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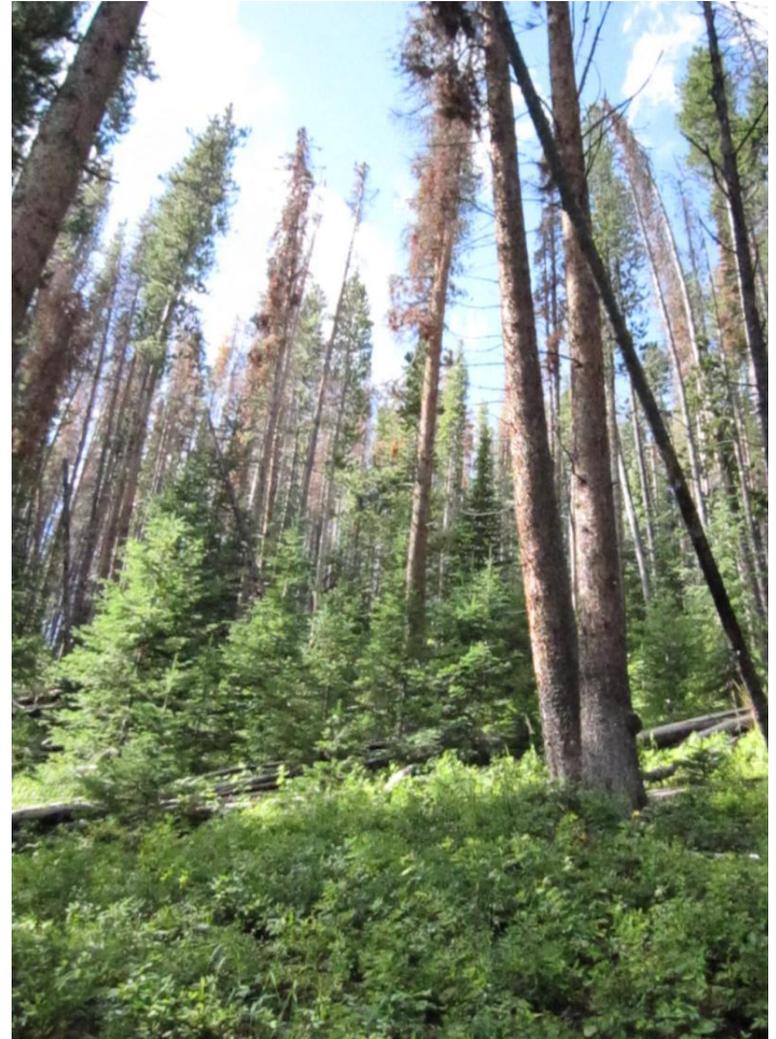
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One size does not fit all: interactions of forest composition and management on fuel complex and predicted fire behavior following a mountain pine beetle outbreak

Outline

- Background about mountain pine beetle
- Forest management goals and constraints
- Objectives
- Data collection and modeling methods
- Modeling results
- Conclusions and implications for future forest management



Recent mountain pine beetle outbreak

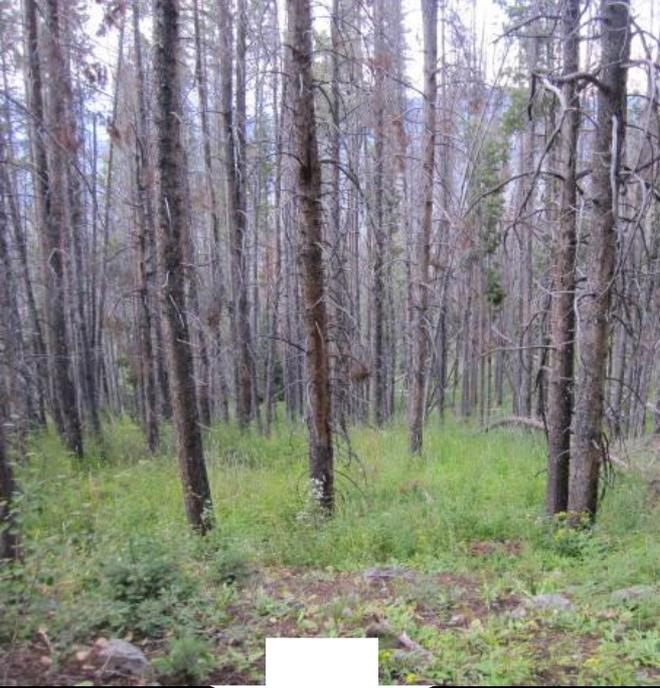
- Killed ~10 – 24 million ha of lodgepole pine-dominated forest (Raffa et al. 2008, Meddens et al. 2012)
- Prompted huge concern and research effort
- General effects on forest/fuels:
 - Surviving trees, advance regeneration likely to be most important to future forest
 - Small fuels (twigs, needles) increase first
 - CWD increases as snags fall
 - Combination of tree regeneration & woody fuels increases long-term fuel hazard



Forest species composition is important

- Compositions in MPB-affected lodgepole pine forest vary
 - Shade-tolerant Engelmann spruce & subalpine fir, quaking aspen
- Shade tolerant spp. under closed canopy
- Trees that remain following MPB form the future forest
 - Density of non-pine spp.
 - Density of advance regeneration





Species' effects on fuel complex

- Lodgepole pine self-prunes
 - Higher canopy base height
- Shade tolerant spruce/fir
 - Lower canopy base height
 - Higher canopy bulk density
 - Regeneration often more dense
- Aspen unlikely to burn



Mountain pine beetle management

- Focus is on removing hazard trees, reducing fire hazard
 - Salvage logging
 - Priority to “high risk” areas (USFS Green Ridge EIS)
- Logistical, liability, \$ constraints
 - ~90% will be untreated
- What are future management options?

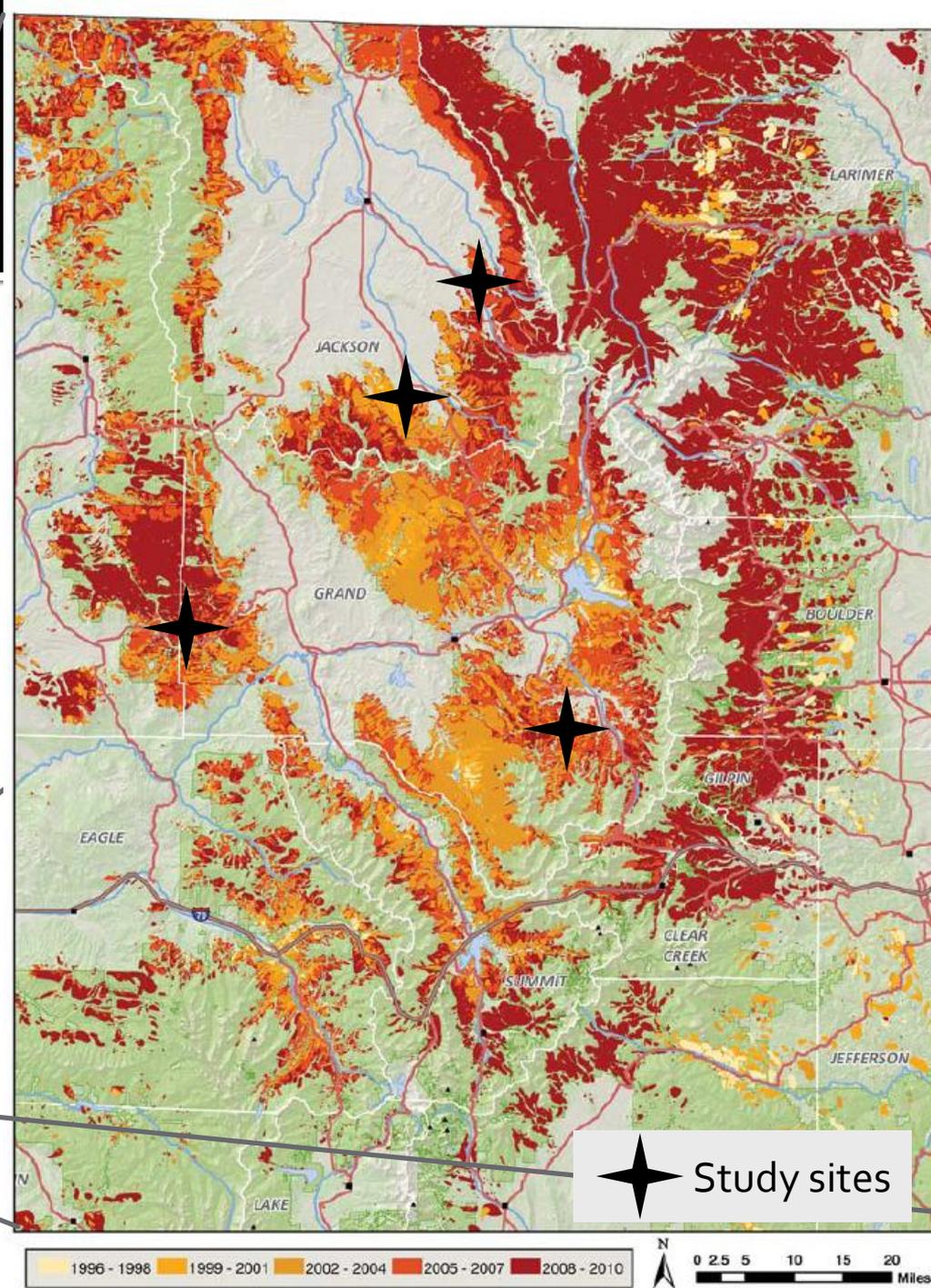
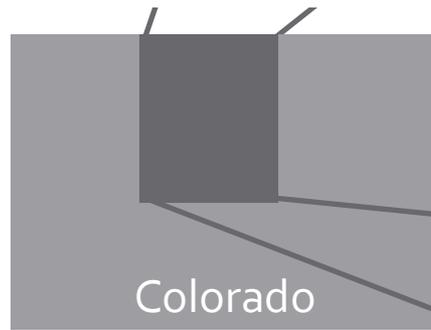


