United States Department of Agriculture
Forest Service

FOREST HEALTH TECHNOLOGY ENTERPRISE TEAM

2011 National Insect and Disease Risk Map Methods and Application Demo

Presented by:

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Fort Collins, Co

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FHM Workgroup Meeting, Savannah, GA

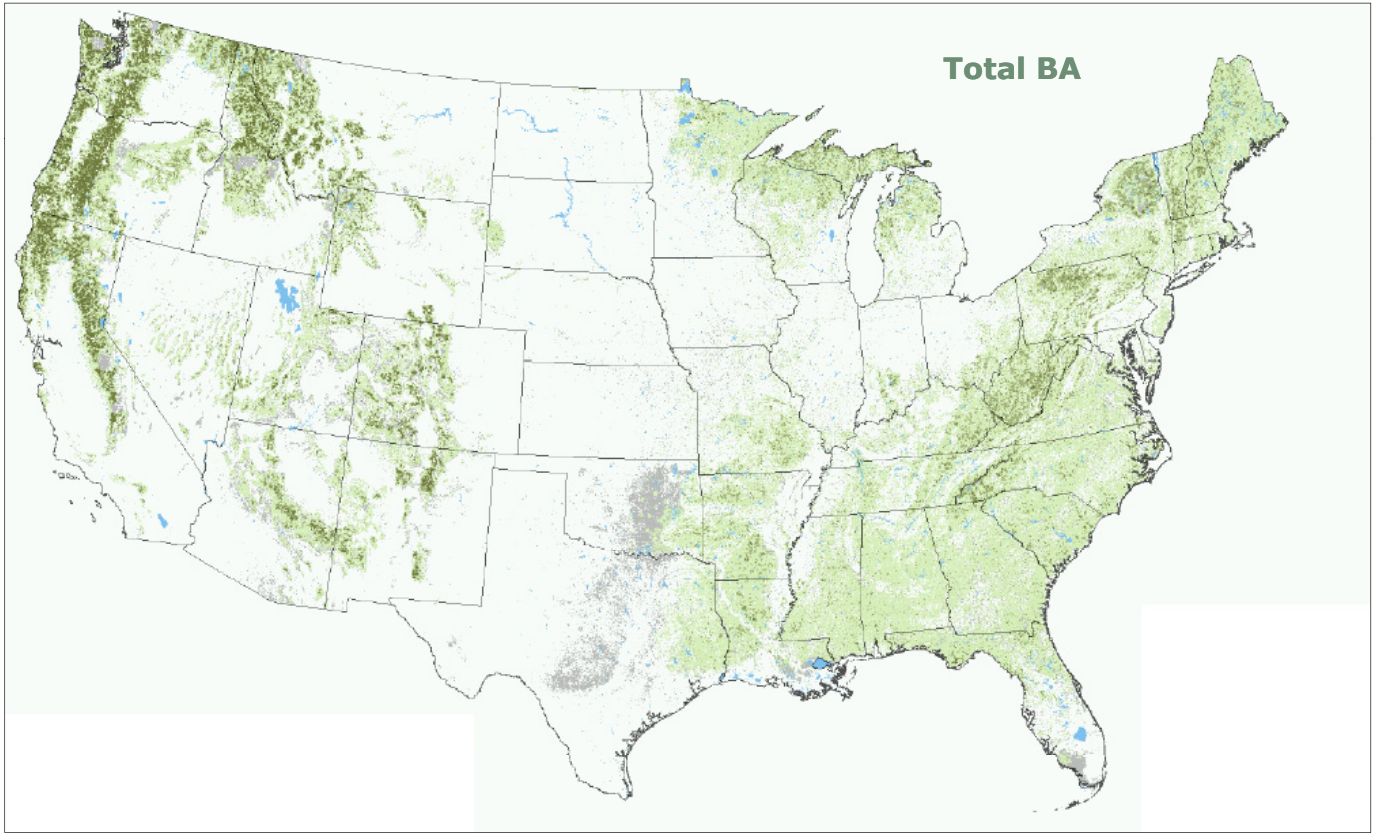
Overview

- **2011 Logistics…**
  - **Def. of Risk (Hazard)**
  - **Application**
  - **Data**
- **2011 Methods Overview**
  - **Same as 2006**
  - **Demo of the Risk Modeling Application**

Definition of Risk (Hazard)

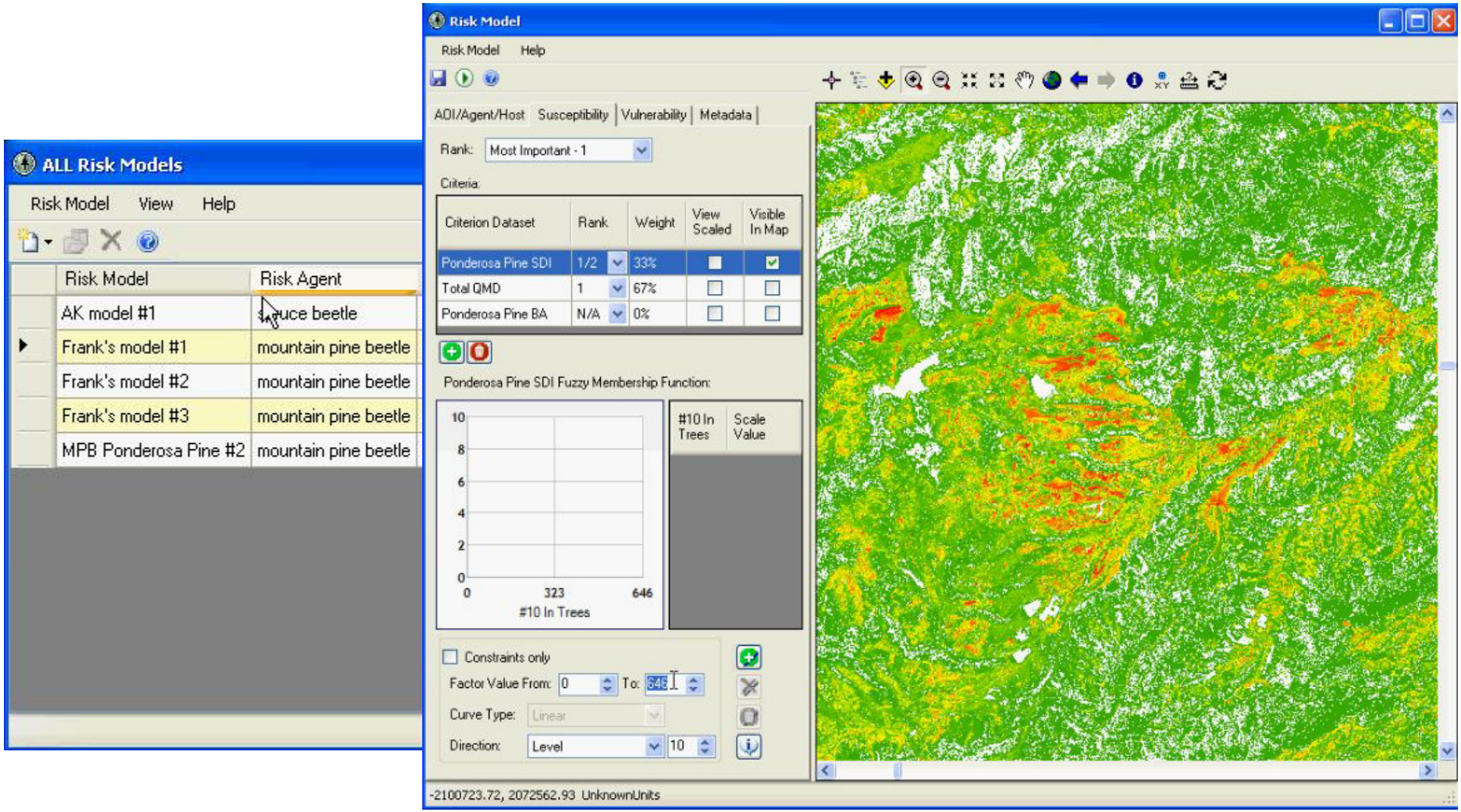
Potential for attack and subsequent harm

