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CONCERNING

THE MANAGEMENT OF FEDERAL FORESTS IN RESPONSE TO CLIMATE CHANGE, INCLUDING FOR NATURAL RESOURCE ADAPTATION AND CARBON SEQUESTRATION

I am a research scientist at the University of Washington with a specialization in forest health and climate change. I am also the Executive Director of CORRIM, the Consortium for Research on Renewable Industrial Materials. CORRIM is a consortium that was created in 1996 between fifteen universities to conduct research on the environmental performance of every stage of forest products manufacture from cradle (planting the tree seed) to grave (landfill of solid wood products at the end of their first use). The research conducted by CORRIM uses life cycle inventory (LCI) and life cycle analysis (LCA) techniques which take into consideration the energy balance and carbon emissions inherent in the growth, procurement, manufacture, and eventual use of wood products.

Effective policy for integrating forest ecology, climate, forest management options, and the potential use of products derived from management must account for interactions both inside and outside the forest boundaries. My goal is to provide you with an understanding of how these interactions can be used to develop optimal strategies for natural resource adaptation and carbon sequestration on national forest lands in the face of climate change. My particular emphasis will be on the forests of the western USA.

The factors central to determining optimal carbon management under climate change are:

1. Each forest site has a carrying capacity which dictates the maximum amount of fiber, wood, or carbon that can be stored in that forest. Carrying capacity is determined by site quality, climate, and to a lesser degree the current species mix.
2. Once forests reach their site's carrying capacity there is enormous *stress* on the living trees which manifests itself in insect outbreaks and disease, culminating in the death of some or all of the trees on site. The mountain pine beetle (MPB) epidemic in western North America epitomizes how existing stressors (forests at or above site carrying capacity) interact with subtle shifts in climate to create unprecedented mortality on our National Forest Lands. The spruce bark beetle epidemic in Alaska is another example of the same impact in a different ecosystem. Climate change is impacting our western forests now. It is not a future possibility or probability.
3. Wildfire ignition is random, but the consequences of wildfires are driven by climate, and prevailing weather and forest conditions. Forests that have reached maximum carrying capacity, and which contain large amounts of dead trees, produce conditions for wildfires that are uncontrollable, with devastating consequences to the forest, the adjacent communities, and the budgets of land management agencies.
4. Wildfires generate enormous releases of carbon dioxide and other greenhouse gases. From 2002-2006 wildfires across the entire US, including Alaska, released the equivalent of 4-6% of the US anthropogenic emissions for that same period. The average yearly emissions from the California wildfires alone were equivalent to the emissions of 7 million cars/year for each year from 2001-2007. Extreme fire conditions can render sites infertile or incapable of regenerating future forests, which effectively leads to deforestation.
5. If we apply the precautionary principle, the most risk adverse option we have at the present time is to thin forests that are at risk to reduce wildfire impacts, reduce insect mortality, and build health and resilience against extreme climate conditions that these forests are expected to face in the near future. The cut material can be used as biofuel feedstocks to support energy independence goals and meet renewable fuel and electricity standards. Even greater carbon benefits are possible if the cut wood is used in green building construction. Using life cycle analysis we can identify optimal carbon sequestration and storage options that include forests as part of the broader matrix of national carbon accounts; failure to account for the carbon interactions beyond the forest can lead to counterproductive policies.
6. Grassroots initiatives aimed at addressing forest health, wildfires, insect outbreaks, and sustainability on federal lands have begun. The goals of removing excess fuels and dead trees for use in bioenergy projects, while generating economically viable and sustainable jobs in rural communities and maintaining sustainable ecosystems are laudable. Policies are needed that integrate the knowledge and trust built by local initiatives, support national renewable energy goals, and recognize the inherent ecological carrying capacity of the land and how it might alter under changing climatic conditions.

