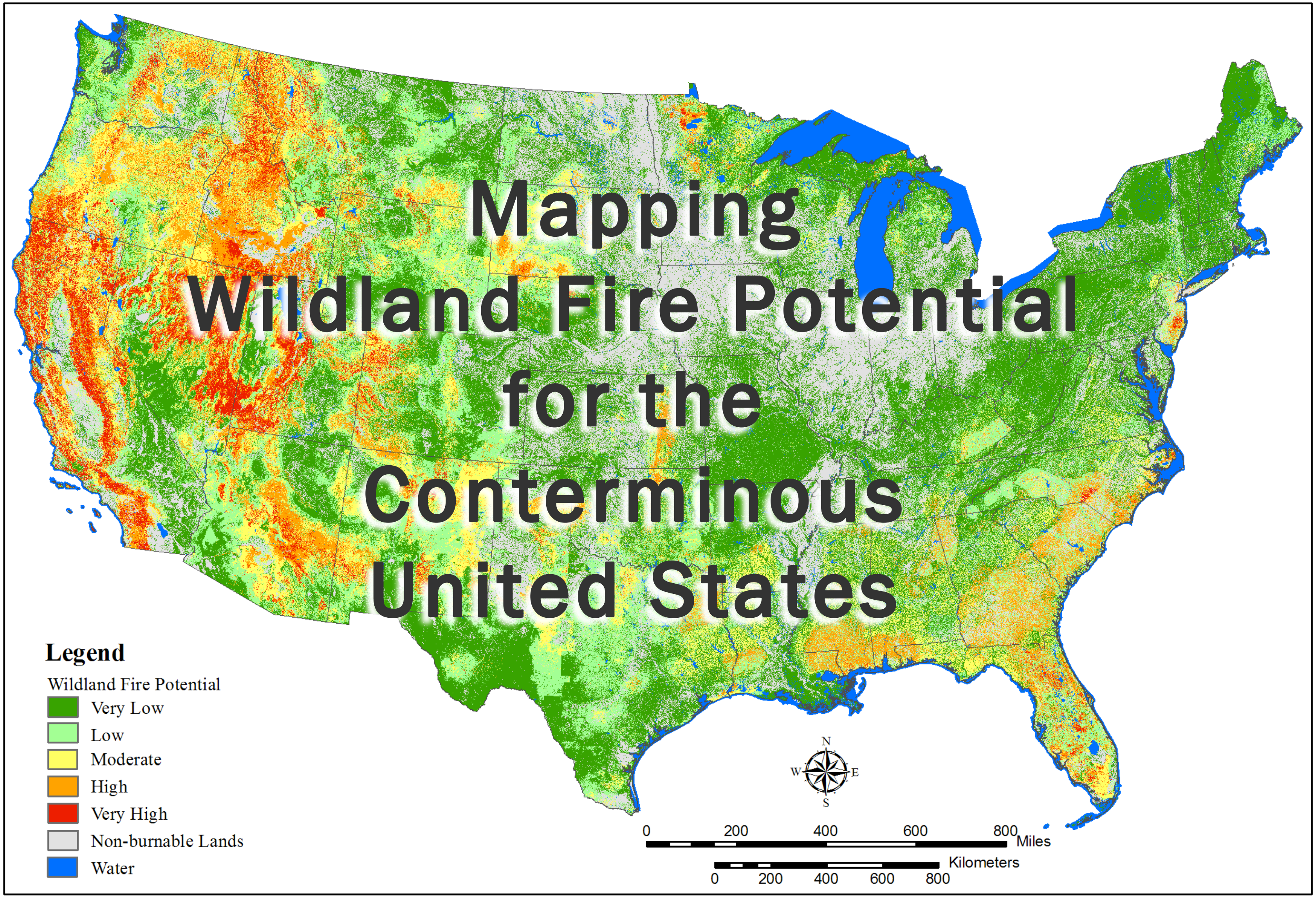
Mapping Wildland Fire Potential for the Conterminous United States



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[1] USDA Forest Service, Fire Modeling Institute, Missoula, MT
[2] USDA Forest Service, Fire and Aviation Management, Washington, D.C.

Wildland Fire Potential: The Basics

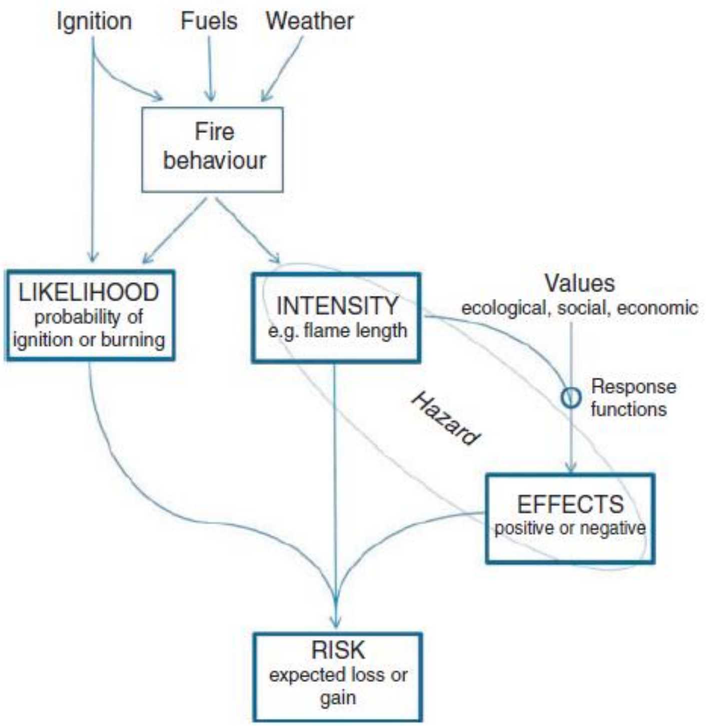
- What is the Wildland Fire Potential Map?
  - The wildland fire potential (WFP) map is a raster geospatial product for the conterminous United States (CONUS) at 270m resolution.
  - The specific objective of the WFP is to depict the relative potential for wildfire that would be difficult for suppression resources to contain, based on past fire occurrence and estimates of wildfire likelihood.
  - Areas with higher WFP values represent fuels with a higher probability of experiencing high-intensity fire with torching, crowning, and other forms of extreme fire behavior under conducive weather conditions.

