Efficient Management of White Pine Blister Rust in High Elevation Ecosystems: A Dynamic Modeling Approach

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Personnel and Institutions

Colorado State University

- Craig Bond (DARE)
- William Jacobi (BioAg Sci. & Pest Mgmt)

University of Colorado

- James Meldrum (Env. Studies)

University of Montana

- Cara Nelson (Ecosys & Conserv. Sci)

USDA Forest Service

- Anna Schoettle, Patricia Champ (RMRS)
- Richard Sniezko (DGRC)

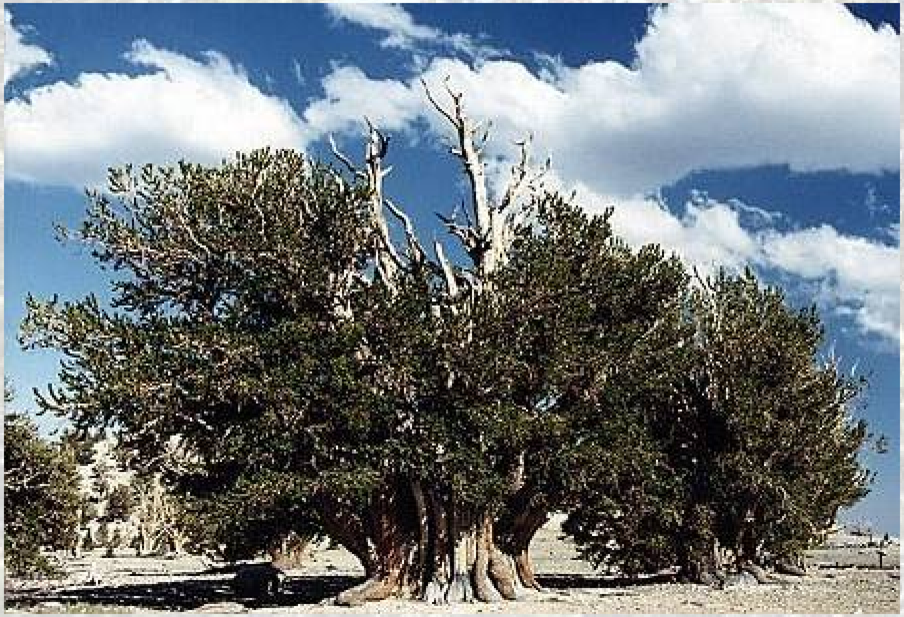
A Quick Biology Primer

- *Cronartium ribicola* is the non-native airborne fungus that causes the disease white pine blister rust (WPBR)
- All North American white pine species are susceptible, with low resistance and high mortality reported