Harm = BA Loss…Areas with Potential of Experiencing 25% Mortality (BA) Over 15 Years



Modeling Application

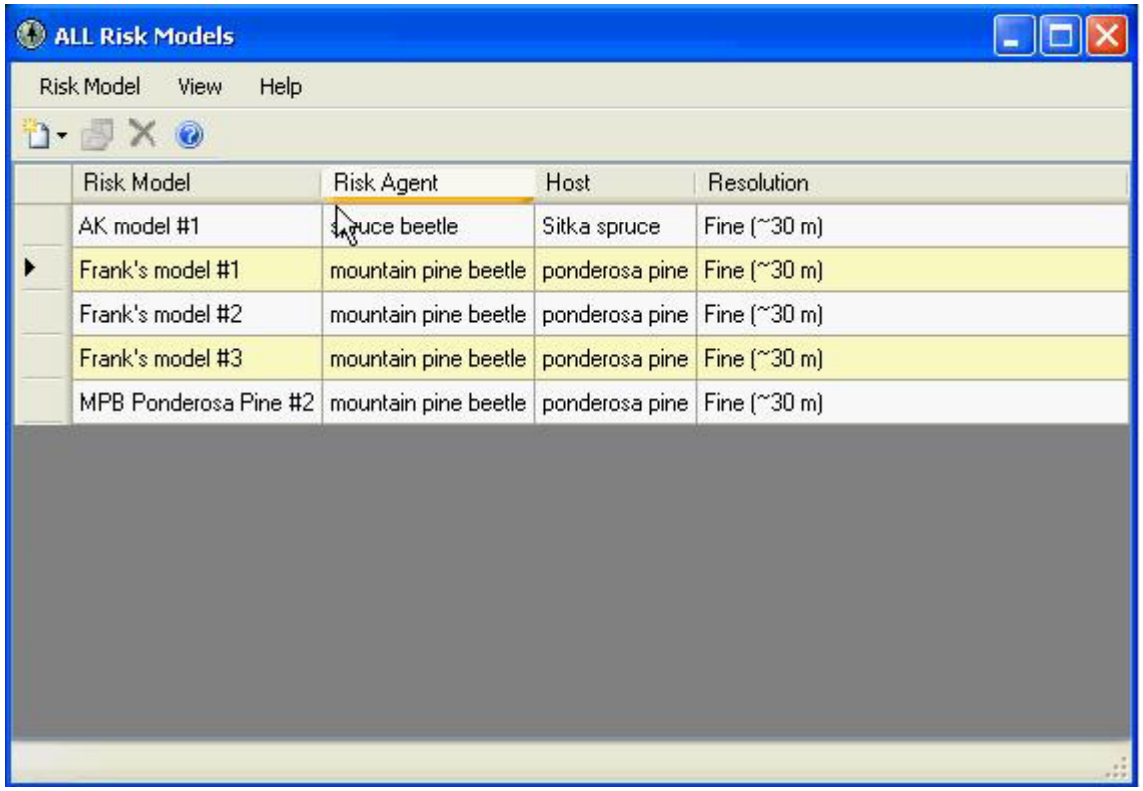
Stand Alone - ArcGIS Application



Modeling Application

- **Application Will…**
  - **Run on a FHTET Server**
    - Access through Remote Desktop & Web Meetings
  - **Point to a Spatial Data Library**

