Plant Health Risk Assessment

Risk

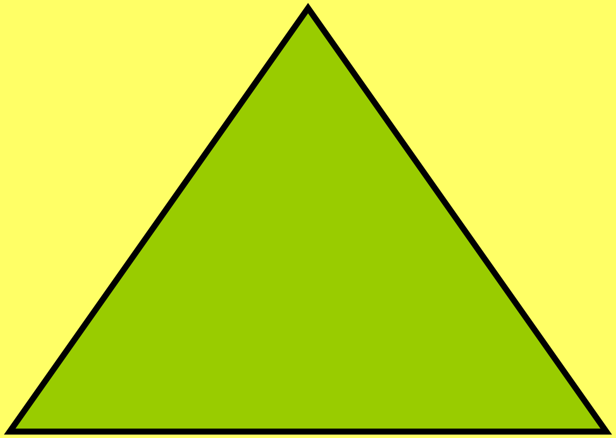
- Two components
  - incidence or likelihood (probability of an event e.g. introduction)
  - Impact of event (consequences)

Two examples:

1) Risk of introduced pest – CFIA (Doreen Watler)

2) Risk of disease for endemic species (Armillaria example- Mike Cruickshank-disease risk Bill Wagner- economic risk)

Economic

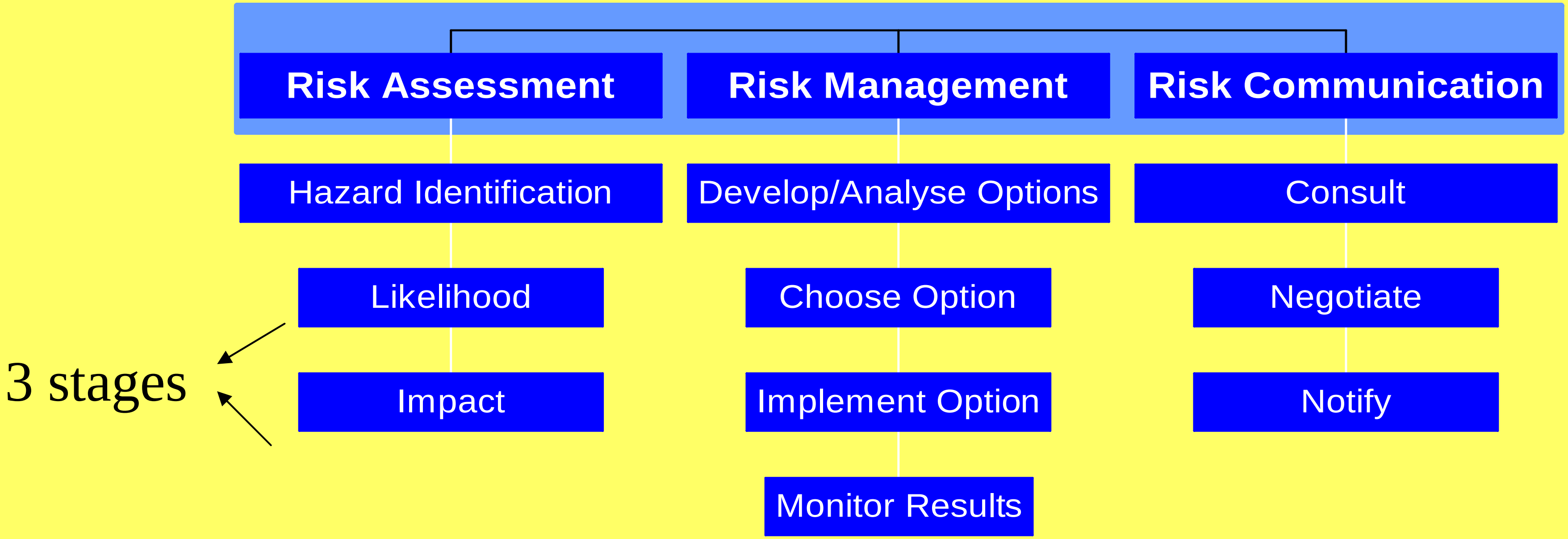


Social

Environmental/ biological

PRA PROCESS

- “Pest Risk Analysis”



- International Aspects to PRA-
  - FAO-IPPC; ISPMs (#2, #11,#21); definitions (e.g., “QP”)
    - https://www.ippc.int/IPP/En/default.jsp
  - GATT; NAFTA – endorse similar principles and promote following international PRA guidelines
  - Provide some scientific basis

Likelihood of introduction

- **Prevalence in Area of Origin**
- **Potential Man-Made Pathways**
- **Likelihood of Pest Being Associated with Pathway at Origin**
- **Survival in Transit**
- **Ease of Detection**

Guidelines for rating Likelihood of introduction

- Given Combination of all of the factors
  - Negligible (0) = extremely low
  - Low (1) = likelihood low but clearly possible, given combination of factors
  - **<u>Medium</u> (2) = likely, given combination of factors**
  - High (3) = very likely or certain

Consequences of introduction (Impact)

- Establishment potential
- Natural spread potential
- Potential economic impact
- Potential environmental importance

Guidelines for Rating Potential Environmental Impact

- Negligible (0) = no potential to degrade environment or alter ecosystem e.g. Cherry rasp virus
- Low (1) = limited potential impact on environment, slight impact on host, some aesthetic or recreational effects e.g. winter moth
- Medium (2) = moderate impact, obvious change in ecological balance e.g. oak wilt
- **High (3) = major damage to environment, significant losses to ecosystems e.g. Chestnut blight, nun moth**

Guidelines for Rating Consequences of introduction

CUMULATIVE SCORES Establishment Potential + Natural Spread Potential + Economic Impact + Environmental Impact	RATING FOR CONSEQUENCES OF INTRODUCTION	NUMERICAL SCORE FOR CONSEQUENCES OF INTRODUCTION
0 - 2	NEGLIGIBLE	0
3 - 6	LOW	1
7 - 10	MEDIUM	2
11 - 12	HIGH	3

Guidelines for Overall Risk Rating

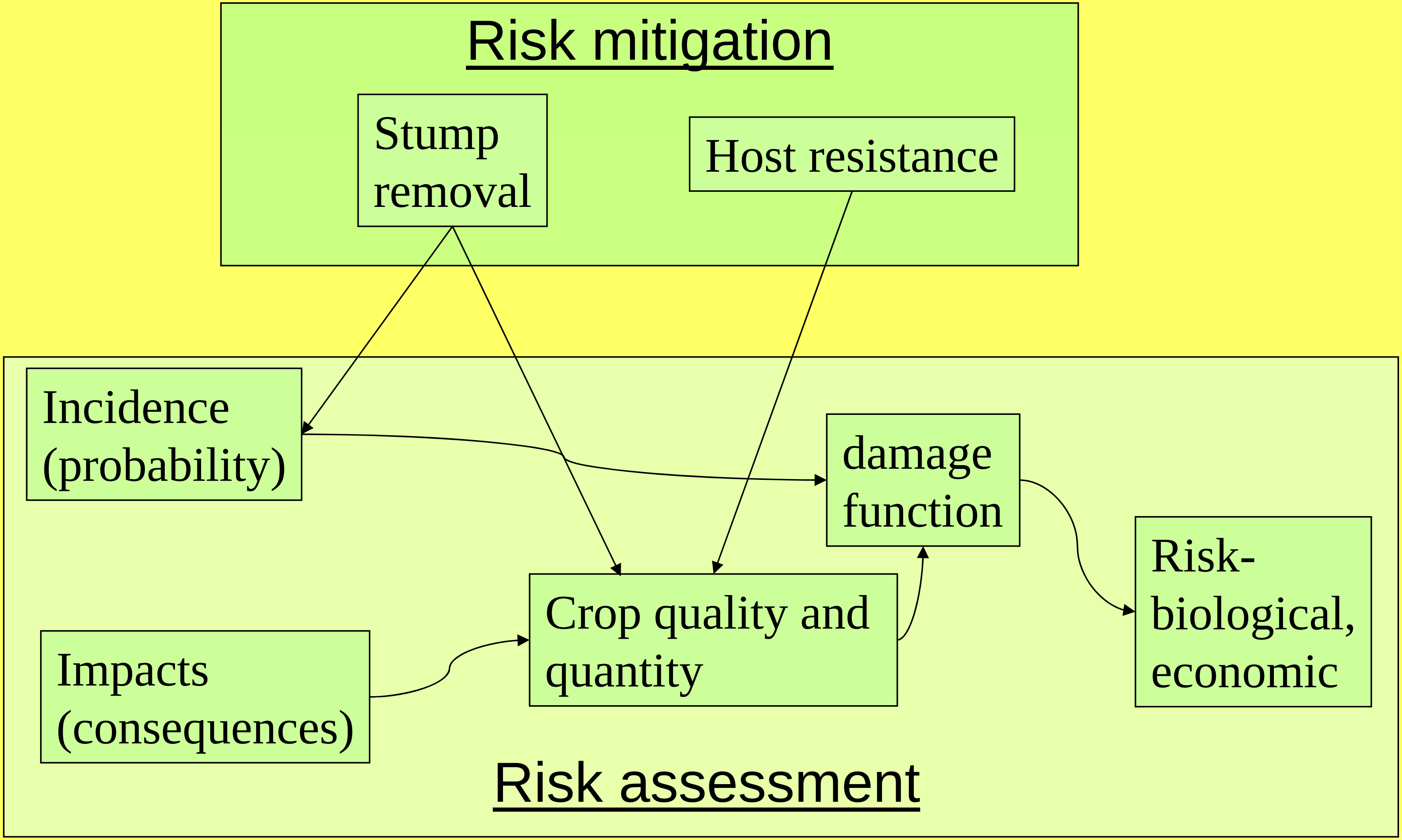
- Multiply together the scores for likelihood of introduction and the overall rating for consequences of introduction

