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Thinning Combined With Biomass Energy Production May Increase, Rather Than Reduce, Greenhouse Gas Emissions

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PHOTO: *Star Fire 2001, Eldorado National Forest, CA, D. Bevington*

EXECUTIVE SUMMARY

Thinning and energy production from biomass are being increasingly implemented in the Western U.S. as a "win-win" approach to reducing fire risk and replacing fossil fuels.[1] Yet questions and uncertainty about ecological impacts and carbon neutrality are highlighted in recent research. Many assumptions justifying the thinning/ biomass approach need to be substantiated to determine whether they are in fact accurate. Due to the global urgency for reducing greenhouse gas emissions and limiting climate change impacts, wide-scale implementation of forest thinning and energy production from biomass without sufficient scientific support is a highly risky approach to limiting climate change, with potentially irreversible long term impacts to forests. In Western U.S. forests, thinning combined with energy production from biomass is based on two core assumptions: (1) fires are increasing in intensity and/or acres burned and thinning is needed to reduce these fire effects; and (2) when the byproducts (trees and shrubs) of thinning are used to replace fossil fuels for energy production, emissions are reduced. Based on our review of the literature, we conclude that:

- **Wildfire is not increasing compared to historic periods** – Wildfires, including very large ones, for the most part, are not increasing in western forests based on published accounts that use historical baselines. Recent increases (past few decades) in acres burned in places (e.g., Sierra Mountains) are ostensibly due to a climate signal but even those have less fire today compared to historical times when fire was much more prevalent.
- **Large fires are driven more by climate than fuels** – Large fires are mainly controlled by extreme weather events, and extreme events are likely to increase as the climate changes.
- **Most carbon is stored, not emitted, during fires** – Large fires are not currently big emitters of carbon dioxide given that fine fuels, not large trees, are combusted and most carbon remains stored in dead trees on site with sequestration rapidly following re-vegetation post-fire.
- **Maturing natural forests are not accumulating more fuels** – As the time between fires increases in mixed-severity fire systems, this is not necessarily associated with higher fire risk presumably due to shading of combustible understory plants as forests mature. Tree plantations accumulate unnaturally high fuel loads and are the biggest fire risk.
- **Thinned areas and fire outbreaks are unlikely to overlap** – Because fires in any single location are extremely rare, the chance of thinned areas, even over large landscapes, encountering fire within the timeframe that thinning is most effective is very low. Thinning over large landscapes is a net emitter of carbon dioxide. To reduce emissions, thinning should be limited to small trees, areas nearest homes, and plantations.
- **Biomass is "renewable" only over long time frames while drastic greenhouse gas emissions cuts are needed over shorter time frames** – There is a mismatch between the deep and immediate cuts that are needed to prevent catastrophic climate change and the emissions trajectory associated with using biomass for energy production, which immediately releases decades to centuries of carbon stored in forests to the atmosphere and requires many decades of regrowth to sequester that carbon again.
- **Biomass can produce higher CO_2 emissions than coal** – The amount of carbon dioxide released from woody biomass combustion per unit of energy produced is comparable to coal and much larger than oil and natural gas.

INTRODUCTION

Many municipalities, electric companies, and small energy producers are replacing fossil fuel energy production with biomass energy in response to global concerns about greenhouse gas emissions and the negative impacts of climate change. Biomass is often classified as a "renewable" energy source and therefore receiving of various incentives and credits because when trees and shrubs grow back they are able to sequester the carbon that was emitted during combustion for energy. This abundant energy source is seen as a "win-win" because it is often sourced from forest thinning byproducts with the intention of reducing the risk of wildfire. According to the Western Governor's Association,[1] 10.6 million acres are available for "hazard fuel reduction" yielding 270 million dry tons of biomass.

