J. W. GOTTSTEIN MEMORIAL TRUST FUND

The National Educational Trust of the Australian Forest Products Industries

GOTTSTEIN
TRUST

ACTIVE FOREST FIRE MANAGEMENT FOR MULTIPLE LANDSCAPE BENEFITS IN THE UNITED STATES AND CANADA

MICHAEL STEPHENS

2013 GOTTSTEIN FELLOWSHIP REPORT

JOSEPH WILLIAM GOTTSTEIN MEMORIAL TRUST FUND

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are,

1. Fellowships and Awards - each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate. Skill Advancement Awards recognise the potential of persons working in the industry to improve their work skills and so advance their career prospects. It takes the form of a monetary grant.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

Further information may be obtained by writing to,

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His research and policy focus has included plantation development and sustainable forest management, rangelands, agroforestry, renewable energy, regional development, forest products industry and climate change policy. From 1998 to 2000 he worked on forestry climate change mitigation with the Canadian Forest Service. Mick has a degree in economics from the Flinders University of South Australia, post-graduate qualifications in environmental science from the University of Canberra and a Master of Forestry from the Australian National University.

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Executive Summary

This report documents a three week study tour of the United States and Canada on the role of active forest management for multiple landscape benefits, most notably for wildfire risk reduction, renewable bioenergy and forest health. This study builds on the earlier Gottstein Fellowship report by Hamilton (2009) into developments in the use of woody biomass for bioenergy in Canada and the western United States, by focusing more directly on the links between fire management and bioenergy.

The information was gathered from field visits to various forest sites and bioenergy facilities and from interviews and correspondence with research scientists, forest economists, field foresters and program administrators.

Internationally, there is growing concern over the issue of wildfires of increasing intensity and scale as a result of climatic trends (e.g. drying conditions) and human activity in terms of high fire suppression and the build-up of biomass fuels and high tree stocking. These conditions have contributed to the phenomenon of 'mega-fires' that are very hot and difficult to contain due to extended dry periods, high fuel loads and forest structural attributes (e.g. high stocking with ladder fuels contributing to crown fires).

Since the early 2000s, many forest land management agencies in the United States and Canada have adopted a more proactive approach to the management of biomass levels for fuel reduction as well as forest health to restore more fire-resistant ecological conditions and biodiversity in forest landscapes. The incidence of pest outbreaks such as the mountain pine beetle has also necessitated the need to manage extensive areas of dead trees that represent a significant fire risk in both Canada and the United States.

The main observations from this study tour for Australian forest managers and policy makers include:

- the high urban-forest interface (east coast of Australia, south-west Western Australia), as in the case in North America;
- similar issues with forest fuel loads and climate predictions, as a consequence of land use history and previous fire suppression;
- an increase in the occurrence of forest fires and area burnt in both North America and Australia over the past decade;
- high level bipartisan political support in the United States for fire management, including implementation of priority area and landscape level fuel reduction treatments for forest health and fire risk reduction;

- an emphasis on active management to return forest landscapes to more historical and fire resilient ecological conditions;

- the use of combined mechanical harvesting and prescribed burning for multiple benefits, including fire prevention, forest health and regional development; and

- the role of bioenergy and the wood products industry as part of an integrated solution for managing fire risk and forest health.

There is a need to rethink whole of landscape fuel reduction in Australia, with a view to adopting similar policies and programs as practiced in North America, particularly for drier forest types that are fire-prone and where previous human activity and fire suppression has contributed to high fuel loads and severe fire risk.

The Bushfire Cooperative Research Centre (2007), for example, has identified significant vegetation changes and forest health issues as a result of changed fire regimes and a preoccupation with suppression in many areas, including the 'Pilliga scrub' in central western New South Wales, the denser forests of the Murray River floodplain and the scrubby foothill forests of Victoria's East Gippsland.

I would recommend that Australian policy makers, forest fire managers and the forest and wood products industry take a more collaborative approach as has occurred in the United States and Canada, who have adopted coordinated land planning and more innovative approaches to fuel management for multiple economic, social and environmental benefits.

A trial program should be established to assess the economic, technical and environmental merits of adopting combined mechanical and fuel burning treatments to reduce fire risk and improve forest management outcomes. Such a trial should focus on selected case study areas with a view to informing a broader national program for long term bushfire mitigation.

Background

The fire management problem

The topic of my Gottstein fellowship 'Active forest fire management for multiple landscape benefits' reflects recent concerns with inadequacies in land management practices in Australia for long term forest fire prevention. In particular, there has been a decline in active fuel reduction activities over the past few decades while at the same time the incidence of bushfires and area burnt has markedly increased (refer Figures 1 and 2).

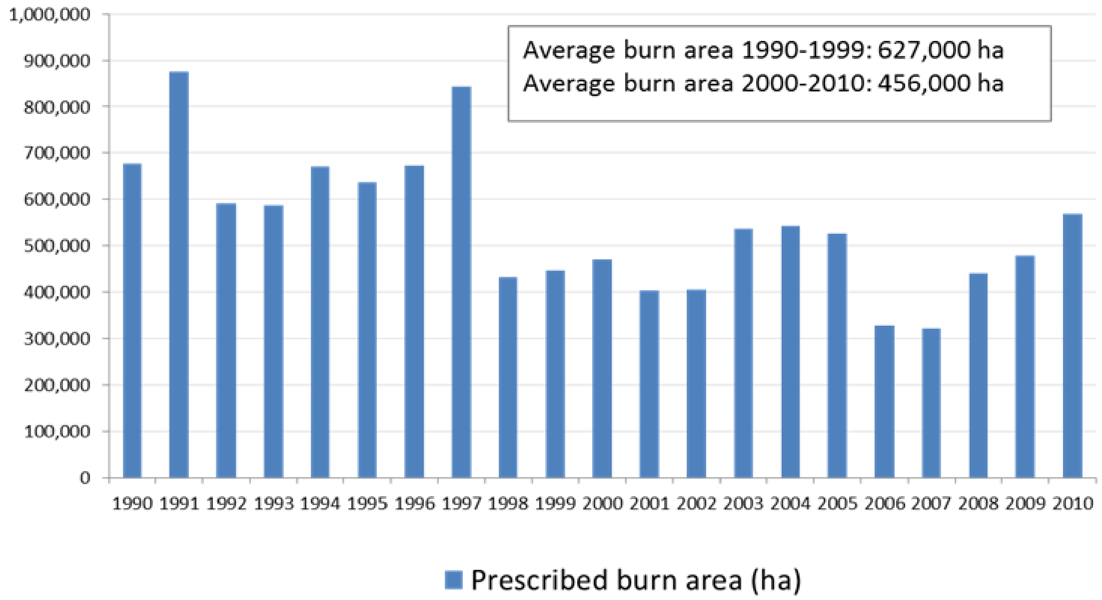

Figure 1. Prescribed burn area, Australia (1990-2010)

Source: Department of Climate Change and Energy Efficiency, 2012. Australian Greenhouse Emissions Information System (AGEIS). http://ageis.climatechange.gov.au/Reports/2012_2010_AUSTRALIA_LULUCF.pdf

The reasons for the decline in fuel reduction measures are complex but reflect a number of institutional and cultural factors (Stephens 2010), including:

- multiple land management agencies and tenures with responsibilities for fire management in addition to other objectives;
- poor fuel reduction practices arising from a passive approach adopted by many conservation land management agencies (i.e. numerous government inquiries have highlighted the inadequacy of fuel management activities);
- a narrow window of weather days for achieving low intensity burns;
- risk and liability issues from fire escape beyond the prescribed burn area;
- limited resources; and

- a decline in forestry trained fire managers, infrastructure and active fuel management practices from the transfer of large tracts of sustainable production forestry areas to formal reserves.