Wildland Fire Potential: The Basics

- What are the intended uses of the WFP map?
  - Analyses of wildfire risk or hazardous fuels prioritization at large landscapes (100s of square miles) up through regional and national scales.
  - On it's own WFP is not an explicit map of wildfire threat or risk; it includes no information on effects of wildfire on specific values.
  - Paired with spatial data depicting highly valued resources, it could be used to create value-specific risk maps.

Wildfire Risk Analysis: Where does WFP fit in?

- The Large Fire Simulator (FSim; [Finney et al. 2011]) produces estimates of the probabilistic components of wildfire risk for FPA.
  - Likelihood: FSim Burn Probability
  - Intensity: FSim Fire Intensity Levels



From Miller, C. and Ager, A. 2012. A review of recent advances in risk analysis for wildfire management. International Journal of Wildland Fire . http://dx.doi.org/10.1071/WF11114.

Wildfire Risk Analysis: Where does WFP fit in?

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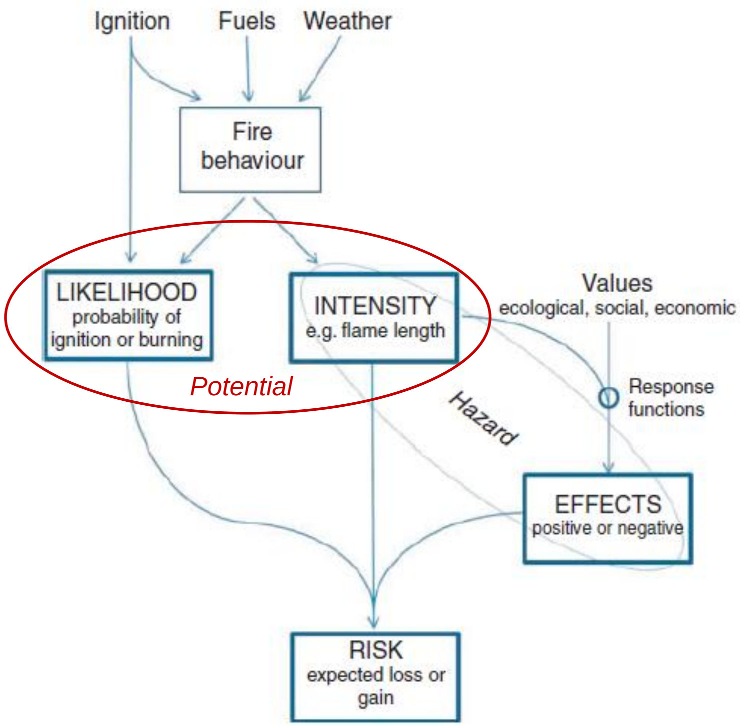
  - Likelihood: FSim Burn Probability
  - Intensity: FSim Fire Intensity Levels
- For WFP, we integrate estimates of likelihood and intensity
- We build upon the FSim products to provide additional information to managers, policy makers, and others



