Forest structure and succession in stands initiated after the wind storm of January 29th, 1921

Establishment Report Robert Van Pelt and Jerry Franklin

INTRODUCTION

Forest structure and stand development in coastal Pacific Northwest forests has received considerable attention in recent decades (Oliver and Larson 1990, Carey and Curtis 1996, Spies and Franklin 1996). More recently, a process-based conceptual model of forest development following disturbance has been proposed and is now widely used (Franklin et al. 2002). While the prime example presented is a Douglas fir/western hemlock (*Pseudotsuga menziesii/Tsuga heterophylla*) forest following wildfire, many of the processes and successional trajectories are common to many other Pacific Northwest forest types.

Along the coastal reaches of the Olympic Peninsula in Northwest Washington, both fire and Douglas fir have been historically uncommon (Van Pelt 2007). In these forests, wind is the primary large-scale disturbance agent, where a dozen hurricane-force wind storms have been recorded since 1788 (Henderson et al. 1989). Among these, the largest occurred on January 29th 1921 (the **'21 Blow**), where winds estimated at in excess of 240 kph were recorded (Campbell 1979).

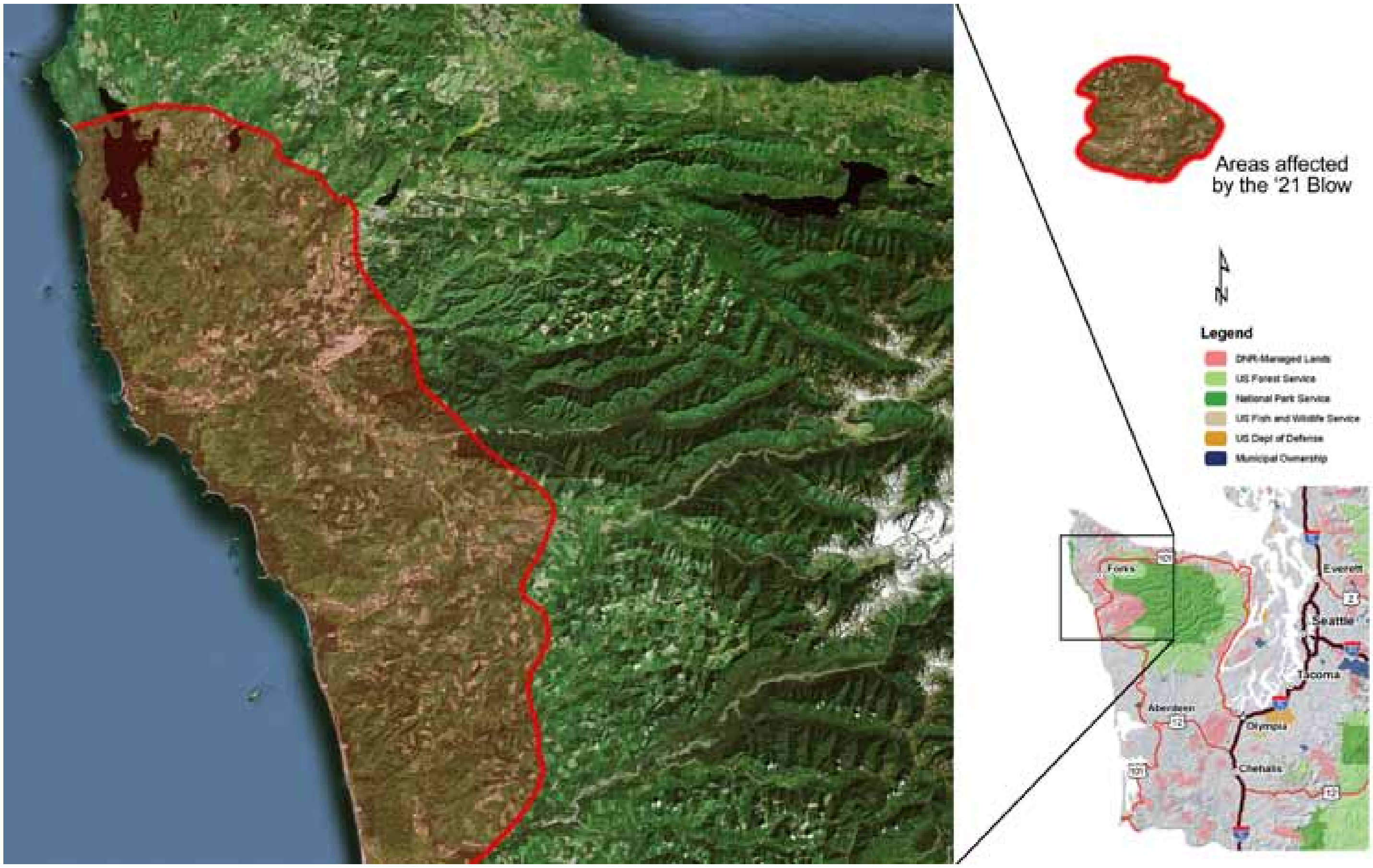
From a forest successional standpoint, there are some major differences in stand development between catastrophic fire and a major windstorm. After a major fire, survivors are likely to be the largest trees with the thickest bark. In contrast, survivors after a major wind event will tend to be among the smallest trees in the stand (Van Pelt 2007). Small, understory trees are more likely to be crushed by falling trees than blown over. Due to this difference, the species composition after a major wind event will include more of the shade-tolerant component of tree species than after fire. Repeat disturbances will shift the entire pool of available seed towards species with high shade tolerance. Indeed, nearly 90 years after this storm most of these mature stands are dominated by western hemlock. Pacific silver fir (*Abies amabilis*), western redcedar (*Thuja plicata*), and Sitka spruce (*Picea sitchensis*) are often minor components in these stands. Douglas fir regeneration is rare.