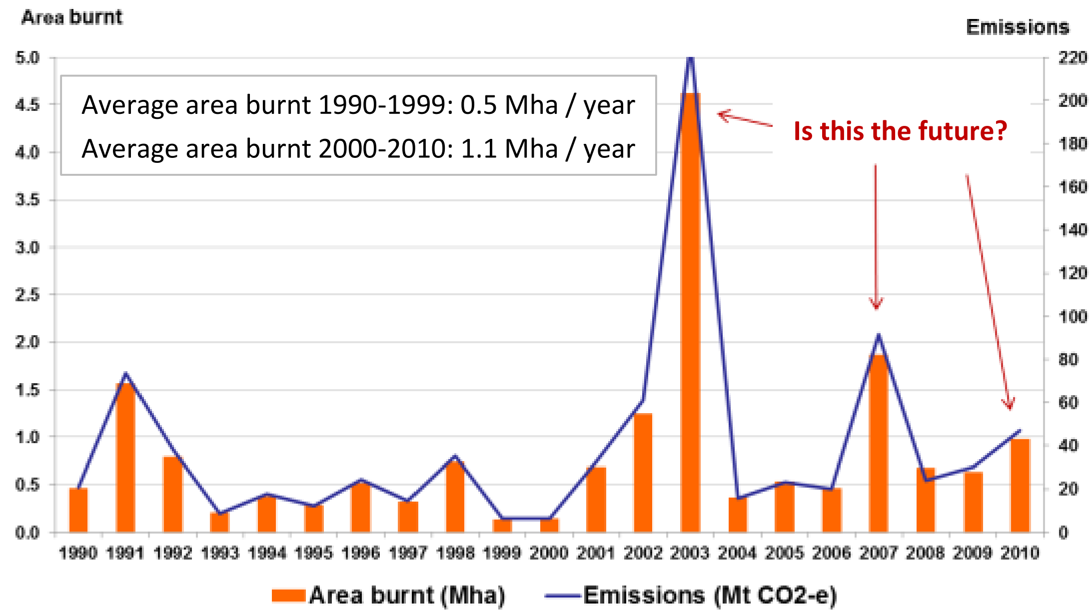

Figure 2. Area of bushfires, Australia (1990-2010)

Source: Department of Climate Change and Energy Efficiency, 2012. Australian Greenhouse Emissions Information System (AGEIS). http://ageis.climatechange.gov.au/Reports/2012_2010_AUSTRALIA_LULUCF.pdf

The incidence of large, hot fires is particularly concerning due to the significant economic, social and environmental impacts of such fires. The 2009 Victorian Black Saturday fires, for example, burnt 430 000 hectares of forest and resulted in the tragic loss of 173 people and significant environmental and infrastructure damage, at an overall estimated cost of $4.2 billion (Attiwill and Adams 2013). The intensity of the 2009 Victorian Black Saturday fires was extreme.

For the forest and forest products industry, the issue of effective fire management at a landscape scale is vitally important, as management practices in one jurisdiction or land tenure can affect fire behaviour and risk in another. In the Black Saturday bushfires, approximately $600 million of commercial eucalypt ash forest and five sawmills were burnt, reflecting the significant risks and costs to industry from the incidence of severe bushfires across the landscape.

Coincidentally, there is evidence that future fire risks in Australia may be exacerbated by projected climate change through warmer and drier conditions and an increased incidence of high fire danger rating days and more extreme weather events (Hennessy et al. 2007).

Recent experience in Canada and the United States

In the United States there has similarly been a trend of increasing wildfires of high intensity and scale, particularly in the drier forests of the western United States. The 2002 fire season was particularly bad in terms of the area burnt and severity of a number of large fires. Following the 2002 season, the concept of 'mega-fires' was acknowledged as an emerging land management problem, largely brought about by changing climatic conditions and previous human activity that has contributed to high fuel loads (Williams 2013). This problem has been attributed to a previous emphasis on fire suppression activities rather than preventative fuel management which has allowed higher tree stocking and fuel loads that have contributed to hotter fires (Adams 2013, Williams 2013).

Given the significant fire management challenges, forest land use policy in the United States has been undergoing a significant rethink in terms of shifting from previous fire suppression strategies to a more active approach to preventative land management and fuel reduction across the landscape, particularly in the drier western forests of North America. The emphasis of recent programs has been on the removal of excess fuels and minimisation of treatment costs for landscape restoration through the contracting of industry and sale of biomass for renewable energy and other products. The active management strategies being adopted have multiple aims and outcomes, including: forest health, reducing fire risk, improving habitat and promoting renewable energy, regional employment and forest products industry renewal.

In Canada, fire managers are developing coherent planning principles to address the risks of large scale severe fires, including through fuel reduction and biomass utilisation. The incidence of pest outbreaks such as the mountain pine beetle has necessitated the need to manage extensive areas of dead trees that represent a significant fire risk in both Canada and the United States.

The main objective of my Gottstein fellowship was therefore to review the active forest management policies and practices at a landscape scale in North America, with a view to better informing Australian policy makers and land managers at federal, state and local government levels.

United States

Fire management policy

National Fire Plan

The National Fire Plan (NFP) was established in 2000 after a particularly bad fire season to actively respond to severe wildfires and ensure sufficient fire fighting capacity in the future. The five priority areas of the NFP are:

- fire fighting;
- rehabilitation;
- hazardous fuels reductions;
- community assistance; and
- accountability.

The NFP provides financial and technical guidance and support for wildfire management across the United States. The federal land management agencies involved (e.g. USDA Forests Service, Bureau of Land Management, US Fisheries and Wildlife, Bureau of Indian Affairs) use the National Fire Plan Operations and Reporting System (NFPORS) to plan and report accomplishments funded by the NFP.

Importantly, the NFP established a long-term hazardous fuels reduction program. Hazardous fuels are reduced through a variety of treatments which remove or modify fuels, thereby reducing the potential for severe fires. Treatments include:

- prescribed fires - the deliberate burning of fuels in either a natural or modified state and under specified environmental conditions, which allows the fire to be confined to a predetermined area;
- mechanical treatments - the manual or mechanical removal or modification of fuels. Examples include chipping, biomass removal, mowing, crushing, and piling; and
- other treatments - methods other than prescribed burns or mechanical treatments, such as application of herbicides, introduction of biological controls, or grazing.

Healthy Forests Initiative

In 2002 there were a series of severe fires which burnt 485 000 hectares in the western states of Arizona, Colorado, Oregon and New Mexico. In 2003 further fires swept across southern California, which destroyed 3 600 homes, led to 24 fatalities and burnt over 739 000 acres (United States Department of Agriculture and United States Department of the Interior 2004).

Largely in response to the 2002 fire season, the United States Administration launched the Healthy Forests Initiative as an additional national level response for tackling the disturbing trend of severe forest fires by restoring forests to more fire-resilient ecological conditions.

Through an executive order to the Council on Environmental Quality, this initiative streamlined planning requirements for fuel reduction treatments under the *National Environmental Policy Act* (NEPA). Previously, planning requirements under NEPA for federal land management agencies were often inhibitive and time consuming. These administrative measures were followed by the broader *Healthy Forests Restoration Act 2003*, which provided the central legislative basis for the Healthy Forests Initiative.

Under that Act, a variety of provisions were put in place to expedite the preparation and implementation of hazardous fuels reduction on federal lands and restore healthy forest and watershed conditions. The Act also authorised large scale silvicultural research and the implementation of forest health and monitoring programs, including for disease and insect outbreaks and watershed functions. Importantly, the Act recognised the need to overcome barriers to the utilisation of woody biomass from fuel reduction and restoration treatments to help communities and industries create economic opportunities from active forest management.

In summary, the initiative provided more flexibility for the United States Department of Agriculture (USDA) Forest Service to plan and conduct fuel reduction treatments across the national forest reserve system, as well as the Bureau of Land Management (BLM) on other federal forest land. However, by allowing agencies to expedite the review process for treatments that met certain criterion (such as areas with high fire risk classifications), the initiative attracted dissension from some environmental groups such as the Centre for Biological Diversity. The main concern from these environmental organisations was an alleged dilution of environmental planning safeguards under NEPA. The federal and state agencies involved have consequently engaged in extensive consultation with local environmental and other stakeholders at the project level, which has assisted in the implementation of the initiative and related programs such as the Collaborative Forest Landscape Restoration Programme (discussed below).

