Determining Threats and Conservation Needs for Mature-Old Growth (MOG) Forests: White Paper by Dominick A. DellaSala, Ph. D, Chief Scientist, Wild Heritage
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Purpose and Need

President Joe Biden's Executive Order 14072 directed federal agencies to inventory MOG for "*conservation purposes*." While conservation was not clearly defined in the EO, and the only "threats" singled out at the time were natural disturbances (e.g., fire and insects) and climate change, the field of conservation biology includes specific definitions, methods, and criteria for identifying threats and assigning risk factors applicable to MOG assessments in the context of biodiversity, climate resilience, and ecological integrity needs. Importantly, anthropogenic and natural disturbances should never be grouped together on the same summary graph as in the Federal Register Notice for the ANPRM (see below). This is because there are major differences in spatial extent, frequency, duration, magnitude, and cumulative effects from anthropogenic disturbances vs. natural ones that are either ecologically beneficial when within historic bounds or are in the process of catching up to historical deficits as in the case of wildfires of all intensities. As noted herein, native species have many adaptations that confer resilience to natural disturbances, but many species cannot adapt quick enough to cumulative anthropogenic disturbances that act more like threats than do natural processes. This clear distinction between anthropogenic vs. natural disturbances in assigning risk factors needs to be recognized in the MOG threat assessment. Rather than using a literature cited section, all citations in this white paper are hyperlinked to the original source.

Using Pulse vs. Press Disturbances to Help Define Threats

Pulse disturbances - As the name implies, a pulse disturbance is short-lived change agent that most species are readily adapted and resilient to and that are important determinants of ecosystem community structure and function. Many species thrive in the pulse disturbance environment like large wildfires of mixed severity effects on plant and wildlife communities (i.e., the pyrodiversity begets biodiversity hypothesis; DellaSala and Hanson 2015). An example in this case is a severe fire that passes through a mature stand killing most trees and creates a pulse of biological legacies (dead and surviving trees, seed propagules, shrubs, burrowing mammals, mycorrhizae that escape the heat, etc) (DellaSala 2019). That pulse sustains coarse woody debris and snag/log requirements for decades and it is ecologically beneficial with high levels of biodiversity associated with the ensuing regenerating, complex early seral forest (Swanson et al. 2010, DellaSala and Hanson 2015, DellaSala et al. 2017). Severe fires also provide a pulse of nutrients to aquatic systems that in turn support invertebrate and nutrient productivity spikes within years following the disturbance that are especially beneficial when there are fire-free and logging-free refugia present (Minshall 2003, Jager et al. 2021). Pulse disturbances are not thought of as "threats" per se to species or ecosystems when operating within evolutionary bounds. Out of bounds, they can shift to press or chronic disturbances especially if compounded by anthropogenic disturbances (see Paine et al. 1998).

Press disturbances - as the name also implies, are long-lasting, creating a disturbance "echo" that reverberates through ecosystems for many decades-centuries. An example is postfire logging after a severe fire damages soil horizons (pile burning), natural conifer regeneration is retarded from logs dragged uphill, biological legacies needed to jump-start natural succession are removed, and hazardous fuels remain on the ground that then primes the next fire (Lindenmayer et al. 2008). Typically, press disturbances accumulate spatially and temporally and operate outside the adaptive capacity of species and resilient ecosystem properties. They can lead to compounded ecological surprises (Paine 1998). This figure from Paine et al. (1998) is instructive on how press disturbances may push ecosystems beyond disturbance thresholds.