Rocky Mountain Bristlecone

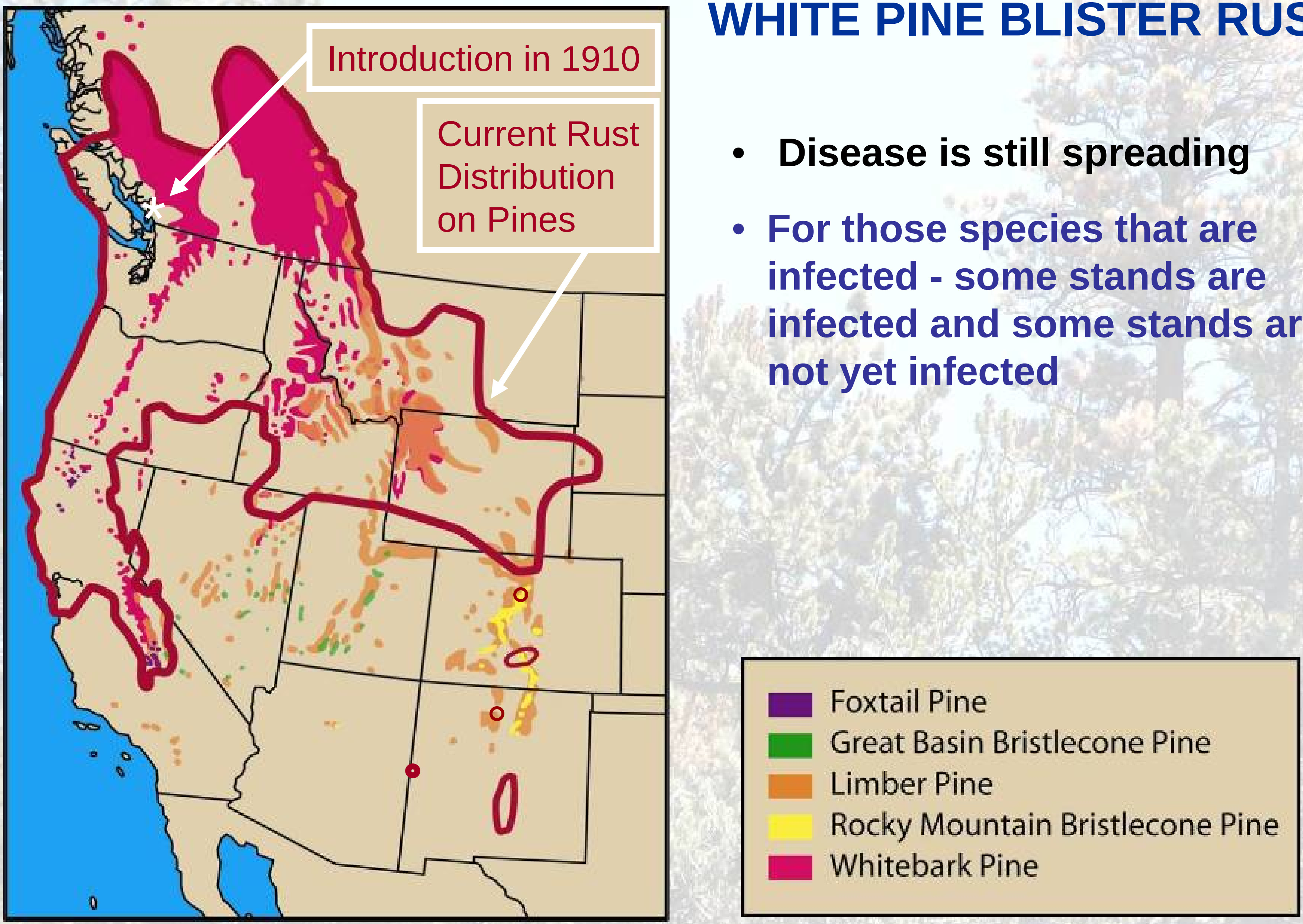

Foxtail


Whitebark


Great Basin Bristlecone


Limber

WHITE PINE BLISTER RUST



- **Disease is still spreading**
- **For those species that are infected - some stands are infected and some stands are not yet infected**

Other NA white pines = western white pine, eastern white pine, SW white pine, sugar pine

White Pine Mortality

- Once infected, WPBR can take years to kill an individual tree, often expressed as “top killing”
- In seedlings and young trees, mortality can be relatively quick (several years)

- Unlike native bark beetles, WPBR infects white pines of all ages, seriously threatening the regeneration process of stands

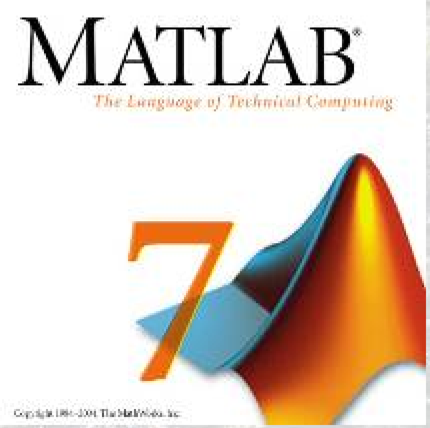
Interesting Aspects of the Problem

- Primarily non-timber values on public lands
- Intergenerational problem due to the nature of the threat
- Stochastic, potentially irreversible processes

- "Management externalities" – will intervention itself decrease values?
- Constrained management budget

Project Objectives

- Estimate intergenerational social costs of WPBR using nonmarket valuation techniques
- Construct basic model of WPBR epidemiology
- Continue research and development of management strategies
- Develop dynamic programming management model
- Evaluate and prescribe management practices under alternative conditions



