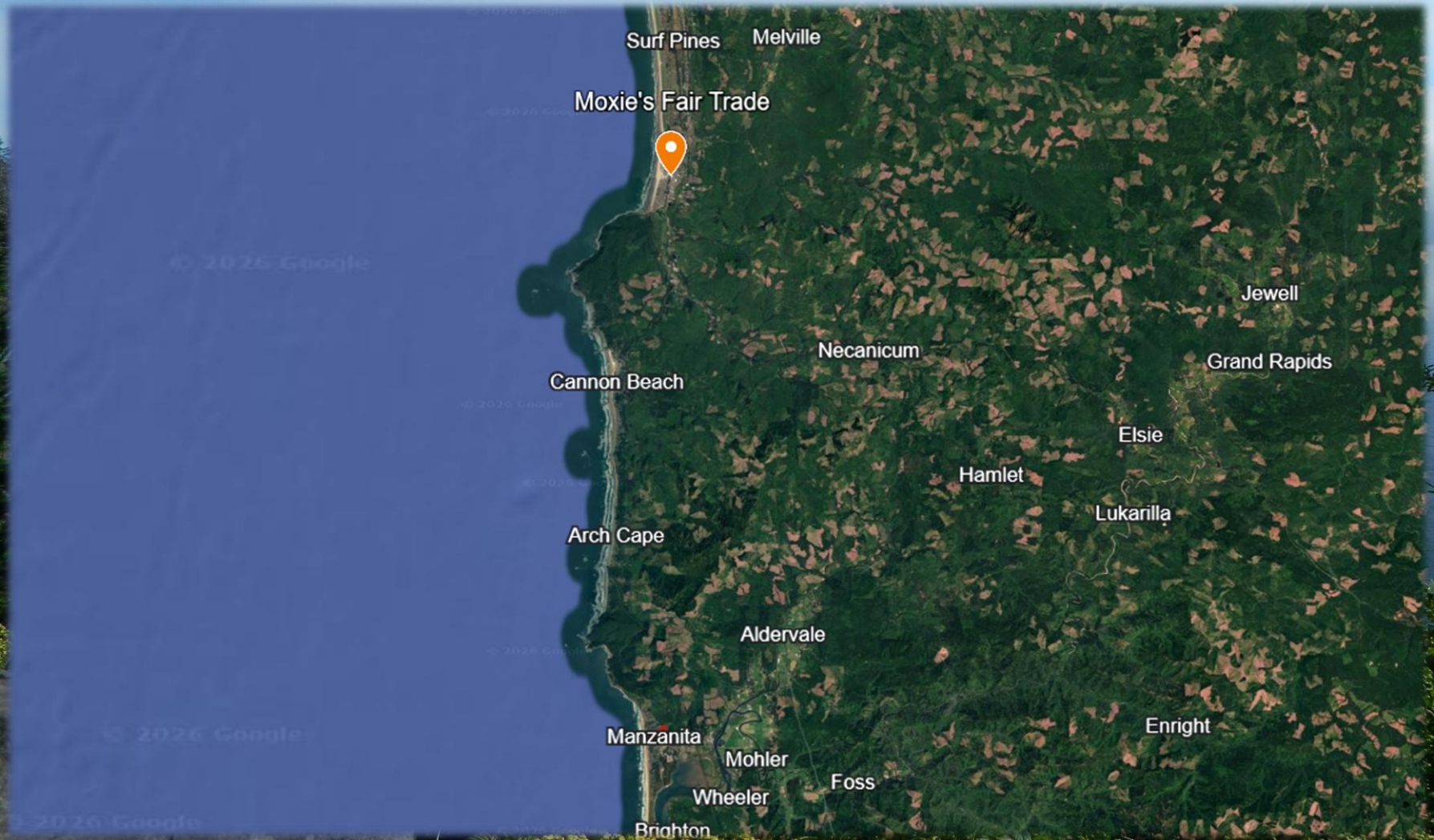
By End of Day 10/15/2016

- Power would be restored to the city, except for 44 buildings.
  - These 44 buildings would have damage to their power transmitters from the tornado.
- All roads cleared, and imminent tree hazards cut down.
  - Noncritical hazards took months to cut everything down.
- The town would be declared open for business again by the end of October 15th.
- The residents of the 4 uninhabitable homes found new temporary places to stay with community help.