Stewardship contracts

The stewardship contracting system has allowed the federal forest land management agencies to trade commercial goods for services, primarily the removal of excess trees and biomass in return for performing restoration work to maintain healthy forest ecosystems (Moseley and Davis 2010). Forestry contractors and businesses are actively encouraged to tender for these contracts, which can offset some of the restoration costs of the forest land management agencies.

The BLM manages 58 million acres of forest and woodland across the United States, with 14 million acres identified as overstocked and at risk from increased insect and disease attack and severe wildfire. Given these risks, the BLM has implemented stewardship contracts to achieve land management goals to improve, maintain and restore forest ecological health including through fuel reduction treatments. An important aspect of the stewardship contracts has been the ability to offset the treatment costs. In the case of removing excess vegetation to reduce hazardous fuels, the costs may be offset by the economic value of the commercial products removed, such as biomass, fuel wood, sawlogs and other forest products (Bureau of Land Management 2011). The BLM harvests around 230 million board feet of timber and 115 000 tonnes of biomass each year, with around 25% of total sales from stewardship contracts.

A typical example of a restoration treatment is the Reed Creek Sanitation and Salvage project in 2011, undertaken in Colorado on a large stand of lodgepole pine damaged by the mountain pine beetle. This project was designed to reduce hazardous fuels near the town of Granby, protect local infrastructure from fire hazard and support the production of forest products from the utilisation of the biomass and sawlogs removed.

Figure 3. Reed Creek Sanitation and Salvage Sale project, Colorado
Source: Bureau of Land Management (2012).

Collaborative Forest Landscape Restoration Programme

In addition to the streamlining of regulatory requirements for hazard reduction and the growing use of stewardship contracts, the United States Congress passed the *Forest Landscape Restoration Act* which established the Collaborative Forest Landscape Restoration Programme (CFLRP) in 2009. This ambitious program has provided up to $400 million over a 10 year period (i.e. $40 million per year) for forest restoration and fire prevention within the system of national forests administered by the USDA Forest Service (see, for example, Schultz et al. 2012).

The CFLRP is a major element of the fuel management effort on US national forests for the 2010-2019 period, and reflects the multiple objectives of reducing wildfire risks and emergency management costs and promoting forest health, reliable wood supply and job stability. As at December 2012 there were 23 CFLRP projects across the national forest system, which has promoted large scale planning, community participation and inter-agency cooperation. The second annual report of the CFLRP program lists the following high level achievements (amongst others) from the program to date:

- removed fuel for destructive mega-fires on 380 000 acres near communities and treated an additional 229 000 acres of fuel elsewhere;
- improved 537 000 acres of wildlife habitat;
- created an extra 4 500 jobs in 2011-12;
- sold 94.1 million cubic feet of timber and produced over 1.1 million green tonnes of biomass;
- generated nearly $320 million in labour income; and
- provided an additional $45 million of external partner investment (Collaborative Forest Landscape Restoration Coalition Steering Committee and USDA Forest Service 2012).

Many of these projects are located in the western United States (Figure 4), given the prevalence of fire hazard issues in forest landscapes.

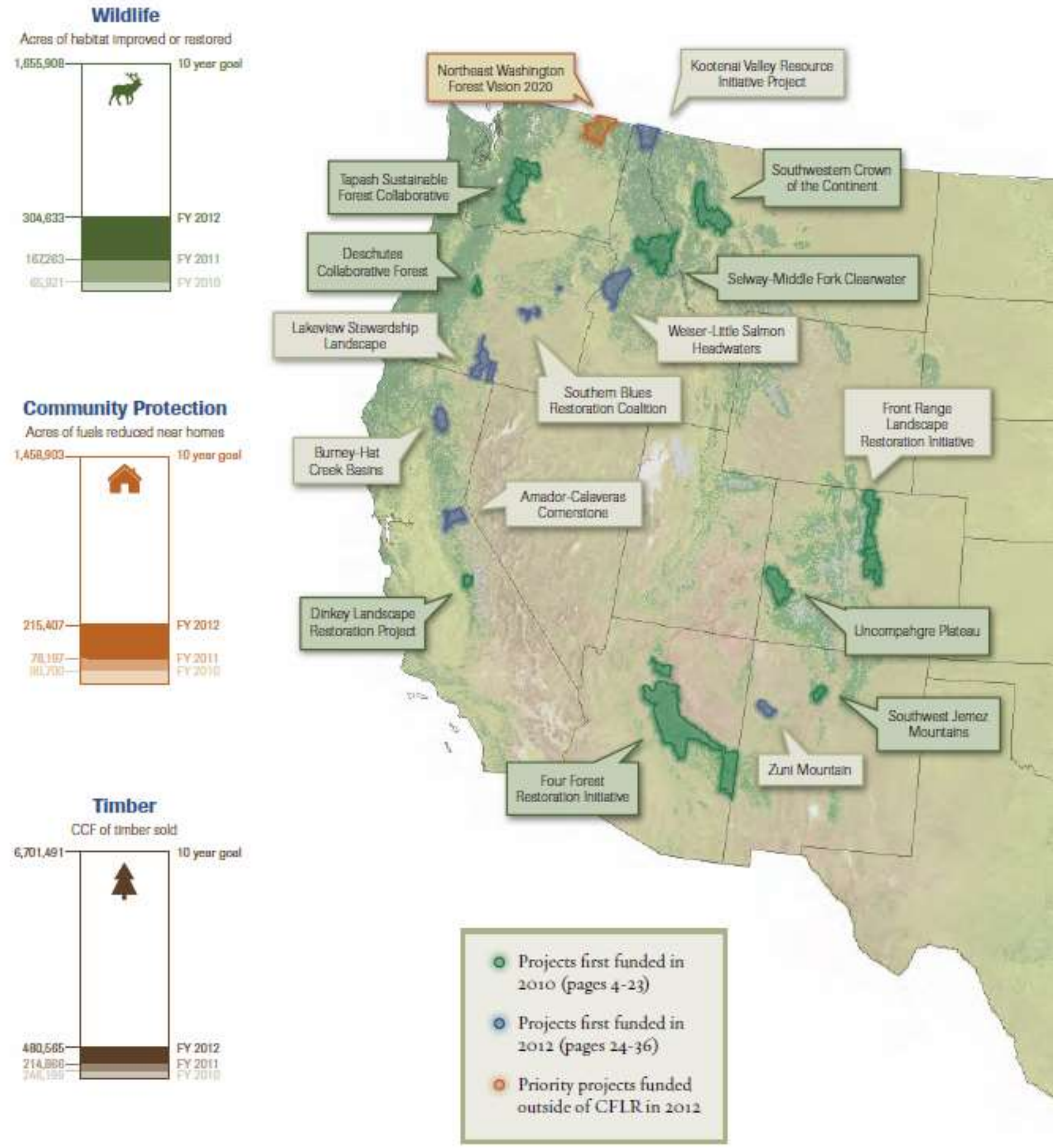

Figure 4. Map of CFLRP projects, western United States

Source: Collaborative Forest Landscape Restoration Coalition Steering Committee and USDA Forest Service (2012).

A key driver of fuel reduction treatments is to reduce the severity and extent of future wildfires as well as reduce the costs of suppression that has been an escalating problem, due to the increasing frequency and scale of wildfires in the western United States. In addition to the expected benefits from avoided damage to high value assets and infrastructure from reduced wildfire, a number of studies are beginning to assess the extent of avoided suppression costs from previous fuel treatments. Using suppression cost data and wildfire simulation modelling across a broad range of simulated fire seasons for a case study region in Oregon, Thompson et al. (2013) found substantial reductions in the distribution of wildfire size and suppression costs in the order of 30% for treated areas and 12% in the broader study area. These results assumed large scale fuel treatments and showed fewer ignitions becoming large fires because of fuel treatments.

