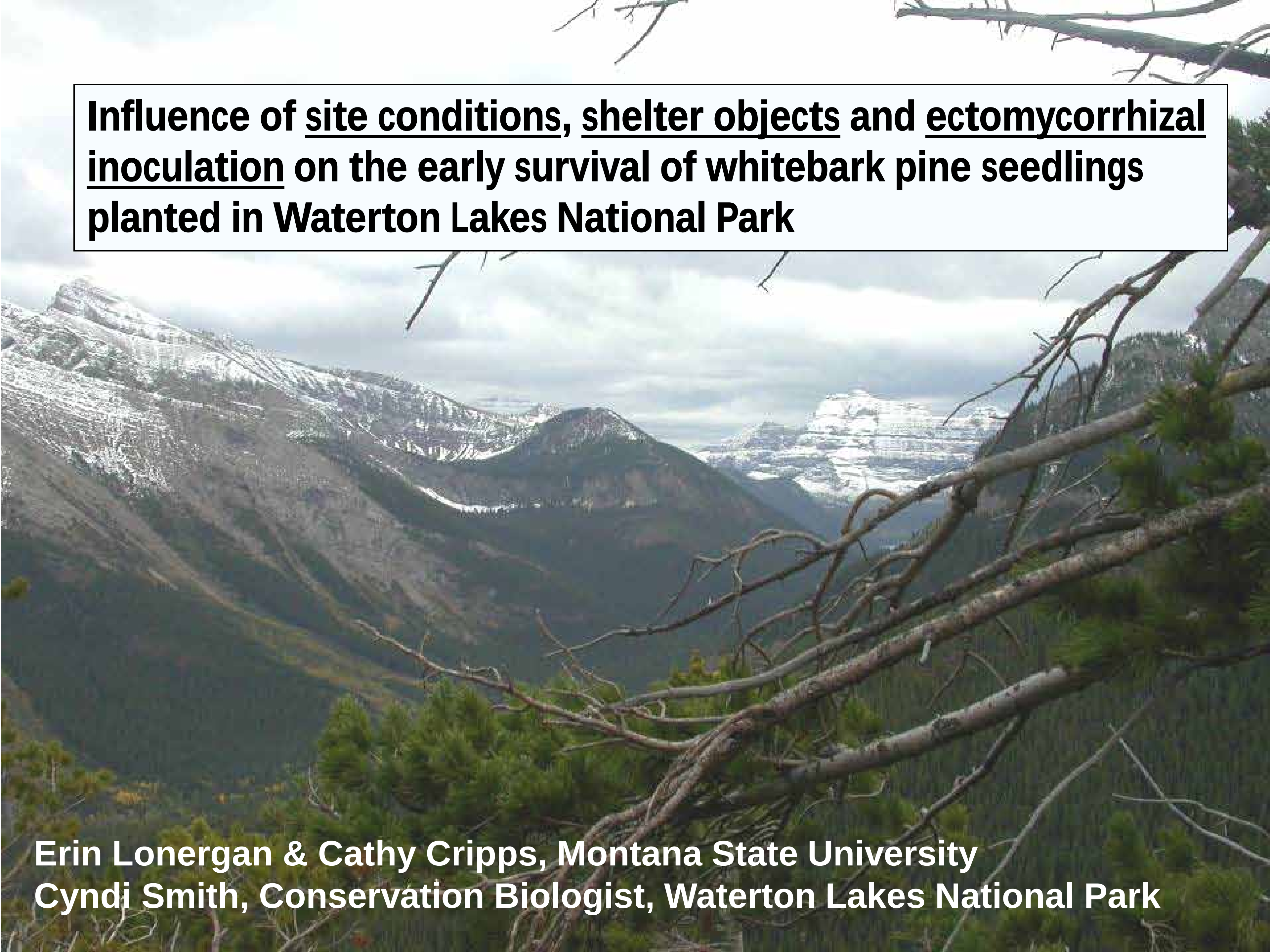
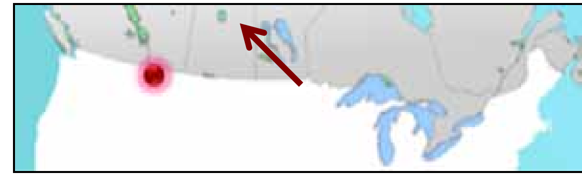


Influence of site conditions, shelter objects and ectomycorrhizal inoculation on the early survival of whitebark pine seedlings planted in Waterton Lakes National Park

Erin Lonergan & Cathy Cripps, Montana State University
Cyndi Smith, Conservation Biologist, Waterton Lakes National Park

“Working Together to Restore Terrestrial Ecosystems” --Waterton Lakes National Park”



Parks Canada investing $7 million to restore terrestrial ecosystems.
In Waterton Lakes National Park, the restoration of native fescue grasslands and of whitebark and limber pine communities are the main focus of this many-sided project.

Volunteer Tree Planting

Help to restore whitebark pine trees in Waterton

On **Wednesday, September 7, 2011**, Parks Canada will continue its work to restore whitebark pine in Waterton Lakes. 300 seedlings need planting and we could use your help

There has been a significant reduction in local whitebark pine populations due to a combination of (1) an infestation of non-native white pine blister rust, (2) mountain pine beetle attacks, and (3) a lack of conditions created by fire which are important for whitebark pine regeneration.

