<u>Questions for the Record for Dr. Thomas Swetnam:</u>

Questions from Chairman Jeff Bingaman:

1. A number of the witnesses mentioned that logging and grazing have contributed to the accumulation of fuels that are contributing to these fires. Can you briefly explain the process by which logging and grazing results in the accumulation of fuels?

Intensive livestock grazing was an important cause of reduction in surface fire occurrence in many Western forests. This effect occurred primarily during the late 1800s and early decades of the 1900s. Very large herds of sheep, goats, cattle and horses removed the grass cover in under stories of ponderosa pine and mixed conifer forests. In 1890, for example, there were more than 5 million sheep and 1.5 million cattle in New Mexico! Prior to this intensive livestock grazing era, more-or-less continuous grass cover promoted fire ignitions by lightning and people, and extensive spread of these fires. Grazing and the creation of livestock trails and "driveways" effectively disrupted the fire ignition and spread process. The sheep industry declined after the First World War, and after 1910 the U.S. Forest Service also began to fight forest fires aggressively, and to reduce overgrazing on federal forest lands. During the subsequent century, lack of frequent surface fires in ponderosa pine and mixed conifer forests allowed many trees to establish and dead fuels (tree needles, branches, logs, and snags) to accumulate. This general history did not occur everywhere in the West, but it was fairly typical in the Southwest and in many pine-dominant and mixed conifer forests of the Sierra Nevada, and inter-mountain regions (Swetnam and Baisan 2003). This effect of livestock grazing, fire suppression, and subsequent fuel accumulation was generally not important in relatively higher elevation, wetter forests, such as spruce-fir and lodgepole pine forests. Grass cover was much less extensive in these forest types, and typically large fires only occurred at long intervals (>100 years), so fire suppression has had less or no effect here in lengthening the intervals between fires (Schoennagel et al. 2004).

Logging (tree harvesting) has a highly variable effect on fire activity. Again, the effects depend on forest type, region, and the kind of management practices employed. It is generally thought that extensive, unregulated logging practices in the late 19th century and early 20th century were a contributing factor to the enormous and destructive wildfires that occurred during this part of the settlement era in the Lake States and West. Some of these massive, historic conflagrations were noted by Senator Domenici in his statement at the beginning of the hearing (for example the Peshtigo Fire of 1871). The unregulated 19th century harvesting, and some modern harvesting in the 20th century, produced massive quantities of surface fuels, deriving from untreated residual branches, tree leaves/needles and boles. These fuels contribute to fire ignition, spread, and unusual fire severity. Although this type of logging – where residual fuels are generated and untreated – has contributed to increased fire extent and severity in some places and times, logging (and thinning) practices can lead to reduced fire hazards when the residual fuels are treated, e.g., by hauling them away or burning in situ in piles or by broadcast burning. There is a building body of scientific evidence supporting the general strategy of forest thinning and prescribed fire as a means of reducing wildfire severity and damaging effects in some western forests (e.g., Schoennagle et al. 2004, Finney et al. 2005, Cram et al. 2006, Omi et al. 2007). The recent Omi et al. study, in particular emphasized the importance of treating surface fuels, and not just reducing overstory tree densities. Again, I would emphasize that such fuels treatments (e.g., thinning) are ecologically appropriate in forests that formerly sustained frequent surface fires, had relatively low tree densities and low accumulated surface fuels, but now have much higher tree densities and accumulated dead fuels. From an ecological perspective, however, such treatments are not justified in wetter, higher elevations forests where frequent surface fires were not a natural occurrence (Schoennagle et al. 2004).

Another effect of logging on fire activity is related to the extensive road building associated with logging. Vast networks of roads built to accommodate logging have allowed many more people to travel into remote areas, and it is likely that this greater access has allowed more human-set fires to occur in these places.

2. You mentioned at the hearing that you believe that thinning should generally focus on small-diameter trees. What is the scientific rationale for focusing on small diameter trees?