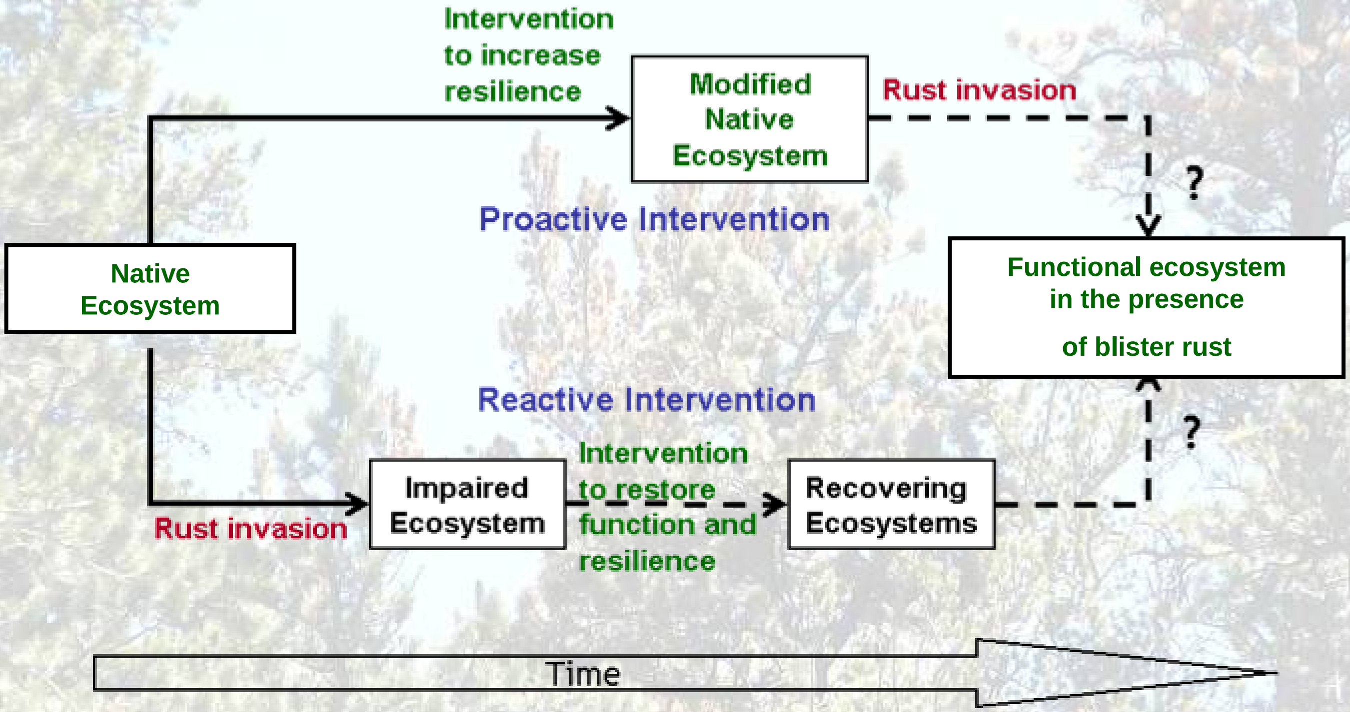
Key Outcomes

- Valuation of non-market benefits associated with white pine ecosystems
- Decision tool to help make better management decisions under a range of circumstances
  - Should managers intervene?
  - If so, how?

Presentation Outline

- Update on Population Modeling Effort
- Update on Epidemiology Effort
- Update on Cost Data Effort
- Update on Non-Market Valuation Effort

Informing the Decision Model: Population Modeling



- What is the ecological efficacy of different management options imposed at different times relative to invasion and impacts of rust?
- What are the ecological trade-offs of proactive vs reactive management?
- Is it possible to avoid the “Impaired Ecosystem” condition with proactive management?