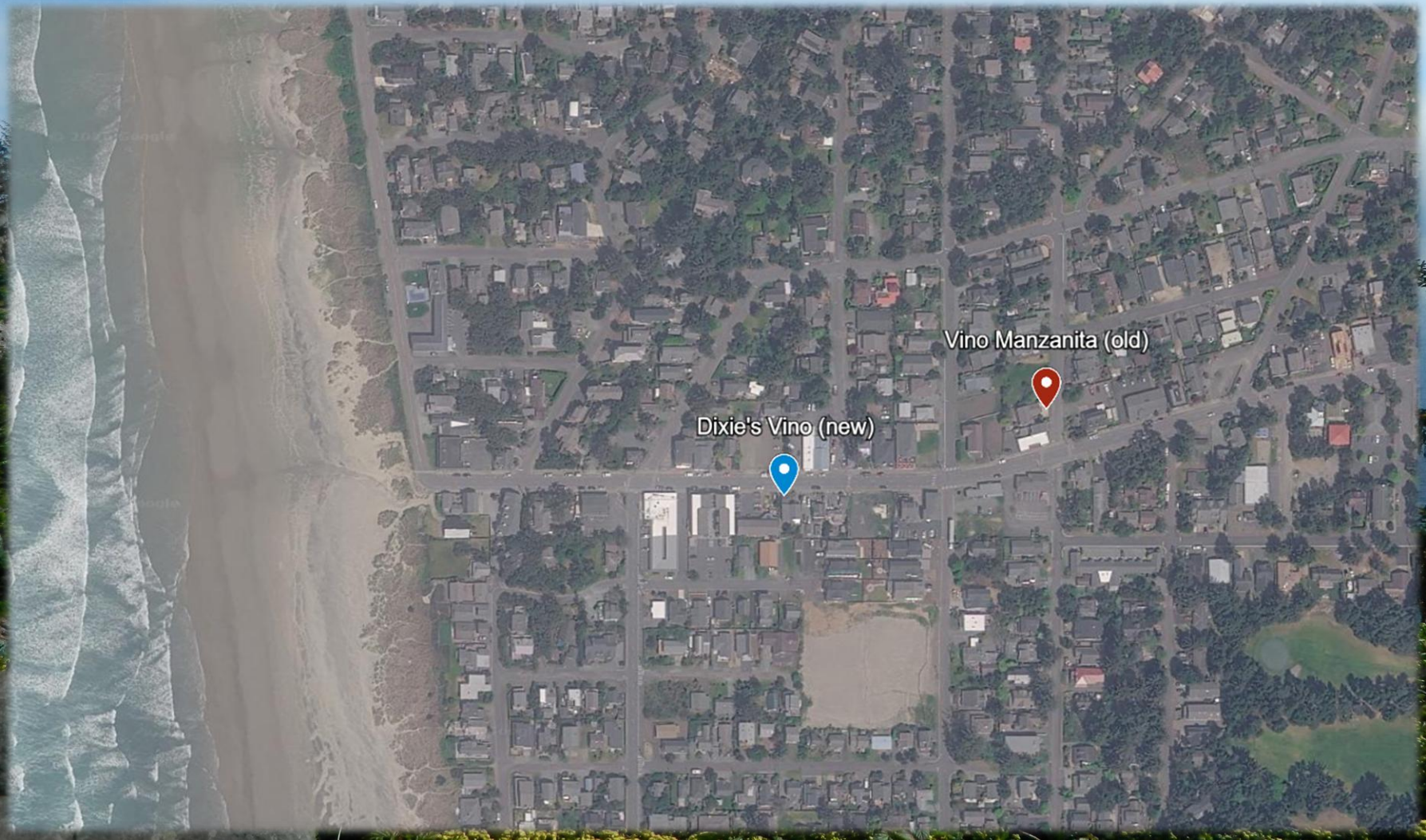
Business Movements

- Moxie's Fair Trade had a 2nd location in Seaside, OR at the time.
- Wisteria Chic moved into a building provided by Sunset Vacation Rentals on Laneda Ave (near 2nd St.)
- Longevity Massage moved into the Nehalem Beehive's 2nd floor.
  - 3 miles east
- Yoga Roots Studio held classes in the local Center for the Arts.
- Siren's salon would not return.
- Vino Manzanita would close for family care, reopening 2 years later as "Dixie's Vino."

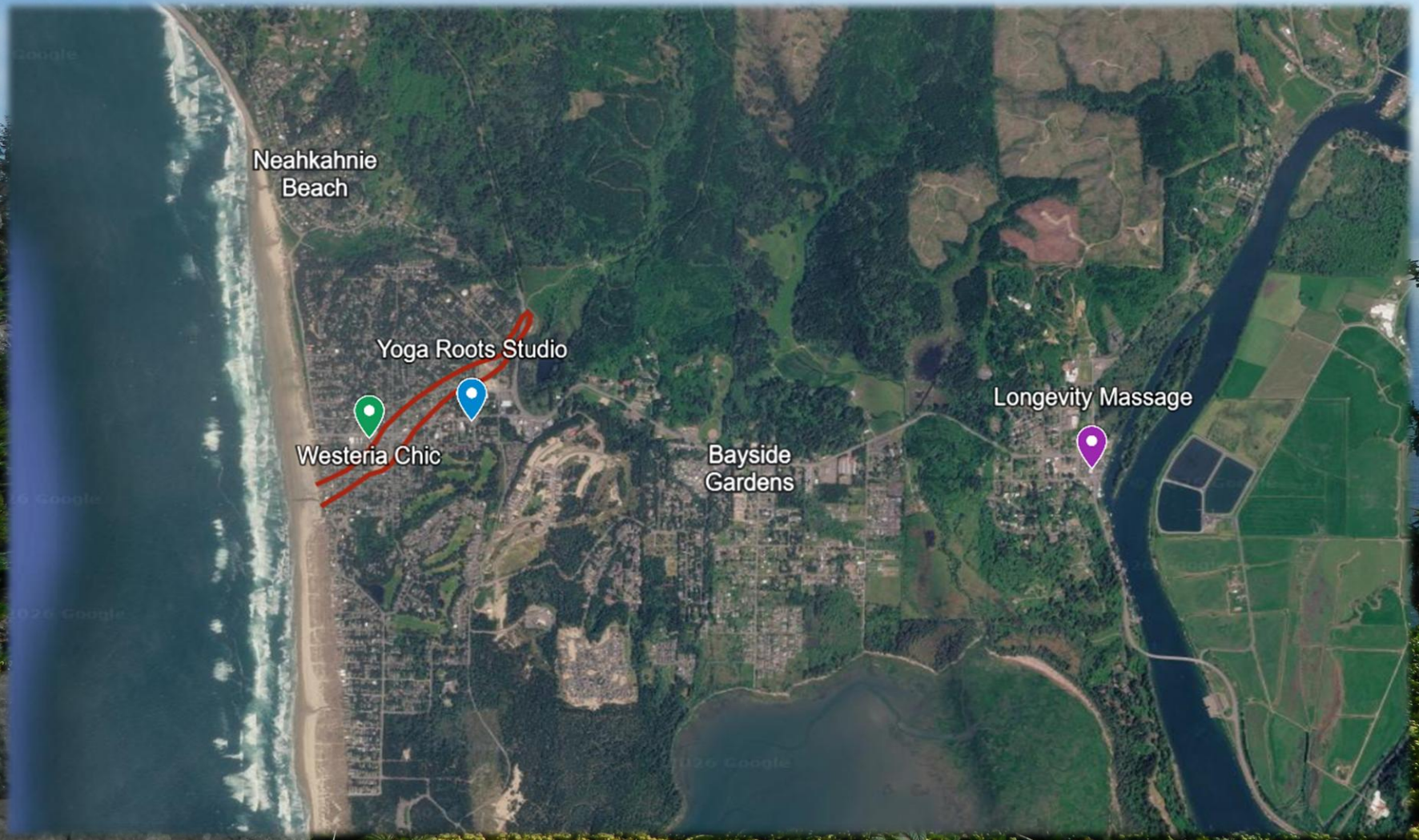
Moxie's 2nd Location



New Location and Name for Vino Manzanita



Other Business Relocations



Monetary Side: Fundraisers

- Local businesses and artists in Tillamook and Clatsop Counties would donate a part of sales to the tornado relief fund.
- Go Fund Me's were set up for 2 of the business (Siren's and Moxie's)
  - Go Fund Me the company would donate $1000.
- Main fundraiser through Manzanita Tornado Relief
- $72,000 raised through these fundraisers.

