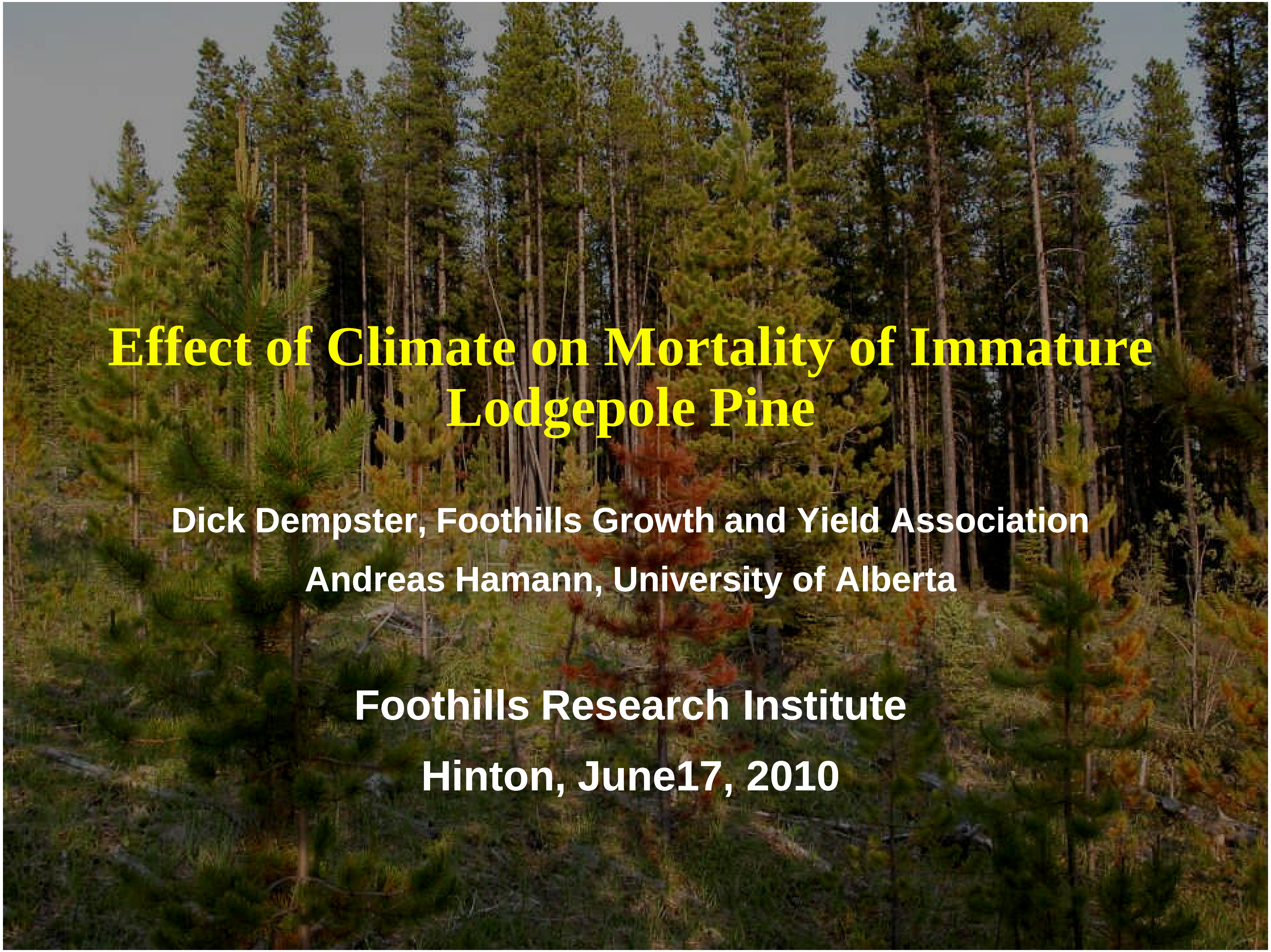


Effect of Climate on Mortality of Immature Lodgepole Pine

Dick Dempster, Foothills Growth and Yield Association

Andreas Hamann, University of Alberta

Foothills Research Institute

Hinton, June17, 2010

Outline

- Concerns:
  - Alberta
  - Elsewhere
- Analyses:
  - Methods
  - Results
- Implications
  - Risks
  - Management

Concerns - Alberta

Generally low level of concern about operational reforestation success?

Vegetative competition

Western gall rust

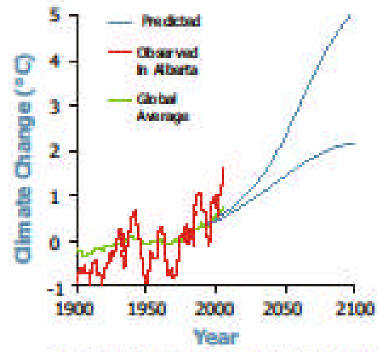
ALBERTA FOREST GENETIC RESOURCES COUNCIL

Forest genetic resources:
Conserving diversity, enhancing productivity

Climate Change and Genetic Resources

The Challenge

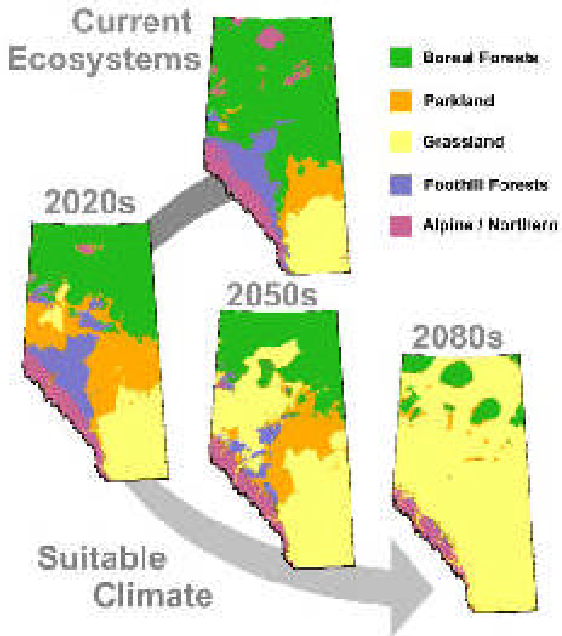
Climate change over the last half century has increased mean annual temperatures by almost 1°C across Alberta. This trend is expected to continue, resulting in warming by about 2 or 3 °C over the next 50 years. Regional and seasonal patterns of precipitation may also change substantially. Although there is some evidence for rapid climate oscillations during the transition from ice ages to warm periods, the rate and direction of projected warming due to greenhouse gases are unprecedented. Such changes create new challenges for forest management, and for forest-based communities which rely economically and socially on the resource.



Data from NASA and AHCCD (http://tinyurl.com/epy8o and http://tinyurl.com/kpsus)

Threats to Forests

Even though warming by 2-3°C does not sound very threatening, the effect on forests could be substantial. The following figure shows how the tree and plant communities of today might be located in order to be well adapted to the predicted climates of the 2020s, 2050s and 2080s. The forests we see today are the result of thousands of years of natural evolution and ecological processes. The anticipated change in climate may be too rapid and severe for successful adaptation by our current forest trees.



Methodology described in Agricultural and Forest Meteorology 128: 211-221

Adapting Forest Management

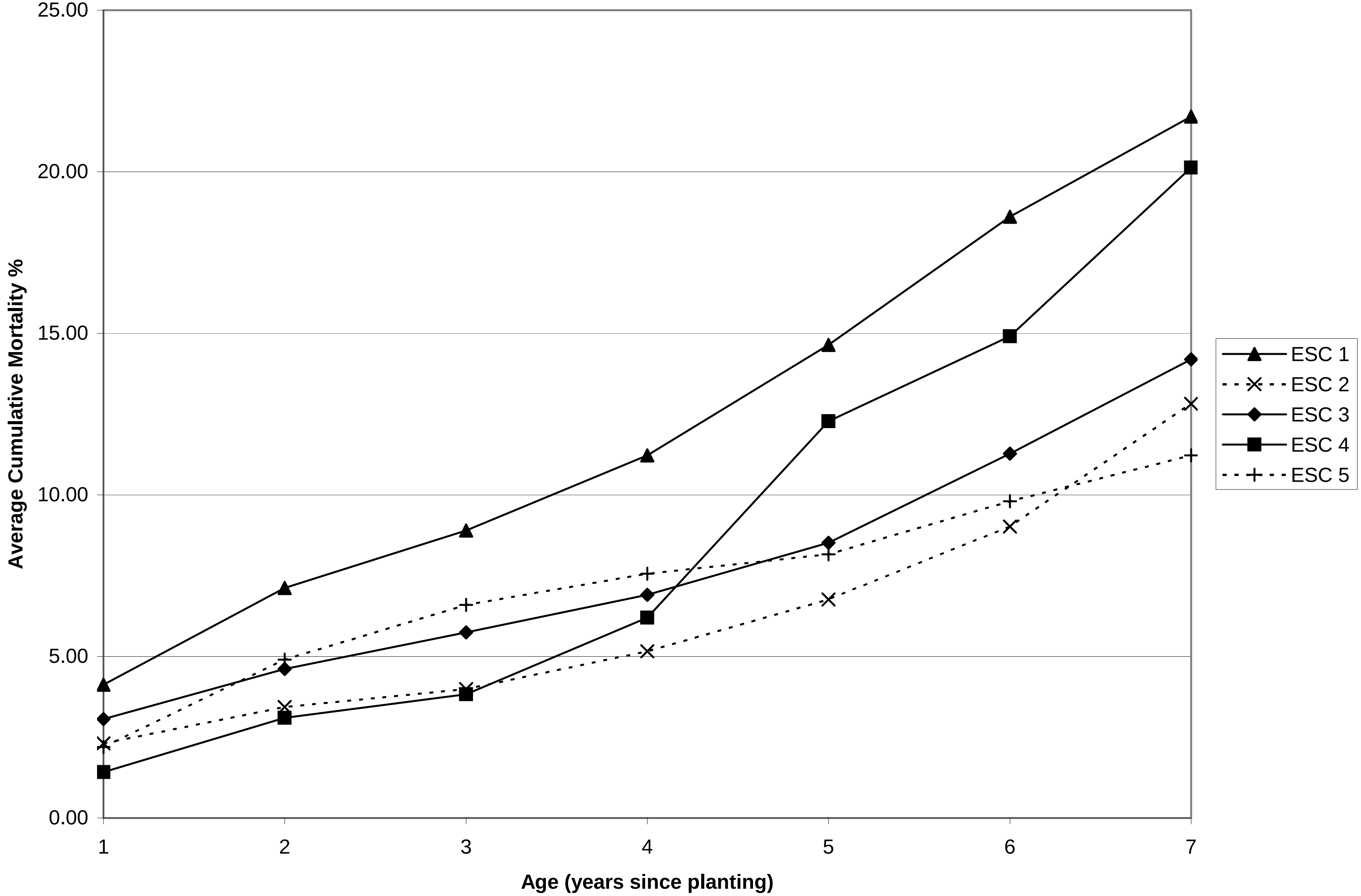
Tree populations can naturally "move," by way of seed dispersal, to more suitable regions and climates in times of stress - but these are slow processes. Careful and well-planned tree breeding and movement of planting stock (further north, and-or to higher elevations) during reforestation activities can assist in population adaptation. Trees that can withstand higher temperatures, changed precipitation patterns and additional threats from pests, diseases and other stress factors will help ensure healthy forests in the future.

