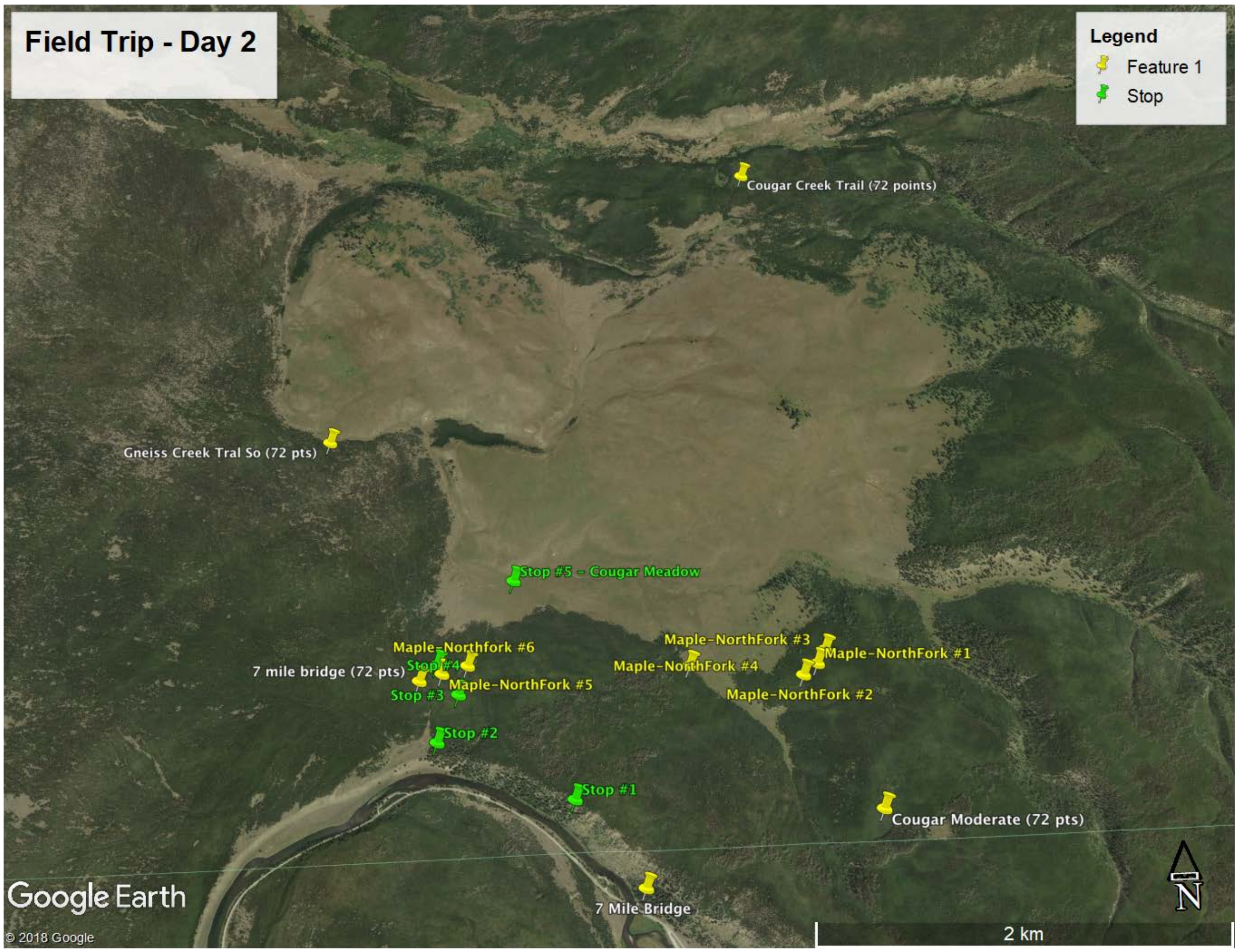
Long-Duration Fire and Re-Burn Effects in Yellowstone National Park – Field Tour
October 16 and 17, 2018

FIELD TRIP HANDOUT (DAY 2)