To reduce fire hazards in forests that previously sustained frequent surface fires (i.e., before intensive livestock grazing and active fire suppression began) the primary emphasis should be on thinning relatively smaller diameter (often younger) trees (Allen et al. 2002). This emphasis is a rather obvious and logical strategy in most of these forest types where past management practices have led to extreme forest structure changes and hazardous fuel accumulations. For example, many ponderosa pine and mixed conifer forests in the Southwest and elsewhere in the West have extraordinarily dense “thickets” of relatively small diameter trees. It has been shown in studies that the vast majority of these small diameter (and often stunted) trees established in these forests as a consequence of and following the disruption of frequent fire regimes by land use practices (e.g., livestock grazing and active fire fighting) (e.g., Fulé et al. 2002). In some cases the stem densities of these stunted tree thickets exceed 5,000 stems per acre (Falk 2004). Moreover, it is clear from fire behavior modeling and observational studies that these dense thickets are an important contributing factor in generating unnaturally severe crown fire behavior in some forests (Cram et al. 2006, Cruz et al. 2006, Allen 2007). It is also generally the case that larger diameter, older trees, are relatively rare in most forest types as a consequence of natural mortality patterns, and because of extensive harvesting of large trees in the past century. Hence, there are ecological, silvicultural, esthetic, and scientific reasons to focus primarily on thinning smaller diameter trees, and to thin (or harvest) larger diameter, older trees sparingly and judiciously (if at all) in these forest types I am referring to.

In my view, it is an unnecessary and counter-productive point of contention for federal agencies, timber industry interests, or forest scientists to insist that specific diameter caps should never be imposed in thinning treatments. It is quite clear that a focus on thinning of the relatively small diameter stems will often and substantially reduce the risk of unnaturally severe fires in these forest types. Importantly, focus on the smaller diameter trees will also reduce contention and challenge of such treatments by concerned citizens and non-governmental organizations. Moreover, it is critical that resulting fuels generated by such thinning be treated by removal (by burning or hauling off site) (Omi et al. 2007). It is important to note here that I use the phrase "small diameter" trees in a relative sense, and specific to forests where natural surface fire regimes were disrupted. The diameter range of trees in high density groups in productive Sierra Nevada forests may be considerably larger than the diameter range of thickets in lower productivity Southwestern forests.

I would also clarify that I am not opposed to traditional forestry practices that involve either even aged or uneven-aged management or rotation-based silvicultural designs in appropriate areas and circumstances. I am trained as a forester myself, and my father was a District Ranger with the U.S. Forest Service for 35 years. However, I believe that in the context of reducing fire hazard in forests where thickets of small diameter trees are a primary cause of increased hazards (i.e., a substantial part of the problem in the West), a focus on small diameter trees makes eminent sense.

3. Your testimony mentions the possibility that global warming could result in "more-or- less permanent 'dust bowl'-like conditions in the Southwest." Are there any indications in the historical or pre-historical records of what that might mean for wildfire activity in New Mexico?

My reference to the potential for a transition to "more-or- less permanent 'dust bowl'-like conditions in the Southwest" was based on the recent paper published in the journal Science by Seager et al (2007). They hypothesized this potential under a scenario of increasing greenhouse gases and continued global warming, and the modeled and observed effects of ocean-atmosphere patterns on regional climate. The most extreme droughts in the past century in New Mexico were the "turn of the century drought" (1890s), the "Dust Bowl drought" of the 1930s, the "1950s drought" (late 1940s to about 1957), and the current drought (since about 1998). The tree-ring record of drought in the Southwest is very extensive, and perhaps the best documented drought history of this type for anywhere in the world. Good quality tree-ring-based drought reconstructions cover all of New Mexico and the broader Southwest over the period from about AD 1500 to present, and some locations have histories extending back nearly 2,000 years (Ni et al. 2002, Cook et al. 2004). These long-term histories show that some pre-20th century droughts exceeded in magnitude and duration any drought experienced during the 20th century. Notable examples include the so-called "megadroughts" of the mid 1100s, and the 1580s. Many of these droughts undoubtedly had profound impacts on human populations and ecosystems. For example, a "Great Drought" at the end of the 13th century AD was a contributing factor in the Anasazi abandonment of the Colorado Plateau, and the migration of many of the ancestors of modern New Mexico Pueblo peoples to the Rio Grande valley.

