Study Plan

Tracking the process of wood softening in snags following fire and thinning in dry forests of eastern Washington.

White-headed woodpecker nest in a burned snag,
Oak Creek, Washington.

Background: Providing habitat for sensitive and keystone wildlife is important in western coniferous forests managed for resilience to disturbance events like wildfire and insect outbreaks. Many sensitive and keystone species benefit from large-scale forest disturbances. They are prone to population declines following intensive management because they rely on the structures that are created in risky, large-scale disturbance events. Finding a means to sustain these species in forests managed with small or low-intensity disturbance is a challenging goal.

As a guild, avian cavity excavators are among the most influential groups of disturbance specialists whose populations are negatively impacted by intensive forest management (e.g., Wisdom and Bate 2008). More colloquially called woodpeckers, they respond quickly and positively to large-scale disturbance events like wildfire that are considered risky for managers. Yet providing habitat for avian cavity excavators in managed forests is an important step for maintaining ecosystem function and biodiversity. Woodpeckers are well-known for providing many keystone functions, including cavity excavation (e.g., Bednarz et al. 2004, Tarbill et al. 2016, Martin et al. 2004), cavity enlargement (Blanc and Walters 2008), sap-well maintenance (Daily et al. 1993), control of insect pests (Fayt et al. 2005), and fungal dispersal (Jusino et al. 2016). Overall, the presence of woodpeckers has well-documented positive impacts on ecosystem health and community diversity (Lindenmayer et al. 2000, Virkkala 2006, Drever et al. 2008).

Research indicates that the availability of suitably decayed snags for nesting and roosting can limit woodpecker use of managed forests. From a woodpecker's perspective, suitable snags are critically different from the typical snag on the landscape because of internal properties of their wood (Conner et al. 1976, Jackson and Jackson 2004, Lorenz et al. 2015a, Jusino et al. 2016). Suitable snags must contain a strip of softened, decayed wood 2 to 10 cm deep in the bole of a snag, with a mass density <0.20 g/cm3. In contrast, the typical snag on a landscape contains harder wood with densities of 0.40 g/cm3 or greater (Lorenz et al. 2015a). Snags suitable for woodpecker excavations are difficult for humans to identify because there are no visible indications of wood density reliably associated with wood decay (e.g., Saint-Germain et al. 2007, Aakala 2010, Paletto and Tosi 2010, Strukeljii et al. 2013). At the same time, research indicates that in managed forests, up to 96% of snags may contain unsuitably dense wood for woodpecker excavation (e.g., >0.20 g/cm3; Lorenz et al. 2015a), and forest management can lead to snag densities 20 times lower than unmanaged forests (Bate et al. 2007, Wisdom and Bate 2008).

Woodpecker behavioral ecology adds complexity to these dynamics. Most species evolved a preference to excavate new nest and roost cavity every year – many also preferring a new snag every year (e.g., Aitken et al. 2002). This necessitates a snag for each breeding pair per year for population persistence. Woodpeckers are also territorial, and thus one snag cannot be used by more than one species in a given year. Species with delayed nesting phenology, particularly the white-headed woodpecker, are especially disadvantaged if snags are limiting because the few suitable snags on a landscape may be taken by earlier-nesting species (Kozma 2009, Lorenz et al. 2015b). Most woodpecker species also appear dispersal-limited (Koenig et al. 2000, Kesler et al. 2010, Rota 2013, Lorenz and Fischer 2014), which can limit the ability of populations to locate and settle in landscapes where suitable snags are low in density.

Collectively, this research suggests that without accounting for wood decay processes and the behavior ecology of species, traditional forest management practices are not likely to provide adequate habitat for avian cavity excavators. Thus, it is not surprising that most woodpecker species in western North America are listed on state management plans as species of conservation concern. Others like white-headed and black-backed woodpecker are listed or proposed for listing as threatened species in Canada or the U.S. This also likely explains why sensitive species like white-headed woodpecker are rare or absent from many managed forests that otherwise appear to contain suitable habitat (e.g., large-diameter pines for foraging; Dixon 1995). The past emphasis on minimum snag densities and snag-retention, without consideration for wood properties and woodpecker behavior, would have favored marginal numbers of snags, most of them unsuitably hard.