Well established and carefully regulated tree-breeding work in Alberta is already providing data and seedlings to help forest managers prepare for these anticipated changes.

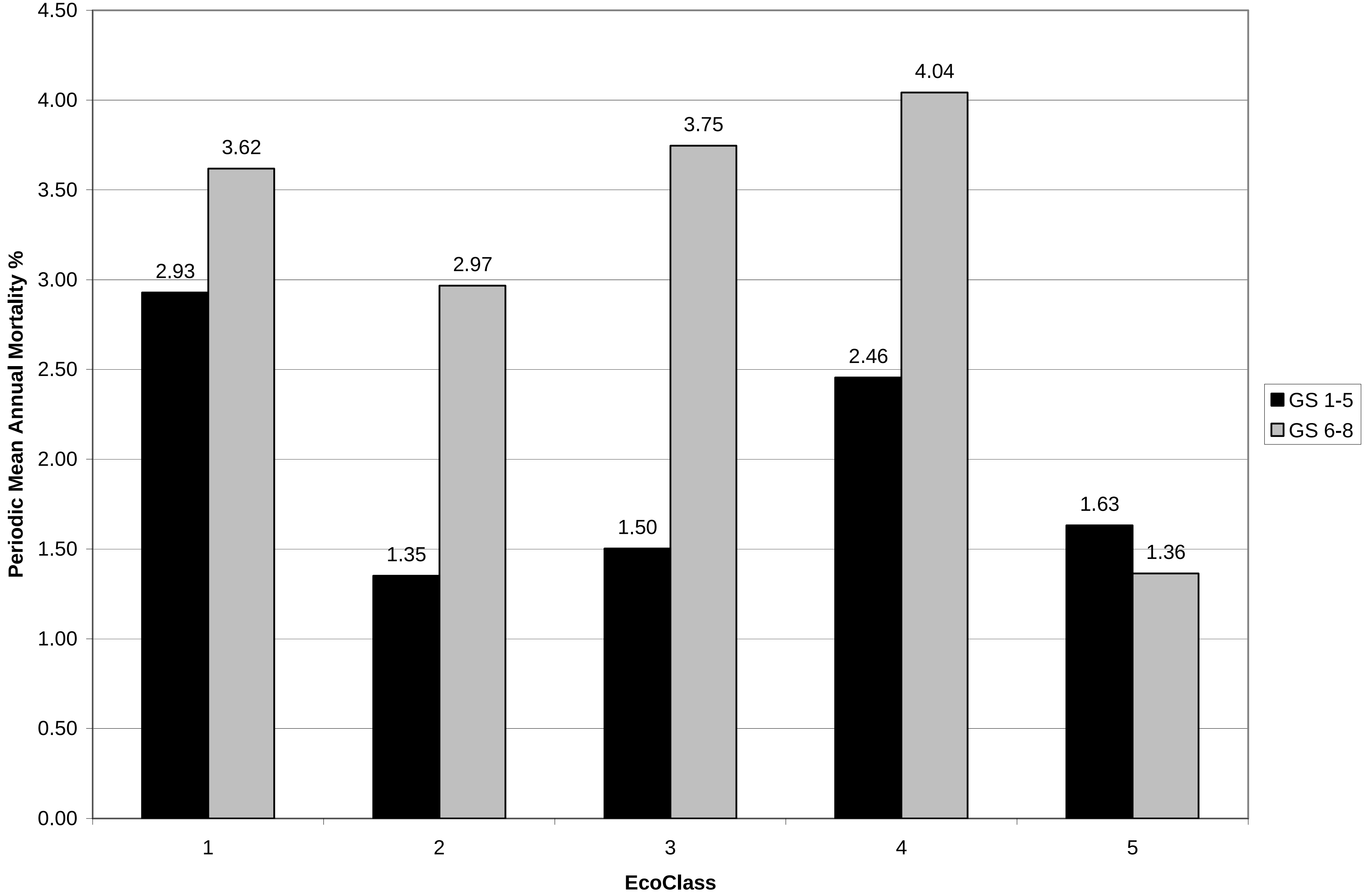
FGYA Regenerated Lodgepole Pine Trial

- High and variable cumulative mortality of planted stock during first 5 - 7 growing seasons led to initial concerns and investigation of climate link
- Annual rate in years 6 – 8 higher than in first 5 years
- Effect of tending on mortality (versus growth) not statistically significant
- Too early to reliably assess mortality in natural regeneration, but rate appears to be increasing