If you would like to participate in this planting event, you should be prepared for a full day outdoors. We will be planting regardless of the weather, so please bring a rain coat and warm clothes, as well as a bagged lunch. If you have garden gloves, bring those as well, otherwise they will be provided.

The day will likely involve hiking approximately 4 km (1.5 hours) one way along a moderate trail, gaining 305 m of elevation.

Meet at 8:30 a.m. at the Warden Office across from Linnet Lake in Waterton.

For more information, please contact David Musto at: (403) 859-2702 or david.musto@pc.gc.ca

Canada

Volunteers planting whitebark pine in Waterton Lakes National Park © Parks Canada / Sean Lemoine

Cyndi Smith, Conservation Biologist WLNP

Initiated restoration of whitebark & limber pine in Waterton Lakes National Park

- High WBP mortality (Smith et al. 2008, Smith et al. 2011)
- Restoration began in 2003
- Plus trees identified 2006, cone collection 2006-2011
- Use of Verbenone to protect selected trees
- Seeds sent for rust resistance screening
- Planting whitebark pine seedlings (2010, 2011, 2012, 2013)
- Inoculated of seedlings with native ectomycorrhizal fungi

Erin Lonergan, M.Sc. Research 2012

“Use of Native Ectomycorrhizal Fungi in the Restoration of Whitebark Pine”

Plant Sciences & Plant Pathology Dept., Montana State University

- experimental design, planting, inoculation
- monitoring seedlings
- statistical analysis

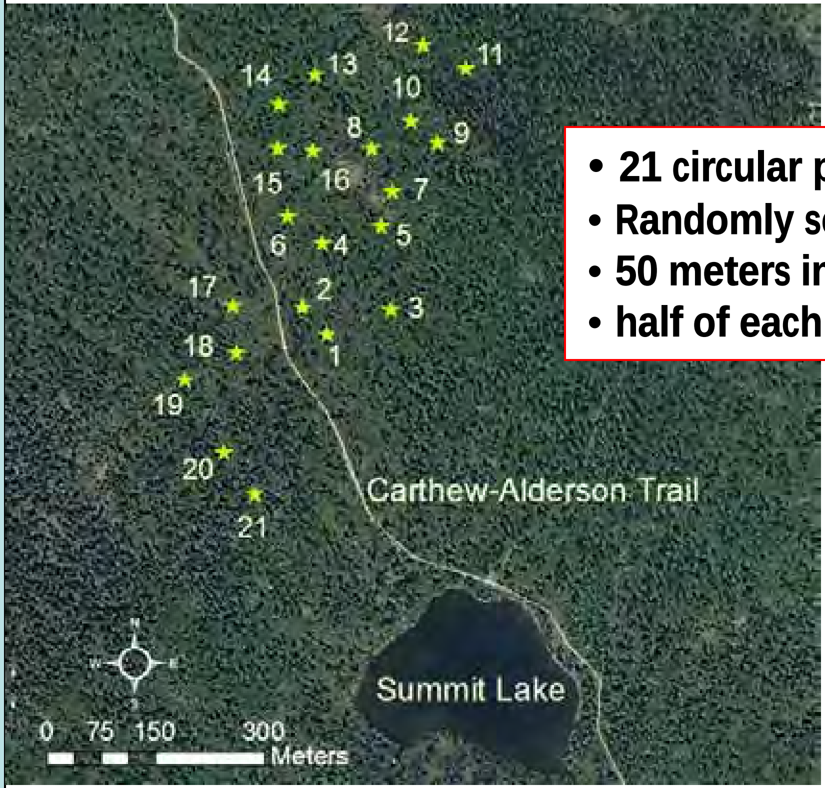
Our Goal:

was to determine how various factors affect the survival of nursery-grown whitebark pine seedlings planted in the park.

- Planting in **burned** areas (terra-torched)
- Planting in **beargrass**
- Planting with **microsites (shelter objects)**
- Inoculation with **ectomycorrhizal fungi**

Waterton Lakes National Park

Summit Lake



- 21 circular plots
- Randomly selected
- 50 meters in diameter
- half of each plot burned