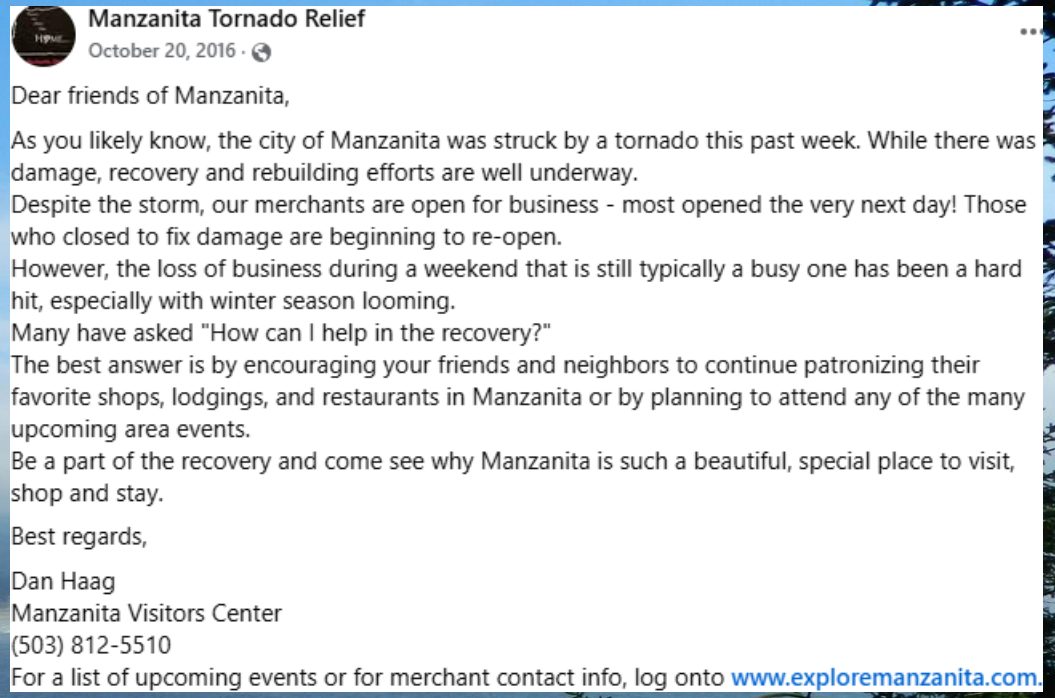
Red Slipper House Became a Symbol of Determination for Manzanita





The Cash Mob Details

- Intended to provide a morale boost and financial support to Manzanita businesses.
- Organized groups would go from business to business.
  - Businesses would have specials as an incentive
- Anyone spending $50 would be entered to win one of many prizes.
  - Paid by the chamber or donated from local shops.
- 2 occurred (one in November, one in February).



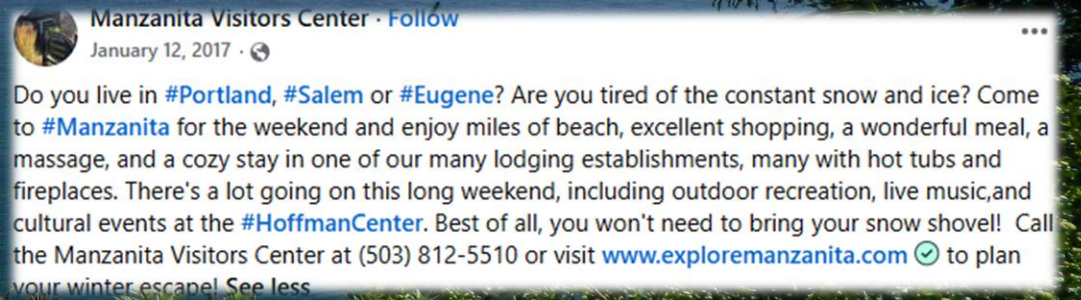
Manzanita Tornado Relief
October 20, 2016 ·

Dear friends of Manzanita,

As you likely know, the city of Manzanita was struck by a tornado this past week. While there was damage, recovery and rebuilding efforts are well underway.
Despite the storm, our merchants are open for business - most opened the very next day! Those who closed to fix damage are beginning to re-open.
However, the loss of business during a weekend that is still typically a busy one has been a hard hit, especially with winter season looming.
Many have asked "How can I help in the recovery?"
The best answer is by encouraging your friends and neighbors to continue patronizing their favorite shops, lodgings, and restaurants in Manzanita or by planning to attend any of the many upcoming area events.
Be a part of the recovery and come see why Manzanita is such a beautiful, special place to visit, shop and stay.

Best regards,

Dan Haag
Manzanita Visitors Center
(503) 812-5510
For a list of upcoming events or for merchant contact info, log onto www.exploremanzanita.com.



Manzanita Visitors Center · Follow
January 12, 2017 ·

Do you live in #Portland, #Salem or #Eugene? Are you tired of the constant snow and ice? Come to #Manzanita for the weekend and enjoy miles of beach, excellent shopping, a wonderful meal, a massage, and a cozy stay in one of our many lodging establishments, many with hot tubs and fireplaces. There's a lot going on this long weekend, including outdoor recreation, live music,and cultural events at the #HoffmanCenter. Best of all, you won't need to bring your snow shovel! Call the Manzanita Visitors Center at (503) 812-5510 or visit www.exploremanzanita.com to plan your winter escape! See less

The Return of Those Most Affected

- Manzanita Sweets: 6 weeks out
- Longevity/Yoga Roots: January 2017
- Westeria/Moxy's: May or June 2017 (depending on the source)
- By Summer 2017: All buildings except Sirens would be fixed or torn down.
  - Siren's Salon Damage is be visible on Street View if you go back to 2018

EVCNB Response/Reflection

- The EVCNB President was grateful for all who helped and that it wasn't worse.
- Ended up being a test run in case something work happened (like a Cascadia Subduction Zone).
  - Everything went off without a hitch.
- Thank you Event happened 3 weeks later.

Warnings

- Manzanita was the first case of a successful warning before the tornado touched down (or, in this case, made landfall) in PQR's history.
  - Some residents would not heed the warnings and left it to chance, citing "tornadoes don't happen here," or treating it like a standard high wind warning.
  - Other residents heeded the warnings and took cover.
  - One was reported to have not known about the warning but saw the tornado heading straight for them and barricaded the door.
- Some, mainly outsiders, claim there should've been tornado sirens sounding.
  - But there are no tornado sirens in the PNW, right?

Meet the Only "Tornado" Siren in the PNW

- Located in Gaston, OR.
  - Tests are 1st Saturday of the month at noon.
- Unlike Tornado Alley, it is manually operated.
- Relocated from Beaverton in 1991ish and had a full reconstruction in 2023.
- Started as a way to call the volunteer fire department in.