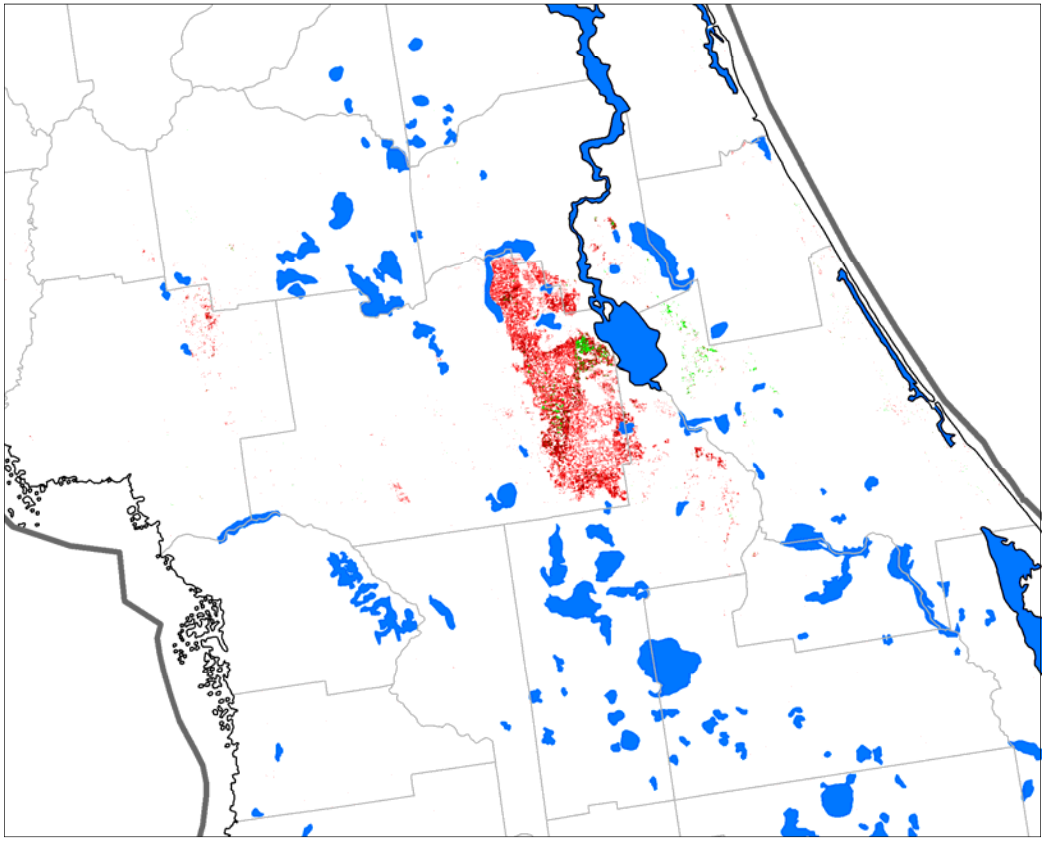
Beta Available Spring/Summer 09



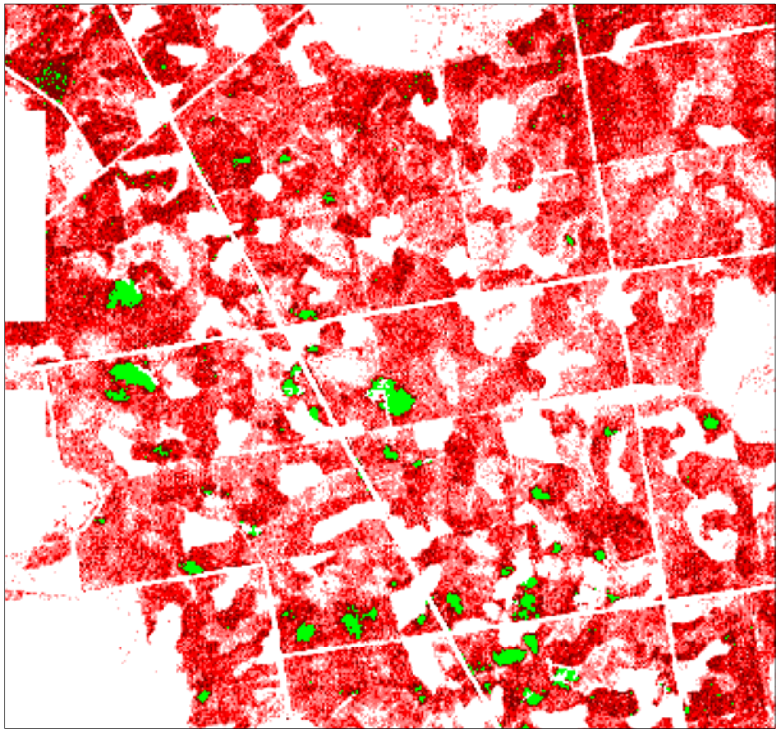
Risk Model	Risk Agent	Host	Resolution
AK model #1	spruce beetle	Sitka spruce	Fine (~30 m)
Frank's model #1	mountain pine beetle	ponderosa pine	Fine (~30 m)
Frank's model #2	mountain pine beetle	ponderosa pine	Fine (~30 m)
Frank's model #3	mountain pine beetle	ponderosa pine	Fine (~30 m)
MPB Ponderosa Pine #2	mountain pine beetle	ponderosa pine	Fine (~30 m)

GIS Layers Depicting Criteria

- Producing Standard 30m GIS layers to Depict Criteria
- Modeling Forest Attributes Nationally (Grow to 2010)
  - BA, SDI, Diameter, etc.



Sand Pine BA - Central FL



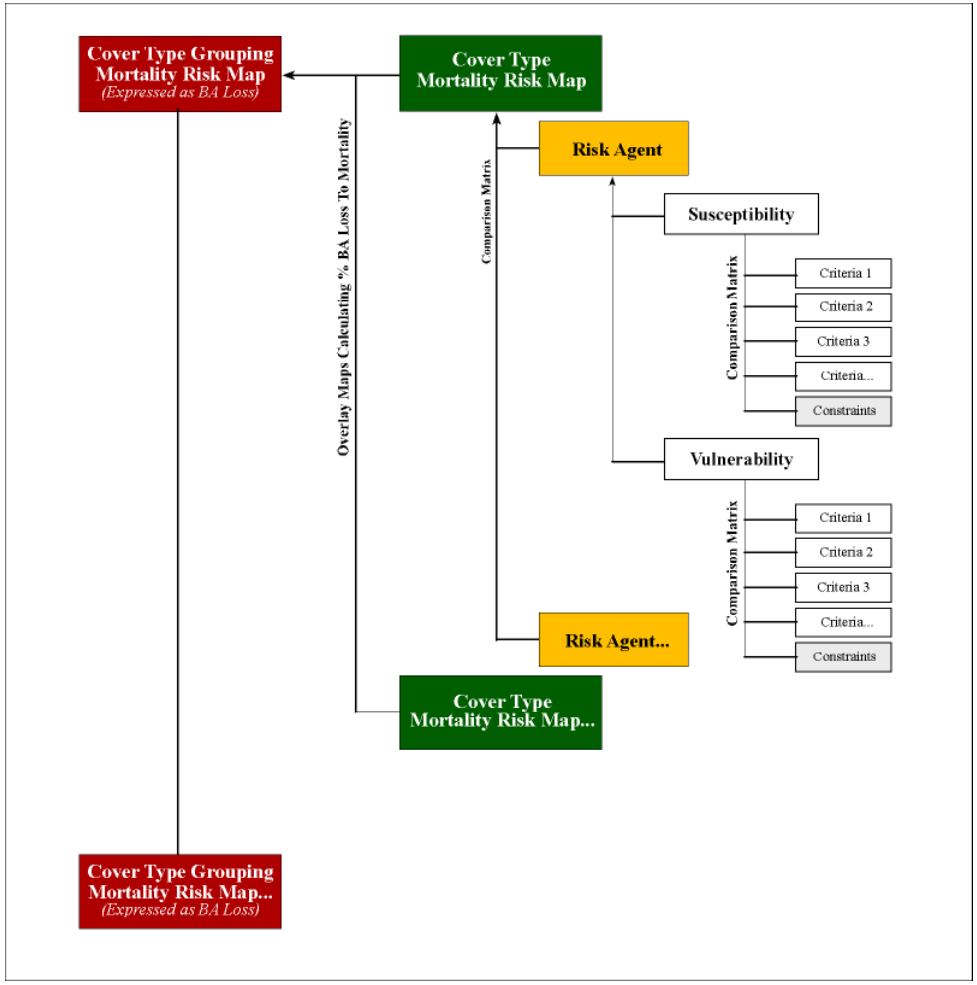
GIS Layers Depicting Criteria

- **Climate Layers**
- **Topography, Soils, etc.**
- **Most of the layers used in the 2006 NIDRM should be available.**

KEY CRITERIA OF TOP 11 AGENTS OF MORTALITY

Criterion	Times Used (Percent)
Basal Area/Stand Density	31.51
Diameter	31.05
Percent Host	14.61
Soil Characteristics	7.76
Climate	5.48
Topography	3.65
Other	3.20
Proximity to Infestations	2.74

What is a Multi-Criteria Model?



