

Tools and Approaches to Help Plan for WFU

- Describe two tools
- Identify uses for WFU/Fire planning

Carol Miller and Anne Black
Aldo Leopold Wilderness Research Institute
Rocky Mountain Research Station
Missoula, MT

Wildland Fire Use For Resource Benefits
Northern Rockies Training Center
February 17, 2005



Research to improve fire stewardship

Fire Effects Planning Framework (FEPF)

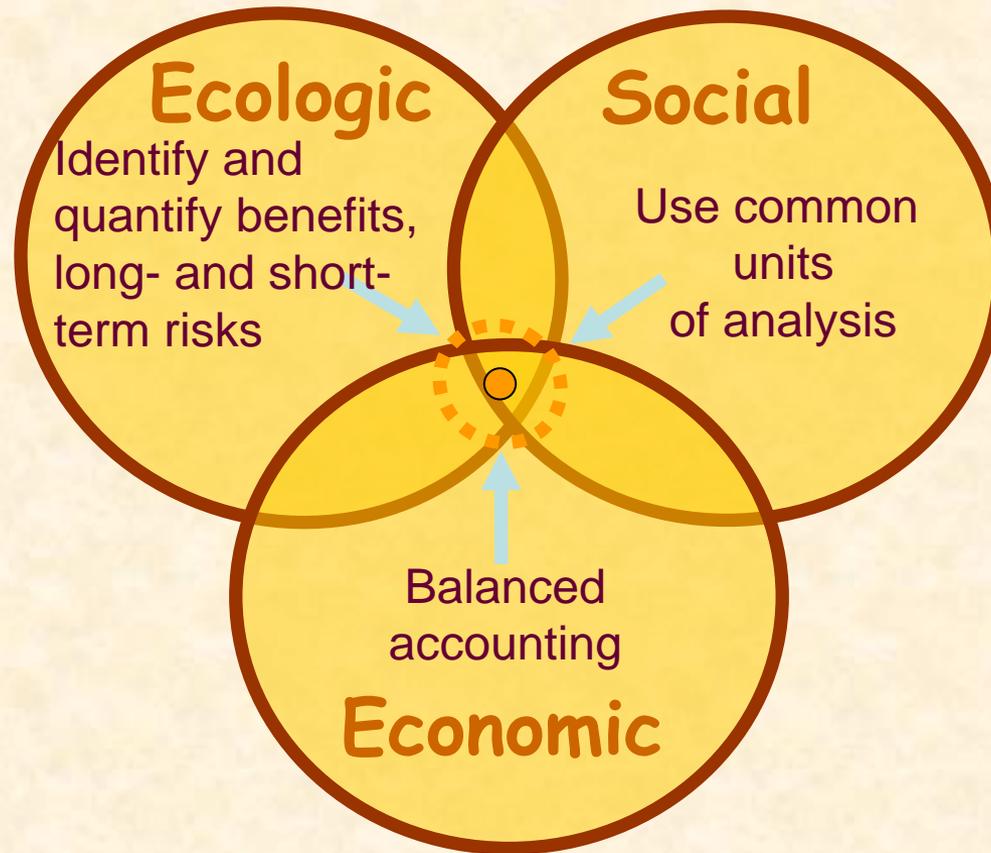
Where and under what conditions will fire create *benefits* and pose *risks* to management objectives?

BurnPro (Probability of Burning)

Where is fire most likely to burn on the landscape, given the *spatial arrangement* of ignitions, fuels & topography?

Fire Effects Planning Framework (FEPF)

Where and under what conditions will fire create *benefits* and pose *risks* to management objectives?



Where is information on resources or benefits used in the fire planning process?

Broad-scale:

Land/Resource Management Plan
Fire Management Plan
WFU Guidebook

Site-specific:

Wildland Fire Implementation Procedures

Stage I

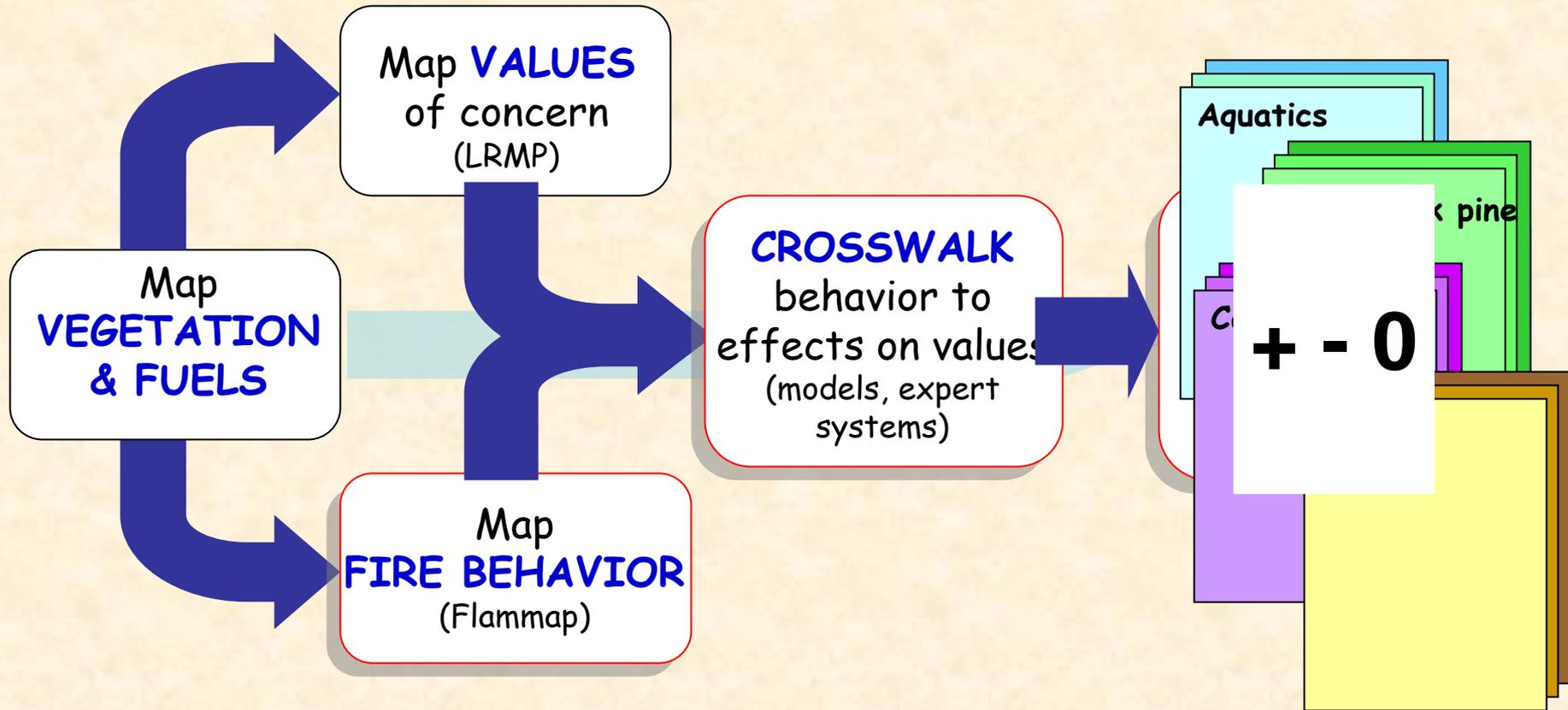
- **Decision Criteria Checklist**
 - effects acceptable?
 - Relative risk acceptable?

Stage II

- Objectives used to establish desired outcomes
 - Tied to land management plans
- SAM - specific, achievable, measurable, relevant, trackable**

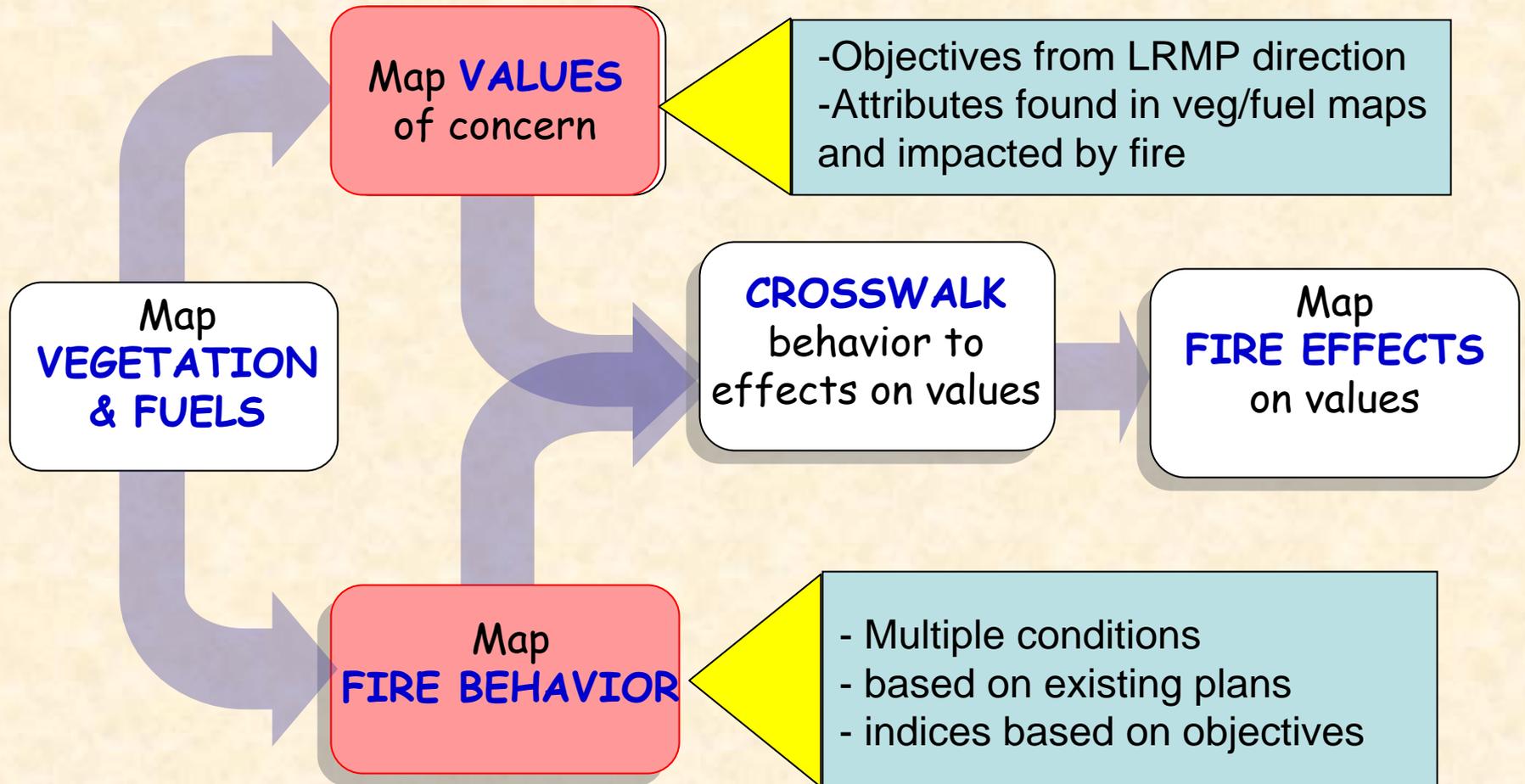
Fire Effects Planning Framework (FEPF)

Where and under what conditions will fire create *benefits* and pose *risks* to management objectives?



Fire Effects Planning Framework (FEPF)

Where and under what conditions will fire create benefits and pose risks to management objectives?



Create Fire Behavior Library

FlamMap

Run : New Run

Inputs | Outputs

Run Name: 80

Fuel Moisture Files

Fuel Moisture File (*.fms): E:\Bitterroot_data\...face80_020904.FMS ...

Use Custom Fuels (*.fmd) ...

Winds

Wind Blowing Uphill Wind Speed (MPH @ 20'): 8

Wind Direction Azimuth (Degrees): 180

Wind Grids

Direction: ...

Speed: ...

Canopy Characteristics

Height(m): 15 Crown Bulk Density(Kg/m3): 0.2

Crown Base Height(m): 5 Foliar Moisture Content (%): 120

Fuel Moisture Settings

Use Fixed Fuel Moistures from Fuel Moisture File

Use Fuel Moisture Conditioning

Weather File (*.wtr): E:\Bitterroot_data\B...face80_020904.WTR ...

Wind File (*.wnd): E:\Bitterroot_data\B...face80_020904.WND ...