We have limited knowledge about the impacts of past megadroughts on ecosystems and fire. However, it is likely that some past droughts led to very large wildfires, bark beetle outbreaks, and direct drought-induced mortality of trees and other plants – much as recent drought effects. Moreover, extreme amplitude "switching" of wet years and dry years during the late 1700s apparently led to many widespread fires in the Southwest (Swetnam and Betancourt 1998). We think the 1580s megadrought probably caused widespread burning and drought/bark beetle-related tree dieoff. This interpretation is based on observations that very few living or dead trees can be found in the Southwest that pre-date this major event. Hence, it appears that a major forest and woodland dieoff occurred, followed by extensive regeneration during a wetter and cooler period in the early 1600s (Swetnam and Betancourt 1998).

During the 20th century, the 1950s drought stands out as the most severe event. Notably, a number of very large forest fires erupted in Southwestern forests during this period. Also, a very extensive bark beetle outbreak and tree mortality occurred in parts of New Mexico during the 1950s drought (Swetnam and Betancourt 1998, Breshears et al. 2005, Allen 2007). However, even though the 1950s drought was more extreme in some areas of the Southwest than the recent drought, both forest fires and bark beetle outbreaks were considerably smaller in extent than during the recent drought. For example, the largest recent fires (i.e., the Rodeo-Chediski in Arizona, 467,000 acres) were almost an order of magnitude larger in size than the largest forest fires during the 1950s in this region. The extraordinary size of both bark beetle outbreaks and wildfires in the recent decade in the Western US (including Alaska) and Canada is a chief reason that I and many of my colleagues have concluded that recent warming temperatures and earlier springs are likely a key factor in these patterns, and not just reduced rainfall (Breshears et al. 2005, Westerling et al. 2006).

Questions from Senator Ken Salazar:

4. What types of adaptation management strategies have been found to best deal with managing the expected increased threat of wildfires?

Fuels treatments using mechanical thinning and prescribed fires are appropriate and effective in some forest types, particularly forests that formerly sustained frequent surface fires in the 19th century and earlier. Climate change increases the urgency to get on with these treatments at much larger scales than has been accomplished so far. A general goal should be to increase the resiliency of these forests to the coming climate "shocks", i.e., drought-induced wildfires, insect outbreaks, and other disturbances. By "resiliency" I mean the ability of ecosystems to resist damaging effects and to recover from disturbances. I would emphasize a need to act at broader spatial scales, and especially to increase the use of fire as a management tool and a key element of ecological restoration. We can not hope to keep fire out of our forests. Fires will happen; the question is: Will they be fires that we have planned for and managed, and are ecologically beneficial, or will they be unplanned, uncontrolled and destructive to ecosystems and human values?

One adaptive strategy I have advocated is utilizing recently burned landscape "mosaics" as an opportunity to engage in landscape-scale follow-up treatments. Most recent, large wildfires have resulted in complex mosaic patterns of high, moderate, and low severity burned areas (proportions of overstory trees killed), and unburned patches. These large mosaics of burned/unburned areas provide an excellent opportunity to engage in large-scale forest restoration/fire use treatment programs. The high severity burned patches and fire lines constructed during the suppression efforts offer safety zones and control features for use of prescribed surface fires. Local communities are energized in these areas and ready to move forward with proactive restoration efforts at improving sustainability and resiliency of forests surrounding their homes. A partnership of federal agencies, community groups, and University scientists are currently engaged in planning such an effort in southern Arizona, where I live and work.