Allows for the combination and weighting of multiple factors related to risk

Also

Provides a flexible framework for evaluating criteria

5-Step Multi-Criteria Modeling Process

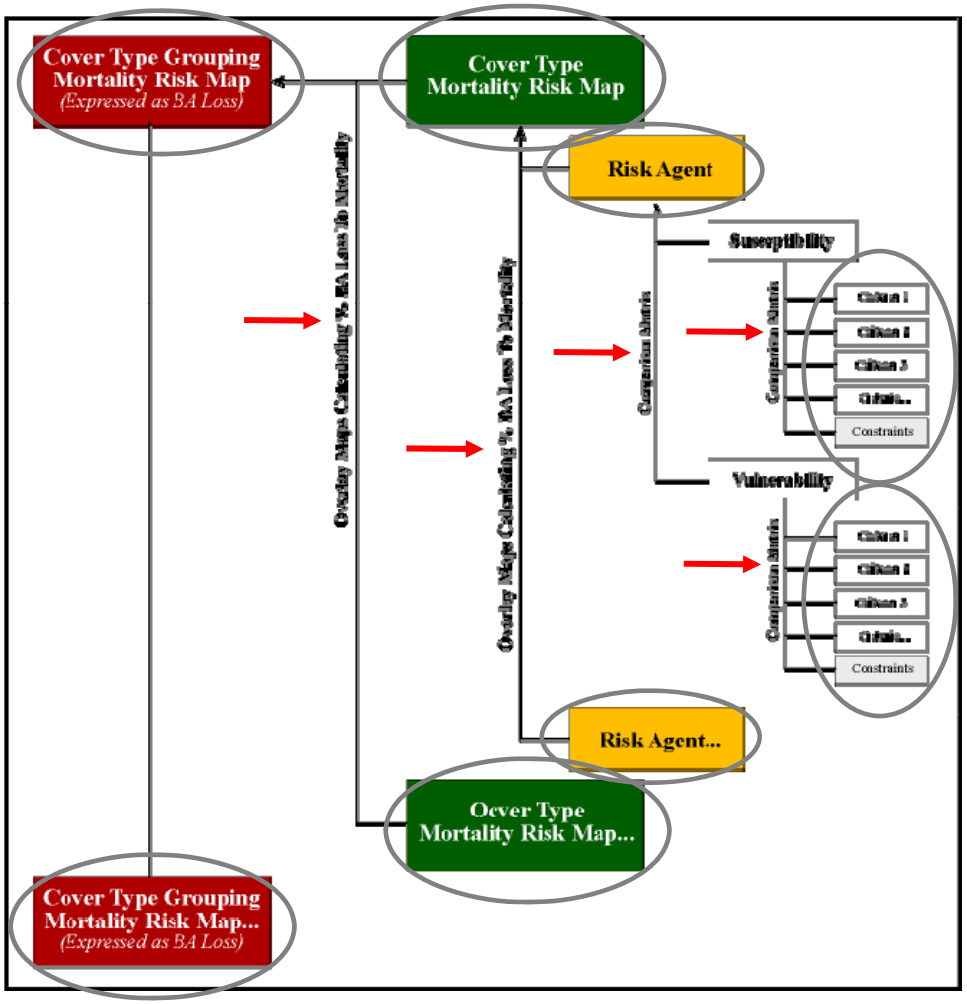
#1 Identify Tree Species and Risk Agents

#2 Identify, Rank, and Weight Risk Agent Criteria

#3 Standardize Criteria Values And Combine Resultant Maps

#4 Convert Values To BA Loss And Sum Them

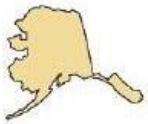
#5 Flag Pixels with Greater Than 25% Simulated BA Loss



Step 1: Identify Tree Species/Risk Agents

- **Start With List From 2006 NIDRM**
- **"Drew's Database"**
  - **Hosts**
  - **Models**
  - **Eric's Demo…**

RISK AGENT AND HOST SPECIES LIST (BY REGION)



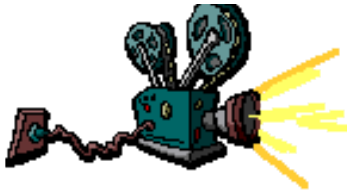
West Coast-Alaska		
Tree Species/Groups	Risk Agent	Number of Models
Alaska-Yellow-Cedar	Alaska Yellow-Cedar Decline	1
Paper/Gray Birch	Heart Rot/Root Rot	1
White Spruce	Northern Spruce Engraver Beetle	1
Sitka Spruce	Spruce Aphid	1
Sitka Spruce	Spruce Beetle	1
White Spruce	Spruce Beetle	1

West Coast-California		
Tree Species/Groups	Risk Agent	Number of Models
Coulter Pine	Annosus Root Disease	1
Jeffrey Pine	Annosus Root Disease	1
Ponderosa Pine	Annosus Root Disease	1
Red Fir	Annosus Root Disease	1
White Fir	Annosus Root Disease	2
Douglas-Fir	Black Stain Root Disease	1
Jeffrey Pine	Black Stain Root Disease	1
Pinyon Pine	Black Stain Root Disease	2
Ponderosa Pine	Black Stain Root Disease	1
White Fir	Douglas-Fir Tussock Moth	1
Douglas-Fir	Dwarf Mistletoe	1
Jeffrey Pine	Dwarf Mistletoe	2
Lodgepole Pine	Dwarf Mistletoe	1
Pinyon Pine	Dwarf Mistletoe	1