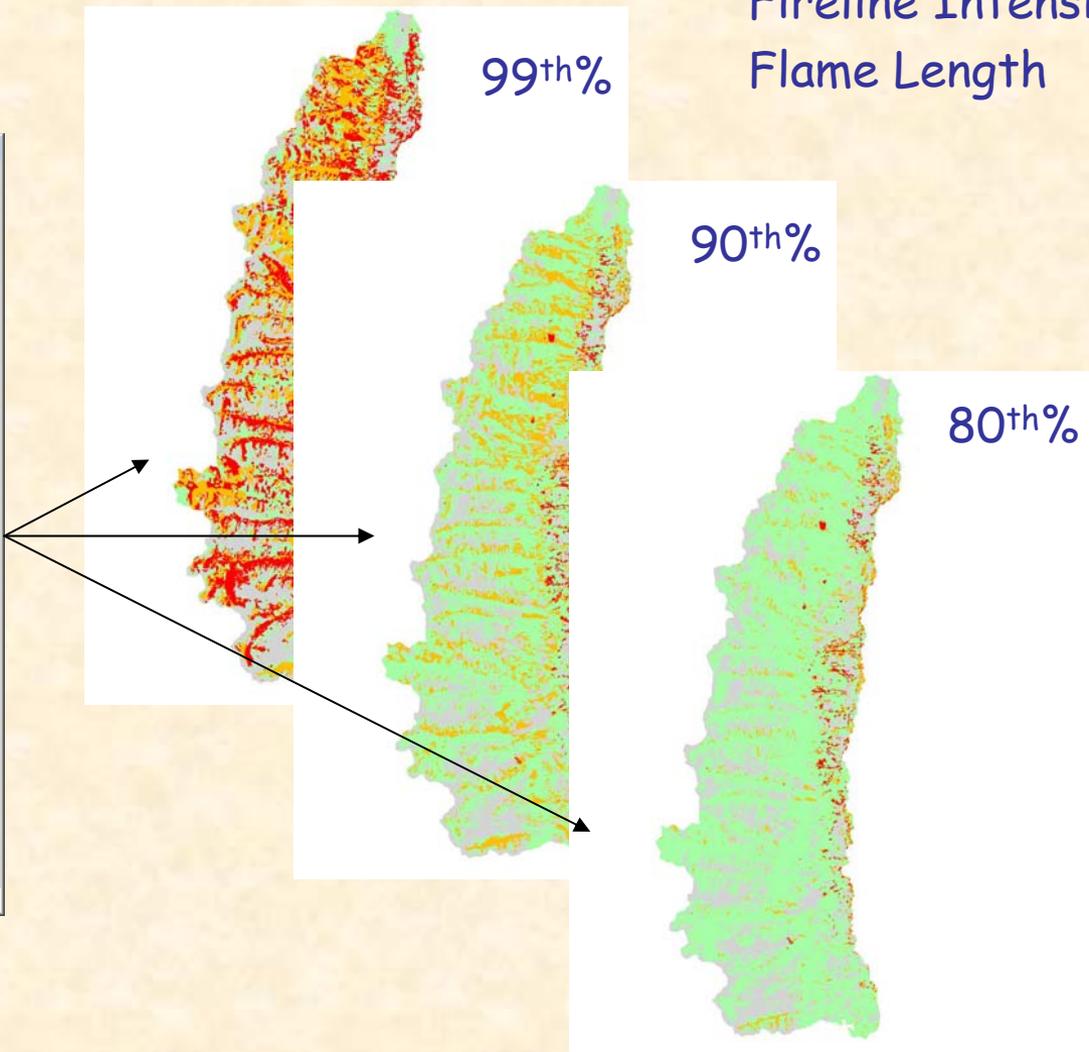
Fuel Moisture Conditioning Period

Day	Time
Start: 7/27/2004	1:00:00 PM
End: 7/31/2004	4:00:00 PM

Launch OK Cancel Apply Help

Need Fuel Moisture File No outputs selected No existing outputs

Crown Fire Potential
Fireline Intensity
Flame Length



Create Fire Effects Crosswalks

Physical Habitat
Characteristics



Fire
Behavior

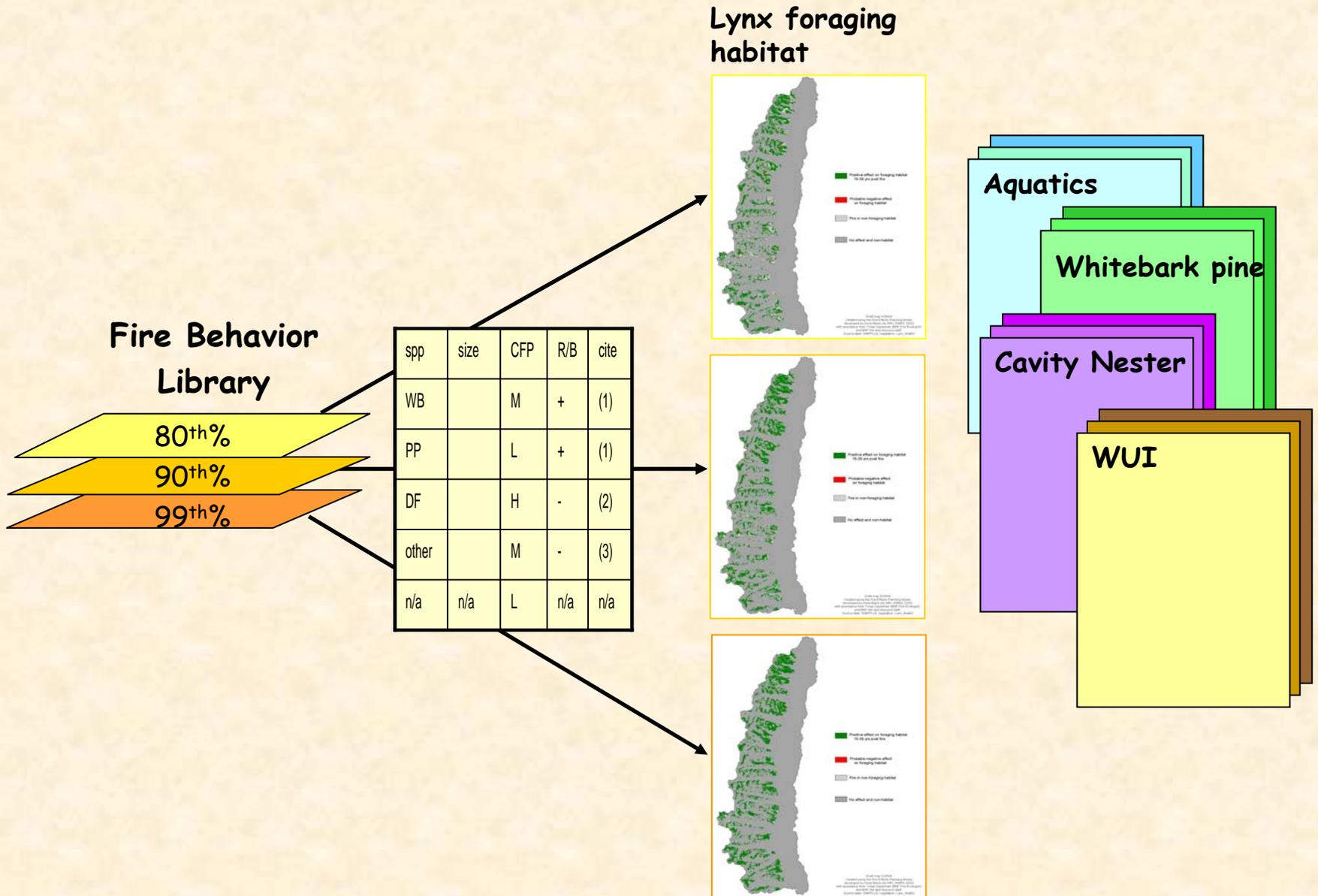


Fire
Effects

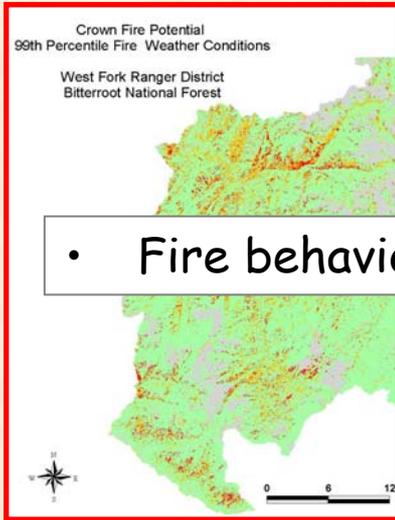


Species	Size/ Structure	Crown fire potential	Benefits/Risks to whitebark pine	Mapping Multiplier	Information Source
WB-AL-AF mix, and WB-ES-AF mix	All	High	Desirable Effects WB to outcompete other conifers	+1	Tomback et al. 2001
		Low or Moderate	Highly Desirable Effects favor late successional WB	+100	Tomback et al. 2001
WB-only	Seed/sap	All fires	Undesirable Effects WB established but not reproducing yet	-100	Tomback et al. 2001; FOFEM
	All except seed/sap		Desirable Effects restore native fire regime	+1	Tomback et al. 2001; FOFEM
All other species mixes	All	High	Highly Desirable Effects provide potential WB habitat	+100	Keane, Arno, pers.comm.
		Low or Moderate	Desirable Effects	+1	Keane, Arno, pers.comm
No Burn	All	None	Not Habitat rock above 6500'	0	N/A

Create Fire Effects Library

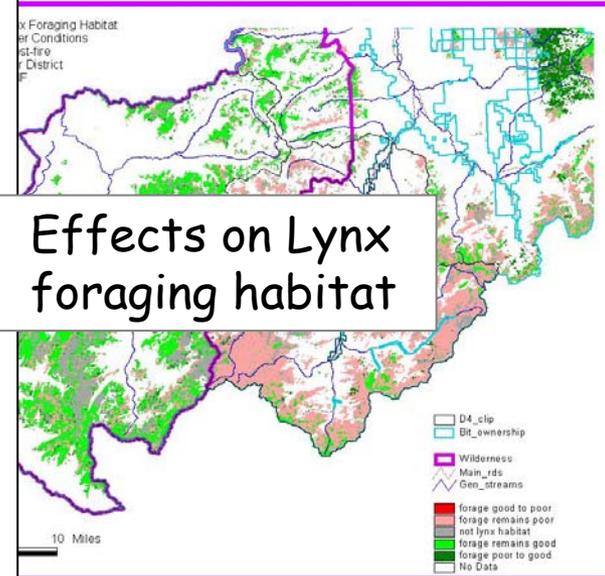


Map Library for Fire Planning



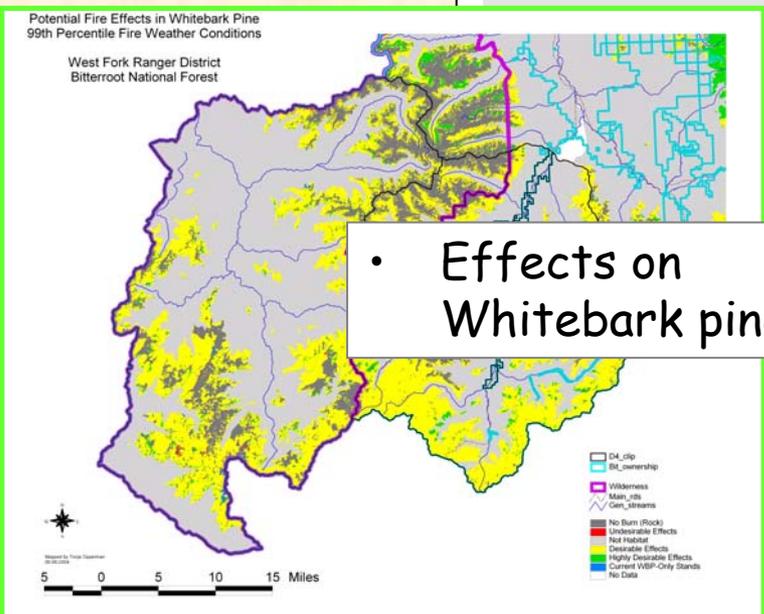
- Fire behavior

BITTERROOT NATIONAL FOREST



- Effects on Lynx foraging habitat

2004 Fire Effects Map Library



- Effects on Whitebark pine



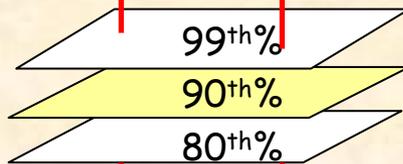
Go/NoGo Support:
WFIP analyses & documentation

Incident Planning:
focus suppression??

Fire Effects Library
(multiple values)

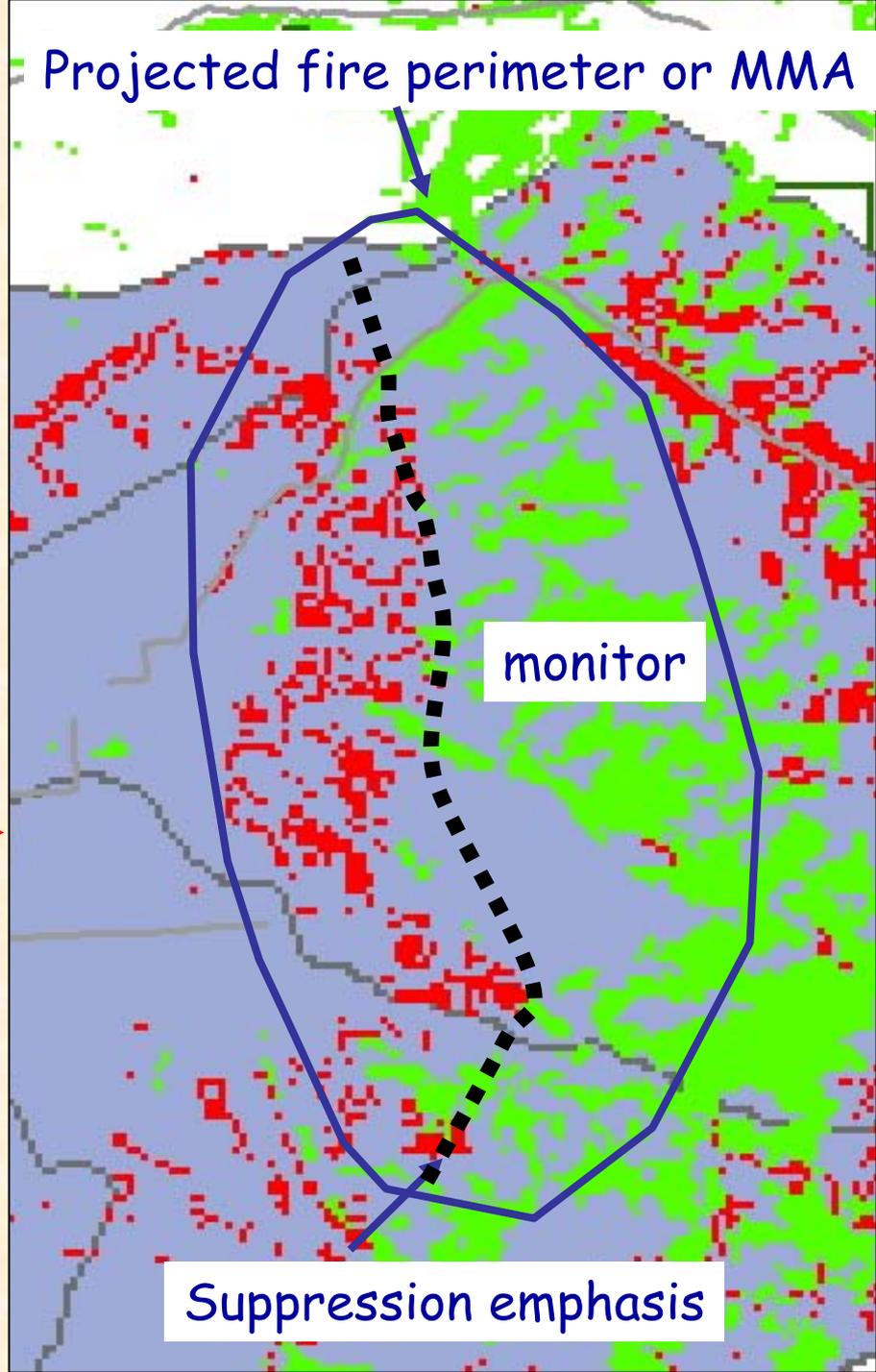


Fire Behavior Library



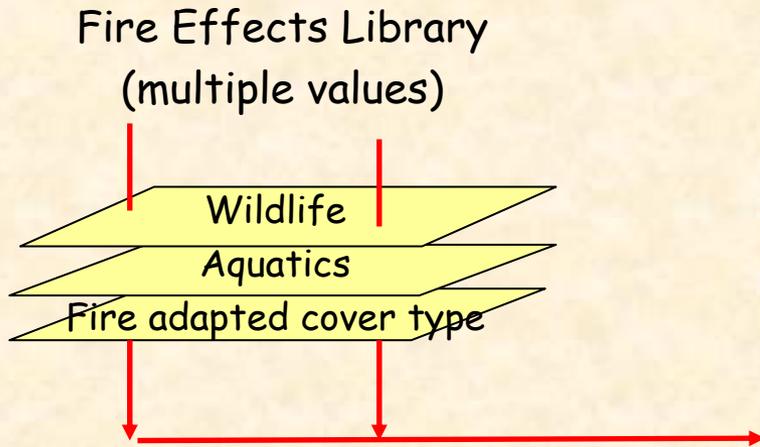
Quantify benefits or reductions in risk within MMA