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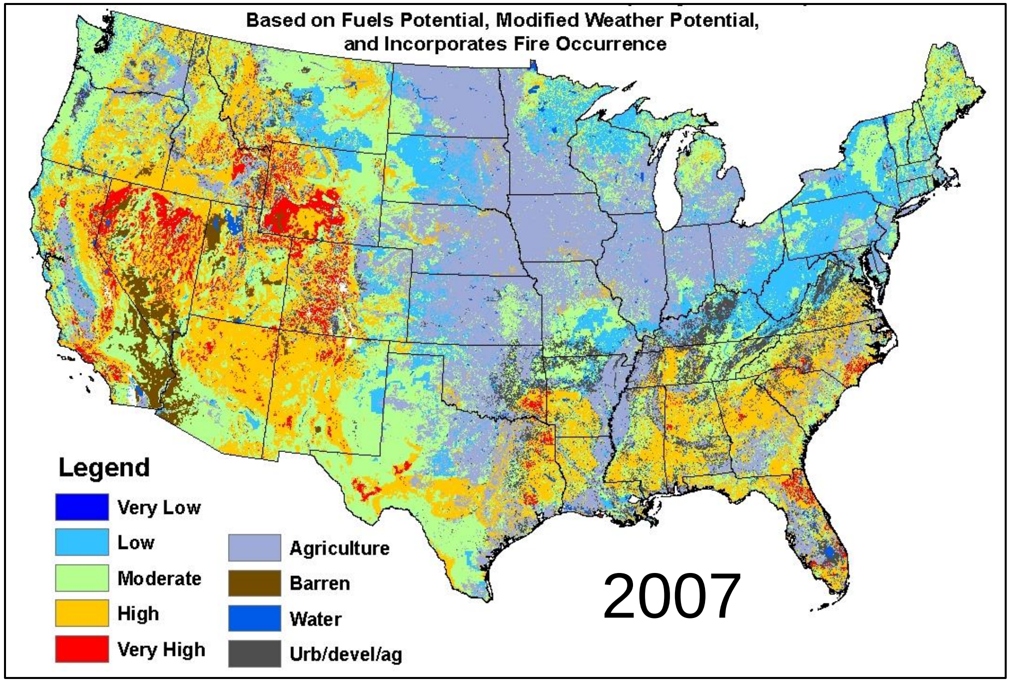
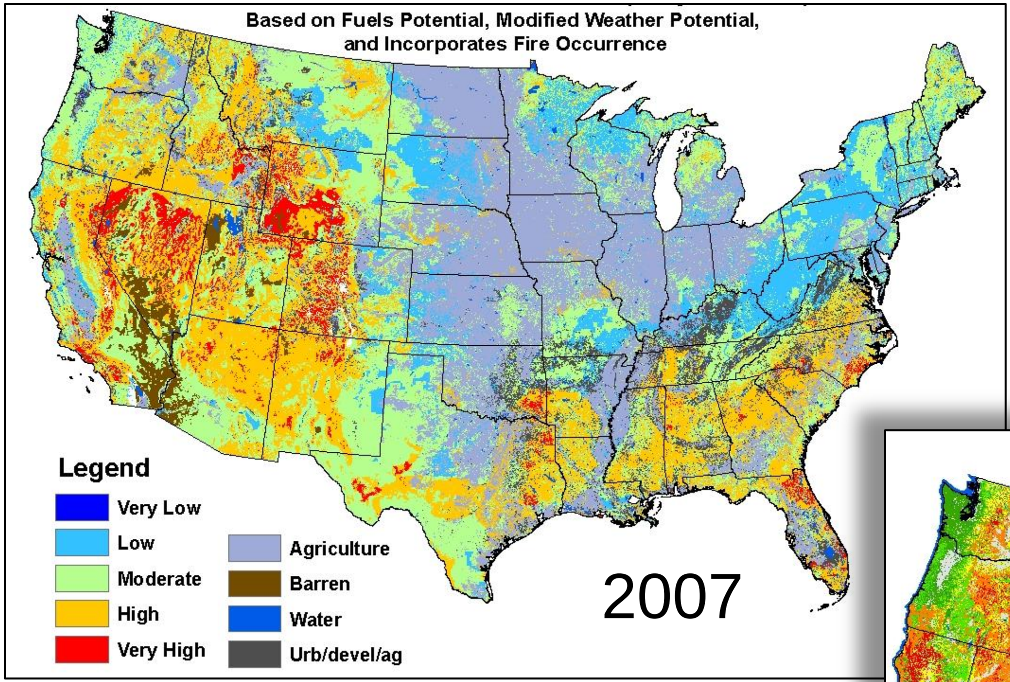
Wildland Fire Potential: The History



- First version was created in 2007 (Menakis 2008)
- Prior to LANDFIRE fuels data and the development of FSim
- Used various land cover, fuels, weather, and fire occurrence inputs