Logging slash near the Greensprings area, southwest Oregon, D. DellaSala

Unfortunately, after quick and often large-scale implementation of biomass energy production in Europe and parts of the U.S., studies are revealing

Rim fire 2013, Stanislaus National Forest, D. Bevington that this approach can result in higher greenhouse gas emissions compared to combustion of fossil fuels, especially within the first few decades.[2] If we are to truly reduce our emissions, as the best science indicates that we must do quickly and substantially, thinning and biomass for energy production may be misguided in many forest systems and especially in fire-adapted forests of the western U.S. as discussed.

Thinning forests to reduce fire occurrence or intensity and using byproducts of thinning in energy production is gaining traction in southwest Oregon[3] and northern California.[4] Concerns have been raised that fires are increasing in intensity and/or area burned and that thinning is needed to reduce these fire effects and related emissions. The byproducts (trees and shrubs) of thinning are increasingly being used as fuel in biomass energy production. Proponents assume such activities are carbon neutral or result in lower greenhouse gas emissions than if these actions were not taken and if fossil fuels were used instead in energy production.

We address many of the assumptions associated with thinning and biomass by reviewing the science and assessing the level of support, including that (1) thinning lowers fire intensity, fire occurrence, and carbon dioxide emissions compared to emissions from wildfire, and (2) biomass is a clean, renewable energy source with lower greenhouse gas emissions than fossil fuels. We examine such claims in relation to best available science to inform managers about whether fuel reduction approaches are ecologically sound and carbon neutral. We caution that based on numerous published studies, improper accounting of carbon and biomass lifecycles could lead to large-scale clearing of forests[5] at a time when enhanced forest growth and reduced deforestation/degradation is needed to combat climate change. Finally, we provide guiding principles for fuel reductions in fire-adapted western forests.

WHAT WE EXAMINED

Thinning in the Ashland watershed, southwest Oregon; photo: D. Odion

In this report, we examine two core assumptions about why thinning is advocated in biomass projects, including it: (1) can be used to lower fire intensity and occurrence and therefore carbon emissions compared to wildfires that are increasing; and (2) biomass produced from thinning can be used as a clean, renewable energy in place of fossil fuels.

CORE ASSUMPTION:
Thinning lowers fire intensity and occurrence, and carbon dioxide emissions compared to wildfires and is needed because wildfires are increasing

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The Chance That a Thinned Site Will Encounter A Fire When Fuels Are Lowest is Slim

The likelihood of thinning treatments and wildfire overlapping in time and space is quite low when the treatment is most effective (<20 yrs[6]). In fact, the chance that thinning will influence fire behavior is based on a number of improbable factors that, in turn, affect emissions, including:

1. Probability of a thinned site encountering a fire when fuels are lowest (<20 years) is only 5–8% based on computer simulations.[7] Similarly, there is just a 2% chance that a thinned site will encounter a severe fire. Therefore, costly fuel treatments would need to be applied every decade or so over large areas in order to keep fuels at lowest levels and even then the thinned sites would have a very low probability of co-occurrence with fire. Repeating fuel treatments increases net carbon dioxide emissions over the life of a project.

2. Thinned sites must encounter a fire during "average" weather conditions when fire intensity is likely to remain low enough to be affected by fuel treatments. Large fires in western forests are mostly driven by severe weather and less so by fuel densities.[8] During severe weather events, even thinned sites will burn.

3. Done incorrectly thinning can actually increase the chance of a severe fire if forest canopies are opened up too much due to increased understory vegetation growth rates, increased surface fuels, (e.g., slash piles), moisture reduction, and greater wind penetrance affecting fire spread.[9] Note – post-fire logging also elevates fuel loads and increases future re-burn potential.[10]

Thinning also decreases carbon storage in a forest and when forests are thinned repeatedly the emitted carbon is never recouped because forests accumulate carbon slowly (decades–centuries) but release much of it quickly in a disturbance.[11]

Forest Fires Are Not Large Emitters of Carbon

Contrary to popular belief, individual fires do not emit large quantities of carbon dioxide to the atmosphere.[12] For all fire severities, most of the vegetation combustion consists of fine fuels, litter and duff, rather than large trees. Even severe fires that kill most of the trees in an area emit only 5–30% of the stored forest as carbon dioxide.[6] Thus, most of the carbon in the burned forest is transferred (stored) from live vegetation to dead trees and is not released to the atmosphere. Lightly to moderately burned areas also continue to sequester (absorb) carbon for decades to centuries while new vegetation in severely burned patches rapidly sequesters carbon. Unless forest fires increase greatly in frequency or severity, they will have little overall impact on carbon dioxide emissions.