Hartsough et al. (2008) similarly evaluated the costs of fuel reduction operations (prescribed fire, mechanical treatment, mechanical treatment plus fire) across seven sites in the western United States. They found that the net costs of mechanical treatment after deducting the values of harvested products were, on most sites, less than those of fire alone. They also found that the mechanical plus fire treatment was the most effective, followed by fire only, at reducing the modelled severity of wildfires under extreme conditions.

In conjunction with active forest management for multiple landscape benefits under such programs as the CFLRP, the US Forest Service has administered a Woody Biomass Utilisation Grant program to further the development of bioenergy facilities and markets for biomass material from fuel reduction and other commercial harvesting activities. In 2012, 20 grant awards were made to small businesses and community groups across the country at a total cost of $3 million. To date, more than 150 grants have been provided under the program. Grants are provided to further the planning of bioenergy facilities by funding the technical services needed for design, regulatory permitting and feasibility analysis.

Other direct incentives include the use of renewable energy standards, which require energy producers (e.g. public and private utilities) to increase production of energy from renewable sources such as wind, solar and biomass. These vary from state to state but in Colorado, for example, the Renewables Portfolio Standard requires 10 to 30 per cent of energy to be renewable by 2020, depending on the type and scale of utility.

Arizona

Four Forest Restoration Initiative (4FRI)

One of the largest CFLRP projects is the 4FRI which is a collaborative effort to restore forest ecosystems on portions of four national forests in northern Arizona – the Coconino, Kaibab, Apache-Sitgraeves and Tonto National Forests.

The project aims to implement restoration treatments on 1 million acres of ponderosa pine forest over a 20 year period (i.e. 50 000 acres per year) within a total landscape of 2.4 million acres. These forests are largely dominated by overstocked stands of ponderosa pine as a result of previous land use practices and fire exclusion. The vision of 4FRI is to restore these forest ecosystems to more fire-resilient natural fire regimes and functioning populations of native plants and animals (Figure 5).

Specifically, the treatments are designed to:

> *'begin restoring the ponderosa pine forest type to a condition more representative of historic conditions. Currently there are too many trees per acre and more expanses of even-aged stands than were present historically. These conditions have left forests that are susceptible to high intensity stand replacing crown fire and bark beetle infestations. The end result of this contract is to leave a forest that is less susceptible to these risks. The desired outcome is a forest with groups of trees of similar size or age, fewer trees per acre, and openings between groups of trees. The groups and openings will be well distributed across the landscape. This first entry treatment is designed to begin the process of converting these dense, mostly even-aged stands to clumpier, open, uneven-aged stands of trees with a vigorous grass and forb understory'.* [1]

The treatments are being managed via stewardship contracts and involve a combination of mechanical (i.e. biomass harvesting) and fuel burning treatments. Approximately 60 per cent of the area is targeted for mechanical treatment which is regarded as an important initiative to offset treatment costs and engage new forest product industries in the region and support local employment.

The carbon stock implications of forest restoration treatments in the Ponderosa pine forests of northern Arizona have been assessed at a stand level, which can help inform public policy on the net costs and benefits of restoration strategies. Finkral and Evans (2008) estimated that thinning treatments did reduce above ground carbon stocks through the removal of standing trees, but this can be outweighed by the reduced threat of wildfire released carbon emissions and the carbon stored in harvested wood products or used to offset fossil fuel.

[1] USDA Forest Service, 3. Solicitation No AG-8371-S-11-0031

Figure 5. Ponderosa pine treatment under 4FRI project, Arizona

Notes: The stand on the left is untreated and overstocked with ladder fuels (contributing to crown fires), the stand on the right is treated via mechanical and fuel burning treatments.

Colorado

The issue of wildfire risk and active forest management to address multiple goals has been particularly relevant in the state of Colorado. These issues are best exemplified by the recent written testimony of Joseph Duda, Deputy State Forester, Colorado State Forest Service (CSFS), to the US House of Representatives Committee on Natural Resources on 11 July 2013. At this hearing, the Deputy State Forester stated:

> *Sixty-eight per cent of Colorado's 24.4 million acres of forestland are in federal ownership and the majority is US Forest Service land. Colorado's national forests are being negatively impacted by bark beetle epidemics and catastrophic forest fires. Over 6.6 million acres of forestland have been severely impacted by bark beetles since 1996. Drought and climate change have contributed to this scenario, but the condition of the forests is the primary underlying factor, with nearly homogenous landscapes of mature, single-age stands that are overly dense and stressed from competing for nutrients and water. In other words, they are ripe for insect attacks and destructive wildfires.*
>
> *The scenario in Colorado described earlier was predicted, as the following statement from the 1992 US Forest Service Rocky Mountain Region Annual Report illustrates:*
>
> *'Following decades of suppressed natural fire, many forested ecosystems – their age, density and species composition – have reached a mature stage where*

*insect infestation and catastrophic fire are the next likely events. Timber harvest offers a controllable alternative to succession while providing a source of needed wood products. Where appropriate, harvesting can improve long term health and productivity of the forest, simultaneously contributing to other multiple-uses and forest values' (*Duda 2013).

While acknowledging that the historical pattern of fire in the Colorado Front Range was a mixed regime with low, moderate and highly severe fires, fire suppression activities have had a marked impact on tree stocking and fuel loads of many forest areas compared to historical benchmarks (Figure 6). These conditions have been associated with a threefold increase in the average size of wildfires in Colorado in the last decade (Colorado State Forest Service, unpublished data).

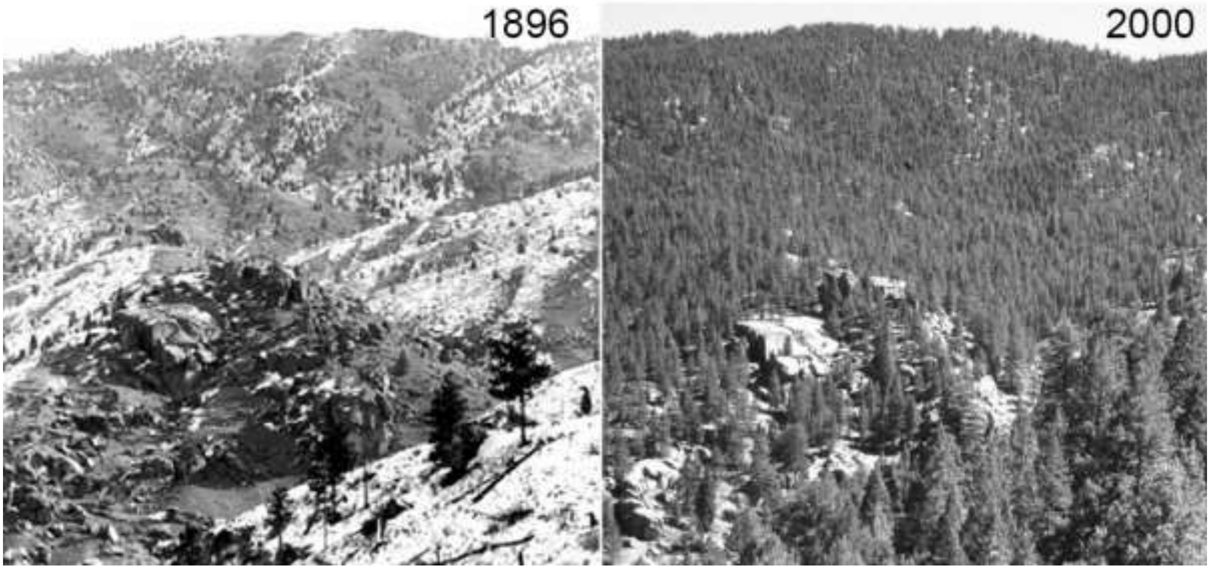

Figure 6. Comparison of tree stocking, Colorado Front Range (1896 and 2000)

Notes: View across Cheesman Reservoir to the west, showing increase in the number of ponderosa (and some Douglas-fir) trees, as well as increasing canopy cover. The 2000 photo by M.R. Kauffman. Source: Kauffman et al. (2005).