5. One of the most enduring ad campaigns in our country's history are the Smokey the Bear public service announcements. There probably isn't a person in the room who hasn't heard the slogan "Only you can prevent forest fires." Given that the majority of wildfires are caused by human activity, are there plans to increase efforts to reach the public on climate change and expected increased wildfire activity, and ways to prevent wildfires?

I understand that the U.S. Forest Service is planning to engage in a new effort to reach out to children to help them understand climate change effects and the importance of forests and natural resources. I am unaware of other specific plans by federal agencies to focus on public communication/education on the wildfire and climate change issue.

Although it is true that the majority of fires are ignited by people nationally, in most mountain and forest regions of the West there are more lightning ignited fires than human ignited fires. Moreover, lightning ignited fires dominate the total area burned in most forest landscapes of the West. In general, more than 95% of total area burned is accounted for by fewer than 5 percent of the fires. Hence, total area burned (or numbers of the very large fires) is a much more relevant statistical factor to consider in terms of wildfire trends, impacts and costs than total numbers of fires ignited. Ignitions by people are important, particularly in some sub-regions, and in some ecosystem types. But the effect of high numbers of human set fires in some sub-regions does not outweigh the dominant role of lightning, fuels and climate change at the scale of the entire Western United States.

I do not mean to imply, however, that there isn't a strong need for public education and fire prevention programs. Careless ignition of fires by people can be extremely destructive, and is a part of the fire problem. Smokey Bear's message is still needed. At the same time, however, I believe we need to greatly increase the public's understanding that not all fire is bad, and in fact, the use of fire as a tool by knowledgeable managers (e.g., prescribed fire and wildland fire use) is essential to maintain the functioning of some ecosystems. Landscape-scale fire use will also be necessary to maintain fuels at safe levels. This is one of the great challenges of land management, I believe, in the coming century: How can we restore fire-dependent ecosystems using fire as an ecological restoration and management tool, while also protecting human property and lives? How can we use fire as a management tool, while also managing smoke and carbon dynamics?

6. The link between climate change and fire is clearly strong, but since this linkage has come to light, some people suggest that climate is more critical than fuel as a driver of fire behavior, and there is no reason to treat fuels to protect communities or restore ecosystems. What are the implications of climate change for fuel treatment and forest restoration?

The implications are twofold. First, warming temperatures, earlier springs, and increasing severity and duration of droughts – and related wildfire responses -- *increases* the urgency of forest restoration and appropriate fire management. Forest and fuel changes because of land uses are very important in some forests (and not in others). Furthermore, invasive species and expanding human populations all point to the necessity to better manage our forests to reduce fire hazards where feasible and ecologically justifiable. Second, there are some forest areas where forest and fuel changes are not outside the historical range of variability, and human land uses have had relatively little effect on the fire regimes or fire severity occurring in these types. In these places fuels treatments (thinning or prescribed surface fires) may or may not mitigate current or future fire hazards, and there is little or no ecological justifications for such treatments. In these cases, development and implementation of land use policies (e.g., wildland fire use, land use zoning, fire fighting and post-fire remediation policies) may be more appropriate local responses than fuels treatments.

7. Fires are becoming increasingly harder to fight and are releasing huge quantities of carbon dioxide. Wildland Fire Use, the practice of allowing some lightning-ignited fires to burn under less extreme conditions, has been suggested as a way to mitigate fires and ensure they release less carbon dioxide. Do you see a role for Wildland Fire Use in changing future fire behavior so it is less extreme, thereby releasing fewer greenhouse gases?

