Fire, Fuel, and Carbon Management in Fire-Prone Forests

Literature review

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- Introduction, background
- Forest mgmt effects on Carbon (C)
- Complexities of C dynamics
- Pattern of recommendations
- Opportunities, challenges, caveats
- Conclusion
- Key messages

No need for taking notes – Extension Note on table

Conundrum:

when do fire management activities

increase C sources or sinks?

Introduction

- Describe forest C dynamics & approaches for dealing with C stocks & flows while managing for fire & a range of natural resource values.

- We're talking about fire-prone forests like those in BC southern interior, where fire has been a natural ecosystem process.

Wildland fire releases CO_2 quickly during combustion, then slowly as fire-killed trees decompose (US-FS photo)

Trees killed by insects emit CO_2 slowly as they decay.

Kevin Buxton photo, BC-FS

Background

Krankina & Harmon 2006

Forests play a major role in the C cycle.

Stored C in live biomass, dead plant material & soils

represents balance between absorbing and releasing CO_2.

Background...

Carbon dioxide (CO_2): produced when any substance containing C is burned or decomposes. 1 kg of CO_2 = 0.27 kg of C.

C pool: reservoir with capacity to accumulate or release C

C source: C pool that's decreasing.

C sink: C pool that's increasing in size.

Forest C:

- above ground (trees, other vegetation)
- surface (logs, branches, twigs)
- below ground (roots, organisms, fungi, other biota...)

Background…

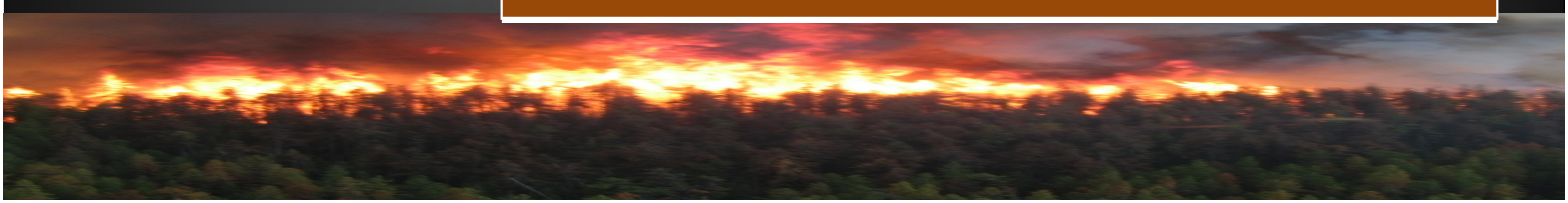
Western North American fire-prone forests

Earlier snow-melt

Increased summer temperatures

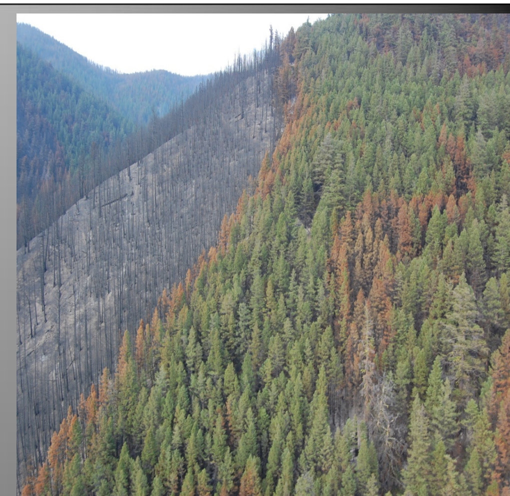
→

- ~ Longer fire seasons
- ~ Higher risk of ignition
- ~ More fires
- ~ Increased fire size
- ~ Longer fire duration
- ~ Higher fire intensity & severity