Consider potential benefits when determining suppression strategy by flank

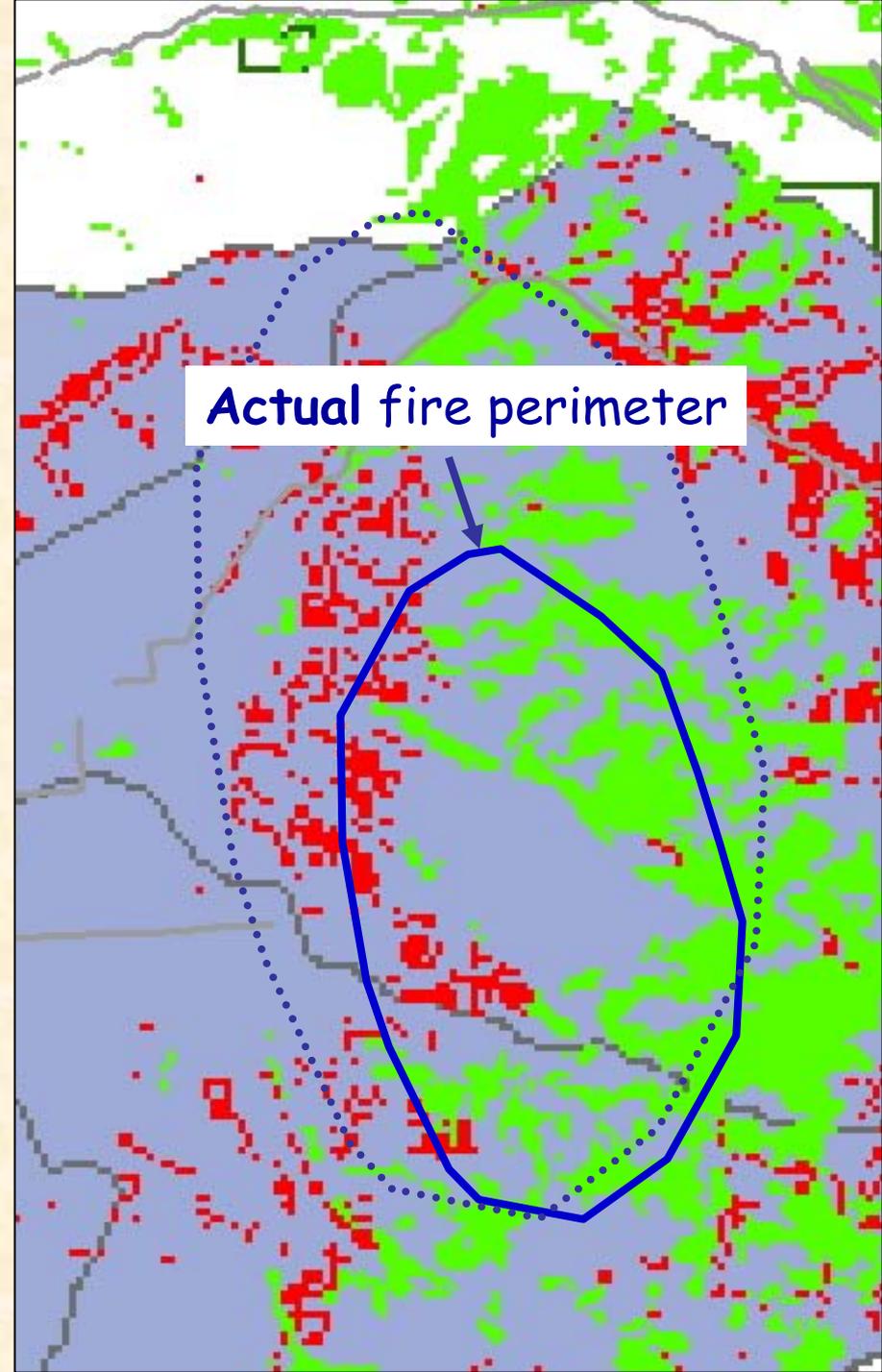




Post season:
Quantify effects and progress
toward LRMP objectives

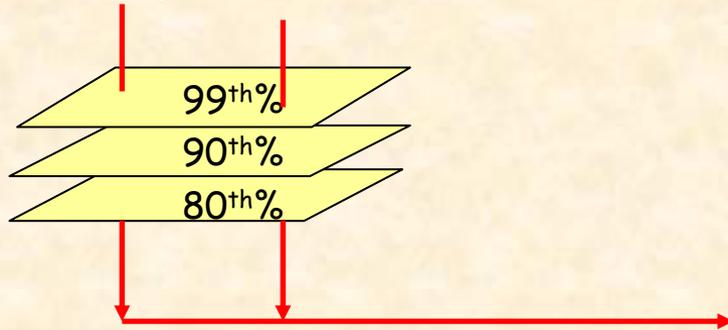


Adjust vegetation map for next season



Long-range - Activity Planning: fuel treatment priorities

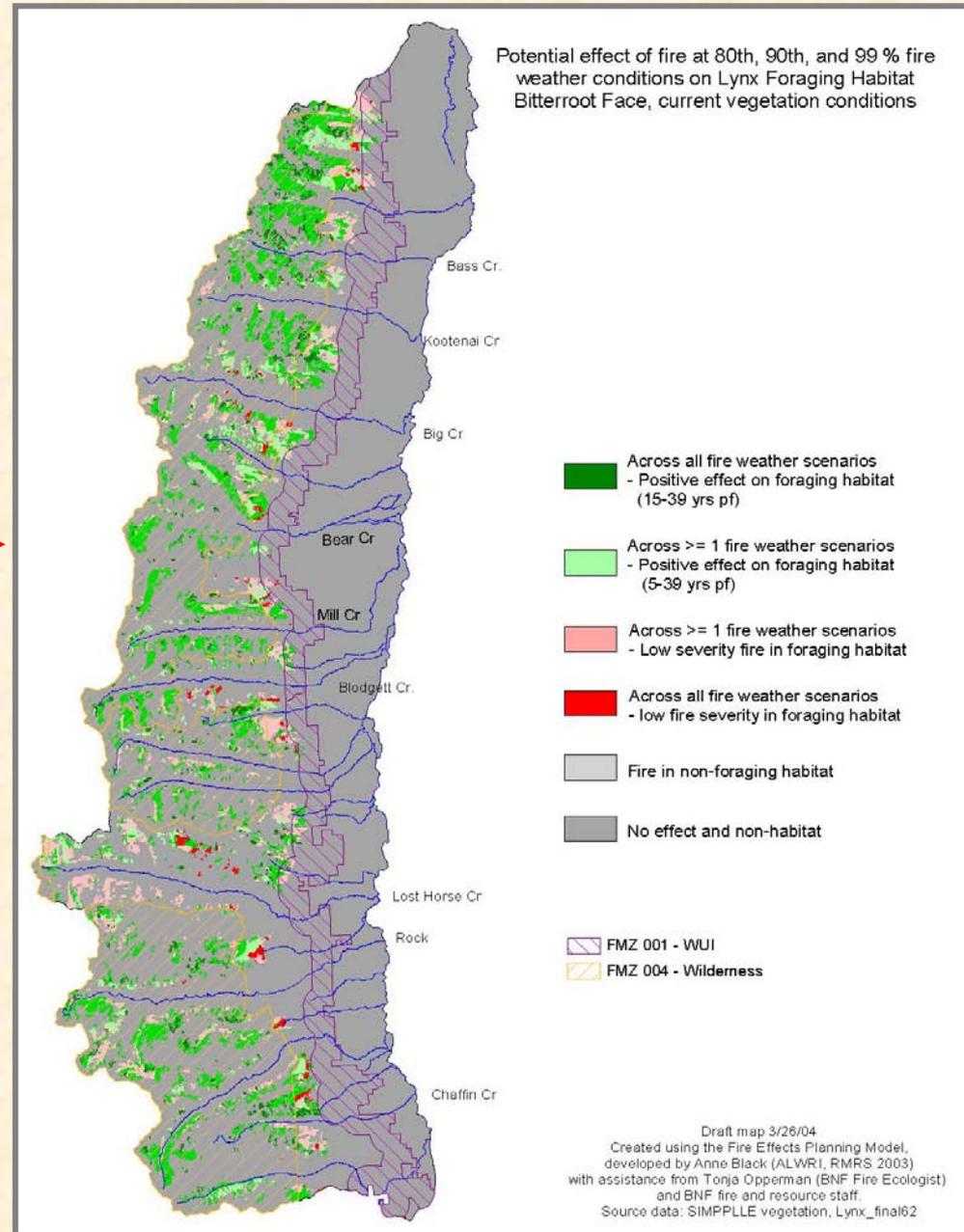
Fire Effects Library
(multiple conditions)



Fire effects always negative
(red): Mechanical treatment

Fire effects always positive
or neutral (green): Rx or
WFU

Fire effects vary (light red,
light green): various



Website

- background
- demonstrations
- fact sheets

FIRE EFFECTS PLANNING FRAMEWORK

A framework for fire planning to assist in determining where and under what conditions fire may create benefits or pose threats to identified ecological conditions or management targets.

<http://leopold.wilderness.net/research/fprojects/F001.htm>

leopold.wilderness.net/research/fprojects/F005.htm

DRAFT

VERSION 0.0.03
2004

Anne E. Black
Aldo Leopold Wilderness Research Institute
Tonja Opperman
Bitterroot National Forest
Produced for a Joint Fire Science Project:
"Wildland Fuels: planning and evaluating benefits and risks"

LEOPOLD INSTITUTE

FEATURED PROJ

Wildland Fuels Management

PROJECTS

Anne Black, C

Aldo Leopold Wi

We are developing benefits from wildli will be used to help identify areas on th treatment. This res scale fire patterns

HOW TO USE THIS

an ongoing and process that is t state, NGO's - tc management go management-ign mapped. We've and species.

The goal is to asan The [Table of Con](#)

JOINT Fire Science Program

This p

[Click](#)

Leop

soft Internet Explorer provided by USDA Forest Service

Address [/F001_B.htm#products](#)

Common questions about

Forest Management

nd feasible

[nd landscape fire projects in the Northern Rockies](#)

l)

[Return to Table of Contents](#)

explanations

[d managers](#)

[ate?](#)

[image? \(3.14 M\)](#)

[ement goals?](#)

[ting National Fire Plan and federal fire policy goals.](#)

[ccess?](#)

[and WFSA's?](#)

javascript:openPopWin("images/compare.gif", 730, 548, 'menubar,scrollbars,resizable', 20, 20)

Internet



Research to improve fire stewardship

Fire Effects Planning Framework (FEPF)

Where and under what conditions will fire create *benefits* and pose *risks* to management objectives?

BurnPro (Probability of Burning)

Where is fire most likely to burn on the landscape, given the *spatial arrangement* of ignitions, fuels & topography?

BurnPro to help understand...

Where is fire is most likely to burn within a landscape?

risk-benefit assessments, prioritization, prevention

Where are the most frequent opportunities for Wildland Fire Use (WFU) within a landscape?

fire management planning, go/no-go decision support

How does suppression on one side of a boundary affect WFU opportunities on the other side?

evaluating & revising objectives

long-term planning processes



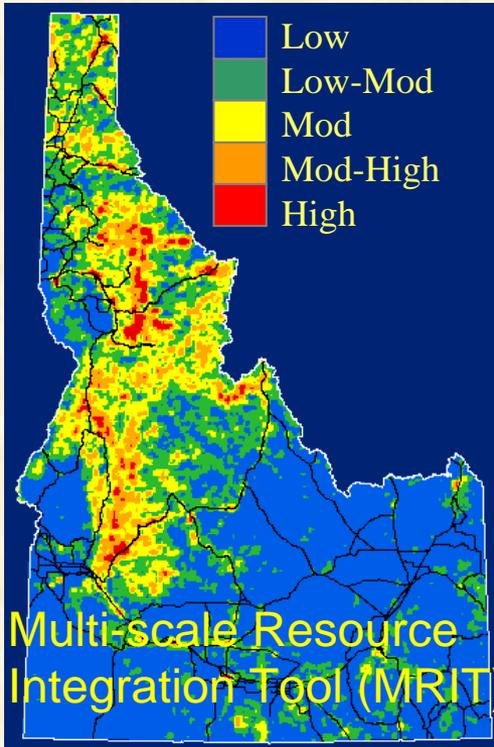
Probability of Ignition

vs.

Probability of Burning

ignitions / area / time period

ignitions * spread
in a spatial context

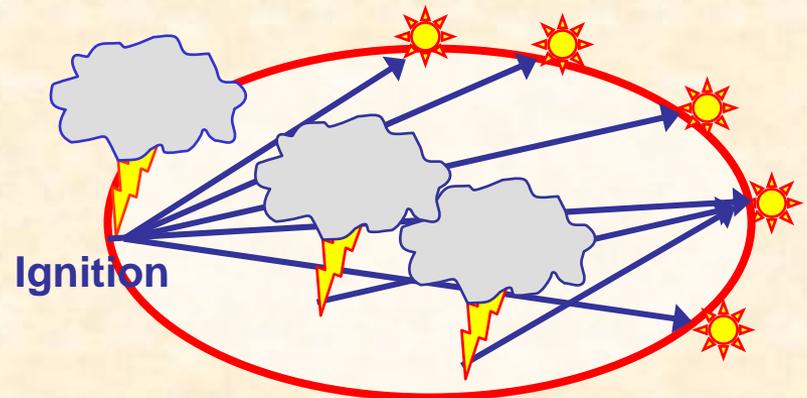


coarse scale
assessment and
planning

Cumulative probability
across entire season
averaged across years
Ignition

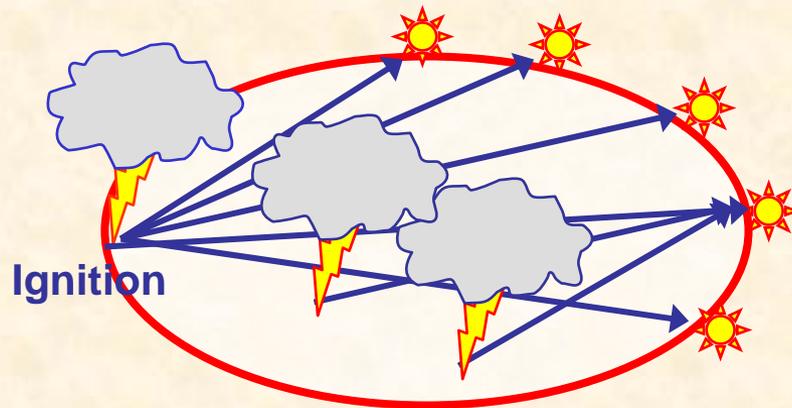
vs.

RERAP (single event)



BurnPro to Estimate Probability of Burning

*Considers ignitions, rate of fire spread, and time available for fire spread, all in a **spatial context***



BurnPro provides:

- **Average** annual value (many events, many years)
- Value for every location on a **raster map**
- **Continuous** values, not categorical—relative values
- Support for **long-term** planning (not incident management)

BurnPro Overview

Probability of burning
(*P_{Burn}*) a location



=

Probability of fire reaching
the location before the end
of the fire season
(*P_{End}*)



X

Probability of a fire stopping
precipitation event *NOT* occurring
before fire reaches the location
(*P_{NoRain}*)



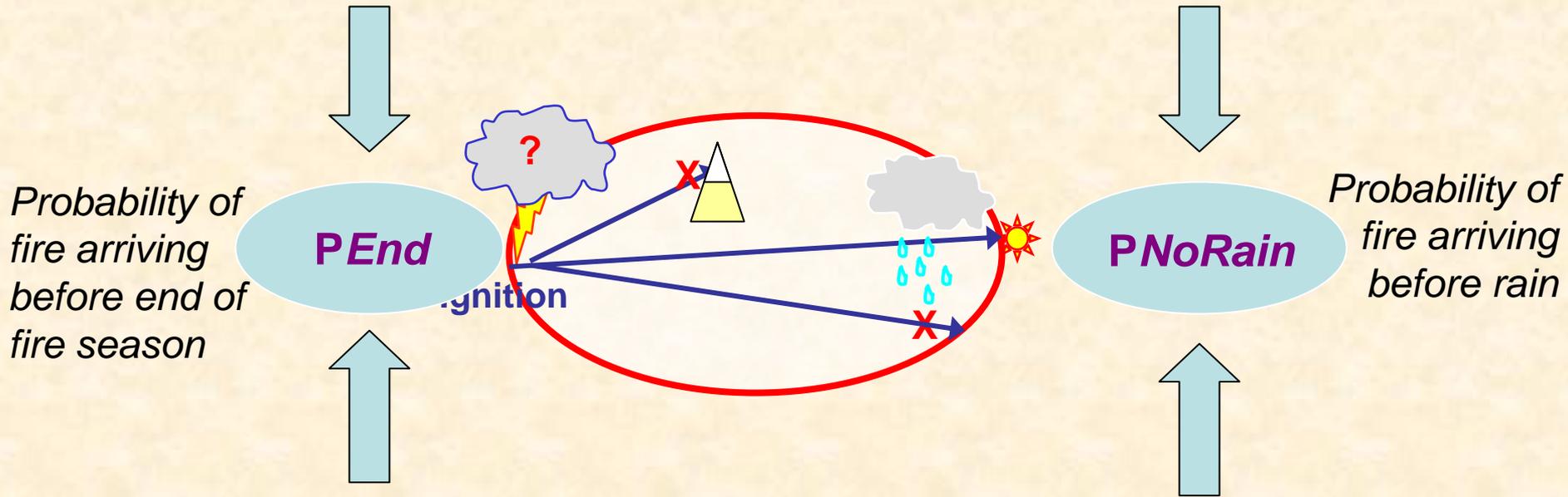


The BurnPro Approach

How long does it tend to take a fire to spread to each point (days of cumulative spread time)?

Where and when do ignitions tend to be?

How fast does fire tend to spread?



How long is the fire season?
(varies over elevation)

How frequent are fire-stopping events (rain)?

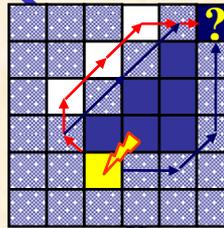


99%
90%
80%
50%

RATE OF SPREAD

FLAMMAP generated
- using FireFamily+ to determine inputs,
- 8 wind directions

■ Rock
■ "Slow" fuels
■ "Fast" fuels



ArcGIS
PATHDISTANCE
function

IGNITIONS

June
July
Aug
Sept

From NIFMID db

LEAST ACCUMULATIVE SPREAD TIME

LENGTH OF FIRE SEASON

RAIN FREQUENCY

Probability of burning
=
 $P_End \times P_NoRain$

From FireFamily+

P_End

likelihood of fire arriving before the end of the fire season

P_NoRain

likelihood of fire arriving before a significant rain event



Risks and Benefits

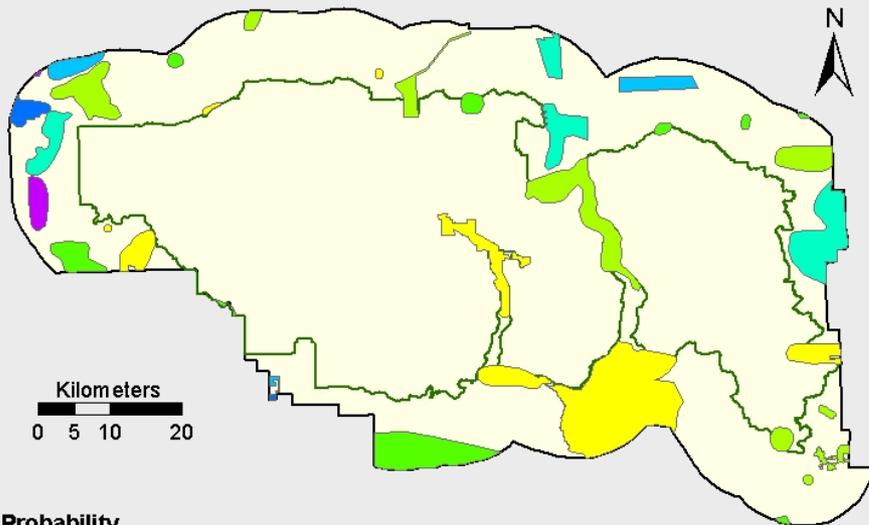
Where is fire most likely to burn within a landscape?
Risk-benefit assessments, priorities