Step 1: Application Demo

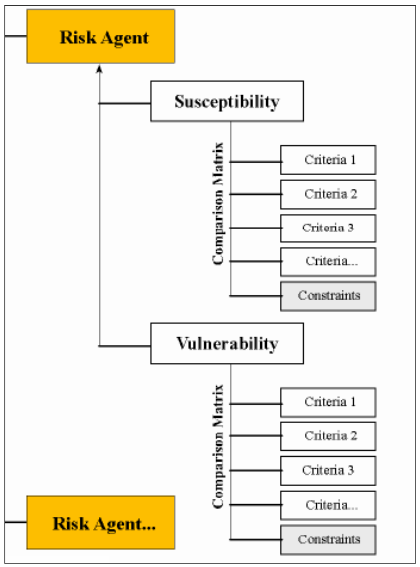
Application Demo #1 and #2

Selecting An Area of Interest (AOI), Agent, and Host



Step 2: Identify, Rank, & Weight Criteria

- **For Each Risk Agent Determine The Criteria Related To The Risk Of:**
  - *Susceptibility*: **criteria related to the *potential* for introduction and establishment, over a 15 year period, of a forest pest within a tree species.**
  - *Vulnerability*: **criteria related to the *potential* for experiencing mortality (at a given threshold such as 100%) of a tree species, over a 15 year period, *IF* a forest pest were to become established.**



Step 2: Identify, Rank, & Weight Criteria

Sample Model…

- **If All Our Criteria Are Met For Susceptibility and Vulnerability it is Our *Belief* That 100% Mortality Will Occur In The Next 15 Years**
- **Susceptibility:**
  - **Criteria (Factors/Constraints)**
    - Constraint: Presence of host species
    - Constraint: Selected Ecoregion
    - Criteria: Distance to known pest locations (closer higher risk)
    - Criteria: average min temp. (warmer temperatures higher risk)
- **Vulnerability:**
  - **Criteria (Factors/Constraints)**
    - Criteria: BA (heavily stocked areas at higher risk)
    - Criteria: QMD (older/larger trees at highest risk)
    - Criteria: Soil dryness/wetness (dryer areas at higher risk)

Step 2: Identify, Rank, & Weight Criteria

- **Each Criterion Is *Ranked* Based On Its Importance (Influence)**

Description	Comparison Rating
Most Important	1
	1/2
Moderately Less	1/3
	1/4
Strongly Less	1/5
	1/6
Very Strongly	1/7
	1/8
Extremely Less	1/9
	1/10
Unsuitable	N/A

Susceptibility:
Dist. To Known Infestation (Most Imp. or 1)
Avg. Min Temp (Moderately Less or 1/3)

Vulnerability:
BA (Most Important or 1)
QMD (Moderately Less or 1/3)
Soil Dry/Wet (Strongly Less Imp. or 1/5)

10-Point Scale Ranking Based Modified From Eastman 1999…

Step 2: Identify, Rank, & Weight Criteria

Application Automatically Generates Weights.

To Calculate Weights by Hand:

1) Convert fractions to decimals
2) Sum the decimals
3) Divide each decimal by the total

1/1 = 1, 1/3 = 0.33, 1/5 = 0.2
1 + 0.33 + 0.2 = 1.53
1 / 1.53 = **0.65**
0.33 / 1.53 = **0.215**
0.2 / 1.53 = **0.13**

Vulnerability Criteria Weights

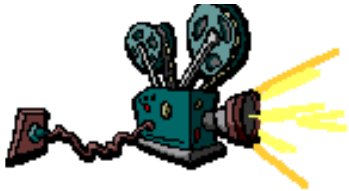
Criteria	Weight
Aspen BA	65%
Aspen QMD	22%
Soil Dryness	13%

Weights Always Sum to 1 or 100%

Step 2: Application Demo

Application Demo #3 and #4

Adding Factors and Constraints - Weighting



Step 3: Standardize & Combine Criteria

- **Standardization**
  - **Allows For The Comparison Of Different Data Sets**
- **Standardization is Based On:**
  - **A common scale or set of values**
    - **0 – 10 Easiest to understand and use, works well with course data (1km resolution) and models**
    - **0 – 100 or 0 – 255 Works well when have fine resolution data and a of model lot of detail**
  - **Assignment of values is based on the suitability of criteria values**
    - 10 = highest risk
    - 0 = little or no chance of risk

Step 3: Standardize & Combine Criteria

Vulnerability to a Risk Agent:
BA Using a 0 – 10 scale

Simple Linear Stretch

Gradient of Potential Risk

BA	Standardized Value
< 20	No Risk
20 - 30	0
31 - 40	1
41 - 50	2
51 - 60	3
61 - 70	4
71 - 80	5
81 - 90	6
91 - 100	7
101 - 110	8
111 - 120	9
> 120	10

At very low levels there is no risk (constraint).

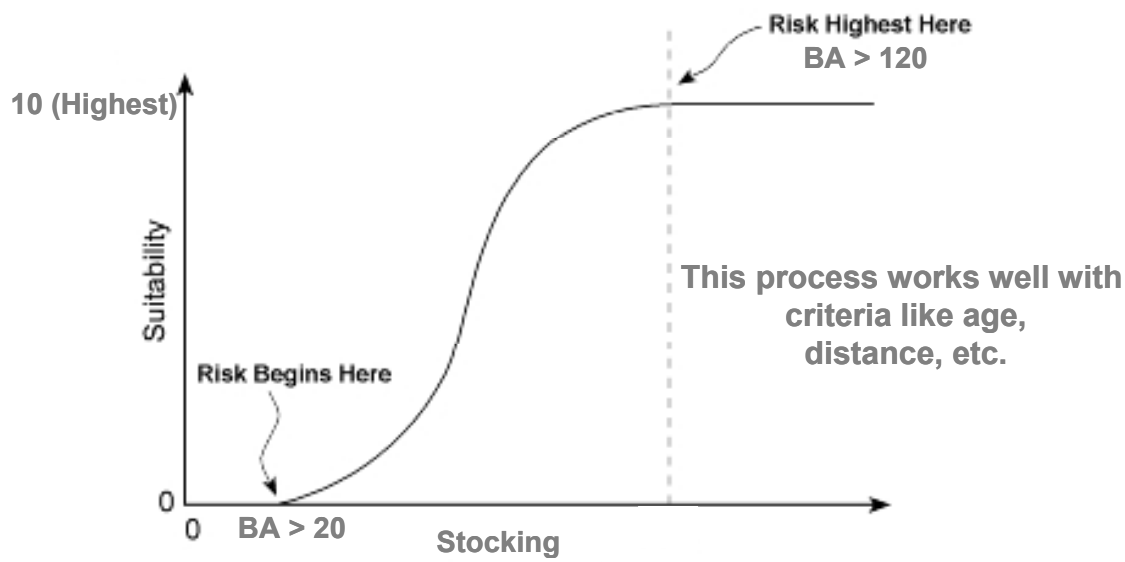
At this stocking level, risk is very low.

