Silviculture Adaptation to Climate Change

Star Creek Experiment

CIF Rocky Mountain Section
Virtual Technical Session
Silviculture – From Basic to Intensive

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Overview

Changing climate

Tree/forest response

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Since the 1940's

- Mean annual temperature has warmed
  - Winters warming faster than summers
- Overall precipitation has increased but…
  - Mostly in the north; no change or slight decrease in the south
- Frost-free period and growing season have lengthened
- Spring snow melt occurring earlier
- Annual potential evapotranspiration has increased

Clark and Kienzle 2019, DeBeer et al. 2016, Gray et al. 2016, Hayhoe and Stoner 2019, Kienzle 2019

These trends are expected to continue

For every 1°C increase in global mean annual temperature:

- Warm by 1.5°C in summer and 2°C in winter
- Remain frost-free for an additional 2 weeks
- Experience 5-10% increase in winter precipitation with little change in summer

Bush and Lemmen 2019, Hayhoe and Stoner 2019

How will tree species/forests respond?

Decreased survival and growth

- Decreased soil moisture
- Increased drought stress
- Increased stressors from insects and disease, wildfire

Increased survival and growth

- Warmer temperatures
- Extended frost-free period
- Extended growing season

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Research questions

1. Do early seedling survival and growth differ by harvesting treatment (overstory, microclimate) designed to have varying influence on snow capture and timing of snowmelt?
2. Is seedling establishment success tree species dependent?

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Harvesting treatments

1. Clearcut (CC) with patch retention*
2. Modified strip shelterwood (SC)
   - Alternating ~35 m wide leave and harvested strips of varying length oriented east - west
3. Partial cut (PC) as a distributed selection cut
   - ‘Leave a tree take a tree’

Harvested during winters 2014 and 2015

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Tree species treatments

Tree species	Tolerance/Resistance D=drought, S=Shade, F=Frost, W=Fire Medium to high tolerance/resistance to stressor (Klinka et al 1999)	Elevation range (m)	Genetic gain GG=ht gain at rotation, GVO=vol gain at rotation, DSB= % of trees not killed by rusts by age 20 years
Lodgepole pine (Pl)*	D, F, W	800-1,200	GG+1.3
White spruce (Sw)	D, S, F. W	500-800	GG+4.4
Douglas-fir (Fd)	D, F, W	1,000-1,800	GVO+34
Western larch (Lw)	D, F, W	800-1,700	GVO+37
Western white pine (Pw)	S, F, W	500-1,400	DSB+65
Ponderosa pine (Py)	D, F, W	1,000-1,700	Wild
Siberian larch (Ls)	W	-	-

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PSB 410, 412 spring stock

Root Growth Potential, 30 days outside

Experimental design
Measurements

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2018 and 2019 Growing Seasons

- 2005-2019 climate record
  - 2018 lowest recorded precipitation (151.1 mm) and 4th warmest (12.5°C)
  - 2019 average precipitation (291.5 mm) and below average temperature (11.3°C)

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2018 and 2019 Growing Seasons

HOBO data loggers at seedling height

Microclimate May - Sept	CC		PC		SC	
	2018	2019	2018	2019	2018	2019
Tmean (°C)	13.4	12.6	13.6	13.7	13.3	13.1
Tmax (°C)	39.9	40.7	35.5	35.9	34.5	28.9
Tmin (°C)	-3.7	-2.7	-1.4	-1.4	-1.4	-1.8
Tmean daily amplitude (°C)	22.2	18.9	17.5	16.4	13.6	12.2

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Suitability of harvest treatments by tree species using PCA

(Height growth, diameter, mortality, canopy cover, environment)

Tree species	Most suitable		Least suitable	
Pl	PC, SC		CC	
Sw	SC		CC	
Fd	PC		CC	
Lw	PC		CC	
Pw	PC		CC	
Py	PC		CC	
Ls	PC		CC	

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Suitability of harvest treatments by tree species using discriminant analysis

(Height growth, diameter, mortality, cover, environment)

Tree species	Most suitable		Least suitable	
Pl	PC, SC	SC-N	CC	SC-F
Sw	SC	SC-N	CC	CC
Fd	PC	PC	CC	CC
Lw	PC	SC-N	CC	SC-F
Pw	PC	SC-N	CC	SC-F
Py	PC	SC-N	CC	CC, SC-F
Ls	PC	SC-N	CC	SC-F

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Research questions

1. Do early seedling survival and growth differ by harvesting treatment (overstory, microclimate) designed to have varying influence on snow capture and timing of snowmelt?

   Yes: PC > SC > CC

   Optimal canopy cover: 30 – 40%

2. Is seedling establishment success tree species dependent?

   Yes: Survival (%): Pl > Py >Pw > Fd > Sw > Lw > Ls

   Yes: Height growth : Pl > Pw > Lw > Ls > Py > Fd > Sw

Questions?