Wildland Fire Potential: The History



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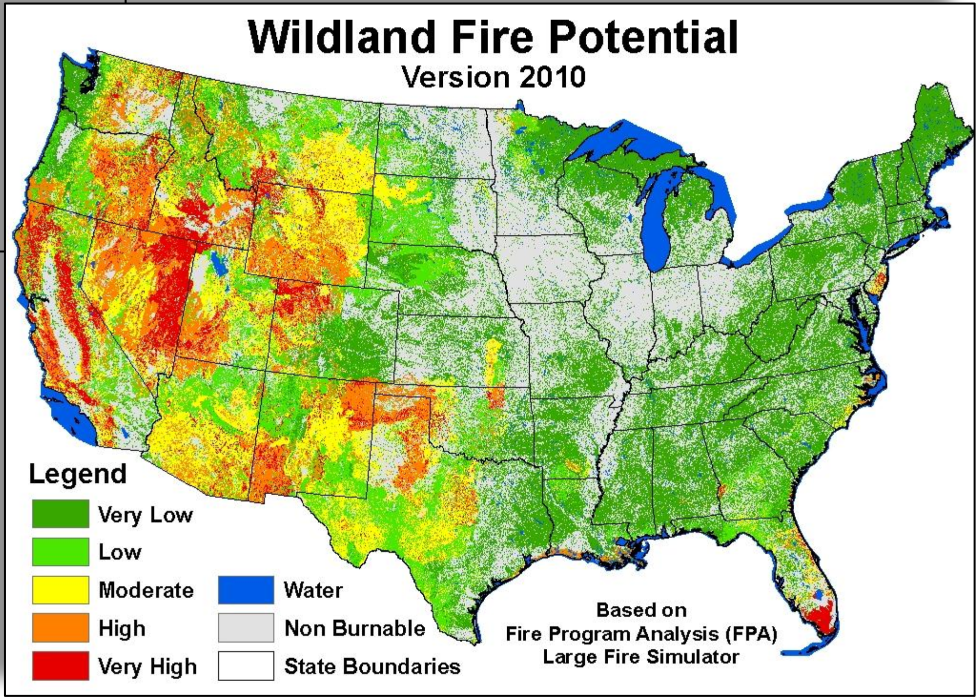
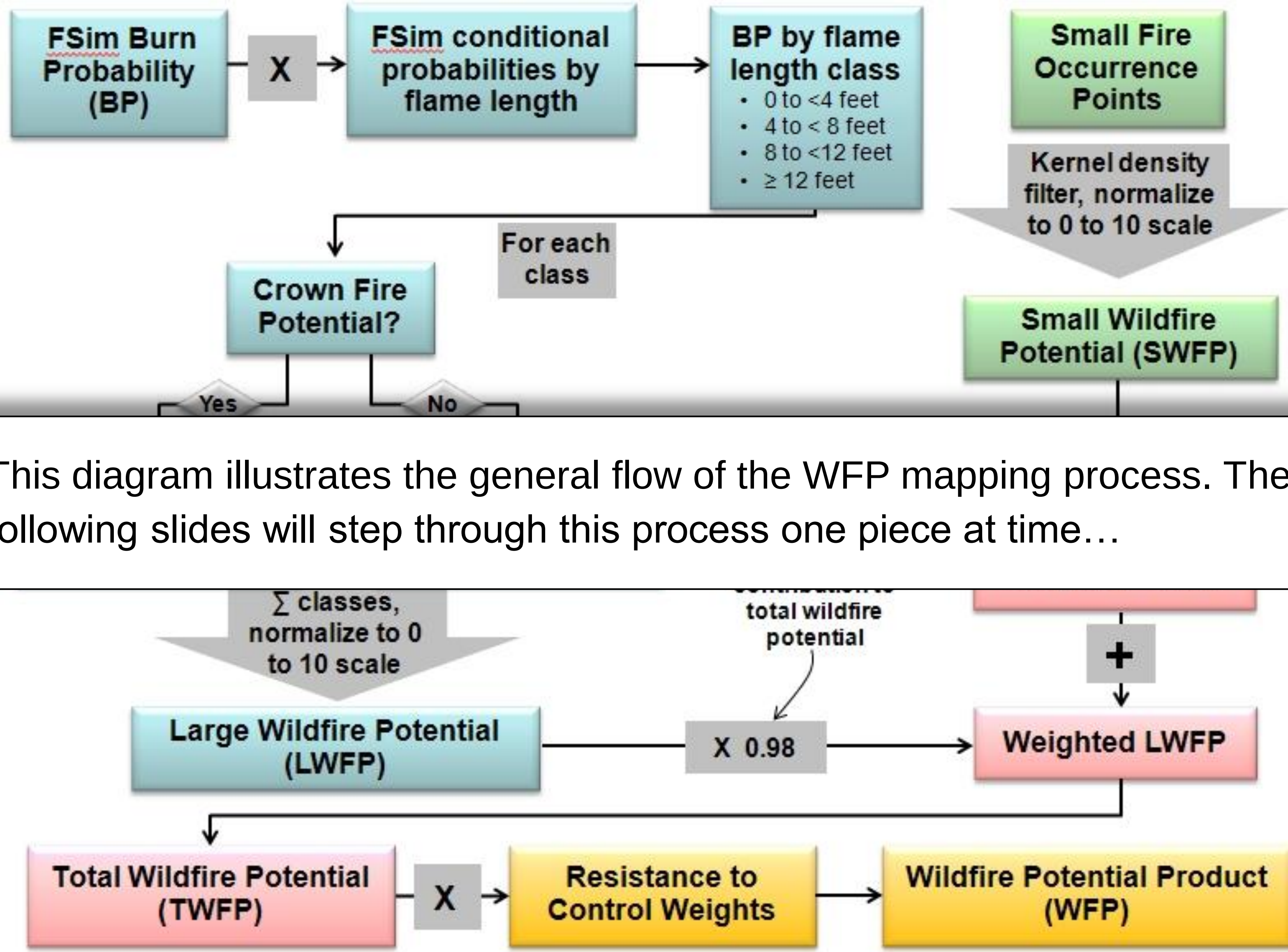