High-severity fire on average only accounts for about 12–14% of the total burn area in large fires.[13] Notably, the difference between forest biomass combusted in high-severity crown fire and low-severity fire is small because even in high-severity fire, less than 5% of total stem mass is combusted.[14]

Fires Are Not Increasing in Much of the West Compared to Historical Baselines

The fire regime in most of the fire-adapted low- to mid-elevation forests of the western U.S. is what fire ecologists call "mixed severity," which includes patches of unburned, low, moderate, and severe fire effects (Figure 1).[15] Despite assumptions that fires are unprecedented in this fire severity type due to a build up of fuels, severe fires, the biggest concern of managers and a component of large

"Although wildfire smoke looks impressive, less carbon is emitted than previously thought" Dr. Beverly Law, Prof. Global Change Biology & Terrestrial Systems Science, Oregon State University. Photo: B. Law

mixed-severity fires, have changed little from historical (early European settlement) times based on multiple studies.[16]

Large fires like the Biscuit fire (2002) near Cave Junction, OR and Rim fire (2013) on the Stanislaus National Forest (Sierra Mountains, CA) illustrate this typical fire mosaic pattern that is considered ecologically beneficial.[17] Such patchy fire behavior in the Klamath-Siskiyou region of southwest Oregon, northern California, for instance, has resulted in a diverse mixture of densely stocked forests composed of mixed evergreens (conifers and hardwoods) interspersed with Douglas-fir and ponderosa pine with more open canopy structures and chaparral and oak woodlands at lower elevations as reported in historical accounts.[18] In this region, forests and shrublands have retained most of their former spatial extents and composition, except for developed areas in low elevations. Notably, closed-canopy forests were common historically in places much like they are today.[20] Thus, over-emphasizing thinning to achieve more open conditions, as done in many fuels-reduction projects, may result in novel ecosystems, a loss of moist microclimates, with consequences to forest resilience, soils, and wildlife populations.