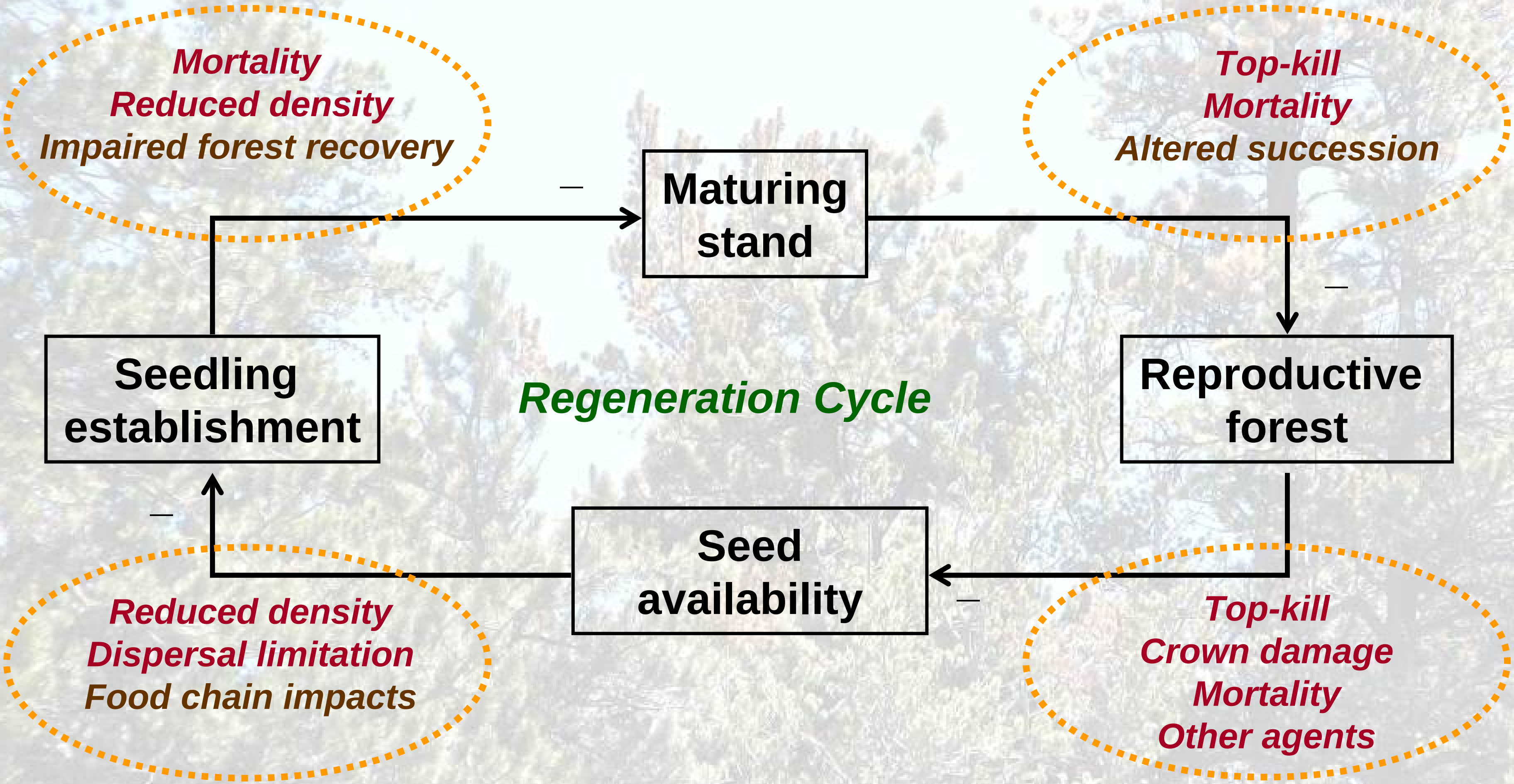
Major Management Options

- Proactive Options
  - Intervention in healthy or early infected stands

- Reactive Options
  - Intervention after 90% mortality

- Managers can proactively or reactively pursue:
  - Planting rust-resistant seedlings
  - Cutting or burning to stimulate natural regeneration

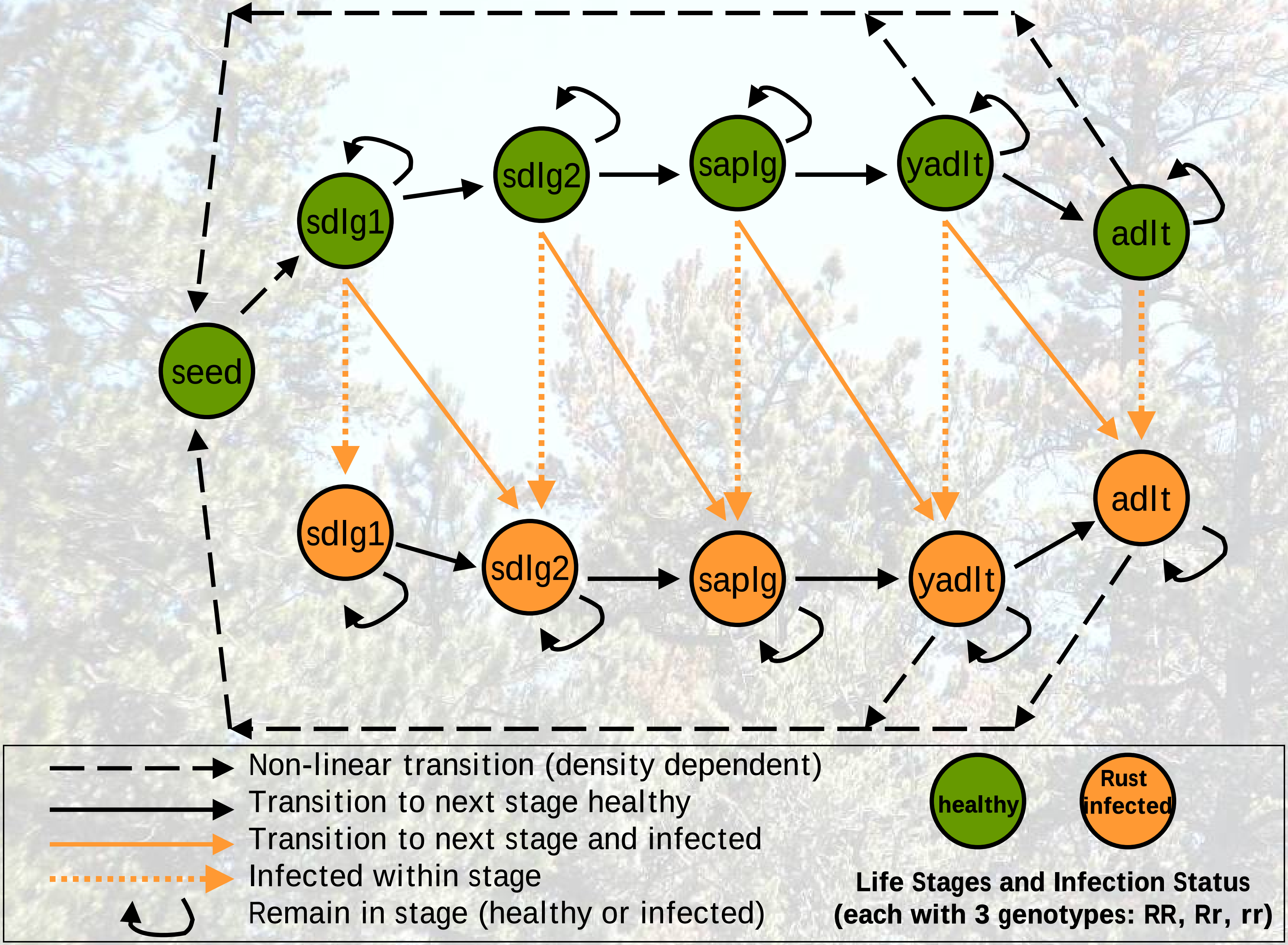
WPBR Kills Trees at All Stages



Stage Structured Population Genetic Infection Model

- Primary Objectives
  - Parameterize a model to project pine populations under different initial stand structures, disease resistance allele frequencies, disease epidemiological conditions and proactive and reactive management scenarios.
  - Provide model outputs and probabilities for integration into the valuation survey and dynamic economic model