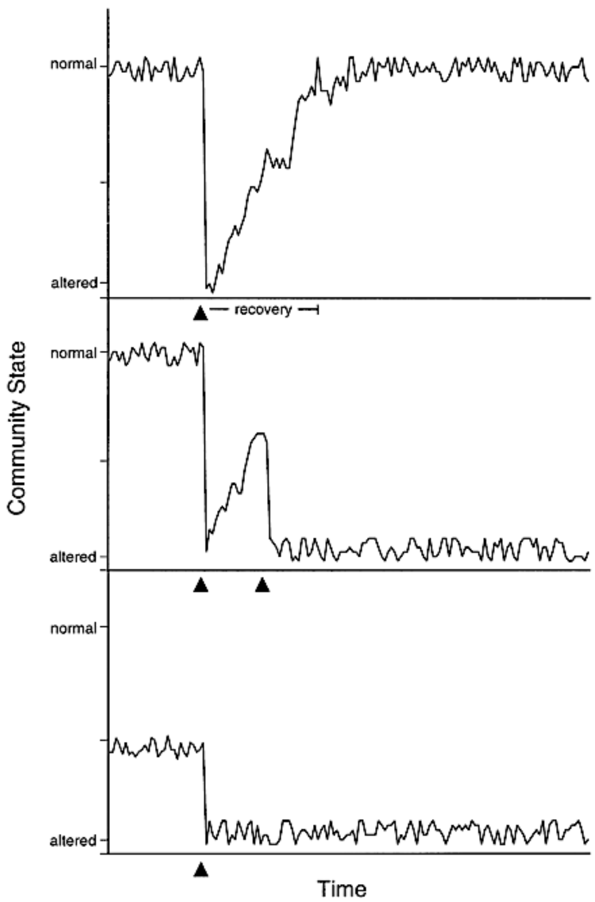
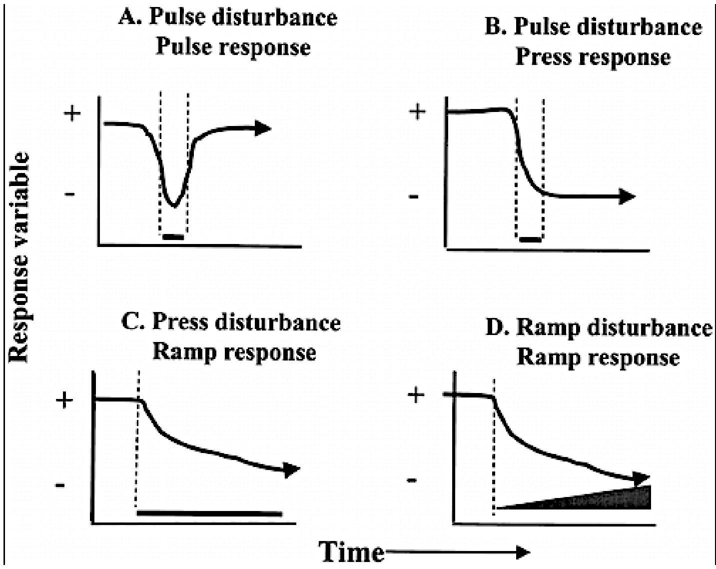


Figure 1. Schematic representation of the effects of large, infrequent disturbances (LIDs) on community state. Top, A normal community is subjected to a single LID and subsequently recovers. Middle, A normal community undergoes a second (or multiple) disturbance(s) before recovery from the first is completed; the combined effects lead to long-term alteration in community state. Bottom, A major disturbance is superimposed on an assemblage already altered by anthropogenic processes or disease; again the combination of stresses leads to long term alteration of community state. Arrowheads mark the disturbances.



This figure from Lake (2000) also illustrates the difference in ecosystem response variables between pulse (natural) vs. press (chronic anthropogenic) disturbance dynamics.

Another example of a press disturbance that accumulates over large areas and across timescales is a site(s) that has been repeatedly logged (e.g., thinned, postfire logged), is accessed by roads with additional or "temporary" ones built that then funnel sediment into streams, and the area is invaded by weeds due to logging machinery, ORVs, and livestock acting as vectors of spread (see DellaSala 2019 for additional examples). Logging, roads, defective culverts, especially on steep fragile soils, also can lead to mass-wasting events during storms. Thus, press disturbances are clear and present dangers to MOG ecosystems and are distinguishable from pulse disturbances.

Threats - based on the above distinction of pulse and press disturbances, we define a "threat" as

any anthropogenic driver(s) of ecosystem change that causes direct, indirect, and cumulative impacts to ecosystem integrity (i.e., native species populations, spatial distributions, ecosystem processes, and functions). This includes human disturbances that accumulate in overall extent, frequency, distribution, and magnitude that push species/ecosystems beyond thresholds/tipping points and create landscape traps (see Lindenmayer et al. 2011) that type convert ecosystems to degraded states. The degree of such impacts should be assessed relative to reference sites/reference conditions (comparable natural areas lacking press disturbances). If pulse disturbances shift to press disturbances, they need to be assessed within the context of anthropogenic causalities and such root causes treated first and foremost (e.g, by removing the stressors).