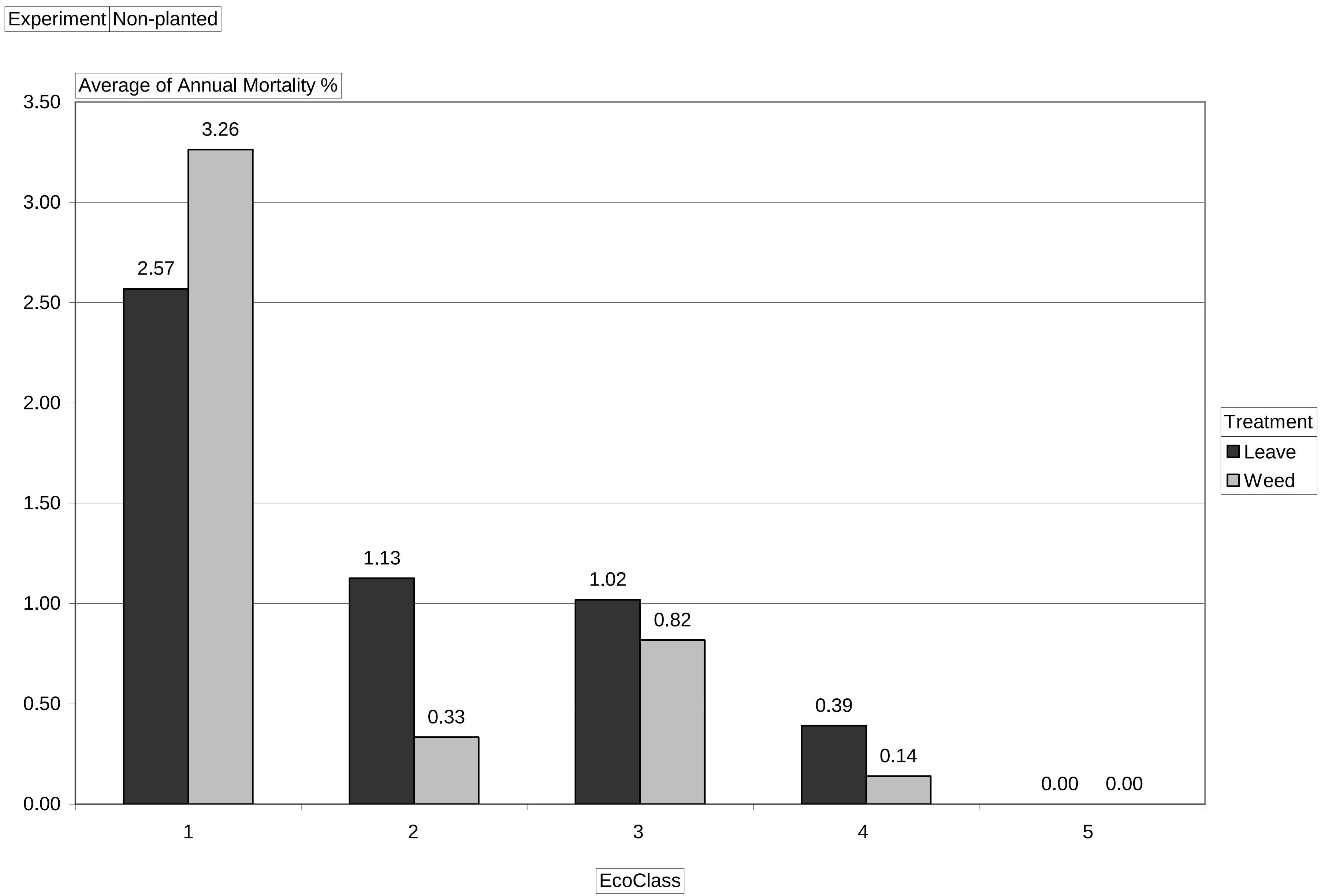
Mortality of planted stock



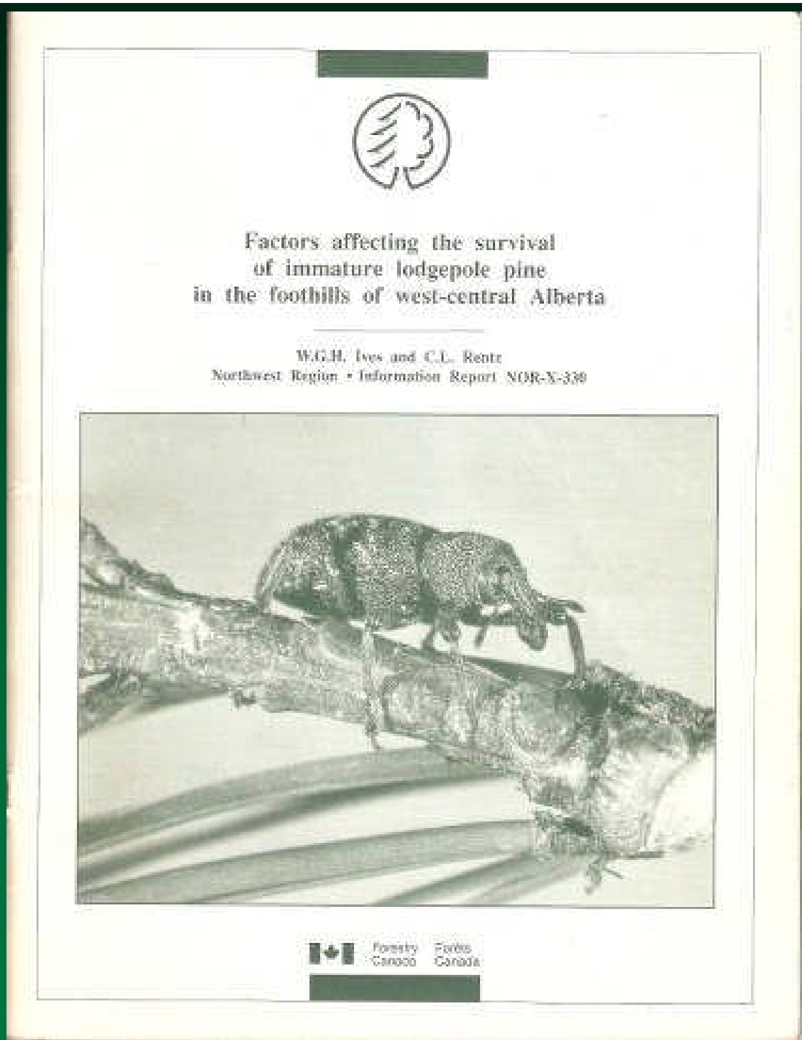
Comparison of mortality between years 1-5 and 6-8



Mortality of natural regeneration



Earlier Report of Persistent Mortality

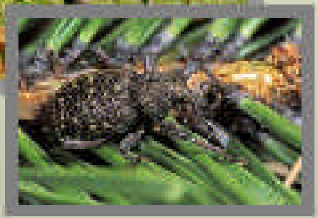

Factors affecting the survival
of immature lodgepole pine
in the foothills of west-central Alberta

W.G.H. Ives and C.L. Rentz
Northwest Region • Information Report NOR-X-330

Forestry Canada Forêts Canada

Concerns – B.C. and Elsewhere

Will free growing lodgepole pine stands meet long-term management objectives?



Warren's root collar weevil (*Hylobius warreni*) damage

The mountain pine beetle epidemic has amplified our concerns about pine health problems, as has the uncertainty about how damaging agents will interact with climate change. Despite early good performance, planted lodgepole pine is not performing well beyond free-growing on some sites (e.g., Woods and Bergerud 2006). Insect, disease, and abiotic problems are reported, but information has not been systematically collected beyond free-growing age. This project is designed to examine problems in 15-30 year old planted pine stands that have been declared free-growing, and to develop risk guidelines for future management.

The workplan

Phase 1 – Conduct a survey of forest practitioners to help us identify the most important damaging agents and to examine current perceptions of the seriousness of the problem.

Phase 2 – Carry out field sampling and preliminary data analysis.

Phase 3 – Supplement field sampling, conduct full data analysis, develop risk guidelines.

Our objectives

1. Quantify the occurrence of serious lodgepole pine damaging agents across the Southern Interior Forest Region.
2. Identify high risk site characteristics (e.g., slope, aspect, BEC unit) and/or treatment history (e.g., harvesting method, site preparation, brushing method, seed source, stocktype).
3. Develop risk guidelines regarding the susceptibility of post-free growing lodgepole pine to specific damaging agents.

Simard, Suzanne. 2007. *Analysis of insect, disease, and abiotic factors affecting post-free-growing lodgepole pine in southern interior British Columbia* (FSP Project Y082313)

Serious Problems in Post-free-growing Pine – B.C.

- *Mountain pine beetle (in stands 15-30 years old!)*
- *Armillaria*, aggravated by tending, problem perceived as poorly managed, disagreement among experts
- Warren's root collar weevil, linked to planting
- Increased incidence of hard pine rusts
- *Atropellis* canker
- Extensive mortality from drought following dry summers
- Ice, snow, hail
- Unprecedented *Dothistroma* epidemic linked to climate change

Examples of Concerns in the USA

- ***Armillaria*: ecology, conducive habitats and threats apparently well understood. Comprehensive mitigation strategies.**
- **Root collar weevil has been a serious forest pest since ever since increased planting of pines in the 1930's. Led to major efforts in developing control strategies and management guidelines.**
- **"Background" (non-catastrophic) tree mortality rates doubling every 17 – 29 years in western states. Regional warming and consequent increases in water deficit implicated.**

Methods

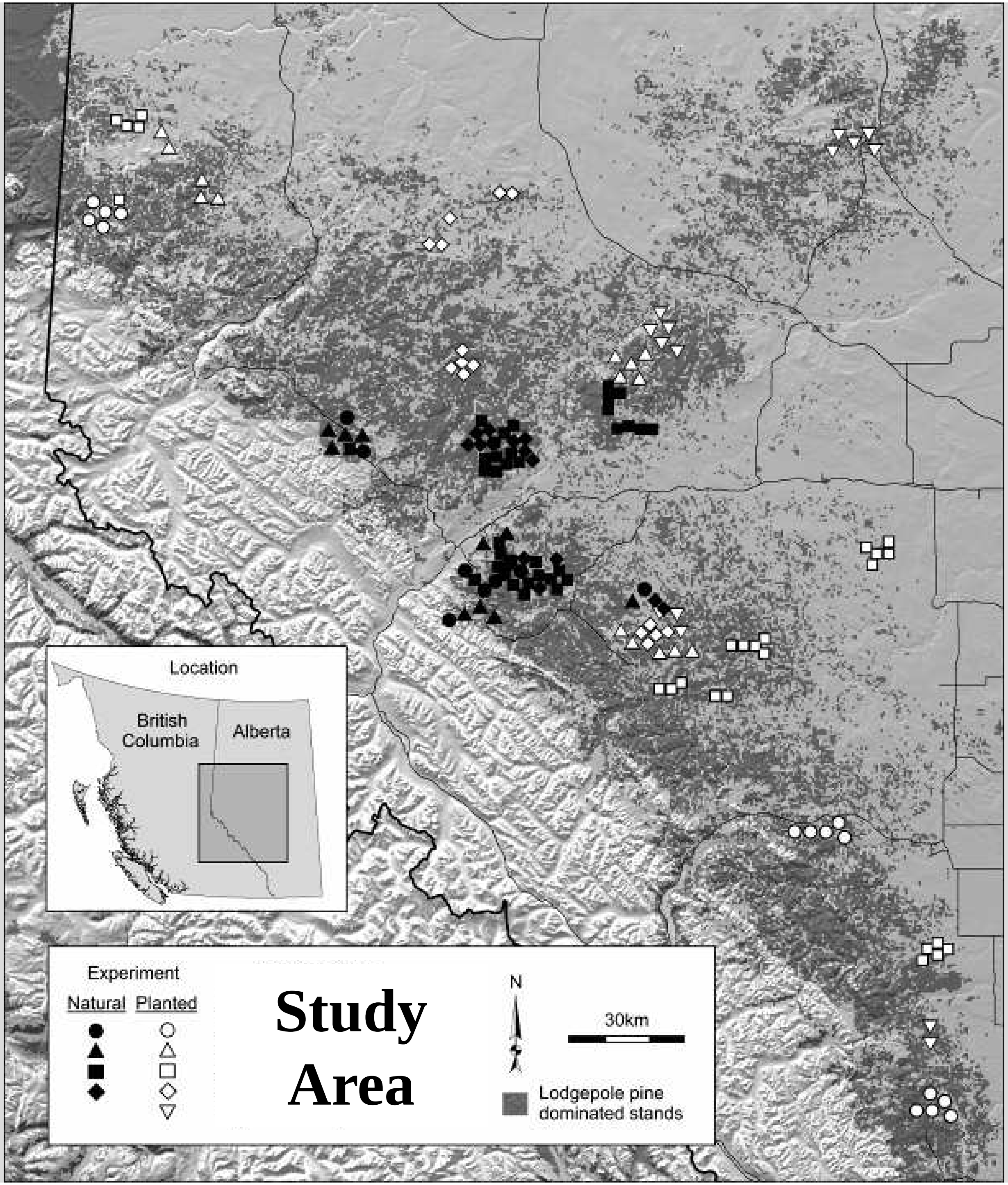
Data Sources

Ives and Rentz

- Plots established to monitor survival of immature lodgepole pine in Sub-alpine and Foothills sub-regions.
- Over 70 cutover areas sampled.
- Conducted between 1981 and 1990.
- 3-year survival rates spanning 9 year period.
- Mostly thinned natural regeneration, 6 to 30+ years since harvesting.

FGYA - RLP

- Established between the summer of 2000 and the spring of 2002; ongoing.
- Designed to monitor stand development of harvest-origin lodgepole pine in relation to site, initial spacing of planted stock, vegetation control (weeding) and density regulation (pre-commercial thinning).
- 102 one-hectare plot clusters distributed primarily throughout Lower and Upper Foothills sub-regions.