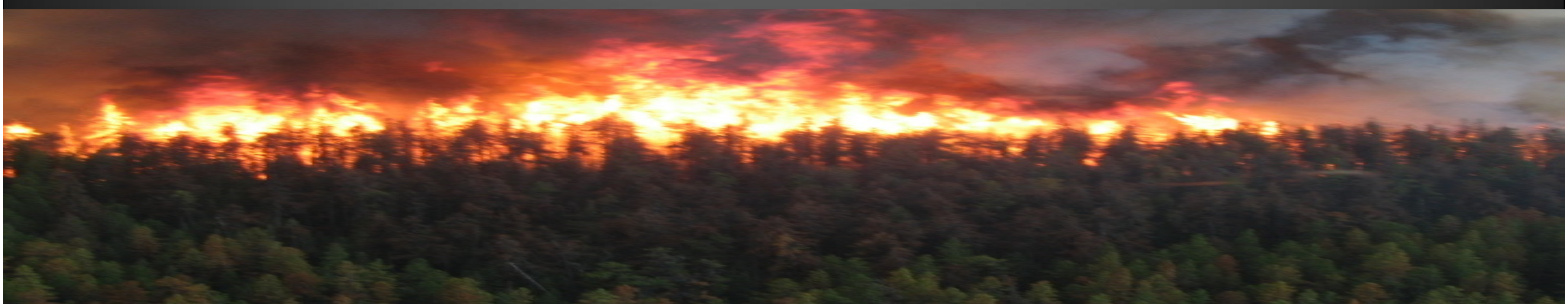
Background...

Forest biomass



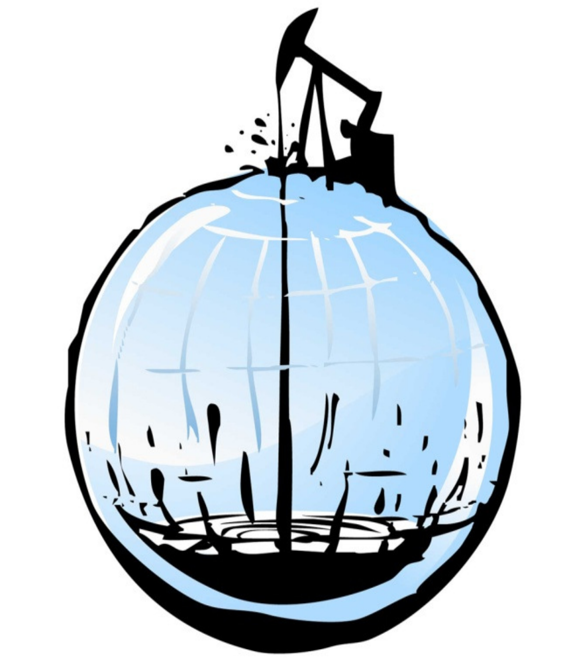
Basically, forests actively recycle CO_2

- Across landscapes, forests release CO_2 (e.g., fire, insects, decomposition)
- At same time, unburned forests & areas regenerating after fires take in CO_2



Background...

Fossil fuels



- Use of fossil fuels releases CO_2
- However, deposits of coal, gas, methane & oil have no such capacity for taking in atmospheric CO_2
- Thus, CO_2 from fossil fuel combustion is the main contributor to greenhouse gases & climate change, not CO_2 from biological sources

Forest management actions

- Most above-ground forest C is stored in largest trees. Thinning small understory trees has minor effect on post-treatment C pool.
- For many dry low-elevation BC ecosystems, past mgmt (e.g., fire exclusion, high-grade logging) has increased small-tree density.

Mgmt alternatives compared:

Fire suppression	Fuel reduction or ecosystem restoration	Modified Fire Response (a.k.a. Wildland Fire Use)

A comparison follows

Forest management actions: Comparing effects on C

Fire suppression	Fuel reduction or ecosystem restoration	Modified Fire Response (a.k.a. Wildland Fire Use)
Continued ► C uptake & storage in unburned areas **Increased:** ➢ short-term C emissions from fossil fuel when fighting fire ➢ long-term C emissions from ecosystem. As biomass accumulates, eventually a disturbance, likely more severe, will release C ➢ mortality of large trees, the main pool of above-ground C		

Forest management actions: Comparing the effects on C

Fire suppression	Fuel reduction or ecosystem restoration	Modified Fire Response (a.k.a. Wildland Fire Use)
	Increased: ➢ short-term C emissions from ecosystem ➢ short-term C emissions from fossil fuel use while thinning ➢ C uptake & storage in restored areas **Decreased:** ➢ mortality of large trees (main pool of above-ground C) ➢ C emissions possible if a fire occurs during the period of time that the treatment is effective	