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Tree growth, competition, and death are governed by known “laws” that have withstood the rigors of scientific investigation for the past 66 years. For example, we have the -3/2 power law (Reineke 1933) which identifies how trees compete, when competition will begin, and when mortality will occur as trees grow, age, and fill the site. Using that law we can characterize each forest site’s carrying capacity, or maximum site occupancy, which is largely a function of soil quality and climate in addition to some interaction with species physiology. Once forests mature, without major disturbances like wind, fire, or insect outbreaks, they fully occupy the site and competition between trees begins. As the forest gets older, eventually growth and mortality reach equilibrium as the trees respond to the resource limits inherent in their site. In effect when a forest stand is mature, it occupies the site at or near maximum carrying capacity. Carrying capacity has historically been measured in tree volume which can easily be converted to biomass and to carbon equivalents. Thus we can estimate the carbon carrying capacity of any forest by understanding the limits of any particular regions soils and climate.

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So what happens when forests are old, the site is fully occupied – at or near carrying capacity - and the climate changes? When we get less precipitation, the soils dry out sooner. These dry soils combined with the hotter and drier summers we have experienced for most of the past nine years in the Inland West have effectively reduced carrying capacity. This generates enormous stress on the trees and you get a pulse of mortality. The mortality agent that is causing the greatest impact is the mountain pine beetle (MPB) – a native insect that kills all pine species found in the western US. The MPB prefers to attack old and stressed trees, and our National Forests are full of old trees. When summers are sufficiently hot and dry enough for these old trees to become stressed, it is a precursor to a population build-up of MPB which eventually manifests as an epidemic outbreak. Since 2000, we have experienced a massive West-wide epidemic that has affected a large percentage of the native pines in Washington, Oregon, Idaho, Montana, Wyoming, Colorado, Utah, New Mexico, Arizona, and California and as far east as South Dakota. A relative of the mountain pine beetle, the spruce beetle, has wrought similar impacts on spruce forests in Alaska. There are pictures in your packet that show the extent of mortality from MPB epidemics across several states where the dead and dying trees are releasing rather than sequestering carbon. Recent research has identified the tipping point that lead to these mountain pine beetle and spruce beetle outbreaks as a shift in climate (Carroll et al 2003, Oneil 2006, Berg et al 2006) but that shift in climate acts in concert with current stand conditions to create the outbreaks that are devastating our forests at the present time. In short, climate change impacts in our western forests are a very serious current reality not a future probability.

In the mid-1990's I was a field forester dealing with MPB and spruce bark beetle (SBB) outbreaks on a regular basis. We did not know it was a climate impact until much later when research scientists, including myself, began to analyze the data and realize that the predictors for these huge mortality events were not necessarily found in the beetle/tree dynamics as had been studied for the prior 30 years, but in the climate. Only in hindsight were we able to see how subtle shifts in average temperature and precipitation masked critical thresholds in winter temperatures in northern latitudes, and extreme summer moisture deficits in more southerly latitudes that tipped the balance in favor of the insect over the trees that were its host. Crossing those threshold values for temperature has led to massive MPB outbreaks in the Inland West at a scale unprecedented in our experience.

Wildfire ignition is random, but the consequences of wildfires are driven by climate, and prevailing weather and forest conditions. Forests that have reached maximum carrying capacity, and which contain large amounts of dead trees, produce conditions for wildfires that are uncontrollable, with devastating consequences to the forest, the adjacent communities, and the budgets of land management agencies.

One consequence of large mortality events associated with MPB outbreaks are devastating and unnatural wildfires that are next to impossible to control. While lightening ignites wildfires more or less randomly, the likelihood of those ignitions producing large uncontrollable fires that kill most or all trees in their path is highly correlated with the underlying forest condition. High levels of prior mortality from MPB were found to increase the likelihood of stand replacing fires during the 1988 Yellowstone wildfire event (Lynch et al. 2006); a result that is also supported by anecdotal evidence from the 2006 Tripod Complex fire that burned over 350,000 acres of National Forests in Washington State's East Cascades within a fire perimeter of approximately 400,000 acres. The fire perimeter for the Tripod Complex had approximately 100 forest inventory and analysis (FIA) plots that comprise the national forest census of which 70% had substantial MPB impact in the prior 5 years (Oneil unpublished data). This fire was estimated to emit 2.1 million tons of carbon dioxide into the atmosphere or the equivalent to the emissions of 1 million Sport Utility Vehicles (SUV's) for 1 year (Mason 2006).