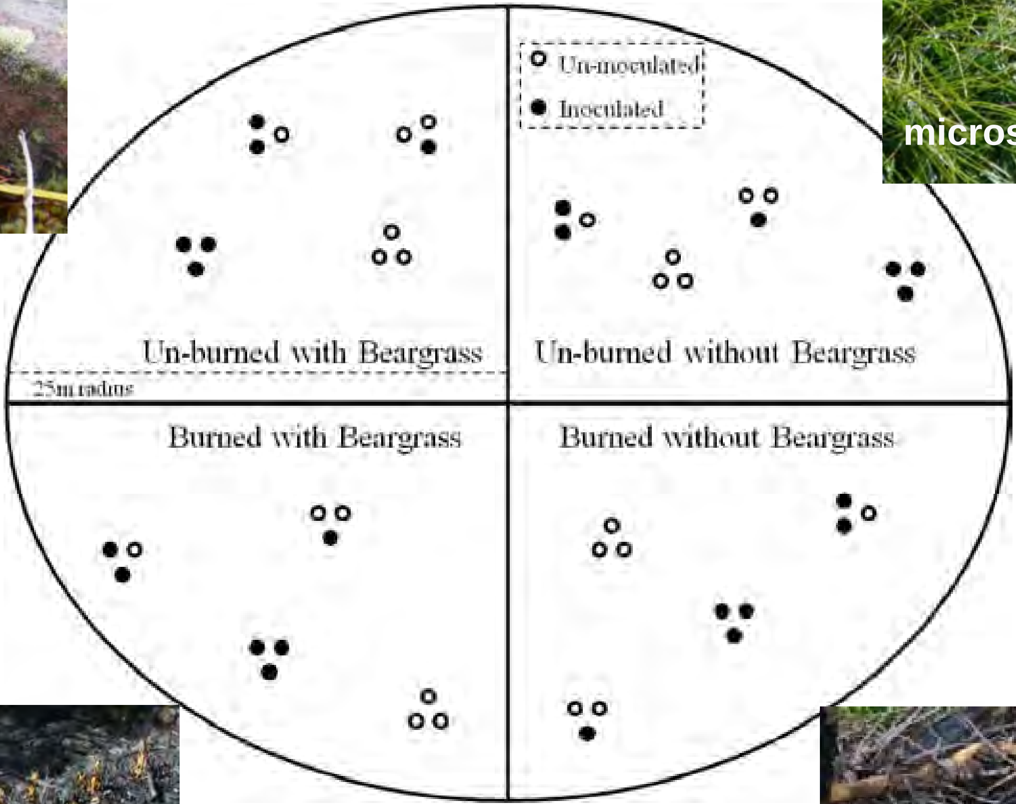
Elevations: 1,500 – 2,000 m

To remove overstory trees, not WBP

4 sets of site conditions on each plot

Unburned without beargrass

Unburned with beargrass

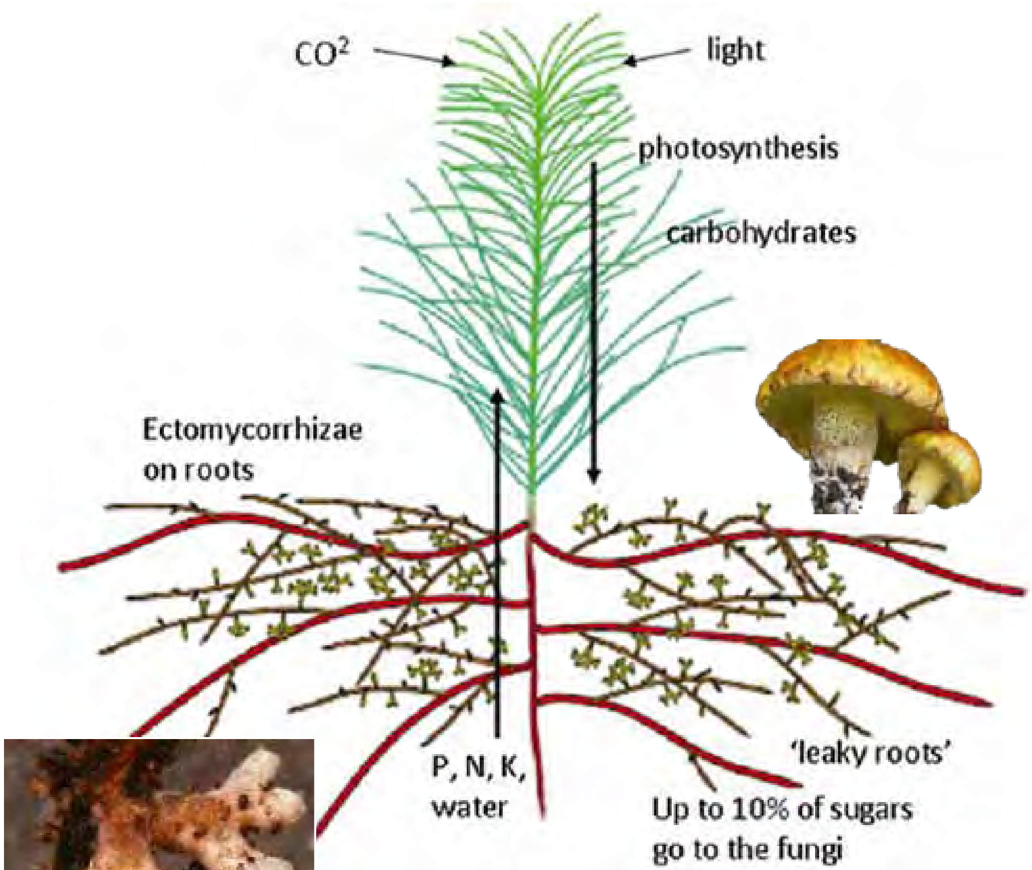


- planted in clusters of 3
- Some planted in microsites
- Some inoculated with ectomycorrhizal fungi (in the nursery)

Burned, beargrass roots still present

Burned, no beargrass present

How do Ectomycorrhizal Fungi benefit plants?




ectomycorrhizae

- enhance nutrient uptake especially nitrogen

provide protection

drought

pathogens

grazers

heavy metals

In nature:

- trees need mycorrhizae to survive
- many different species of fungi on roots

Cripps, CL 2002. Mycorrhiza. In: Pscheidt & Ocamb, Pacfic NW Plant Disease Management Handbook

Method for inoculation with Native Ectomycorrhizal Fungi

Native Suilloid fungi are collected from whitebark pine forests

Cripps & Antibus 2011: Hi-Five Proceedings

Spore slurries are made from mushrooms

Fertilization stopped & spores injected onto the soil- 1 to 3 months before planting