Average Annual Probability of Burning

Potential WFU Lightning Ignitions

Probability of Burning WUI

Potential WFU Lightning Ignitions

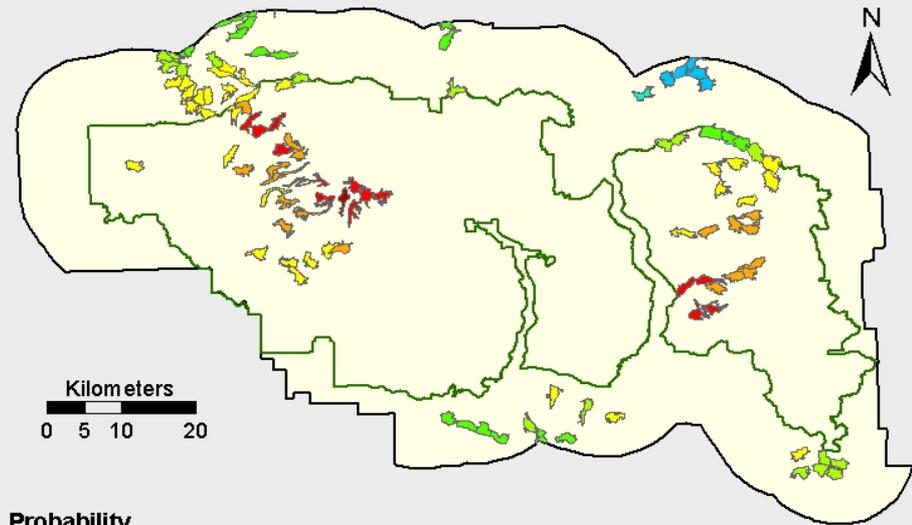


Probability

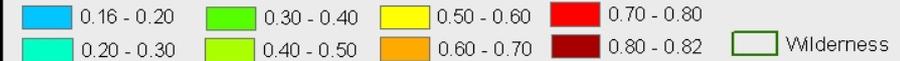


Probability of Burning MSO Habitat

Potential WFU Lightning Ignitions



Probability

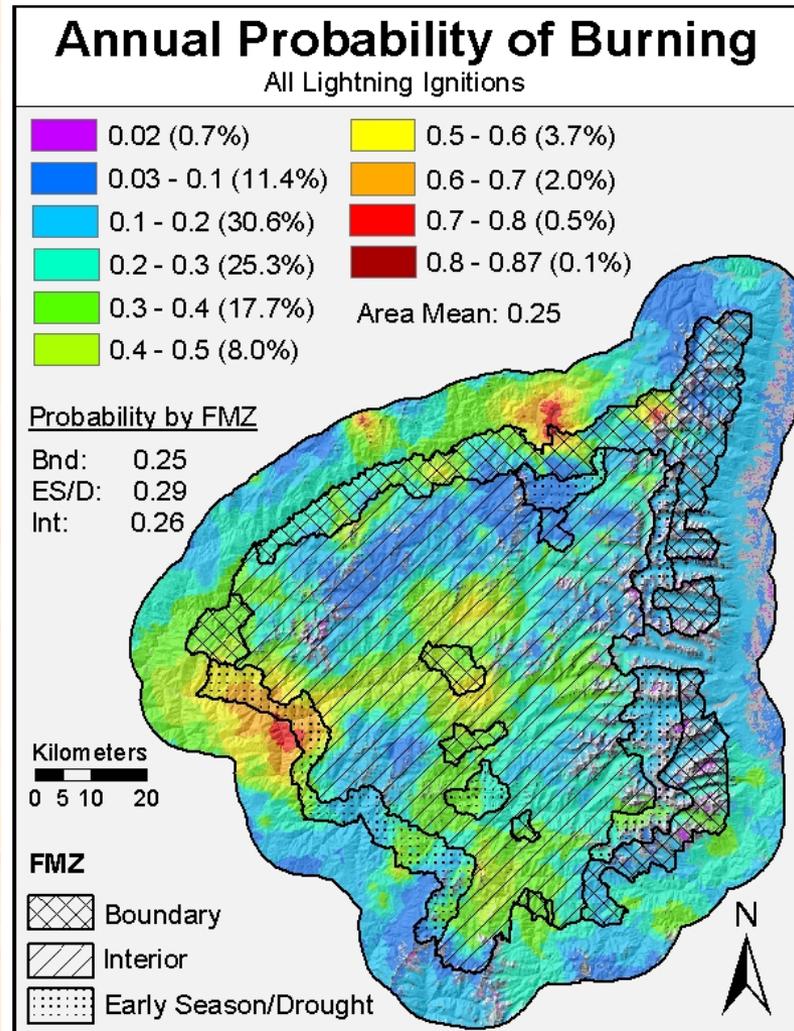


Old and Lopez Wilderness, New Mexico



Opportunities

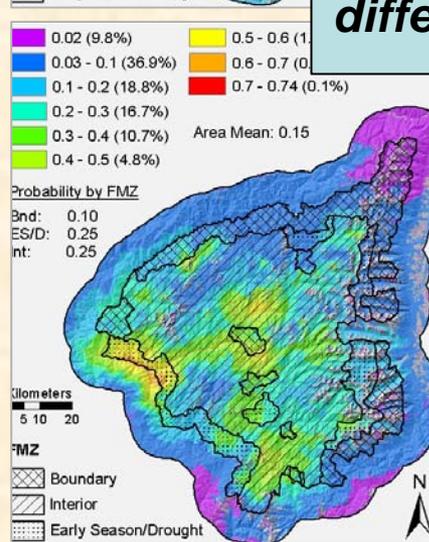
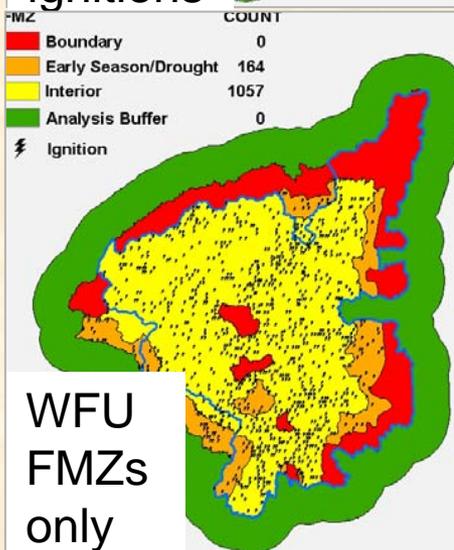
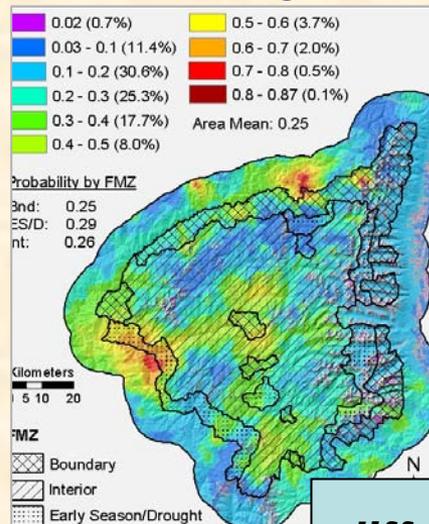
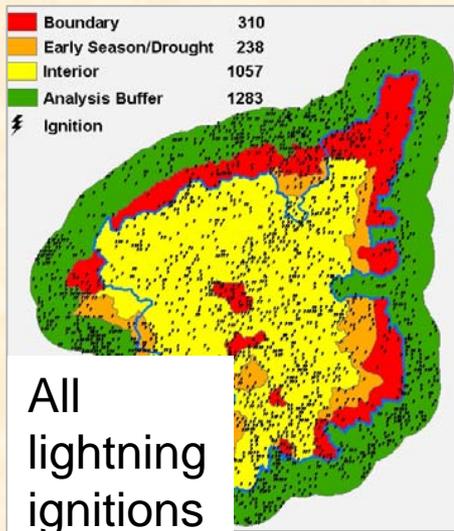
Where are the most frequent WFU opportunities? The most rare?
FMP, go/no-go support



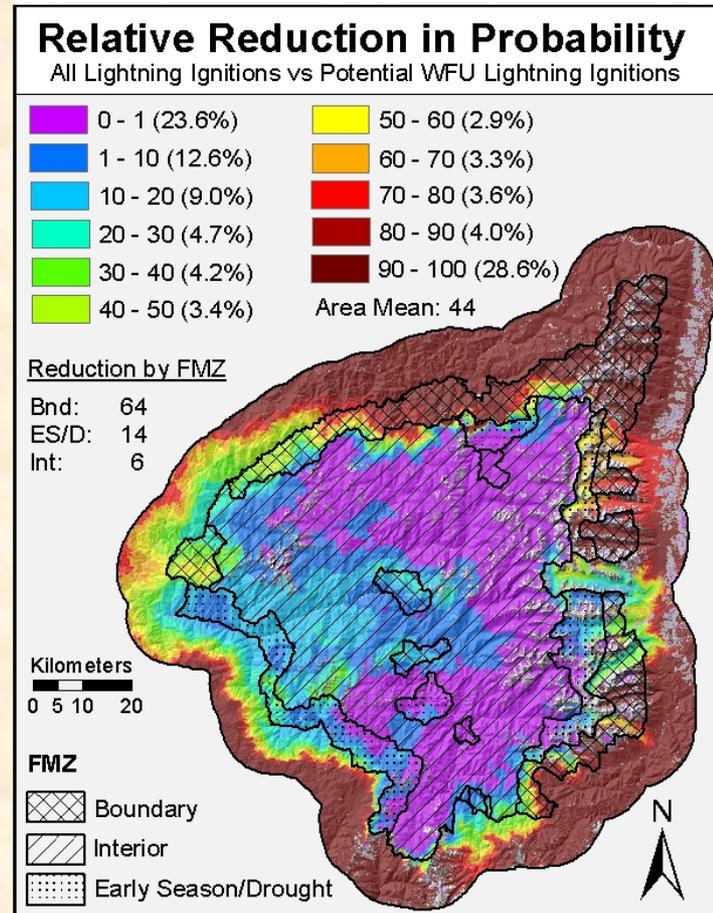
Selway-Bitterroot Wilderness, ID/MT

Cross-Boundary Suppression Effects

How does suppression on one side of a boundary affect WFU opportunities on the other side?
evaluating & revising objectives

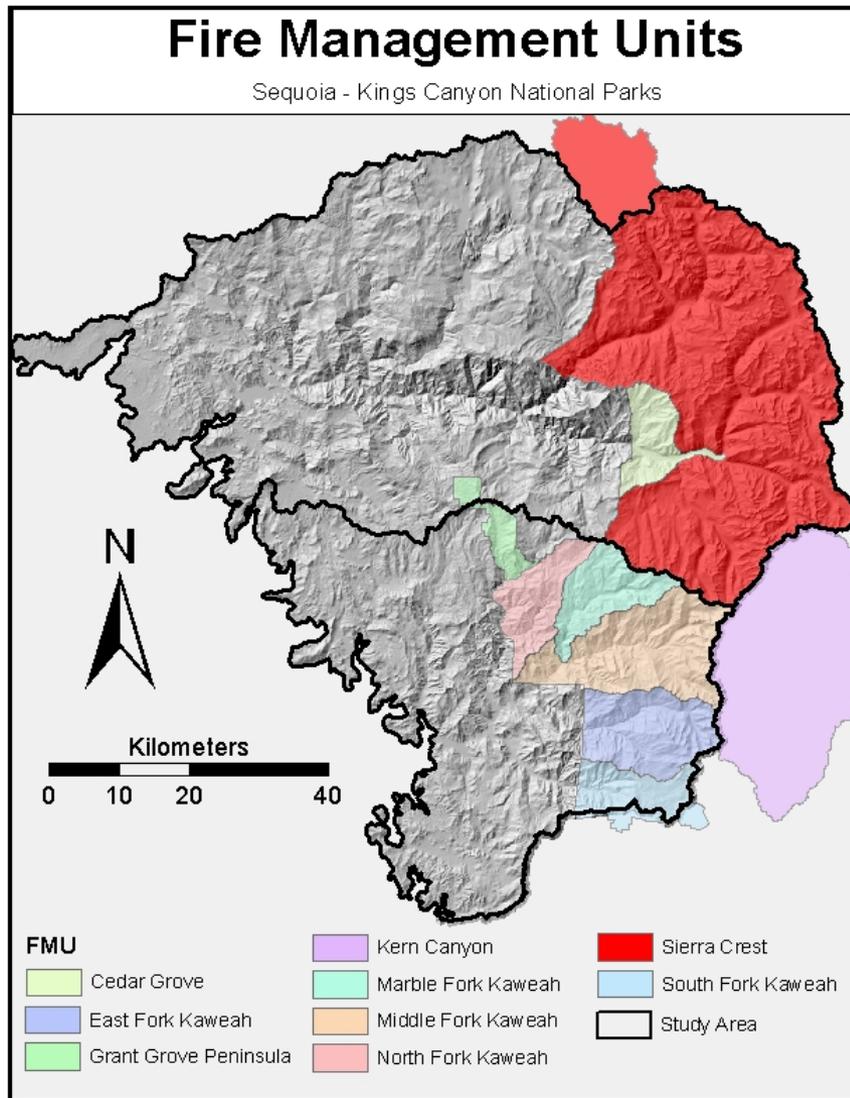


difference



Supplement with Rx?

BurnPro Results - Fire Management Plans

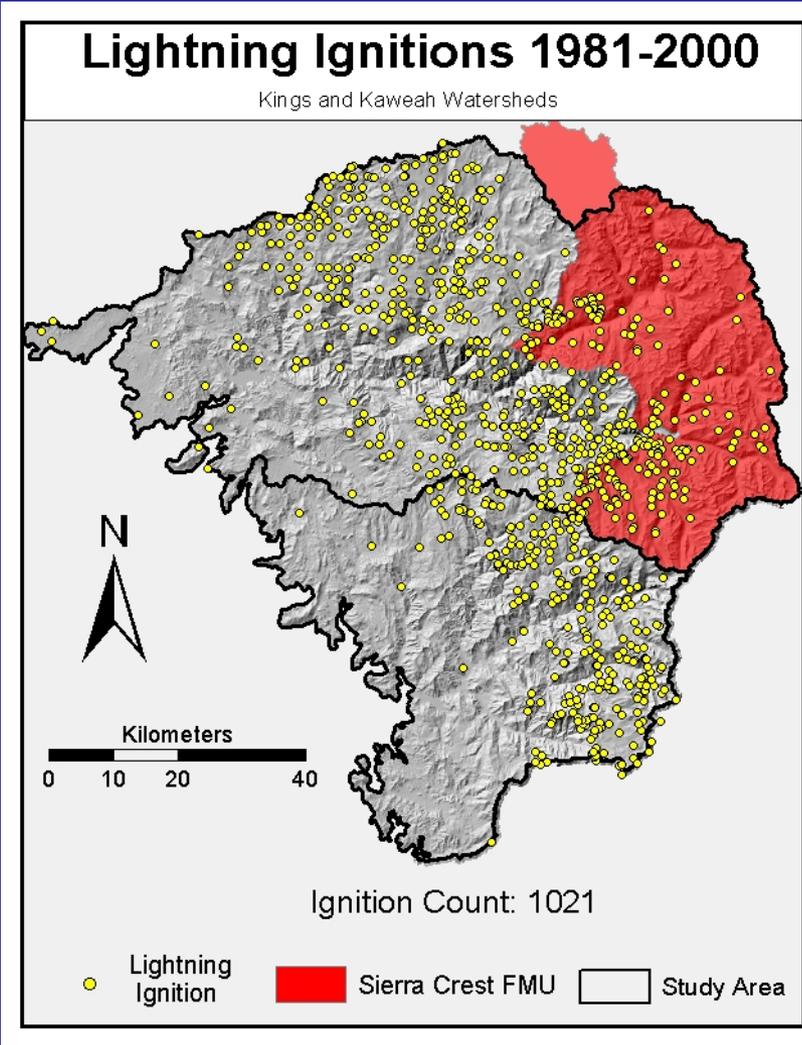


Sierra Crest FMU:

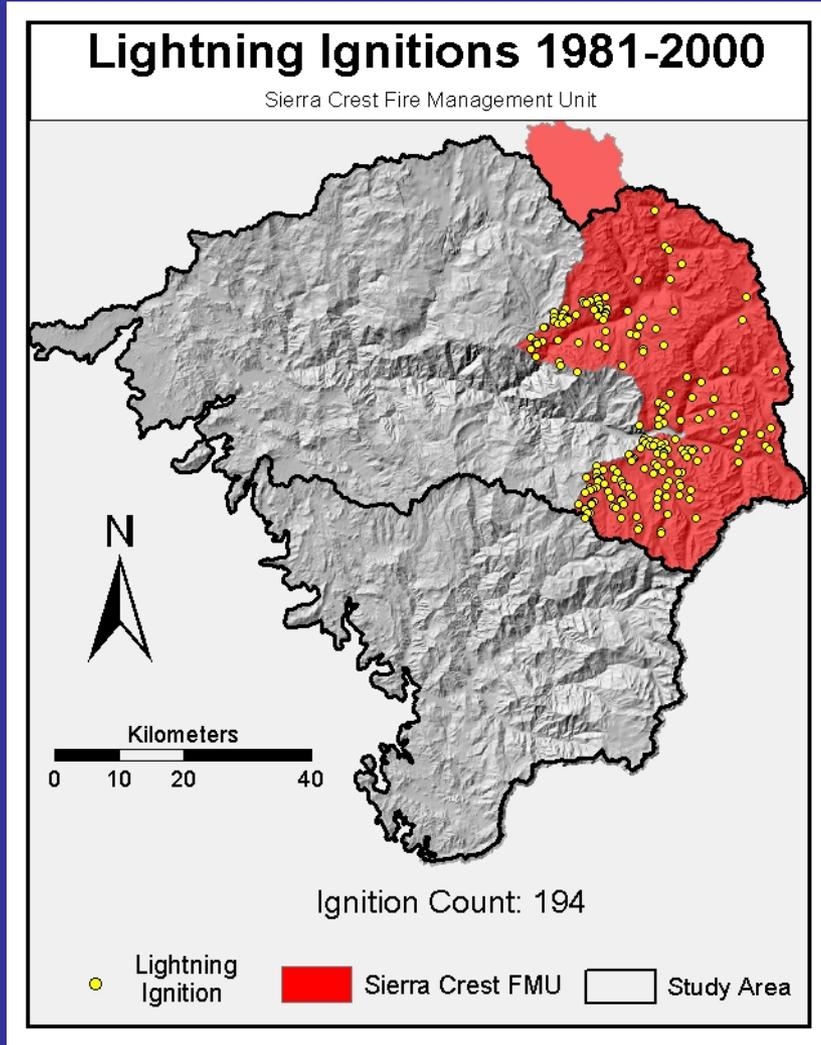
Managed for natural processes applying WFU as the primary tool

How much is the probability of burning reduced when we eliminate the importation of fire from outside the Sierra Crest FMU?