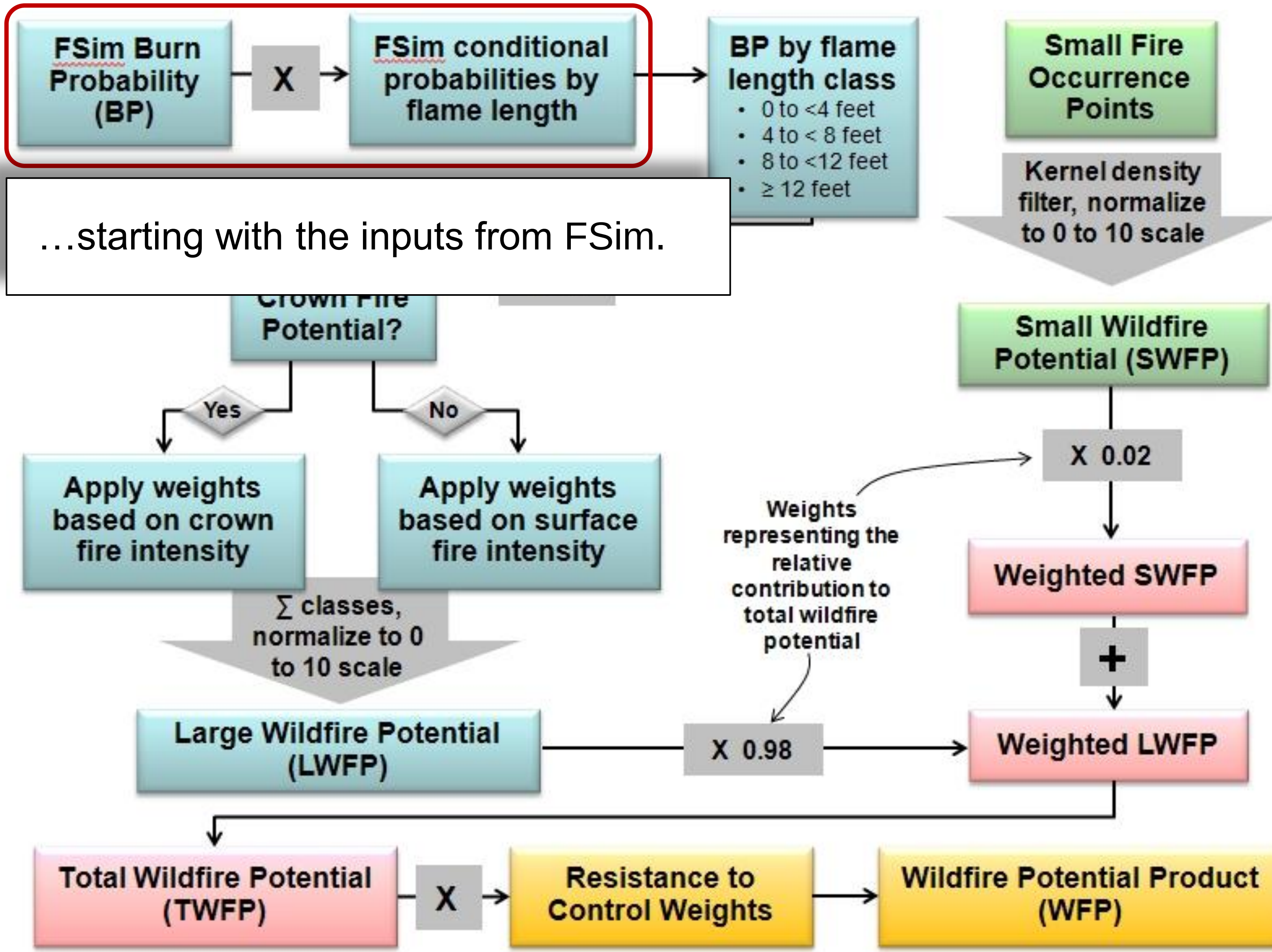
- 2010 version was created from the first set of national outputs from FSim
- Cannot directly compare these two versions due to significant differences in inputs and methods

Wildland Fire Potential 2012: Methods



This diagram illustrates the general flow of the WFP mapping process. The following slides will step through this process one piece at time…

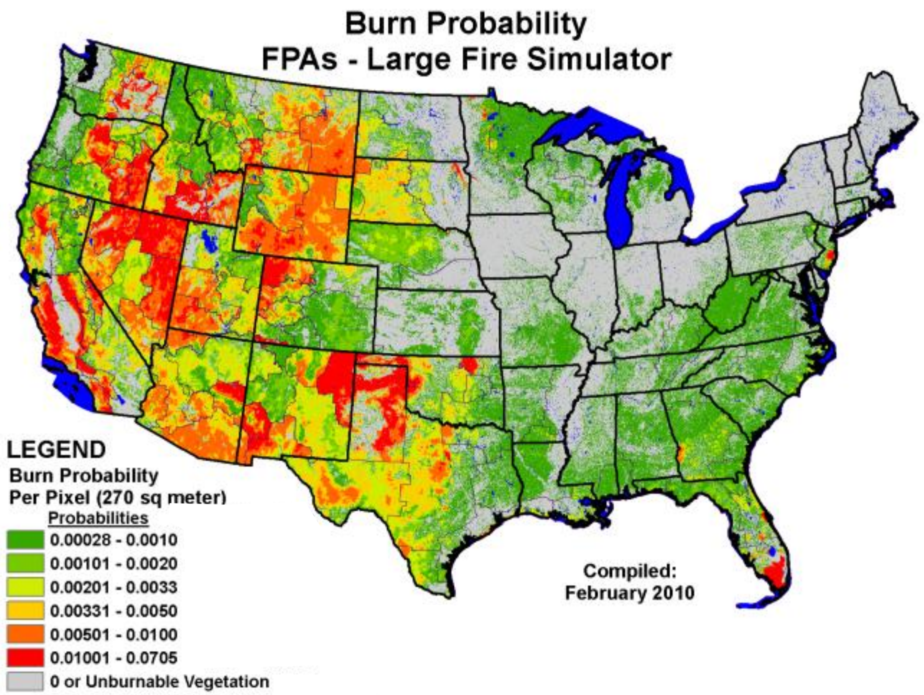
Wildland Fire Potential 2012: Methods



…starting with the inputs from FSim.

FSim Burn Probability (BP)

2010



- 2010 was the first time FSim had been run for all Fire Planning Units (FPUs) nationally.
- Burn probabilities were not calibrated between FPUs and seam lines were evident