Seedlings colonized with ectomycorrrhizal fungi

Cripps & Grimme 2011: Hi-five proceedings

Seedlings were out-planted in clusters

Three ectomycorrhizal treatments

Inoculated – seedlings inoculated with **native** ectomycorrhizal fungus in the greenhouse

Exposed - seedlings not inoculated but adjacent to inoculated seedlings in a cluster

Not inoculated – seedlings were not inoculated or not exposed

adjacent exposed seedlings

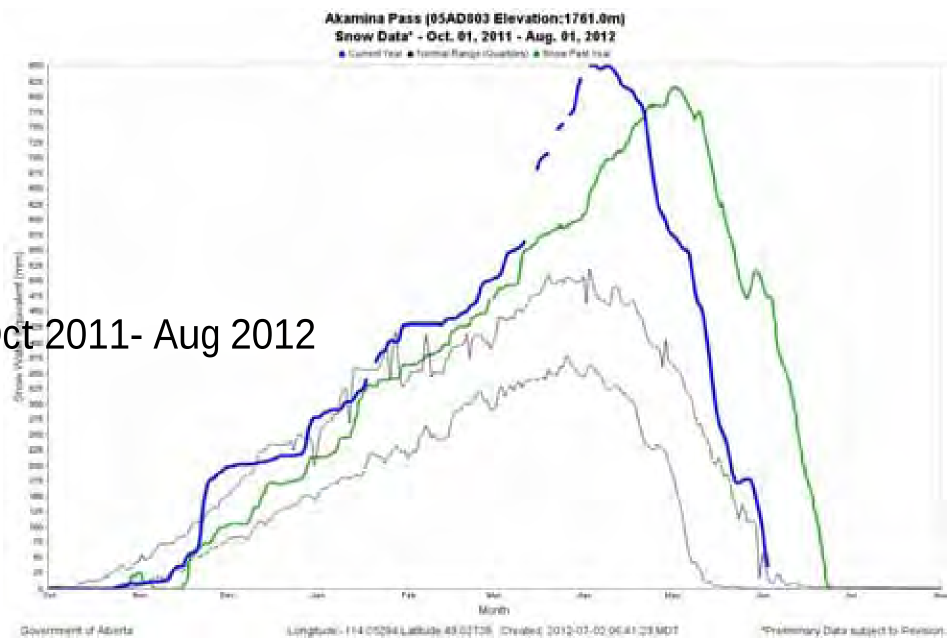
Inoculated seedlings were tagged

Monitoring seedling survival

1000 nursery grown seedlings planted in 2010

Treatment	Unburned No Beargrass	Unburned Beargrass	Burned No Beargrass	Burned Beargrass
Un-inoculated	27 seedlings	54 seedlings	87 seedlings	92 seedlings
Exposed	16 seedlings	47 seedlings	99 seedlings	85 seedlings
Inoculated	41 seedlings	70 seedlings	174 seedlings	191 seedlings

Above normal precipitation in monitoring years one (2011) and two (2012)