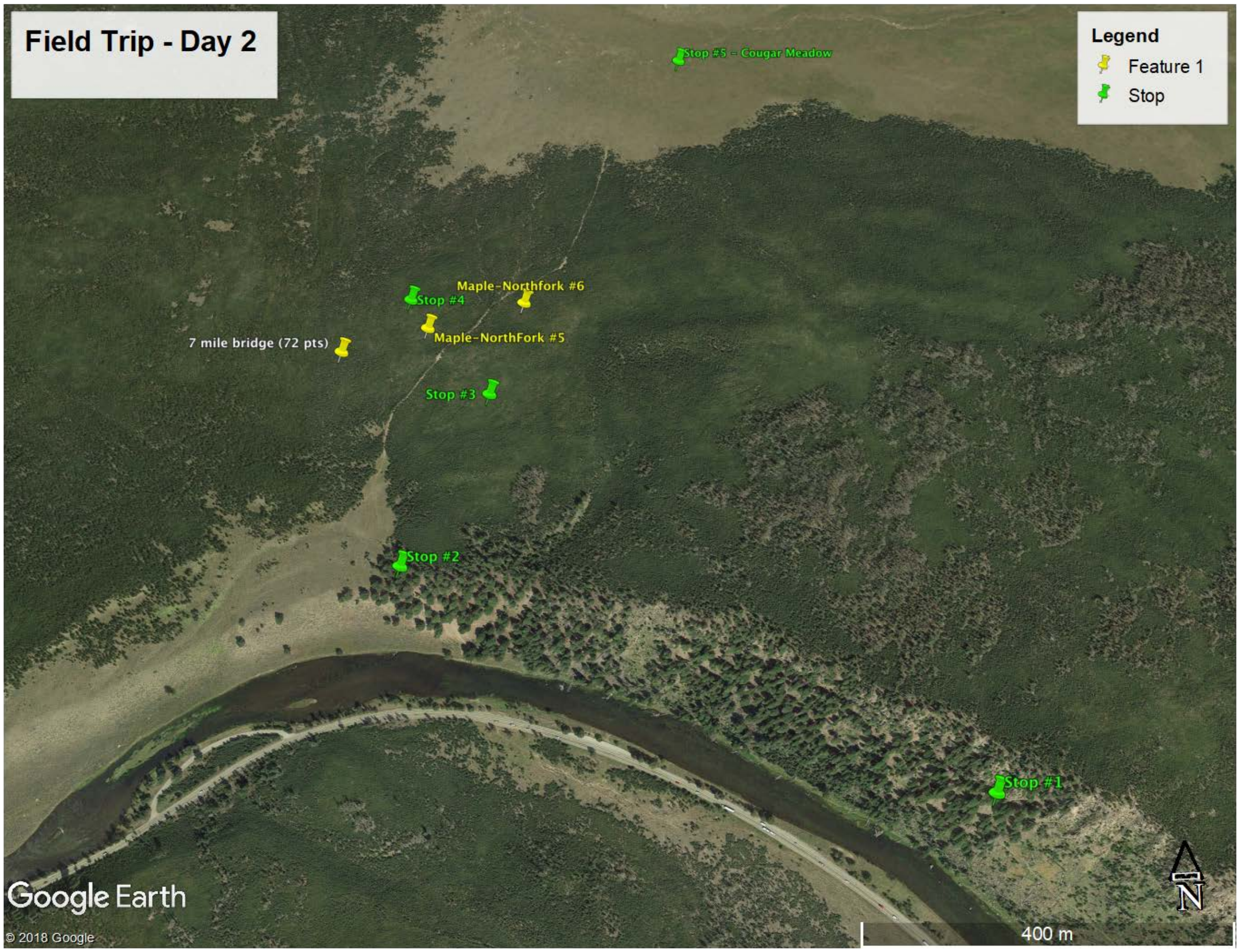
Overview of the southern end of the Gneiss Creek Trail and Cougar Meadow (from GoogleEarth)

- Field trip stops are shown in green.
- Reburn plots (*n* = 6, 0.25 ha) sampled in 2017 within the Maple-NorthFork fires are shown in yellow.
- Long-term plots (*n* = 4, 0.25 ha) from the 1988 fires are shown in white (these are among the Turner et al. 2016 and Nelson et al. 2017 sample plots).



Closer view of stops along the Gneiss Creek Trail (from GoogleEarth)

- Field trip stops are shown in green.
- Reburn plots (*n* = 6, 0.25 ha) sampled in 2017 within the Maple-NorthFork fires are shown in yellow.
- Long-term plots (*n* = 4, 0.25 ha) from the 1988 fires are shown in white (these are among the Turner et al. 2016 and Nelson et al. 2017 sample plots).