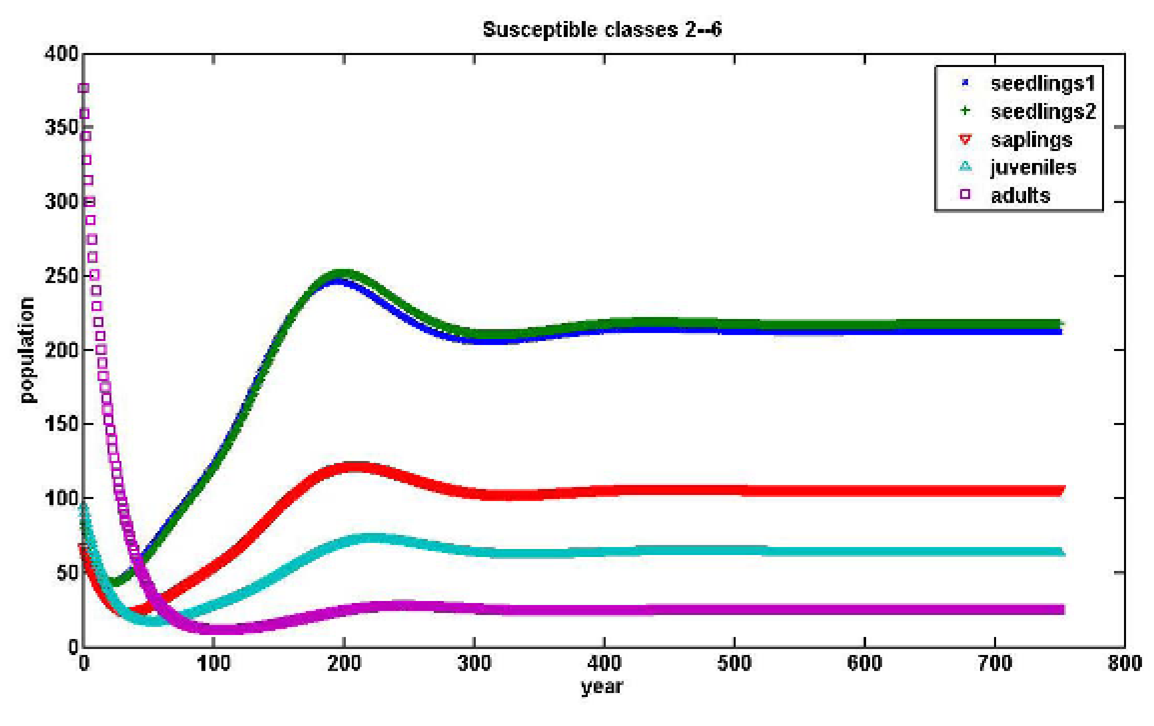
Stage-structured Population Genetic Infection Model



Stage Structured Population Genetic Infection Model

Progress Year 1:

- The model, less the genetics, has been developed, parameterized and coded (12 vector matrix).
  - Growth, survival and WPBR infection probabilities of each of 6 age class can be varied independently
  - Includes linear and non-linear dynamics
  - Evaluated sensitivities for 40 parameters – discrete-time iterative procedure



Sample run with no management, rust invasion at time zero

Stage Structured Population Genetic Infection Model

- Still to Come
  - Addition of disease resistance allele frequencies for each age class (36 vector matrix)
    - Examine the evolution of resistance over time in the population
    - Assess ecological efficacy of management scenarios under the full array of conditions

Informing the Decision Model: Cost of Treatment Data

- What treatments are being included?
  - Forest Service and Park Service lands in the range of limber and whitebark pine
    - 83 National Forests
    - 16 National Parks

- How is information being collected?
  - Survey of natural resource managers involved with designing and implementing treatments.

Assessing the Cost and Efficacy of Treatments to Control WPBR

Progress Year 1:

- Conducted a literature review to assess the types of treatments being conducted and their efficacy
- Developed a survey for obtaining information on costs of treatments and efficacy
- Identified over 100 resource managers to include in the survey