Forest management actions: Comparing the effects on C

Fire suppression	Fuel reduction or ecosystem restoration	Modified Fire Response (a.k.a. Wildland Fire Use)
		Continued ► C uptake & storage in unburned portions within fire perimeter **Increased:** ➢ short-term C emissions from ecosystem during fire ➢ short-term C emissions from fossil fuel use when monitoring the fire (less than C emitted during fire suppression) ➢ mid- & long-term C emissions after fire, as a result of fire-induced tree mortality ➢ mid- & long-term C uptake & storage in burned area as the forest regenerates

Forest management actions: Comparing the effects on C

Fire suppression	Fuel reduction or ecosystem restoration	Modified Fire Response (a.k.a. Wildland Fire Use)

With all 3 mgmt approaches, net benefit remains unknown because, in part, it depends on:

- when future fires occur relative to mgmt actions
- fire behaviour
- fire effects
- fire size, relative to size of the area treated

Analysis & mgmt of CO_2 dynamics is complex

There are concerns about methods for measuring & modelling C

- Uncertainties. E.g., inventories based on commercial timber. Lack info about C in other live & dead vegetation, forest floor & soil
- However, this traditional inventory information can be used to estimate forest C through use of models
- There are now models to estimate whole tree, stand, or forest ecosystem C, & impacts of forest mgmt or natural disturbances

In spite of the complexities...

for droughty fire-prone forests similar to those in BC's interior...

- there are C-related conclusions & recommendations, such as:

Hurteau in McDaniel 2008

"keep managing forests based on scientific understanding of the processes

promote a fully functioning system,

end up in best position with regards to C storage...

If you thin a fire-prone forest,

the C stock is better protected."

Tyrrell et al. 2009

"In order to maintain resilient forests

with lower risk of catastrophic C loss,

sometimes necessary to lower C stocks

(e.g. fuel reduction thinning in fire-prone forests)"

Krankina & Harmon 2006

"Fuel reduction (e.g., Rx burns) reduces C stores (at least temporarily)

but Rx burns can reduce burning intensity in future fires

& thus maintain higher C stores in long run."

Hurteau & North 2010

“initial C reduction after fuel treatments

but C stocks quickly recover

if treatments retain

large, fire-resistant overstory trees”

McDaniel 2008

"prescribed fire & reducing fuels

are essential strategies to reduce losses

in long-term productivity,

lower GHG emissions,

& improve C storage"

North et al. 2009

"reduce surface fuels

thin small trees

remove only fire-sensitive species

to retain most of the C-pool,

reduce Rx burn & potential future wildfire emissions,

favour development of large, fire-resistant trees

that better stabilize C stocks."

Note however...

Prichard et al. 2010

thinning alone does not reduce fire severity

(too many surface fuels remain)

reducing tree density & surface fuels by thinning followed by Rx burning is effective

at mitigating wildfire severity & large- tree mortality

←1 year after thin & burn

13 years after thin & burn ↓

Opportunities & Challenges

- Biomass for bio-energy
- Storing c in forest products
- C markets
- Other benefits
- Public perception

Biomass for bioenergy

- Use thinned trees for heat (Fuels for Schools), electricity, or co-generation.
- Offset fossil fuel use with bioenergy. ‘Green’ jobs. Retain dollars in the community
- With bioenergy, long-term CO_2 emissions are offset by forest re-growth

-- not so with fossil fuels

Storing C in forest products

- Forest thinning often includes merchantable trees
- Thus, opportunities to store C in building products
- Manufacture of wood construction materials produces fewer fossil-fuel emissions than concrete, steel, aluminum
- But, some CO_2 released during wood product manufacturing

Carbon markets

- Can C markets help pay for fuel reductions?
- Doubtful: Fuel treatments unlikely to be eligible, regulated markets do not pay on ‘futures’.
- Doubtful: Fire suppression activities unlikely to qualify for C credits because they are part of normal business practice.
- Maybe: Forests take in and release C. Thus, bio-energy may be considered carbon-neutral in some offset markets (e.g., substitute biomass for propane to heat rural schools)

Other benefits of managing fuel hazards & fire risk

Market & non-market benefits

- **Avoided public costs:** fire-fighting, post-fire rehabilitation, regeneration, lost facilities & timber
- **Regional economic benefits:** local employment, cost savings of substituting forest biomass for fossil fuel

Other benefits, continued...