The other key policy issue in Colorado is the forest-urban interface through the encroachment of housing and related development along the Front Range of the Rocky Mountains. This populous area in the eastern foothills of the Rockies has necessitated collaborative approaches between communities and forest land management agencies to develop more fire resilient communities and implement fuel reduction programs. It has been estimated that approximately 6.3 million acres of forest land in Colorado is at high risk of catastrophic fire, with 2.4 million acres along the Colorado Front Range (Figure 7).

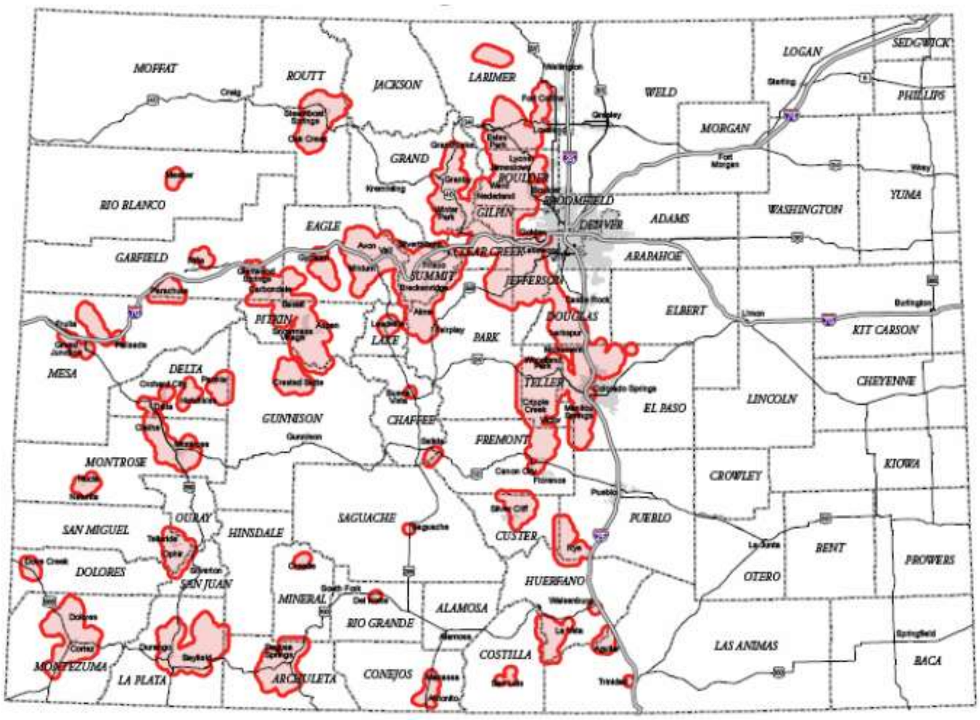

Figure 7. Interface areas of high wildfire risk in Colorado

Source: Kurt Mackes, Colorado State University.

An important process that has helped with inter-agency cooperation and local stakeholder engagement has been the Front Range Roundtable. This Roundtable is comprised of representatives from state and federal agencies, local governments, environmental and conservation organizations, the academic and scientific communities, and industry and forest user groups. The Roundtable's focus area includes 10 Front Range counties with the primary aim to:

> *'serve as a focal point for diverse stakeholder input into efforts to reduce wildland fire risks and improve forest health through sustained fuels treatment along the Colorado Front Range'.*

The Roundtable has helped to build understanding and awareness of fuel treatment activities and assisted land managers such as the US Forest Service in implementing stewardship contracts and CFLRP projects in the Arapho and Roosevelt National Forests.

In addition, the Colorado State Forest Service (CSFS) has been active in the implementation of fuel management programs on non-federal lands, including state wide assessments and strategies and community protection plans. At a municipal level, for example, the CSFS has undertaken thinning treatments for the Denver water authority along the Front Range, primarily to reduce fuel loads and protect water pumping infrastructure and related assets (Figure 8).

Figure 8. Thinning for asset protection, Denver water catchment

Notes: Scott Woods (CSFS), with post-treated areas in the foreground and on the ridge to the left.

Another important element of the state-wide strategy is the promotion of industries and markets for the available biomass to promote the dual objectives of fuel reduction and forest products industry development. The attraction of new industry and the promotion of markets is seen as providing important income to offset fuel reduction treatment costs, which often range from $US 1200 to $US 3000 per acre. The CSFS has promoted the use of woody biomass for bioenergy, given the state's heating demands and relevance to the utilisation of small diameter wood from fuel treatments (Figure 9).

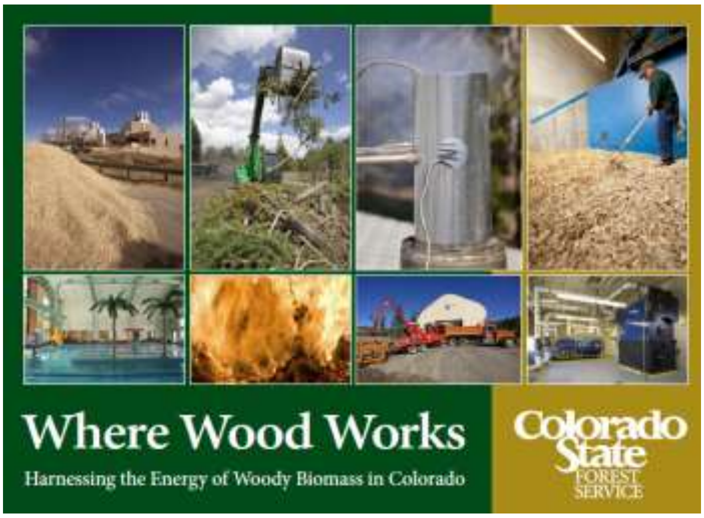

Figure 9. Cover of woody biomass for energy information brochure, Colorado

Source: CSFS (see http://www.csfs.colostate.edu/cowood/library/where-wood-works-2011.pdf).

At the municipal level, there are also good examples of the strategic link between fuel reduction and bioenergy generation to meet local heating and power needs. The Boulder County Parks and Open Space complex is heated using a wood fired boiler (3.3M BTU/hour) that can utilise 650 tonnes per year of locally thinned trees as a biomass feedstock. Boulder County manages 18 000 acres of pine forest for public amenity and thins these areas for hazardous fuel reduction while using the biomass as a heat source for 120 000 square feet of administration and other buildings (Figure 10).

Figure 10. Boulder County Parks and Open Space bioenergy heating project

Notes: Therese Glowacki, Resource Manager, outlining the forest area subject to regular thinning (left image) and the biomass storage bays in the foreground and the main administration building in the background (right image).

Similarly, the Colorado State University has installed a biomass heating plant (1.5M BTU/hour) at its Foothills Campus in Fort Collins that is capable of supporting the thinning of 50 acres of forest per year. The woody biomass is sourced primarily from beetle killed trees and forest fire mitigation projects along the Colorado Front Range. The new plant is estimated to save the university around $12 000 per annum (compared to natural gas) and was a collaborative project with the CSFS.

Figure 11. Biomass boiler at Colorado State University, Fort Collins

California

The issue of wildfire management is equally relevant in the state of California, which has experienced a number of severe fires over the past decade. In 2003, southern California experienced a severe fire season with over 739 000 acres burnt, destroying 3 600 homes, claiming 24 lives and costing $157 million to contain (United States Department of Agriculture and United States Department of the Interior 2004).

There has also been considerable research into wildfire management in California, including through the Fire Science Laboratory at the University of California, Berkeley. This Laboratory has included work on federal and state wildfire management policy and science (see Stephens and Ruth 2005), particularly the impacts of fuel treatments on forest ecology, carbon balances and forest structure.

From a carbon stocks perspective, Stephens et al. (2009) evaluated fuel treatment effects (that included burn only, mechanical removal only and combined mechanical removal and burn) on stand-level carbon pools for a mixed conifer forest in the Sierra Nevada, which is the most productive forest type in California. Importantly, wildfire area and severity has increased in most Sierra Nevada forests since the mid-1980s and has a direct bearing on carbon dynamics at a stand and landscape level. The study found that while fuel treatments emitted more carbon than for the untreated site, the modelling results for wildfire demonstrated that 90 per cent of the live tree carbon in the control site had a high (>75%) chance of being killed in a wildfire. This was in contrast to the low vulnerabilities for carbon loss from fire for the treated sites, justifying management actions designed to increase fire resistance for long term carbon storage.