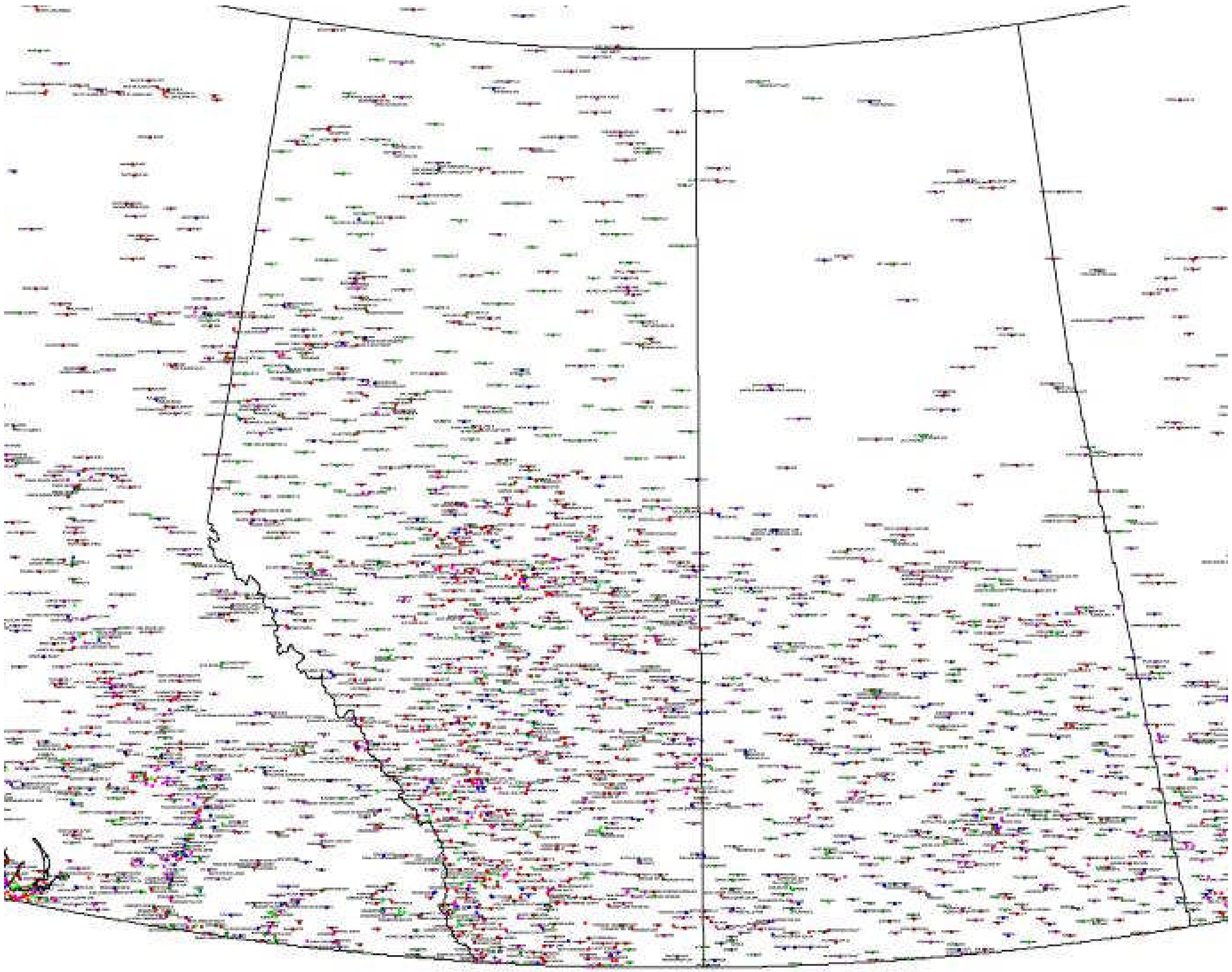

Location
British Columbia
Alberta
Experiment
Natural
Planted
Study Area
N
30km
Lodgepole pine dominated stands

Tool Used for Climate Analysis: ClimateAB

- **Computer program integrating climate normals and historical data for genecology and climate change studies in Alberta.***
- **Calculates seasonal and annual climate variables for point locations based on weather-station data adjusted for latitude, longitude and elevation.**
- **Reports historical monthly, seasonal and annual climate variables for individual years and periods between 1901-2006.**
- **Also predicts future climate using various global circulation models.**
- **Output includes both directly calculated and derived climate variables.**

* Wang, T., Hamann, A., Spittlehouse, D., and Aitken, S. N. 2006. Development of scale-free climate data for western Canada for use in resource management. *International Journal of Climatology*, 26(3):383-397.

Weather Stations



Analytical Approach

- Using FGYA data for period 2001-2006, explored relationship between periodic mortality rates (regardless of apparent cause) and climate variables extracted for each sample location by ClimateAB.
- Many climate variables showed significant correlations to mortality and each other. Mean annual temperature (MAT) most consistent.
- Analysis of mortality-MAT relationship extended and compared to Ives-Rentz periodic survival data (1981-1990).
- Periodic mortality was tested for relationship to MAT, and differences between strata and between datasets, using linear and non-linear regression and analysis of variance.
- Indirect gradient analysis using non-linear multidimensional scaling was applied to RLP dataset to ordinate sites according to mortality causes, with subsequent vector fitting of climate variables

Stratification of Data

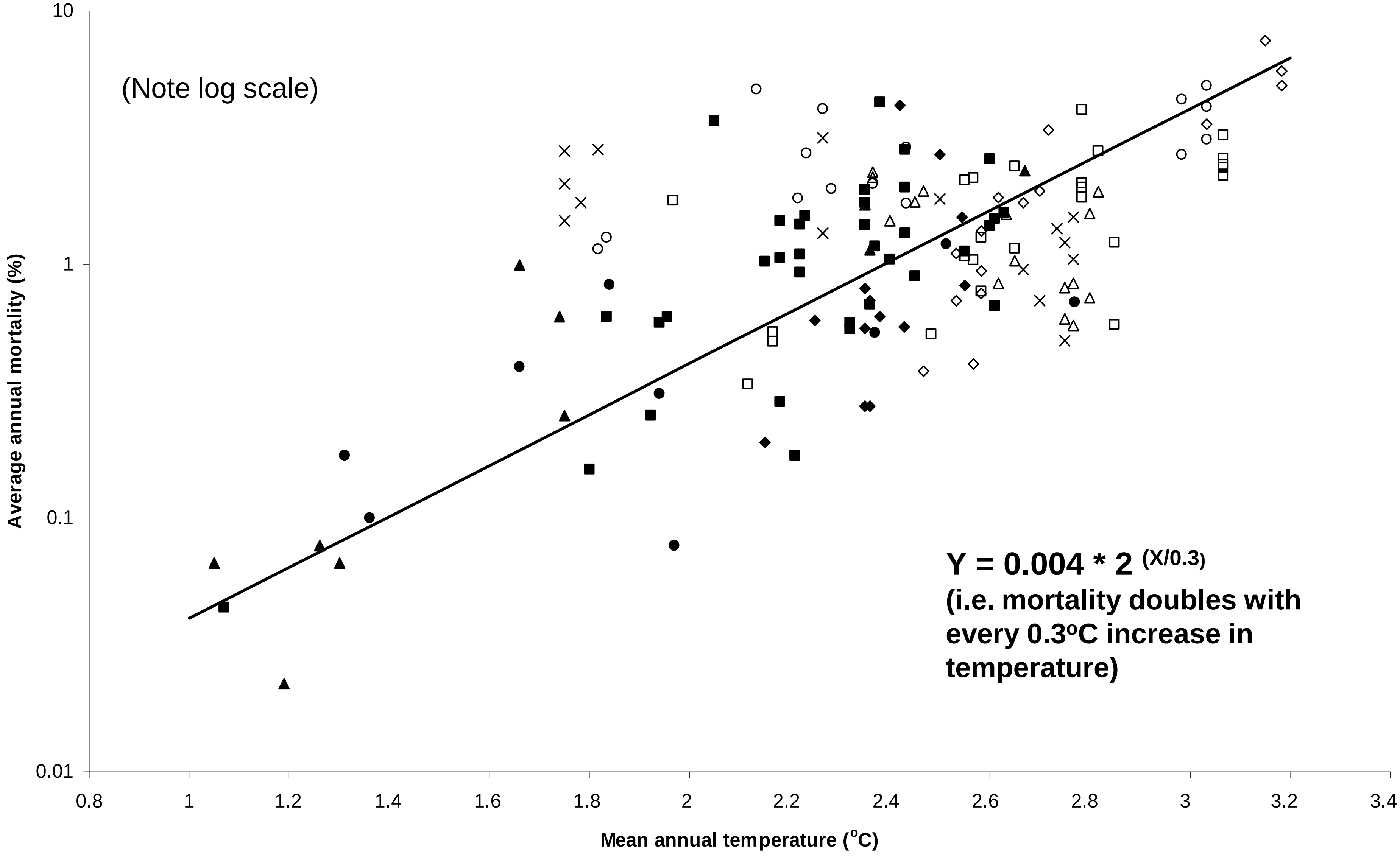
Trial	EcoClass	Ecosite		Regime		Vegetation	Stratum
		WC	SW	Moisture	Nutrient		
Ives and Rentz (**N**atural regeneration)	1	b, c	-	submesic	medium - poor	non-*Ledum*	N1
	2	d	-	mesic	poor	*Ledum*	N2
	3	e	-	mesic	medium	non-*Ledum*	N3
	4	f	-	subhygric	rich	non-*Ledum*	N4
RLP (**P**lanted stock)	1	b, c	b	submesic	medium - poor	non-*Ledum*	P1
	2	d	c	mesic	poor	*Ledum*	P2
	3	e	d	mesic	medium	non-*Ledum*	P3
	4	f	e	subhygric	rich	non-*Ledum*	P4
	5	h	f	hygric	poor	*Ledum*	P5