Research objectives:

- How does forest composition, fuel complex and predicted fire behavior vary among common lodgepole pine dominated forest types in century following MPB?
- How will future forest management scenarios (thin-from-below and prescribed burn) affect forest types in century following MPB?

Study area

- Sites had similar abiotic conditions and MPB mortality
- Forest of lodgepole pine, often mixed with quaking aspen, Engelmann spruce, subalpine fir
- Selected for Collins et al. (2010, 2011, 2012) & other work



Methods: field data collection

- Forest inventory
 - Overstory - trees ≥ 2.5 cm dbh
 - Species, dbh, status (L, D, MPB-killed)
 - Regeneration - trees < 2.5 cm dbh
 - Species and height
- Surface fuels
 - Brown's transects (2 per overstory transect)
 - Fuels recorded in 1 (0-.6 cm), 10 (.6 – 2.5 cm), 100 (2.5 – 7.6 cm), 1000+ hour (≥ 7.6 cm) size classes
 - 3 measurements of litter and duff depth



Overstory forest type groups

1. Lodgepole pine (n=11)

- Basal area 98% lodgepole pine
- Regeneration: lodgepole, aspen, spruce, fir

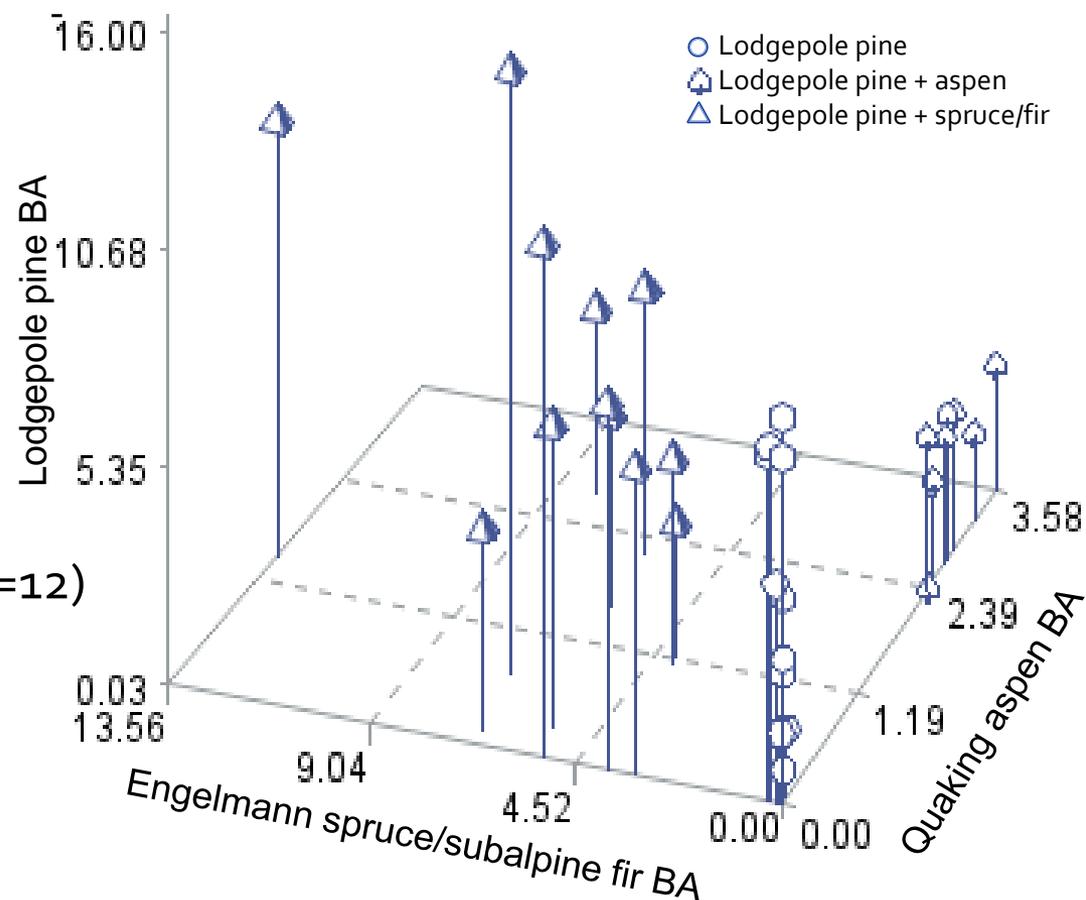
2. Lodgepole pine+aspen (n=8)

- Basal area 54% aspen, 48% lodgepole pine
- Regeneration: lodgepole, aspen, spruce

3. Lodgepole pine+spruce/fir (n=12)

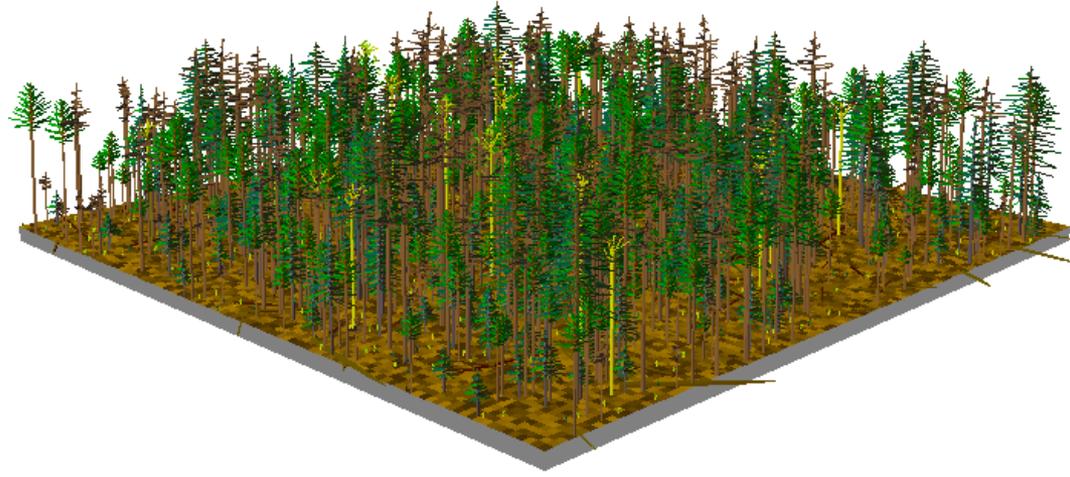
- 41% spruce/fir, 52% lodgepole
- Regeneration: lodgepole, aspen, spruce, fir

Forest type groups' basal area (m²/ha)