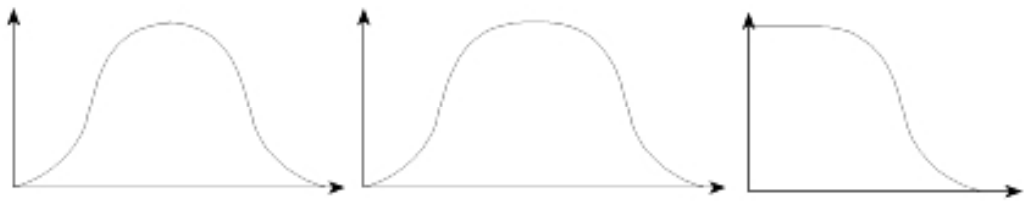
At and above this stocking level very high risk

BA converted to a common/standard scale

Step 3: Standardize & Combine Criteria

Sigmoidal Membership Functions



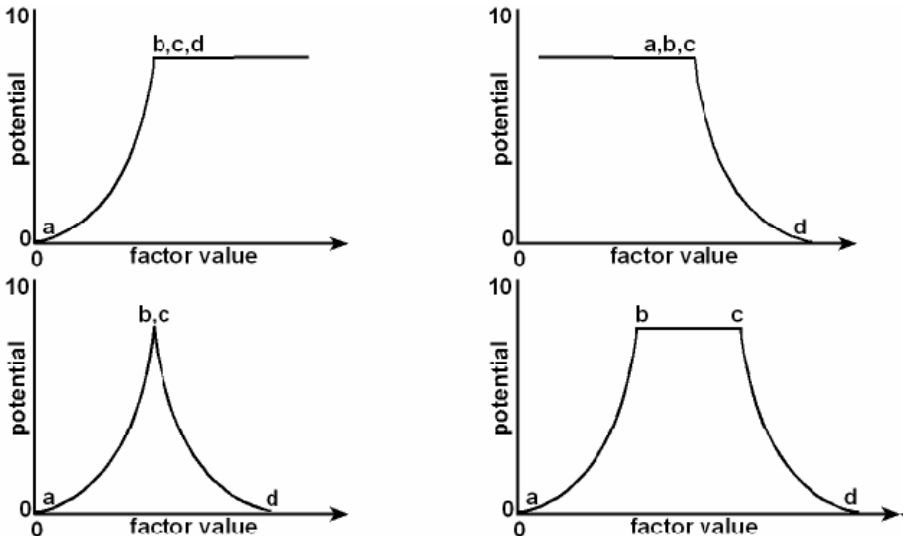


Based on Eastman 1999…

Stretched Values Would Look Like This:

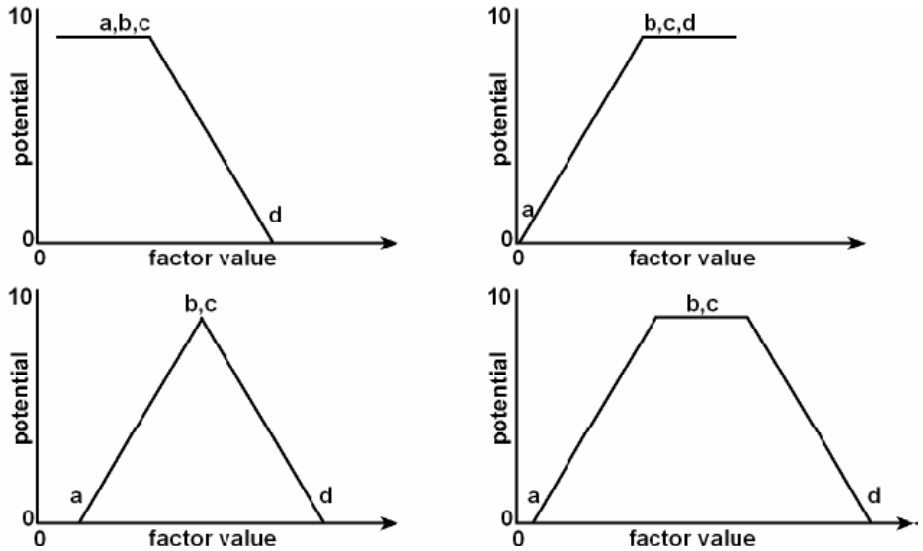
BA	Value
< 20	No Risk
20 - 30	0
31 - 40	0
41 - 50	0.3
51 - 60	1.2
61 - 70	2.5
71 - 80	4.1
81 - 90	5.9
91 - 100	7.5
101 - 110	8.8
111 - 120	9.7
> 120	10

Step 3: Standardize & Combine Criteria



J - Curves

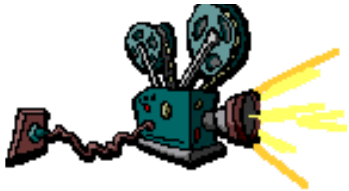
Linear - Curves



Step 3: Application Demo

Application Demo #5 - #7

Standardizing and Viewing Criteria



Step 3: Standardize & Combine Criteria

Use a Weighted Overlay to Combine Criteria Values

Standardized Criterion Values (0 – 10) are Combined Using a Weighted Overlay

Vulnerability = (**BA** * Weight) + (**QMD** * Weight) + (**Soil Dryness** * Weight)

High Risk — Low. Risk — Med. Risk — High Risk

SPB Risk = (**10** * 0.65) + (**3** * 0.22) + (**5** * 0.13) = **7.8**

Vulnerability Potential

BA	QMD	Soil Dryness	Risk
125 Sq. Feet High Risk (10)	3 in Trees Low Risk (3)	Well Drained Medium Risk (5)	8

Also use weighted overlays for:

1) **Susceptibility**
2) **To combine Susceptibility and Vulnerability Models**

Step 4: Convert Potential Risk to BA Loss

- **Calculate The BA Loss**
  - **Convert the scaled (0 – 10) values for mortality potential to a percent and multiply by the BA of the host species present in each pixel**
- **When Multiple Pests Are Acting In An Area**
  - **Adjust mortality potential based on interactions**
  - **Simplifying Assumption**

Examples:

1) A pixel with 100 BA has a medium risk or mortality potential of 5

100% mortality threshold or max. realizable mortality

100 BA * 50% = 50 BA Loss

2) Two agents with a maximum realizable mortality of 75% and 96% acting on 100 BA