Probability of burning from all lightning ignitions

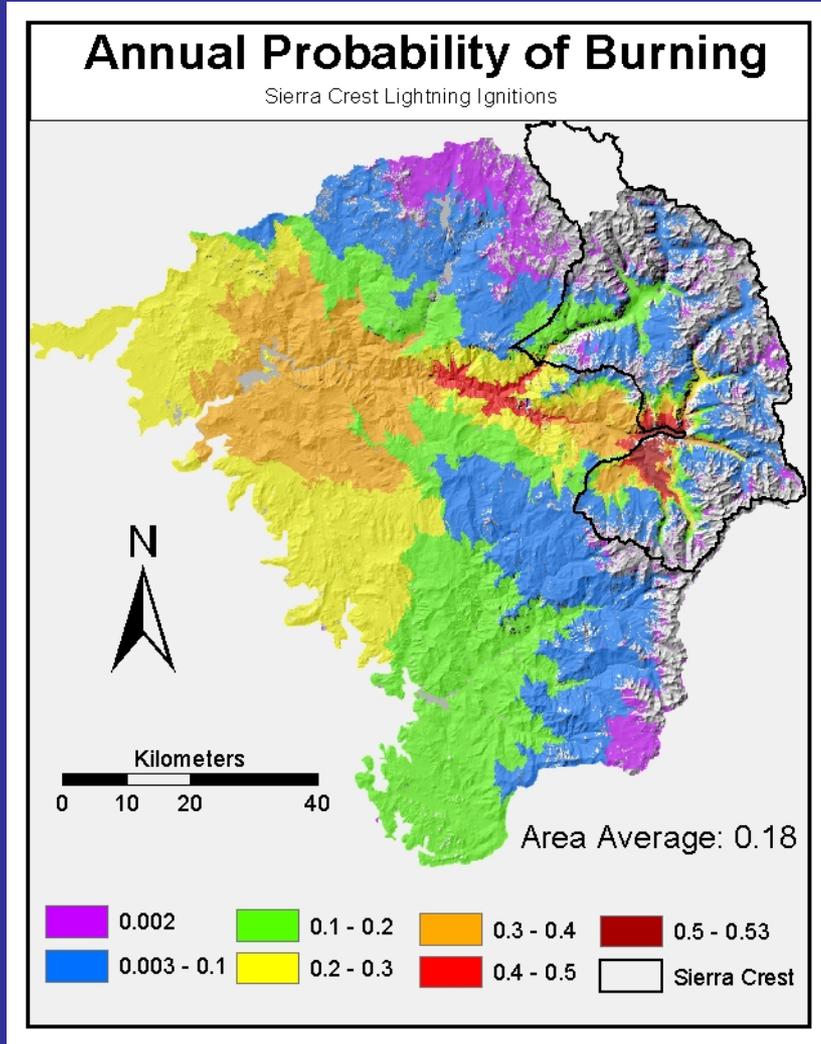
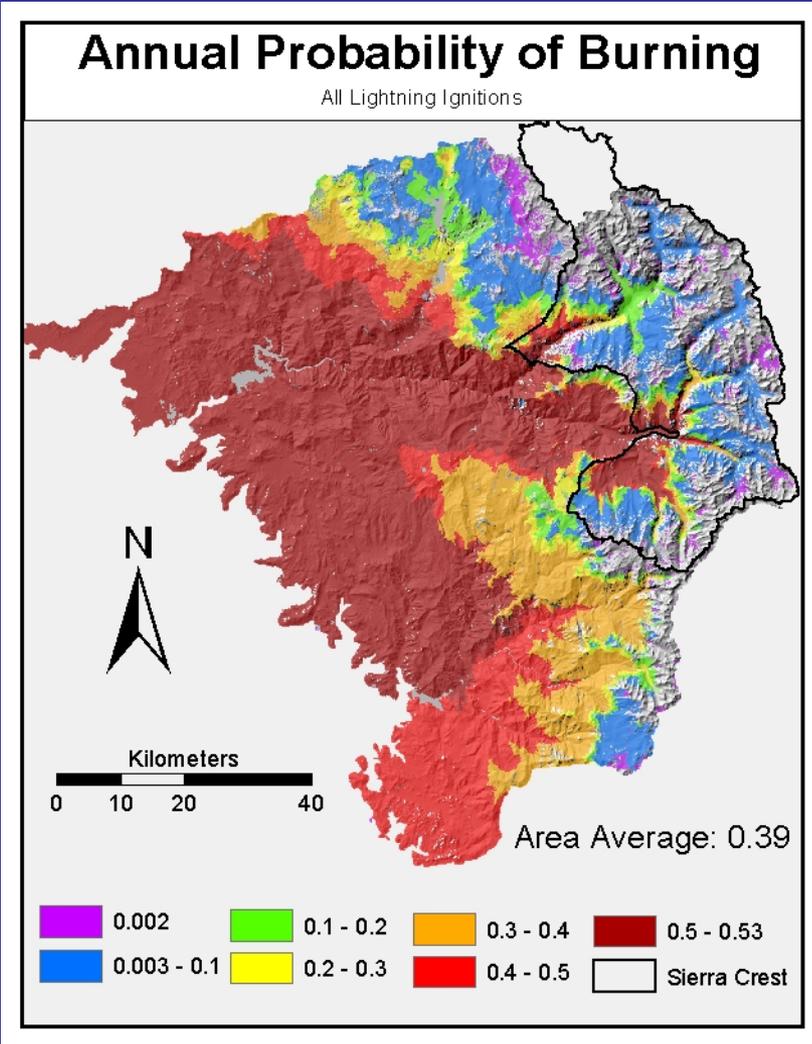


Probability of burning from FMU lightning ignitions only



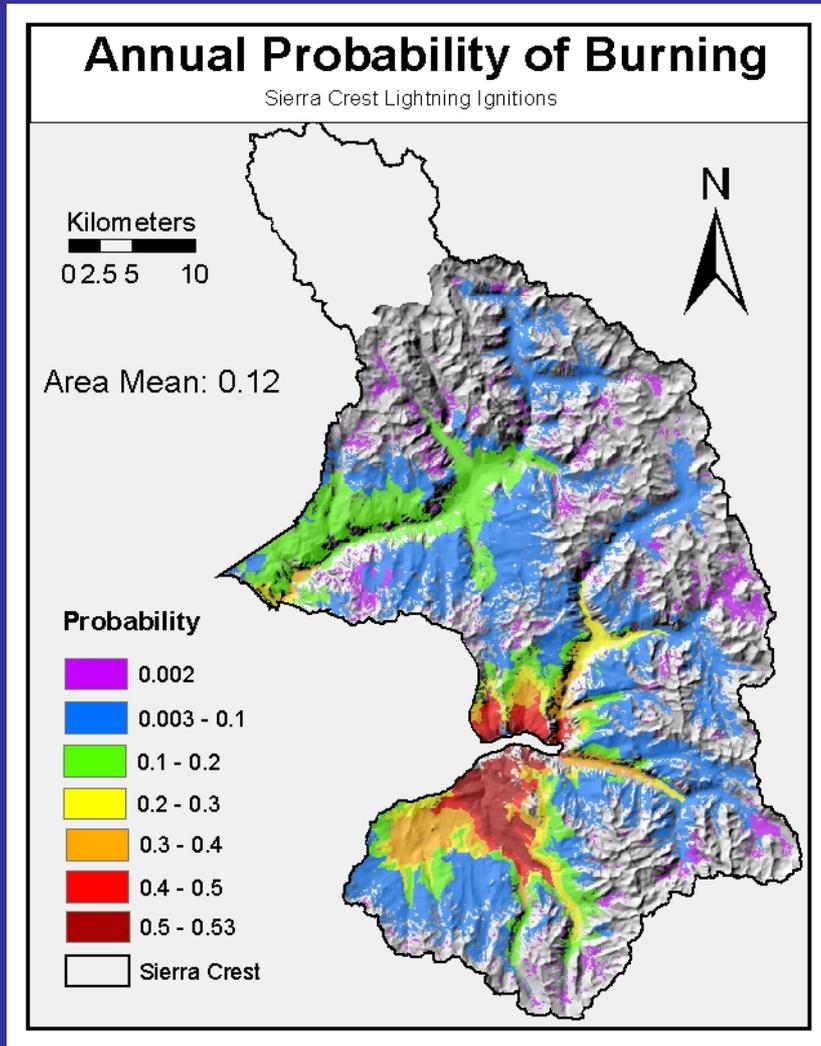
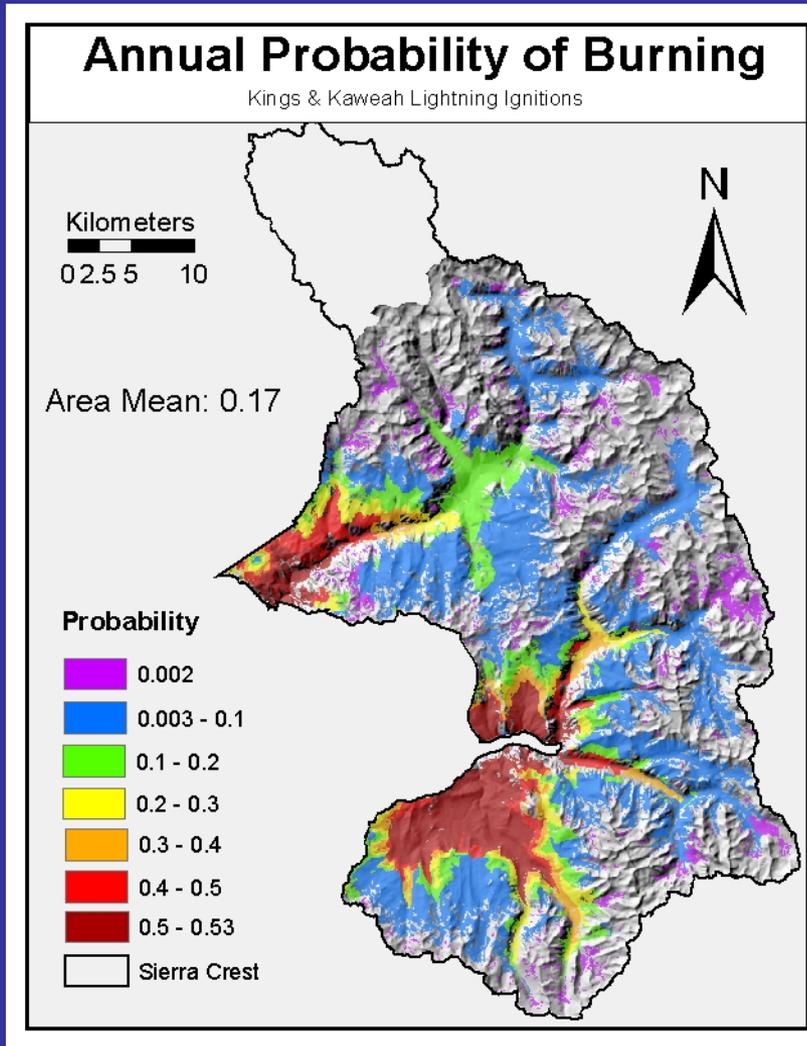
Probability of burning from all lightning ignitions

Probability of burning from FMU lightning ignitions only



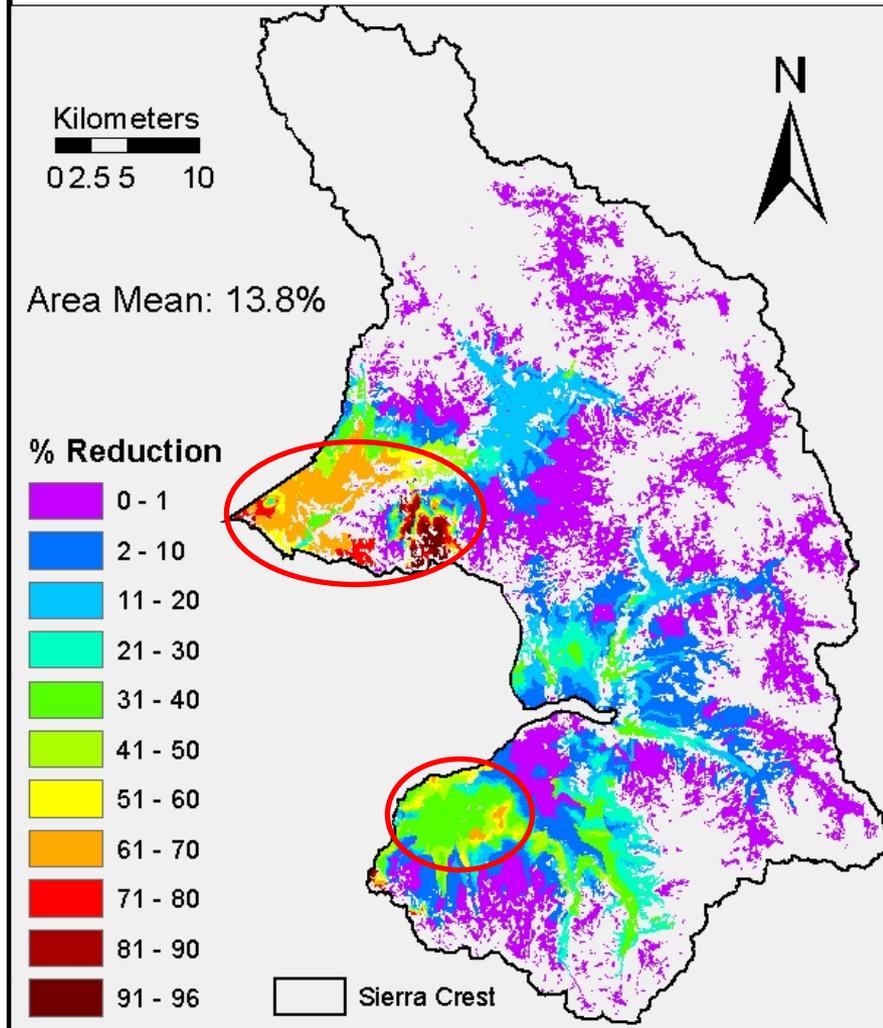
Probability of burning from all lightning ignitions

Probability of burning from FMU lightning ignitions only



Relative Reduction in Probability

Sierra Crest Fire Management Unit

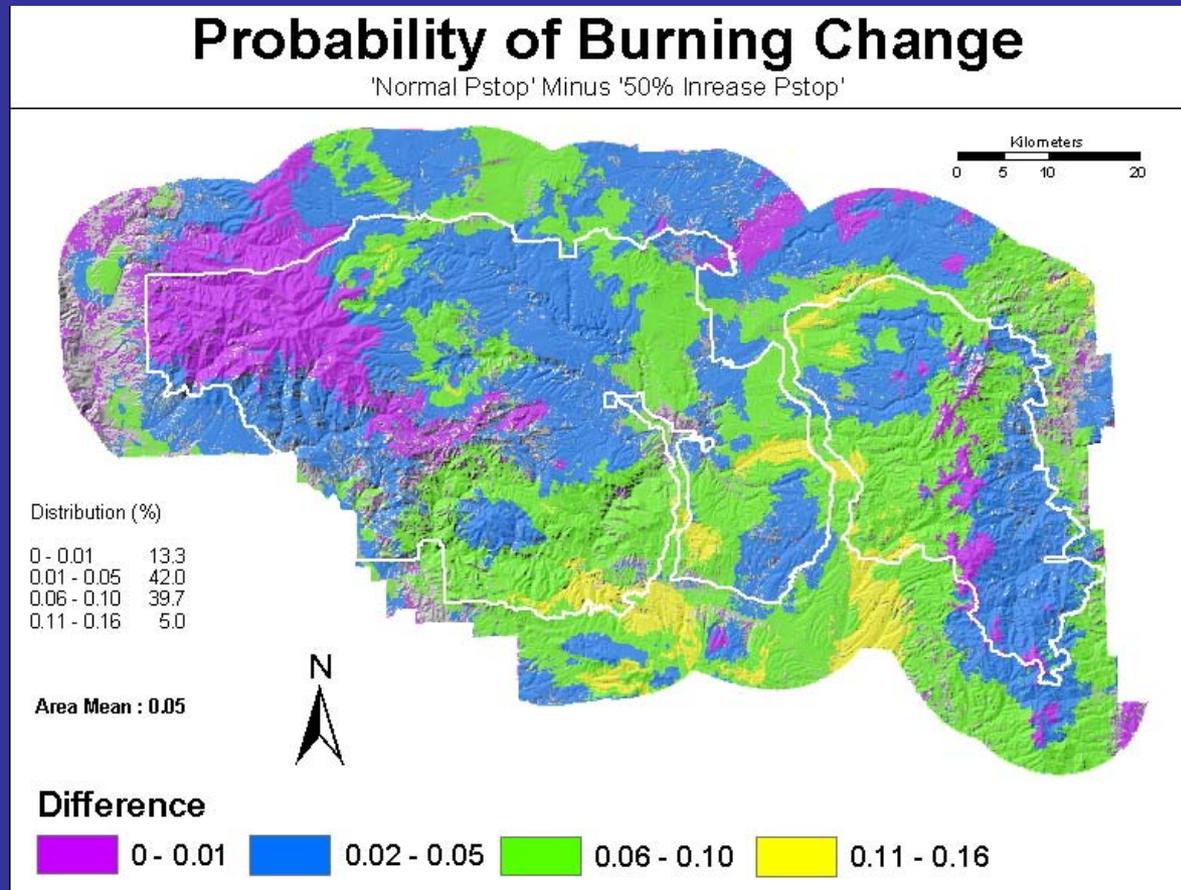


Overall small differences

Certain areas with large differences

- Challenges for restoration objectives
- Periodic Rx fire?
- Maximize WFU opportunities?