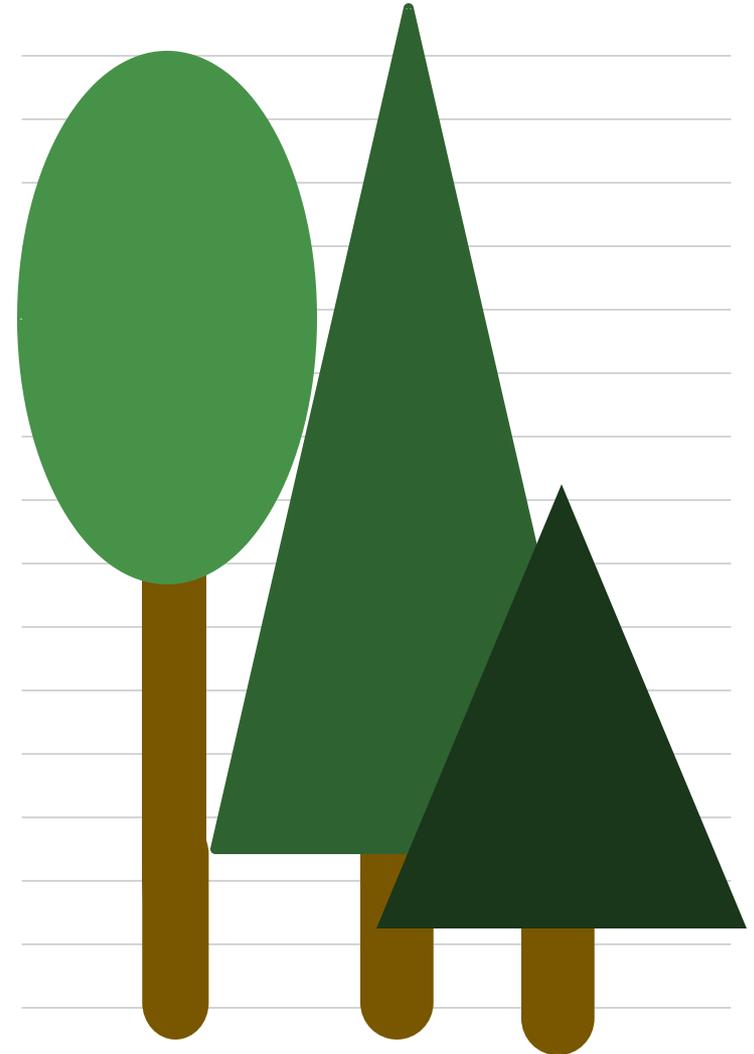
Modeling with Forest Vegetation Simulator

- Central Rockies variant & Fire and Fuels Extension
- Modifications:
 - Reduce growth and thin aspen to match regional data (USFS R2 Inventory, Shepperd 1993)
 - Tree establishment not automatic: modeled with Regeneration Imputation Extractor (Vandendriesche 2010)
- Fuels/fire behavior:
 - 40 fuel models (Scott & Burgan 2005)
 - Fire weather
 - Severe: 97%
 - Moderate: 50%



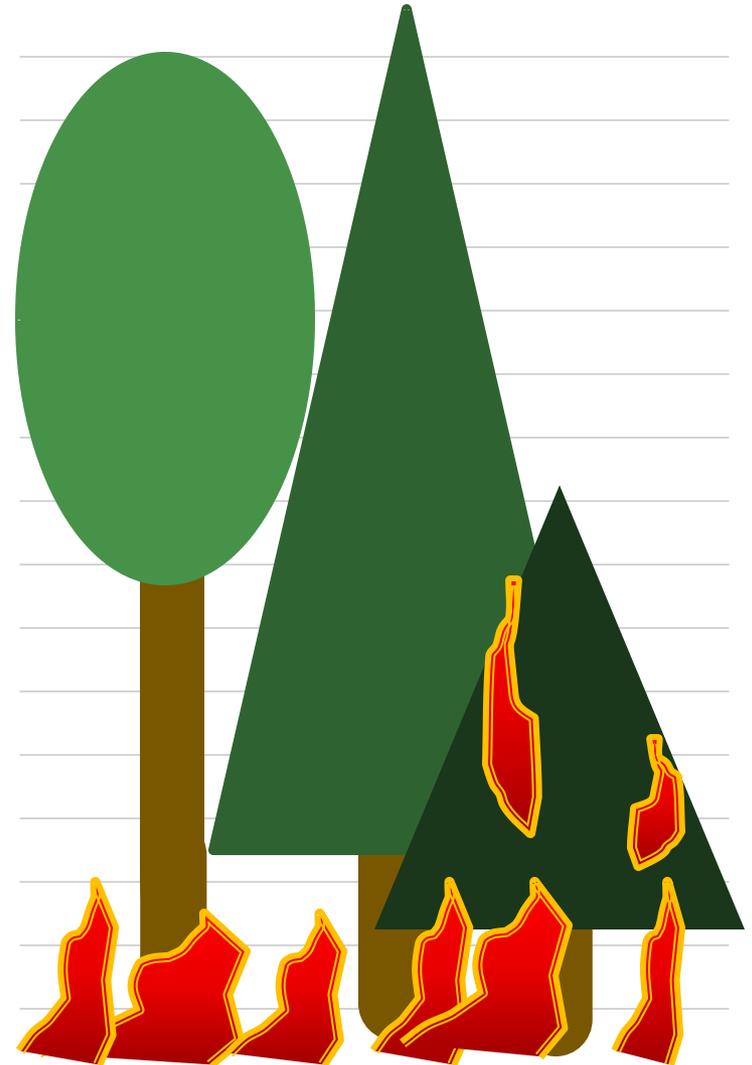
Crown fire behavior metrics

- FVS-FFE averages canopy across horizontal layers to calculate canopy fuels & potential fire behavior
- Probability of torching
 - Probability a given tree's crown will burn in given weather conditions
 - Sensitive to forest canopy base height and surface fuels
- Crowning index
 - Minimum windspeed needed for active crown fire (propagation from crown to crown) IF torching also occurs
 - Sensitive to torching (CBH) and canopy bulk density (max. canopy kg/m^3)



