The Carbon Implications of Western Forest Health and Wildfire Conditions

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The United States is caught in a greenhouse gas (GHG) emissions dilemma as well as an ecological and financial disaster in the western wildfire situation. This region, composed of almost 308 million hectares in 11 States, is almost half (143 mha) managed by the Federal government (USDA-NRCS 1999). The region is largely rural, with some 104 million acres (42 mha) of forest in the National Forest System (Powell et al. 1993). Over one-third (39 million acres, 16 mha) of those NFS forests have been identified as being seriously outside historical ranges of ecological conditions, indicating that when they burn, they risk losing significant ecosystem components or processes (Hardy and Bunnell 1999). In plain terms, these forests have fuel conditions that can support a fire so severe that the ecosystems may be damaged in long-term or permanent ways if a wildfire is allowed to burn. And, unless they are treated to reduce fuels and improve forest health, wildfire is a near-certainty at some future date.

The most pervasive influence on Western forest conditions has been fire exclusion in the 20th Century. The effect has been most pronounced on the forest types that historically experienced frequent, low-intensity wildfires (Agee 1998). These ecosystems, in a climate that is dry in the summer and cold in the winter, produce more biomass than can be recycled by decomposition alone (Harvey 1994). Low-intensity fires once provided this recycling, ranging annually over large areas, producing a patchy forest pattern that affected subsequent fires. A century of fire exclusion has resulted in a convergence, or filling-in, of this patch structure, so that large areas are now very similar. When wildfire strikes those areas, much larger fires produce more uniformly severe effects (Neuenschwander et al. 2000).

Forest Types of the West

About 55 recognized forest types exist in the West, with over 80 percent of the total unreserved forest area characterized by five forest types (Table 1).

Table 1. Unreserved forest land (in thousands of acres), all productivity classes and all owners, Western United States (1997 RPA, Table 9).

	Pacific Northwest		Pacific Southwest[a]		Intermountain		Western States	
Forest Type	Area	Percent	Area	Percent	Area	Percent	Area	Percent
Pinyon-juniper	2,552	5.59	1,461	4.28	42,927	35.67	46,940	23.46
Douglas-fir	17,237	37.77	1,979	5.80	17,860	14.84	37,076	18.53
Ponderosa pine[b]	7,095	15.55	7,327	21.47	15,245	12.67	29,667	14.83
Western hardwoods	5,210	11.42	9,186	26.91	13,303	11.05	27,699	13.84
Fir-spruce	4,294	9.41	2,946	8.63	14,617	12.15	21,857	10.92
Lodgepole pine	2,426	5.32	166	0.49	10,499	8.72	13,091	6.54
Chaparral	235	0.51	4,386	12.85	126	0.10	4,747	2.37
Other softwoods	232	0.51	5,136	15.05	2,619	2.18	7,987	3.99
Non-stocked	900	1.97	697	2.04	617	0.51	2,214	1.11
Hemlock-Sitka spruce	5,108	11.19	11	0.03	1,510	1.25	6,629	3.31
Larch	287	0.63	0	0.00	889	0.74	1,176	0.59
Redwood	6	0.01	732	2.14	0	0.00	738	0.37
Western white pine	54	0.12%	105	0.31%	131	0.11%	290	0.14%
All Forest Types	45,636	100.00	34,132	100.00	120,343	100.00	200,111	100.00

[a] Hawaii is included in this regional summary. Its 1.6 million acres of unreserved forests are classified mainly as western hardwoods.

[b] Jeffrey pine is included with ponderosa pine, mainly in the Pacific Southwest.

The existing forest data says very little about forest health or condition. Where it shows timber in the 5-to-7-inch size category, for example, it is not known whether these are young forests growing freely to become larger trees, or old, stagnated stands that will not grow before insects or fire kills them. As the area of stagnated stands grows larger under non-management, this distinction becomes more important.

A recent study of historical vegetative conditions compared to current conditions arrived at estimates of forest types that are significantly outside their historical range of variability (Hardy and Bunnell 1999). Forest condition was described by three categories:

Condition 1—The ecosystem is largely intact and functioning in historical patterns. It may be subject to wildfire, but the disturbance patterns and severity should be fairly normal.

Condition 2—The ecosystem has undergone moderate changes, and conditions have shifted toward a less resilient system. A wildfire disturbance may or may not cause the loss of ecosystem components or processes.

Condition 3—The natural, historical disturbance regime of the ecosystem has been significantly altered, and the current condition predisposes the system to major changes, including the possible loss of key components or processes.