High levels of insect attack are not the only precursor to the largely uncontrollable wildfire events of recent years. Dense forests with multi-layered canopies, large amounts of dead wood, and thick understory vegetation make fire control difficult or impossible under all but the most benign weather conditions. The federal forests of the Inland West are dominated by forests with extensive mortality from MPB and SBB and/or have these dense forest canopies as a result of 50 years of fire suppression making them highly susceptible to uncontrollable wildfires.

Wildfires generate enormous releases of carbon dioxide and other greenhouse gases. From 2002-2006 wildfires across the entire US, including Alaska, released the equivalent of 4-6% of the US anthropogenic emissions for that same period. . The average yearly emissions from the California wildfires alone were equivalent to the emissions of 7 million cars/year for each year from 2001-2007. Extreme fire conditions can render sites infertile or incapable of regenerating future forests, which effectively leads to deforestation.

The carbon released to the atmosphere from increasingly large, uncontrollable wildfire events exceeds our efforts to mitigate emissions. Widenmeyer and Neff (2007) found that the average CO2 emissions from wildfire from 2002-2006 were 213 Tg/yr for the lower 48 states with an additional 80 Tg CO2/yr emitted from Alaska's wildfires which is the equivalent to 4-6% of anthropogenic emissions for those years. In Alaska there are double the CO2 emissions from wildfires than there are from human fossil fuel emissions; in Idaho the CO2 emissions from wildfires are 93% of those from fossil fuels; and in Montana wildfire emissions are 43% of the emissions from human fossil fuel use based on 2002-2006 fire occurrence.

Analysis of California wildfires from 2001-2007 calculates that 277 million tons of CO2 were released by fires and the ultimate decay of the dead trees (Bonnicksen 2009). This is equivalent to the emissions from 7 million cars each year over those 7 years or about half of the registered cars in the state. The figures highlight how the cost of wildfires are much more than just the direct cost of fighting fires, the impacts on communities, human health, and loss of infrastructure. There is an immediate CO2 emissions cost to wildfire with subsequent CO2 emissions from decay that are larger than the fire emissions. Of the 882,759 acres of land where all trees were killed during the California wildfires, an estimate of 86% of the land affected (762,000 acres) will not be reforested with any substantial tree cover within the next century because of regeneration failures (Bonnicksen 2009). This means that the CO2 emissions from fires are compounded by the loss of CO2 sequestration capacity from regenerating forests. The burnt forests are not being replanted and there is little chance for re-establishment of sufficient future forests to offset these emissions without substantial investment in replanting, stand tending, and management. In short, wildfire in these harsh dry environments is creating deforestation just when we most need that tree growth to offset carbon emissions from other sources. As with the MPB climate thresholds that have only been identified within the past decade, there may well be a threshold value that we have not identified yet wherein large areas of current forest become shrub land with much diminished capacity for carbon sequestration because of regeneration difficulties.

As a consequence of successful fire prevention for the 50 years prior to 2000, national census data (FIA) indicate that at present we are storing about double the carbon per acre on federal lands than on actively managed private forests in the Inland West (Oneil et al in review). But we are also burning more acres of federal land than non-federal land. For example 89% of the acres burned in Washington State since 1995 have been on federal lands which make up 53% of total forested acreage. These comparisons are for eastern Washington where over 90% of our wildfires occur.

We know that growing trees is the best carbon mitigation tool we have to transfer atmospheric carbon into sequestered carbon that reduces greenhouse gas concentrations. Trees are the most efficient plants for carbon capture with low demand for water and nutrients relative to the carbon uptake they perform. They also actively sequester enormous amounts of carbon relative to other kinds of crops because of the large amount of above ground biomass. Pacala et al. (2001) estimated that 20-40% of all terrestrial carbon sequestration in the United States occurred in western forests. Because of the significant role of trees in forest carbon sequestration, broad scale tree mortality can turn the forest from a net carbon sink to a net carbon source. Increases in wildfire frequency and intensity that release stored forest carbon could result in western forests becoming a source of carbon rather than a sink (Westerling et al. 2006). In British Columbia, Canada, which is experiencing perhaps the largest mortality event from MPB in all of western North America, the forests are now net carbon sources because of the level of mortality (Kurz et al. 2008). While we think the western US forests are still acting as net carbon sinks, the cumulative impacts of MPB outbreaks and wildfires on the carbon budget are substantial and growing every single year.