Stop 1: Halfway up trail that parallels the Madison River – look across the river to the areas of very dense lodgepole pine that regenerated following the North Fork Fire. Discuss more generally the variation in forest structure and fuels in the forests that regenerated following the 1988 fires.

Main points:

- Most forests that burned in 1988 were 100-300 years old.
- After the 1988 fires, postfire density of lodgepole pine was set within the first 2 years.
    - Historically, these landscape patterns of stand structure persist for >150 years.
- Variation in postfire tree density across the burned landscape was (and still is!) enormous!
    - Very high lodgepole pine density, as seen here, where the percent of trees bearing serotinous cones before the fires was high. West-central YNP has the highest level of serotiny (~60%, on average).
    - Serotiny varies with elevation and stand age
        - At high elevations (> 2400 m, > 7800 ft)
            - Historical FRI averaged 280-310 yrs
            - Serotiny is low (< 5%)
        - At low elevations
            - Historical FRI averaged 135-185 yrs
            - Serotiny is low (< 5%) in stands < 100 yrs old, high (> 25%) in older
    - Locally high lodgepole pine density (given serotiny) in areas of high-severity surface fire that killed the trees, but did not consume the canopy fuels and cones.
- The dense young lodgepole pine forests we see across the Madison River
    - Lodgepole pine density ~ 74,000 to 340,000 stems/ha (30,000 to 138,000 stems/acre)
    - Canopy base height ~ 0.7 m (2.3 ft)
    - Biomass of 10,000-hr dead fuels ~ 72 Mg/ha (32 tons/acre)

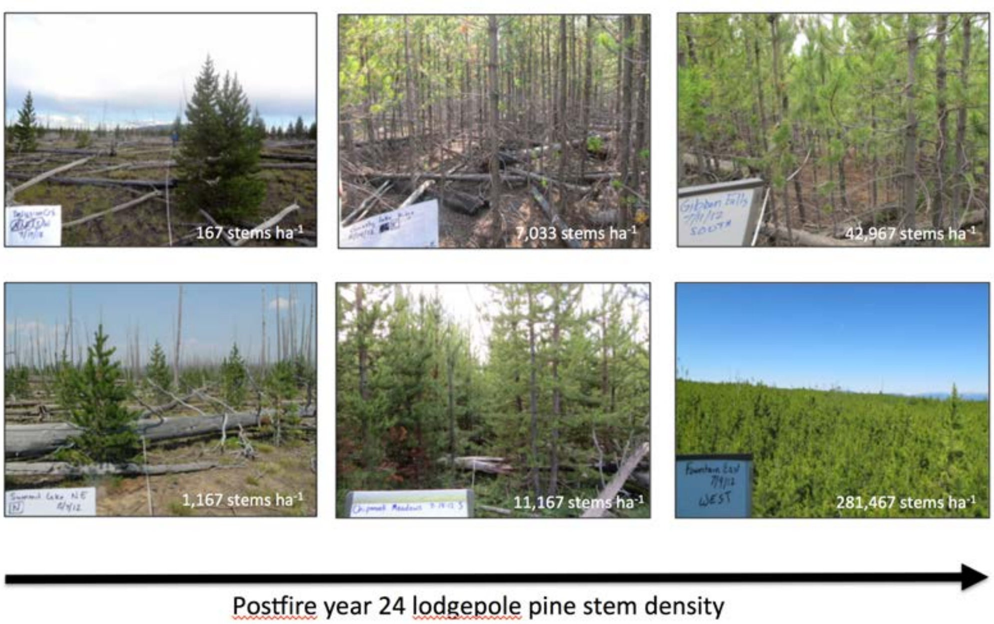


Figure 1.1 Variation in postfire lodgepole pine density 24 years after the 1988 Yellowstone Fires (Turner et al. 2016)

Stop 1-Selected references

Overviews

Romme, W. H., M. S. Boyce, R. E. Gresswell, E. H. Merrill, G. W. Minshall, C. Whitlock and M. G. Turner. 2011. Twenty years after the 1988 Yellowstone fires: lessons about disturbance and ecosystems. Ecosystems 14:1196-1215.

Turner, M. G., D. C. Donato, W. D. Hansen, B. J. Harvey, W. H. Romme, and A. L. Westerling. 2016. Climate change and novel disturbance regimes in national park landscapes. Pages 77-101 In: S. R. Beissinger, D. D. Ackerly, H. Doremus, and G. Machlis, editors. Science, conservation, and national parks. University of Chicago Press, Chicago, IL.