This would be the Only Direction They Would Have to a Fire, Plus the Switch



Meet the Only "Tornado" Siren in the PNW

- Tests started in response to 2025 Texas Floods.
- The main reason it's there is that if the Scoggins Valley Dam were to fail, Gaston would be 20 feet underwater.
  - It was confirmed to me that this would activate during a tornado warning.
- Most tornado sirens (including this one) started off as Cold War civil defense sirens.



Let's Hope They Never Hear This Outside of Test Time

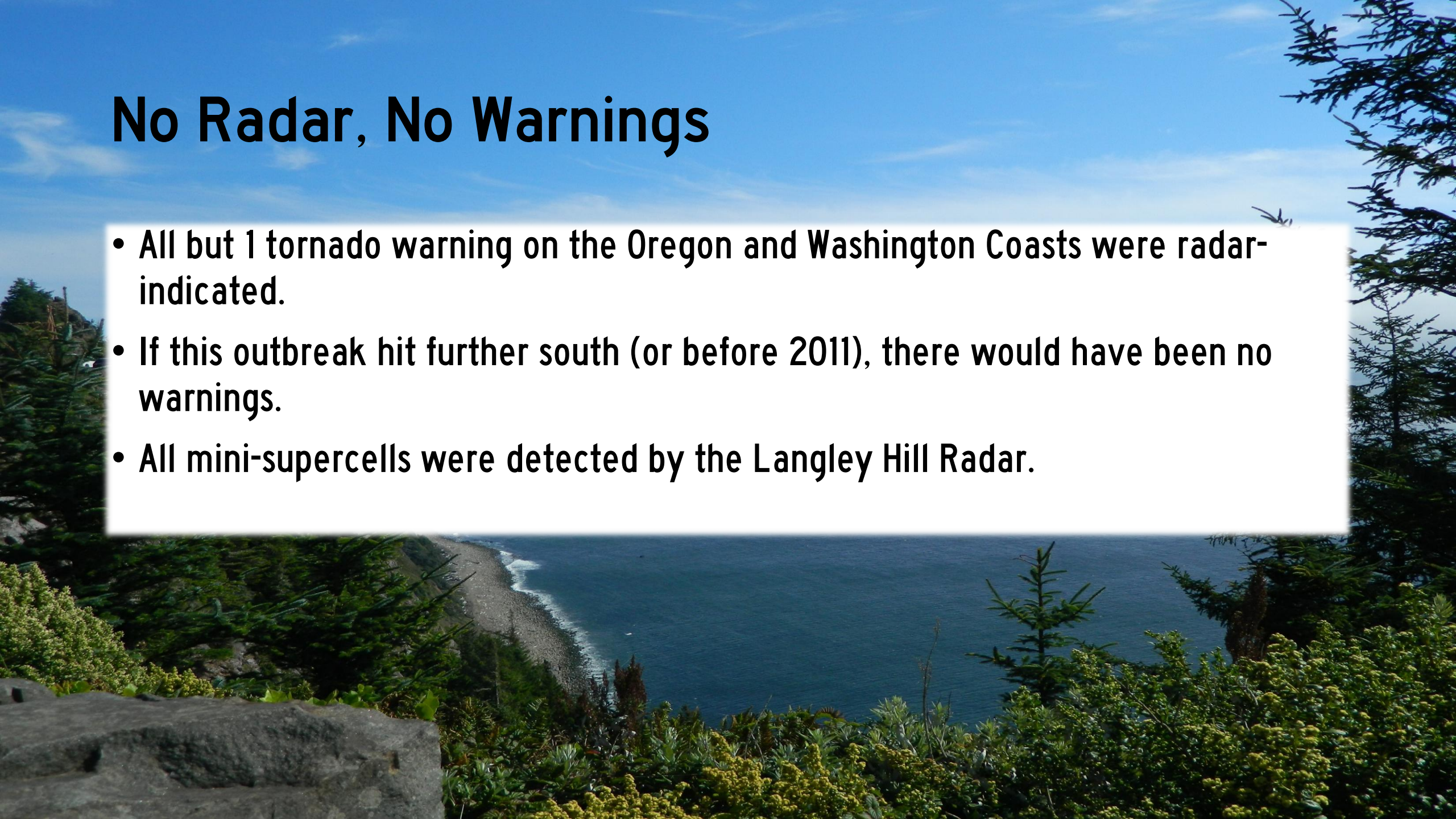


Tornado vs. Tsunami Sirens

- They're technically the same thing.
  - Both are former civil defense sirens with different purposes.
- Located primarily in Clatsop County and Northward.
- If these were activated during the tornado, most residents would assume there is a tsunami and take higher cover outside.
  - Some, like Cannon Beach, have a voice system that could reduce this risk.
- Or just turn on EAS alerts on your phone.