As with many disturbance types, there is a wide variety of disturbance intensities associated with this storm, from complete blowdown to unaffected stands. Many stands have living biological legacies (live trees that survived the event) mixed in with the now mature regenerated forest. Legacy trees are represented by several species, but many are redcedars, as these are often large trees with very wide bases and relatively small crowns. The highest concentration of near stand-replacing windthrow occurred across a 1300 km^2 area centered between the Quillayute/Bogachiel and Hoh Rivers on the Olympic Peninsula (Figure 1, Scott Horton pers. comm.). Within this broad area, the extent of stand-replacing windthrow diminishes to the north and south of those river corridors. The storm track was SW to NE with a powerful cyclonic component that caused the winds to be from the SW to SE depending on location relative to the passage of the storm center. The bulk of the stand-replacing windthrow was restricted to low-lying areas or windward slopes on ridges, as steep topography took the force out of the wind.

There is very little '21 Blow in the Queets drainage, due in part to the '1890 Blow' which has been described as consisting of several events centered around 1890. These stands are roughly 30 years older and thus are taller than '21 Blow stands, with a well developed sapling understory. Many of these stands appear to be 'falling apart', since many of the blow-origin trees are overly tall for their diameter (Scott Horton pers. comm.).

Much of the forests which developed following the '21 Blow have been logged, and the Washington State Department of Natural Resources (DNR) manages the majority of those remaining (4–7,000 hectares depending on how it is defined, Scott Horton pers. comm.). Most of the remainder is found in either Olympic National Park (coastal strip and Bogachiel Valley) or Olympic National Forest (Figure 1).

Figure 1. The approximate extent of the ‘21 Blow on the western Olympic Peninsula. The shaded area delimits the region in which the greatest impacts occurred. The smaller map depicts most of western Washington and the public land ownerships.



Many of these stands have become of interest to the scientific community as of late, as many stands are extremely dense with little understory regeneration (Franklin and Van Pelt pers. obs.). Throughout much of western Washington’s naturally regenerated mature forests of similar age, there is abundant tree regeneration in the understories. Many of the nearly pure hemlock stands that developed following the ‘21 Blow, however, have such dense hemlock main canopies that understories, even after 90 years, still primarily consist of bryophytes and little else (Figure 2). So, there is a natural curiosity as to the future fate of these stands. Will these stands quickly develop understories once the main canopy begins to thin, or will there be a lag? In addition, many of these dense, nearly pure hemlock stands are packed with tall, similarly-sized trees with high, small crowns. Once gaps begin to form through competition-based mortality, further wind damage, or decay – will the increased exposure cause a catastrophic falling apart, leaving these stands with very sparse main canopies for an extended period.