This analysis was extended in Stephens et al. (2012) which measured the effects of fuel reduction treatments on carbon pools composed of dead and living biomass as well as potential wildfire emissions from six different sites across four western US states. The carbon loss from modelled wildfire and tree mortality was lowest in the mechanical plus prescribed fire treatments followed by the prescribed fire-only treatments (Figure 12). The results suggest that while carbon gains can be obtained in the short term by maximising tree stocking and on-site carbon, the trade-off in removing some carbon through prescribed fire and mechanical means to increase fire-resistance may provide better long term carbon stock management.

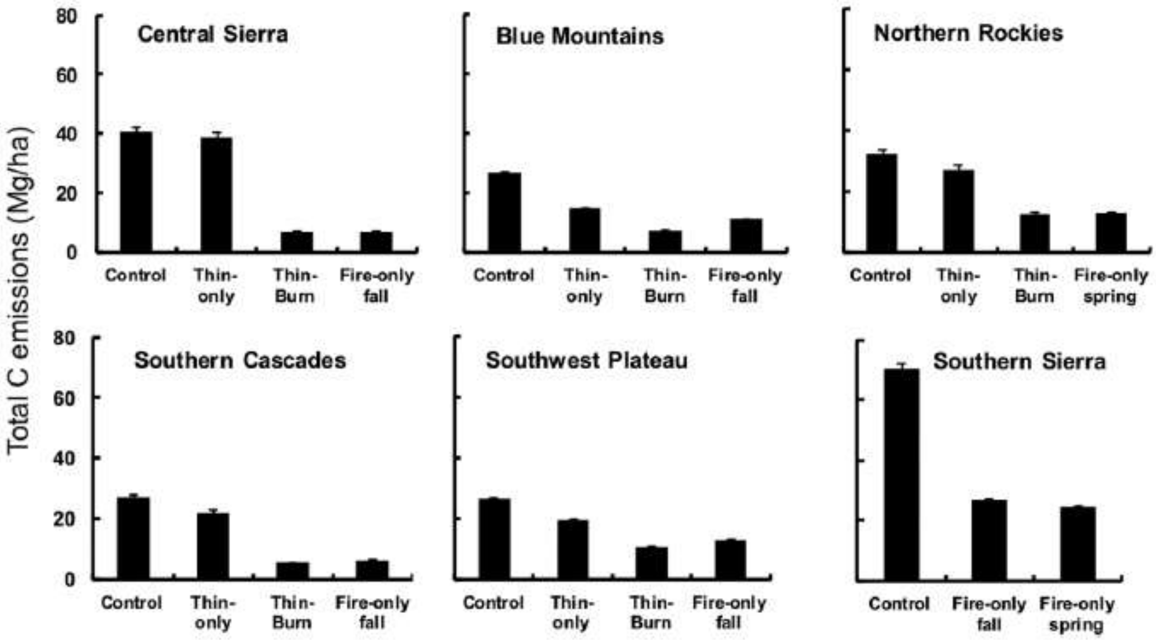

Figure 12. Wildfire carbon emissions from six western US study sites

Notes: Mean post-treatment wildfire carbon emissions estimated at 97.5 percentile fire weather conditions by treatment type for the six western US Fire and Fire Surrogate study sites in Montana, Oregon, California and Arizona. Source: Stephens et al. (2012).

The link between active forest management for fuel reduction and renewable energy is also recognised in the 2012 Bioenergy Action Plan prepared by the state level bioenergy interagency working group (California Energy Commission 2012). This plan outlines strategies and goals to increase bioenergy development in California and states:

> *Bioenergy offers multiple economic and environmental benefits, if biomass is sustainably harvested and converted to energy. These benefits include, but are not limited to, locally sourced renewable energy, improved air and water quality and other ecosystem benefits, less waste buried in landfills, as well as reducing California's dependence on fossil fuels and vulnerability to wildfire. These benefits can produce economic growth and increase employment, avoid catastrophic wildfires, improve public health, and reduce net greenhouse gas emissions* (California Energy Commission 2012).

The Plan recognises that wildfire management costs in California (state and federal) averaged approximately $1.2 billion per annum from 2006 to 2010. The Plan also identifies an ongoing feedstock of 25 million dry tonnes of forestry residues per annum for bioenergy development and encourages policies to increase the use of forestry residues for bioenergy including through fuel reduction programs for public safety and forest health.

The similarities with regard to bushfires in Western Australia's south-west eucalypt forests and the mixed conifer forests of California have also been noted, with both regions sharing a mediterranean climate with large areas of fire-adapted forests and a forest-urban interface with high risk of severe fires (Sneeuwjagt et al. 2013). Land management agencies in Western Australia have in fact undertaken regular fuel reduction burning at a landscape level over several decades, with documented outcomes for enhanced community safety and fire resilience (Sneeuwjagt et al. 2013, Adams 2013). The fuel management and community engagement practices in Western Australia have been recommended as a useful model for land management agencies in California (Sneeuwjagt et al. 2013).

Canada

Fire management in Canada is undergoing high level policy development via the Canadian Wildland Fire Strategy (CWFS) to develop coherent principles and address the risks of wildfires, including through biomass utilisation. Following severe fires in the early to mid-2000s (including in western Canada, the Yukon, Quebec and Ontario), the federal, provincial and territorial Forest Ministers identified the need for a new, strategic approach to wildfire management based on a risk management framework. Three primary catalysts were identified in the development of the CWFS:

- the impact of unwanted wildfires on people and property;
- declining suppression capacity and the need to supplement fire suppression with proactive hazard mitigation; and
- a growing public awareness of the threats from natural disasters including wildfires (Canadian Council of Forest Ministers 2005).

Under the national strategy, fire risk management (i.e. mitigation, preparation and response) is recognised as a cornerstone of forest management and is considered important to the overall health and productivity of the forest, public safety and modern business practices via the maintenance of equipment, training and effective partnerships (Figure 13).

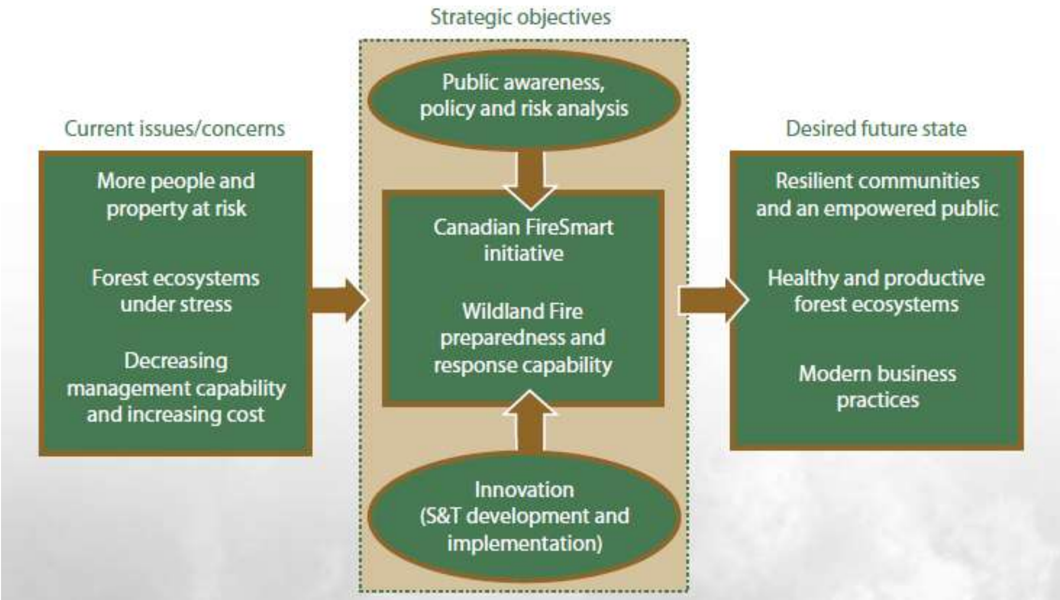

Figure 13. Strategic objectives and desired future outcomes from the CFWS

Source: Canadian Council of Forest Ministers (2005).