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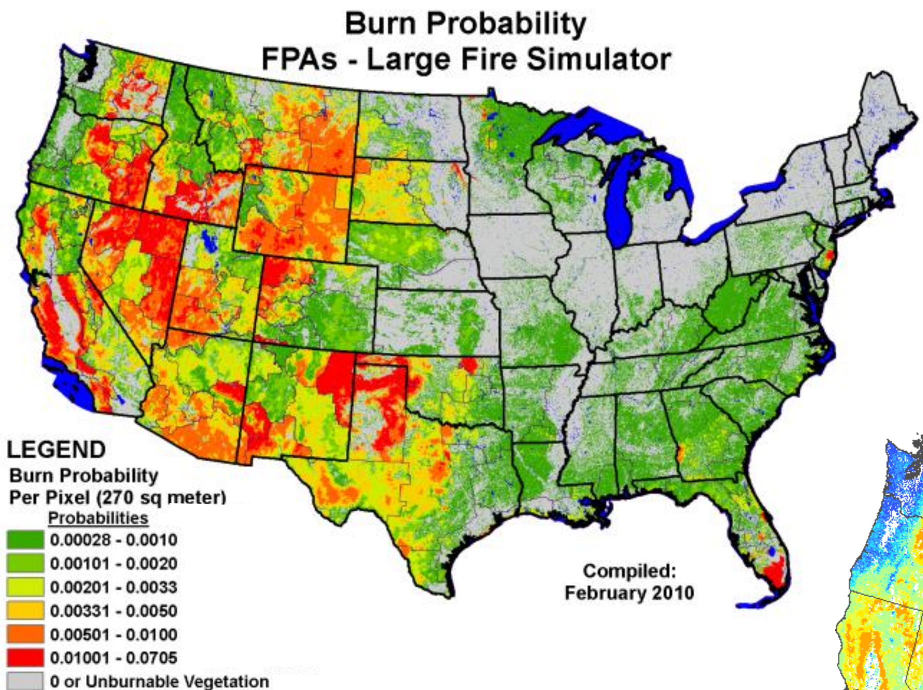

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