Fire History and Fire Ecology in Yellowstone Field Tour Day 2

Serotiny in lodgepole pine: A key driver of postfire forest structural trajectories. At the first two stops today, we will visit locations where lodgepole pine forests burned in the 1988 fires, but contained contrasting levels of prefire lodgepole pine serotiny.

Background. Lodgepole pine is well known as a serotinous conifer, but the prevalence of serotinous vs. non-serotinous cones varies considerably. Within the GYE, serotiny varies with elevation and stand age. Lodgepole pine serotiny is high at low elevations (<2400 m; Figure 1), where average fire-return intervals are approx. 180 yrs. At low elevations, serotiny increases with stand age, with stands older than 75 yrs containing more serotinous trees. Serotiny is low at high elevations (>2400 m) irrespective of stand age (Figure 2). Variability in serotiny has enormous consequences for postfire forest trajectories, as serotiny determines the on-site seed availability after a fire.

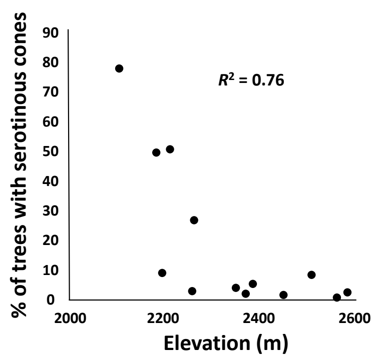

Figure 1. From Tinker et al. (1994, *Can. J. For. Res*)

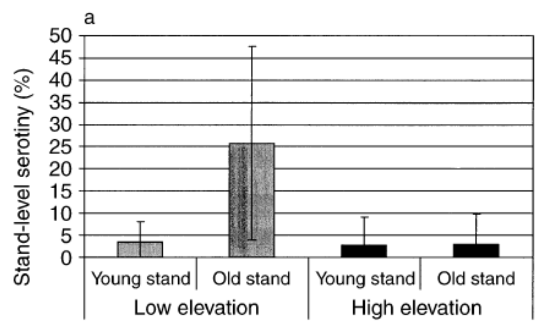

Figure 2. From Schoennagel et al. (2003, *Ecol.*)

Stop 1, Madison River Drainage, is a low-elevation site (~2075 m) where prefire serotiny was very high (~65% of prefire trees had serotinous cones; Turner et al. 1997, *Ecol. Monogr.*). This area has extremely high postfire lodgepole pine density. Abundant seed sources from serotinous cones meant that the size and shape of burned patches mattered little to postfire seedling densities. In such high-density sites, post-1988 forest stands are already self-thinning (Table 1).

Stop 2, Grebe Lake Trailhead, is a high-elevation site (~2500 m) where prefire serotiny was very low (<10% of prefire trees had serotinous cones). Postfire lodgepole pines are generally sparse in this area, and the lack of on-site seed sources from serotinous cones dictates that postfire tree density decreases toward the interior of burned patches. These stands of initially lower tree density fill in gradually (Table 1; also Kashian et al. 2004, *Ecology*). Stands converge to approx. 1200 stems/ha by approx. 175 years after fire.

Table 1. Data from Turner et al. (2004, *Ecosystems*) and Turner et al. (in review).

	Postfire tree density (stems/ha)		**Basal area** (m^2/ha)	**Plant spp. richness** (per 0.25 ha plot)	
Site	***1999***	***2012***	***2012***	***1999***	***2012***
Stop 1 – Madison River Drainage - high prefire serotiny, elev. ~2100 m	454,200	344,067	42	9	17
Stop 2 – Grebe Lake Trailhead - low prefire serotiny, elev. ~2500 m	433	1,767	11	20	35

Multiple disturbances interact (or not!) to affect forests in surprising ways. At our last two stops today, we will explore multiple disturbances and their potential interactions. Whether it is fires following beetle outbreaks, blowdowns, or even other recent fires, this topic is becoming increasingly relevant with more disturbance activity overall raising the probability of overlapping disturbances.

Stop 3, Cygnet Fire, burned in 2012 across an area that included forests regenerating after the 1988 fires. With expected increases in fire frequency driven by climate warming (Westerling et al. 2011, *PNAS*), this area gives us a possible glimpse into the future of the GYE. For comparison, there are two other recent "reburns" in the GYE, where two severe fires (Boundary and Bearpaw fires) occurred within a 30-yr period. Looking at the information available, what are some hypotheses for the causes of variability in postfire trajectories in reburns?

Table 2. Unpublished data from Turner et al. (*recorded in 2011 and 2013*).

	Postfire tree density (stems/ha)		
Site	***First fire***	***Reburn***	***Notes***
Stop 3 – Cygnet Fire - burned in1988 and 2012(24 yr FRI), elev. ~2500 m	10,600	250	Few cones and no serotiny in 1988 postfire cohort ; stand density decreased following 2nd fire
Information for comparison:			
Boundary Fire - burned in 1988 and 2000 (12 yr FRI), elev. ~2200 m	5,333	438	Few cones produced in 1988 postfire cohort by the second fire in 2000; stand density decreased following the 2nd fire, quaking aspen regeneration increased.
Bearpaw Fire - burned in 1981 and 2009 (28 yr FRI), elev. ~2100 m	11,600	10,200	Serotinous cones present in 1981 postfire cohort by the time of the next fire in 2009; stand density unchanged after 2nd fire

Stop 4 (final stop), the 1984 blowdown and 1988 fire interpretive site, experienced a severe blowdown in 1984 where most canopy trees were knocked down by wind. Four years later, the area severely burned in the 1988 fires, leading many to believe that this area would take several decades to become a forest again. What do we see today? What surprises lay in the future?

Table 3. Data from Turner et al. (2004, *Ecosystems*) and Turner et al. (in review).

	Postfire tree density (stems/ha)		**Basal area** (m^2/ha)	**Plant spp. richness** (per 0.25 ha plot)	
Site	***1999***	***2012***	***2012***	***1999***	***2012***
Stop 4 – 84 Blowdown - blowdown in 1984, burned in 1988 elev. ~2400 m	3,700	4,333	36	9	19

Bark beetles. Another disturbance interaction for which there is much concern among scientists and managers is the potential interaction between bark beetle outbreaks and subsequent fires. Research in Greater Yellowstone and the Northern Rockies shows minimal effects of pre-fire outbreaks on fire severity and postfire tree regeneration. For more information, see:

Harvey, B. J., D. C. Donato, and M. G. Turner. 2014. Recent mountain pine beetle outbreaks, wildfire severity, and postfire tree regeneration in the US Northern Rockies. Proceedings of the National Academy of Sciences 111: 15120–15125.

Note: Other citations referenced on this handout are available on Monica Turner's handout from Day 1.