Results

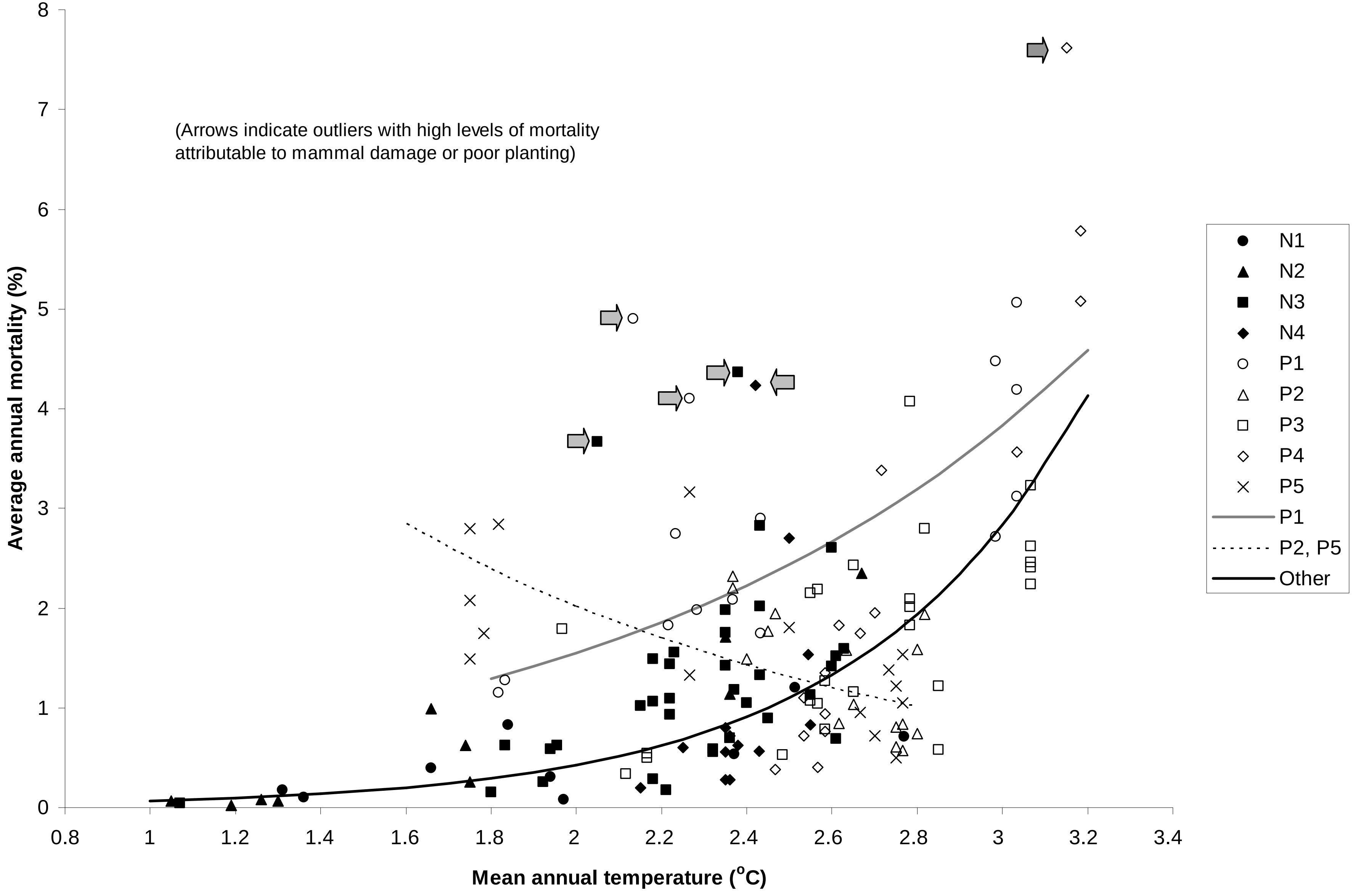
Climatology of the Study Area

Climate Variable	Climate Normal 1961-1990	Recent Decade 1997-2006	Ives Study 1981-1990	RLP Study 2001-2006	Correlation with MAT
Mean annual temperature (°C)	1.6	2.4	2.2	2.6	1.00
Mean July temperature (°C)	13.7	14.3	13.8	14.8	0.87
Mean January temperature (°C)	-11.6	-9.8	-8.2	-8.0	0.02
Mean annual precipitation (mm)	617	575	598	580	-0.40
Mean summer precipitation (mm)	414	385	423	378	0.12
Precipitation as snow (mm)	165	147	140	153	-0.68
Annual heat moisture index (°C/m)	19	22	20	22	0.77
Summer heat moisture index (°C/m)	33	37	33	39	0.47
Chilling degree days (dd<0°C)	1330	1074	1133	1052	-0.38
Growing degree days (dd>5°C)	1004	1038	1004	1076	0.88

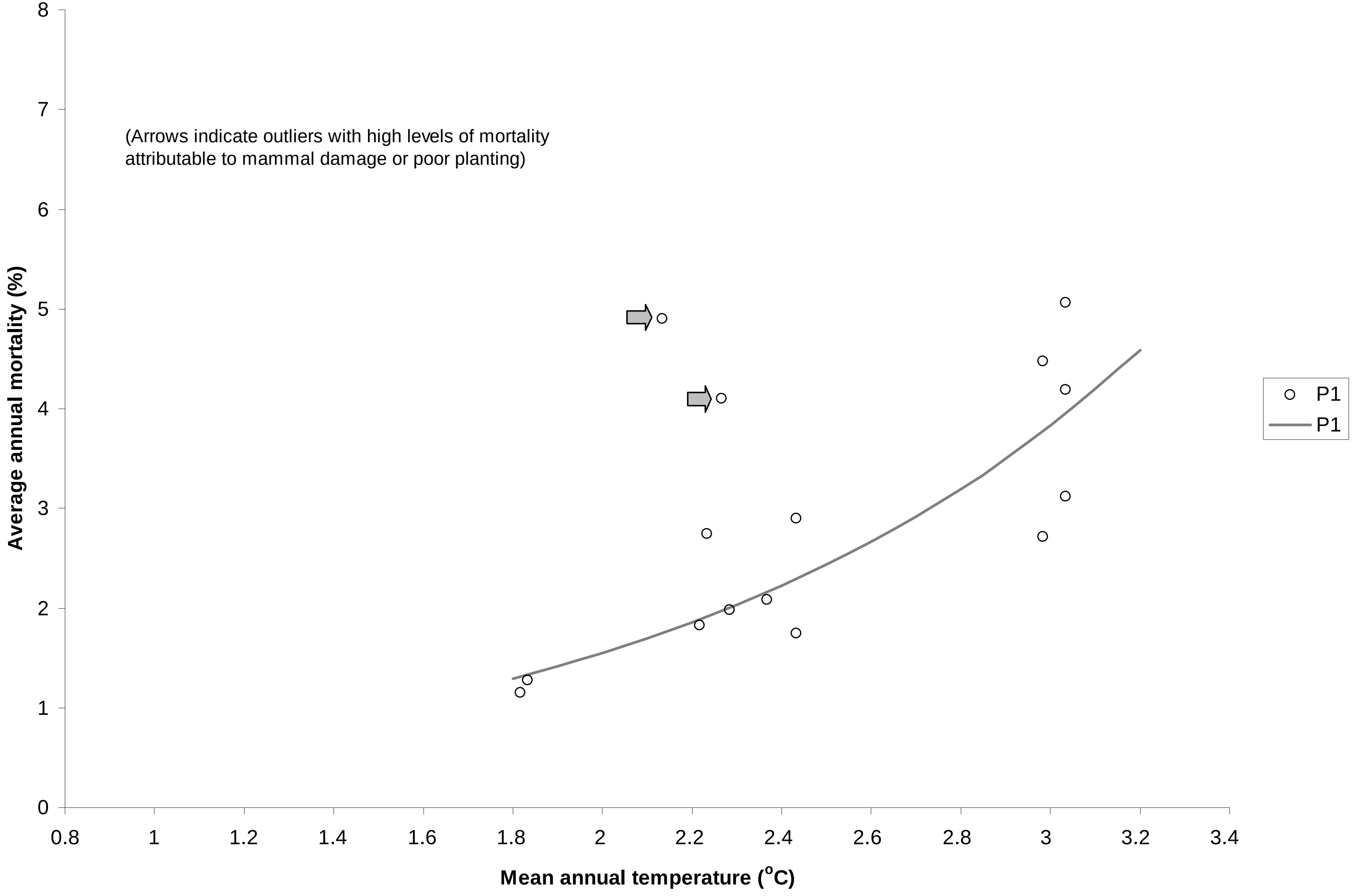
Mortality and Temperature – Overall Trend



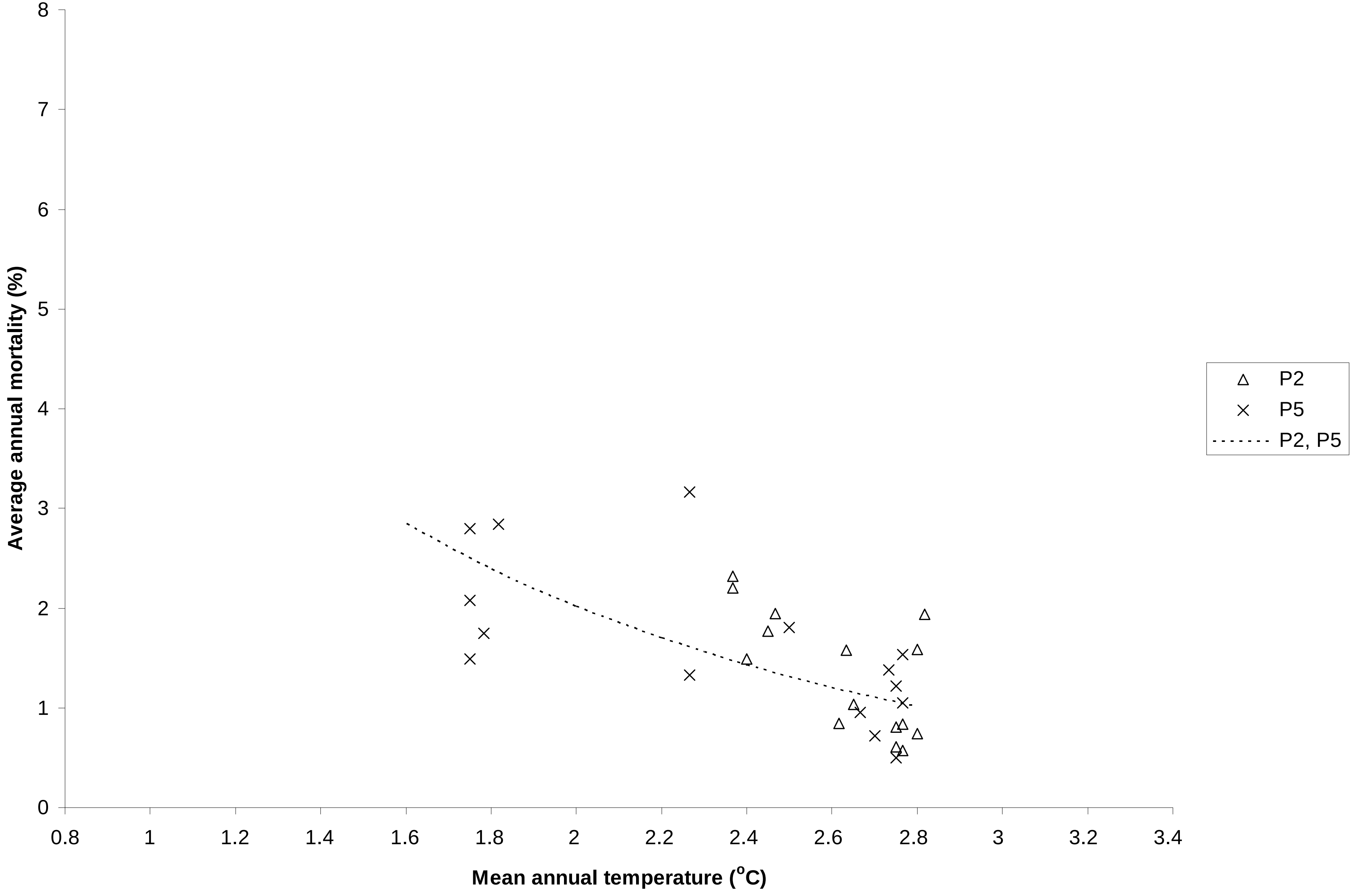
Mortality and Temperature – Partitioned Trends