Condition 3 describes places that are a concern to economic, environmental and national climate policy. Table 2 highlights the fact that by far the largest category of Condition 3 on the National Forests includes land with historical fire regimes that featured return intervals of 0 to 35 years and low-severity fires. That category is dominated by the ponderosa pine and dry Douglas-fir forests, reinforcing the conclusion that it is these forest types that are at greatest ecological risk.

Table 2. Estimated amount of forestland in the National Forest System, Western States, by historical fire regime and current condition, 1999.

Historical Fire Regime	Condition 1	Condition 2	Condition 3	Fire Regime Totals
0 – 35 years; low severity	4,846,406	23,719,091	24,158,447	52,723,944
0 – 35 years; stand replacement	762,311	621,459	284,168	1,667,938
35 – 100+ years; mixed severity	14,242,726	23,535,004	6,177,545	43,955,275
35 – 100+ years; stand replacement	3,689,236	830,755	7,561,081	12,081,072
200+ years; stand replacement	14,829,079	1,030,166	1,132,111	16,991,356
Condition Class Totals	38,369,758	49,736,475	39,313,352	127,419,585

Source: Hardy and Bunnell 1999.

Note that Table 2 is limited to the National Forest System. Thus, it does not include significant areas of land managed by other federal and state agencies, as well as private owners. So, while it is a large area, it presents a conservative estimate of the total amount of forest likely to burn in the near future.

The current condition of these high-risk forest areas is a result of past and current management – of that there is little controversy. The challenge now is to return them to a more ecologically stable state (Sampson 1992). Some propose to allow nature to take its course. Because past management was part of the problem, this argument goes, future management might make matters worse. Others argue that past management has provided lessons upon which future management can be based. Because of the enormous amount of fuel involved, the inevitable result of "letting nature take its course" is fire severity that can damage soils and watersheds, set ecosystems back into degraded conditions and slow forest recovery. From this perspective, the future is best served by management actions that improve the chances for the forest to be more tolerant of future wildfire conditions, preferably to the point where the forest ecosystem is sustainable long into the future (USDA Forest

Service 2000).

In 2000, there were over 5 million acres (2.1 mha) of wildfires reported in the 11 western states by November 11, near the end of the annual fire season (Table 3, NIFC 2000). Those wildfires demonstrated how a dry summer can produce major events, and since there have been 4 such summers in the last 10, dry conditions are to be expected. We don=t know how much of the 39 million acres of at-risk National Forests burned during the 2000 fire season, but since many of the fires were in grass and shrub systems, and some of the burned forests were high-elevation forest types that are generally within their historic range of ecological conditions, the best guess is that the at-risk forest systems only accounted for some 1-2 million acres. If that=s the case, the region still has 35-40 million acres ready to burn in wildfires that are likely to produce high-severity impacts.

Table 3. Year 2000 wildfire acres by State, as of 11/10/2000, with estimate of fuel type consumed.

			Forest		
State	Grass	Shrubs	Open	Dense	Total
Arizona	17,107	25,661	17,107	25,661	85,537
Colorado	12,675	38,024	38,024	38,024	126,745
Idaho	128,292	128,292	128,292	898,043	1,282,918
Montana	95,012	95,012	190,024	570,072	950,120
Nevada	190,723	127,148	190,723	127,148	635,742
New Mexico	103,834	155,751	103,834	155,751	519,171
Utah	46,816	93,632	46,816	46,816	234,079
Wyoming	55,747	83,621	83,621	55,747	278,736
California	23,467	46,934	46,934	117,335	234,669
Oregon	47,768	95,536	47,768	286,607	477,678
Washington	25,678	25,678	51,355	154,066	256,777
Total	747,118	915,288	944,497	2,475,269	5,082,172

Those high-severity impacts include not only the short-term emission of CO_2, CH_4, and other greenhouse gases in the burning of some 10 to 80 tons of forest biomass per acre, but a longer-term emission from the burned lands as blackened soils heat up, soil moistures are higher due to lower plant uptake, and soil organic carbon that was not emitted by the fire=s impact is emitted due to accelerated microbial decomposition (Neuenschwander and Sampson 2000). In addition, these soils sometimes suffer significant erosion from rainfall prior to re-vegetation. Research suggests that up to 20% of the soil organic carbon that is displaced in the erosion process is emitted, while the rest may be re-distributed to lower landscape positions or water bodies (Lal et al. 1998). Finally, where soils are degraded by high-severity fire, recovery of the forest ecosystem may be delayed or, in the worst cases, prevented. Soils degraded too seriously may even enter into a desertification decline, although the extent of that phenomenon in relation to these wildfires has not been estimated.

