Research Brief for Resource Managers

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Perturbing Natural Fire Brings Type-conversion

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Management Implications

- Natural fire disturbance is necessary in fire-adapted ecosystems, so a single fire is not necessarily a problem.
- However, ongoing perturbations of the natural fire disturbance can result in vegetation shifts, or type-conversion.
- Perturbation of the natural fire regime occurs if one or some of its parameters (i.e., frequency, pattern, fuel structure, or intensity) are altered.
- In the case of ecosystems that haven't co-evolved with fire (e.g., the Sonoran desert or a tropical woodland), a single fire in itself should be considered a perturbation.

Fire is not intrinsically a problem for a fire-adapted ecosystem, not unless it's an anomalous fire. That is, fire only becomes an unnatural perturbation if it falls outside of the ecosystem's normal range of fire parameters. If the fire has characteristics that do not adhere to the fire parameters with which the fire-adapted ecosystem has evolved over the last millenia, then it may impact resilience and cause ecosystem services to be lost. Specifically, anthropogenically driven changes in: **1)** average fire frequency, **2)** fire patchiness, **3)** consumable fuel structure, and **4)** fire intensity, are all to blame for turning otherwise helpful fire into a conservation problem.

For example, chaparral and lodgepole pine are particularly susceptible to increases in fire frequency (i.e., shortened fire return intervals, or FRIs), which causes vegetation shifts for both (Fig.2).

In contrast, mixed conifer forests suffer structural changes with decreasing fire frequencies (i.e., lengthened FRIs), where the proximate perturbation would be the structural change in consumable fuels that results from the ultimate cause: fire suppression (Fig.3).

In the case of Great Basin scrub, land use changes resulting in increased livestock grazing and prescription burning produce alterations in fire pattern, and patchiness, resulting from an influx of invasive grasses that caused normally small and patchy fires to become contiguous and large. A further example is how boreal forests have become vulnerable to global warming that has resulted in changes in fire intensity, which causes essential moss substrates to disintegrate (Fig.4).

In the real world, fire parameter perturbations don't usually work in isolation. However, sorting them into parameter-specific case studies for five different ecosystems provides a useful illustration of the diversity in mechanics behind fire driven type-conversion.

Fig. 2. Impact of unnaturally high fire frequency: (*a*) entire chaparral landscape in the frame burned in 1970, half of the foreground burned again in 2001 and the far right third of the foreground burned a third time in 2003, all by human-caused ignitions. Vegetation recovery following the 2001 fire comprises native shrub and subshrub regeneration, those areas burned a third time in 2003 are dominated by alien red brome grass invasion (photo by R. W. Halsey). (*b*) Massive lodgepole forest regeneration following the 1988 North Fork Fire, which burned over 200 000 ha of Yellowstone lodgepole forests, was partially reburned after 28 years in the 2016 Maple Fire of 18 200 ha. Although the proximal cause of this reburn was a natural lightning ignition, the ultimate cause was likely tied to anthropogenic global warming that increased young fuel aridity. This atypical short interval resulted in very little regeneration; casual observations by the first author in the summer of 2018 revealed ~10 to 1 ratio of adult skeletons to seedlings, clearly not stand-replacing recruitment, see also Turner *et al.* (2018) (photo by J. E. Keeley).

Fig. 3. Wildfire in ponderosa-dominated forests where the more natural low-intensity understorey burning seen in the foreground is replaced by high intensity evident in the background (photo by J. E. Keeley). As these pines require surviving parent trees for seed sources, the background landscape, owing to limited dispersal ability and lack of seed sources, is likely to lack forest recovery for a century or more.

Fig. 4. In Alaska taiga north of Fairbanks: (*a*) post-fire recruitment of black spruce (*Picea mariana*) in sphagnum substrate; and (*b*) higher-intensity burned spots where safe sites for spruce are eliminated, leaving substrate more suitable for broadleaf tree establishment (photos by J. E. Keeley).