Assessing the Cost and Efficacy of Treatments to Control WPBR

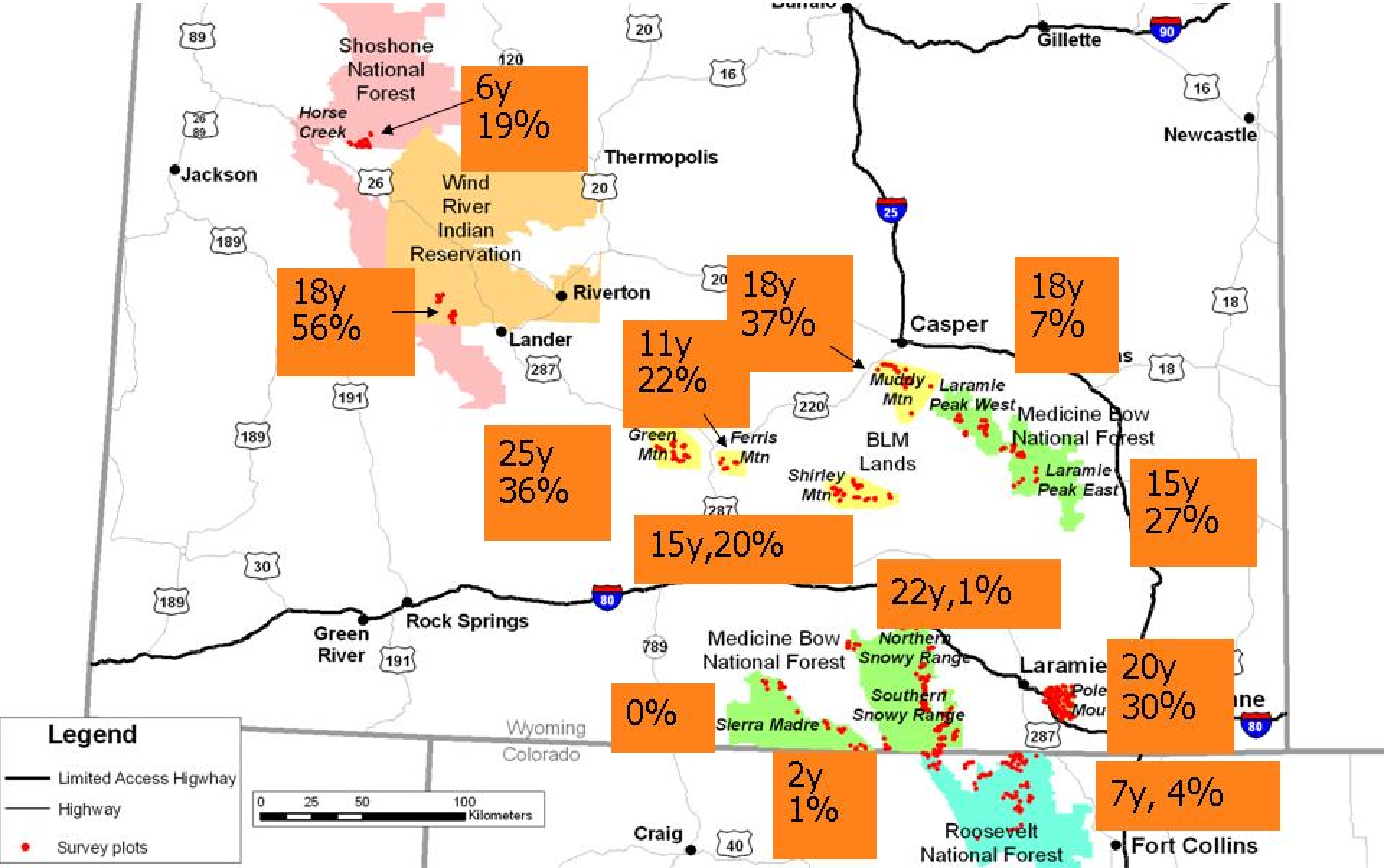
- Next steps?
  - The survey will be mailed out in mid-October.
  - Researchers at University of Montana will contact all survey recipients to help and encourage them to provide requested information.
  - Data from the survey will be analyzed in January.
  - Findings related to costs of treatments and effects of management will be feed into the economic optimization models.