Smart, effective wildland fire use will be essential in managing carbon dynamics in our forests in coming years. The issue is not whether we will generate smoke and carbon inputs to the atmosphere via fire, but how much, and to what extent can we manage such inputs? A general hypothesis is that planned, frequent low severity fires (in appropriate ecosystems) will result in less smoke and carbon input than uncontrolled, high severity wildfires. I am not very familiar with published literature on this topic, but my impression is that there is limited information on the short and long-term effects of fire use practices versus wildfires, particularly at the scales of landscapes (i.e., multiple watersheds and mountain ranges). I think more research is needed on this subject.

8. It has been suggested that because young forests grow fast and older forests grow slowly we can cut down old forests and replace them with fast-growing plantations to maximize the uptake of carbon dioxide and reduce global warming. What is the current scientific understanding of the effects of logging older forests on the uptake or release of greenhouse gases?

The specific role of older forests versus younger forests in sequestering carbon is beyond my knowledge and expertise. I suspect that there is some scientific literature on this topic, but I doubt that there is a scientific basis for such a drastic step as removing old forests for this purpose. In general, old growth forests are a quite small proportion of the remaining forests in U.S., and so harvesting them for the purpose of planting young trees would unlikely be a significant benefit to carbon sequestration. The losses of the special values of old growth forests would also be great (e.g., wildlife habitat, esthetic, and scientific values). On the other hand, it may well be that expanding plantations in some previously harvested lands, or perhaps converting grasslands or other ecosystem types (where feasible) to forests for carbon sequestration may be a useful approach in the future.

Questions from Senator Pete Domenici:

Dr. Swetnam you suggested that it might be too late to manage in high-elevation long fire rotation stands and that it might be wiser to focus management in the Ponderosa Pine forests of the Southwest.

9. If the low elevation and southern Ponderosa Pine forests are likely to have to migrate to higher elevations and to the north, do you believe it would be wise to ignore the fires at higher elevations in the northern Intermountain States?

During the hearing I stated that prioritization of management treatments, such as forest thinning and prescribed burning, should be focused in areas where forest structures and fuel levels have changed the most as a consequence of past land use practices (e.g., livestock grazing and fire suppression). High severity fires are a much larger problem – from an ecological and sustainability perspective -- in these forests (e.g., ponderosa pine dominated and drier mixed conifer forests) than in some higher elevation, northern forests (e.g., spruce-fir and lodgepole pine forests). Also, there are extensive areas of ponderosa pine and mixed conifer outside of the Southwest that have experienced disrupted surface fire regimes, increased forest densities and fuel accumulations, and are in need of fuels treatments to reduce risk of large unnaturally high severity fires. Current federal agency approaches and tools for mapping, and assessing fire hazards and treatment prioritization (e.g.., LANDFIRE and Fire Regime Condition Class assessments) do in fact consider such historical and natural aspects of fire and forest changes.

Perhaps climate change (e.g., warming) will eventually establish more landscape areas in the higher elevations and northern Western states suitable for ponderosa pine. If this happens on a large-scale there will probably be many negative repercussions that will outweigh concerns about whether or not ponderosa pine can migrate to or grow in these places. For example, what will we do if the vast forests of spruce-fir, lodgepole pine, western hemlock, Douglas-fir etc. in the northern, Western states convert en masse to other ecosystem types as a consequence of extraordinarily large fires, forest insect outbreaks, and direct drought-induced mortality? Extreme watershed impacts, such as reduced water quality and rapid sedimentation of municipal reservoirs will likely occur in this scenario, as well as loss of critical wildlife habitat, and loss of human lives and built structures in the wildland urban-interface.

Given this worrisome potential scenario, I do not at all believe we should "ignore" the changes occurring in high elevations, or northern forests. The key question is what can we do about these changes, if anything? It is possible that some kind of forest management might mitigate future changes in these forests. However, broad-scale forest thinning or the use of prescribed surface fires within these forests (i.e., long-interval fire regime types), has much less (or no) ecological basis or justification. Open, low-density forests and frequent surface fires were generally not a historical, ecological condition of most of these forests in the past; they are not evolutionarily adapted to this type of fire regime or forest condition. It is not at all clear that thinning treatments or surface fire use will help maintain or sustain these forests in the face of climate changes. It is possible that high severity fires, which are occurring more frequently in the recent decade, will begin to "self limit" the extent of future high severity fires. By "self-limit", I mean that formerly burned areas (n previous years and decades) may begin to limit the spread and extent of future fires.