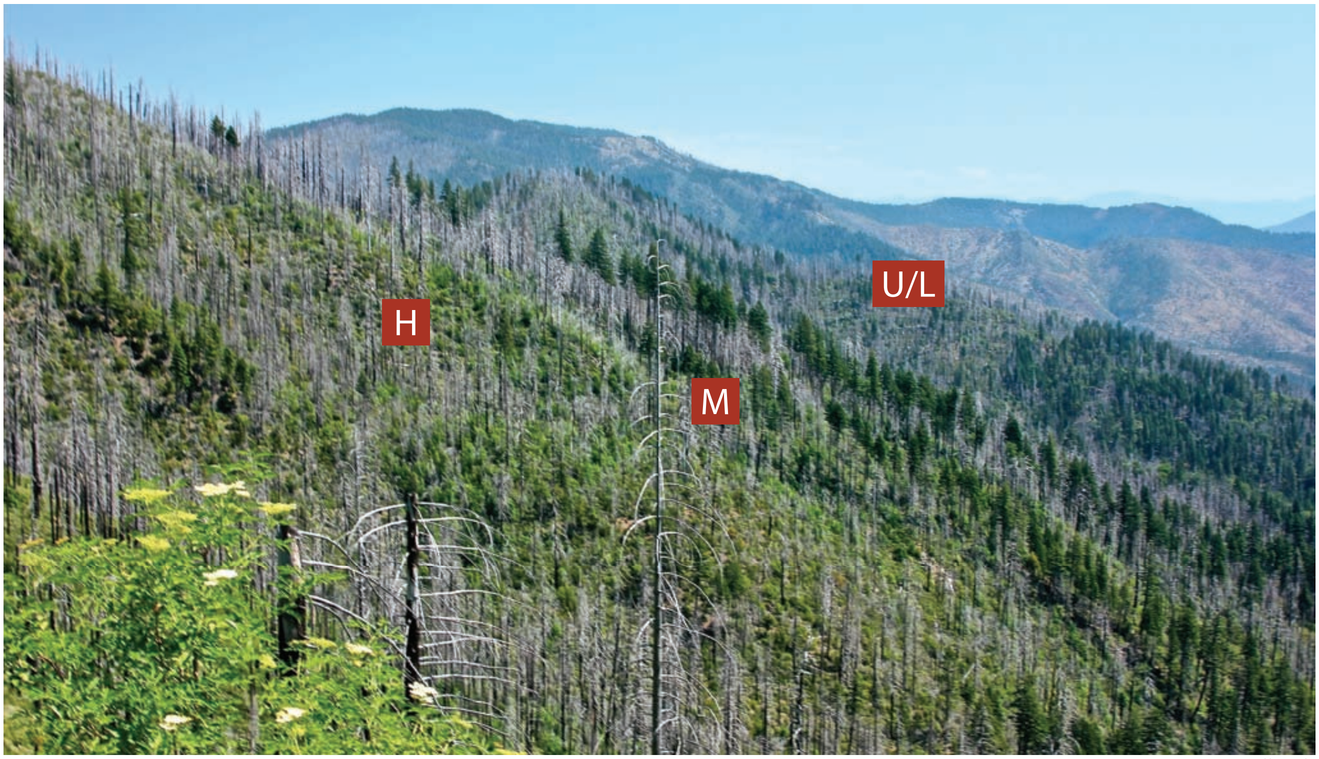

PHOTO: D. DellaSala

Figure 1 Mixed-severity Biscuit 2002 fire, southwest Oregon, taken July 2012. Note patches of unburned/low (U/L), moderate (M), and high (H) severity are typical of mixed-severity fires governed mainly by extreme weather.

Fire Risks Do Not Necessarily Increase As Time Between Fire Increases

Mixed-evergreen forests of the Klamath-Siskiyou region do not show the same fire and fuels relationships as low elevation ponderosa pine forests that they are often compared with in fuel-reduction projects. In the Klamath-Siskiyou, as the time since fire increases, fuel densities and fire severity does not increase, with the exception of plantations where trees are unnaturally dense and fires are severe (Figure 2).[19] This is presumably because as mixed-evergreen forests mature, they begin to shade out more flammable understory vegetation, naturally lowering fire severity. Additionally, because large fires in this region are influenced mainly by extreme weather (climate-influenced fires) and less so by fuels,[20] thinning for fuels reduction (a secondary driver of fire behavior) will become less effective as the fire-climate gets more extreme. Finally, fuel reduction models have been criticized because they have had a tendency to over-predict effects of thinning on fire intensity and they lack empirical testing.[21] Relying too much on thinning to reduce fire intensity using these models is creating a false sense of security that fires will burn in low intensity in what are predominately mixed-severity, climate-influenced systems.