Informing the Decision Model: Epidemiology

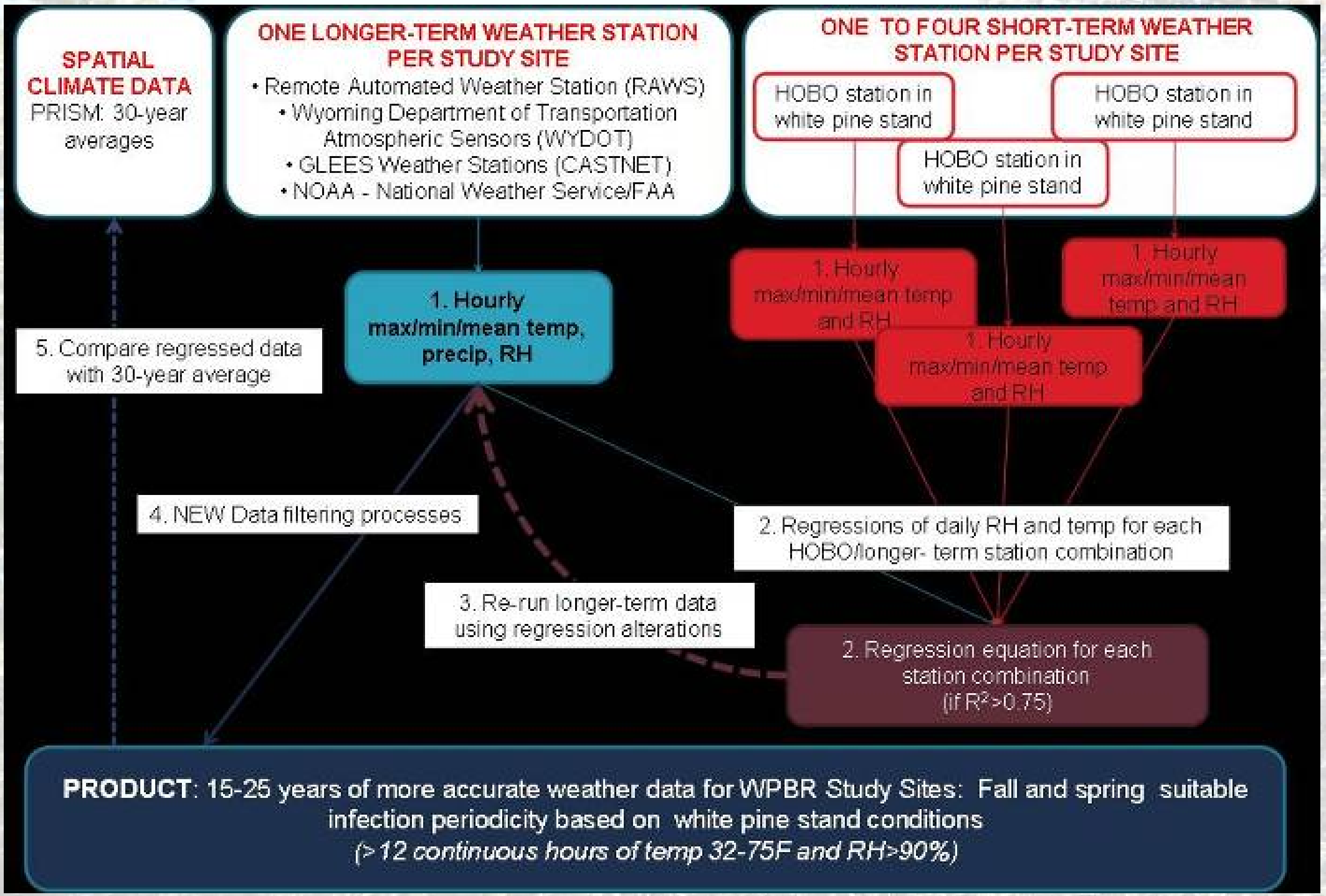
Primary Objective: Disease incidence and intensification predictions

- Determine if Suitable Infection Periods (SIP) are related to:
  - incidence and severity of WPBR
  - WPBR intensity and periodicity
  - WPBR canker sizes

Incidence and Estimated Yrs of Infestation



Incorporating Climate and Weather Data into Statistical Models



Epidemiology Progress

- Progress Year 1
  - incidence and severity at 13 study sites in WY/northern CO
  - incidence and severity in new southern Colorado infestations
  - time estimations and periodicity per study site (canker sizes)
  - local meteorological variation per study site (spatial)

- Still to Come
  - relationships between local variation and rust intensity (spatial)
  - relationships between time, disease periodicity and local meteorological conditions (spatial and temporal)

- Epidemiology model will provide temporally realistic forest health information at local scales

Value of High Elevation Stands

- Primary Objectives
  - Estimate intergenerational social costs of WPBR using nonmarket valuation techniques
    - Choice Experiment format with contingent valuation question on entire Western program
    - Knowledge Networks to administer to primary population (General population, Western US); secondary population invited to complete via team-hosted website (http://wpbr.x10hosting.com/)

WPBR Values

- Recreational Values (sightseeing, hiking, camping, etc…)
- Option Values
- Existence Values
- Ecosystem service values

- Note that many of these stands exist in high-value areas such as state and national parks

Value of High Elevation Stands

- Progress to date:
  - Literature review and `ologist meetings to identify:
    - potential important attributes
    - methodological approaches to complex management problems and outcomes
  - Three focus groups to develop background material and identify attributes
    - Feb 27, 2009
    - May 1, 2009
    - Aug 13, 2009

Attributes and Choice Sets

- Participants ranked the following attributes highly in terms of importance:
  - Long-run forest health (defined as continuity of life cycle)
  - Dependent Wildlife Health (generally co-linear w/ forest health)
  - Threat/Infection Level
  - Stream Flows
  - Dead tree ratio
  - Cost
- Note shift away from recreational values

Choice Set to Date

Characteristics:

- General site location
- Infection/threat varies across and between respondents
- 3 time scales (immediate, 30-50 yrs, 150 years)
- Probabilities of “healthy forest” in long run

<u>Question #</u>: Managers are considering different options for addressing *WPBR* in a 1000-acre *high-elevation forest* in the Rocky Mountain region. If the only three options were those below, which of the three would you prefer? In choosing, be sure to consider the different effects and costs of the options.