Oct 2011- Aug 2012

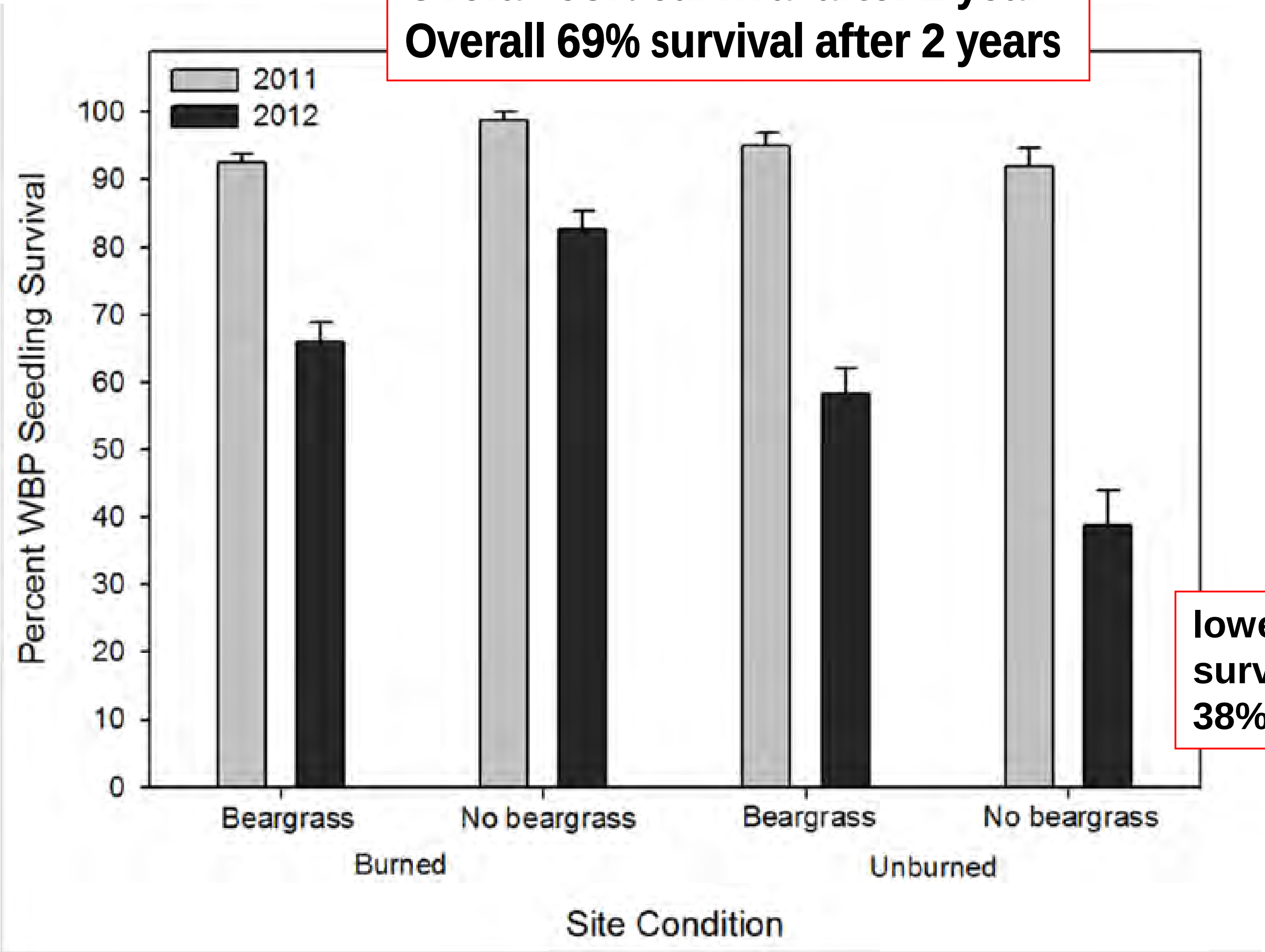
Early results – 2 years

Variables

- **With/without beargrass**
- **Unburned/burned**
- **With/without microsite**
- **With/without mycorrhizal inoculation**

Early Seedling Survival 1 and 2 years after planting

Overall 95% survival after 1 year
Overall 69% survival after 2 years



lowest survival 38%

After 2 years, overall survival averaged:
70% on burns **51% unburned areas**

Results of **binary logistic regression** of site conditions, shelter object presence, and ectomycorrhizal inoculation treatment on the survival of out-planted whitebark pine seedlings.

BINARY REGRESSION MODEL

logit(odds of survival) = β0 + β1 b + β2 bg + β3 so + β4 exposed + β5 inoculated + β6 b*bg + β7 b*so + β8 bg*so + β9 b*exposed + β10 bg*exposed + β11 b*inoculated + β12 bg*inoculated

Exp(B) = odds of survival in comparison to outgroup

Model Terms	Estimate (β)[1]	SE	Wald z^2	df	Prob.	Exp(β)[3]
Outgroup: Unburned without beargrass, Uninoculated, No shelter object						
Intercept	-1.109	0.387	-2.865	1	0.004	0.330
Burn	2.083	0.434	4.803	1	< 0.001	8.029
Beargrass	0.877	0.404	2.168	1	0.030	2.404
Exposed	0.497	0.468	1.062	1	0.288	1.644
Inoculated	-0.042	0.399	-0.105	1	0.917	0.959
Shelter object	1.151	0.359	3.211	1	0.001	3.161
Outgroup: Unburned with beargrass, Uninoculated, No shelter object						
Intercept	-0.233	0.286	-0.814	1	0.415	0.792
Burn	0.572	0.347	1.648	1	0.099	1.773
No Beargrass	-0.877	0.404	-2.168	1	0.030	0.416
Exposed	0.798	0.377	2.114	1	0.035	2.220
Inoculated	0.604	0.331	1.824	1	0.068	1.829
Shelter object	0.551	0.290	1.902	1	0.057	1.735
Outgroup: Burned without beargrass, Uninoculated, No shelter object						
Intercept	0.974	0.384	2.536	1	0.011	2.647
unburned	-2.083	0.434	-4.803	1	> 0.001	0.125
Beargrass	-0.634	0.420	-1.510	1	0.131	0.530
Exposed	-0.583	0.363	-1.608	1	0.108	0.558
Inoculated	-0.359	0.332	-1.082	1	0.279	0.698
Shelter object	1.030	0.328	3.141	1	0.002	2.801
Outgroup: Burned with beargrass, Uninoculated, No shelter object						
Intercept	0.340	0.237	1.435	1	0.151	1.404
Unburned	-0.572	0.347	-1.648	1	0.099	0.564
No Beargrass	0.634	0.420	1.510	1	0.131	1.885
Exposed	-0.283	0.293	-0.964	1	0.335	0.754
Inoculated	0.286	0.253	1.131	1	0.258	1.331
Shelter object	0.429	0.215	1.996	1	0.046	1.536
Interactions						
Burn x Beargrasss	-1.511	0.357	-4.229	1	< 0.001	0.221
Burn x Exposed	-1.080	0.435	-2.483	1	0.013	0.340
Burn x Inoculated	-0.318	0.377	-0.843	1	0.399	0.728
Burn x Shelter object	-0.121	0.331	-0.366	1	0.714	0.886
Beargrass x Exposed	0.301	0.426	0.706	1	0.480	1.351
Beargrass x Inoculated	0.645	0.377	1.711	1	0.087	1.906
Beargrass x Shelter object	-0.601	0.353	-1.702	1	0.089	0.548