Postfire stand structure and function, and plant community composition (recent)

Donato, D. C., B. J. Harvey, and M. G. Turner. 2016. Regeneration of lower-montane forests a quarter-century after the 1988 Yellowstone Fires: a fire-catalyzed shift in lower treelines? Ecosphere 7(8) Article e01410.

Hansen, W. D., W. H. Romme, A. Ba, and M. G. Turner. 2016. Shifting ecological filters mediate postfire expansion of seedling aspen (*Populus tremuloides*) in Yellowstone. Forest Ecology and Management 362:218-230

Romme, W. H., T. G. Whitby, D. B. Tinker, and M. G. Turner. 2016. Deterministic and stochastic processes lead to divergence in plant communities during the first 25 years after the 1988 Yellowstone Fires. Ecological Monographs 86:327-351.

*Turner, M. G., T. G. Whitby, D. B. Tinker, and W. H. Romme. 2016. Twenty-four years after the Yellowstone Fires: Are postfire lodgepole pine stands converging in structure and function? Ecology 97:1260-1273.

Fuels in the 25-yr old postfire forests

*Nelson, K. N., M. G. Turner, W. H. Romme, and D. B. Tinker. 2016. Landscape variation in tree regeneration and snag fall drive fuel loads in 24-yr old post-fire lodgepole pine forests. Ecological Applications 26:2424-2438.

Nelson, K. N., M. G. Turner, W. H. Romme, and D. B. Tinker. 2017. Wind and fuels drive fire behavior in young, postfire lodgepole pine forests. International Journal of Wildland Fire 26:852-865.

Stop 2:

When the trail hits the top of the ridge, NPS fire ecologists (Becky, Diane) will discuss NPS plot-based monitoring that provides information on fire effects and informs management decisions. Park staff who observed fire behavior of the Maple Fire may use this stop to share some of these observations.

Figure 2.1 Maple Fire burns through the 28-yr old lodgepole pines that regenerated after the 1988 North Fork Fire. (NPS photo)

Stop 3: Walk north along the trail, stop on east side of the trail where the Maple Fire burned as a "typical" crown fire. Fire-killed trees are standing, cones are visible on the trees. Discuss burn severity, postfire tree regeneration, and the remaining fuels.

Main points:

- Based on the re-sampling of our long-term plots in this vicinity (we have 4 plots nearby that were sampled in 2012-13; see white text on overview map on page 1), lodgepole pine density averaged 71,800 stems/ha, downed coarse wood biomass (mostly trees killed in the 1988 fires and now fallen) averaged 81.9 Mg/ha, and canopy foliage biomass averaged 8 Mg/ha.
- In summer 2017, we sampled 6 plots in this area that were reburned in the 2016 Maple Fire (see yellow text in overview map on page 1). We could reconstruct the tree size and density in each stand at the time of the fire, and we measured postfire tree density also. Data for all six plots are summarized in Table 1.
- Stop #3 is a "densetown" in the vicinity of Plot #6 (see close-up map on page 2).
- Most of the young trees are still standing (only about 11% were combusted)
- Coarse wood consumption, postfire regeneration, "typical" for stand-replacing fires in YNP
- ***By the numbers (Turner et al., in preparation)***
    - Lodgepole pine density before the reburn: 99,800 stems/ha
    - Median basal diameter 1.9 cm
    - Lodgepole pine stumps after the reburn: 11,200 stumps/ha
    - Percent of lodgepole pine trees combusted: 11%
    - Cones remaining on the burned trees: 231,536 cones/ha
    - Lodgepole pine seedling density after the reburn: 39,600 stems/ha
    - Coarse wood mass remaining after fire: 27 Mg/ha
    - Percent cover of "ghost logs": 7%
    - Percent aboveground C lost to fire: 61%

Stop 4: West side of the trail where the Maple Fire burned as a "crown fire plus." Compare and contrast burn severity and regeneration, discuss combustion of fuels.