Notably, logging is often used by land managers mistakenly to mimic natural disturbances but there are major differences that need to be addressed in this assumption. For instance, most natural disturbances generate long-lasting legacies that perform vital ecosystem functions, whereas most forms of logging remove or damage legacies and associated processes. Logging does not mimic pulse disturbances and instead can tip ecosystems beyond thresholds especially when accumulating across time and spatial scales.

In a global analysis of threats, Bowler et al. (2020) concluded that climate change and anthropogenic drivers of biodiversity loss are present worldwide but are unequal in distribution, with several that overlap in the same place (cumulative). Additionally, according to Bowler et al. (2020), "climate change, habitat change, exploitation, pollution and invasive alien species have been recognized as the most important and widespread direct anthropogenic causes of biodiversity change (IPBES, **2019**; IPCC, **2013**; Pereira, Navarro, & Martins, **2012**). These five main drivers have been linked with changes in multiple dimensions of biodiversity, including genetic diversity, species' population sizes, community richness and ecosystem functioning (Pereira et al., **2012**). The impacts of anthropogenic drivers on a biological community in any given region critically depend on the *amount of exposure to each driver*, which is described by its local magnitude or change (such as the strength of climate change or intensity magnitude, and frequency of land-use). An important, but so far underexplored, step towards understanding the global patterns of biodiversity change is *characterizing the exposure patterns of biological communities to different types of environmental change*." In this case, researchers did not consider natural disturbances as a formidable threat.

Several other researchers have defined threats as human activities that reshape biological communities and ecosystem functions and they are increasing globally, triggering the sixth great extinction spasm (Barnosky et al. 2011, Dornelas et al. 2014, Isbell et al. 2017, Bowler et al. 2020). Likewise, global threat assessments (e.g., ecological or human footprint analyses) are anthropogenically focused and do not consider natural disturbances a threat per se. Importantly, meeting the global challenge of conservation (and in this case the conservation of MOG) requires not only quantifying biodiversity loss but also identifying the root causes of such loss, which in the case of MOG is historic and ongoing (albeit lower federal levels) logging (DellaSala et al. 2022a), the only disturbance that land managers can realistically control at scale.

In sum, wildfires and insects need to be considered pulse disturbances and unequivocal evidence provided when they are not operating within evolutionary bounds. We note that the evidence on fire being a press disturbance is indeed equivocal. While some researchers contend contemporary large wildfires ("megafires") are operating out of bounds (e.g., Miller and Safford 2012, Hessburg et al. 2021), others have provided evidence where it is not (e.g., Law and Waring 2015, Parks et al. 2015, Baker 2015, DellaSala and Hanson 2019). This is particularly true for mesic mixed conifer forests (Jaffe et al 2023) and dry mixed conifer and pine forests (Odion et al. 2014a, DellaSala and Hanson 2019) that have been shown to be quite resilient to high severity fires (e.g., postfire "seed rains" are more than enough for pioneer species to jump start succession).

Much of the differences in interpretation of high severity fire effects are due, in part, to an overreliance on fire return intervals derived from limited fire-scar sampling extrapolated over large areas, which has been shown to be biased and unreliable (Baker 2017), the omission of multiple lines of evidence that show otherwise (Baker et al. 2023), plot sampling problems (Hanson and Chi 2021), and failure to account for tree mortality from thinning itself (Hanson 2022).

LANDFIRE departure classes also have been used to assess fire risks, which likewise has been shown to over-estimate high severity fire due to differences between predictions and observations on the ground following fires (Odion and Hanson 2008). Importantly, high severity fire rotations (return of fire over a pre-defined landscape area) are still on the order of centuries, providing ample opportunity for naturally disturbed forests to succeed to old-growth conditions, including with projected climate change related increases in fire severity overtime (e.g., Odion et al. 2014ab). And at least one study has shown that high severity fire patches have not increased in area or proportion of mixed severity fire mosaics since the 1990s (DellaSala and Hanson 2019).