Mixed-evergreen forest, southwest Oregon, Photo: K. Schaffer

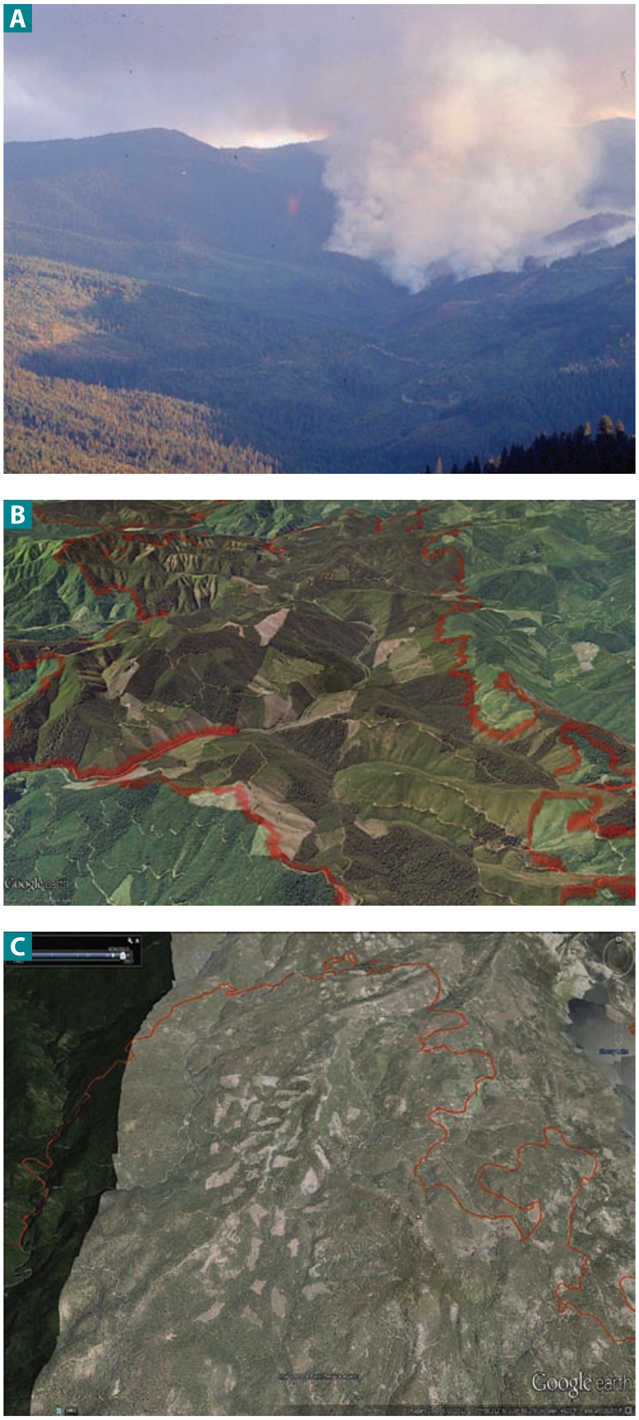

Figure 2 Three views of where fires burned unnaturally severe: (a) Quartz fire 2001, southwest Oregon, burned hottest in cut over lands; (b) Douglas-fire 2013 complex (red border) in southwest Oregon burned hottest in tree plantations; (c) Rim fire 2013(red border), Stanislaus National Forest, burned hottest in the image center where tree plantations were dominant. Fire severity analysis in preparation.

CORE ASSUMPTION: Biofuels are clean, renewable energy with lower greenhouse gas emissions than fossil fuels

> *"… clearing or cutting forests for energy, either to burn trees directly in power plants or to replace forests with bioenergy crops, has the net effect of releasing otherwise sequestered carbon into the atmosphere, just like the extraction and burning of fossil fuels. That creates a carbon debt, may reduce ongoing carbon uptake by the forest, and as a result may increase net greenhouse gas emissions for an extended time period and thereby undercut greenhouse gas reductions needed over the next several decades."* [22]

Burning Woody Biomass for Fuel Emits More Carbon Dioxide than Coal

Biomass is often considered a clean, renewable fuel because, under ideal conditions and over long timeframes, carbon emitted during combustion for energy is re-sequestered once trees regrow. Because wood byproducts from lumber mills and other manufacturing are plentiful and would decompose anyway, there are many situations where energy production from biomass at lumber mills can be carbon neutral. The amount of carbon dioxide released from woody biomass combustion per unit of energy produced, however, is often comparable to coal and much larger than that of oil and natural gas due to inefficiencies in burning wood for fuel compared to more energy-dense fossil fuels.[23] Additionally, it takes decades to recoup carbon removed from a forest for biomass production as some estimates indicate this source of energy would actually release more carbon dioxide emissions compared to coal and natural gas (Figure 3). Biomass emissions would especially accumulate from projects that include shortrotation timber harvests and repeat thinning to keep fuels at low levels (not shown in Figure 3).