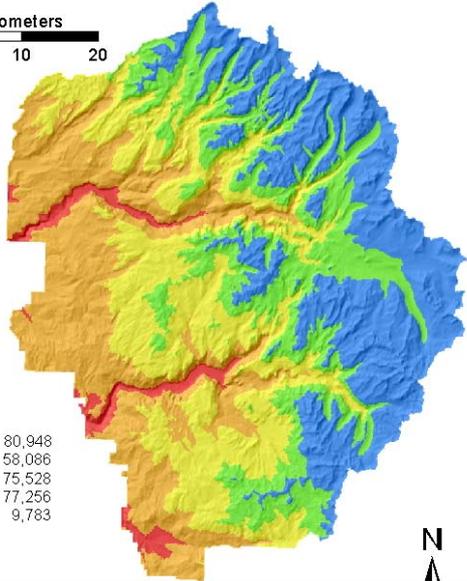
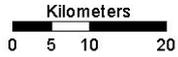
Sensitivity Analysis: frequency of fire-stopping events



Some places are more sensitive to changes in rain frequency than others

Length of Fire Season

Original FACET Definition

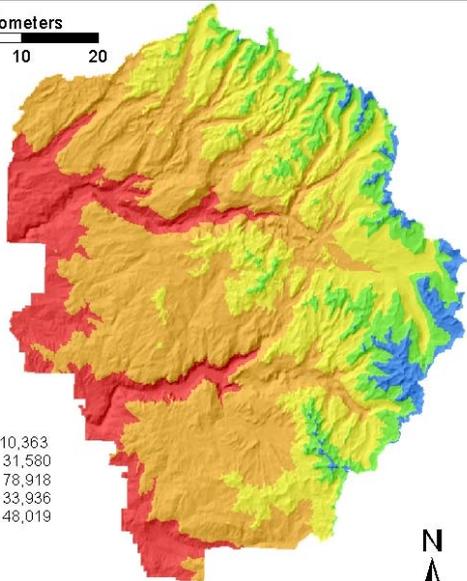
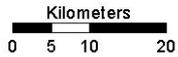


Hectares

1 Month	80,948
2 Months	58,086
3 Months	75,528
4 Months	77,256
5 Months	9,783



Increased by 500 Meters



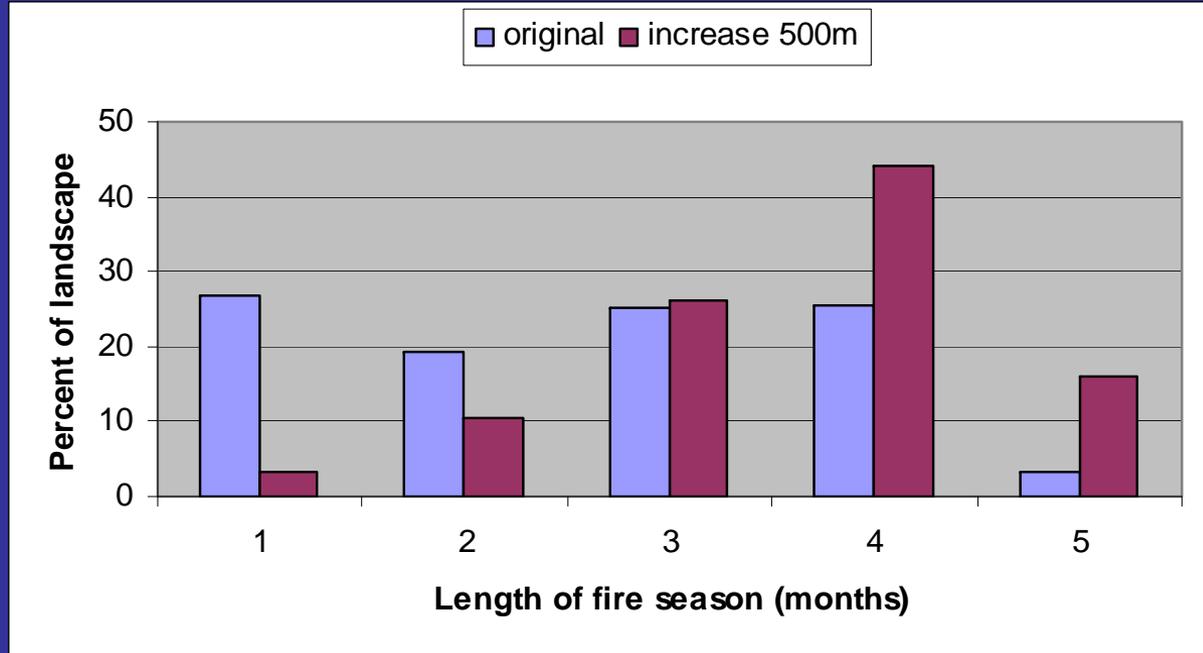
Hectares

1 Month	10,363
2 Months	31,580
3 Months	78,918
4 Months	133,936
5 Months	48,019



Sensitivity Analysis: length of fire season

Shifted uphill by 500m



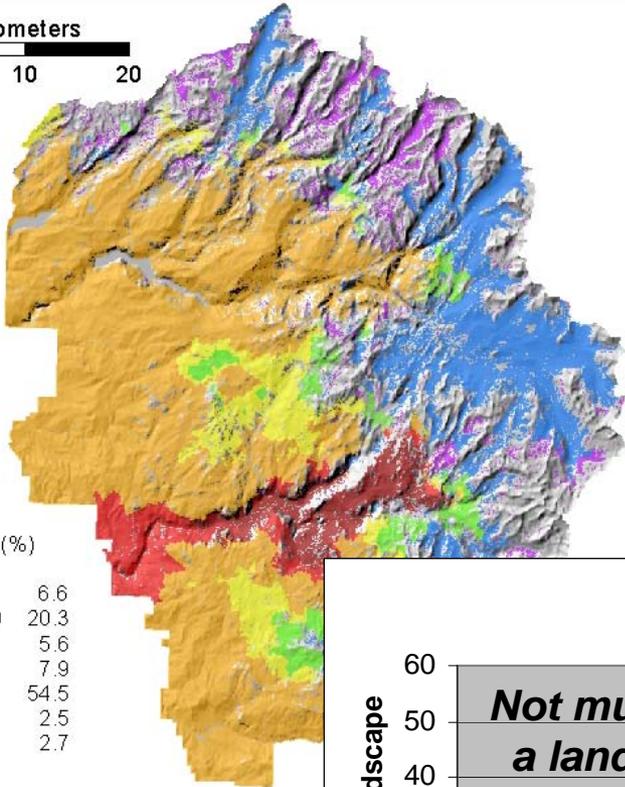
**Dramatic change in length of season
over much of landscape**

Sensitivity Analysis: length of fire season

Annual Probability of Burning

Original Length of Fire Season

Kilometers
0 5 10 20



Distribution (%)

0.002	6.6
0.003 - 0.10	20.3
0.10 - 0.20	5.6
0.20 - 0.30	7.9
0.30 - 0.40	54.5
0.40 - 0.50	2.5
0.50 - 0.59	2.7

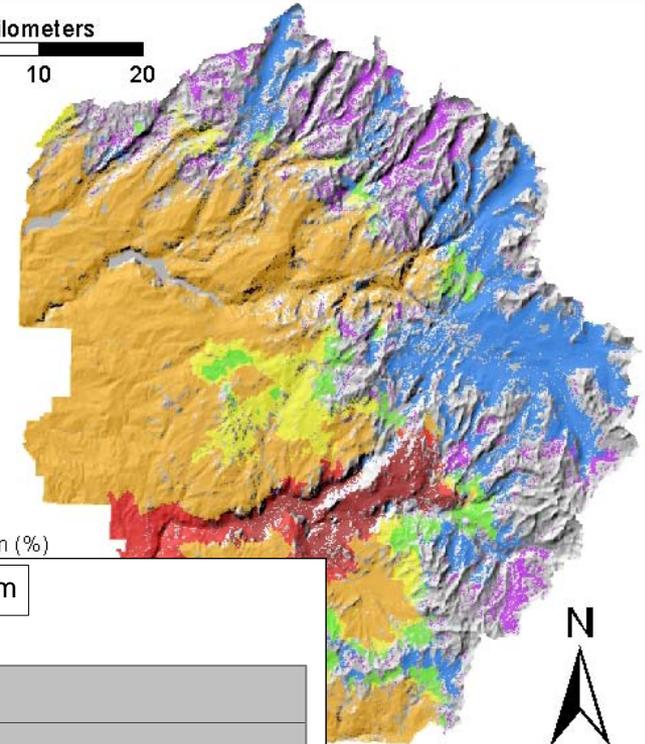
Probability

0.002	0.003 - 0.10	0.10 - 0.20
0.20 - 0.30	0.30 - 0.40	0.40 - 0.50
0.50 - 0.59		

Annual Probability of Burning

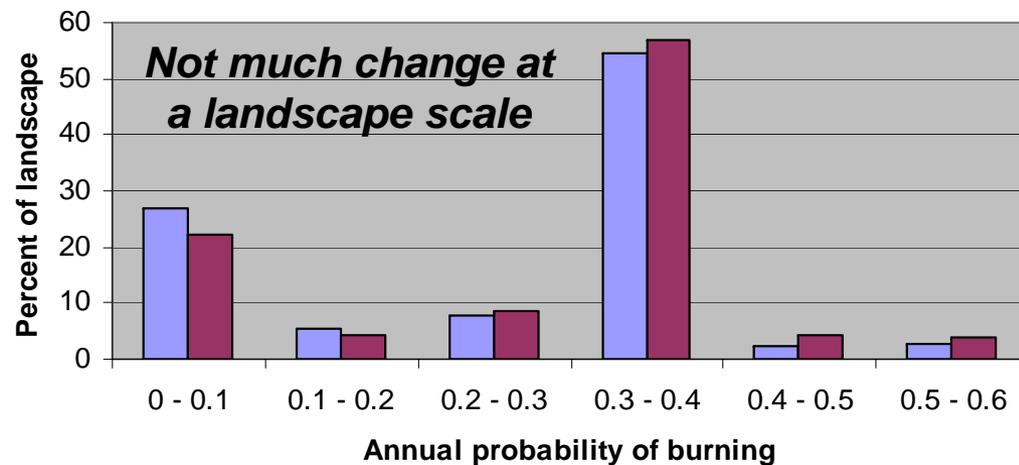
Fire Season Increased 500 Meters

Kilometers
0 5 10 20



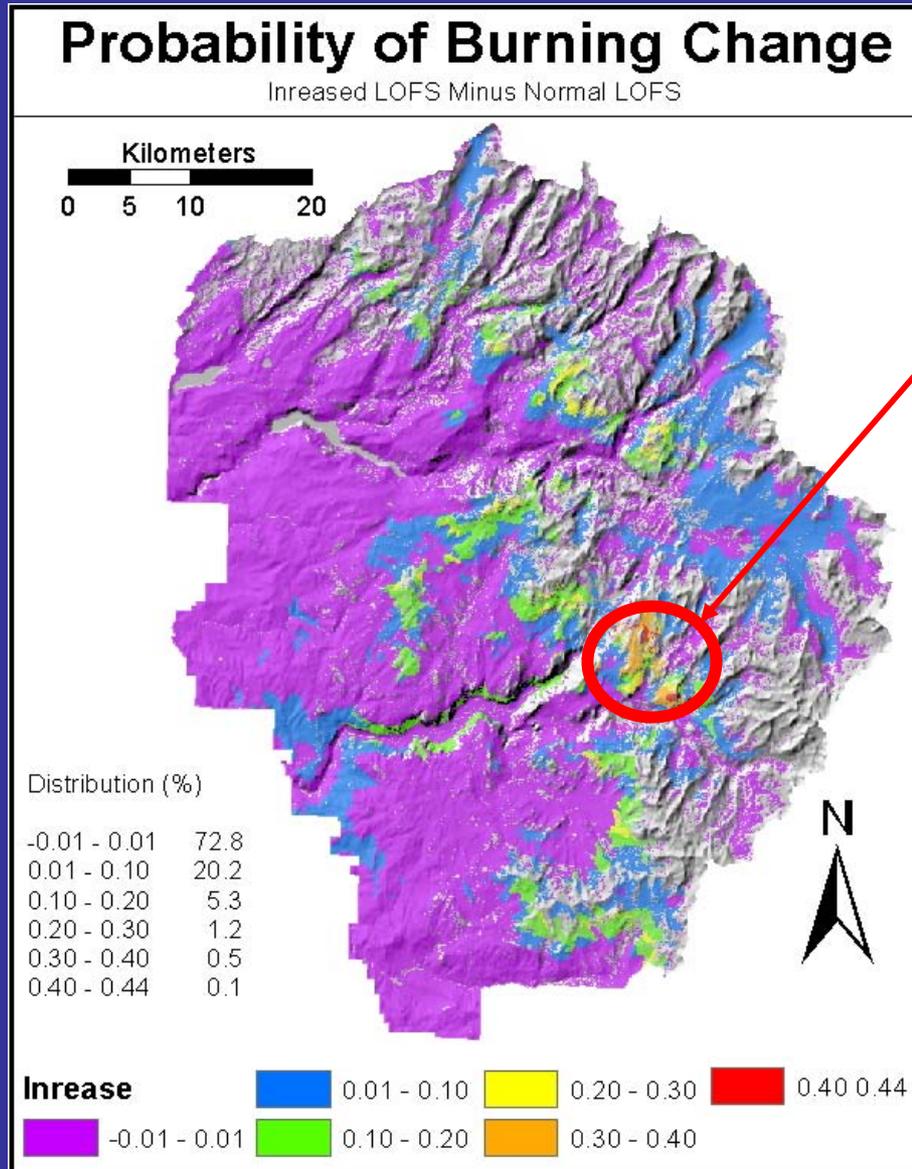
Distribution (%)

original increase 500m



0.20 - 0.30 0.40 - 0.50
0.30 - 0.40 0.50 - 0.59

Sensitivity Analysis: length of fire season

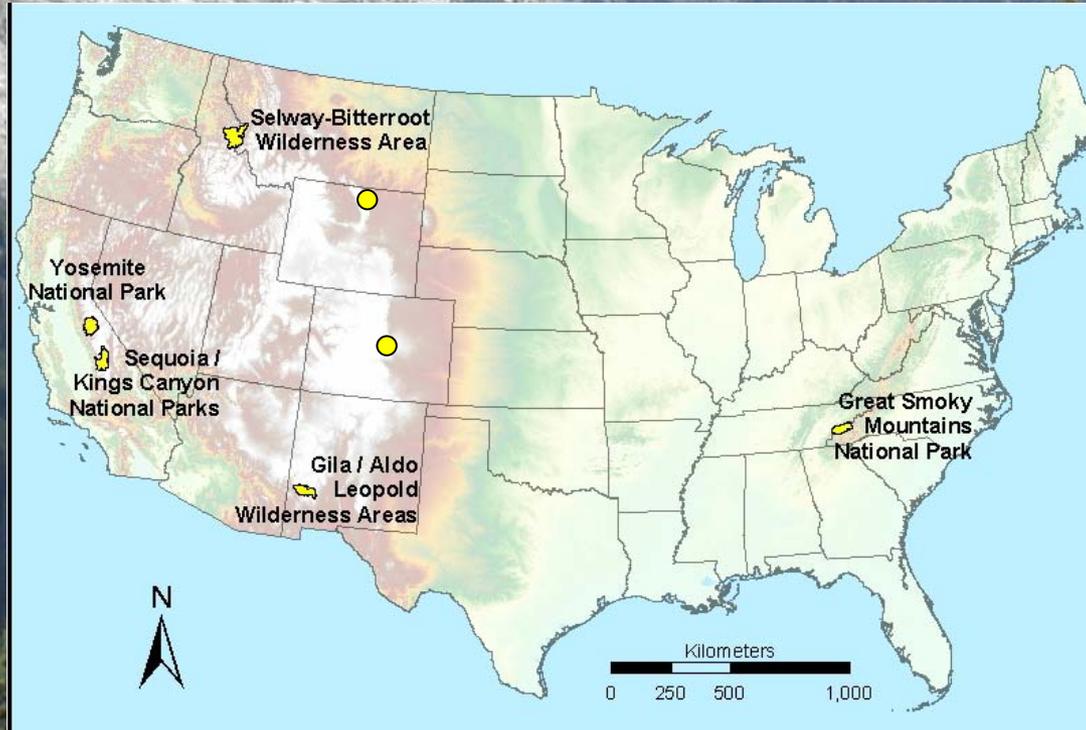


Dramatic change in some places

Spatial context matters!