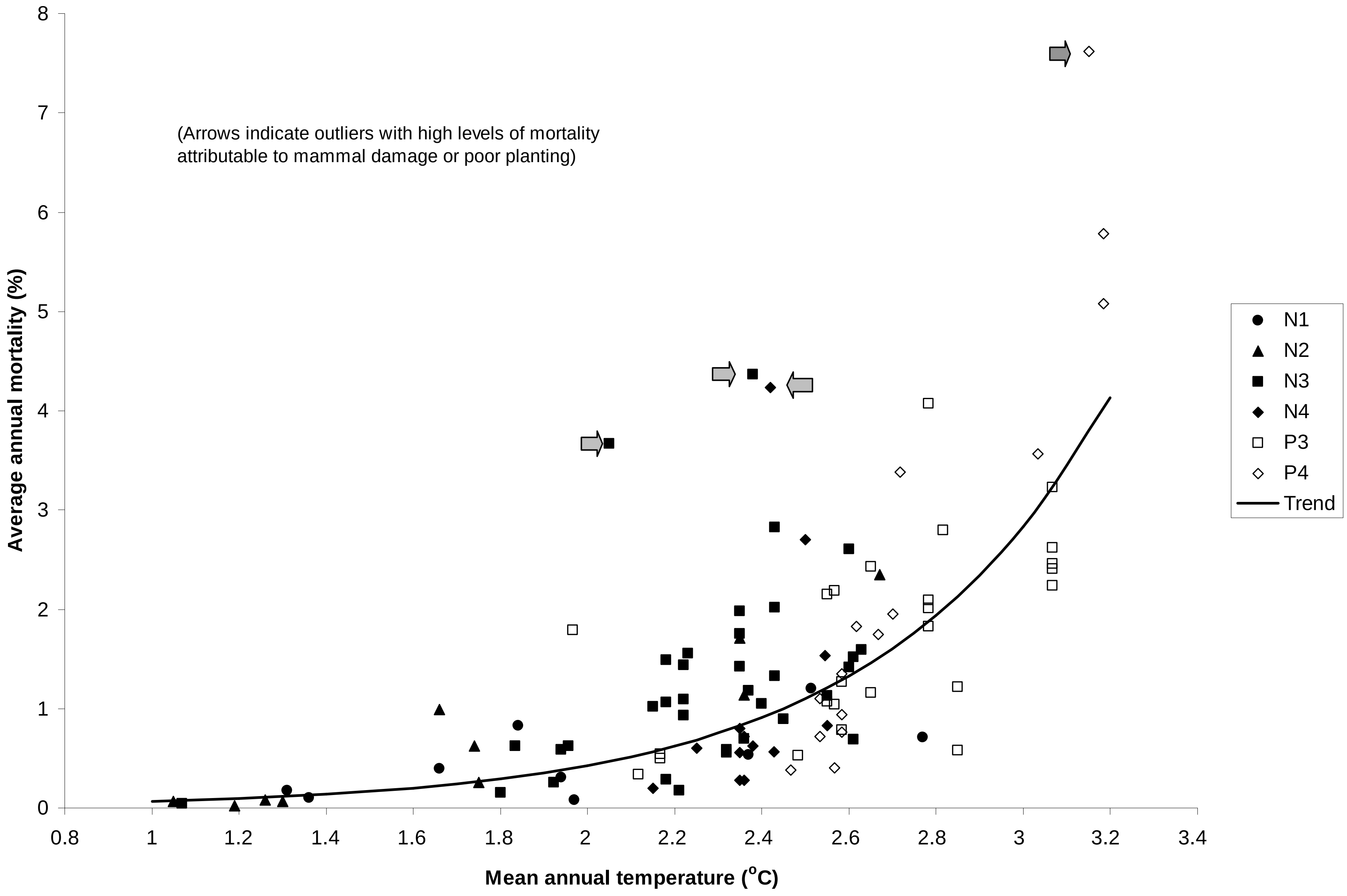
Mortality and Temperature – P1 (Planted – Dry) Sites



Mortality and Temperature – P2, P5 (Planted *Ledum*) Sites



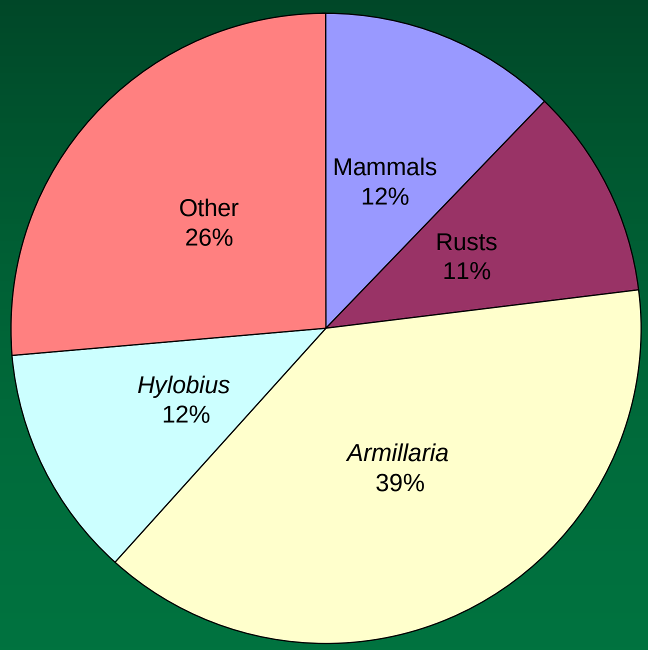
Mortality and Temperature – All Other Sites



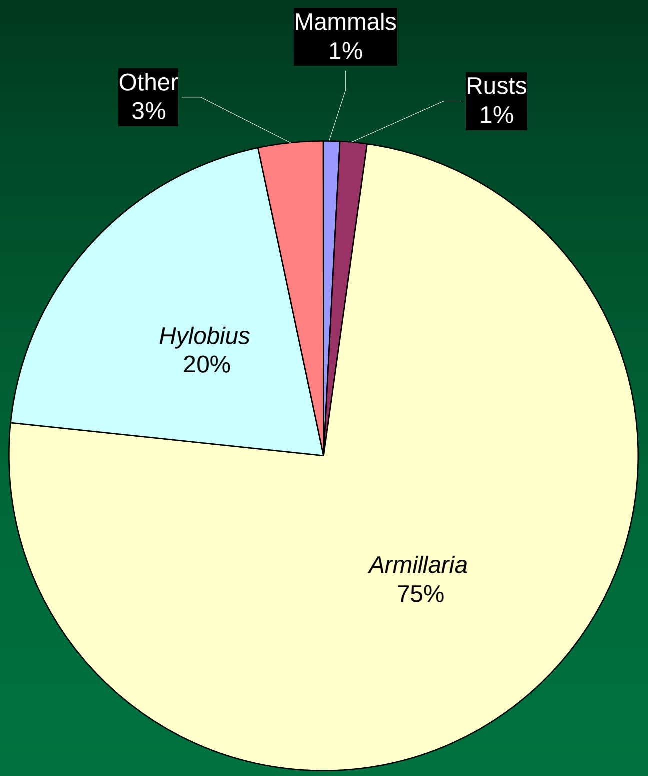
Direct Causes of Mortality Are Primarily Biotic