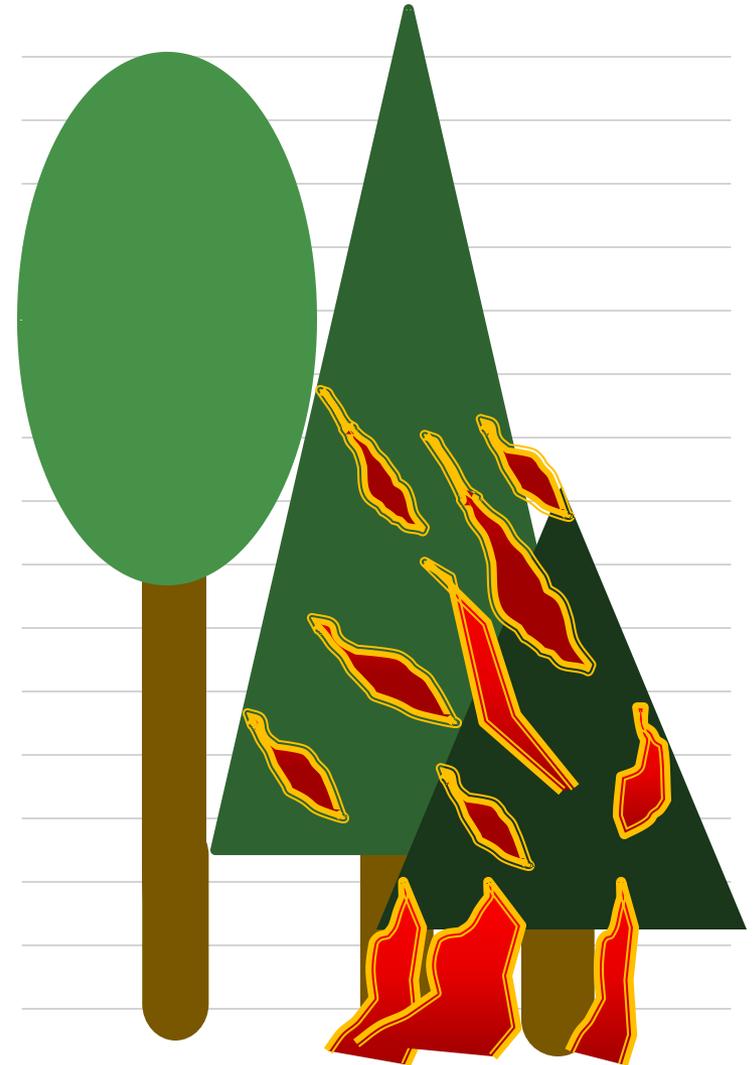
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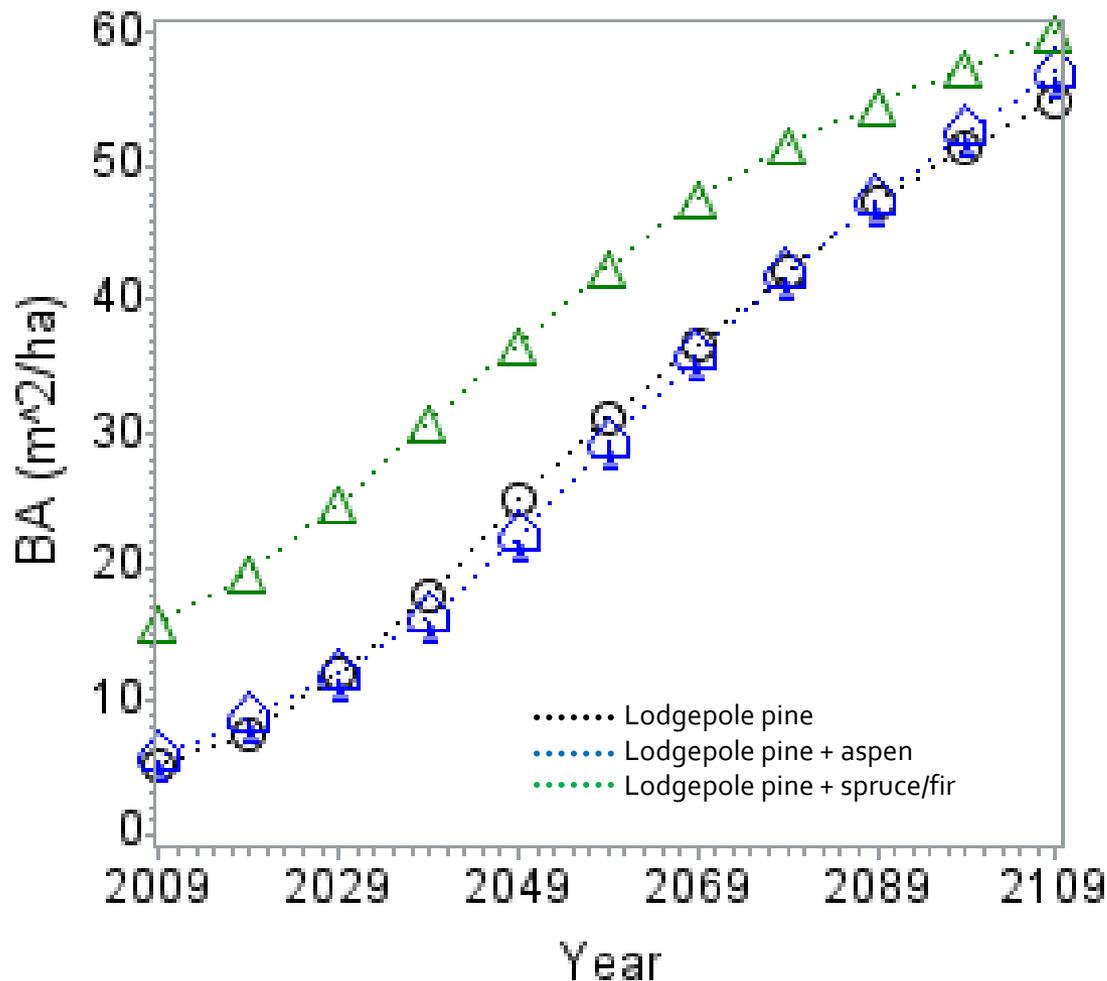
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Basal area/species composition

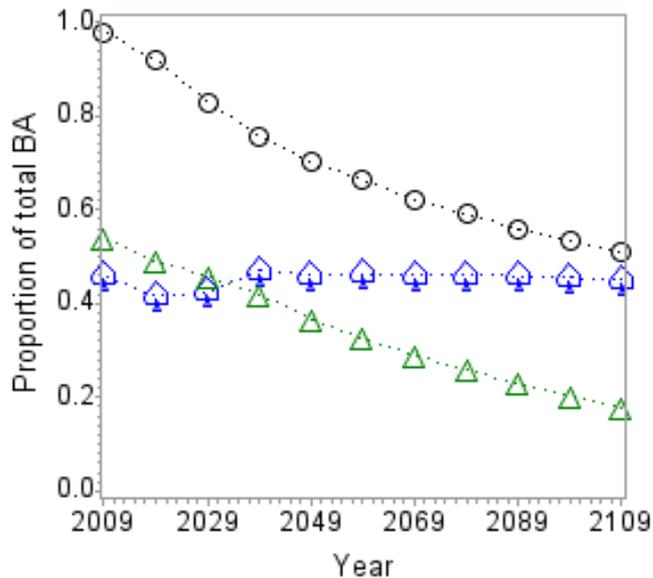
Total basal area



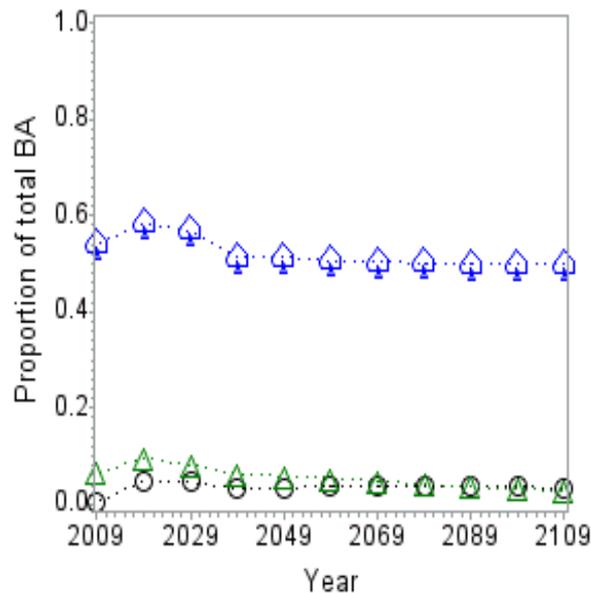
- Total basal area (includes all species) consistently highest in the lodgepole + spruce/fir forest type group