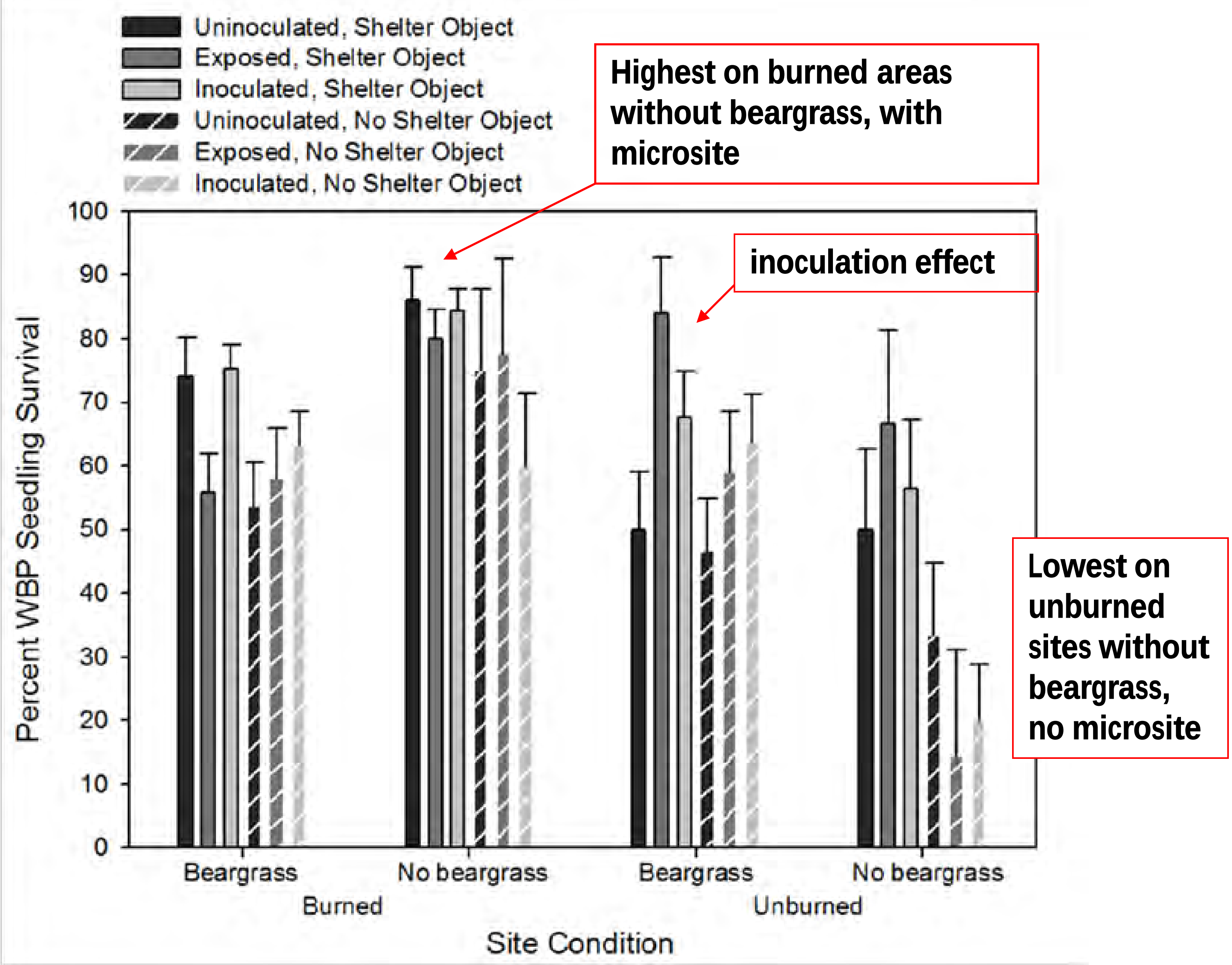
[1] Coeffecient

[2] Wald chi-square value = (Wald Z value)^2

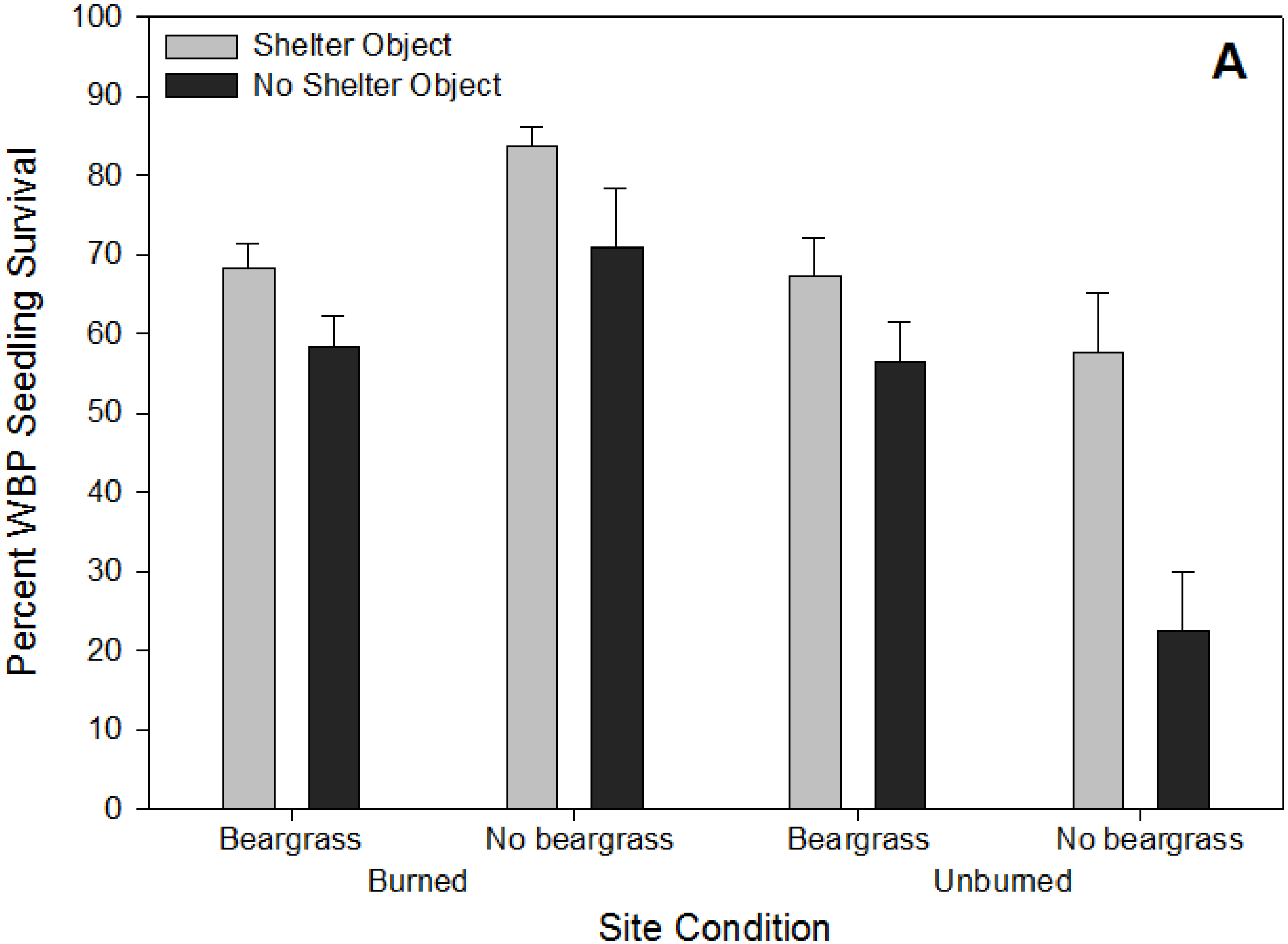
[3] Odds ratio of survival for the predictors

Lonergan, Cripps, Smith (accepted)