100 BA * 99% = 99 BA Loss

$$D = 1-(1-p1)(1-p2)$$

$$D = 1-(1-0.75)(1-0.96)$$

$$D = 0.99$$

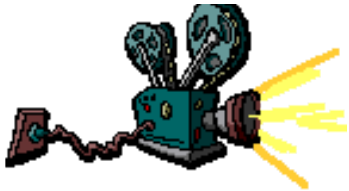
D = Total Proportionate Mortality

P = Proportionate Mortality

Step 4: Application Demo

Application Demo #8

Save and Run A Model – All Calculations Run Behind the Scenes

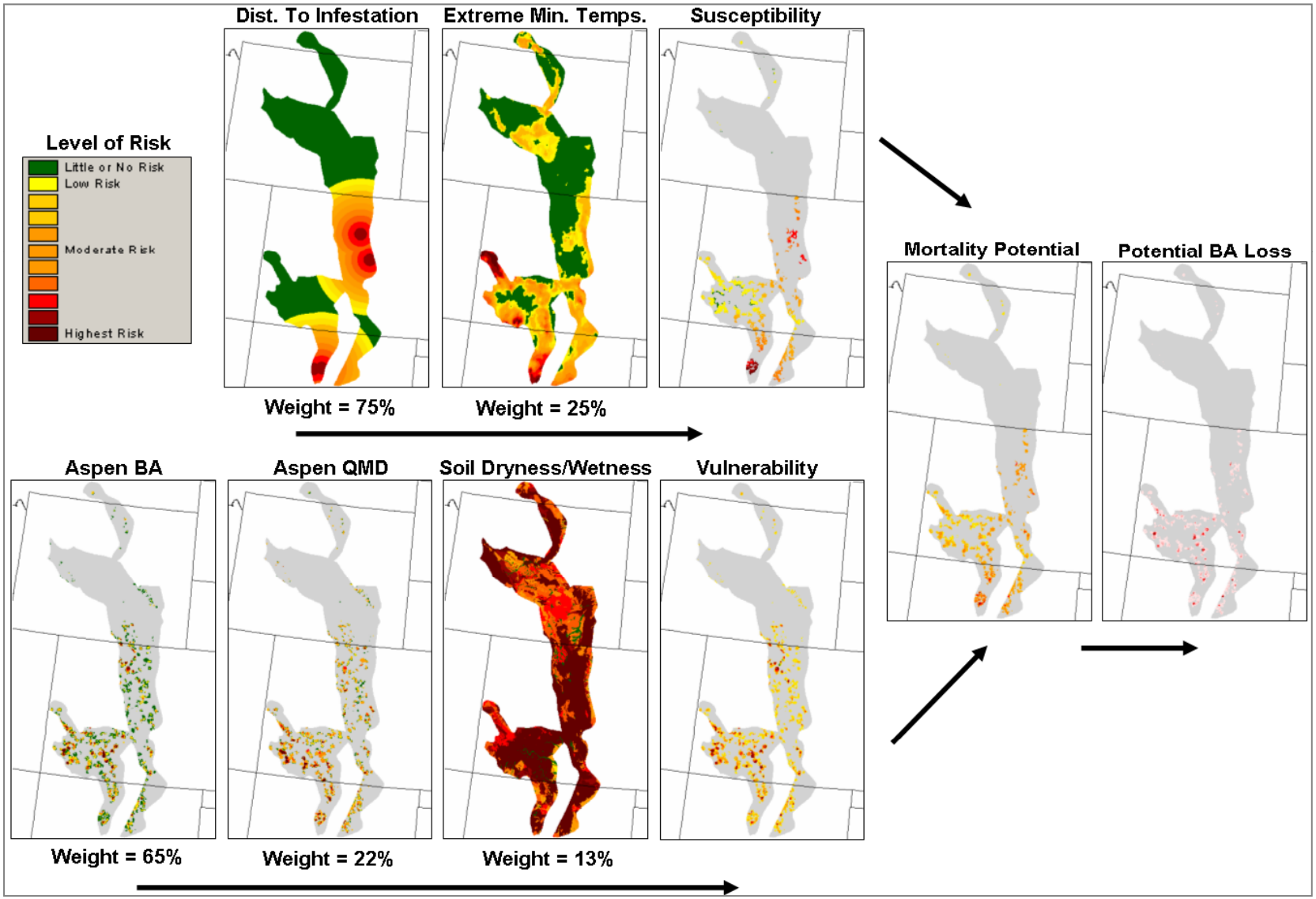


Step 5: Flag Pixels on NIDRM

- **Run all Models, Combine Estimated Potential BA Loss**
- **Areas With the Potential to Hit 25% or Greater Mortality Were Flagged**
- **Can Also Look at Other Thresholds (50%, 75%, etc.), Data is Continuous**
- **Can Also Look at Impacts on Individual Host Species**
  - **% of host lost**

Remember these are estimates of potential mortality (most without confidence limits) based on expert knowledge and or analysis!!!