Mortality Causes during 1st Decade after Establishment

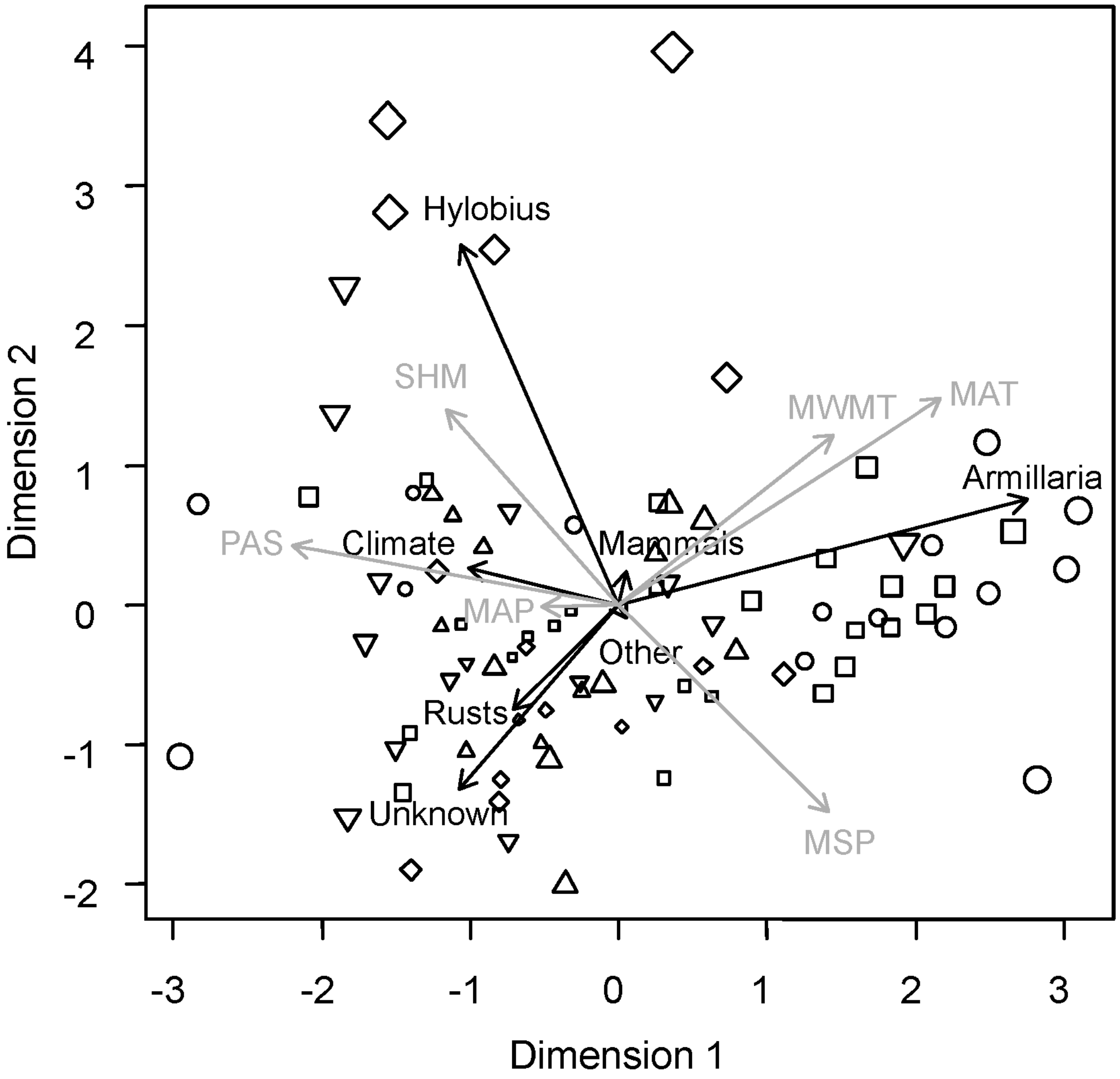
Ives Natural Regeneration



RLP Planted Stock



Mortality Cause Ordination

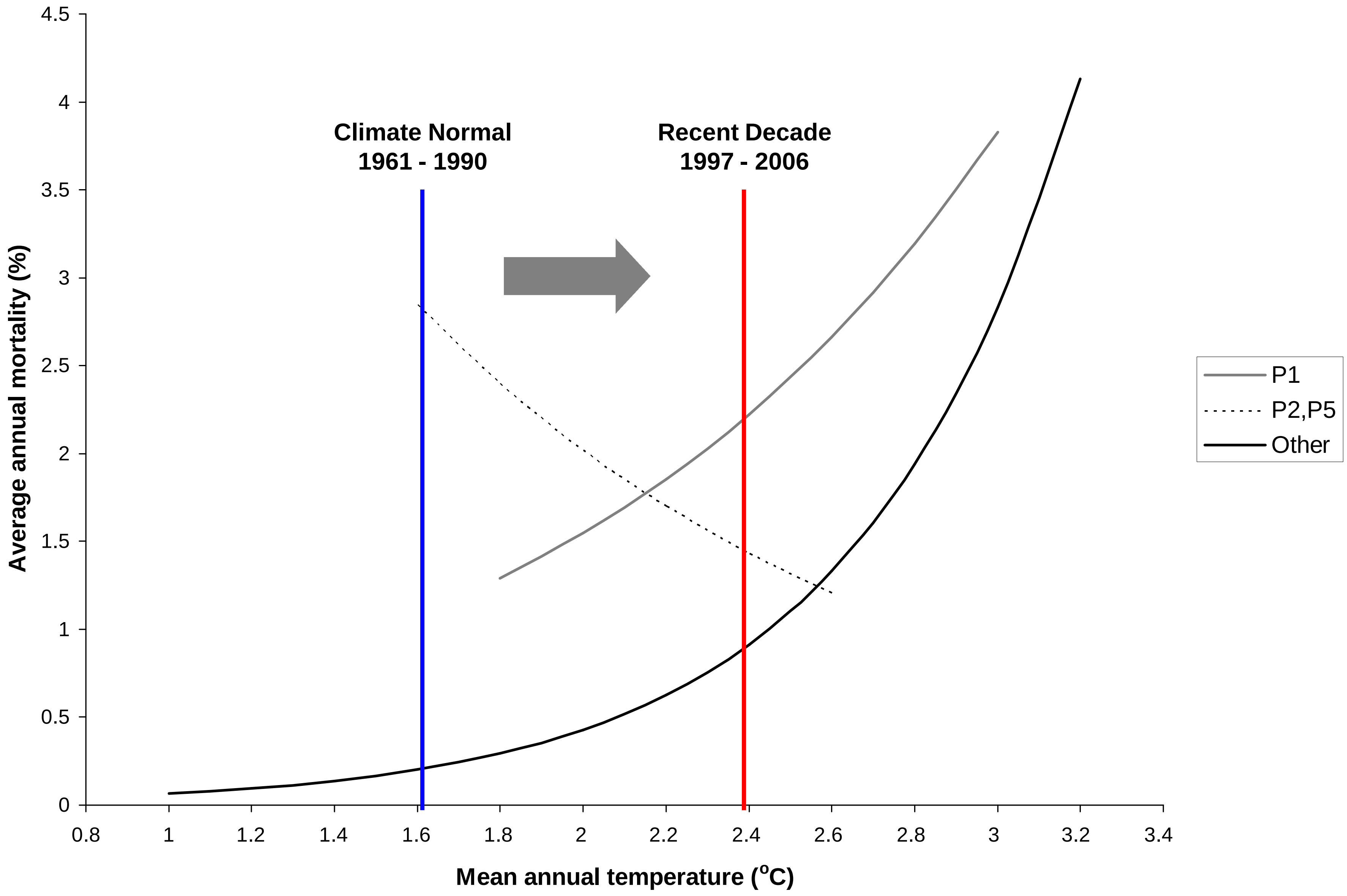


Interpretation of Ordination

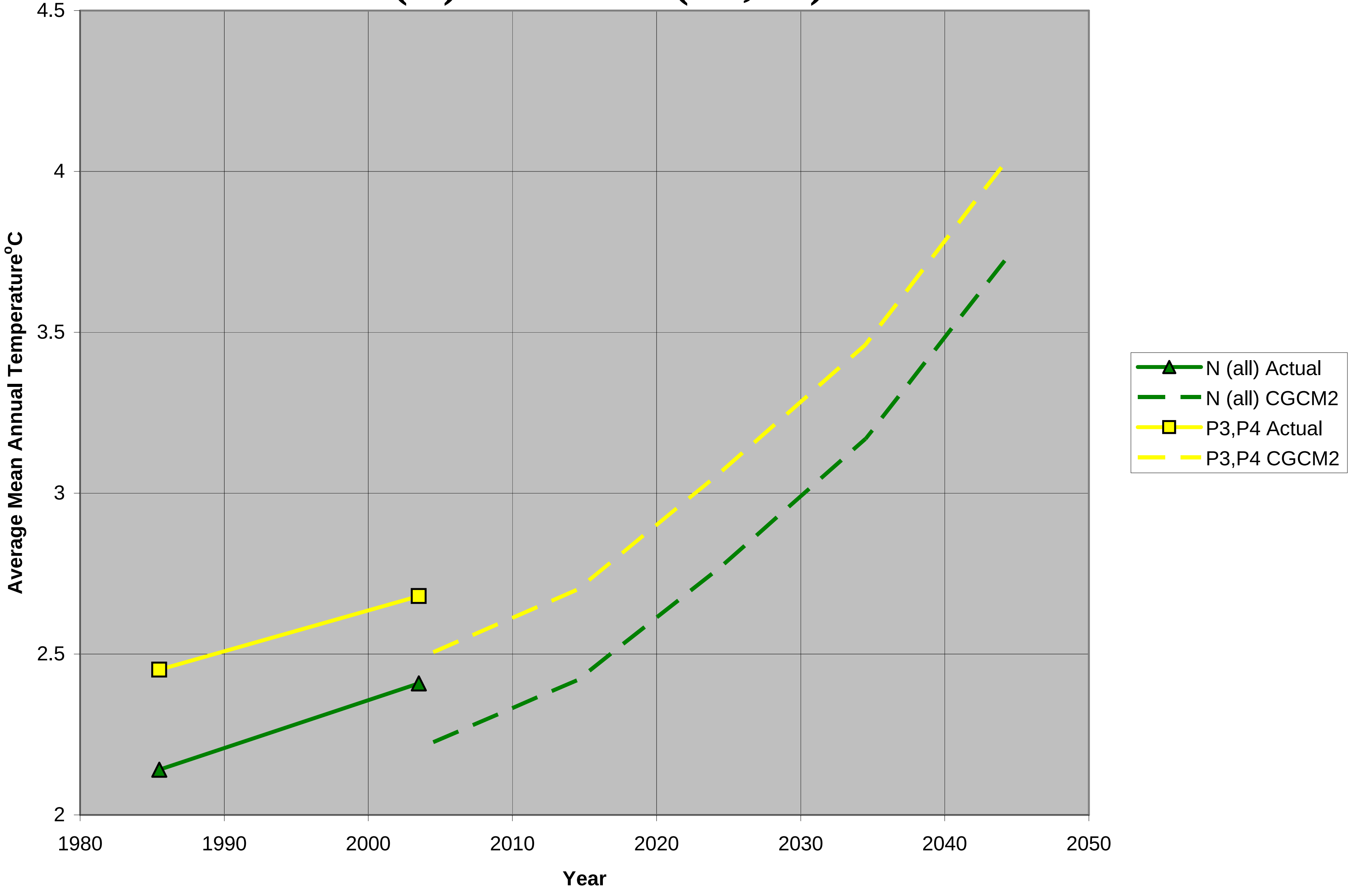
- Results are primarily driven by mortality due to *Armillaria* along the first dimension.
- High mortality due to *Armillaria* is associated with high mean annual temperature and is highest on submesic / medium-poor sites.
- Along the second dimension, *Hylobius* is related to dry summer conditions (opposite of the MSP vector) especially on rich sites.
- Direct climate effects, rusts, and unknown causes occur more randomly (shorter vectors).
- Overall, the highest lodgepole pine mortality rates occur on sites that are warm and/or dry.