In national estimates of forest carbon flows, periodic forest inventories have been used to estimate the net growth or decline of forest biomass, which indicated annual carbon flux. These national estimates miss many of the GHG impacts described above, because of their focus on growing stock and their inability to estimate post-fire and soil emissions. They also rely on an underlying assumption that burned forest systems will respond in a normal fashion in the post-fire years. The frequency of the field inventories (many are 10-15 years old), coupled with the recent sharp increase in wildfire events, means that they may underestimate the impacts due to reliance on older trends. The emissions from wildfire in the national reports appear to range somewhere around 15-20 million tons C per year more than national reports have estimated, and in a year like 2000, the difference could be as much as 40-50 million tons (Sampson 1997).

To test the extent of recent events, the fire data from the 2000 fire season were used as the basis for an emissions estimate. Such an estimate requires input data that are not collected in fire data reporting, so must rely on judgment estimates. The most important piece of missing information is the amount of fuel consumed in the fires. Pre-fire fuel loading surveys from which accurate post-fire estimates can be made seldom exist. To create the estimate, the fire acreage was divided into four fuel categories: (1) grass land; (2) shrub land; (3) open forest; and (4) dense forest. Average fuel consumption for those categories was estimated at 5, 10, 20, and 50 tons of biomass per acre, respectively (Neuenschwander and Sampson 2000). The fire area for the western states was then divided into those fuel groups, based on knowledge of the region and the general locations of the largest wildfires (Table 2). A more accurate estimate could be made from a map of fire areas that could be compared to the coarse-filter vegetation maps available for the region. Such an overlay would still, however, provide only coarse-filter estimates.

The estimates of biomass consumption were converted in GHG emission estimates, on the basis that about 45% of the dry biomass consumed is emitted as CO or CO_2, while CH_4 emissions are 0.006 tons per ton consumed (Table 4). The estimate suggested around 70 million tons of CO or CO_2 emissions and around 933 thousand tons of methane emissions. Using the factor of 21 for the Global Warming Potential (GWP) of methane, the total was an estimate of around 75 million tons of carbon equivalent (MTCE) for the wildfire emissions in the 11 western states in the year 2000.

Table 4. Estimate of GHG emissions from the year 2000 wildfires in the 11 Western United States.

			Forest		
	Grass	Shrub	Open	Dense	Total
Acres of wildfire estimated	747,118	915,288	944,497	2,475,269	5,082,172
Biomass consumed per acre	5	10	20	50	
Biomass burned (tons)	3,735,590	9,152,876	18,889,942	123,763,470	155,541,878
C release in CO & CO_2 @ 45%	1,681,015	4,118,794	8,500,474	55,693,562	69,993,845
CO_2 release @ C * 44/12	6,163,723	15,102,245	31,168,404	204,209,726	256,644,098
Tons CH_4 released @ 0.006 tons/ton	22,414	54,917	113,340	742,581	933,251
MTCE in CH_4 @ 21x CO_2	128,368	314,526	649,127	4,252,963	5,344,985
MTCE in CH_4 and CO_2 releases	1,809,384	4,433,320	9,149,601	59,946,524	75,338,829

While this estimate contains significant uncertainty, it indicates the potential for major GHG emissions in the western U.S. As uncertain as it is to project future wildfire events, the basic ecological situation in these Category 3 forests suggests that those that remain untreated are in a highly unstable condition that will almost certainly lead to wildfire within a decade or two. If 40 million acres of forests were to burn within 20 years, the result would be an average annual emission rate of around 75 MTCE. In other words, the high emissions rate experienced in 2000 could become the average rate in the future unless major actions to reduce fuel loading and improve forest health are undertaken.

The dilemma is that just as the world is seeking to reduce GHG emissions due to increasing concern over global climate change, millions of acres of inland western U.S. forests are set to emit a major GHG pulse from wildfires that are a direct result of the hundred-year experiment with forest management based on timber harvest and fire suppression. The question is not whether these forests will burn if left untreated, but when, and at what levels of intensity and severity.

The resulting challenge is both political, since there is considerable opposition to carrying out forest treatments on the public forests of the West, and economic, since much of the material that needs to be removed from these forests will not be merchantable in current industrial markets. The most likely means for disposing of this excess biomass safely would be a rapid and major expansion of the biomass energy production capacity in western forest regions. While both electricity and liquid fuels are technically feasible as products from this biomass, the current low prices of natural gas and coal mean that biomass production is not competitive in the market. One answer would be a major national program to subsidize biomass energy, using the rationale that it would provide a least-cost way to do necessary forest health treatment while providing significant offsets against fossil fuel combustion. The chances of such a policy emerging, in light of the current administration's energy policy proposals and lack of attention to climate change seem, however, sadly remote.

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