Differences in species composition

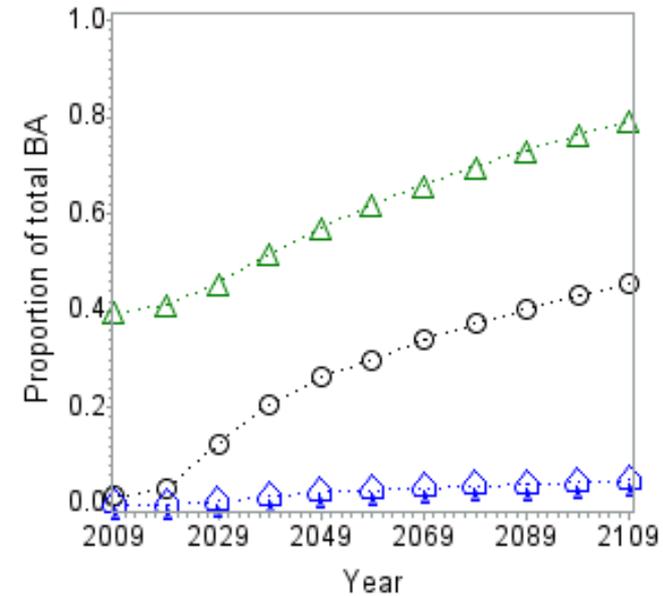
Proportion lodgepole



Proportion aspen



Proportion spruce/fir



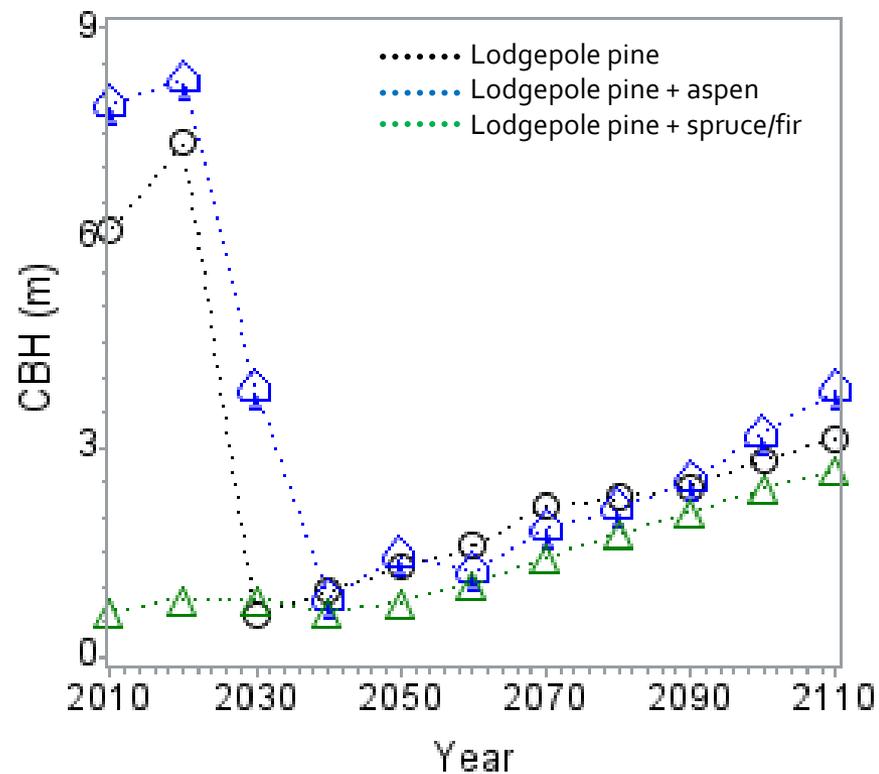
Forest type groups:

- Lodgepole pine
- Lodgepole pine + aspen
- Lodgepole pine + spruce/fir

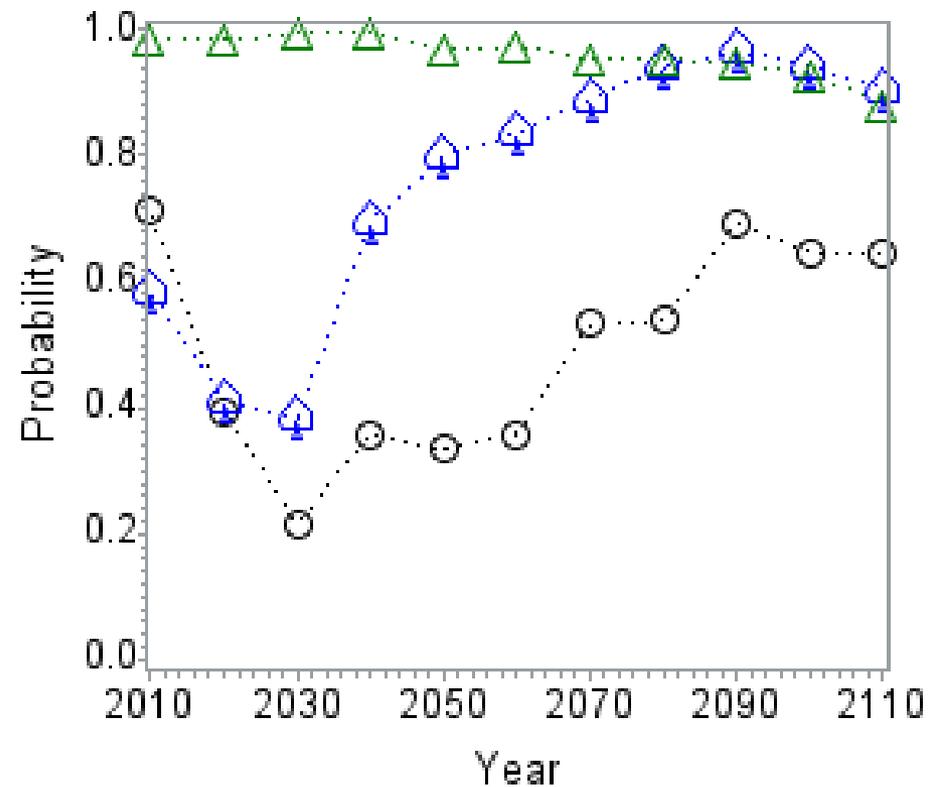
- Fir and spruce increase steadily in both lodgepole and lodgepole + spruce/fir types
- After 100 years, lodgepole pine type has composition of lodgepole + spruce/fir type today
- Lodgepole + aspen type stable