In the near-term, and at the much broader global-scale, I believe the most important thing we can do to reduce future negative impacts in our high elevation and northern forests is to proceed rapidly to significantly reduce our greenhouse gas emissions.

10. What does the field of forestry tell us about the ability of tree species to invade and reforest lands that have been heavily impacted by fires, including the loss of soil and the changes in moisture regimes after high intensity fires?

There is a considerable scientific literature on post-fire responses of vegetation and soils. I am not an expert in these areas, or very familiar with all of the recent literature. However, I will comment on the case of ponderosa pine in the Southwest, which I know best. A recent published study of post-fire forest recovery in Southwestern ponderosa pine landscapes (Savage and Mast 2005) found that re-establishment of forests in high severity burned areas was highly variable. In some cases trees did re-establish, and in other areas, burned areas have not recovered to forest – even 50+ years after the fire. Ponderosa pine produces large seed crops only erratically, and the seeds are heavy and do not travel very far by wind. Hence, large canopy holes created by severe fire may not recover for centuries. Where seedlings do establish following severe fires, Savage and Mast found that sometimes very dense stands regenerated. If these dense stands are not subsequently thinning by surface fires or mechanical treatments, they may create conditions that will generate additional high severity fires in the future.

Regarding soil effects, it has been observed that soil loss and erosion is sometimes extreme following high severity crown fires in the Southwest. For example, a recent crown fire in the Chiricahua Mountain of Southern Arizona resulted in a 30 foot deep, 60 foot wide gully at about 9000 feet elevation in this mountain (personal observation). Sheet erosion of soils, flooding and debris flows have occurred widely in Southwestern mountain ranges following recent fires (Allen 2007). In some cases, thin ancient soils in some burned areas in Southwestern Mountain ranges have been completely eroded away, and it is unlikely that soils or trees will re-establish on these sites for centuries, and possibly millennia.

11. If trees sometimes have a more difficult time regenerating after high intensity fires and water retention and run off are negatively impacted in the absence of tree cover; and we do experience higher temperatures, are we more likely to see brush fields, or stands of new trees as species have to migrate up in elevation and to the north through these heavily burned lands?

We are already seeing some ecosystem-type conversions as a consequence of high severity fire and erosion in some Southwestern forests, as I described in response to the previous question. An example that Senator Domenici is familiar with is the Bandelier-Los Alamos area in the Jemez Mountains of northern New Mexico. A series of high severity crown fires in this landscape (including the 1977 La Mesa Fire and the 2000 Cerro Grande Fire) has resulted in conversion of ponderosa pine and mixed conifer landscapes to grasslands and shrub fields over significant areas (Allen 2007). At this point, it seems that grasslands and shrub fields are likely to be the most common ecosystem type replacing forests in the Southwest, and perhaps elsewhere in the West.

12. Dr. Swetnam, much of your testimony was focused on the Pacific Southwest and Southwest, yet many of the climate change models suggest that in the short and middle term the tree species composition in the upper Great Lakes and the Southeast are likely to see the largest changes, while the Western U.S. could even see an expansion of forests due to wetter winters. If one assumes that increased global temperatures will result in drier climates in these areas and that these areas may also experience increased fire activity, what steps can the land managers in these states take to mitigate the changes, or to prepare for the changes?

