SOIL-WATER VEGETATION: THE ROLE OF SUB-WATERSHED SCALE TOPOGRAPHY AND HYDROLOGIC CONNECTIVITY IN FOREST ECOSYSTEM PROCESSES.

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General Question: Does sub-watershed scale topography redistribute soil moisture along hillslopes and thereby influence spatial patterns of forest productivity?

Rationale: Soil moisture availability controls forest productivity (Littel et al. 2008; Sierra et al. 2009; Woolley et al., in press), decomposition (Harmon 2009), and even tree mortality (van Mantgem et al. 2009). Despite its importance, we have not yet examined the factors that drive spatial patterns in soil moisture availability at the Andrews Forest. However, the movement of water within watersheds is strongly controlled by sub-watershed scale topography in steep, highly-dissected terrain with shallow soils (Jensco 2009). This redistribution of water on hillslopes should both create and connect resource patches and also control hillslope connectivity to stream and riparian ecosystems. In LTER7, we will test how topography influences hydrologic connectivity by redistributing soil moisture, modulating forest ecosystem response to seasonal drought and inter-annual variation in climate, and ultimately, influencing long-term ecosystem vulnerability to climate change.

Hypothesis: *Spatial redistribution of water on hillslopes produces detectable patterns in available soil moisture and primary productivity.* **Alternate Hypothesis:** *The redistribution of water will have little influence on growing season moisture availability because of the strong seasonality of precipitation or because soils may be too deep for redistributed water to be available to trees.*

Approach: We will locate approximately 50 soil moisture monitoring sites in WS01. We will use the LiDAR-based fine-scale DEM constructed in LTER6 to map the upslope accumulated area (UAA) draining through any point in the landscape. Sites will be spatially nested in a design that stratifies for differences in elevation, slope position, aspect, and other terrain indices from which we can evaluate the relationship between UAA and soil moisture as a function of season. We will use time domain reflectometry (TDR; following Gray and Spies 1995) to monitor moisture at each site, installing 4 probes, two in the rooting-zone and two below the rooting-zone to help resolve within-site variation. We will also measure soil depth at each site. Measurements will be made monthly, over two years. We expect to capture the majority of the potential temporal variability in two years because intra-annual variability greatly exceeds inter-annual variability in discharge and, by implication, soil moisture. After two years of monitoring, we will identify a small subset of sites that can be maintained for long-term measurements.

We will relate stream discharge to observed spatial patterns of soil moisture availability and then use historical precipitation and stream discharge records as a proxy measure of soil moisture, integrated over the entire watershed, to reconstruct historical seasonal and inter-annual variations in soil-moisture patterns. We will test how modeled and measured soil-moisture availability are related to tree growth and mortality using existing tree-ring records (Tepley 2010); LiDAR-based measurements of tree height, canopy diameter, and modeled biomass (Seidl et al. 2012); and growth and mortality in 50-yr permanent vegetation plots in WS1 (Lutz and Halpern 2006, Halpern and Lutz 2013). Ground-based multispectral and thermal-infrared remote sensing imagery will be collected from sampled areas to relate fine-grained soil-based measurements to canopy attributes, providing a way to diagnose drought stress as a function of location and microclimate, and providing a method to transfer intensive, site-based measurements to larger areas.

A more extensive soil-moisture monitoring network of approximately 20 sites will be initiated in a subset of the existing long-term vegetation plots and phenology plots established in LTER6. The vegetation plots will allow us to test soil-moisture relationship to tree growth and mortality across a wider suite of environmental conditions than is present in WS01. Air temperature is already being monitored at phenology plots, however, soil moisture availability can mediate air temperatures via evaporation (Ashcroft and Gollan 2013) and moisture availability can change species response to temperature. The extensive monitoring network will explore the influence of moisture availability on ecosystem productivity and phenology at larger spatial scales and across larger environmental gradients at the Andrews Forest.