Canopy base height and torching

Canopy base height

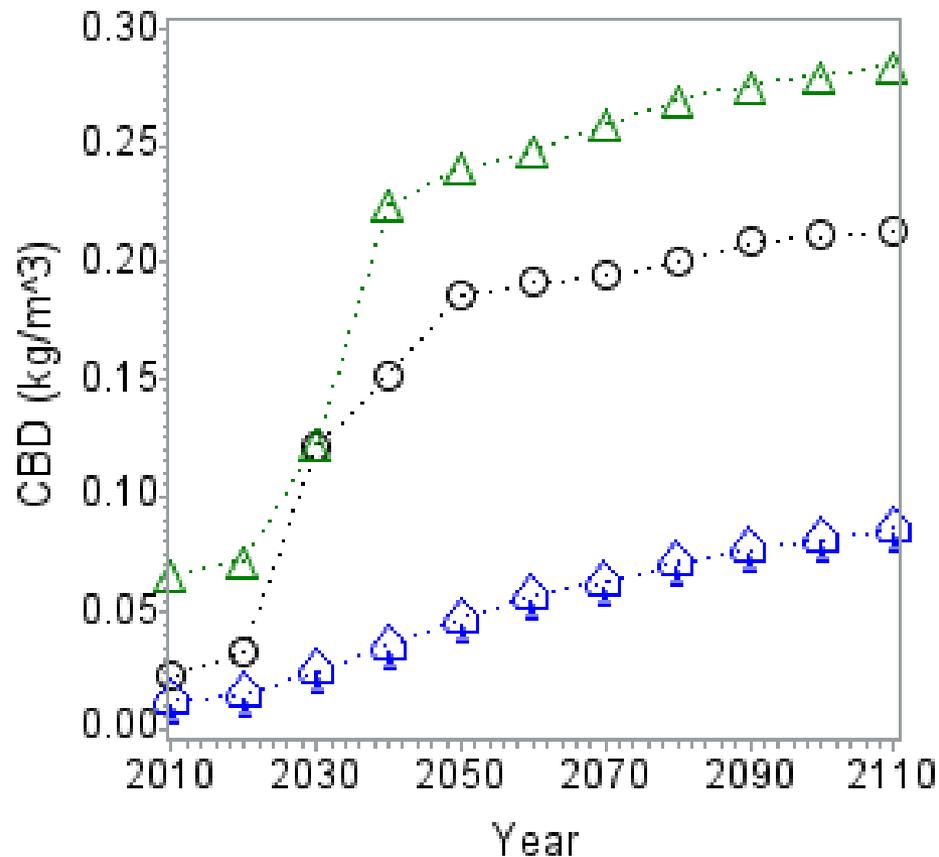


Torching probability Severe (97%ile) fire weather

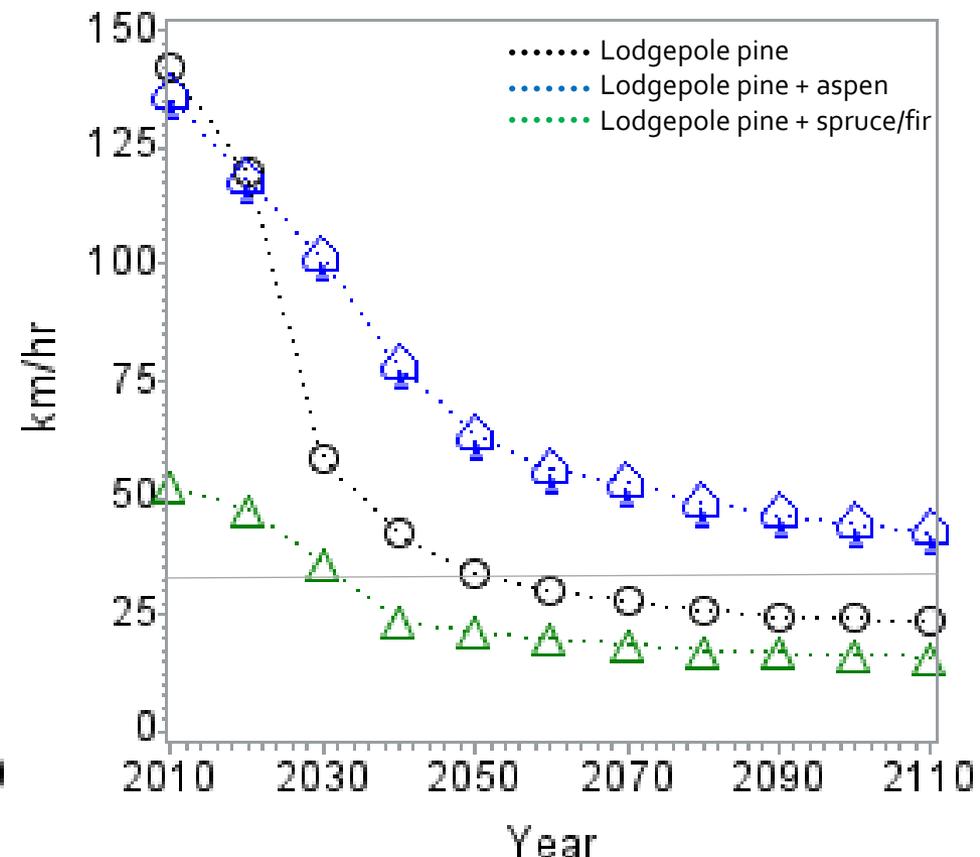


Canopy bulk density and crowning index

Canopy bulk density

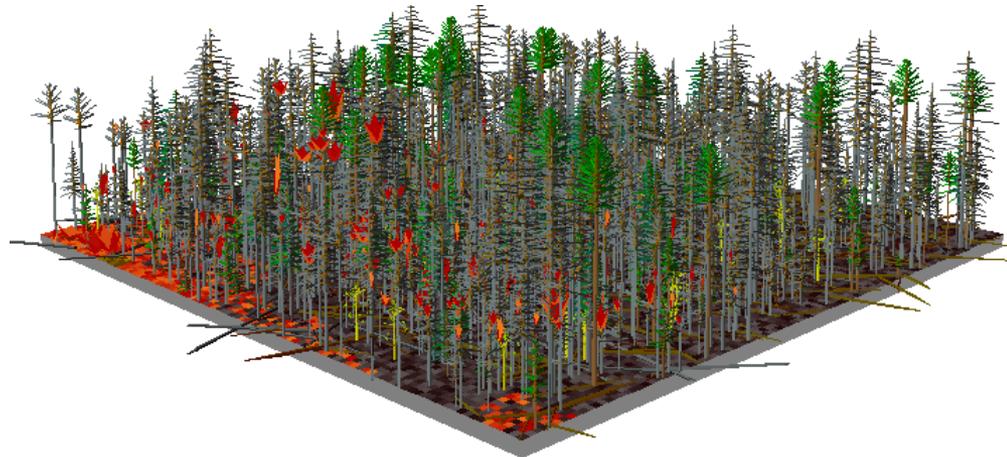
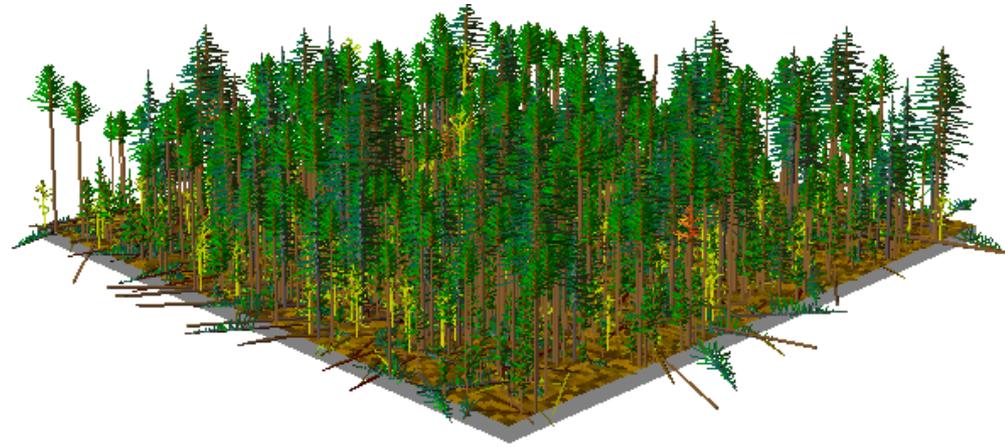


Crowning index



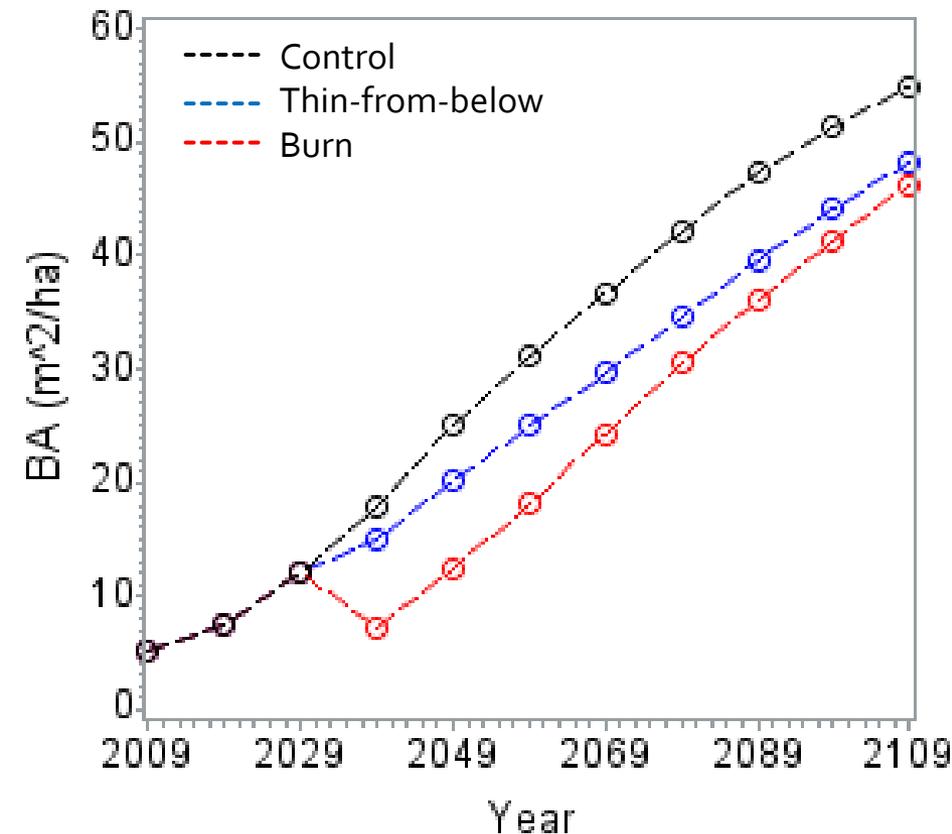
Modeling treatment effects

- Two treatments in 2029
 - Objectives: increase aspen, decrease fuels and potential fire behavior (USFS Green Ridge EIS)
- Thin-from-below
 - 95% of all spruce and fir <12.7 cm dbh
- Prescribed fire
 - 19.5°C, 13 km/hr windspeed, fall burn with “dry” moisture conditions