	<u>Option 1:</u> Treatment Plan 1	<u>Option 2:</u> Treatment Plan 2	<u>Option 3:</u> No Treatment
<u>Effects in 2010</u>			
Treatment Method	Area burned	Other trees cut down and seedlings planted	No treatment
Size of Area Treated	30 acres	300 acres	0 acres
Total Cost per Household	$20	$100	$0
<u>Effects in 30 Years</u>			
Status of Entire Forest in 2040	Somewhat Healthy: Few species of trees, some different ages of trees, slightly fewer animals than today	Healthy: Many species of trees, many different ages of trees, as many animals as today	Not healthy: Very few species of trees, most trees are the same age, a lot fewer animals than today
Impact on Water in 2040	Flows slightly reduced	Little Impact	Flows reduced a lot
<u>Effects in 150 Years</u>			
Chance of Healthy Forest in 2160	50%	90%	10%
Your Preferred Option: (Choose one)	☐	☐	☐

High Elevation Pine Valuation

Next Steps?

- Focus Group #4 to test choice experiment
- Pre-Test
- Full survey out to both populations, October/November 2009
- Analyze data

Dynamic Management Model

Still to Come:

- Key is integration of population dynamic, epidemiology, benefit, and cost data into coherent and tractable model framework
- Uncertainty plays a central role

$$V(x_t, \theta_t) = \max_{c_t} \{u(c_t, x_t) + \beta E[V(x_{t+1}, \theta_{t+1})]\}$$

$$= \max_{c} \{u(c_t, x_t) + \beta E[V(f(c_t, x_t; \gamma, \alpha) + \varepsilon_{t+1}, G(c_t, \varepsilon_{t+1}, x_t, \theta_t))]\}$$

Pitfalls/Potential Limitations

- Parsimonious expression of relevant WPBR spread and management efficacy
- Incomplete survey of all relevant ecosystem values
- Accuracy of dynamic model and the “curse of dimensionality”

Progress vs. Work Plan

		Timing (Months)							
		Year 1				Year 2			
Task	Personnel	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24
Non-market valuation/choice set data collection	Champ, Bond, Meldrum	■	■	■					
Non-market valuation/choice set statistical analysis	Champ, Bond, Meldrum			■	■				
Natural science tasks (epidemiology analyses; parameterization of genetic population model)	Schoettle, Jacobi, Koski, Nelson, and Sniezko	■	■	■	■	■	■		
Bioeconomic model development (coding)	Bond, Meldrum				■	■	■		
Bioeconomic analysis (sensitivity analysis, what-if scenarios, etc…)	Bond, Meldrum						■	■	
Final report and journal article preparation and submission	All				■	■	■	■	■
Presentation of research results	All				■	■	■	■	■

Work generally proceeding on schedule, despite one significant personnel issue

- Valuation exercise slightly behind schedule
- Significant momentum going forward
- Communication between research team is excellent

Whitebark Pine Ecosystem Foundation

Save the Date!

"High-Five" Symposium:
The Future of High-Elevation Five-Needle White Pines in Western North America

June 28-30, 2010

The University of Montana Campus — Missoula, MT

* Future of Whitebark, Limber, Foxtail, Southwestern White, Rocky Mountain Bristlecone, and Great Basin Bristlecone Pines
* Latest Research Findings: Distribution, Ecology, Pathology, Wildlife relations, and Restoration
* Management Strategies & Experiences/Restoration Opportunities
* Call for Papers in midsummer 2009
* Who Should Attend: Managers, Researchers, Students, Administrators, and all people interested in or concerned about five-needled pines

More Information and Online Registration will be available Fall 2009

www.umt.edu/ce/ (website address to be determined)

If you have questions, please contact:

Continuing Education - UM
Chelsea Thompson
Email: chelsea.thompson@umontana.edu

Products from our PREISM project will be presented in multiple talks at this international meeting in 2010.

The integrated bio-economic approach being developed by this project will be a unique and innovative contribution to the meeting.

Members of our team are serving on the steering committee.

http://www.umt.edu/ce/cps/highfive/

Presentations and Potential Contributions

PRESENTATIONS

Antolin, MF, SG Field, J Klutsch, AW Schoettle, SJ Tavener. 2009. A stage-structured model for spread of pathogens into naive populations. Oral presentation at the 94th Annual Meeting of the Ecological Society of America; August 2-7, 2009; Albuquerque, NM. Abstract published at: http://eco.confex.com/eco/2009/techprogram/P19372.HTM

Schoettle, AW. 2009. Sustaining high elevation pines in the presence of white pine blister rust. Oral presentation at the Rocky Mountain Research Station Wilderness Workshop: Exploring Wilderness Science in the Interior West. Missoula, MT. April 28-30, 2009.

PLANNED CONTRIBUTIONS

Epidemiology model(s)
Population Dynamics model(s)
Treatment Costs
General Choice Set/Valuation
General Dynamic Model
Long Run vs. Short Run Values
Valuation and Uncertainty

Payment schedule/Discount Rates
Values associated with Alternative Management Regimes
Overall project summary in broad interest journal
Intransitivity in preferences over choice set
Factor analysis on preferences and WTP from NEP
Methods paper on survey administration
State dependent marginal effects

Thank You!

Questions, Comments, Suggestions?

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