Main points:

- Stop #4 is a "stumptown" in the vicinity of Plot #5 (see close-up map on page 2).
- Nearly all of the young trees were combusted in the fire.
- Coarse wood consumption, postfire regeneration, much more extreme than previously observed; this pattern is repeated within the Maple Fire reburns and also the Glade Fire reburns in Grand Teton National Park.
- ***By the numbers (Turner et al., in preparation)***
    - Lodgepole pine density before the reburn: 107,633 stems/ha
    - Median basal diameter 2.7 cm
    - Lodgepole pine stumps after the reburn: 105,533 stumps/ha
    - Percent of lodgepole pine trees combusted: 98%
    - Cones remaining on the burned trees: 0 cones/ha
    - Lodgepole pine seedling density after the reburn: 833 stems/ha
    - Coarse wood mass remaining after fire: 15 Mg/ha
    - Percent cover of "ghost logs": 14%
    - Percent aboveground C lost to fire: 93%

Table 4.1. Mean characteristics of young lodgepole pine forests that regenerated after the1988 North Fork Fire and reburned in the 2016 Maple Fire (28-year fire return interval). Plots were 50 m x 50 m (0.25 ha); *n* = 6. Values are mean (standard error). From Turner et al. (in preparation); please do not cite unpublished data without permission.

Attribute	Pre-Maple Fire	Post-Maple Fire
Stand structure and biomass		
Lodgepole pine density (stems ha^{-1})	76,511 (14,176)	14,355 (7011)
Mean tree basal diameter (cm)	3.5 (0.6)	--
Lodgepole pine biomass (Mg ha^{-1})		
Foliage biomass	9.2 (1.0)	--
Bole biomass	31.8 (2.8)	--
Branch biomass	3.7 (0.7)	--
Total aboveground biomass	45.2 (4.5)	--
Cone supply		
Cone abundance (10^3 cones ha^{-1})	§55.5 (35.4)	--
Prop. trees with ≥1 serotinous cone	§0.20 (0)	--
Downed coarse wood (>7.5 cm)		
Coarse wood cover (%)	§15.3 (2.8)	5.8 (1.8)
Coarse wood volume (m^3 ha^{-1})	§172.8 (27.2)	40.9 (17.8)
Coarse wood biomass (Mg ha^{-1})	§67.5 (11.0)	12.2 (4.5)

§ could not be estimated within plots that reburned; thus, data were also collected during summer 2017 in 3 nearby plots that regenerated from the North Fork Fire and did not reburn in 2016.

Stop 5: Cougar Meadow – Walk around meadow, look toward the east, and observe the landscape heterogeneity of the burn severity. Discuss how these patterns may change in a warming climate, how seed dispersal may become increasingly important (even in lodgepole pine), how the warming climate interacts with topography, and the experiments underway in this area to quantify these effects.