Finally, the tree survivors of beetle infestations carry important survival traits that may resist the next infestation but are often removed in logging operations (Six et al. 2014, 2018). Like fire, insect infestations are pulse disturbances that are increasing in frequency and magnitude in places, becoming press disturbances, due predominately to climate change and homogenization of landscapes from logging (Black et al. 2013). In such cases, treating the root causes - climate change and logging - are the best ways to effectively ameliorate the threat.

Establishing the Baseline for Threat Assessments

Establishing a reference condition or baseline in threat assessments is fundamental. For MOG specifically, there is only one historical map prior that Greeley (1925) published to estimate "virgin" forests before European colonization. Other methods for back casting have often been used in regional studies of primary or MOG forests via potential vegetation mapping that can be used in areas with long-intervals between disturbances.

It is also important to avoid a shifting baseline perspective in threat assessments that occurs when the baseline is inappropriately moved to a more recent period and called "historical." For instance, placing too high a risk on contemporary fire in MOG (mainly high severity) by using a more recent historical timeline fails to take notice of the early 1900s when fire activity was much greater. Instead of the 1900s historical baseline a more recent one - usually the 1980s - is used to track wildfire activity mainly because this is the period when MTBS began tracking high severity fire. Consequently, the baseline is inappropriately shifted to the 1980s instead of a longer and more ecologically relevant historical timeline. Another factor that affects the baseline is back-burning that is often done in burn-out operations and can overestimate high severity fire that could have been triggered by the backburn itself (this is hard to determine given inaccuracies in fire perimeter estimates and incomplete reporting on backburning). Fire severity estimates are also often skewed by using RAVG that has been shown to overestimate high severity fire given some conifers are known to flush needles postfire when they were incorrectly classified as "dead" (Hanson and North 2009, DellaSala et al. 2022a: supplemental).

Conservation purposes - we define conservation as protection of MOG from press disturbances originating from anthopogenic sources. The main restoration treatment in this case is simply remove or greatly contain/restrict the anthropogenic stressors. Some examples include ending commercial logging of MOG that would begin restoring the extent of MOG writ-large. In other cases, it could mean active restoration also to remove the stressor(s) like road ripping (Hanson et al. 2009). While most land managers think of active restoration as some form of logging ('active management'), there are many interventions that are compatible with ecosystem integrity maintenance and restoration that do not involve logging, including upgrading culverts, rewilding landscapes, contributing to recovery of imperiled species, invasive weed containment, etc.

Notably, most assessments of biodiversity loss focus on rank ordering threats to species and ecosystems from anthropogenic factors that are then used to develop robust reserve and connectivity proposals to achieve conservation objectives (e.g., 30 x 30). A relevant example is the chronic loss of MOG nationwide has resulted in numerous, Red-listed ecosystems and Species, many of which are also listed under the US Endangered Species Act (DellaSala et al. 2022a). The conservation imperative in this case (supported by the evidence) is to protect MOG from the main anthropogenic stressors (logging, roads) by designing a robust reserve strategy (e.g., the NW Forest Plan reserves, carbon reserves, Law et al. 2022).

Some examples of large-scale map-based assessments of press disturbances are also available for reference as “ecological footprint analyses” (Sanderson et al. 2002, Venter et al. 2016) and many are specific to the USA, including forest fragmentation assessments that include road densities and logging (Heilman et al. 2002). The MOG threat team needs to incorporate ecological footprint analysis into its threat assessment to show cumulative losses that far exceed perceived losses from natural disturbances.

Conclusions

Based on the above, we strongly advise that you clearly distinguish anthropogenic from natural disturbances in scale, distribution, frequency, magnitude and effect on ecosystem integrity and biodiversity, and that you do not group them all under the “disturbance” or “threat” section of the assessment. For instance, by using a stacked histogram, this figure from the ANPRM assumes all 3 disturbances have equivalent effects on ecosystems, clearly, they do not.