Permanent plots have a proven record at being able to accurately track a population of individuals through time (Franklin and DeBell 1988, Acker et al. 1998, Van Mantgem and Stephenson 2007). This proposal is intended to begin a series of permanent plots in mature, nearly pure, ‘21 Blow stands and to monitor morality and growth over these next, perhaps dramatic, decades.

METHODS

Forest disturbances associated with high wind events are extremely variable, from completely blown over forests at one end, to stands with relatively minor effects at the other. The living biological legacies (surviving trees) dramatically affect how forest succession proceeds, and after nearly 90 years stands with a high legacy component resemble old-growth forests in many aspects. Since the succession of the 1921 cohort is the primary objective in this study, stands were chosen that had a minimal legacy component.

Figure 2. Interior view of one of the DNR-owned sections of stands affected by the '21 Blow. Note the even size and density of the mature trees and a sparse understory.

The three major public land owners on the western Olympic Peninsula each have land associated with the '21 Blow, and the natural variability within the geography of the '21 Blow gives each ownership different forested conditions within the affected area. To maintain this natural variability within the proposed study, and to involve all three land management agencies in the project, one stand was chosen in each of the three ownerships (Figure 3).

Given the size of these mature stands, the natural variability therein (canopy height, tree spatial patterns, and canopy texture), and the need to track gap formation and expansion into the future, each of the three sites had two plots installed, each 150 x 30 m. This size is sufficient to adequately capture the current stand structure and associated stand variability (Van Pelt and Nadkarni 2004), and wide enough to track and follow spatially aggregated mortality (Van Pelt and Franklin 2000). The three stands initially chosen, each of which are large enough to easily accommodate the proposed plots, are shown in Figures 4–6.

Within each of the three selected stands, stand boundaries were delineated in a GIS by creating polygons limited to areas of the '21 Blow with a minimal legacy component (red areas in Figures 4–6). Using these polygons, each of the two plots were placed using random starting points and random azimuths. If more than 10 percent of the plot then fell outside of the polygon, it was rejected. The first two plots whose boundaries fit these conditions were chosen. Final plot locations are summarized in Table 1.

Figure 3. Above. A satellite view of the northwestern portion of the Olympic Peninsula, showing the three stand locations.