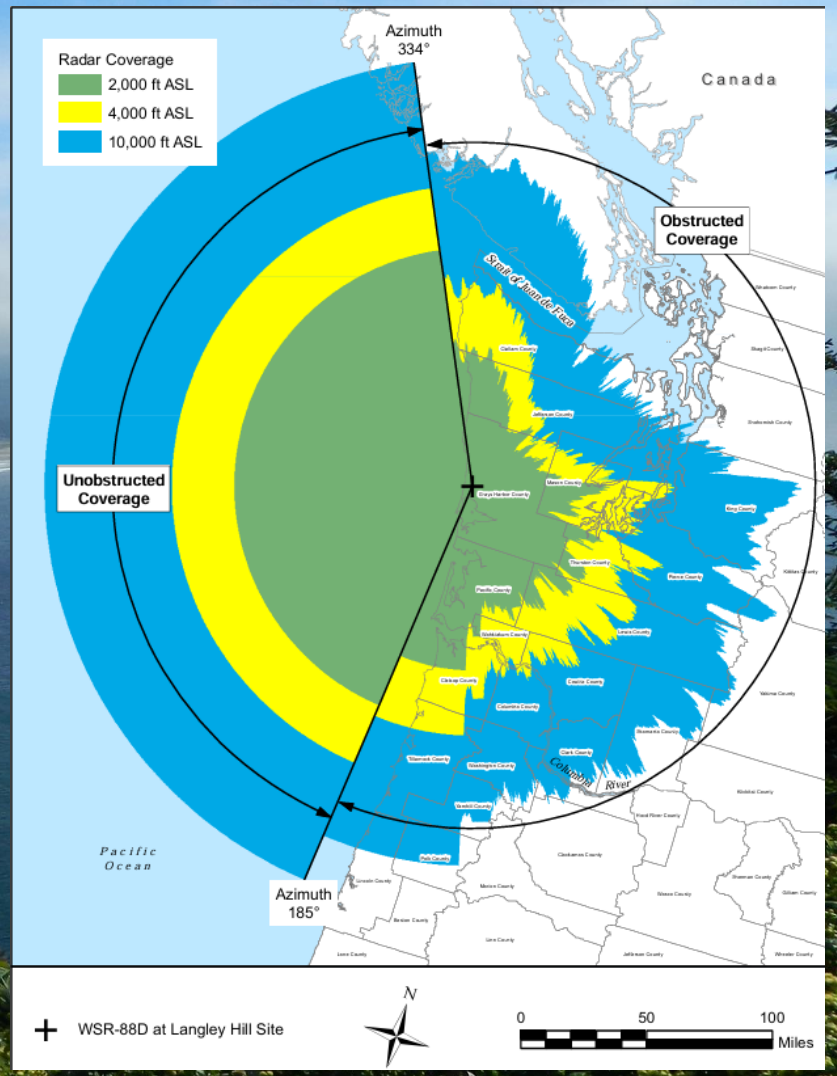
No Radar, No Warnings

- All but 1 tornado warning on the Oregon and Washington Coasts were radar-indicated.
- If this outbreak hit further south (or before 2011), there would have been no warnings.
- All mini-supercells were detected by the Langley Hill Radar.



The Unique thing about Langley Hill

- The first weather radar with the lowest beam below 0.5 degrees.
  - Was approved at 0.2 degrees.
  - Since then, some radars high up in Mountains (2000 feet or higher above the coverage area) have had this or lower angles.
- This increases the range of the radar by 30-50 miles.
- Con: it can pick up on ocean spray near the site.



Improving Predictability of Pacific Northwest Coastal Tornadoes

Evan Bentley
Meteorologist
National Weather Service, Portland, OR

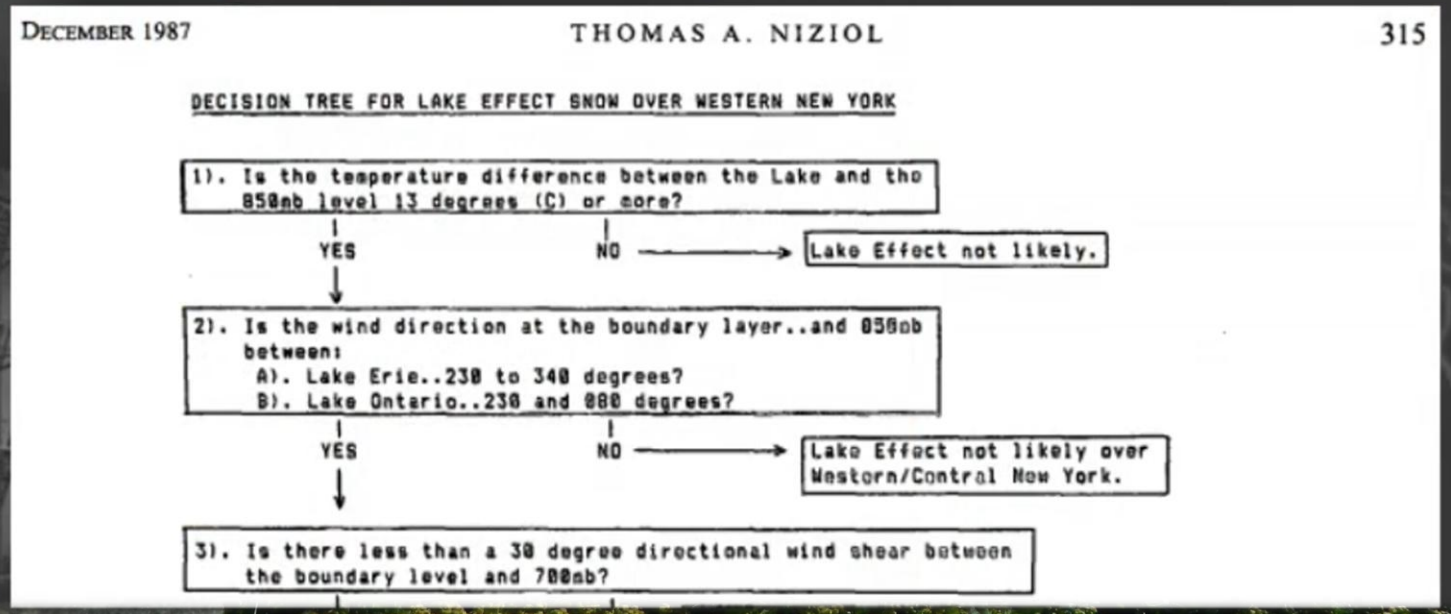


Screenshots from their presentation at the 2018 AMS Annual Meeting

98th AMS Annual Meeting
Austin, TX

Why Coastal Tornadoes may be Easier to Predict

- We get sufficient wind shear frequently
- Instability is the inhibiting factor
  - *Inland instability is difficult to predict due to dependence on cloud cover*
  - *Ocean based instability primarily fueled by ocean water temperatures*
    - These temperatures do not change much



DECEMBER 1987 THOMAS A. NIZIOL 315

DECISION TREE FOR LAKE EFFECT SNOW OVER WESTERN NEW YORK

1). Is the temperature difference between the Lake and the 850mb level 13 degrees (C) or more?

YES

NO → Lake Effect not likely.

2). Is the wind direction at the boundary layer..and 850mb between:
A). Lake Erie..230 to 340 degrees?
B). Lake Ontario..230 and 080 degrees?