- Overall risk rating is assigned as followed:
  - Negligible = 0
  - Low = 1-3
  - **Medium = 4-6**
  - High = 9

Uncertainty: conflicting, incorrect or missing information
- difficult to assess some components under new conditions

A forestry example of endemic disease– *Armillaria ostoyae*

- Sampled directly with an ecosystem for incidence and severity- not done with categorical scale
- Economic analysis based on biological risk- Bill Wagner



Note: Needs to be done in space and time

What we know before starting risk assessment

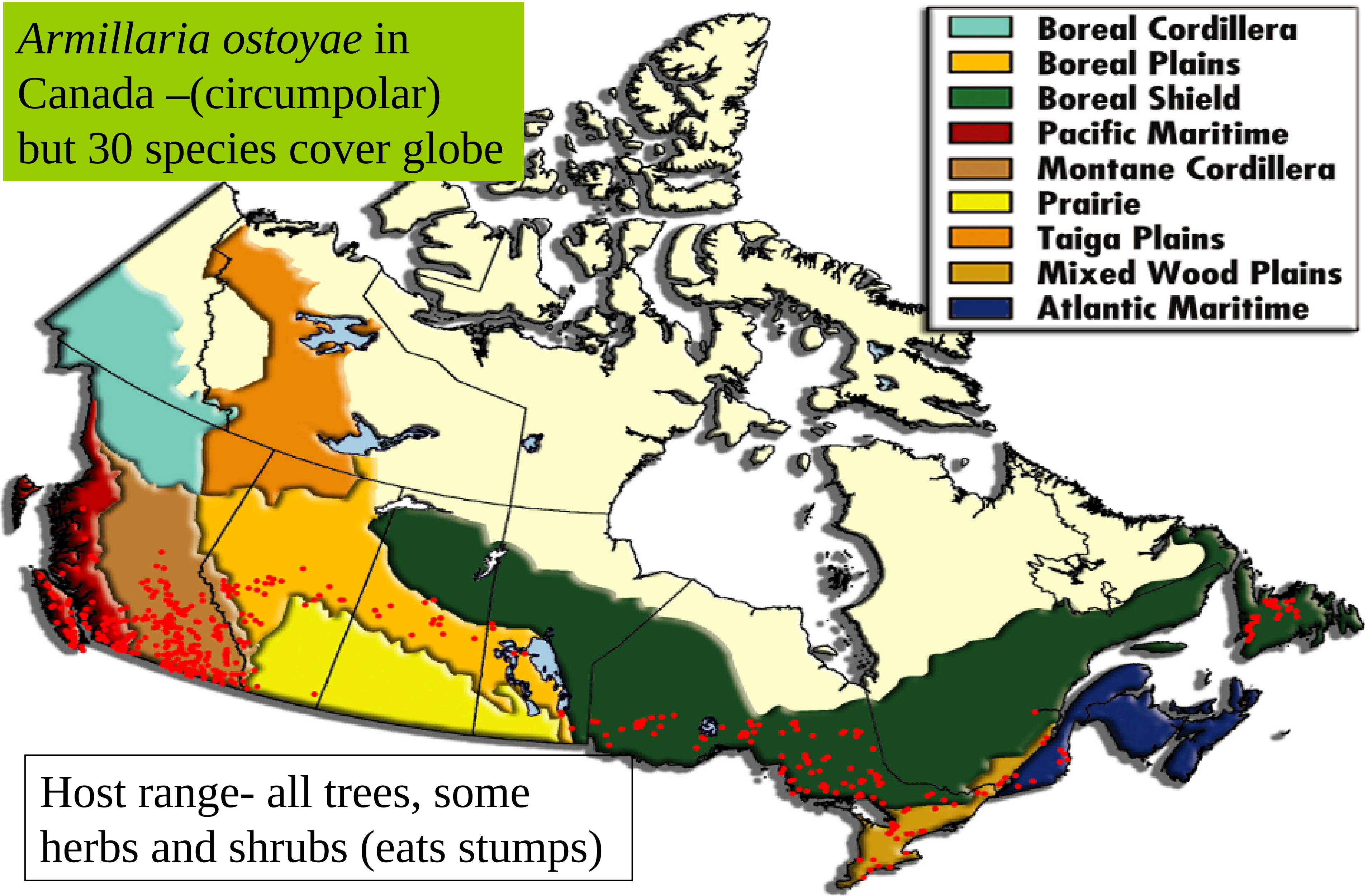
- Poor data at tree level, no data at stand or landscape level- difficult to determine over time.
- Infects most trees, many shrubs and herbs
- This disease is widely distributed in Canada and worldwide
- One risk component (incidence) is high (good data in BC and Ontario both show near 100% infection by age 100) therefore worth looking at impacts
- We looked at best and worst stands to get the range of impacts not average (average too expensive)
- Took existing data and built Armillaria OAFs for TIPSY, then built TASS/ROTSIM simulator and compared.

Armillaria Biology summary

- Fungus- basidiomycetes
- Over 30 species worldwide
- *Armillaria ostoyae* – Canada and northern hemisphere
- Spreads slowly between roots underground- rarely by spores
- Infection not easily seen above ground
- Infects all tree species
- Colonizes stumps quickly- builds up inoculum
- Stumps the principle problem especially in partial cuts (see Canadian Silviculture Magazine Vol. 5 no.1 1997).

Distribution mapping

Armillaria ostoyae in Canada –(circumpolar) but 30 species cover globe



Host range- all trees, some herbs and shrubs (eats stumps)

Disease related to lumber quality

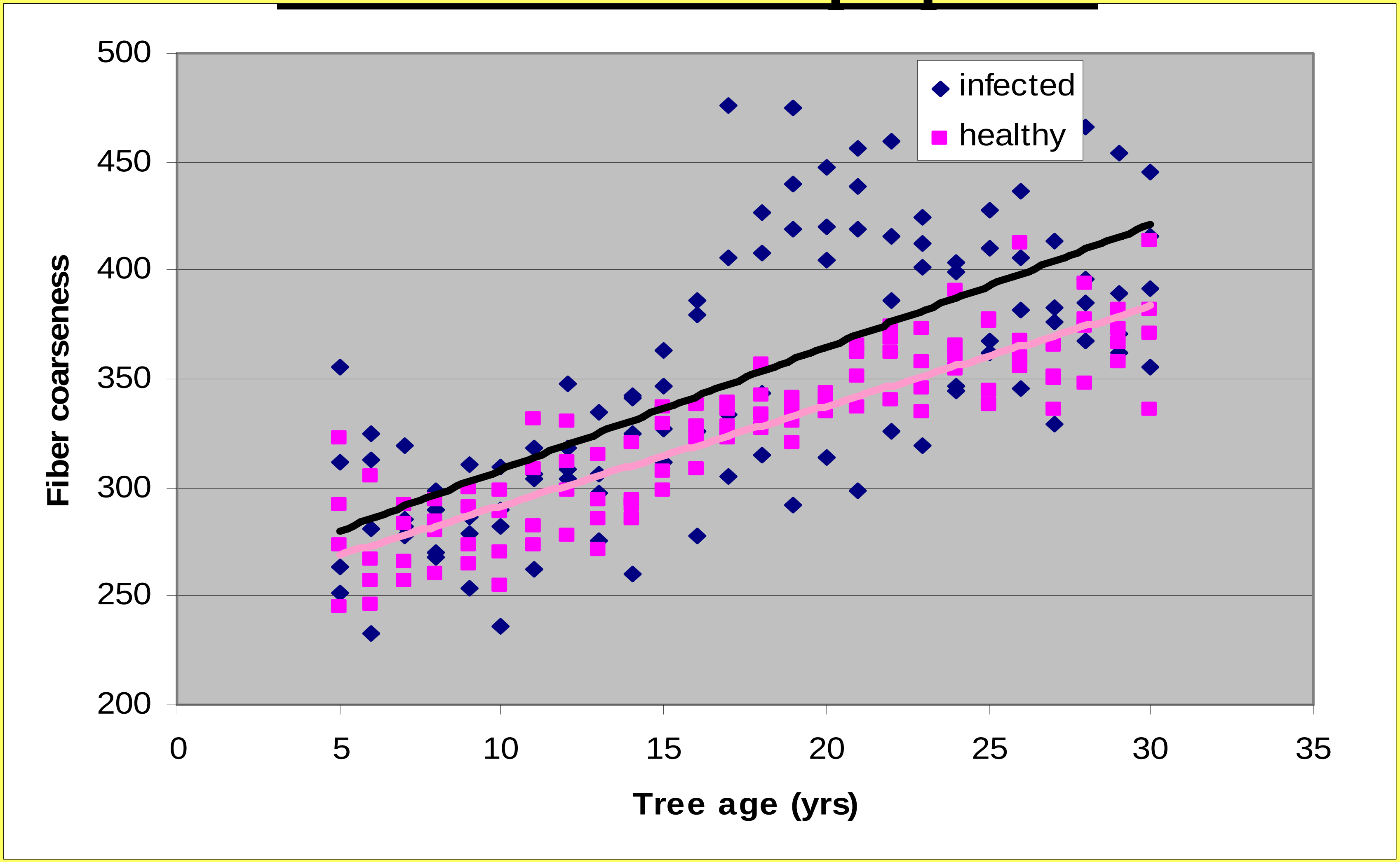
Log	Healthy							Diseased						
	None	Knots	Shake	Split	Wane	Warp	Healthy total	None	Knots	Shake	Split	Wane	Warp	Diseased total
1	7	3	3			1	14	1	2		1	1	5	10
2	1	6	1	1		2	11	2	3				4	9
3		6			1	3	10	2	1	1			2	6
4		3			1	2	6	2					2	4
5		1	1			1	3		2				1	3
6			1		1	1	3		1					1
Total	8	19	6	1	3	10	47	7	9	1	1	1	14	33
Proportion	0.17	0.40	0.13	0.02	0.06	0.21	1	0.21	0.27	0.03	0.03	0.03	0.42	1