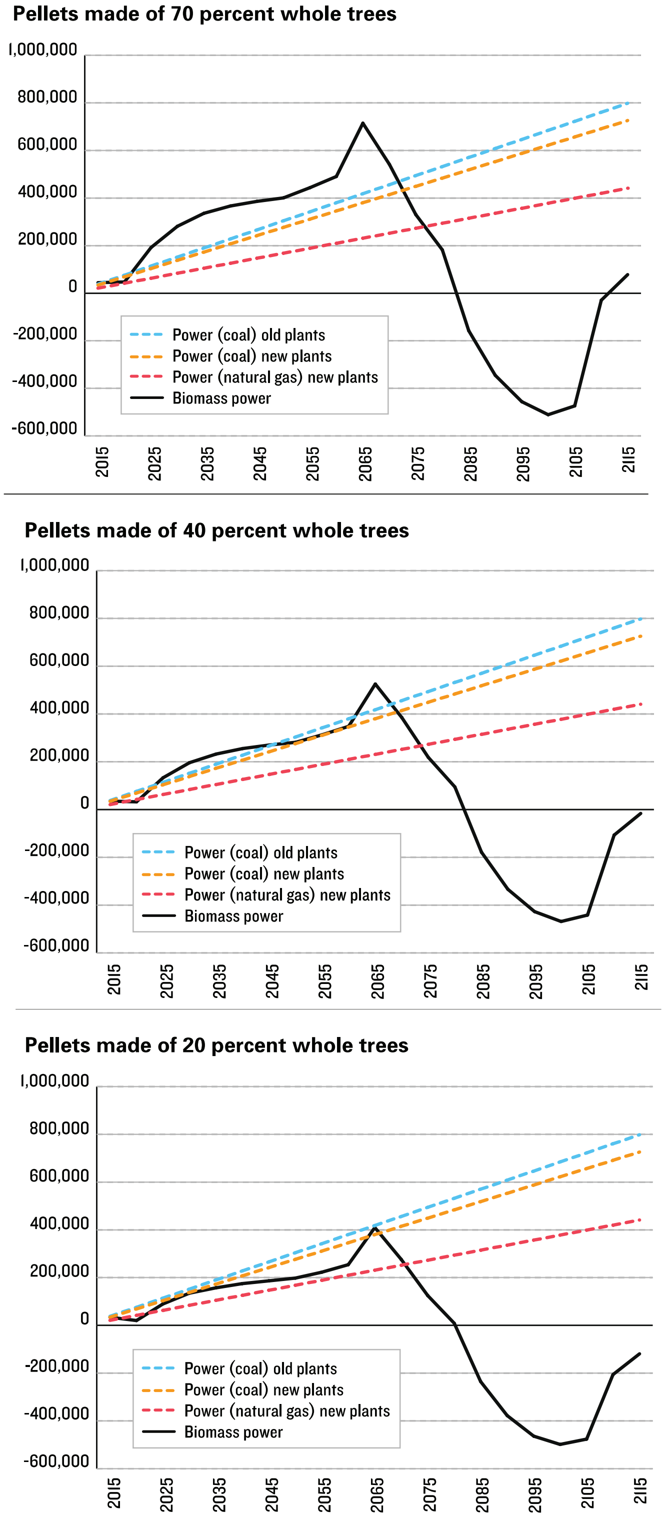

Figure 3 Cumulative emissions (MgCO_2e/MW) from pellets made of various percentages of whole trees (reprinted from NRDC 2015[24]). For the first few decades, wood burning creates a pulse of emissions that rival coal and natural gas production.

Even if the trees are allowed to grow back (if they are not perpetually thinned), the timeframe for re-sequestering the original quantity of carbon conflicts with current policy imperatives requiring drastic cuts in emissions over the near term.