Sensitivity varies across landscape

BurnPro is still under development and testing



website <http://leopold.wilderness.net/research/fprojects/F002.htm>

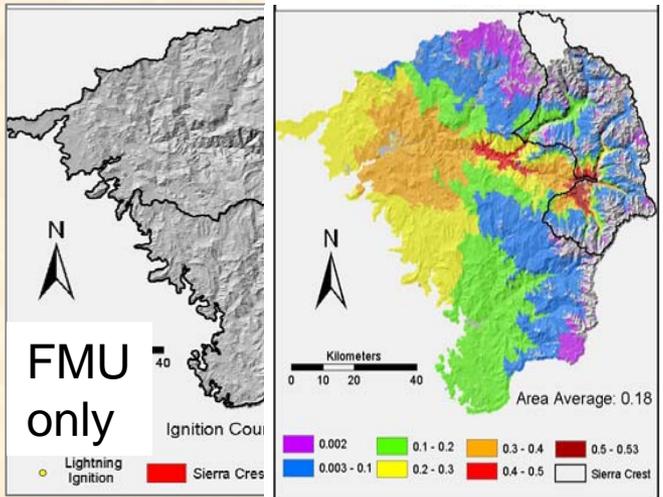
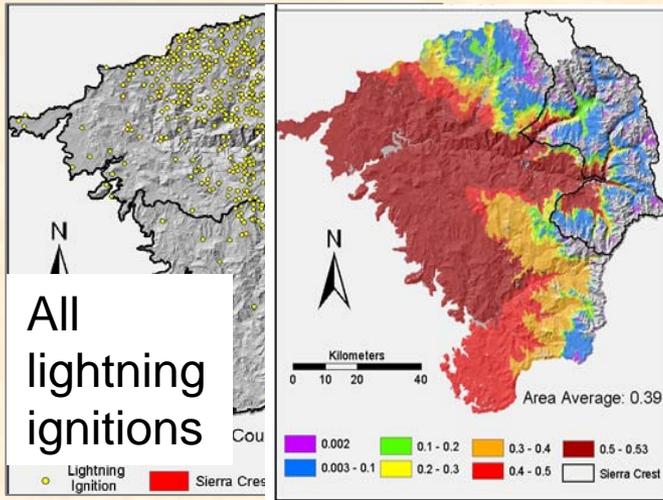
Thanks!

aebblack@fs.fed.us or cmiller04@fs.fed.us

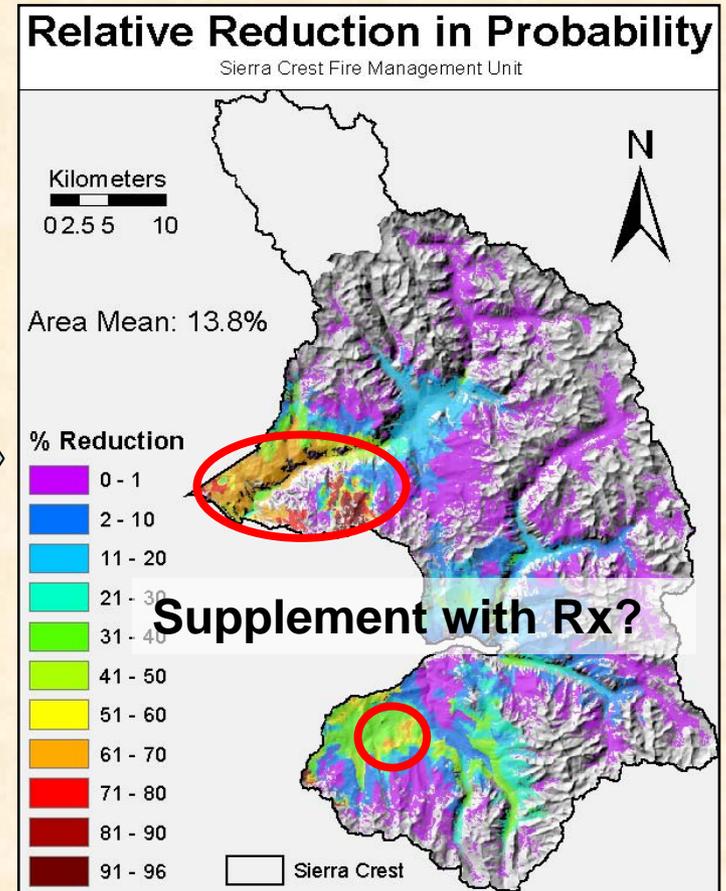
<http://leopold.wilderness.net>

Cross-Boundary Suppression Effects

How does suppression on one side of a boundary affect WFU opportunities on the other side?
evaluating & revising objectives



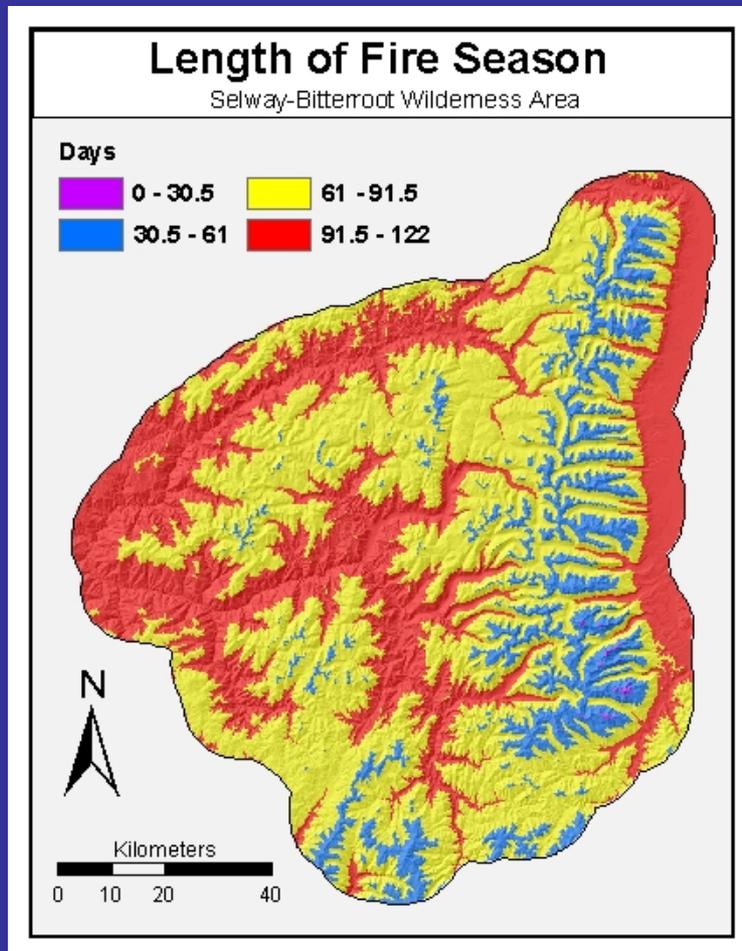
difference



Sierra: Sequoia-Kings Canyon NP and neighbors

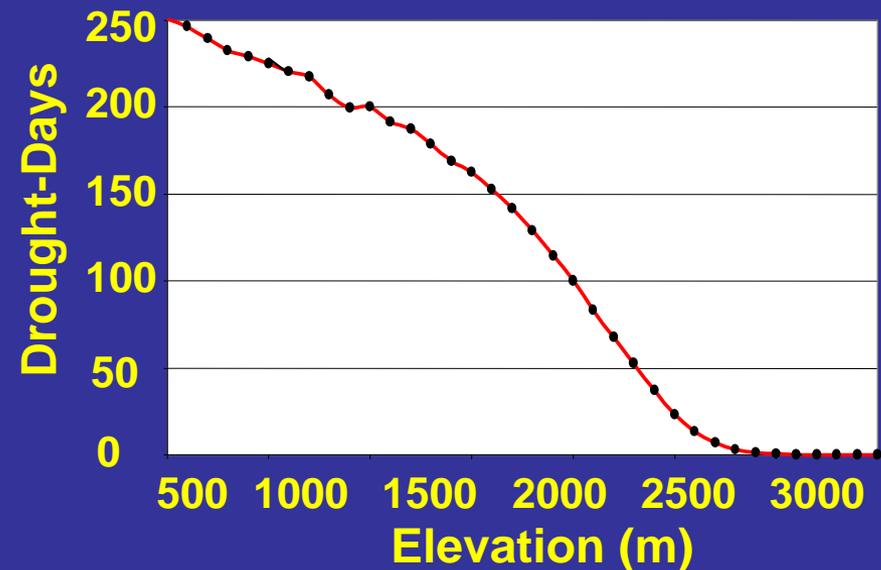


1. How does length of fire season vary over elevation?



- **FACET** (*Urban, D.L. et al. 2000*)

- Drought-day function
- Historic weather data



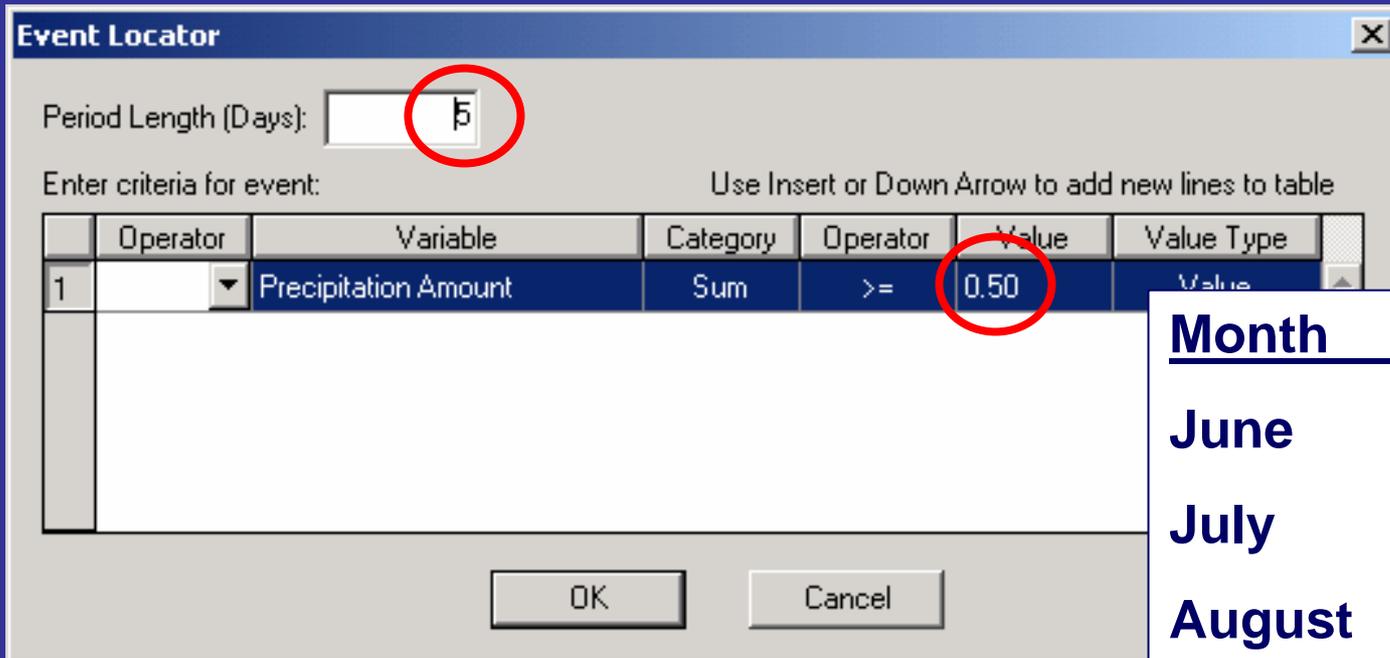
- Scaled to fire season (4 months)
- Proxy for season variation

2. How frequently does the area experience a fire-stopping event?

- **Fire Family Plus: Event Locator**

- 0.5 in. rain w/in 5 days (Latham, D.J. and Rothermel, R.C. 1993)

- **Compute mean monthly frequency**



The image shows a software dialog box titled "Event Locator". It has a "Period Length (Days)" field with the value "5" circled in red. Below this is a table for "Enter criteria for event:" with columns for "Operator", "Variable", "Category", "Operator", "Value", and "Value Type". The first row contains a dropdown arrow, "Precipitation Amount", "Sum", ">=", "0.50" (circled in red), and "Value". At the bottom are "OK" and "Cancel" buttons.

<u>Month</u>	<u>Frequency</u>
June	2.43
July	1.29
August	1.40
September	1.25



3a. Where and when are ignitions?

- **Historic ignition data**

From NIFMID (1986 - present), separated into month of occurrence

- **Calculate ignition density**

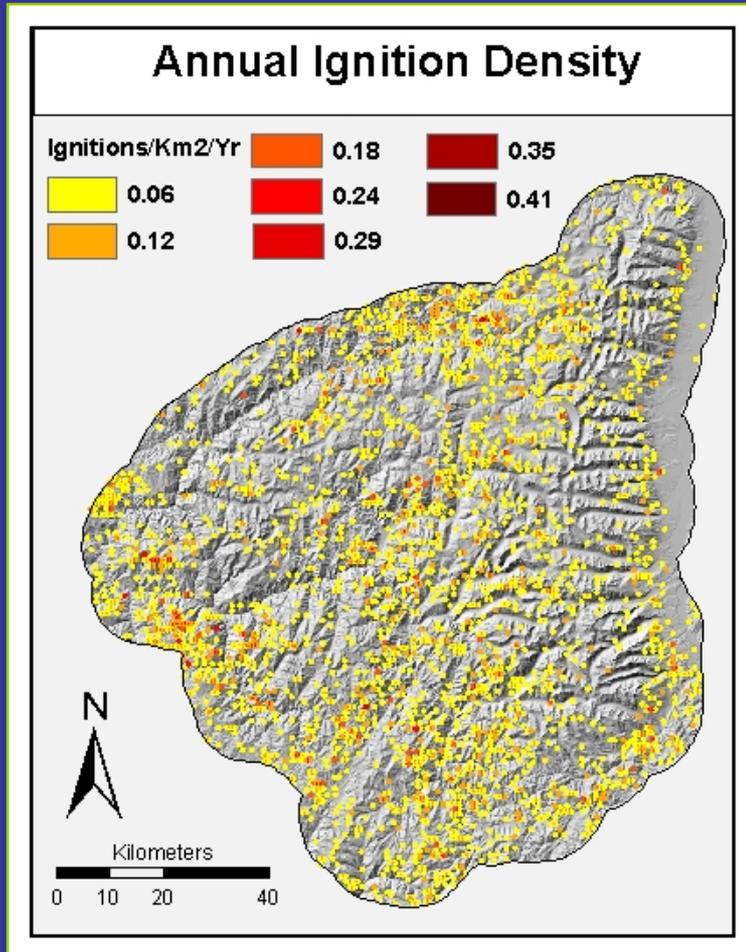
Arc POINTSTATS, search radius 564m, divided by #years of data

- **Create up to 5 density classes per month**

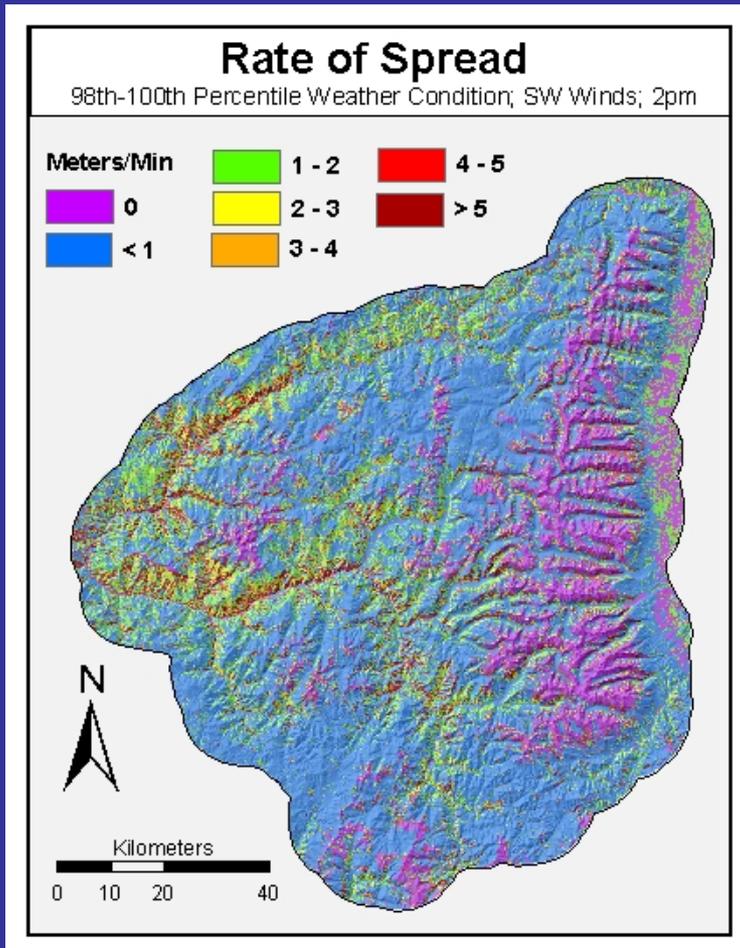
1, 2, 3, 4, 5+ per km² per year

- **Create up to 20 ignition grids: 4 months x 5 classes**

Month & density class will allow weighting of probability results



3b. How fast can fire spread?