Diseased trees have:

More warp

Fewer boards in trees of similar size

Disease risk on fiber properties



Disease probably increases fiber coarseness and variability

Disease does reduce cell division and possibly increases lignin and extractives

Damage functions and incidence used in disease simulator

- **Damage functions (tree level)**
  - – Annual increment reduction=f (years since first infection)
  - – Mortality=f (percent girdled root collar)=>75% girdling= dead
- **Incidence (tree level)**
  - – Incidence = number of infected plants/total number of plants
  - – Mortality and growth loss related to incidence of infection to determine risk

Risk

Risk (stand level)

=f [(mortality + growth loss + quality loss) x (incidence x time)]

Damage function and incidence are measured at the tree level

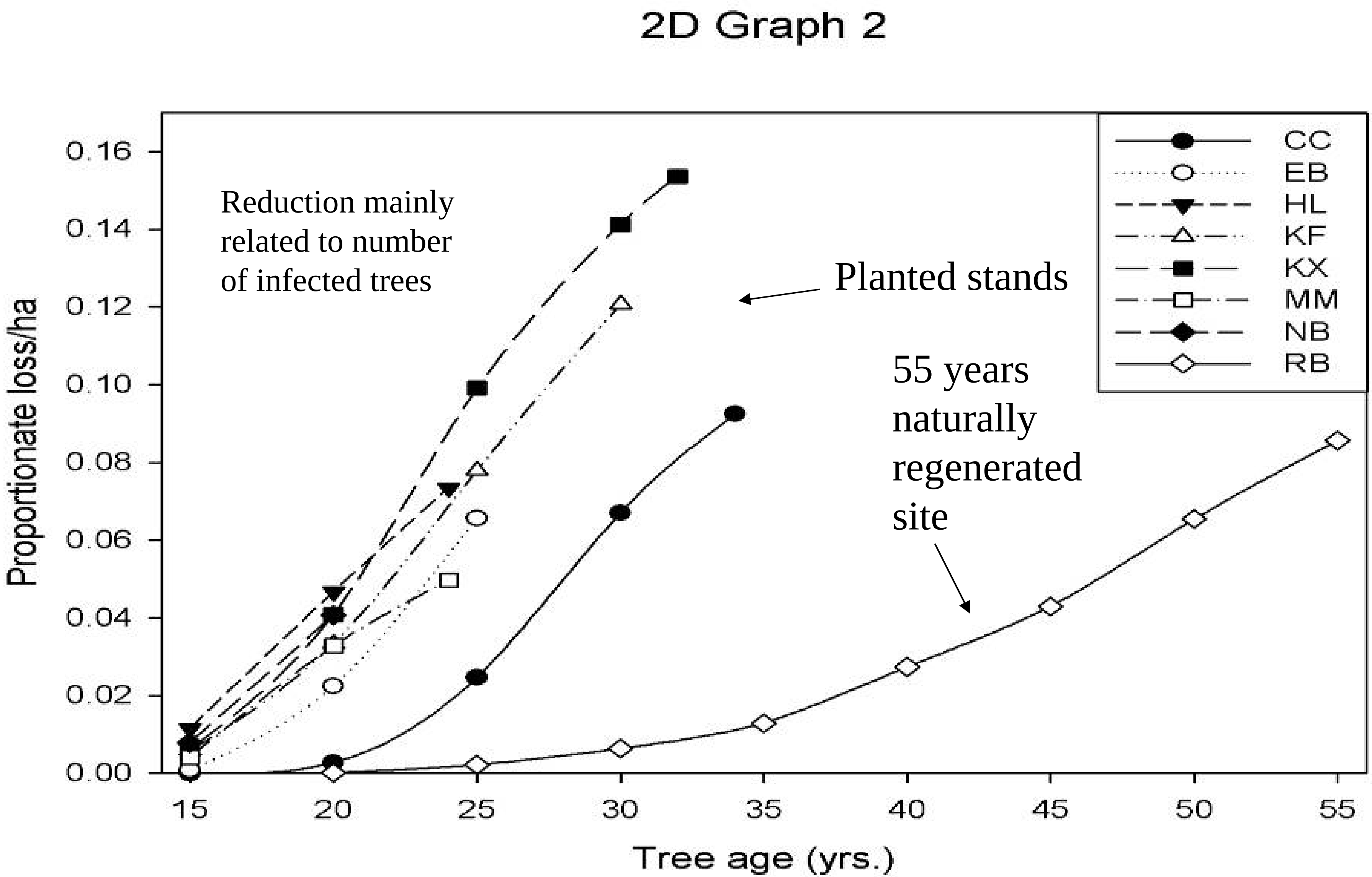
Two damage functions together with incidence give stand level risk at a given time

10 plantations

1000 trees/site

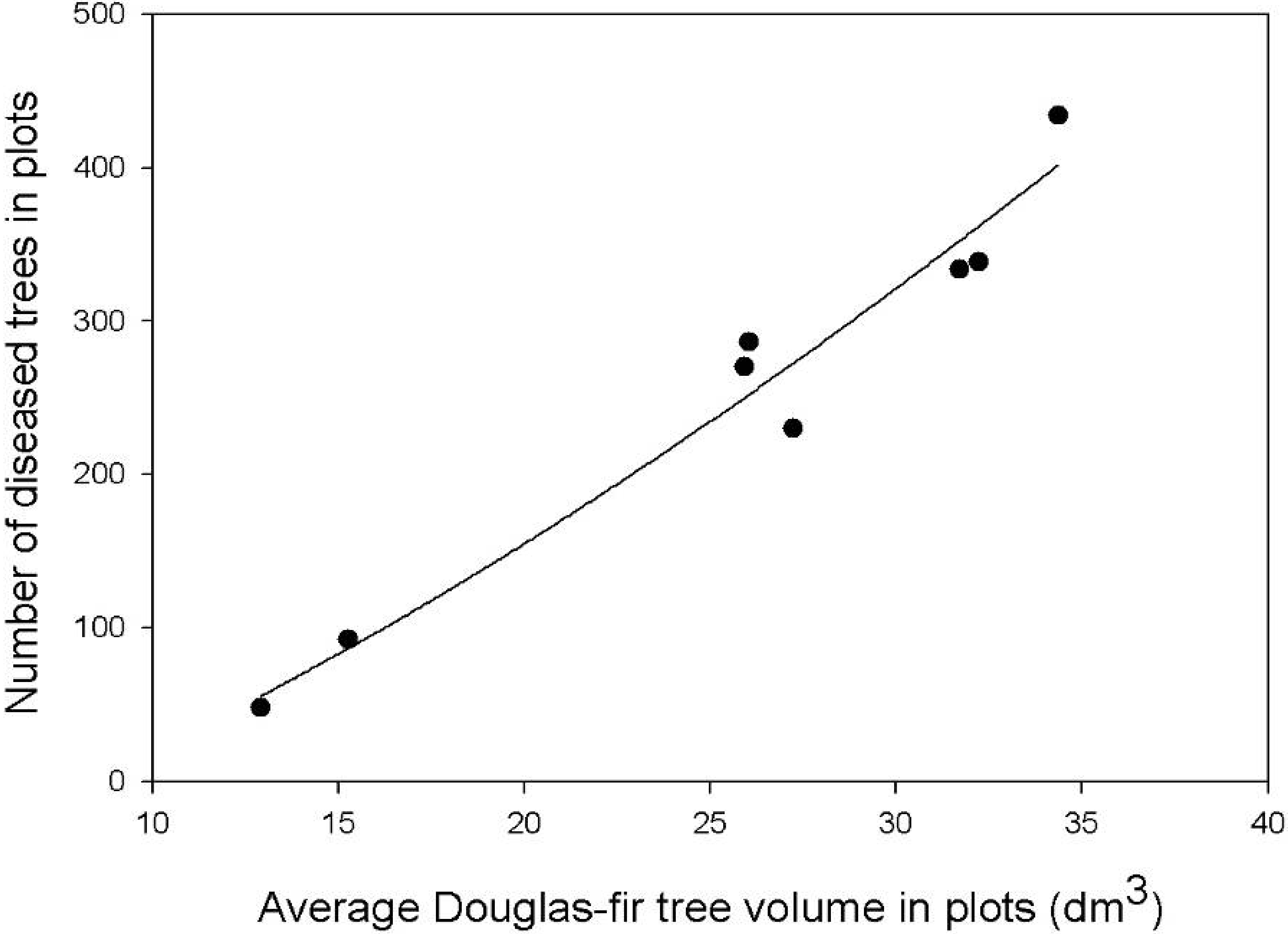
- many roots infected on one side but still functioning do affect tree growth
- most lesions are callused