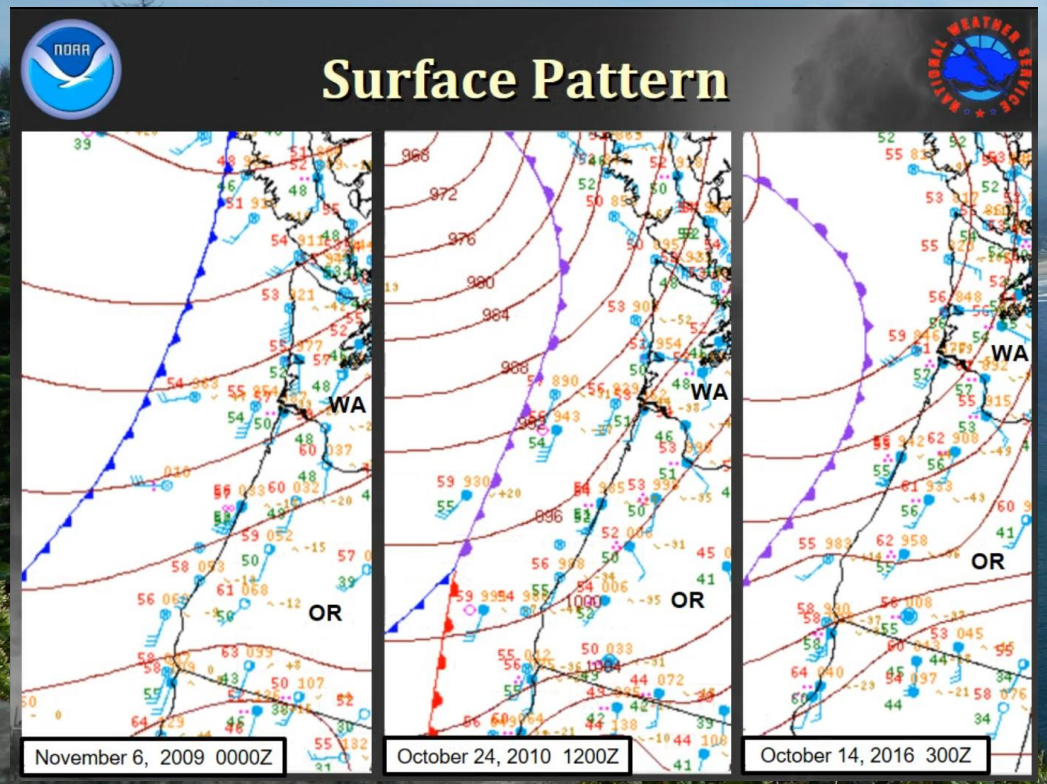
YES

NO → Lake Effect not likely over Western/Central New York.

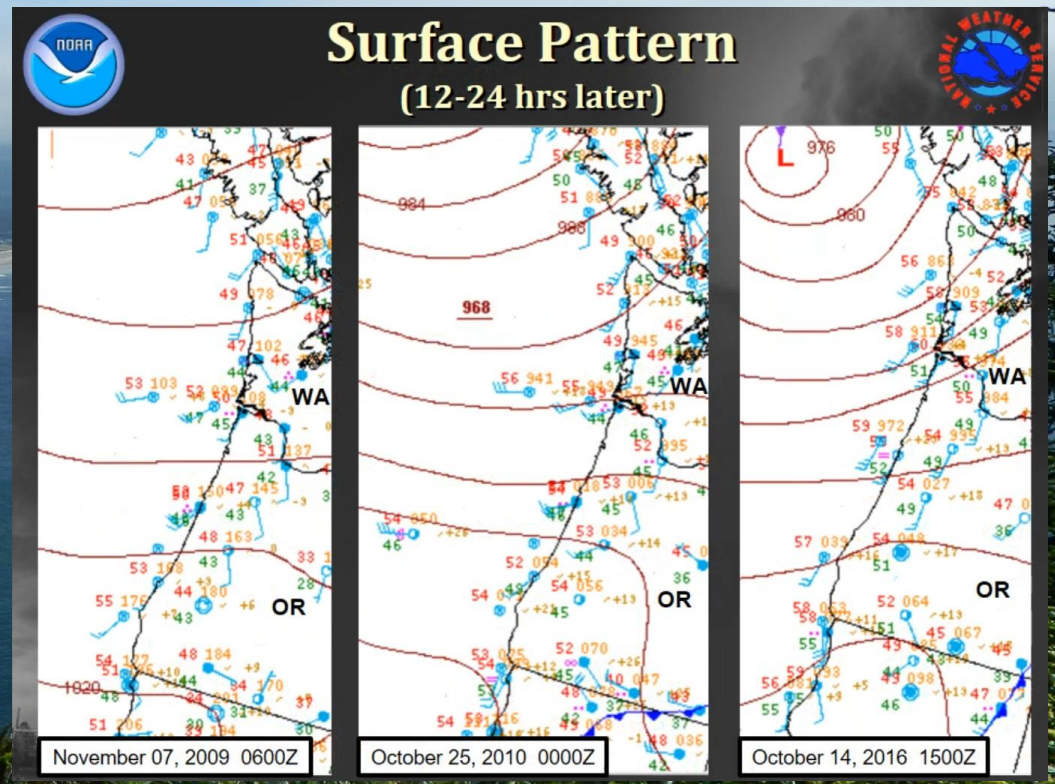
3). Is there less than a 30 degree directional wind shear between the boundary level and 700mb?

Most Tornadoes are Post-Frontal

Pre-Frontal



Post-Frontal

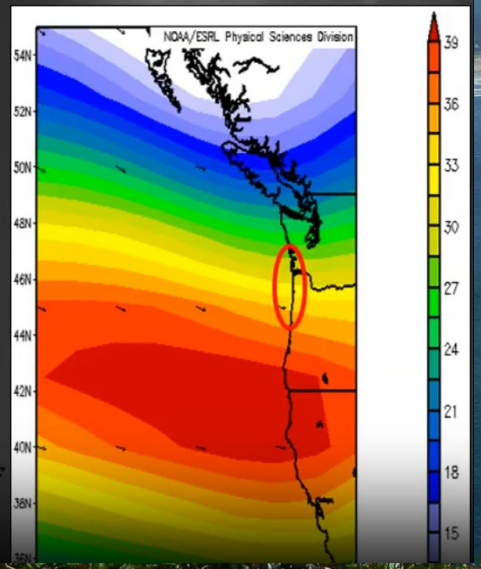


850 mb Look

850 mb jet streak

Synoptic Environment

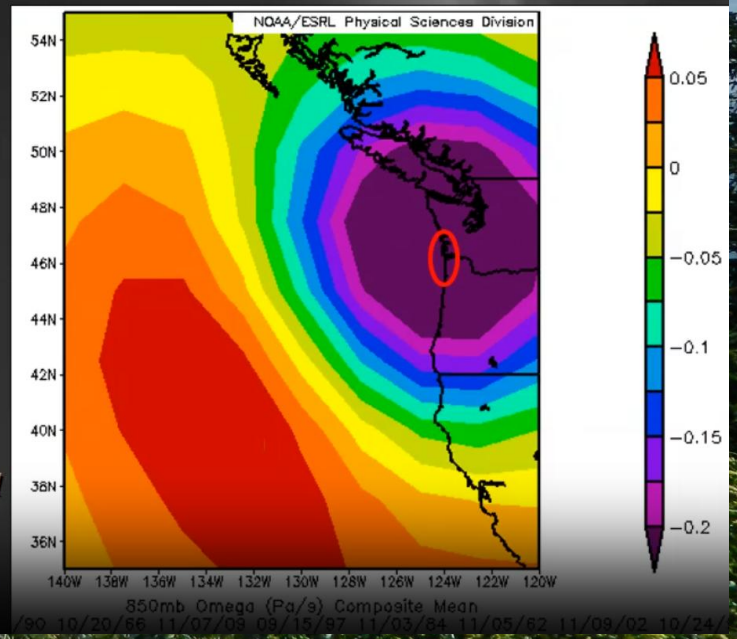
- NCEP/NCAR Composite Reanalysis of 19 tornado days
  - *Left-exit region of 300 mb jet streak (Uccellini & Johnson 1979)*
    - Average intensity ~80 kts
  - *Nose of 850 mb jet streak*
    - Average intensity ~25 kts
  - *Surface low pressure center NW of Vancouver Island*