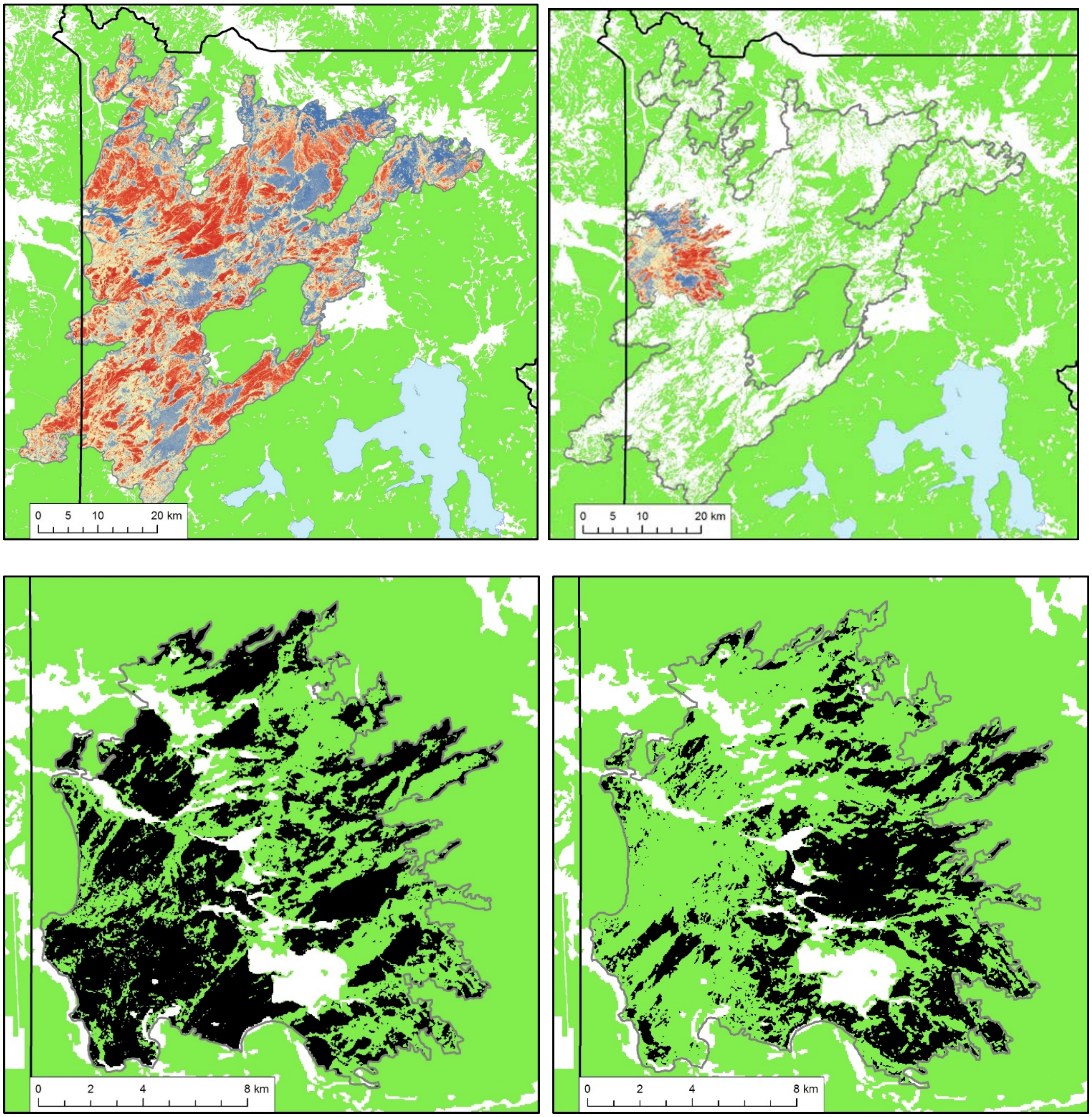


Figure 5.1 ***TOP:*** Burn severity patterns within the 1988 North Fork Fire (upper left) and 2016 Maple Fire (upper right). Red indicates higher burn severity. ***BOTTOM:*** Zooming into the Maple Fire perimeter, areas of stand-replacing fire from the 1988 North Fork Fire (bottom left) and 2016 Maple Fire (bottom right). From Harvey et al., in preparation.

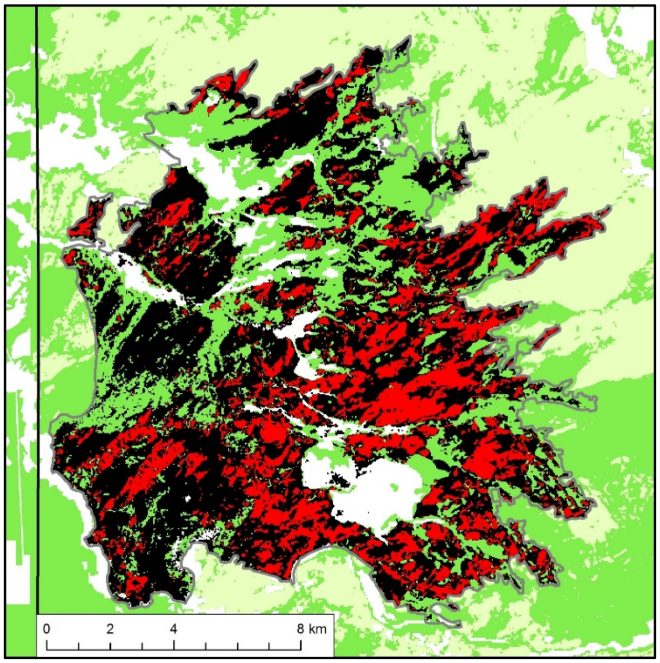


Figure 5.2 Red areas depict forests that burned as stand-replacing fire in BOTH fires (1988 North Fork and 2016 Maple Fires).