Risk of non-lethal yield reduction-growth reduction

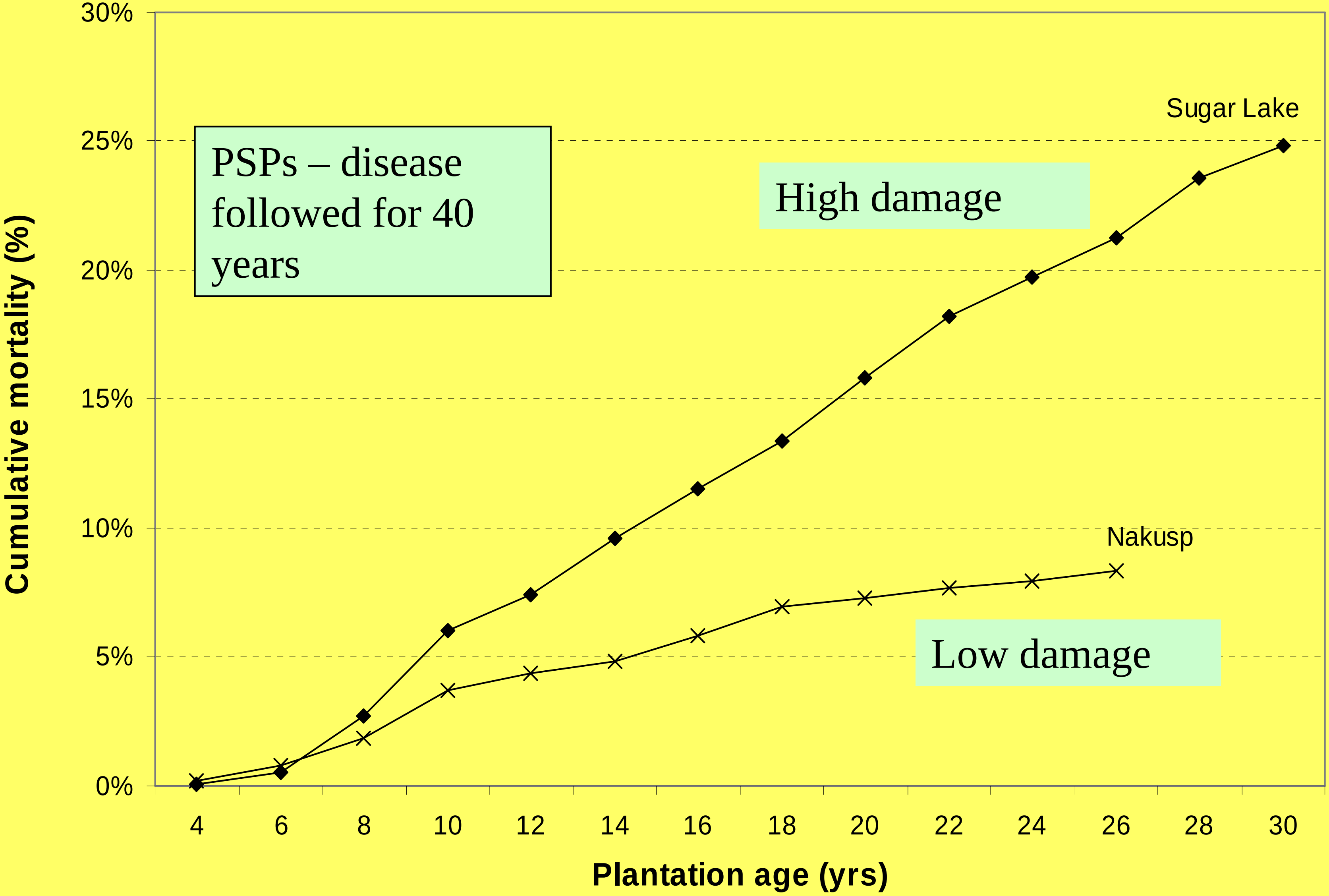


Disease interferes with genetic potential of stands

Number of diseased trees at age 20



Cumulative mortality of planted Douglas-fir caused by A. ostoyae in 2 ha plots in two plantations in the ICH.