In tree plantations, thinning can benefit ecosystem health and may lead to faster tree growth and carbon sequestration, potentially making the thinning/biomass combination lower in emissions than fossil fuels.[25] A thorough carbon accounting must be done for each particular situation. In sum, the large demand of many biomass plants for "feedstock" and the economics of woody debris removal often lead to whole trees, rather than just woody debris, being removed, chipped, or turned into pellets for combustion that emits more carbon than fossil fuels.

GUIDELINES AND RECOMMENDATIONS FOR THINNING AND BIOMASS

The best way to store carbon in a forest is to protect from logging the older high-biomass forests and increase the interval between timber harvests.[26] For instance, compared to tree plantations, older forests store 3-10 times more carbon than young forests,[27] and continue to sequester at high rates as they mature.[28] Also, if timber harvest rates were lengthened by 50 years compared to status quo logging, carbon stores would increase by 15.[29]

We close with 11 principles for fuel reduction projects qualifying for public incentives based on recommendations modified from conservation groups[30] and 90 scientists submitted to the House Natural Resources and Senate leadership in 2010.[24]

Require full carbon accounting: Assess net carbon flux from thinning and biofuels using published probabilities of treatment efficacy under "average" vs. extreme weather. Invest in carbon flux

Low-elevation fuel treatment, Lomakatsi Restoration Project, D. DellaSala

models[31] and ground verification of fuel models and carbon assessments (accuracy assessment). Independent verification of assessments should be factored into a project's operating costs, much like carbon offset projects.

Assure Sustainability: Production, sourcing, and utilization of biomass must assure the protection of all natural ecosystems (including those on public and private lands), habitat values, and air and water quality and quantity, and must not adversely affect soils or contribute to soil erosion.

Prevent Global Warming & Ocean Acidifying Emissions: Projects must result in lower life cycle, cumulative and net emissions, and ocean acidifying emissions within 20 years and also over the longer term than the energy sources they replace or compete with.

Protect Conservation Land: Biomass must not come from protected areas or agricultural conservation lands including but not limited to any area designated by federal or state governments for conservation purposes such as Wilderness or Wilderness study Areas, old-growth forests, Inventories Roadless Areas, or aquatic buffers except for invasive alien species and for material whose removal is necessary to protect public health and safety (i.e., near homes).

Safeguard Special Ecosystems: Biomass must not come from lands identified at the federal or state level as endangered, rare, or threatened; at the global, national, or state level, such as old-growth forests and native grasslands or other seriously diminished ecosystems such as late-successional stands except for material whose removal is required for restoration of characteristic structure, composition, and function of the ecosystem involved if consistent with the other principles herein and with the regional and local fire regimes and characteristic vegetation of the area.

Prevent Loss of Natural Ecosystems: Biomass removed from lands converted from forests, grasslands or other natural systems into plantations or simplified, intensively managed or cultivated systems shall not qualify for incentives if the conversion occurs after the adoption date of such incentive program.

Protect Threatened and Endangered Species: Biomass harvest must not occur on lands identified at the federal or state level as harboring or potentially harboring any species classified as endangered, rare, or threatened at the global, national, or state level, or is a candidate for such status, except for material whose removal is required for restoration of the species' habitat and protection of the species.

Avoid Toxic and Other Air Pollutants: Biomass energy facilities must not contribute to greater air pollution per unit of energy produced than would result from the energy source they replace or compete with, including, for example, nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulate matter (PM), must not increase local community exposure to such pollutants, and must not be afforded special treatment under the Clean Air Act.

Be Energy Efficient: Biomass energy production must meet strong standards for efficiency in the conversion of biomass to useful energy.

Require Sustainable Procurement: Biomass energy producing facilities must develop and implement a biomass source plan that satisfies the above principles and is capable of supplying the facility for its operational life, accounting for competing biomass demand in the sourcing area.

Prioritize Fuel Reduction Treatments: Fuel reduction is most likely to influence fire intensity during average weather conditions, within unnaturally overstocked tree plantations, and by removal of small trees.[32] Proponents should factor in the likely occurrence of more extreme fire behavior due to climate change, provide realistic estimates of thinning efficacy, and account for collateral damage to ecosystems.

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