Research indicates that avian cavity excavators would benefit from a management emphasis that aims to provide a consistent population of suitably decayed snags on the landscape. For managed forests, where disturbance events that generate large numbers of snags must be minimized, this requires information on the decay mechanisms by which suitable snags are created. Unfortunately, information is lacking on the most basic aspects of wood decay in woodpecker nest snags in these systems. No past studies have identified wood decay fungi at woodpecker nests in western coniferous forests, nor measured the temporal or spatial scales at which decay processes operate. For example, there is no information on how many years it takes for recently dead snags to decay to a density of 0.20 g/cm3, or the species of basidiomycota associated with cellulose or lignin breakdown at woodpecker nest sites. Information is also needed on the spatial ecology of these fungi, and the moisture or temperature conditions under which fungal decay is optimized. Most woodpeckers show a preference for nesting in post-fire habitats (e.g., Hutto et al. 2008), and it is not known whether this is due to wood decay processes that differ in post-fire landscapes, or other factors.

Objectives:
To address some of the information gaps, we plan to conduct a study that follows the progression of wood softening in snags over many years. We have established study plots in areas treated with prescribed fire, wildfire, and thinning. We aim to provide information on the following questions of management interest:

1. Following tree death, how long does it take for wood to soften to a suitable density to enable use by woodpeckers for cavity excavation?
2. How do fungal communities differ in trees killed from fire versus tree topping?
3. Paired with information on fungi species in woodpecker nests (collected as part of another study in 2016) how long does it take for fungi associated with nests to colonize newly created snags?
4. Are there traits of snags and/or sites that lend themselves more quickly to wood softening?
5. Do decay processes differ by snag-creation method (fire versus tree topping), or by other snag- or site-specific characteristics such as tree diameter, number of infection routes (e.g., broken limbs, top), tree height, slope, canopy cover, or proximity to other snags or downed wood?

Methods: To address our objectives, in 2016 we initiated what we hope will be a long-term study of wood softening and wood decay in ponderosa pine snags in eastern Washington. The year 2016 was ideal for initiating this study. In 2016, wet summer-fall weather enabled the Naches Ranger District to burn several hundred acres of ponderosa pine forest in two separate project areas. A wildfire occurred in October in a third location between the two prescribed burns, enabling a study of wood softening in snags in three distinct and separate burns. Meanwhile, several hundred ponderosa pine snags had been created by tree topping in timber sales conducted by Washington Department of Fish and Wildlife and Naches Ranger District between 2015 and 2016.

Within each of the five project areas (two prescribed burns, one wildfire burn, and two timber sales) we randomly selected 10 ponderosa pine snags by creating random points using the ArcGIS random point tool. At each snag we measured wood hardness from 0 to 10 cm deep, took a sterile sample of wood shavings, and plugged the hole with a sterile microcentrifuge tube. We restricted our sampling to ponderosa pines snags that were 100% dead (i.e., >95% needles browned and scorched) and 12.6 and 21.3 inches diameter. This size class represents the interquartile range of ponderosa pine snags used by woodpeckers for nesting in this region (from among 259 measured nests 2011-2013; Lorenz et al. 2015). On each tree, we sampled wood at 7.7 ft above ground and at 170 degrees, or the median height and orientation of woodpecker excavations for this region (for nests in ponderosa pines).

At each site, we also measured tree diameter, ground cover, canopy cover, tree and snag density, woody debris cover, and bole and crown scorch. We noted the presence of woodpecker foraging and fungal conks. We noted visible external signs of beetle activity. However, we did not alter the physical environment of the wood at sites (for example by removing bark) and we likely missed many indications of wood boring and bark beetle activity. We individually marked trees with tree tags and we intend to return to trees to sample them at least once yearly. We will then quantify rates of wood softening, fungal colonization and woodpecker use based on time-since-death, snag species, snag size, management prescription, and the aforementioned habitat features.

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Figure 1. Study area showing burns and timber sales used for measuring wood decay in ponderosa pine snags in central Washington in October and November 2016.