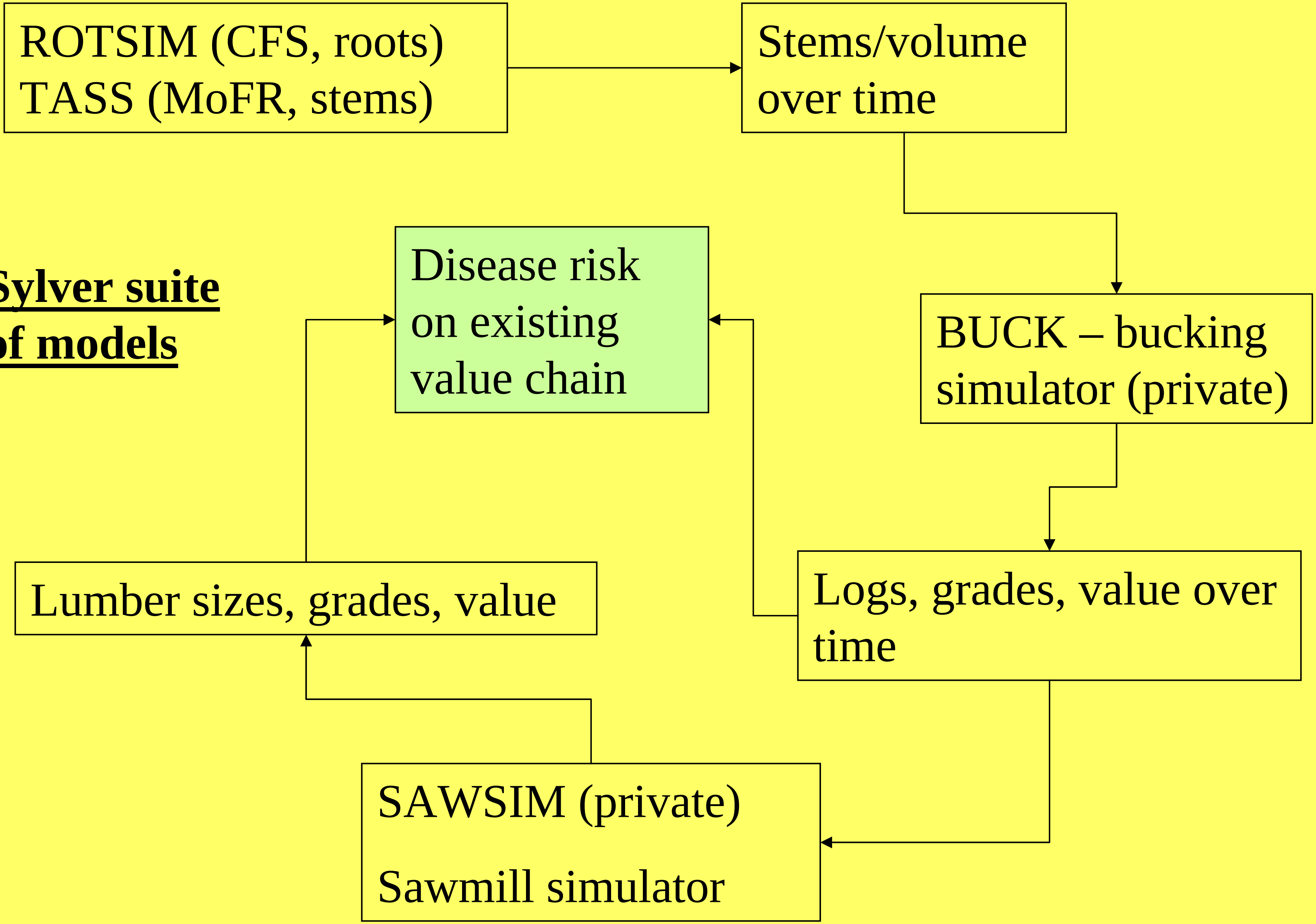


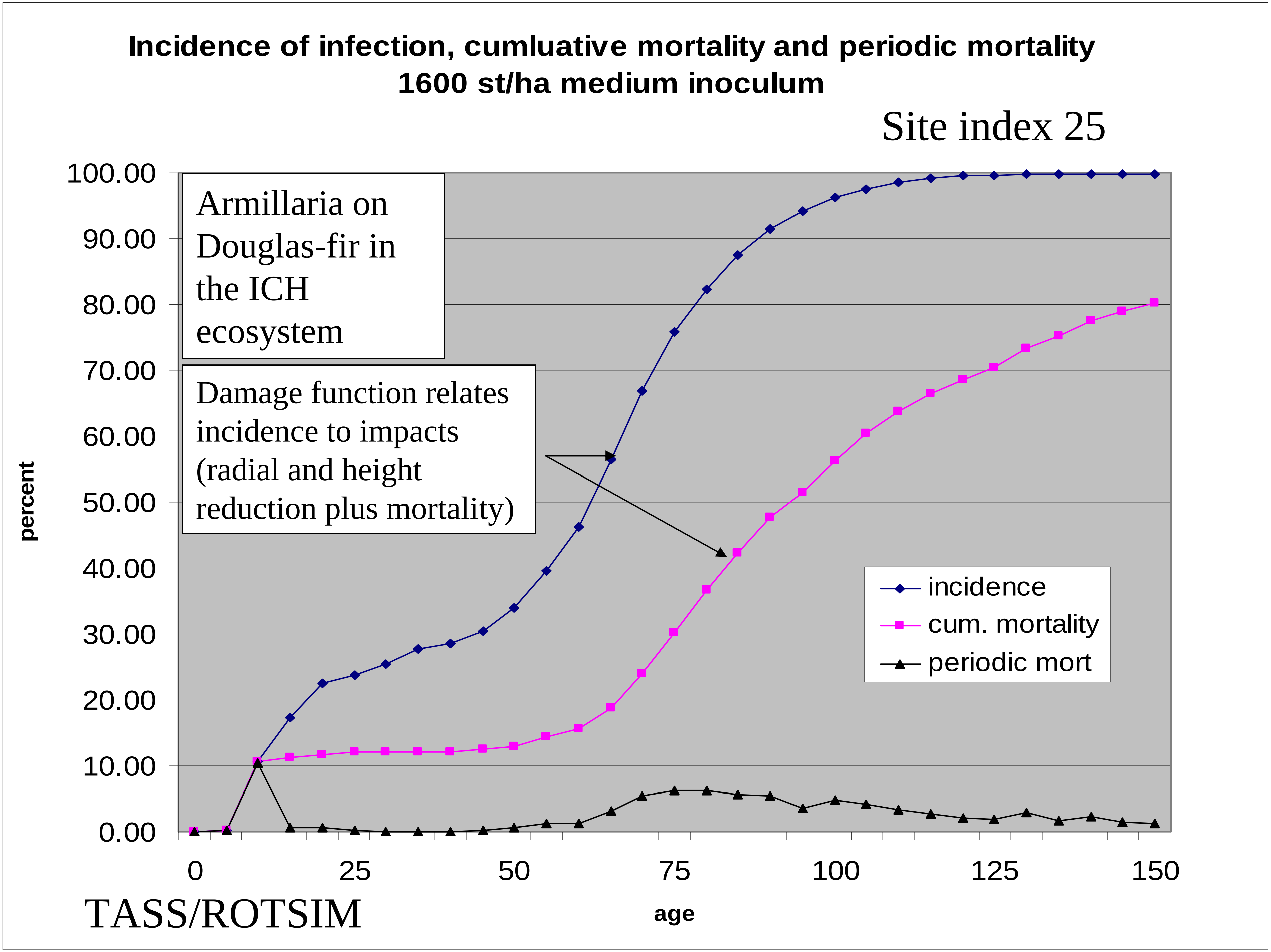
Disease modeling - risk

- Partnered with BC ministry of forests research branch- for stem growth and yield –TASS/ROTSIM and TIPSY (Goudie, Mitchell, Cameron)

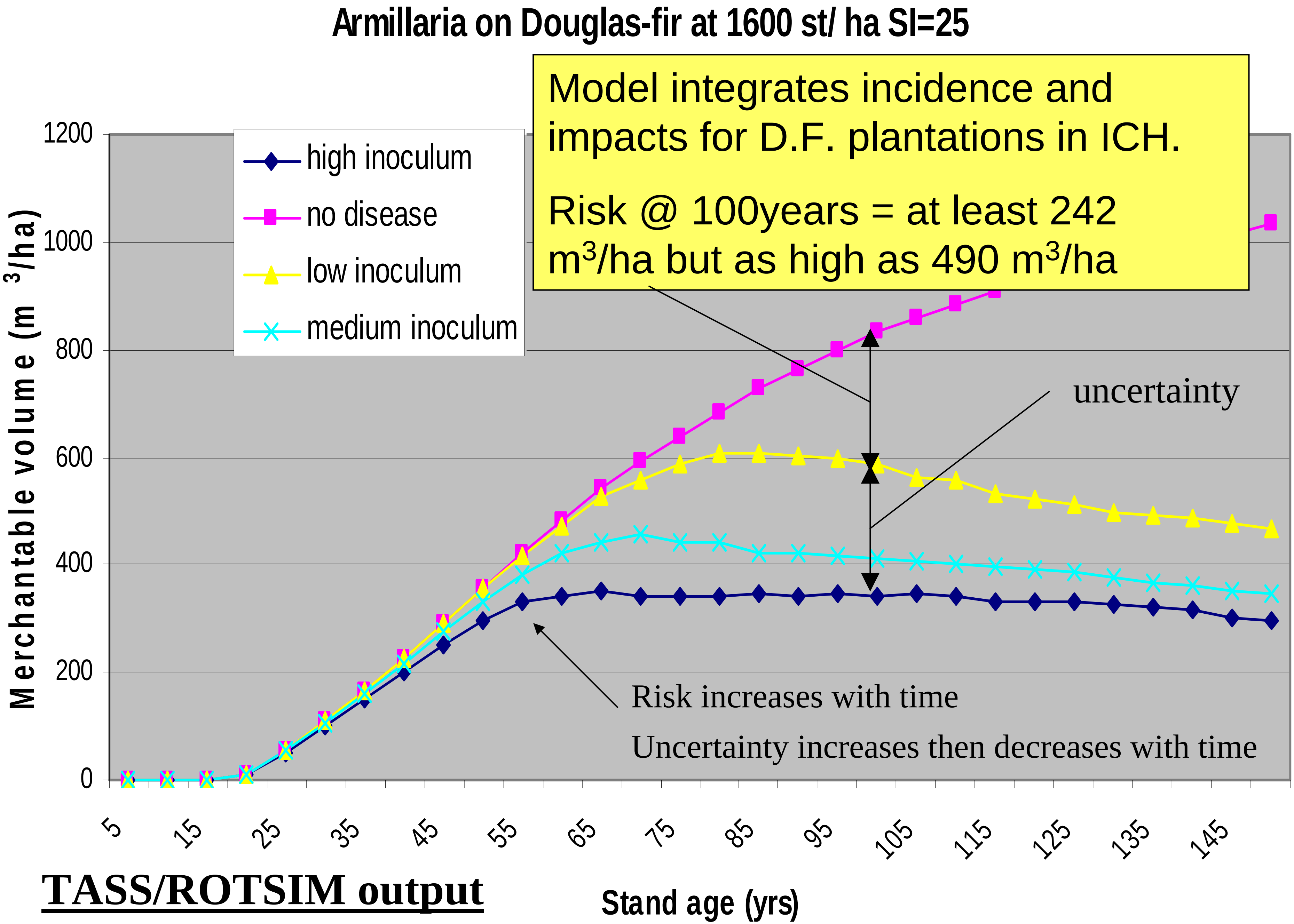
- Updated an existing CFS Phellinus root disease model (ROTSIM) to handle Armillaria- empirical data from large scale sampling - Ramsoft systems (MacDonald)