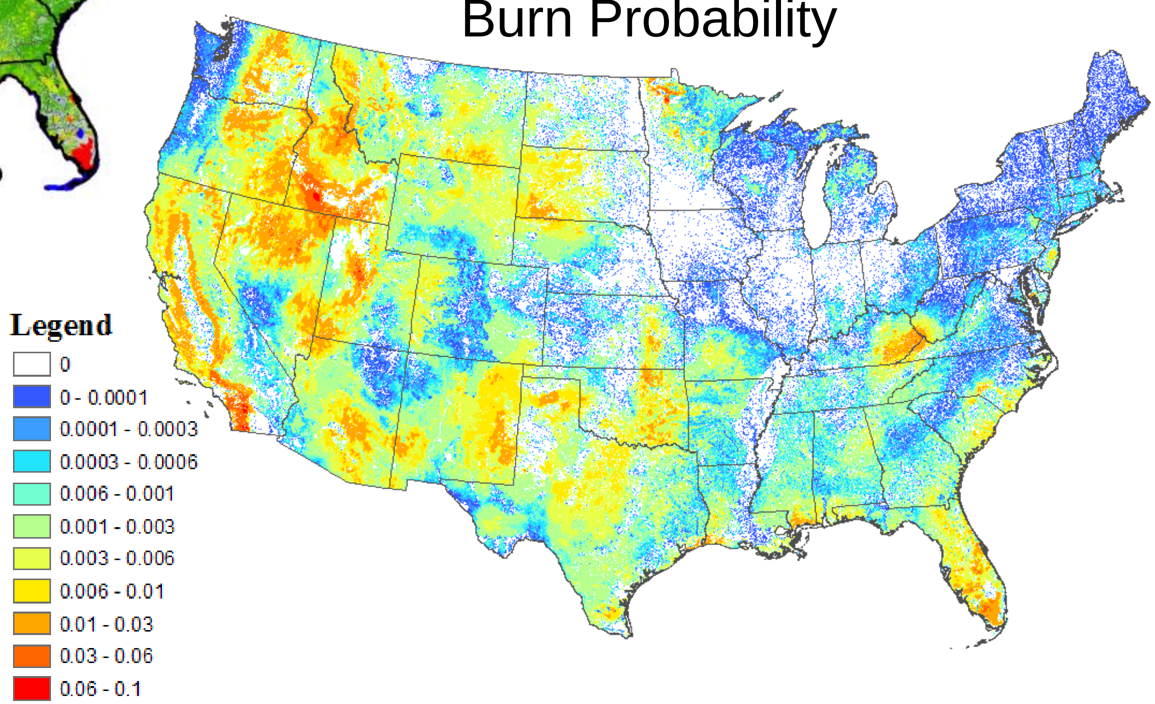
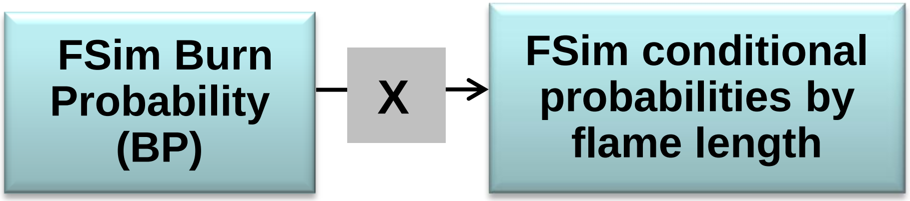
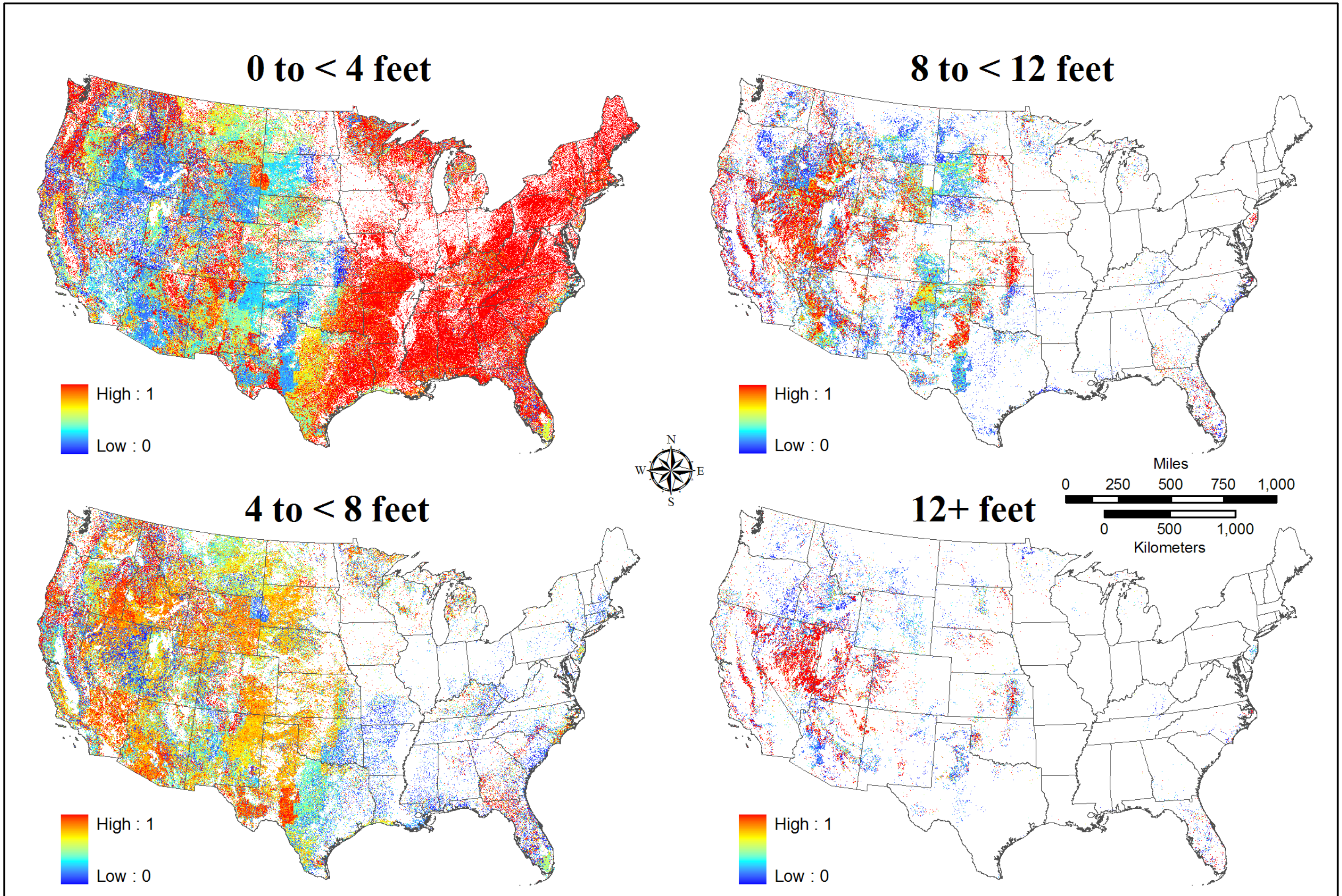
2012 FPA FSim Burn Probability