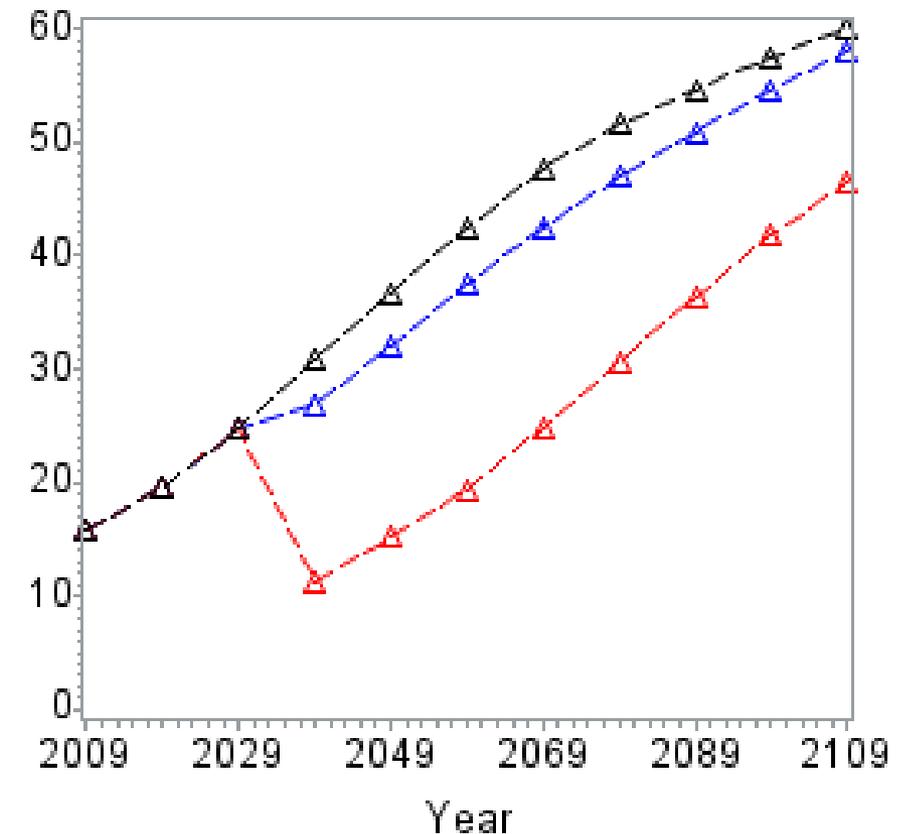


Effects of treatments: Total basal area

Lodgepole type



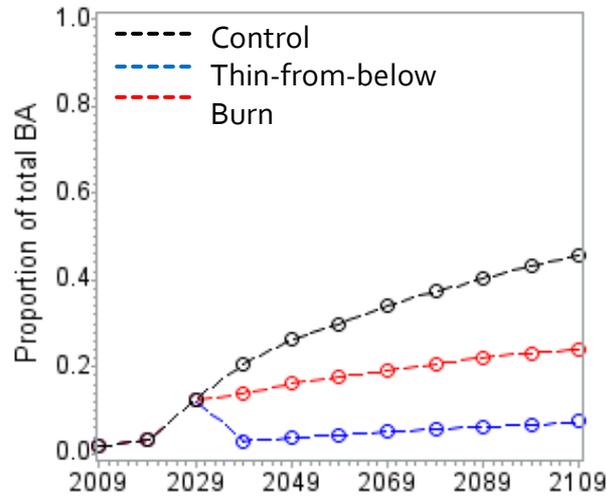
Lodgepole+spruce/fir type



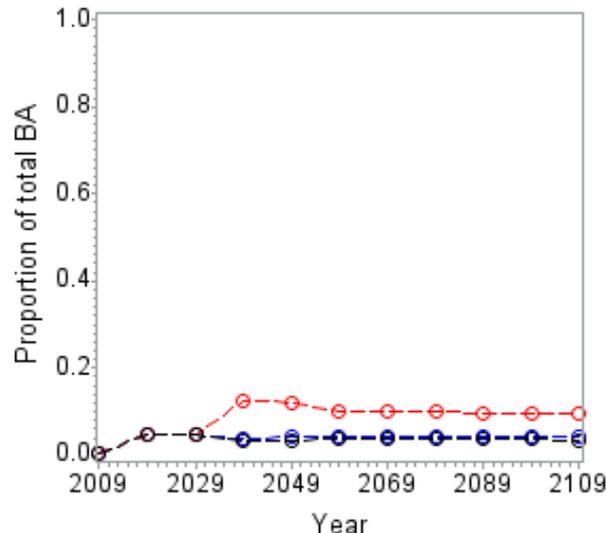
Species composition changes

Lodgepole pine type:

Fir/spruce

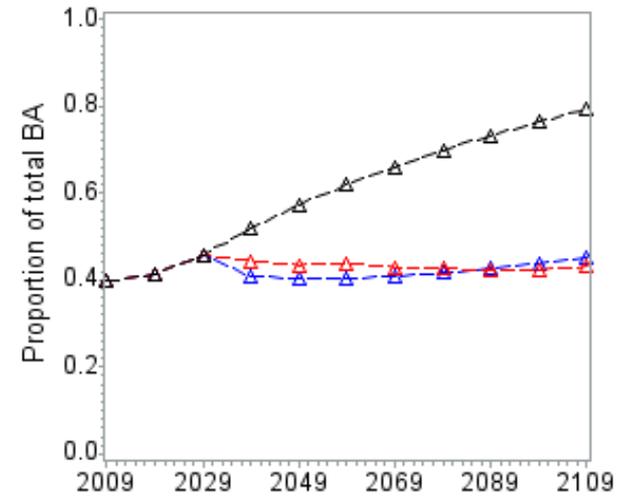


Aspen

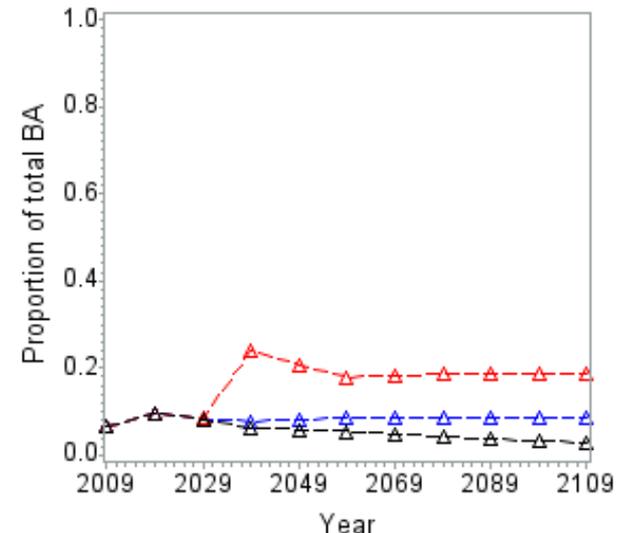


Lodgepole + spruce/fir type:

Fir/spruce



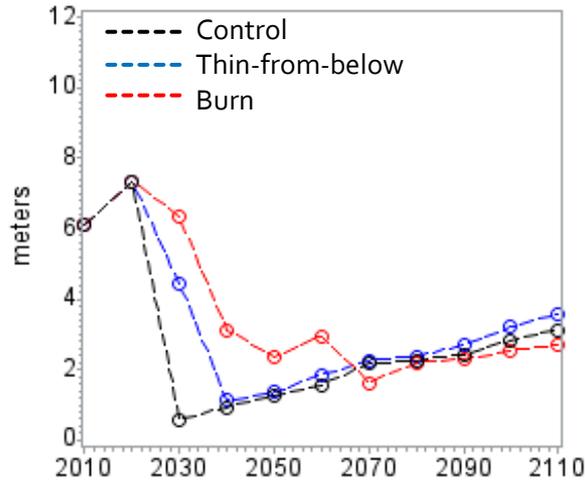
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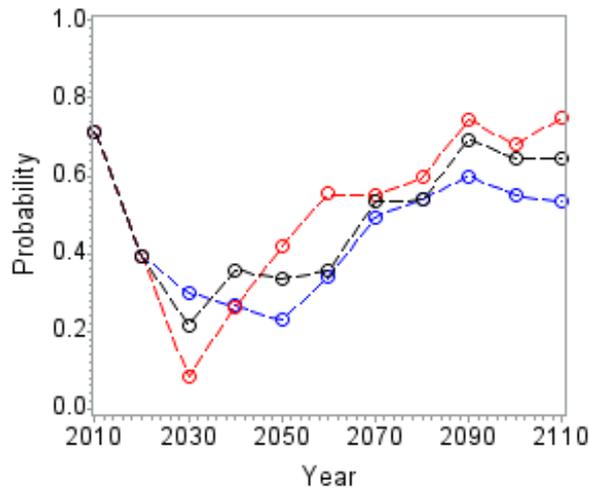
Canopy base height & torching

Lodgepole pine type:

Canopy base height

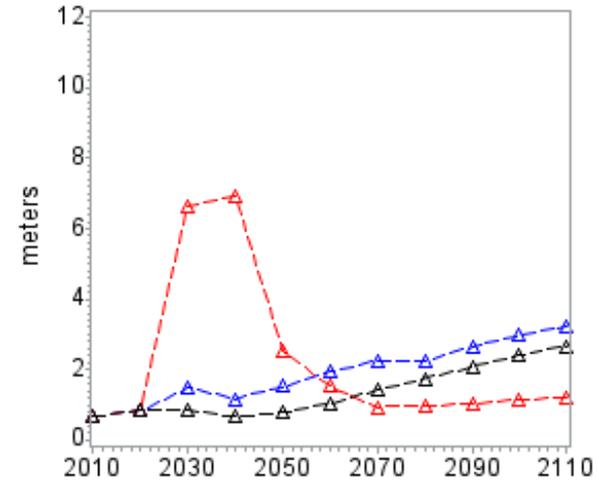


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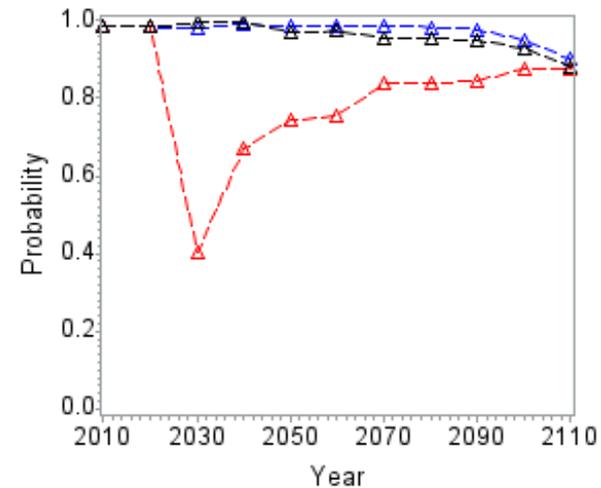


Lodgepole + spruce/fir type:

Canopy base height

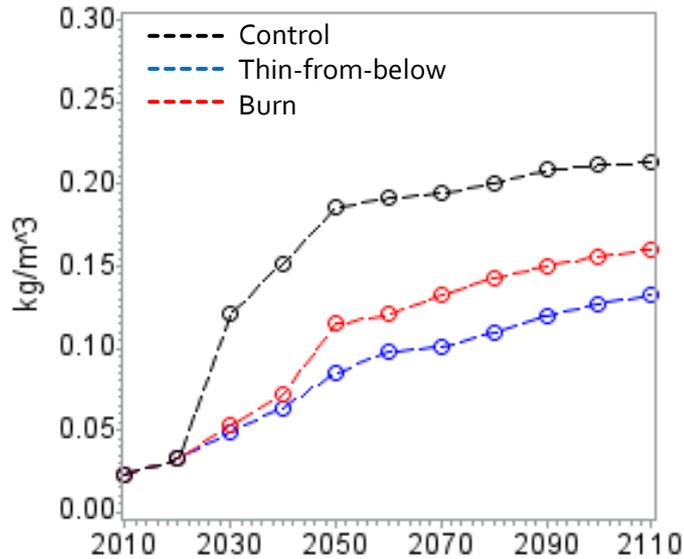


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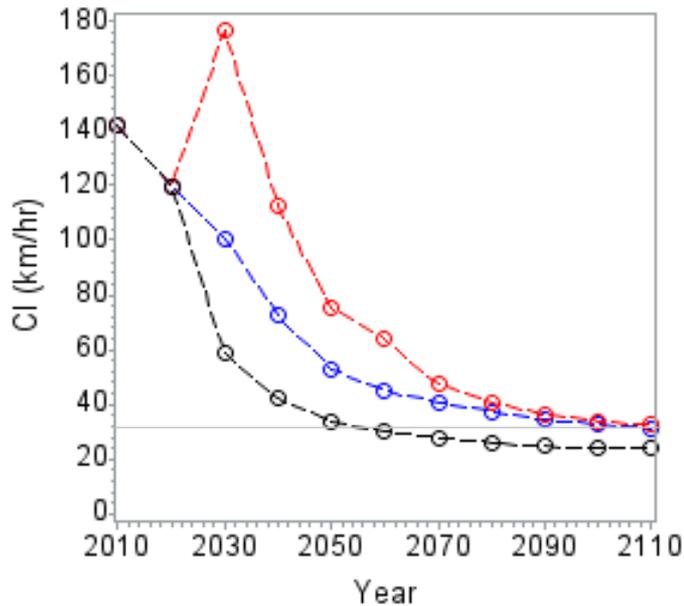


Lodgepole pine type:

Canopy bulk density

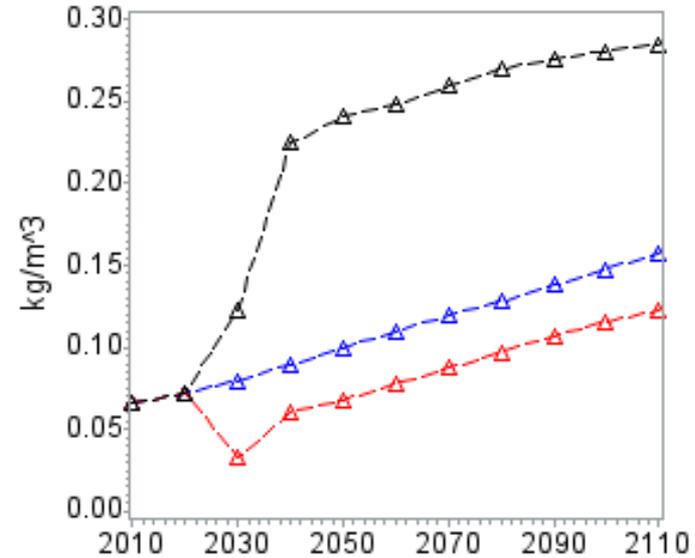


Crowning index

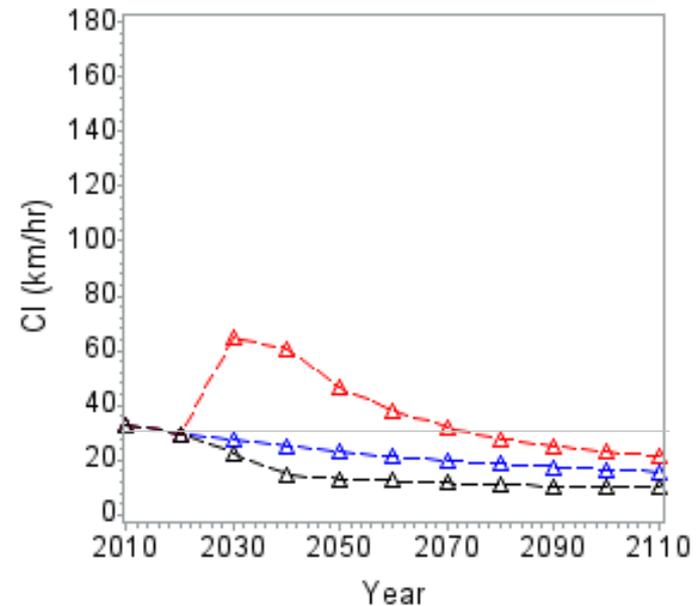


Lodgepole + spruce/fir type:

Canopy bulk density



Crowning index



Conclusions & Implications for management

- MPB-affected forests with spruce, fir will change composition most, have highest fire hazard
 - Treatments with fire hazard reduction goal should focus here
- Effectiveness of treatments:
 - Fire:
 - Reduces crown fire hazard, promotes aspen in both forest types
 - Basal area and crown fire hazard reduction greatest in lodgepole pine + spruce/fir
 - Thin-from-below:
 - In lodgepole pine may be more effective than burning at reducing crown fire hazard
 - Thinning does not reduce crown fire hazard in lodgepole + spruce/fir type
 - Overall, prescribed fire most effective treatment across forest types

Acknowledgements

- Thanks to Don Vandendriesche, Lance Asherin, Wayne Shepperd, and the USFS Forest Vegetation Simulator Support Staff for assistance with forest growth modeling.
- We gratefully acknowledge Byron Collins, Daniel Bowker and numerous technicians for field data collection.