Main points: Landscape patterns of burn severity

- **Fires still create a heterogeneous burn mosaic, but sequential fires interact**
  - 1988 North Fork Fire burned 206,000 ha of forests that were largely > 150 years old.
    - 54% of the burned area was stand-replacing fire.
    - 19% (39,400 ha) of burned forest was > 150 m from live trees
  - 2016 Maple Fire re-burned 18,350 ha of the North Fork Fire
    - 35% of the burned area was stand-replacing fire
    - 5% (1,000 ha) of burned forest was > 150 m from live trees
  - Interactions from one fire to the next are complex (Harvey et al. 2016)
    - Across Northern Rockies, for reburns that occurred between 1984 and 2010, burn severity was ~5-13% lower in second fire
    - Negative interactions (lower severity in 2nd fire)
      - Low-elevation forests and woodlands
      - Fire intervals < 10 yrs
      - Relatively low burn severity in the 1st fire
    - Positive interactions (high severity begets high severity)
      - Mid-montane and subalpine forests
      - Fire intervals > 10 yrs
      - High burn severity in the 1st fire
  - Ongoing research will quantify patterns of burn severity within the 2016 fires, focused especially on ability of satellite data to assess the extremely high burn severity (crown plus) correctly.

Figure 5.3 East end of Cougar Meadow as seen in July 2013, 25 years after the 1988 Fires (left), and again as seen in July 2017, one year after the Maple Fire reburned the young forests (right). Photos by M. G. Turner.

Main points: Forest resilience

- **Forest regeneration will depend on multiple factors**
  - Are seed sources available within the burned patch? Was the forest old enough to have developed an abundant canopy seedbank? If cones were present, were they combusted in the fire?
  - If an *in situ* seed source is absent, how large are the patches of stand-replacing fire? What seed is available in the surrounding green forest? How far away is the seed source, and is dispersal likely to reach the burned area? Will seed predators (e.g., rodents) consume seeds?
  - If seeds arrive at the burned patch, are the climate conditions suitable for germination and establishment?
- Recent research suggests postfire tree establishment will be low in projected mid-21st century climate (Hansen and Turner, in press).
- Experiments are underway to separate effects of seed availability from environmental conditions on postfire tree regeneration
  - PhD student Tyler Hoecker has experiments underway in four reburns.
    - Maple-NorthFork and Buffalo+1988 in Yellowstone
    - Berry-Glade and Berry-Huck in Grand Teton
  - Postdoc Nate Gill has seed traps out in unburned forests, long-interval fire, and short-interval fire in and around the Berry Fire, Grand Teton
- Understanding mechanisms underpinning forest resilience to changing climate and fire is a major focus of research among forest ecologists.

Stop 5-Selected references

Landscape patterns of burn severity

Harvey, B. J., D. C. Donato and M. G. Turner. 2016. Drivers and trends in spatial patterns of burn severity in forests of the US Northern Rocky Mountains (1984-2010). Landscape Ecology 31:2367-2383.

Harvey, B. J., D. C. Donato and M. G. Turner. 2016. Burn me twice, shame on who? Interactions between successive forest fires across a temperate mountain region. Ecology 97:2272-2282.

Forest resilience and future forests in Yellowstone

Frock, C. F., and M. G. Turner. 2018. Microhabitat conditions and landscape pattern explain nocturnal rodent activity, but not seed removal, in burned and unburned lodgepole pine forests. Landscape Ecology. https://doi.org/10.1007/s10980-018-0717-x

Hansen, W. D., K. H. Braziunas, W. Rammer, R. Seidl, and M. G. Turner. 2018. It takes a few to tango: changing climate and fire regimes can cause regeneration failure of two subalpine conifers. Ecology 99:966-977.

Hansen, W. D., and M. G. Turner. 2018. Origins of abrupt change? Postfire subalpine conifer regeneration declines nonlinearly with warming and drying. Ecological Monographs (In press).

Harvey, B. J., D. C. Donato and M. G. Turner. 2016. High and dry: Postfire drought and large stand-replacing burn patches reduce postfire tree regeneration in subalpine forests. Global Ecology and Biogeography 25:655-669.

Johnstone, J. F., C. D. Allen, J. F. Franklin, L. E. Frelich, B. J. Harvey, P. E. Higuera, M. C. Mack, R. K. Meentemeyer, M. R. Metz, G. L. W. Perry, T. Schoennagel, and M. G. Turner. 2016. Changing disturbance regimes, climate warming and forest resilience. Frontiers in Ecology and the Environment 14:369-378.

Romme, W. H. and M. G. Turner. 2015. Ecological implications of climate change in Yellowstone: moving into uncharted territory? Yellowstone Science 23(1):6-13.