It is only relatively recently that down-scaled, regional climate models have become sufficiently accurate to assess with some confidence what may occur climatically in regions of U.S. under different scenarios of increasing greenhouse gases in the atmosphere. I am not familiar with results of forecasts in most U.S. regions, but information on the Southwestern U.S. (e.g., Seager et al. 2007, Hoerling 2007) are not encouraging. Precipitation forecasts are still much less consistent and reliable that temperature estimates. However, even in models showing some increases in winter precipitation, warming temperatures and consequent increased evaporation and evapotranspiration are likely to override rainfall increases, resulting in a net decrease in soil moisture and river flows (Hoerling 2007).

Regarding what to do to mitigate and prepare for these changes, I would refer to my answer to a similar question (#6) by Senator Salazar. In summary, I think climate changes (warming and increased droughts, in particular), increase the urgency of forest restoration and fuels treatments, but these should be focused in landscapes where forests have changed the most and have become more conducive to crown fires because of past management actions, and where large, high severity fires are generally outside the historical range of variability. It also makes sense to focus fuels treatments at the wildland-urban-interface, but not exclusively.

13. Dr. Swetnam, in the most aggressive models of increased temperature and moisture changes can you describe where forests might exist in Arizona and New Mexico, as well as what the species composition might be at various altitudes say 50 years from now? And in 100 years?

This is a critically important question, not only for Arizona and New Mexico, but also for the rest of the U.S., and the globe, i.e., what forest and ecosystem changes will occur due to warming and drought trends, when and where? I frankly do not think anyone has reliable answers to these questions yet. As I pointed out in the previous question (#12) there are improved regional climate change model results that are useful in addressing this question. There are also dynamic vegetation models that are beginning to address these questions (e.g., Bachelet et al. 2001). Some of the vegetation models do contain wildfire-climate sub-models, and some include insect outbreak dynamics. However, I don't think the important combined effects of fires and insect outbreaks have been addressed, and I know of no such results for Arizona and New Mexico in particular. I do think this is an important topical area needing much further research.

Questions from Senator Bob Corker:

14. Do we need to reconsider forest management policies or other mitigation activities? Are there currently obstacles to forest management that could significantly reduce the damage caused by fires that will only continue to compound the problem if temperatures continue to rise?

As I have articulated in response to previous questions by Senator Salazar (#4, 6, 7) and Senator Domenici (#9, 12), I believe we need to increase our forest restoration and fuels treatments substantially in forest types that have undergone major changes in tree density and fuel loads because of past management activities. We especially need to re-introduce surface fires as an ecological process in many of these forests. This will require planning and implementation at landscape-scales (i.e., watersheds to mountain ranges), and it will especially require collaboration with local communities. As I describe in response to Senator Salazar's question (#4), I think utilization of recently burned landscape "mosaics" is an outstanding opportunity to carryout much larger treatments, especially using prescribed fire. Moreover, there is urgency in quickly moving to landscape-scale treatments in these areas because it has been demonstrated in recent studies (Finney et al. 2005, Omi et al. 2007) that there is a fairly short window of time (10 years or less) that these treatments can effectively mitigate the effects of future wildfires.

There are many obstacles to carrying out ecological restoration and mitigating/adapting to climate change and future wildfires using thinning and prescribed fire treatments. A few examples include smoke emissions, risk of escaped prescribed fires, liabilities in the use of fire as a management tool, public/agency conflicts over goals and means of carrying out restoration programs, etc. Dealing with all of these obstacles is daunting, but doable, I think, so long as collaborative approaches involving all concerned are a central part of the process.

I would mention one obstacle in particular at this point: The professional capacity for fire management must be increased substantially within the federal agencies if we are to meet the challenge of creating more resilient and sustainable ecosystems in the face of coming climate changes. By this I mean that we need a much larger corps of well-trained, experienced, year-round fuels and fire managers. The task of fire fighting must not continue to overwhelm the ability to manage fuels and forests. An investment in much greater personnel capacity and expertise to plan and implement thinning and prescribed burning in the context of building ecological resiliency is essential to move beyond the current reactive mode of management in response to increasingly severe wildfire seasons (see the recent GAO report, 2007).

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