Forest Science

% Survival of Planted Whitebark Pine Seedlings for all Variables



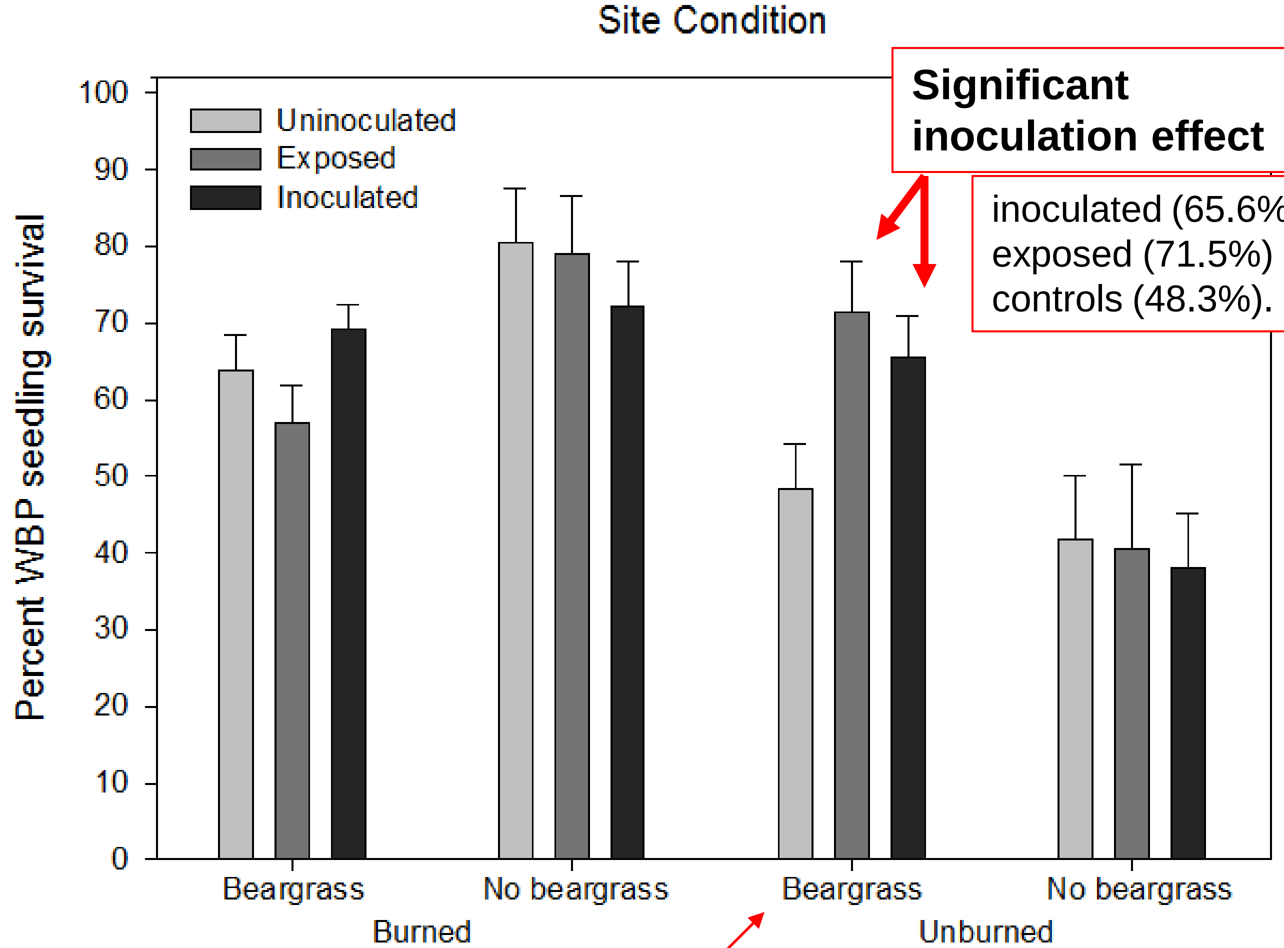
Effect of Planting near <u>shelter objects (microsite)</u> on survival of planted whitebark pine seedlings