The direct costs for wildfire suppression in Canada typically range from $400 to $800 million per year depending on the severity of the fire season. There is an increasing interest in fuels management and other mitigation activities to reduce the severity of fire behaviour in forest lands both around communities and in forest landscapes (Canadian Council of Forest Ministers 2006). At the local planning level, the FireSmart initiative is a national program aimed at educating communities in better fire preparedness and hazard reduction activities. For example, the FireSmart manual in British Columbia (see Figure 14) outlines preventative actions for home protection, including fuel reduction thinning and pruning in priority interface zones within 10 metres to beyond 100 metres of a property, as well as advice on building design and construction materials.

Figure 14. The Home Owners FireSmart Manual, British Columbia

Source: Ministry of Forests, Lands and Natural Resource Operations, British Columbia. http://www.bcwildfire.ca/prevention/firesmart.htm

The CFWS has been progressed by the high level of commitment of the Canadian Council of Forest Ministers and national research program headed by the Canadian Forest Service (CFS) and various provincial forest land management agencies. The CFS is involved in fire monitoring, research and modelling, and has predicted an increase in the incidence of fires of up to 20 per cent by 2020 compared to 2000 levels (Mike Fullerton, Canadian Forest Service, personal communication).

A related issue in terms of fire risk and forest health in Canada has been the extensive infestation of the mountain pine beetle (MPB) and their impacts on tree mortality in over 17 million hectares of pine forest (Figure 15). The fire risks from large stands of dead and dying trees can be significant and considerable effort is being devoted to actively managing these areas to restore forest health as well as commercially utilise the available biomass.

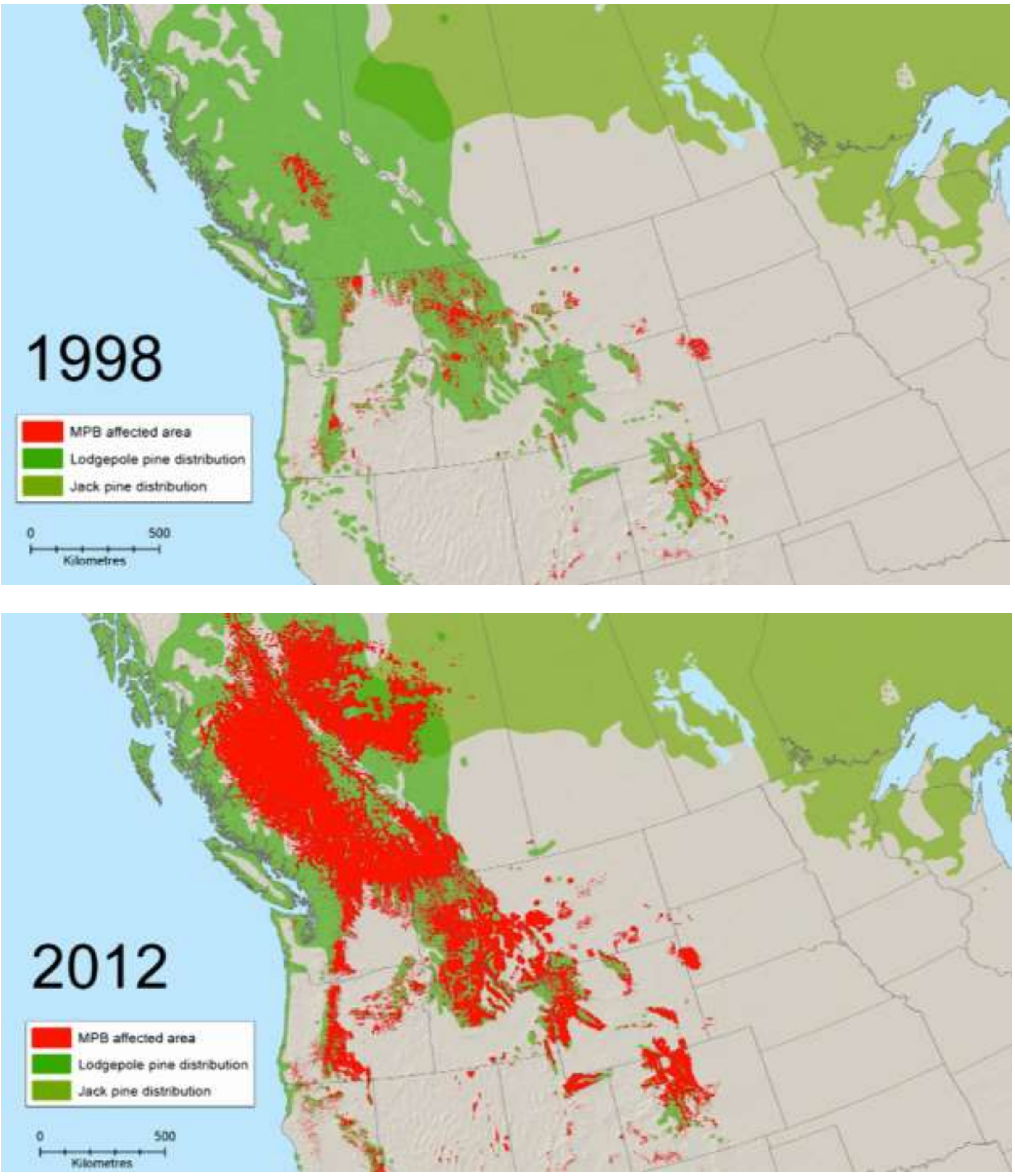

Figure 15. Area affected by mountain pine beetle outbreak, 1998 and 2012
Source: McBeath (2013).

In light of the projected fall in the harvest of timber for traditional forest products in these areas, Niquidet et al. (2012) assessed the costs of utilising the available biomass in British Columbia as a feedstock for energy over a 25 year time period. The analysis showed that feedstock costs could potentially double over this period due largely to transport costs and spatial variability in wood volume, while recognising that these costs could be moderated to some extent by the spatial location of new bioenergy facilities of significant scale (e.g. > 330 MW).

Lamers et al. (2014) similarly evaluated the opportunities to mitigate carbon emissions from the greater utilisation of MPB killed stands in British Columbia for wood pellet production, which is primarily exported to the European bioenergy market. Based on current business as usual (BAU) scenarios, the forests of British Columbia are forecast to become a net source of carbon due to tree death and decay caused primarily by MPB and related post-harvest slash burning. However, by using the post-harvest slash (i.e. material left in the forest after harvest) in addition to sawmill residues for pellet production to displace coal sourced energy, direct carbon benefits can be generated compared to BAU scenarios. The study found that harvesting pine dominated sites for timber (i.e. long lived products) while using slash for bioenergy was more carbon beneficial than a protection (no harvest) reference scenario, taking into account assumed fire disturbances.

The utilisation of MPB killed trees for bioenergy is actively promoted by various provincial governments such as in British Columbia (BC), where bioenergy is considered critical to achieving the province’s climate goals and economic objectives. The BC Bioenergy Strategy aims to turn the challenges of the MPB infestation into new opportunities and to adopt future bioenergy technologies, including bioenergy for electricity and heat, wood pellets and biofuels.

British Columbia

Forestry and its associated industries play an important role in the economy of British Columbia, employing over 53 000 people in 2011 and contributing considerable export income. However, the issue of forest fire management is equally important given predictions that as climate changes, fire seasons will become longer and result in more wildfire ignitions, larger wildfires, and increased fire severity and duration (Daigle and Dymond 2010).

Over the past decade the average area of forest burnt each year in British Columbia has increased, consistent with the trend in the western United States (Figure 16). This has been attributed partly to previous fire suppression, particularly in the drier interior regions of the province.