850 mb Omega Levels

Synoptic Environment

- Composite analysis of 21 tornado days
  - *850 Omega*
    - Average below -0.2 Pa/s
      - *2.5x2.5 degree global grid*
    - Indicates synoptic scale lift



Criteria Found

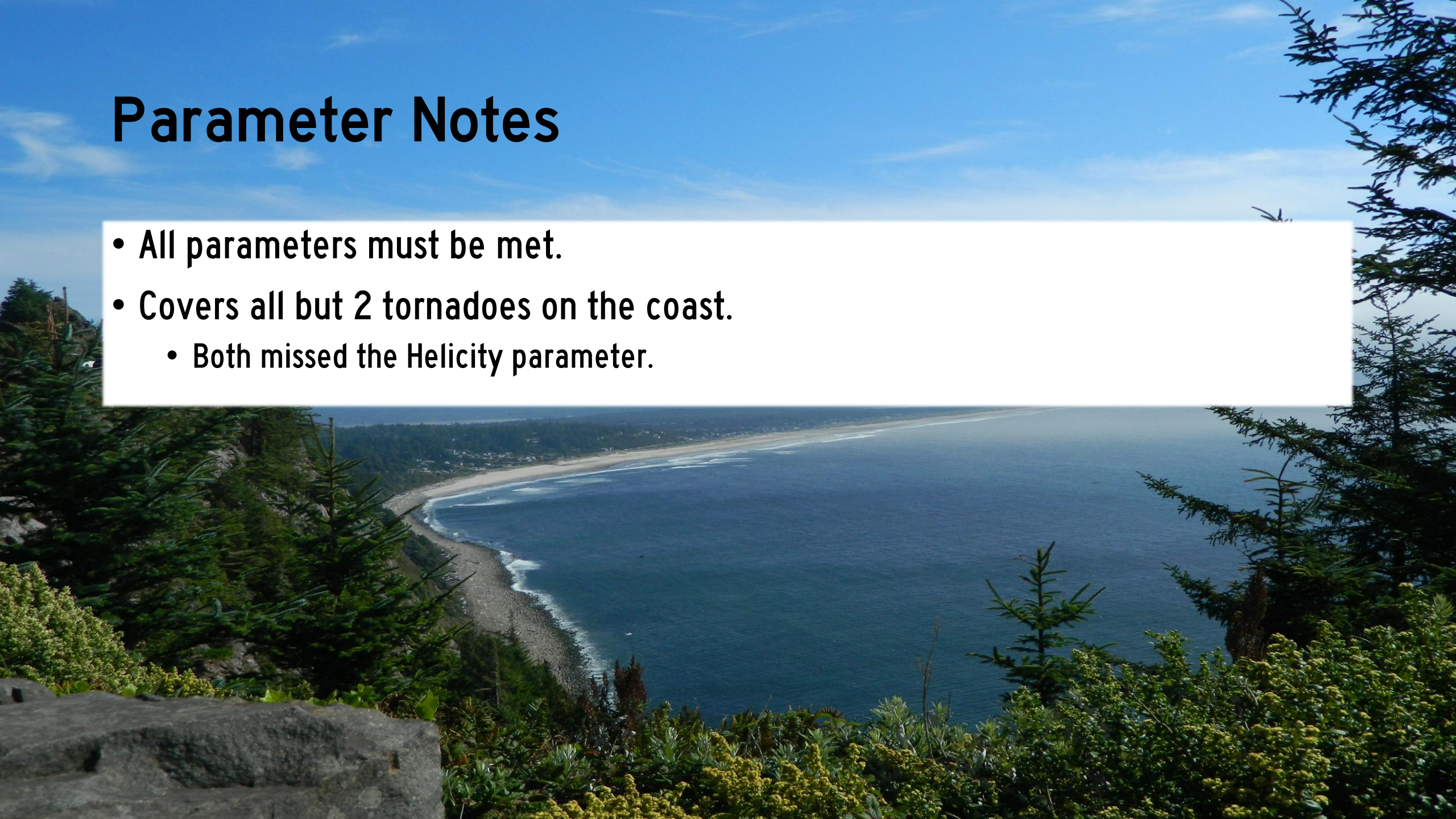
Criteria	Threshold	Manzanita 8:00 am Value
Sea Level to 850 mb (4000 ft.)	At least 8°C Cooler	
Sea Level to 700 mb (10000 ft.)	At least 18°C Cooler	
0-3 km Helicity (Rotation Parameter)	At least 150 m^2/s^2	
850 mb wind direction	At least 20 mph	
500 and 850 mb wind direction	Within 45° of 270° (from due west)	

Parameters compared to Manzanita

Criteria	Threshold	Manzanita 8:00 am Value
Sea Level to 850 mb (4000 ft.)	At least 8°C Cooler	9°C Cooler
Sea Level to 700 mb (10000 ft.)	At least 18°C Cooler	19°C Cooler
0-3 km Helicity (Rotation Parameter)	At least 150 m^2/s^2	469 m^2/s^2
850 mb wind speed	At least 20 mph	65 mph
500 and 850 mb wind direction	Within 45° of 270° (from due west)	~295° (From SW)

Parameter Notes

- All parameters must be met.
- Covers all but 2 tornadoes on the coast.
  - Both missed the Helicity parameter.



How Accurate are the Parameters

- If active, a mini-supercell is detected 80% of the time.
- Of the 20% False alarms, 89% were in November or December.
- Extended setup warning time from 2 hours to 1-2 days since 2017.

New Residential Development

- The lot of Trees in SW Manzanita would be rezoned for residential.
- Homes are starting to go up as of September.