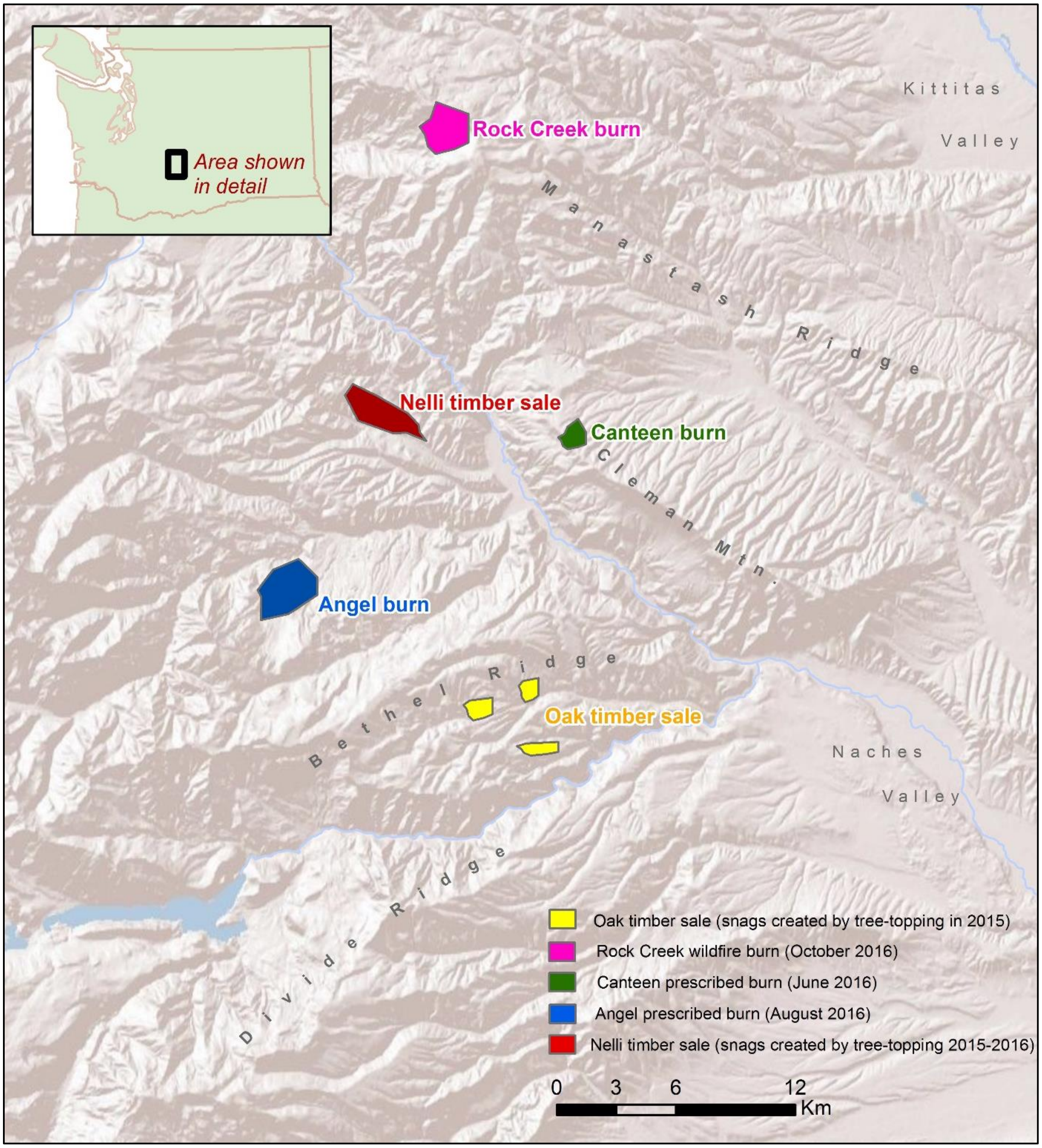
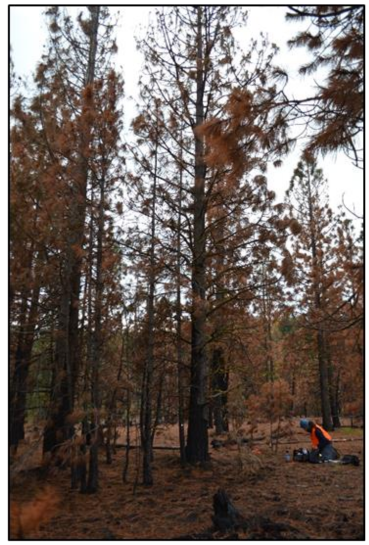


Figure 2. Photos of study areas.

Juvenile black-backed #370 watching us sample in angel burn. (what are those weird humans doing now?)

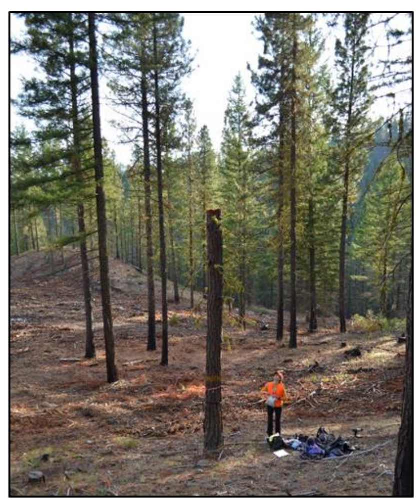
1. Sampling in Angel prescribed burn.



2. Sampling in Canteen prescribed burn.

3. Sampling in Rock Creek wildfire burn.

4. Sampling “topped” trees in WDFW Oak timber sale.



5. Sampling “topped” trees in USFS Nelli timber sale.

Appendix A. Field protocol.