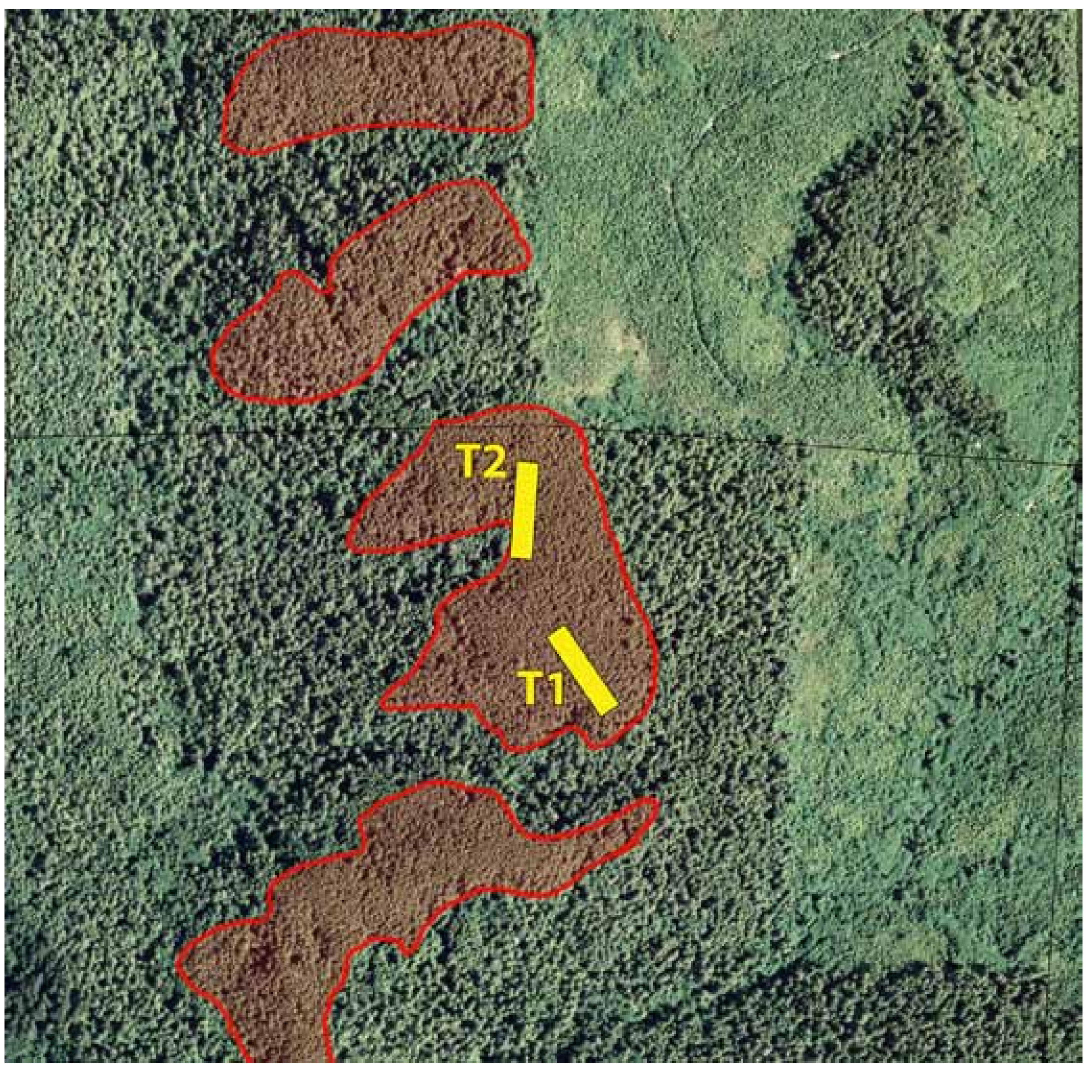


Figure 4. Right. Johnson Creek Ridge in Olympic National Park. Areas shaded red are nearly pure '21Blow stands with low levels of legacy trees. The two plots installed in 2008 are shown - Plot T2 has two *Picea* and one *Tsuga* legacies from the pre-1921 stand.