Sylver suite of models



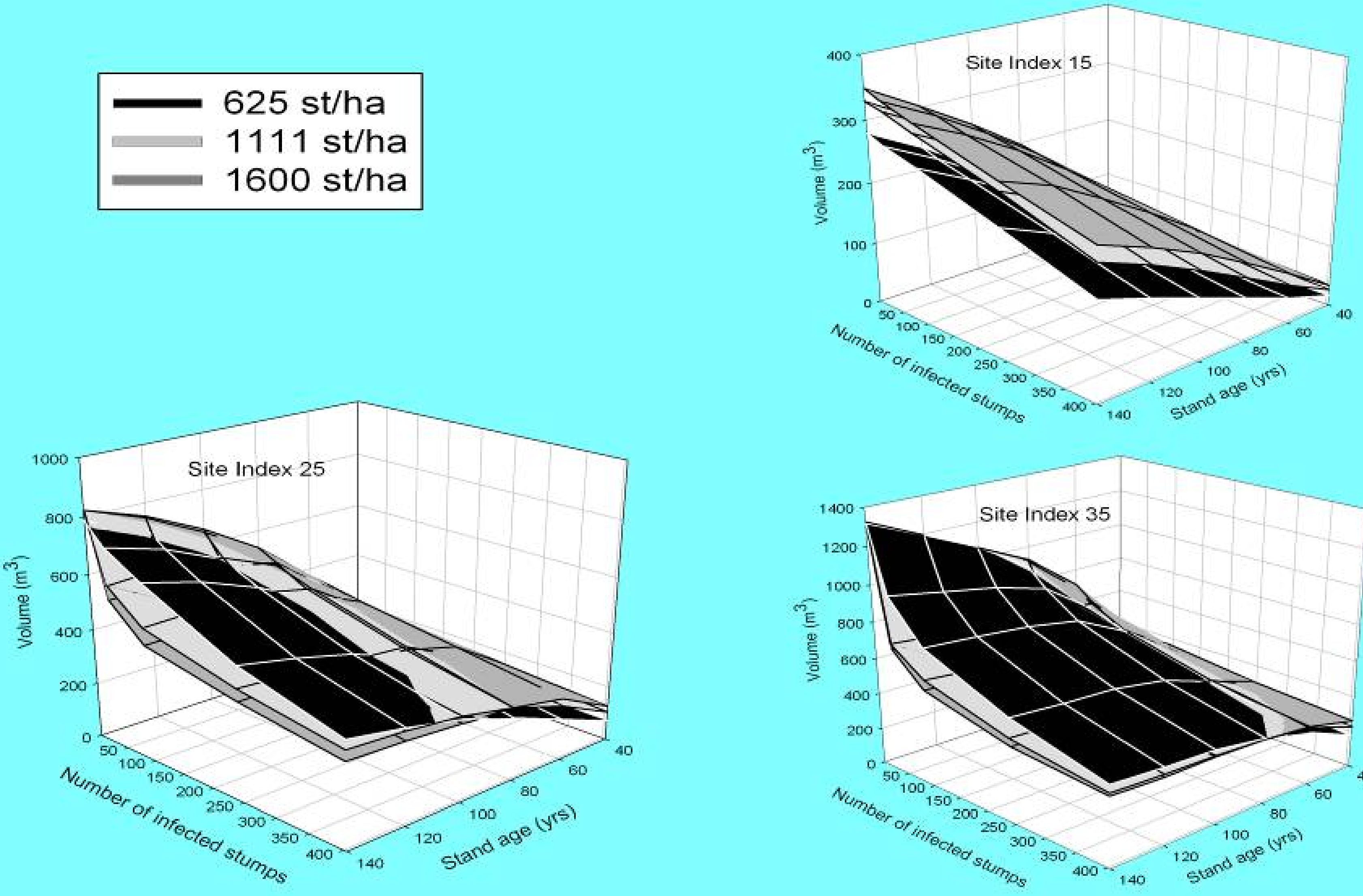


Incidence of infection, cumluative mortality and periodic mortality
1600 st/ha medium inoculum
Site index 25
Armillaria on Douglas-fir in the ICH ecosystem
Damage function relates incidence to impacts (radial and height reduction plus mortality)
percent
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
25
50
75
100
125
150
age
incidence
cum. mortality
periodic mort
TASS/ROTSIM



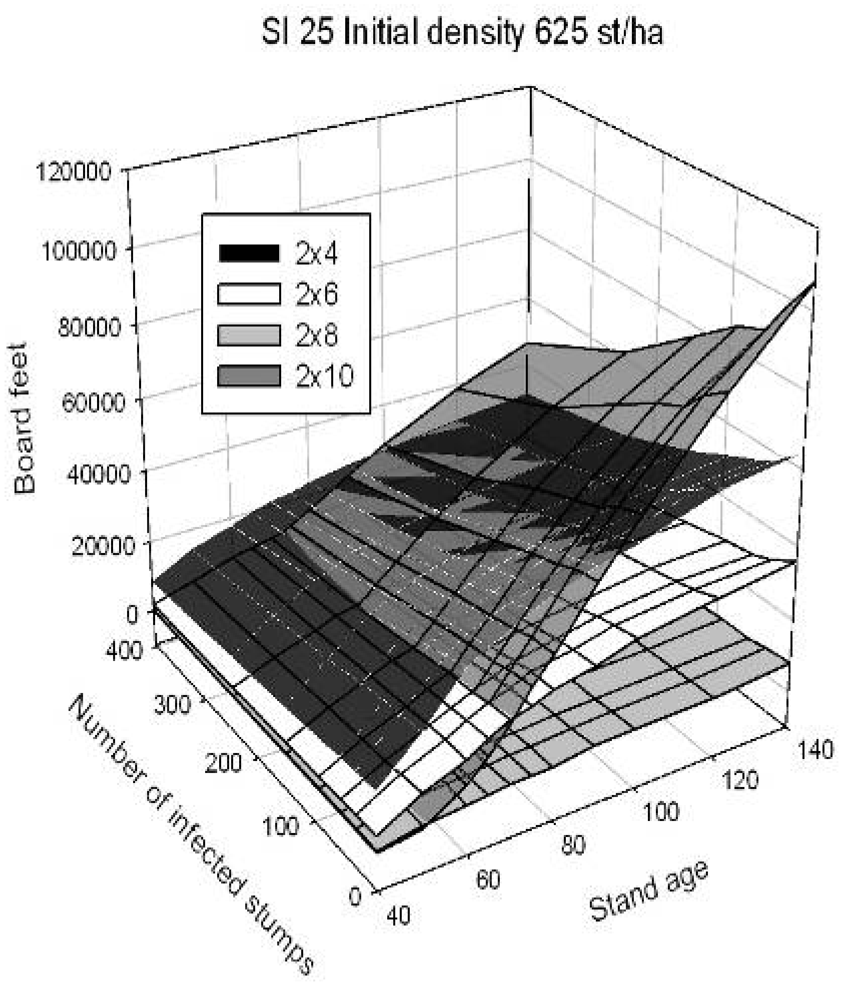
TASS/ROTSIM output

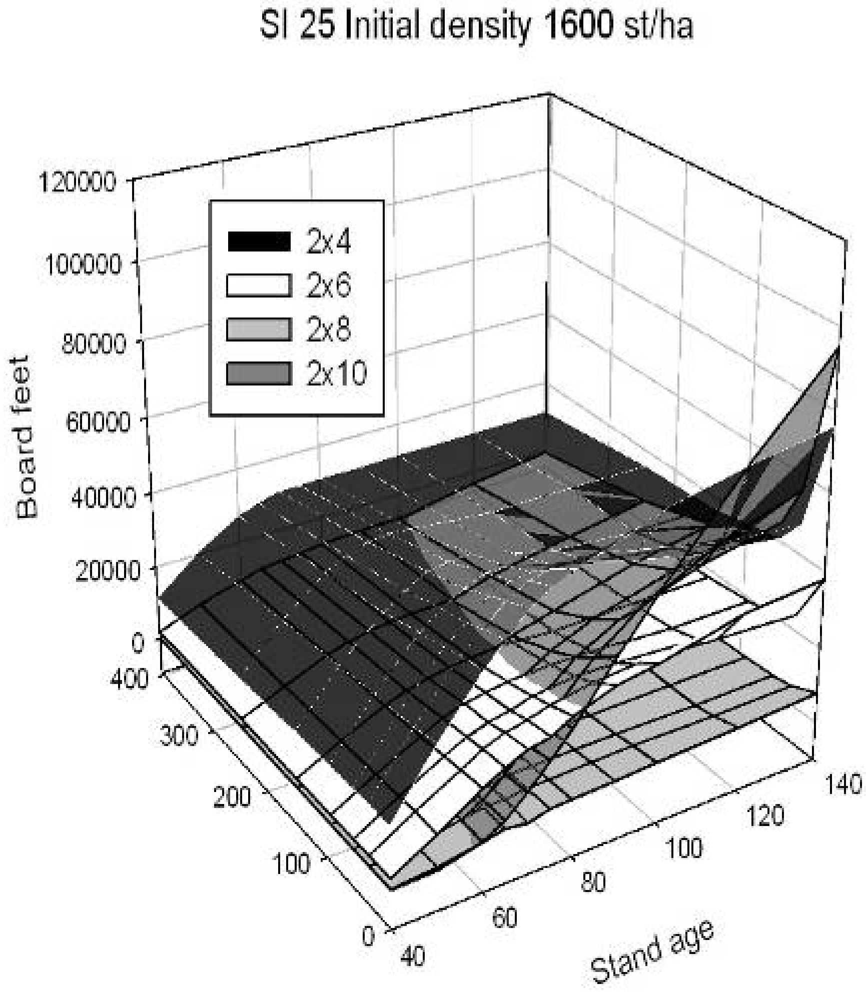
Disease risk on volume- Planted Douglas-fir



Disease directly reduces volume due to the effect on height, radial growth and mortality. Disease probably lowers site index.