Implications - Risks

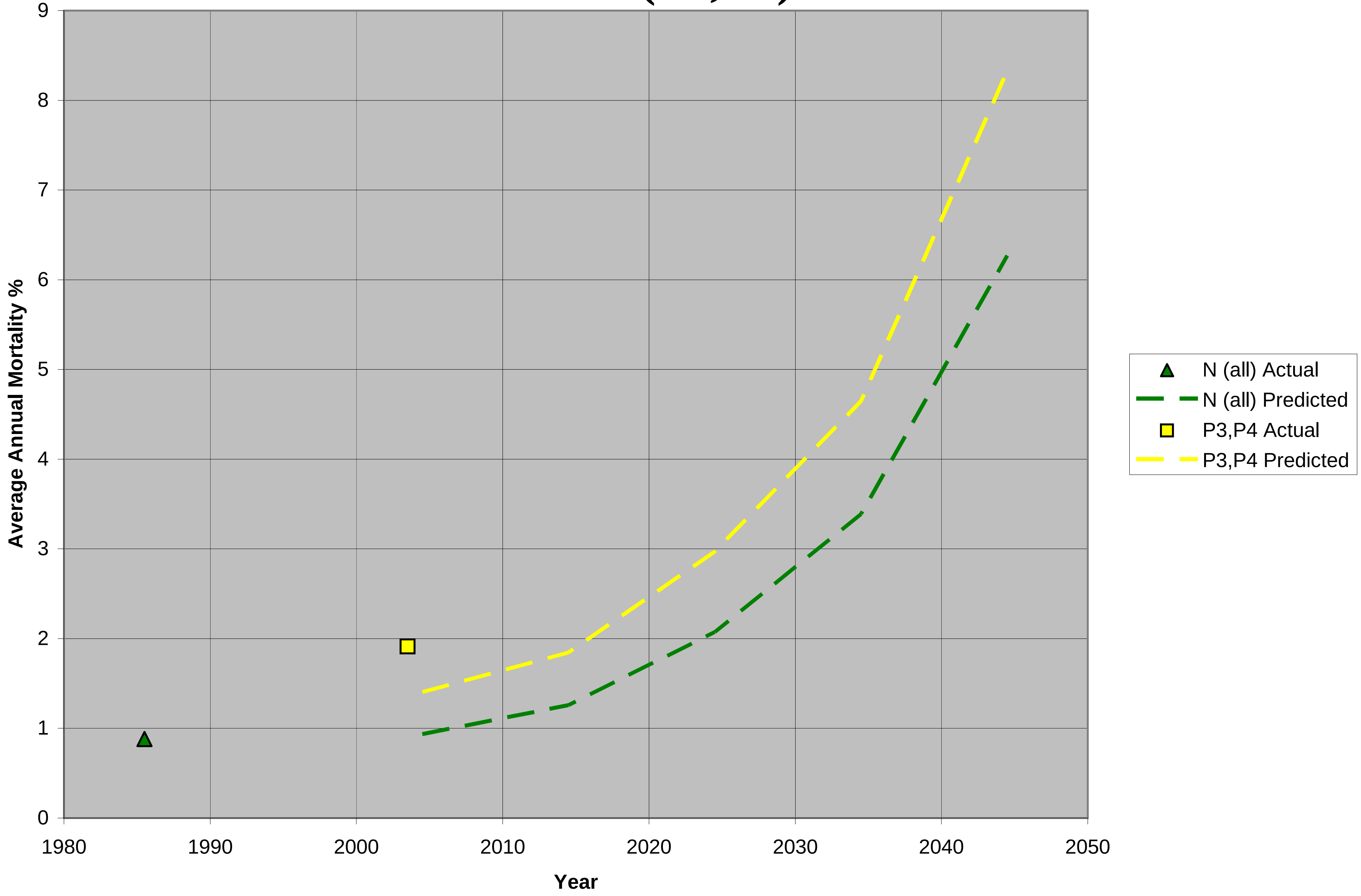
Mortality Trends and Temperature Shifts



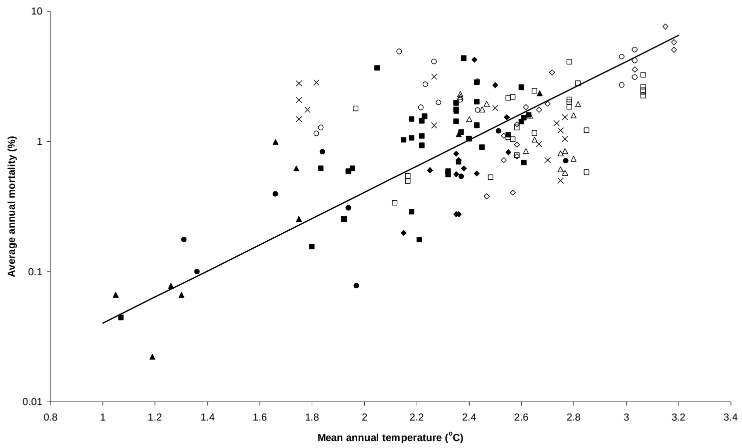
Actual and Projected Average Temperatures for Ives (N) and RLP (P3,P4) Sites

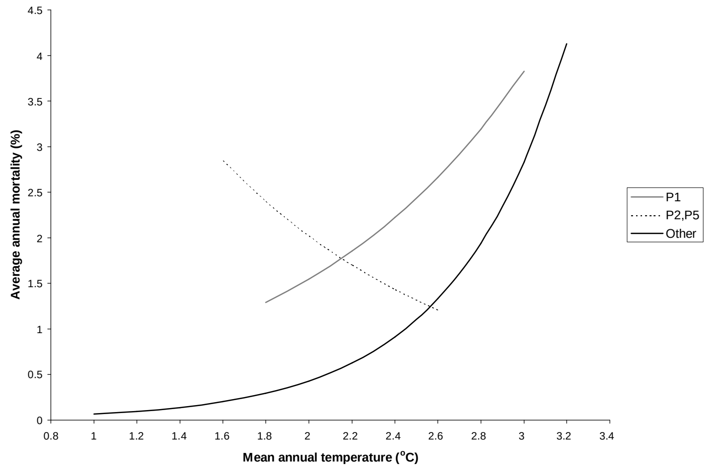


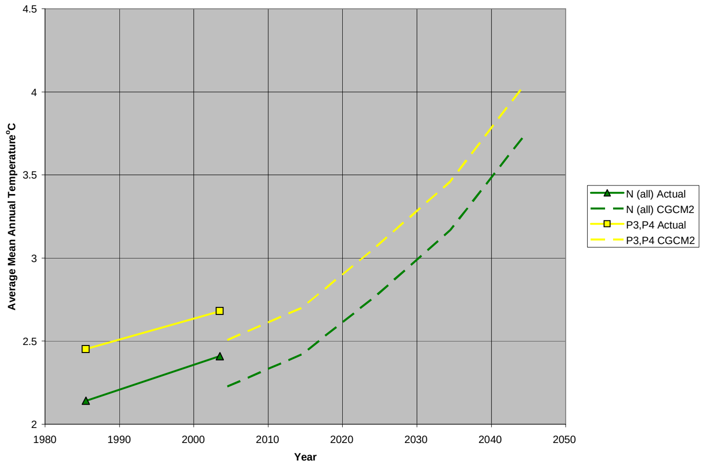
Actual and Projected Average Mortality for Ives (N) and RLP (P3,P4) Sites



Interpretation







Average mortality rates of immature lodgepole pine are likely to double within 10 to 20 years

Implications - Management

Do Not……

- **Panic:**
  - Current problems localized
  - Slow spread rates
  - Prolific natural regeneration in lodgepole pine
  - Site potential may actually be increasing
  - Enhanced diversity and wildlife habitat
  - Mitigation possible
- **Ignore:**
  - High risk of serious consequences
- **Delay:**
  - Now is the time to act
- **Aggravate susceptibilities:**
  - Some practices may be counterproductive

Examples of mitigation strategies - *Armillaria*

- Assess sites affected to determine conditions responsible for tree stress so that they may be avoided on similar sites in the future
- Avoid introduction of stock likely to become stressed
- Plant or interplant with resistant species
- Minimize site disturbance and number of stand entries
- Avoid soil compaction
- Insist on quality planting and carefully match planting stock to the site
- Space stands with low levels of infection to increase vigour and reduce stress
- Avoid spacing in infected areas

Examples of mitigation strategies - *Hylobius*

- Site evaluation for weevil hazard and risk
- No planting of medium-high risk stands within 0.8 km of infestation source
- Adjust timing of planting and fill-in
- Consider alternative species on all except low-hazard areas
- Check potential brood trees for weevils and remove or chemically treat before planting
- High establishment densities with minimum openings
- Shallow planting
- Mix or intersperse pine with spruce, larch
- Plant only on good sites, or improve vigour by fertilization etc.
- Survey plantings regularly
- Sanitation to remove dead-dying trees
- Low pruning and litter removal
- Pesticide last resort

Examples of mitigation strategies – General Climate Adaptation

- **Species selection**
  - Currently no mechanism in Alberta for evaluating species choice in light of climate change
- **Breeding for survival**
  - More attention may need to be paid to juvenile survival, versus traits such as individual tree height and diameter
- **Assisted migration:**
  - Revised seed zones and CPP regions
  - BC / PNW Assisted Migration Adaptation Trial

Do……

- Learn from successes and failures
- Place more emphasis on assessing risks before conducting silvicultural operations
- Develop meaningful mitigation strategies and guidelines for reducing risks
- Review selection and deployment strategies for planted and improved stock
- Assess trends and susceptibilities in other species
- Agree on priorities for research and development
- Network