Protocol

Record

1. Tree DBH
2. GPS waypoint at tree
3. Put in tree tag on a sturdy nearby dead tree or stump, and note distance and compass bearing to tree. Do not put tree tag into the tree to be sampled because the nails are not sterile.
4. Take 9 photos – first tree tag, and then ground photos (in this order - north, east, south, west) and then tree photos (north, east, south, west, standing back 10 m)

For fungi sample/hardness:

1. Put on new, unused, clean gloves. Spray gloved hands with isopropyl or place >1 tablespoon bleach mixture in hand and rub all over gloves. Wipe on clean paper towel and discard paper towel. At first tree every day (or at about every 5 trees) wipe cordless drill housing and torque wrench handle with bleach/isopropyl also.
2. Vigorously clean drill bit with wire brush. For many trees, this means a good 2 or more minutes of vigorous, hard scrubbing to get off all residue from the previous tree. Scrutinize closely to makes sure there is nothing remaining, using a finger nail if necessary to probe around on edges of the flutes (then wipe gloves with isopropyl or bleach afterwards). Then wipe off drill bit with a clean (dry) towel.
3. Place drill bit in bleach solution for at least 30 seconds. Make sure bleach level is as high as the deepest place you plan to drill (i.e., make sure the first 10 cm of drill are sitting in the bleach for 30 seconds – sometimes when the bleach level gets low this means tilting the bleach bottle). Wipe drill bit dry with new and clean paper towel, starting at the end where your hand is, and wiping down the bit.
4. Spray drill bit thoroughly with isopropyl and flame sterilize with cigar lighter. At this point, do not touch any part of the sterilized bit, or allow it to come in contact with anything but air. If it touches the tree or your hand, go back to step 3 and re-sterilize.
5. Insert in tree and drill to >11 cm deep. Then extract the drill bit and collect wood sample in sterile tube. Write tree tag number on sterile tube. Place on ice as soon as reasonably possible, and freeze immediately after getting home. The sooner it is frozen, the better.
6. Set drill down and also wipe bigger wood chips off the bit quickly with a re-usable towel. Sometimes there are a lot of wood chips on your clothes and do not bush them off with your hands unless you plan to change your gloves. You can try shaking your body to get the looser wood chips off of you.
7. Re-sterilize your gloves by spraying them with isopropyl or wiping with bleach, and wiping gloved hands with clean paper towel (this important step will get black soot off of your gloves, plus little bits of blackened bark and wood chips that may be clinging to them).
8. Repeat steps 3 and 4 with the increment borer, but also use a clean sterile cotton swabs to wipe down the inside of the increment borer after bleach bath. Then insert the increment borer into the tree and record hardness, taking care not to touch the increment borer between 0 and 10 cm with your hands.
9. Remove the increment borer and re-sterilize gloves using method in step 1. Get a sterile microcentrifuge tube from inside the sterile baggy and place it in the hole, taking care that only sterilized parts of your gloved hands touch the outside of the tub. Gently tap into place with the rubber mallet.

Tree must be a pipo with >95% needles brown/dead.
DBH (diameter at 4.5 ft) of this tree must be between 12.6 – 21.3 inches (inclusive).
Orientation for drill spot must be 170 degrees. Height for drill spot must be 7.7 ft.

Appendix B. Field datasheet

Tree must be a pipo with >95% needles brown/dead.
DBH (diameter at 4.5 ft) of this tree must be between 12.6 – 21.3 inches (inclusive).
Orientation for drill spot should be 170 degrees. Height for drill spot should be 7.7 ft.

1. Site name (angel, canteen, rock creek, nelli, oak): ______________________

2. Date:__________________

3. Random tree number: ____________________________

4. DBH:_______________________________

5. Waypoint number (and GPS name, if necessary): ____

6. Tree tag number ______________ is _____________ ft and __________________ degrees from tree.

7. Hardness

    0 ______________

    1 ______________

    2 ______________

    3 ______________

    4 ______________

    5 ______________

    6 ______________

    7 ______________

    8 ______________

    9 ______________

    10 ______________

8. Take 9 photos (tree tag, 4 ground photos, 4 tree photos)

Daily check-off list

fill up isopropyl in pink bottle
get additional sterile tubes
get additional gloves (get at least one pair for every tree you plan to sample)
paper towels in clean zip lock bag (get lots – 5 or more for every tree you plan to sample)
empty out trash bag
top off bleach bottle
remember the cooler and ice packs
new datasheets
refill sterile swabs
check battery level on drill