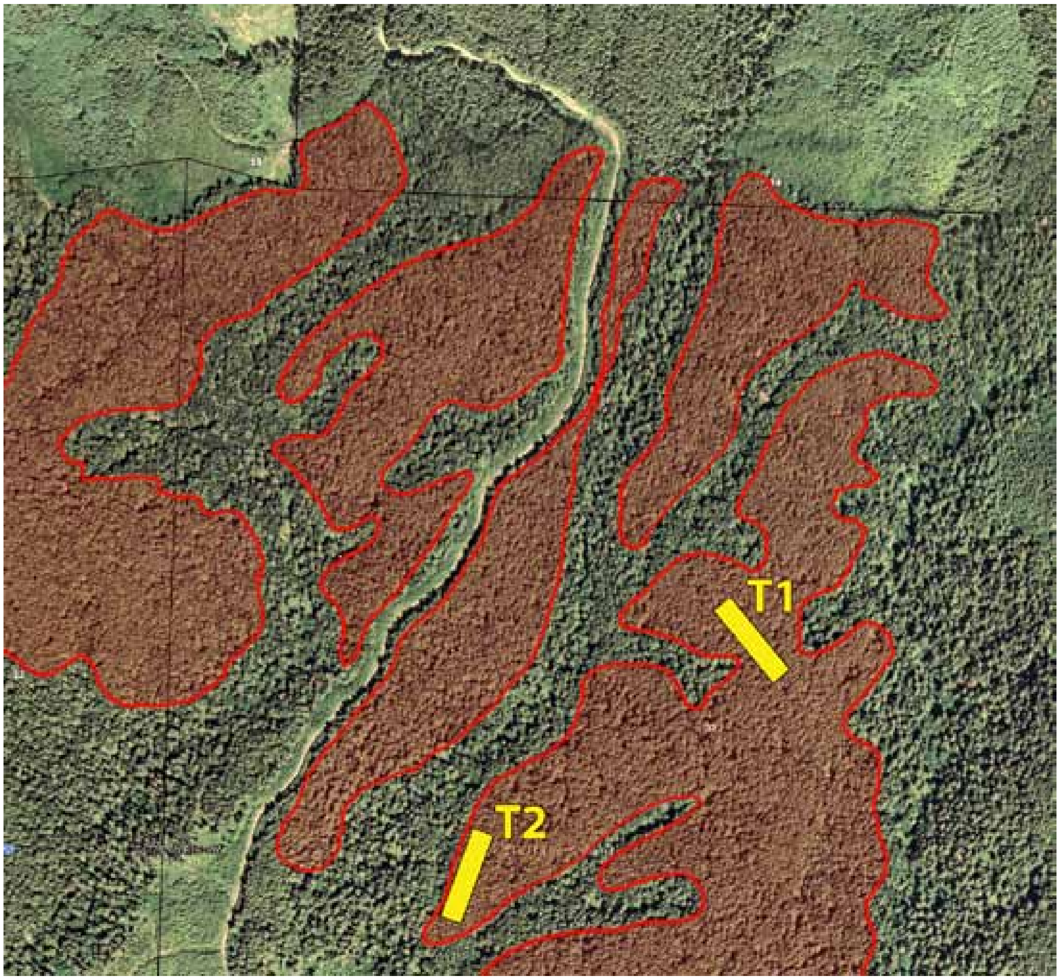


Figure 5. Coon Creek Ridge on State of Washington land. This is perhaps the largest and most intact forested area affected by the ’21 Blow, and the chosen patch has been removed from the timber base.

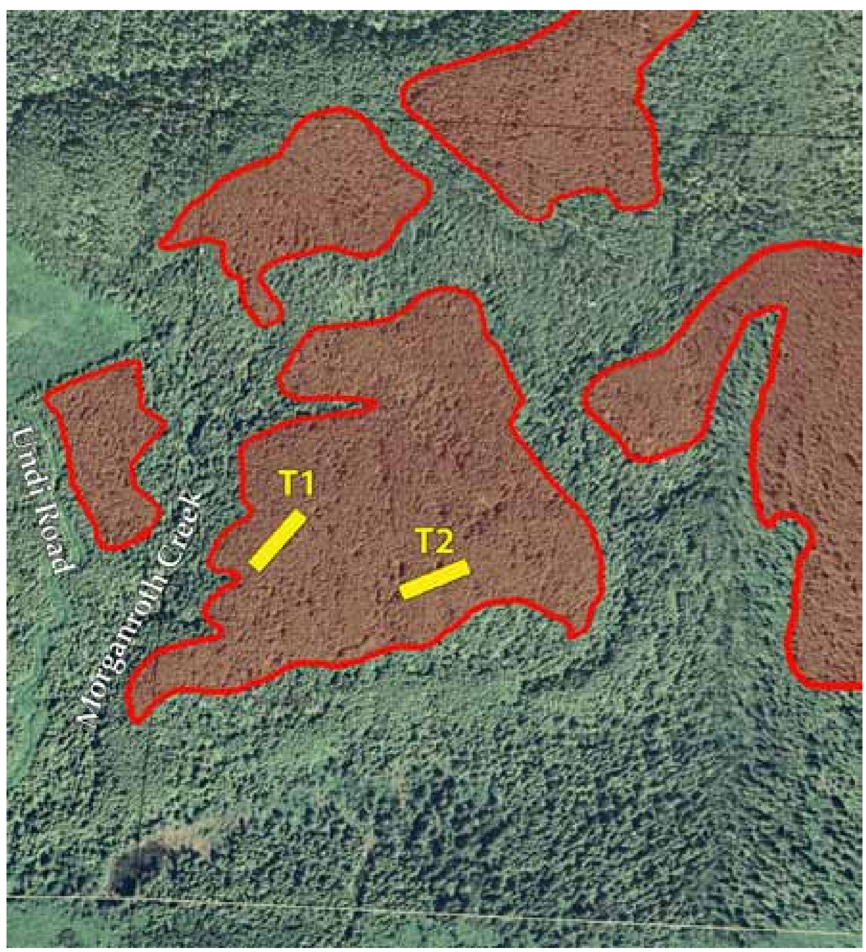


Figure 6. Morganroth Knoll on Olympic National Forest land. The two plot locations are in a large ’21 Blow patch above stream drainages with variable amounts of legacy.

Table 1.