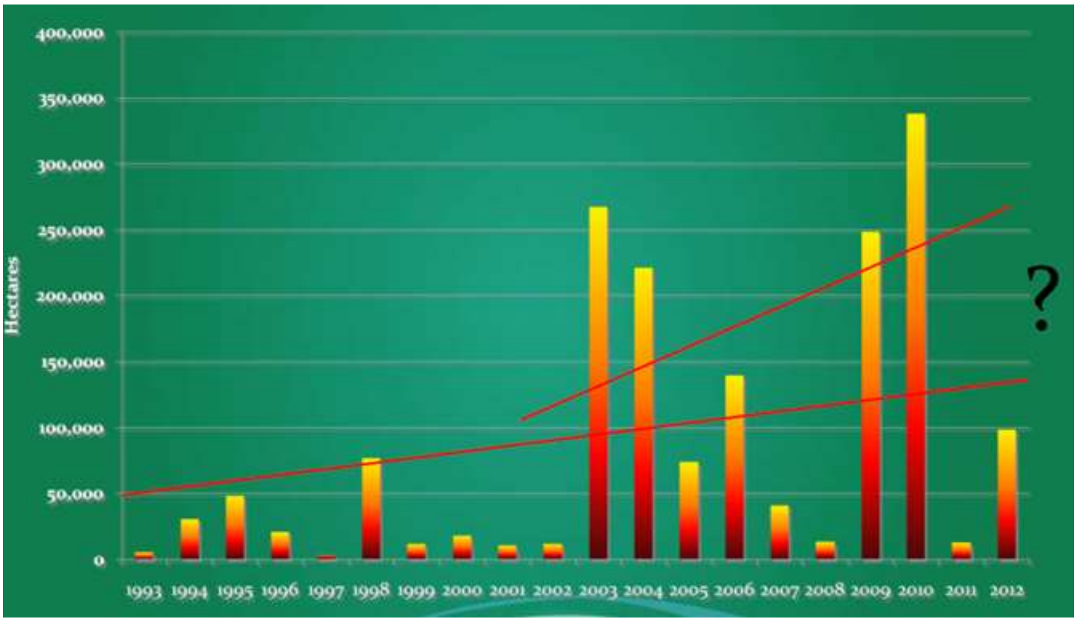

Figure 16. Area burned in British Columbia, 1993-2012

Source: Lyle Gawalko, Ministry of Forests, Lands and Natural Resource Operations, British Columbia.

In response to these threats, the provincial Government actively manages 84 million hectares for fire protection, with an average of around 2 500 fires each year of which half is caused by humans and the rest attributed to lightning. The Wildfire Management Branch is the lead wildfire agency for the province and undertakes regular planning including the 2012-2017 Strategic Plan with a strong emphasis on:

- fuel management: to reduce loss and damage from wildland fires through community wildfire protection planning and fuel hazard reduction;
- landscape level management planning: to lead landscape fire management planning that results in fire-adapted communities and fire-resilient ecosystems; and
- wildfire management practices: to develop and promote innovative wildfire management science, practices, technology and decision support models (Ministry of Forests, Lands and Natural Resource Operations 2012).

In my discussions with senior wildfire managers it was evident that the scale of the wildfire problem is a major factor affecting the risk management approach being adopted, which recognises the limited resources for suppression and benefits from more active planning around high value assets and prevention through fuel reduction and other treatments.

The wildfire management strategy recognises the role of fire management at a range of spatial scales which may require different management actions depending on which zone is being targeted (Figure 17). There is a high level of inter-agency cooperation and community consultation in the implementation of management actions as well as with international partners (e.g. United States, Australia) in terms of the sharing of fire fighting resources and personnel during the fire season.

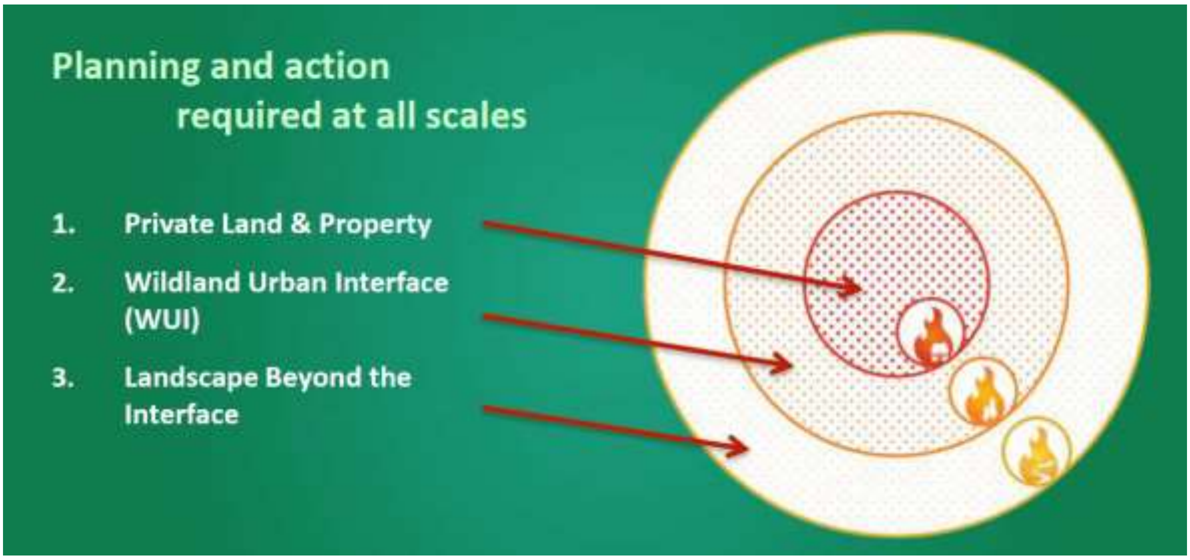

Figure 17. Planning scales for wildfire management, British Columbia

Source: Lyle Gawalko, Ministry of Forests, Lands and Natural Resource Operations, British Columbia.

In addition to wildfire monitoring and the identification of areas of high or extreme fire risk, a broad range of treatments is actively promoted to reduce fire risks. These treatments include:

- harvesting and commercial thinning;
- line corridor fuel breaks;
- increased prescribed fire;
- large scale fuel breaks;
- alternative silviculture regimes;
- energy/biomass use; and
- better initial attack (access, response and resources).

Main observations and recommendations for future policy

The main observations from this study tour for Australian forest managers and policy makers include:

- the high urban-forest interface (east coast of Australia, south-west Western Australia), as in the case in North America;
- similar issues with forest fuel loads and climate predictions, as a consequence of land use history and previous fire suppression;
- an increase in the occurrence of forest fires and area burnt in both North America and Australia over the past decade;
- high level bipartisan political support in the United States for fire management, including implementation of priority area and landscape level fuel reduction treatments for forest health and fire risk reduction;
- an emphasis on active management to return forest landscapes to more historical and fire resilient ecological conditions;
- the use of combined mechanical harvesting and prescribed burning for multiple benefits, including fire prevention, forest health and regional development; and
- the role of bioenergy and the wood products industry as part of an integrated solution for managing fire risk and forest health.

There is a need to rethink whole of landscape fuel reduction in Australia, with a view to adopting similar policies and programs as practiced in North America, particularly for drier forest types that are fire-prone and where previous human activity and fire suppression has contributed to high fuel loads and severe fire risk.

The Bushfire Cooperative Research Centre (2007), for example, has identified significant vegetation changes and forest health issues as a result of changed fire regimes and a preoccupation with suppression in many areas, including the ‘Pilliga scrub’ in central western New South Wales, the denser forests of the Murray River floodplain and the scrubby foothill forests of Victoria’s East Gippsland.

I would recommend that Australian policy makers, forest fire managers and the forest and wood products industry take a more collaborative approach as has occurred in the United States and Canada, who have adopted coordinated land planning and more innovative approaches to fuel management for multiple economic, social and environmental benefits.

A trial program should be established to assess the economic, technical and environmental merits of adopting combined mechanical and fuel burning treatments to reduce fire risk and improve forest management outcomes. Such a trial should focus on selected case study areas with a view to informing a broader national program for long term bushfire mitigation.

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