- **ROS from FlamMap**

Snapshot of expected fire behavior

Current fuels

Constant wind

Constant fuel moistures conditioned under specified weather conditions

- **Static Conditions = Multiple Runs**

Wind direction (8)

Fuels conditioned with percentile weather defined using FireFamily+ (4)

- **Create up to 32 ROS grids:
8 wind directions x 4 weather classes**

Wind direction & weather class will allow weighting of probability results



Additional detail: conditioning fuels

FireFamily+ to compute Spread Component index and weather parameters associated with selected percentile weather conditions

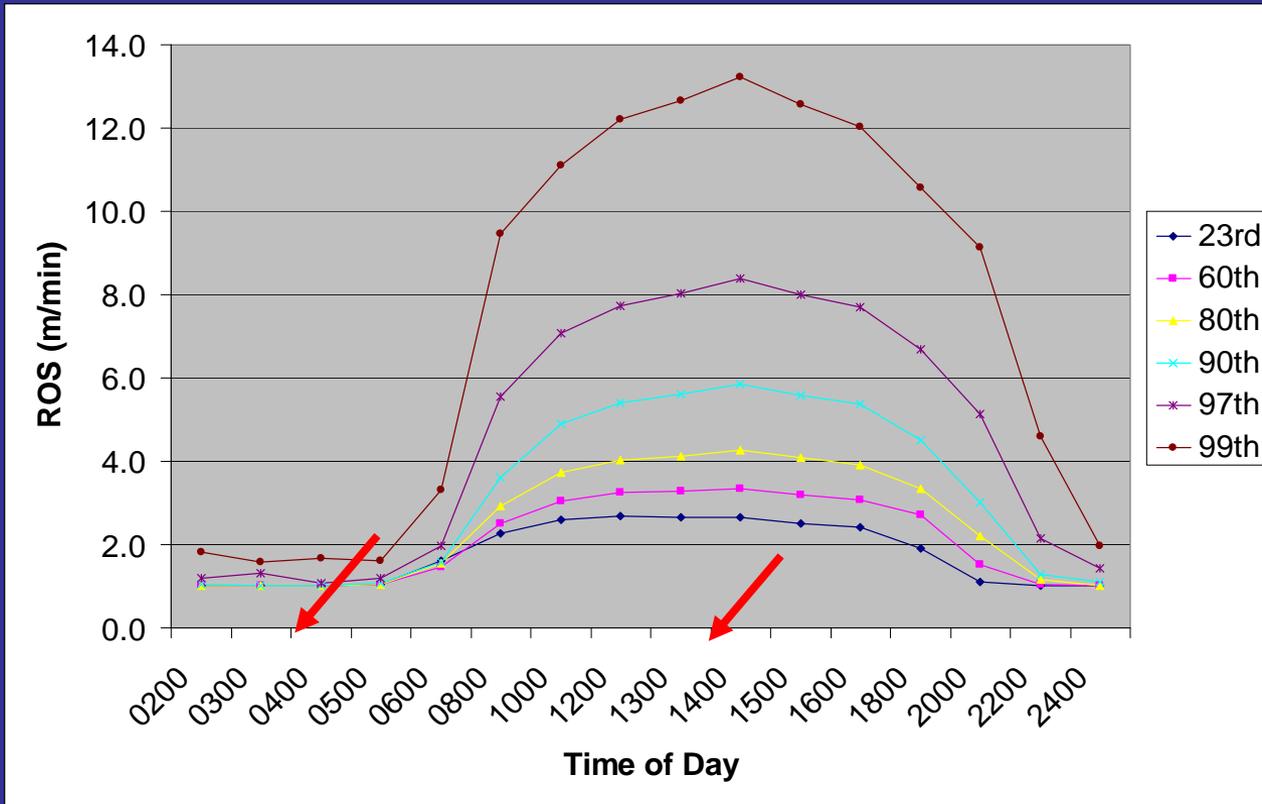
Average daily Rhmin, Rhmax, Tmin, Tmax, and wind speed used in FlamMap's .WTR and .WND files to condition fuels

The screenshot shows the FireFamily Plus software interface. The main window is titled "FireFamily Plus - [gila.mdb - Working Set]". The "Run: 0-15" dialog box is open, showing the "Inputs" tab. The "Run Name" is "0-15". The "Fuel Moisture Files" section shows "Fuel Moisture File (*.fms): C:\Projects\BurnPro\SEKI\fla...\0-15.fms" and "Use Custom Fuels (*.fmd) C:\Projects\Bu...\SSGIC_CustomFuel.fmc". The "Winds" section has "Wind Direction" selected, with "Wind Speed (MPH @ 20')" set to 4 and "Azimuth (Degrees)" set to 0. The "Canopy Characteristics" section has "Height(m): 15", "Crown Bulk Density(Kg/m3): 0.2", "Crown Base Height(m): 5", and "Foliar Moisture Content (%): 100". The "Fuel Moisture Settings" section has "Use Fuel Moisture Conditioning" selected, with "Weather File (*.wtr): C:\Projects\BurnPro\SEKI\flammap...\0-15.wtr" and "Wind File (*.wnd): C:\Projects\BurnPro\SEKI\flam...\0-15.WND". The "Fuel Moisture Conditioning Period" section is circled in red, showing "Start" as 7/ 2/2004 at 2:00:00 PM and "End" as 7/ 8/2004 at 2:00:00 PM. The "Launch" button is disabled, and the "OK" button is highlighted. The status bar at the bottom shows "Inputs OK", "2 outputs selected", and "Existing outputs out of date".



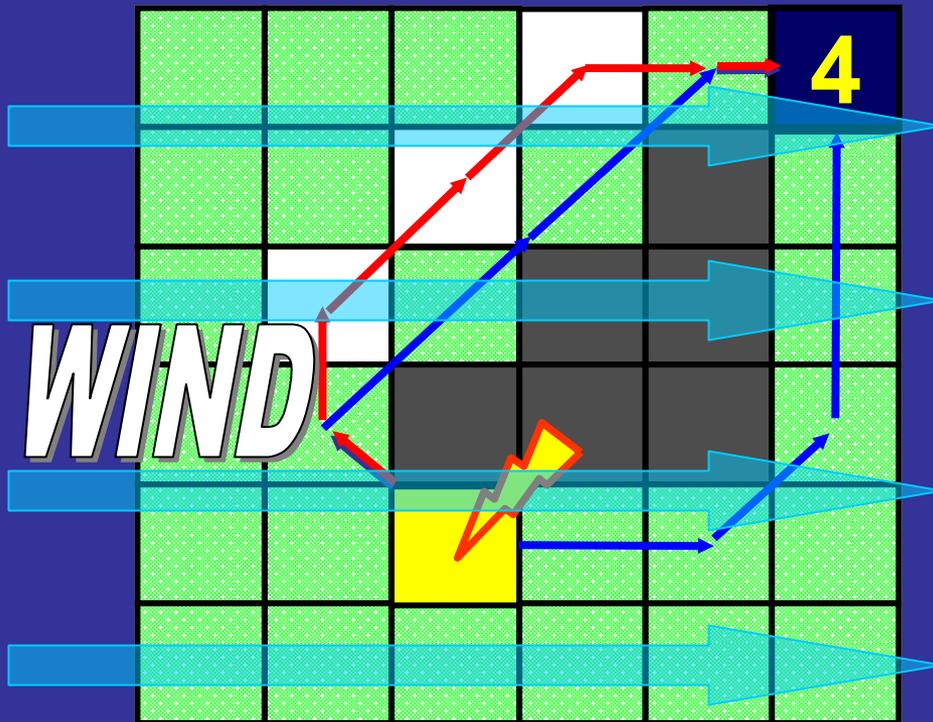
Additional detail: diurnal variation

Averaged ROS for conditioning periods ending at 4am and 2pm



3. How many days for fire to spread to each point?

- **PATHDISTANCE** – Least Accumulative ~~Cost Distance~~
Spread Time



- Rock
- “Slow” fuels (e.g., timber)
- “Fast” fuels (e.g., grass)

-“Source” grid = ignition grid

Up to 20 of these: 4 months x 5 density classes

-“Cost” grid = Time = $1/\text{ROS}$

32 of these: 4 weather conditions x 8 wind directions

-**Cumulative Spread Time**

Up to 640 of these: 20 source grids x 32 cost grids (e.g., June ignitions, density class 1, ROS for 90th percentile weather and winds from west.)

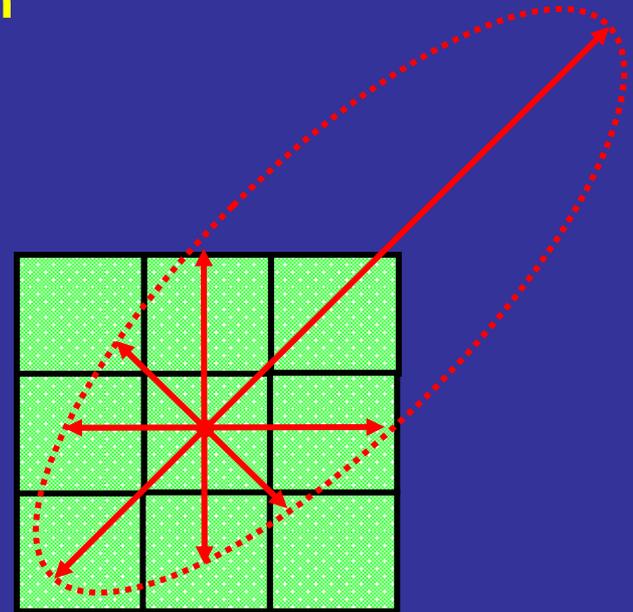


Additional detail: spread direction

ROS values apply to the direction of **maximum** spread.

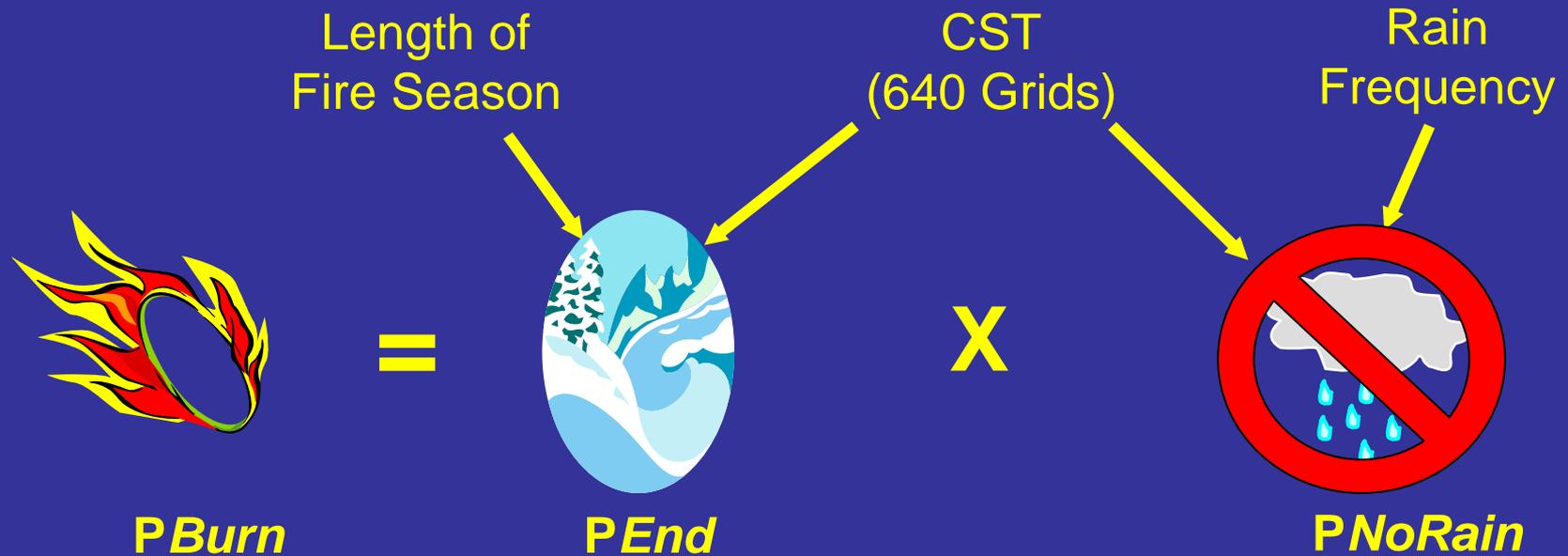
We use **Maximum Spread Direction** (from FlamMap) and a table of **adjustment factors** (Anderson 1983) to account for different spread rates in heading, backing and flanking directions

Factors vary with **windspeed**



Direction Max ROS = 45 degrees		
	Adj factor	Adj factor
<u>Direction</u>	<u>2 mph wind</u>	<u>6 mph wind</u>
45 (max)	1.00	1.00
75	0.74	0.47
105	0.53	0.28
135	0.43	0.21
175	0.36	0.16

CST to compute P_{End} and P_{NoRain}



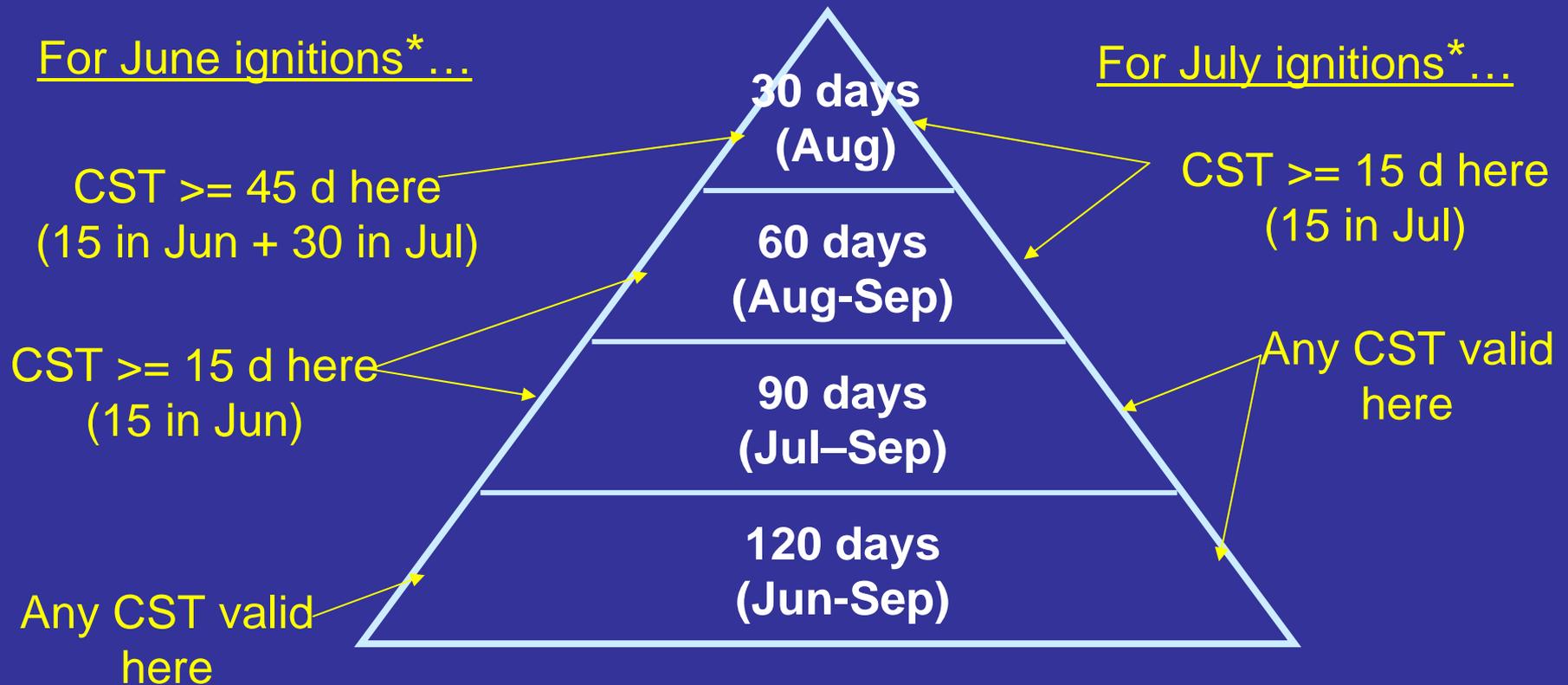
640
Probability
Grids

$$P_{End} = \exp \left[- \left(\frac{CST}{\text{season length}} \right)^n \right]$$

$$P_{NoRain} = 1 - P_{Rain}$$



Additional detail: timing of fire season and spread time



* For simplicity, ignitions assumed to occur mid-month

Average Annual Probability of Burning

