Understory communities in mature lodgepole pine stands: Stability and structuring processes

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Background

Lodgepole pine (*Pinus contorta*) ecosystems are widely distributed throughout western North America

Distribution map:
Pinus contorta subsp. ***contorta***

- Dominated by frequent stand-initiating fires
- Most often exist as young, pine-dominated stands
- Early succession dynamics have been extensively studied
- Vegetation dynamics in mature and later successional stages less studied.

Areas of mature logepole pine forest experiencing canopy decline and successional transition are increasing due to:

- Lower fire frequencies in recent decades
- Recent mountain Pine beetle outbreaks

Rhemtulla et al 2002

Important to understand how this affects understory communities as these are:

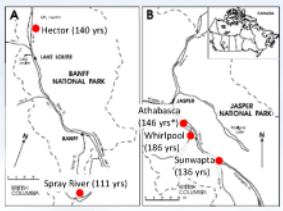
- An important component of biodiversity
- Serve as food source and habitat for many other life forms
- Play an important role in nutrient cycling
- Influence regeneration of tree species

Objective 1
Quantify the long term (45 yrs) compositional changes of mature lodgepole pine forests

Objective 2
Determine the relative importance of the environment vs other spatial processes in structuring the understory communities and how these change over time.

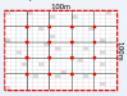
Methods

Sample sites
5 - 1ha permanent plots along a moisture/elevation gradient



* The Athabasca site also had a 114 year old cohort of Pinus contorta due to a surface fire that occurred around 1900

Sampling design
400 5x5m quadrats in which understory, overstory and topography variables were sampled in 1967, 1989 and 2012.

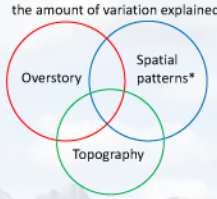


% cover of all vascular plant and main moss species

Nbr of tree stems by species and DBH classes

Elevation of quadrat corners (just in 1967)

The size of the circle is proportional to the amount of variation explained



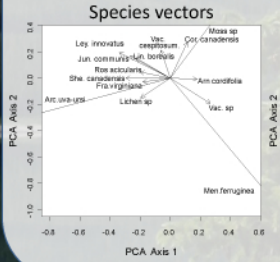
*Built using the Principal coordinates of neighbor matrices (PCNM).

Statistical analyses

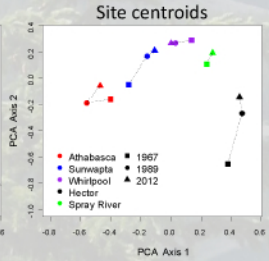
1) PCA ordination of understory community (all sites and sample times)
2) Species occurrence ratio $\frac{\text{2012 frequency}}{\text{1967 frequency}}$
3) Variation partitioning with constrained ordination (RDA) of understory community composition and richness
4) Detailed inspection of community spatial structure.

How stable are these communities?

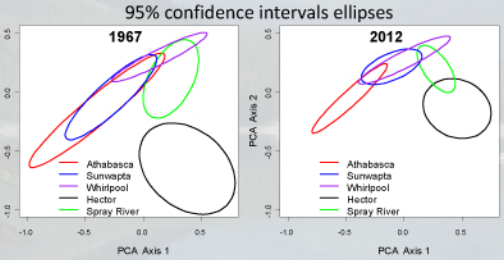
Species vectors



Site centroids



95% confidence intervals ellipses



PCA ordination results

1) PCA axis #1 → gradient from xeric (Athabasca) to moist sites (Hector and Spray River)
2) All sites (except Whirlpool) becoming more homogeneous (reduction of 95% confidence ellipses in time).

Occurrence ratio results

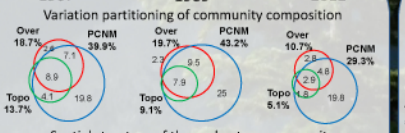
1) 26 species (mostly moist adapted) increased in frequency (by ≥ 25 % in at least one site; never decreased by >25% in any site)
2) 14 species (all associated with open micro habitats) decreased in frequency (by ≥ 25 % in at least one site and never increased by more than 25% in any sites.

What is structuring these communities?

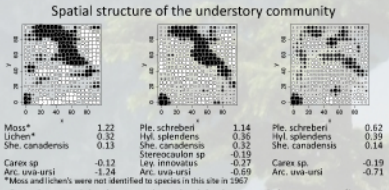
Athabasca (xeric)

1967 1989 2012

Variation partitioning of community composition



Spatial structure of the understory community



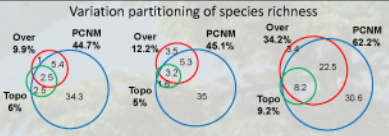
1967		1989		2012	
Moss*	1.22	Ple. schreberi	1.14	Ple. schreberi	0.62
Lichen*	0.32	Hyl. splendens	0.36	Hyl. splendens	0.39
She. canadensis	0.13	She. canadensis	0.32	She. canadensis	0.14
		Stereocaulon sp	-0.19		
Carex sp	-0.12	Ley. innovatus	-0.27	Carex sp.	-0.19
Arc. uva-ursi	-1.24	Arc. uva-ursi	-0.69	Arc. uva-ursi	-0.71

*Moss and lichen's were not identified to species in this site in 1967

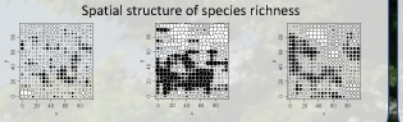
Species positively correlated with the spatial structure (large black circles) were associated with areas of dense small pine trees in lower microsites.