If we apply the precautionary principle, the most risk adverse option we have at the present time is to thin at risk forests to reduce wildfire impacts, reduce insect mortality, and build health and resilience against extreme climate conditions that these forests are expected to face in the near future. The cut material can be used as biofuel feedstocks to support energy independence goals and meet renewable fuel and electricity standards. Even greater carbon benefits are possible if the cut wood is used in green building construction. Using life cycle analysis we can identify optimal carbon sequestration and storage options that include forests as part of the broader matrix of national carbon accounts; failure to account for the carbon interactions beyond the forest can lead to counterproductive policies.

Fire impacts can be substantially reduced by thinning treatments that restore densities more like those observed before fire suppression was introduced. Multiple studies have shown that thinning reduces fire severity, sufficient for firefighters to gain control and maintain forest structure, tree seed source, and other values (e.g. Agee and Skinner 2005, Moghaddas 2006, Skinner et al. 2004). After the 2002 fire year, which in hindsight was relatively mild, Dr. Jerry Franklin (ecologist) and Dr. Jim Agee (fire scientist) from the University of Washington offered their perspective on the need for a rationale national forest policy that incorporated ecology, fire science, known benefits of treatment and social benefits. Their perspective is that “Letting nature take its course in the current landscape is certain to result in losses of native biodiversity and ecosystem functions and other social benefits…” (Franklin and Agee 2003).

Coupled with the impacts of current wildfire extent and severity is the very real risk of dramatically increased wildfire extent in the near future as a result of further summer warming and drought. Climate impact studies across the west have identified that future climate will likely double wildfire extent in most areas (McKenzie et al 2004, Littell et al 2009) with some areas experiencing a tripling of the current acres burned which will interact with current forest conditions to increase CO2 emissions from wildfire in the near future. The projected climate impacts, including hotter drier summers, earlier snowmelt with subsequent reduced summer moisture (Westerling et al. 2006), and increasing summer moisture deficits which portend substantial changes in regeneration success at the current forest margins (Littell et al 2009).

Managing federal forests to address the need for increased carbon sequestration and storage, reduced carbon emissions, and adaptation requires an integrated approach that considers the inherent carrying capacity of the land, the fire regime for a specific region and forest type, and societal benefits at local, regional, and national scales. Reducing forest carbon inventories to bring them in line with new estimates of carrying capacity is necessary to increase resilience in the surviving trees, and reduce risks of further mortality from the MPB and other insects. If designed with multiple goals in mind, thinning treatments can also provide better options for wildfire control, restore forest structure, maintain critical habitat, and adjust for the overstocking that has occurred because of 50 years of fire suppression. Optimal thinning strategies will vary by region, forest type, and fire and insect risk. In ecology, one size does not fit all: the kinds of treatments needed in the dry interior west to address climate change and carbon storage are quite different than what is needed at high elevations or in coastal forests. Using local expertise coupled with grass roots input from concerned citizens can ensure that the activities are sustainable over the long term. The result can be at least a triple win scenario with improved habitat, reduced carbon emissions and avoided future wildfire fighting costs.

Paying for these management interventions to reduce fire severity and risk, and to reduce forest densities so as to reduce stress on remaining trees, is a challenge during our current budgetary crisis. There is a huge opportunity to use the material that must be removed from Inland West federal forests to allow them to adapt to climate change. That excess material is a carbon dense renewable feedstock that can be used for meeting energy independence goals under EISA (2007), the renewable fuels standard (RFS) and/or the renewable electricity standard (RES).