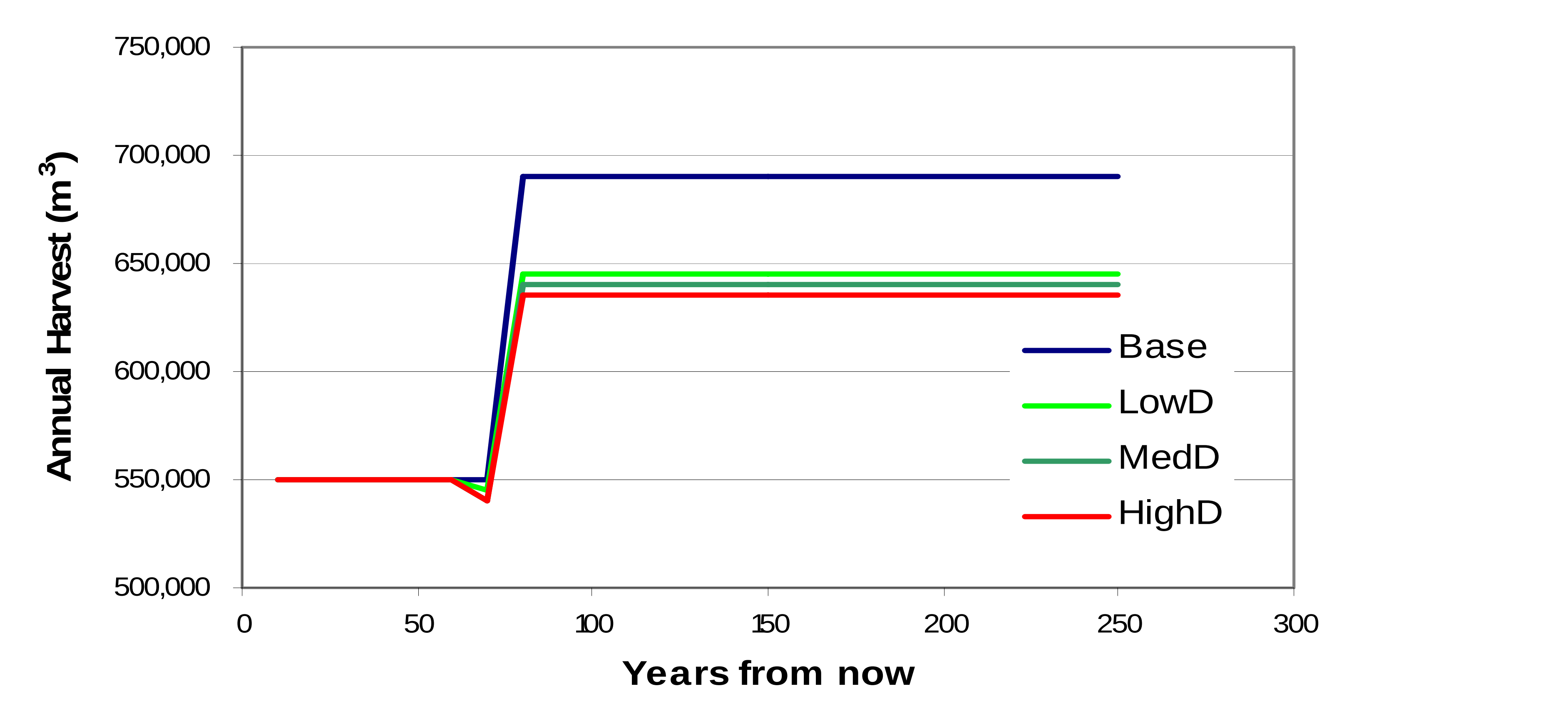
Disease effect on lumber





Armillaria impacts on TSR for Arrow TSA-TISPY

Only for Douglas-fir plantations not natural stands- also seven other species are also impacted but not quantified.



(Ref=2003)

- **Impact for med severity = 7.5%**
- **Impacts would increase as more stands converted to Douglas-fir**

Risk Mitigation

- Host resistance Partnership with province of BC- Barry Jaquish - Kalamalka

- Sanitation- stump removal- long term trials - 45 years old

Implications

- Disease interferes with reaching site potential- can have a lasting effect on site productivity
  - Mostly ignored because it acts slowly

- Climate change- warmer/drier climate = more disease plus disease worst when wetter climates become drier.

- forest management, forest economics, timber supply

- We can alter disease impacts by reducing or coping with disease

- We can balance forest activities with ecosystem productivity and stand stability

- Main problem→ stumps especially partial cuts, climate change (increasing frequency of dry periods)

Some Economics of *Armillaria* in Douglas Fir in BC– Using Science to Reduce Risk

William L. Wagner, PhD, RPF
February 24, 2010

Economic Assessment of *Armillaria* in Douglas Fir

An excellent way to examine environmental and economic unknowns is under the concepts of uncertainty and risk.

The two are closely associated with one another, but are not identical. Uncertainty may involve things that are completely unknown, whereas risks are often understood via calculable probabilities.

Economic Risk – no shortage of definitions

Society For Risk Analysis (sra.org):

Estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the consequence of the event given that it has occurred.

Duerr et al (1979) – the terms risk and uncertainty are used interchangeably.
Kangas & Kangas (2004) – under risk and uncertainty, the state of nature is not known with certainty.
Leuschner (1984) – Risk exists if a probability distribution can be attached to different states of nature.
Price (1989) – knowledge of the probability of each state of nature.
Worrell (1959) – is the outcome whose probability of occurrence can be established in a quantitative manner.

Uncertainty and Risk in Valuing Douglas Fir Plantations in the Interior Cedar Hemlock Zone

Forestry is dynamic and inherently uncertain:

- Numerous potential futures – environmental uncertainty!
- Innovation alters the possible products
- Markets are difficult, if not impossible, to predict

Hoogstra and Schanz (2008) researching professionals, found that there is not a high level of perception of uncertainty in forestry. Indeed, the future is the most certain time period to many forest decision-makers.

Uncertainty and Risk - continued

Price (1989) suggested that the range of uncontrollable and unpredictable factors operating over the long-term forest rotation periods may be so horrifying that foresters ignore these uncertainties altogether.

Hoogstra, M.A. and Schanz, H. 2008. "How (Un)Certain is the Future in Forestry?" For. Sc.54(3) 316-327

Price,. 1989. *Theory and application of forest economics.* Blackwell, Oxford, UK 402p

Uncertainty and Risk - continued

Guess where that tactic leads?

Uncertainty and Risk - continued

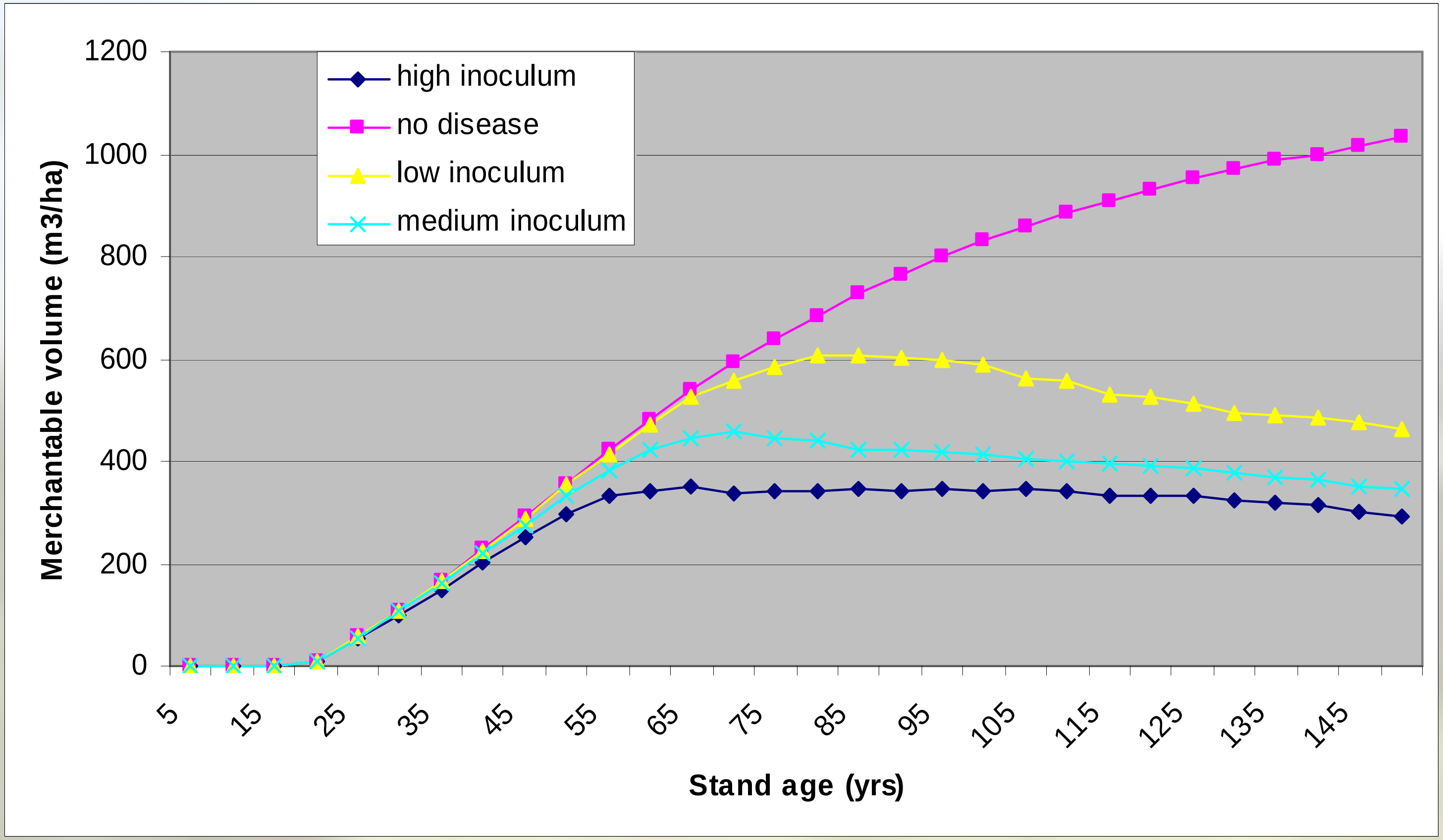
Mike and other researchers here at PFC along with support from the Ministry of Forests have started to put numbers together to develop a model for *Armillaria* in the Interior Cedar Hemlock Zone. With these numbers, Mike and MoF are developing strategies to deal with the disease – stumping and species mixes.

Other Alternatives (not studied):

Fallow - 15 -20 years

Pure Hardwood Rotation – 20 year birch rotation

Initial Results: Growth Impacts of *Armillaria* on Douglas Fir Plantations



Armillaria Impacts on Douglas Fir Plantations - assumptions

- Although we now know that the disease impacts wood quality, potential products distribution and value, we assume there is no impact.
- All Douglas Fir plantations are infected with *Armillaria* in the ICH.
- Disease does not affect logging costs through smaller piece size and lower volumes per hectare.
- All disease impacts are in the medium range. High and low impacts are considered as medium in impact.
- All Planted DF are assumed to be using a site index of 25 m at 50 years
- Stumping causes no site quality affect.