Plot Locations

			Decimal degrees		UTM	
			Latitude	Longitude	Northing	Easting
Olympic National Park						
	Transect 1	End1	47.9543	124.6437	377279	5312526
		End2	47.9531	124.6426	377360	5312394
	Transect 2	End1	47.9512	124.642	377398	5312176
		End2	47.9516	124.644	377256	5312229
Olympic National Forest						
	Transect 1	End1	47.8878	124.266	405356	5304606
		End2	47.8891	124.2655	405402	5304754
	Transect 2	End1	47.8868	124.2618	405668	5304495
		End2	47.8878	124.2603	405788	5304594
Washington State DNR						
	Transect 1	End1	47.9223	124.3499	399156	5308543
		End2	47.9213	124.3514	399039	5308434
	Transect 2	End1	47.9193	124.3434	399633	5308208
		End2	47.9182	124.342	399735	5308084

Field Procedures

Phase I sampling

Trees – Plots were located in the field during the spring of 2009 using the GPS coordinates determined by the computer randomization process. Plots were installed as transects, using procedures already previously described (Van Pelt et al. 2004). Trees taller than breast height (1.37 m above average ground level) were mapped and measured throughout the entire plot. Tapes were stretched down the center of the long axis of the plot and a tree's location (dead or alive – including stumps) was recorded as the distance along the tape (X value), a perpendicular distance away from the tape (Y value – measured using a compass and laser rangefinder [Impulse 200LR – Laser Technologies Inc.]), and whether it was located to the right or left of the tape (+/– Y value). Y values > 15 m put the tree out of the plot and were not measured. Each tree was marked with small, numbered tags at 1.37 m for future relocation and measurement. During this initial mapping process, each tree was measured for species, dbh (diameter at breast height – 1.37 m above average ground level), and live or dead. In certain cases (wounds, burls, roots) the diameter was measured at a different height – in which case the tag is put at the new height and this is recorded in the notes.

Shrubs and small trees – Trees < 1.37 m tall yet ≥ 50 cm in height and all other woody vegetation ≥ 50 cm in height was sub-sampled in a plot 150 x 3 m centered on the main transect, which is 10% of the entire plot. Species, basal diameter, height, and crown spread was collected for each tree, and all but crown spread was record for shrubs.

Herbaceous vegetation and seedlings – Understory vegetation was sampled every 4m using 1 m diameter circular plots down the entire length of each transect, which yields 38 plots. Understory vegetation included all herbaceous vegetation, as well all small trees and woody vegetation not yet previously measured (plants < 50 cm tall). Herbaceous vegetation was identified to species and recorded as percent cover – all woody plants were tallied by species. Coarse woody debris (all pieces ≥ 50 cm diameter at the tape) was sampled using the line intercept method (Harmon and Sexton 1996, Van Pelt et al. 2004).

Phase II sampling

Data from Phase I sampling was entered and stem maps and field sheets were prepared. During the second visit, the stem maps will be checked for errors in tree location, species, live/dead status, or tag number as each tree is revisited for further information on tree structure (Figure 7). Each tree was measured for total height, crown height, and the 4 cardinal crown radii. Departures from normalcy (conks, sparse crowns, oozing wounds, excessive lean, broken tops, visible rot, etc.) were noted. Stumps, snags, and broken trees had their top diameter estimated to the nearest 5 cm. Tree with dead tops had both the total tree height and height to topmost leaf recorded. Relocating each tree using the stem map for these supplemental data has proven an excellent method to error-check the stem map (Van Pelt et al. 2004).

In each stand (not necessarily restricted to the plots), a subset of trees from the 1921 cohort were chosen for stem volume measurements. The random sample will include the full range of tree sizes and species present. A survey laser and reticle-scope (Macroscope 25 – RF Inter-Science Co.) was used to measure trunk diameters at approximately 3–6 m along the entire stem. These data were used to develop regression equations to predict trunk volume from height and DBH.

Monitoring and future measurements

A mortality check occurred during the spring of 2010, where each tagged tree was revisited to check its live/dead status. If dead, the primary (and secondary – if present) mortality agents were recorded. If recently damaged, or anomalous conditions not previously recorded are present – these will be recorded. Any trees that were now ≥ 5 cm dbh but were untagged were tagged, and all needed structural information was collected. These new trees were mapped by locating them relative to nearby trees. Ideally annual visits to record mortality and ingrowth will continue. Annual checks allow for a much stronger linking of mortality to known events then occasional checks (Van Mantgem et al. 2009). At 4–7 year intervals (staggered among all plots as time and funding permits), all tagged trees will be remeasured for dbh during the mortality check to document growth.