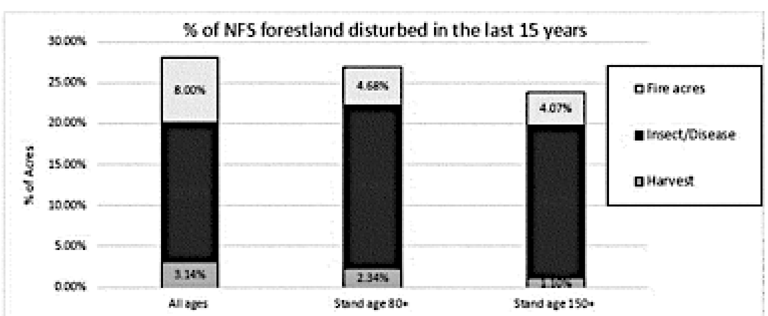


Figure 2. National Forest disturbance has increased over the past fifteen years driven primarily by overstocked forests that are susceptible to insects, disease and wildfire. Forests are also disturbed by timber harvest (these figures include harvest for ecological restoration and fire risk reduction). Most forest disturbances result in different plants, animals, and fungi colonizing an area due to the shift of environmental factors in the area of disturbance.

We request that you provide where possible spatially and temporally explicit (map based) assessments of the amount, type, and rate of MOG logging over time and split this out by land ownership while comparing how much of the federal MOG is in the GAP land-use designations (GAP1-4).

A split analysis of natural disturbance processes (fire, insects) vs. anthropogenic is needed to clearly distinguish species and ecosystem responses and adaptations/resilience potential - i.e., there are winners and losers in natural disturbances and MOG species have numerous adaptations, including at the genome level as the survivors of natural disturbances often contain highly varied gene pools (Baker and Williams 2015, Six et al. 2018). This is not the case for press disturbances that routinely degrade ecosystem integrity and push ecosystems and species to their limits.

We request that you include a MOG patch size and distribution fragmentation/footprint analysis region by region, including a discussion of habitat fragmentation and edge effects from logging and roads. We also recommend that you include a broad sweep of the literature on the ecological importance of mixed and high severity fires and insect outbreaks in regenerating ecosystems and jump-starting natural succession. Federal agencies have a tendency to look only at the negative effects. Logging is often used to reduce fire severity but is most detrimental to MOG functionality and will not work in a changing climate (DellaSala et al. 2022b).

Finally, we are greatly concerned about the consistent misreporting on the role of forest carbon sinks in a changing climate. The latest misinformation was posted in ClimateWire (and Scientific American) and included extensive comments by Lynn Riley (American Forest Foundation) about a USDA forest report on carbon that are not based on best available science of carbon accounting.

The article and USDA report is misinformed for the following reasons and this needs to be considered in the MOG assessment:

1. There is simply no substitute for MOG as long-term carbon sinks. While carbon capture slows as forests mature at the *stand level*, the most important issue is to retain carbon stored for centuries in large trees, foliage, and soils by not logging them (see Mackey et al. 2013 for importance of long-term stores). Cutting down "some" MOG and replacing with young trees is counterproductive and damaging to the climate and ecosystems (Moomaw and Law 2023). It would violate the intent of EO 14072 - to "conserve" MOG.
2. At the *tree level*, the rate of carbon accumulation increases continuously with tree size (Stephenson et al. 2014; Mildrexler et al. 2020; Mildrexler et al. 2023) and thus large trees of all species can be thought of as carbon banks (Birdsey et al. 2023).
3. Logging results in emitting >80% of the carbon stored in forests overtime (Law et al. 2018; Hudiburg et al. 2019), which is far greater than all natural disturbances combined at scale (Harris et al. 2016; Merrill et al. 2018).
4. The carbon costs of global wood harvests and wood substitution costs are far greater than previously estimated (Harmon 2019; Peng et al. 2023); meaning, storing some carbon in wood products is a lose-lose situation and planting young trees is no substitute for the carbon debt created by cutting down MOG (Law et al. 2018; Moomaw and Law 2023).
5. Allowing forests to mature - a process called proforestation (Moomaw et al. 2019), along with protecting existing mature and old-growth forests as carbon reserves (Law et al. 2022, DellaSala et al. 2022a) is the best natural climate solution.
6. Even if forests do switch to a net carbon source from increased climate-related tree mortality, logging them will only exacerbate the rate of carbon released to the atmosphere. This is because nearly all of the carbon in naturally severely disturbed forests transfers from live to dead pools and soils. For instance, nearly all the carbon present in large trees before the Rim and Creek fires in the Sierra Nevada was still present in those trees after these severe burns (Harmon et al. 2022). And carbon in dead pools would slowly (decades-centuries) decompose, much of it would be retained in soils, and new growth would quickly compensate for losses provided those forests are not postfire logged.