Species negatively correlated with the spatial structure (large white circles) were associated with open, higher microhabitats.

Variation partitioning of species richness



Spatial structure of species richness

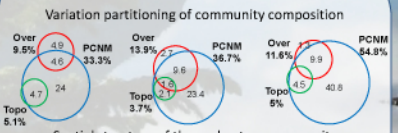


High species richness (large black circles) associated with open microhabitats ; low species richness (large white circles) found in areas of dense canopy cover.

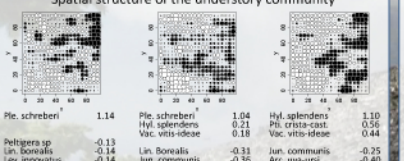
Sunwapta (mesic)

1967 1989 2012

Variation partitioning of community composition



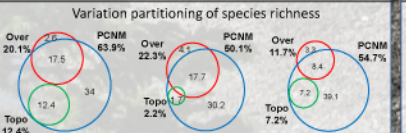
Spatial structure of the understory community



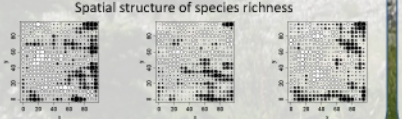
1967		1989		2012	
Ple. schreberi	1.14	Ple. schreberi	1.04	Hyl. splendens	1.10
		Hyl. splendens	0.21	Pti. crista-cast.	0.56
		Vac. vitis-ideae	0.18	Vac. vitis-ideae	0.44
Peltigera sp	-0.13				
Lin. borealis	-0.14	Lin. Borealis	-0.31	Jun. communis	-0.25
Ley. innovatus	-0.14	Jun. communis	-0.36	Arc. uva-ursi	-0.40
She. canadensis	-0.49	She. canadensis	-0.41	Ple. schreberi	-0.64

Gradient from moist adapted species (black circles) to drought tolerant species (white circles).
Species adapted to moist micro habitats were always associated with areas of dense pine saplings.

Variation partitioning of species richness



Spatial structure of species richness

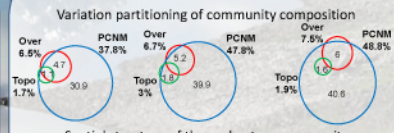


High species richness associated with pine and aspen saplings; low species richness found under large pine trees.

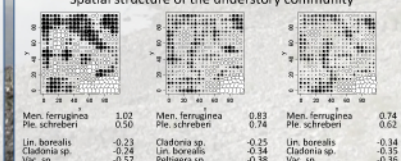
Hector (moist)

1967 1989 2012

Variation partitioning of community composition



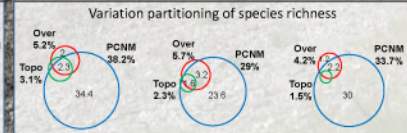
Spatial structure of the understory community



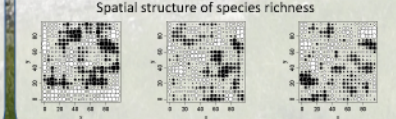
1967		1989		2012	
Men. ferruginea	1.02	Men. ferruginea	0.83	Men. ferruginea	0.74
Ple. schreberi	0.50	Ple. schreberi	0.74	Ple. schreberi	0.62
Lin. borealis	-0.23	Cladonia sp.	-0.25	Lin. borealis	-0.34
Cladonia sp.	-0.24	Lin. borealis	-0.34	Cladonia sp.	-0.35
Vac. sp.	-0.57	Peltigera sp.	-0.38	Vac. sp.	-0.36
She. canadensis	-0.98	She. canadensis	-0.84	She. canadensis	-0.78

Gradient from moist adapted species (black circles) to drought tolerant species (white circles).
However environmental variables measured don't explain much of this gradient.

Variation partitioning of species richness



Spatial structure of species richness



The spatial structure of species richness was more or less constant and poorly explained by environmental variables measured.

Spatial structure results

1) All sites had spatially structured understory communities.
2) Changes in the influence of the overstory in explaining species richness in the xeric and mesic site are due to the expansion of moist adapted species in previously inhospitable micro habitats.
3) All sites have a gradient from moist to dry adapted species which suggest moisture is an important factor in structuring theses communities.
4) Environmental variables played a stronger role in structuring the understory communities in xeric than moist stands.

Conclusion

1) These understory communities are still dynamic even 100 years after fire.
2) When resources are limited, deterministic process (environmental control) are more important while neutral process might be more important otherwise.

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