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BULLETIN

Forest Disturbances in a Changing Climate

JULY 28, 2017 / BY JENNIFER HUSHAW

Disturbance shapes the character and composition of ecosystems and it is "a pervasive feature of forests" (Perry 1994). Wildfires, blowdowns, pests and other disturbance agents affect the spatial patterns of vegetation and ecosystem processes, creating a diversity of conditions across the landscape, and they can leave an imprint that shapes forest dynamics for decades to centuries after the initial disturbance event (Turner 2010).

Global Trends in Forest Disturbance

There is an increasing amount of research on forest disturbance in a changing climate, including a number of studies that suggest certain types of disturbance (e.g., wildfire or insect outbreaks) are increasing over time (as noted in previous bulletins). In a recent review in the journal *Nature Climate Change*, researchers noted that increases in the occurrence and severity of forest disturbance have been documented worldwide and they provide a more comprehensive analysis of these changing dynamics by elucidating global trends from hundreds of separate studies (Seidl et al., 2017).

OVERVIEW

Researchers synthesized results from over 670 studies (published from 1990 to the present) that assessed how forest disturbance changed in response to a change in climate, focusing on six disturbance agents (fire, drought, wind, snow and ice, insects, and pathogens). From these results, they isolated over 1,600 observations for further analysis.

For each type of disturbance, they looked at the evidence for direct, indirect, and interaction effects of climate change. They determined whether climate change had a predominantly amplifying or dampening effect on disturbance, as well as the relative size of that effect. This allowed them to assess the degree of climate sensitivity. In particular, they examined whether disturbance was likely to increase or decrease under either (1) warmer and wetter or (2) warmer and drier conditions.

Direct effects are "unmediated impacts of climate variables on disturbance processes," e.g. a change in frequency of drought periods.

Indirect effects are "a climate influence on disturbance through effects on vegetation and other ecosystem processes," e.g. climate-mediated changes in forest structure or species composition that change susceptibility to wind throw or drought.

Interaction effects are "linked or compounding relationships between disturbance agents," e.g. increased risk of bark beetle outbreaks due to drought.

Note: *The disturbance agents included in this study have been discussed in previous CSLN bulletins, including wildfire (Part I & Part II), drought (here & here), wind, snow and ice (Part I & Part II), and pests/pathogens. Refer to those publications for a more in-depth discussion of climate change effects.*

TAKE HOMES

Climate Shapes Disturbance Regimes

- Climate has a "substantial influence" on forest disturbance – direct effects were most common (~57% of observations), followed by indirect (25%) and interaction (~18%) effects.
- Temperature had a greater influence on disturbance at higher latitudes (most important in boreal regions), while water availability was more influential at lower latitudes (most important in the tropics).
- Interaction between agents tended to increase disturbance – posing an increased risk of crossing ecological tipping points.
    - "In particular, disturbances by drought and wind strongly facilitate the activity of other disturbance agents, such as insects and fire […]."
- Indirect climate effects commonly had a dampening influence by reducing ecosystem vulnerability to disturbance over the long-term,
    - E.g. a climate-mediated shift toward more drought tolerant tree species reduces potential for drought-induced forest mortality.
- It can take years to centuries for the disturbance regime to respond to the change in climate.
    - Interaction effects resulted in the fastest response time (< 6 years in 81% of cases),
        - E.g. drought weakens tree defenses, leading to an increased risk of bark beetle outbreak within a few years.
    - Indirect effects resulted in the slowest response time (> 25 years in ~45% of cases),
        - E.g. a forested area becomes progressively drier over time, leading to self-thinning and a reduction in stand density (after many decades), which reduces risk of wildfire.

Forest Disturbance Will Likely Increase in the Future

- Recently documented increases in disturbance are "likely to continue in the coming decades as climate warms further."
    - Studies indicate disturbance activity will increase in all biomes and more for conifer forests than broadleaved and mixed forest types.
- Overall, disturbances from fire, drought, wind, insects, and pathogens are likely to increase, while disturbances from snow and ice are likely to decrease.
    - Fire, insects, and pathogens will increase "regardless of changes in water availability."
    - Drought, wind, and snow will be "strongly contingent on changes in water availability."
- Under *warmer and drier* conditions, most studies show:
    - ↑ fire
    - ↑ drought
    - ↑ insect activity
- Under *warmer and wetter* conditions, most studies show:
    - ↑ wind disturbance
    - ↑ pathogen disturbance

Caveats:

- Longer term effects of climate change on disturbance regimes may be underestimated because the analysis is limited by the length of the observational period used in the original studies.
- The predominance of direct climate effects may be partially due to the fact that they are easier to detect and measure than indirect or interaction effects.
- The majority of observations they analyzed were from ecosystems in North America and Europe, making it unclear whether some of the observed trends (e.g. greater impacts on disturbance in boreal regions) are due to the degree of climate change and ecosystem characteristics or (at least partially) the result of publication bias.
- The scientific literature focused more on fire, drought, insects, and pathogens than the other disturbance agents.
- Invasive alien pests were not considered in their analysis, but will likely play a part in future disturbance change.

Things to Do

Forest management can ameliorate negative impacts from increasing disturbance, by actively promoting the characteristics of resilient forests, and shifting species composition, stand density, and other features in a way that reduces vulnerability to disturbance and ensures that when disturbance (inevitably) happens the damage is minimized.

MANAGEMENT

Addressing changes in forest disturbance is an important part of climate change adaptation. In fact, "Plan for and respond to disturbance" is one of the ten major adaptation strategies proposed by the USDA Forest Service in *Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers*. The approaches they suggest include:

- Prepare for more frequent and more severe disturbances
- Prepare to realign management of significantly altered ecosystems to meet expected future environmental conditions
- Promptly revegetate sites after disturbance
- Allow for areas of natural regeneration after disturbance
- Maintain seed or nursery stock of desired species for use following severe disturbance
- Remove or prevent establishment of invasives and other competitors following disturbance (Butler et al., 2012)

In previous bulletins we have discussed various management actions that can be taken to reduce the effects of specific types of disturbance. For example…

- Building wind firmness in older and developing stands to minimize damage from wind and ice.
- Increasing resilience to future drought events by promoting regeneration of drought-tolerant species and thinning to reduce stand density.
- Reducing fuel loads and forest density to decrease wildfire risk.
- Preparing staff and equipment for increased fire potential.

MONITORING

In addition to active management that reduces the likelihood, severity, or extent of forest disturbance, it will be increasingly important to monitor changes in disturbance regimes such as those outlined in the Seidl et al. (2017) study. We are addressing this need through the Resiliency Assessment Framework, which is currently under development. The major categories of monitoring information that will be collected are related to forests, climate, disturbance, and operations. Potential research questions and example monitoring metrics for disturbance agents are listed below:

	ARE THERE CHANGES IN…	EXAMPLE METRICS
Fire	…wildfire frequency, intensity, or area burned?	Burned area; burn severity; fire frequency
Wind Throw / Storm Damage	… the incidence of wind throw or damage? … microbursts, downdrafts, line storms, tornados?	Frequency or extent of wind damage Storm event date, duration, speed
Herbivory	… level of herbivory (from insects, deer, etc.)?	Area affected; intensity of browse
Ice Damage	… level or extent of ice damage?	Area affected
Pests & Disease	… pest & disease pressure? … new pests or diseases? … forest health impacts from new or existing pests? … insect phenology?	Area affected; outbreak frequency & severity Outbreak timing; life cycles per season
Invasives	… spread or extent of invasives?	Area affected

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