In general, planting near microsites improved survival 10-12.5% on burns and 31% on unburned areas

Effect of ectomycorrhizal inoculation on survival of planted whitebark pine seedlings

Site specific



Significant inoculation effect

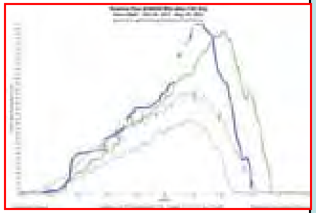
inoculated (65.6%) exposed (71.5%) controls (48.3%).

Inoculation of 1, 2, or 3 in cluster improved seedling survival.

Inoculation or exposure to ectomycorrhizal inoculum increased survival 17-24% on unburned sites with beargrass

Conclusions from <u>early</u> monitoring after 2 years

Izlar 2007:
100,000 seedlings
year 1 = 74%
year 2 3-15l = 38%



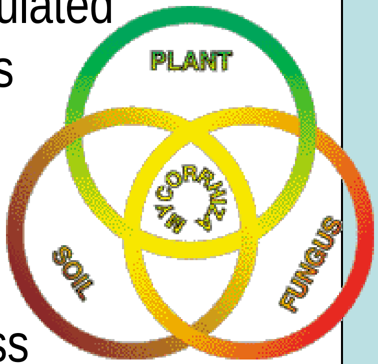
- This study had some of the **highest early survival rates** of any reports (overall 95% in year 1 and 69% year 2)

What role did exceptional moisture conditions have on early survival?
What role did treatments have on early surivival?

- Burned (terra-torched) areas without beargrass roots supported some of the highest seedling survival rates (82%)

- Planting near shelter objects (microsite) increased survival 10-12.5% on burns and 31% on unburned areas without beargrass (poor planting sites)

- Inoculation with native ectomycorrhizal fungi (or exposure to inoculated seedlings) increased survival 17-24% on unburned sites with beargrass



- Long-term monitoring necessary to assess the ultimate effectiveness of the restoration techniques tested.

Ongoing Efforts

Out-plantings of seedlings inoculated with native ectomycorrhizal fungi

- 500 Whitebark- Glacier 2009
- 1000 Whitebark– Waterton 2010
- 1000– Whitebark Waterton 2011
- 1000– Limber Pine Waterton 2012
- 1000—Whitebark– Waterton 2012
- 1000—Whitebark—Waterton 2013

Can it help increase the survival of expensive WBP seedlings?

Need carefully planned studies for inoculation:

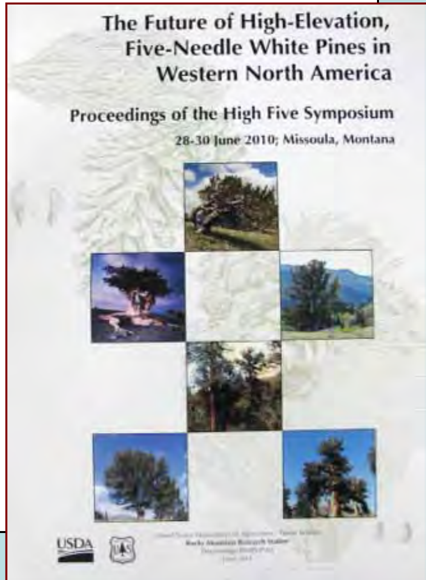
-usual seedling production to 1.5 yrs

-stop fertilization 1-2 months

-inoculate 2-3 months before planting

-monitor, monitor, monitor

Have gun, will travel!



← Further information online →

2 papers coming soon

We thank

Parks Canada for funding this research and the Whitebark Pine Ecosystem Foundation for additional resources , Joyce Lapp, Tara Carolin, and the Glacier Park Revegetation Crew and the volunteers.

And our field assistants

- **Ed Barge**
- **Rosemary Keating**
- **John Mason**
- **Don Bachman**

Regeneration of whitebark pine is tedious business…thanks to all who have dedicated themselves to saving this important tree species

Erin Longergan is currently searching for employment in the USDA Forest Service, Parks Service, in restoration, or private industry

Particularly in the PNW area (OR, WA) elonergan3@gmail.com