Economic Impacts of *Armillaria* on Douglas Fir Plantations

Douglas fir is a very susceptible species and the most valuable.

Huge investment in plantations.

High incidence of infection - disease increases with age and size of tree in the stand.

Initial Valuation of Douglas Fir Plantations in the Interior Cedar Hemlock Zone

Some Numbers - 3% discount rate

Total DF Plantations in ICH: 98361 ha

Average Stocking: 1600 stems/Ha

Average rotation: 100 years

Average Establishment cost: $1,356/Ha

2007 value of Planting cost (3%): $196,711,400

Average 2007 value of Douglas Fir: $74.01/m^3

Volume loss at 100 years: High 59%; Medium 50%; Low 29%

Initial Economic Impacts of Armillaria on Douglas Fir Plantations

2007 Value of median impacted DF Plantations
@ 3% discount rate

Healthy:	$454,884,490
Infected:	$226,073,760
Difference:	$228,810,730

The 2007 cost of doing nothing was about 229 million dollars!!!

Economic Threshold of Treatment - Stumping

Economic threshold is the population density at which management intervention should be taken to prevent the disease from reaching the economic injury level.

The economic injury level is the break-even point of population density and the cost to control the disease are equal to the amount of damage it inflicts (actual or potential).

Initial Estimate the Economic Threshold of Treatment - Excavator Method of Stumping

% Value loss necessary for stumping treatment to be worthwhile = ET = [C/Y(K/100)] x 100%

Where:
C = the cost of treatment: $1300/ha X 98361 = $127,869,300
Y = the expected yield of the crop: $454,884,490
and
K = the expected effectiveness of the treatment = 80%.

ET = 35% disease impact

Thus, both high and medium risk sites appear to be good candidates for treatment in BC.

Types of Stumping

Push-over-1 entry

Pop-up – modified feller buncher- 1 entry

Excavator- 2 entries, most expensive

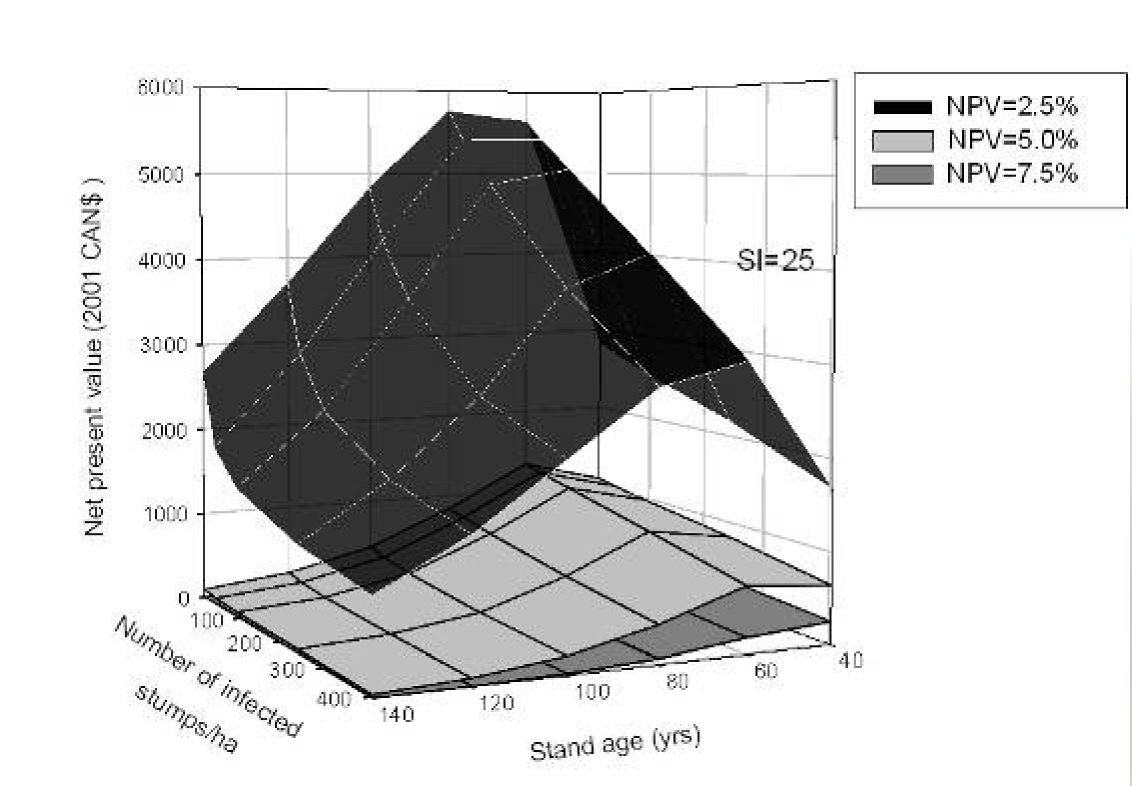
Some Notes on Discounting – Discount Rate (i)

The higher the risk the higher the discount rate.

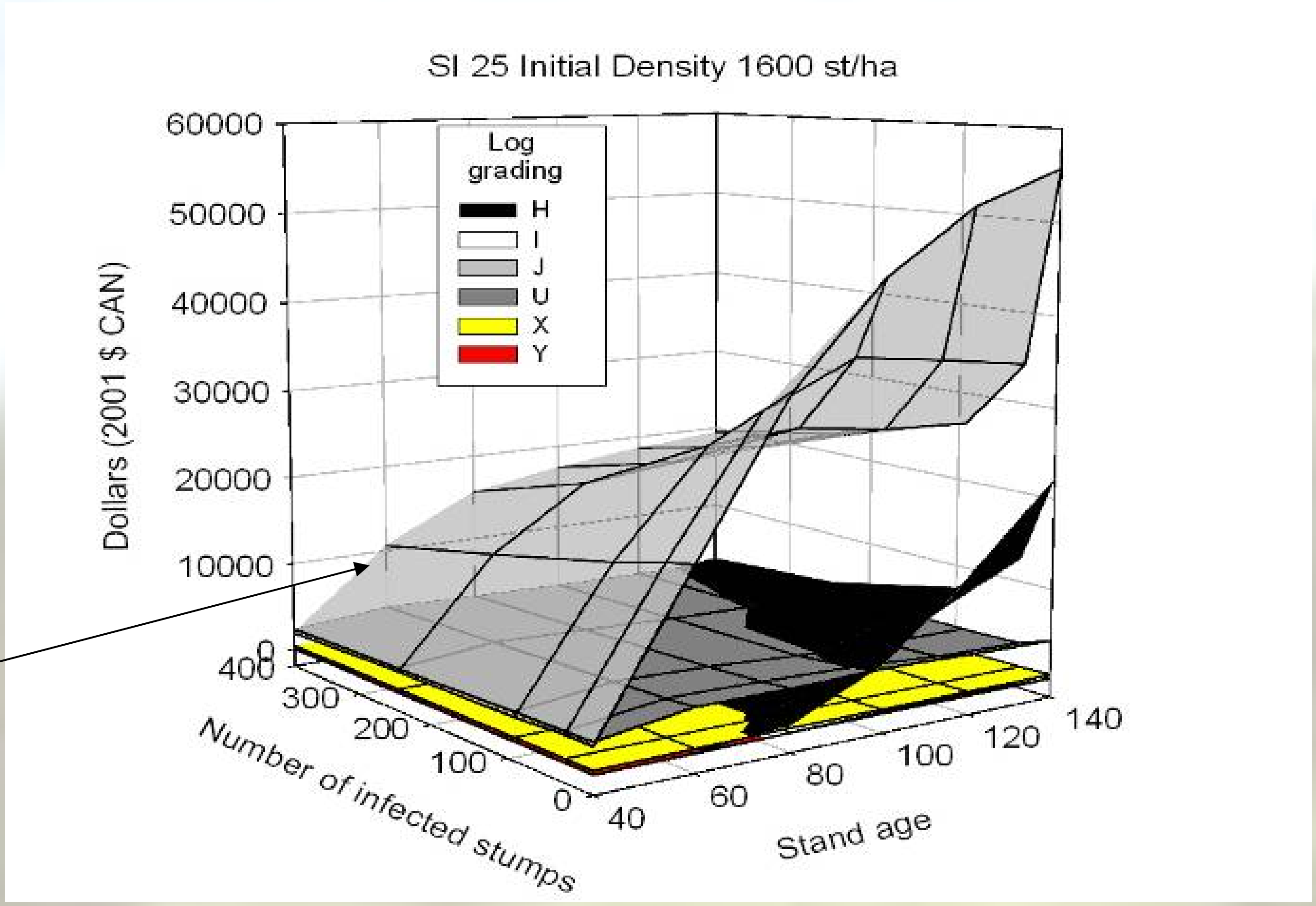
Risk analysis based on science show:

- Root disease increases risk
- Root disease increases the discount rate
- Risk can reduced by minimizing disease

Some Notes on Discounting - Interest Rate (i)



New Research Results: Expected Cost of the Disease on Log Production



Impact at age 60

Economic Impacts of *Armillaria* on Douglas Fir Plantations

Conclusions

- *Armillaria* is a serious problem in SE BC but Canada as a whole

- Costs progress through time

- It is economic to manage the disease (stumping) Other treatment options have lower or no cost.

- The next step in research: wood characteristics and value.