Protection & restoration of:

- native vegetation, animals, habitat, long-term site productivity, forest health
- water & air quality, aesthetics, recreation, tourism
- safer living conditions (fewer evacuations & fatalities)
- peace of mind resulting from reduced fire risk

Other benefits, continued...

Lippke et al. 2007

"If negative impacts of crown fires were fully reflected in the market,

much higher motivation to avoid them,

providing incentive to remove high fuel loads

in spite of the cost. ***...continued***

Other benefits, continued...

Lippke et al. 2007 continued

"Land mgmt decisions aimed at reducing fire risk

can have a high benefit-to-cost ratio,

if all market & nonmarket costs & benefits

are included."

Public perception

Social contract between public & land/ resource managers is important

- Otherwise, public may not support or accept proposed practices
- Thus, two-way outreach is important to establish trust, find shared values, understand attitudes & opinions, & seek solutions

Caveats

- Carbon in – Carbon out
- Other BC forests
- Dry forests – Wet forests
- Less moisture – More fires

Caveat: **Carbon in – Carbon out**

Forests naturally take up CO_2.

Fire mgmt activities may add GHG emissions or enhance uptake & storage of CO_2

Examples:

- Thinning slash decomposes or is reduced by controlled burns

- Skidding & hauling thinned timber create fossil fuel GHG emissions
- Fire suppression actions emit GHG: fossil fuel use in aircraft, trucks, pumps
- Protect C in large fire-resistant trees

Caveat: Other BC forests

This is a summary of the literature related to forest C, fuel & fire mgmt in fire-prone ecosystems

In BC, some fuel reduction treatments are being implemented in Montane Spruce, Sub-Boreal Spruce, & Sub-Boreal Pine Spruce ecosystems

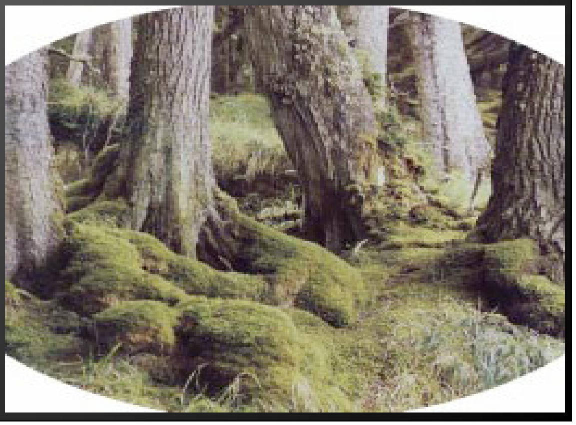
- However, for these areas, research related to fuels, fire, & C has not been published -- thus is not included here

Caveat: **Dry forests -- wet forests**

Dry fire-prone ecosystems & wet ecosystems differ

- Dry forests of south-central BC: fire has had important ecological & cultural roles
- Wetter ecosystems evolved in different ways, these tended to renew via different ecosystem processes (e.g., intense wind storms).

  However, over time, it's possible that climate change may result in more coastal fires, particularly in rain-shadow areas



Caveat: **Less moisture -- more fires**

In fire-prone forests, if the size and severity of wildland fires increase because of climate change, fire-derived C emissions could accelerate global warming.

Conclusion

Objectives:

- Fire & forest mgmt decisions never made solely on basis of C emissions or storage.
- In many instances, other objectives will require decision-makers plan & implement actions that reduce threats to human lives, homes & infrastructure.
- Adding consideration of C during decision-making can help affirm societal support for forest mgmt.

Conclusion

Tradeoffs:

- There’ll be tradeoffs when striving for maximum C pools & minimum C emissions while addressing fuel hazards, fire risk, & other forest values.

- Strategic application of mgmt treatments will be required.

Key messages

as climate changes,

- fire seasons will become longer
- more wildfire ignitions, larger wildfires
- increased fire severity & duration

Key messages

There are ways of managing fire-prone forests:

- to maintain & protect C stored in them
- to protect people & their communities
- to reduce the costs of fire-fighting, rehabilitating post-fire conditions, & regenerating new forests

Key messages

When fuel hazards are reduced, other forest values can be maintained or protected.

These include:

- water & air quality
- native vegetation, habitat, site productivity & forest health
- aesthetics
- recreation & tourism

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Thanks for your interest