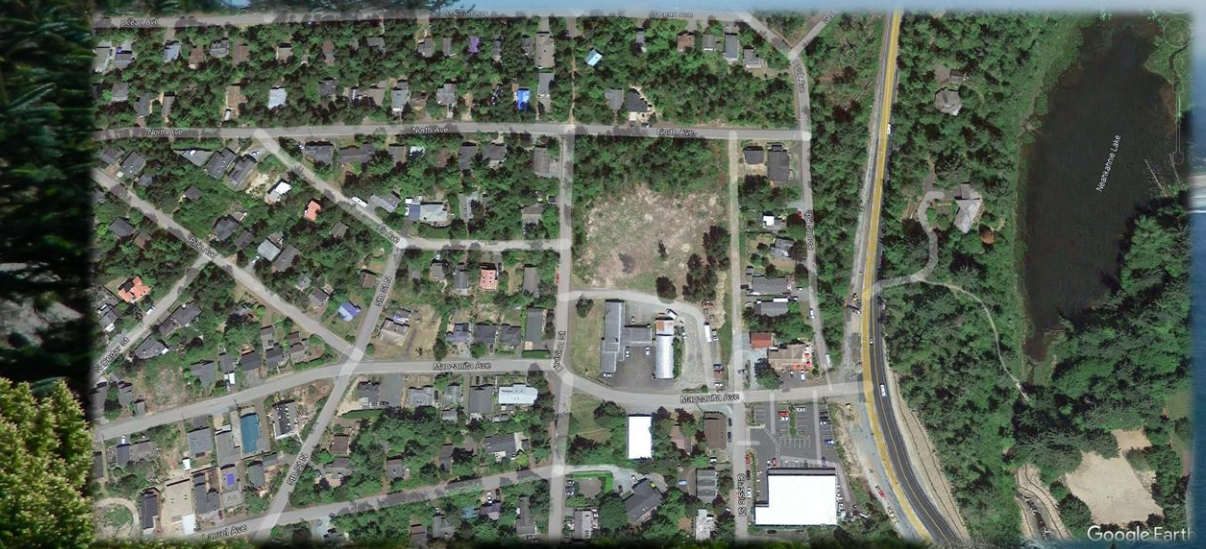


New City Hall

- There was a need to get out of the tsunami inundation zone and to establish a more centralized emergency response location.
- Underhill Plaza's newly killed trees left an open field for events or the farmers' market.
- Opened in 2025.
- Talks to use the wood or ties of the Legett in the new space. Unsure if this happened.



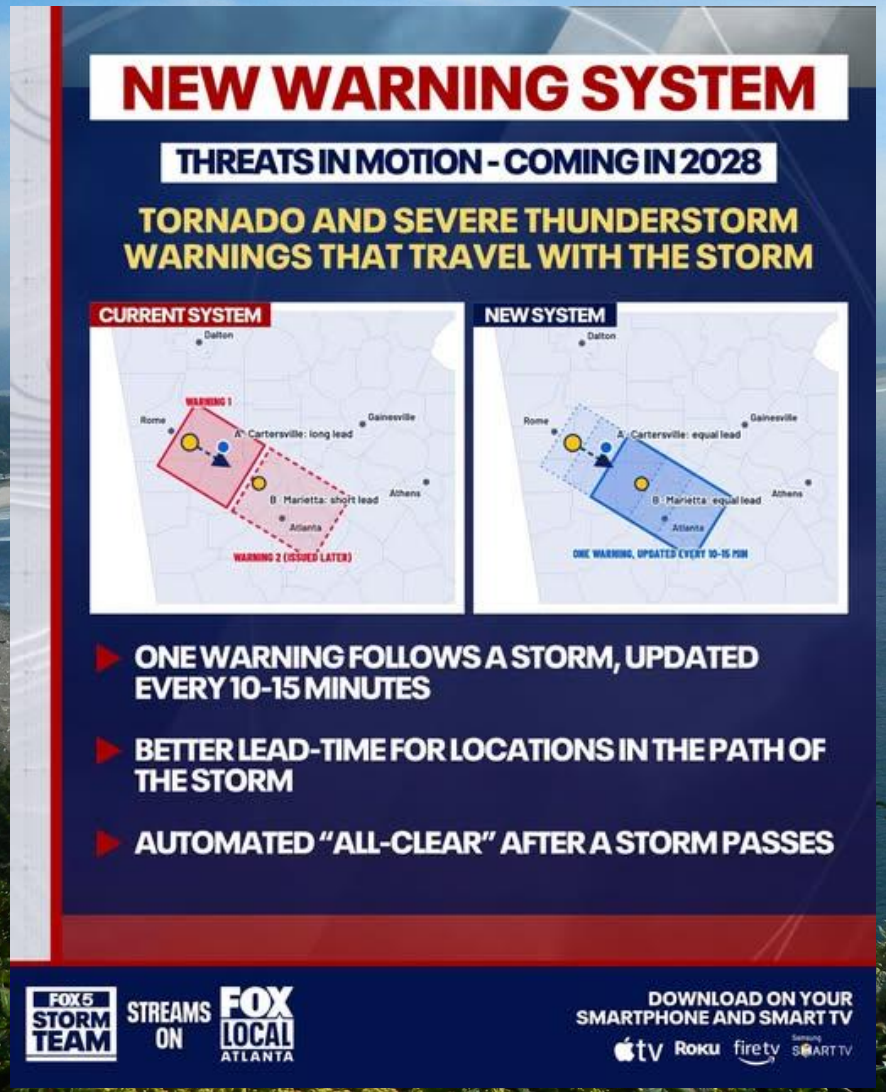
The Site of the City Hall





Looking behind City Hall into the field.

Coming in 2028: Warnings are Changing: Threats in Motion (Fox Atlanta Graphic)



The Drought

- PQR's AOR has gone 9 years and 2 months since the last EF1+ tornado (9/18/2017, Lacomb, OR)
  - Old record 7 years 7 months (3/8/1960 to 10/3/1967)
- West of the Cascades (OR/WA) current streak is 6 years 1 month since the last EF1+ (10/6/2020, rural Grays Harbor County, WA), also a record.
  - Old record 5 years 4 months. (12/6/1951 to 4/12/1957)

A Quote to Summarize it from Dixie Lee: Owner of Dixie's Vino

- The tornado was a traumatic experience, for sure, but do realize that transition and change is part of life."



Special Thanks

- Linda Kozlowski EVCNB
  - Double special thanks for the 1-hour interview.
- Evan Bentley, SPC
- Sarah Simmons, Moxie's Fair Trade
- Christina, Longevity Massage
- "Deb," Westeria Chic
- Dixie Lee, Dixie's Vino
- The staff at Manzanita Sweets



Owners of Moxie's (Sarah Simmons) and Wisteria Chic (Deb) taken on September 2026.

Thank You