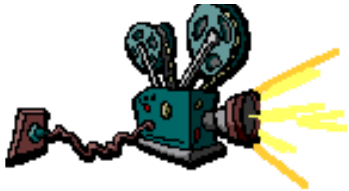
Model Summary



Other Application Features

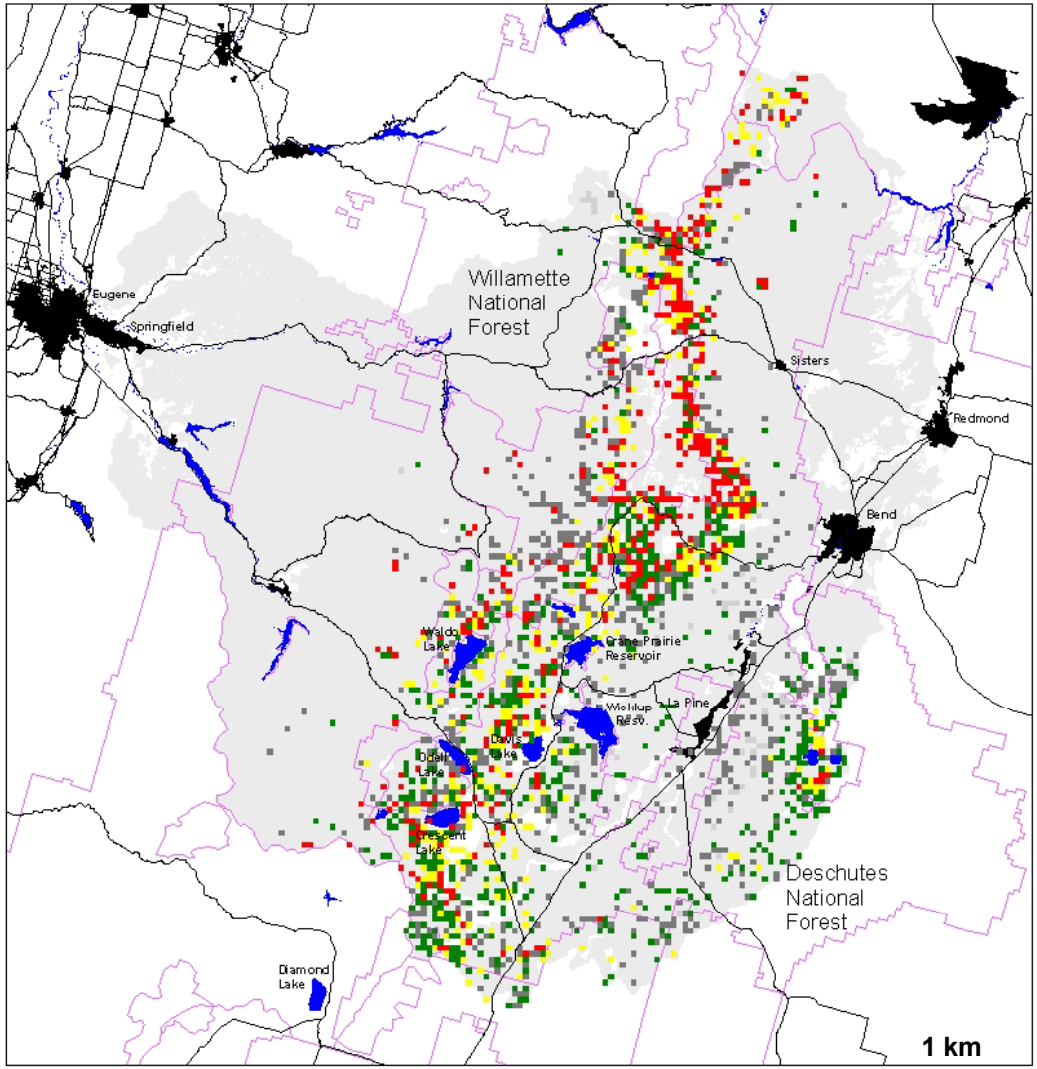
Application Demo #9 - 11

Viewing 2006 Risk Models - Creating Metadata - Web Meetings



Multi-Resolution Risk Models

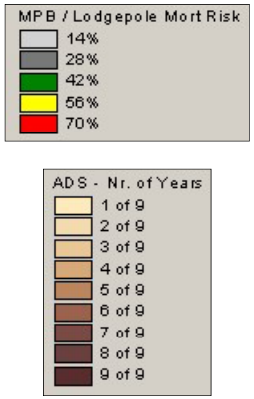
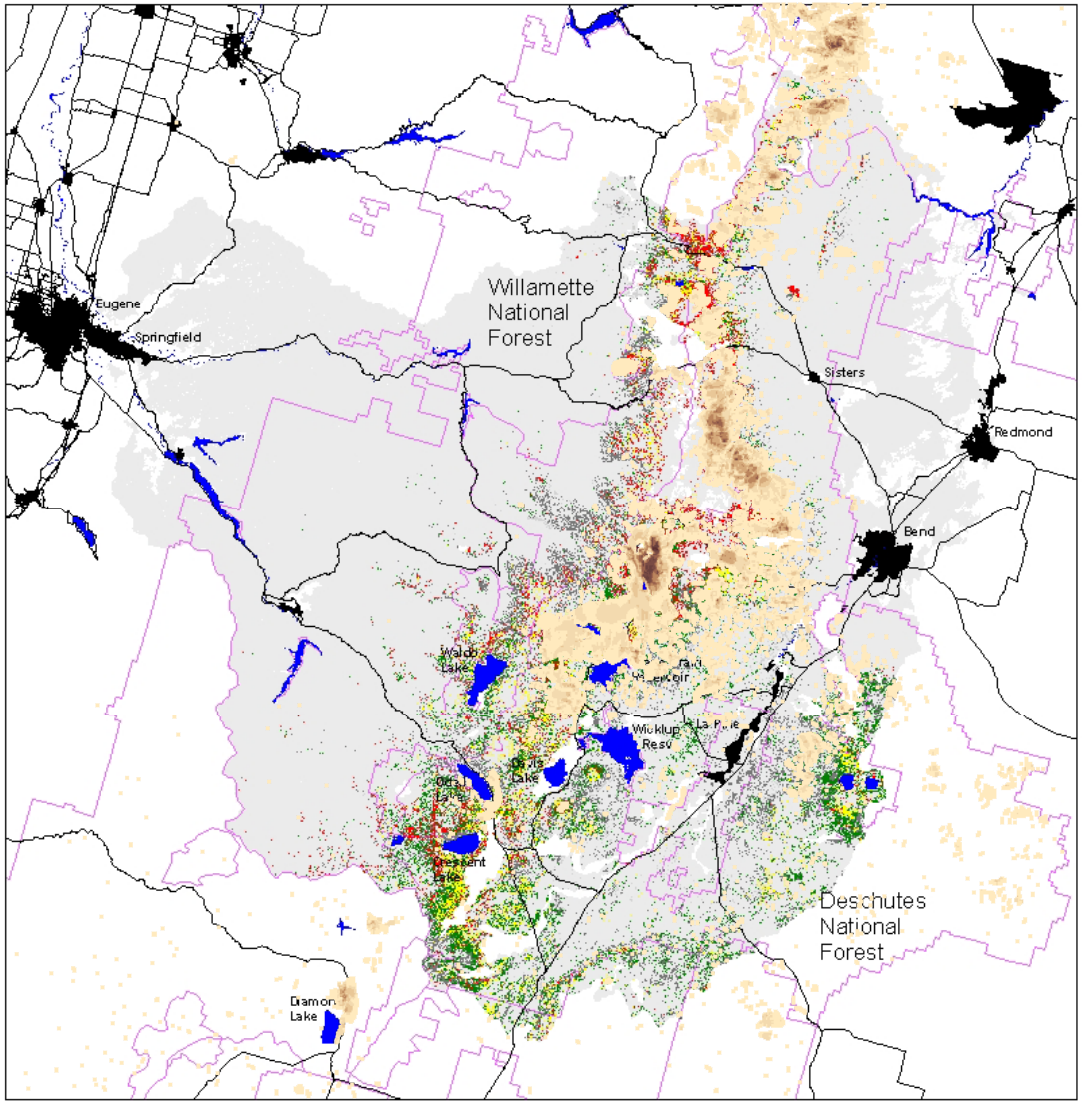
Resampled to Various Resolutions for Regional and National Use



MPB / Lodgepole Mort Risk
- 14%
- 28%
- 42%
- 56%
- 70%

Model Validation

Mountain Pine Beetle Risk Model

Risk Expressed as % BA Loss Since 1996

Compared with 9 yrs. of ADS Data