Thinning forests can offset carbon emissions from fossil sources if used for energy production either by producing liquid transportation fuels or electricity generation. Based on life cycle analysis conducted to ISO 14044 standards, CORRIM has found that an even better choice from a carbon perspective is to produce products that store carbon and substitute for fossil energy intensive products made of steel or concrete (Perez-Garcia 2005, Milota et al 2005). For example, a ton of wood in engineered wood floor joists displaces 7 tonnes of CO2 emissions when substituted for a steel floor joist. This is approximately 7 times more beneficial from a carbon accounting perspective than burning the wood for energy. CORRIM is currently conducting additional life cycle analysis of woody biomass for an array of bio-fuels, processing technologies, and material inputs to determine the optimal uses of these renewable fuel feedstocks from a carbon perspective.

As climate change and carbon sequestration are global issues, accounting for only the carbon interactions in the forest without consideration for the wildfire impacts, the ultimate use of potential forest products that can be removed to reduce fire and insect impacts, and current and future societal needs for energy and building products is like a bank measuring only debits without consideration for credits. Losing the carbon that trees sequester to insect epidemics and wildfire under the guise of naturalness or the precautionary principle, not only emits carbon, particulates, and other greenhouse gases to the atmosphere, it is a lost opportunity to store that forest carbon in buildings where the risks of wildfires are largely absent. It is also occurring at a time and on a scale where the increasing rate of CO2 emissions portends a threshold, or tipping point, that may exacerbate current disturbance trends and subsequent opportunities for management, sequestration, and fire control. In essence, forest thinning operations that reduce fire severity and risk are the most risk adverse option we have at our disposal at this time.

Grassroots initiatives aimed at addressing forest health, wildfire, insect outbreaks, and sustainability on federal lands have begun. The goals of removing excess fuels and dead trees for use in bioenergy projects while generating economically viable and sustainable jobs in rural communities and maintaining sustainable ecosystems are laudable. Policies are needed that integrate the knowledge and trust built by local initiatives, support national renewable energy goals, and recognize the inherent ecological carrying capacity of the land and how it might alter under changing climatic conditions.

As a forester, there is nothing worse than losing your stands to insect attack or fire and in the process losing all the values cherished by your local rural community. If the nearby federal forests, under the guise of naturalness, are not managed, except to suppress fires when they threaten structures, private and other public landowners have no control in preventing the insect invasions and wildfires that start on federal lands but then spread to nearby private and state lands with equally costly and devastating impacts. The degree of interest in the topic of federal land management to reduce these impacts and risks along with the potential to provide resources for bioenergy initiatives is substantial. Recently a large constituency spent three days discussing the issues around biomass utilization in their communities and their region at the Plum Creek Conference on Forests and Energy at the University of Montana. As a speaker at that conference I was thrilled to see the level of interest, integrity, care, and sincere appreciation for the complexity of the task ahead. No one wants to see another 'timber war' or extractive industry with little thought to long term sustainability of the federal lands in their region. But neither do they want to see their backyard go up in flames as the forests around them succumb to MPB and then burn as they were during the conference in September. This fire was particularly notable as it burned vigorously despite record breaking rainfall during the prior month.

Many members of the audience at that conference were already working diligently with local USFS managers to devise plans that would produce not only sustainable forests, but sustainable livelihoods for local people. In the process they are building trust, crafting community, and with the appropriate top down policies that recognize the need to manage these forests and make a living, they will also be able to provide renewable energy that will help to meet the energy needs and greenhouse gas reduction goals outlined in federal policy.

Summary

We have experienced a decade of unprecedented mortality in our western forests, and much of that mortality is concentrated on federal lands. Broad scale mortality means that forests are emitting carbon rather than sequestering it, thus exacerbating our current greenhouse gas emissions profile. The current rate of mortality is unsustainable and may well lead to a tipping point wherein additional uncontrolled damage can be expected. It is doubtful that any one scientist or group of scientists has any idea where that tipping point is and what reaching it might cause. With policies and management approaches that pull us back from that brink by reducing risk and building resilience we can ensure that these forests remain a part of our heritage and serve a vital role as carbon sinks into the future.

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