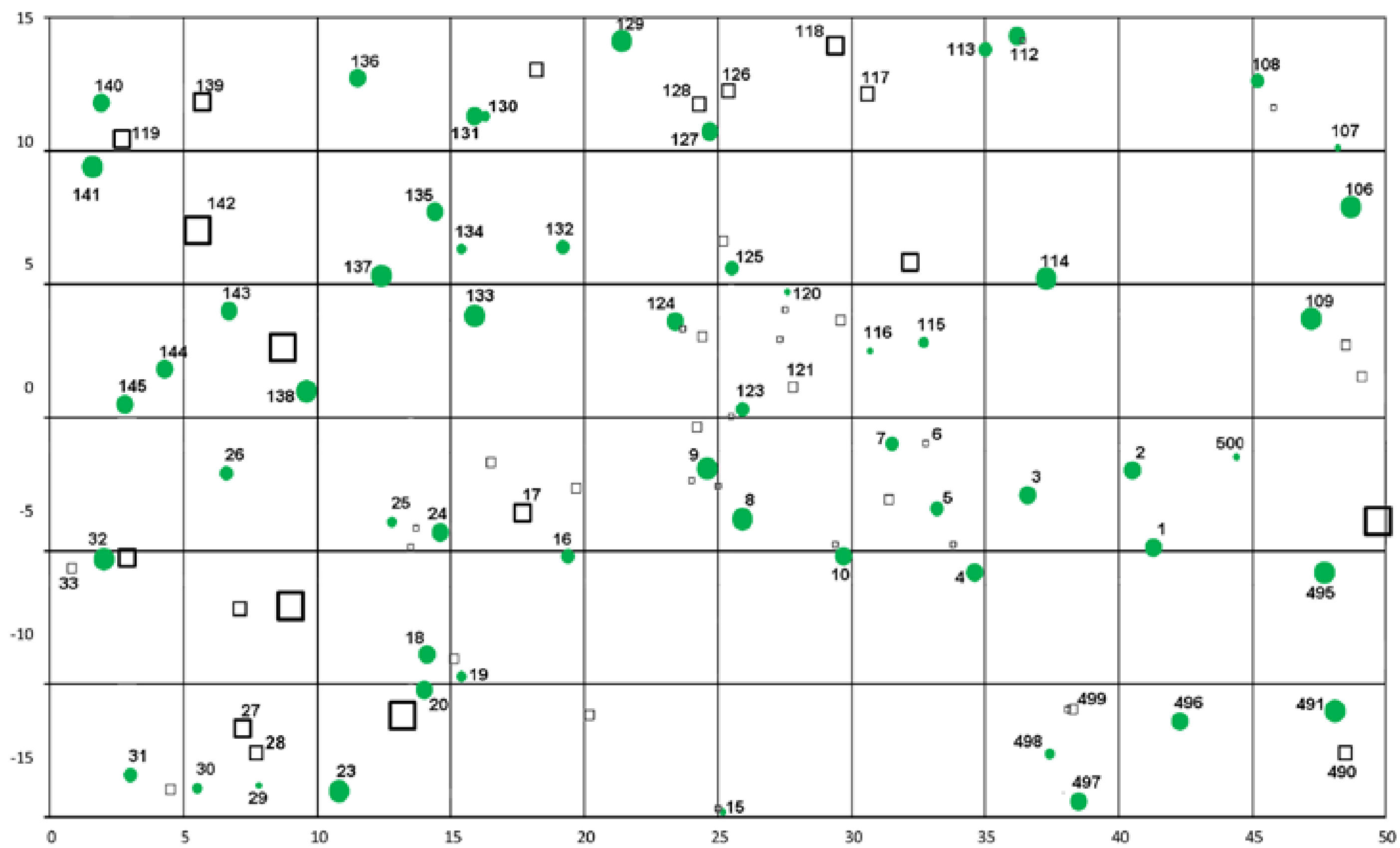


Figure 7. A portion of a plot. Green circles are hemlock stems and square boxes are dead stems. Boxes without a number are either too rotten or short to support a tag.

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