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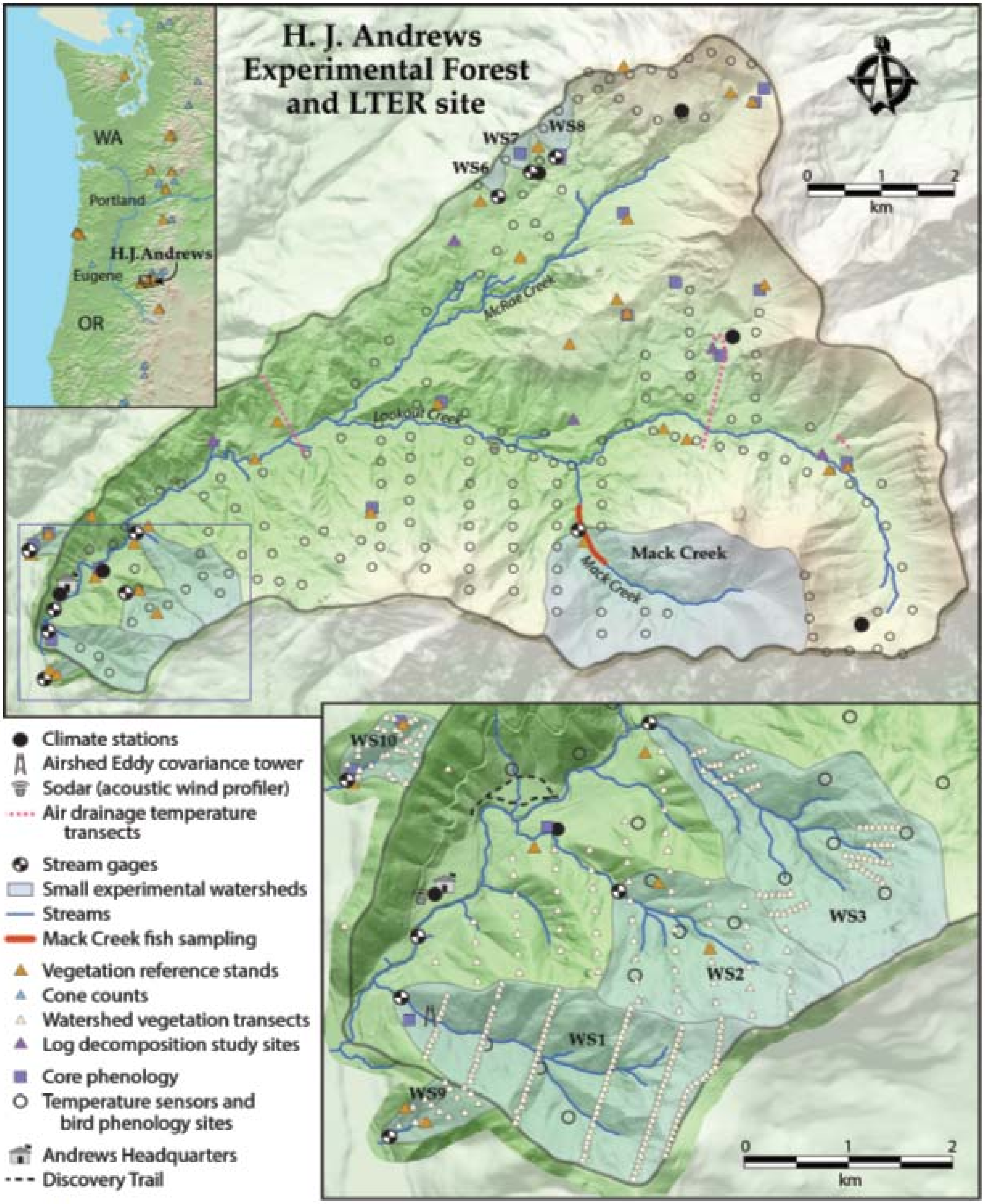

Figure 1. The Andrews Forest LTER covers 6400 ha and is located in the western Cascade mountains of Oregon. The site ranges from 400 to over 1600 m in elevation. Vegetation is dominated by conifer forests. Climate measurements include 6 climate stations, long-term temperature measurements in reference stands, a distributed temperature sensor network including phenology and air drainage sites, acoustic wind profilers, and an eddy covariance tower. Hydrology and stream measurements include 10 gaged streams ranging from 9 to 6200 ha, 8 small gaged watersheds in three paired watershed experiments at low, intermediate, and high elevation; and long-term fish sampling. Vegetation measurements include a network of old-growth forest reference stands, permanent vegetation study plots, and log decomposition experimental plots.