- FSim modeling improvements and calibration between FPUs led to vastly improved burn probabilities in 2012.
- Updated LANDFIRE data (Refresh 2008) were also used as inputs in 2012.



If a location were to burn, what proportion of the time would it experience a particular flame length?

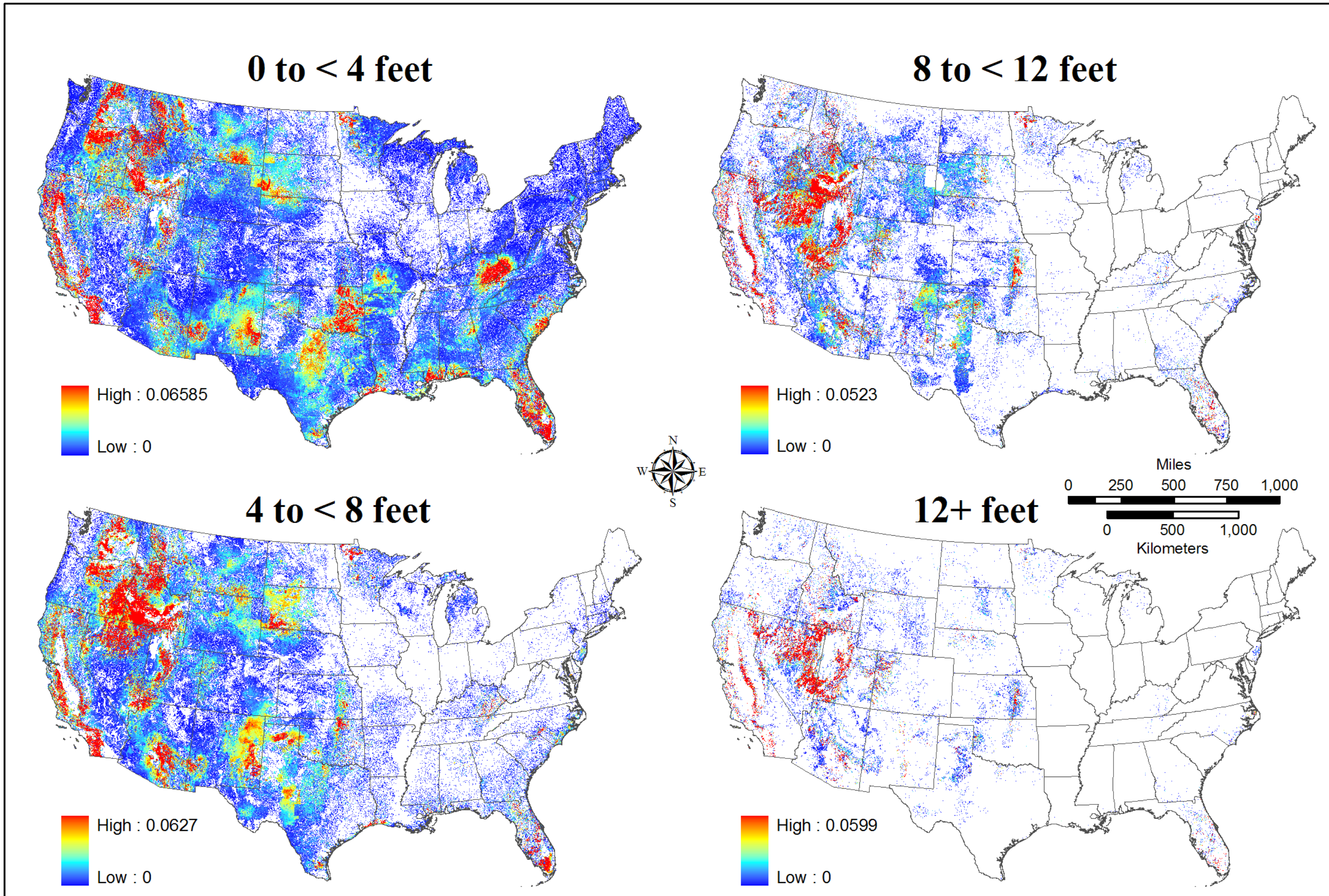


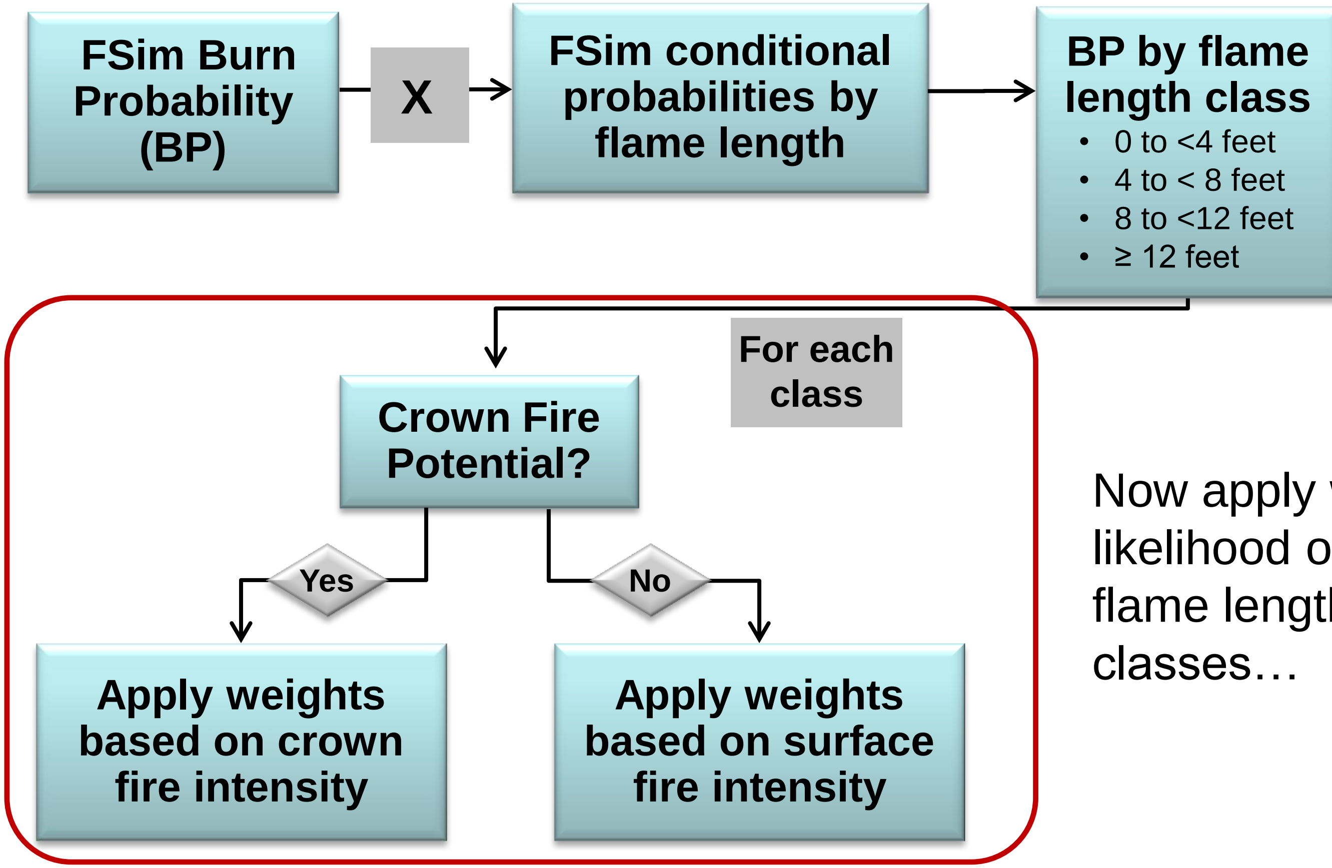
Note: FSim produces outputs in 6 flame lengths (0 to <2ft; 2 to <4ft; 4 to <6ft; 6 to <8ft; 8 to <12ft; 12ft+), which we group into 4 classes

FSim Burn Probability (BP) X **FSim conditional probabilities by flame length** → **BP by flame length class**

- 0 to <4 feet
- 4 to < 8 feet
- 8 to <12 feet
- ≥ 12 feet

Apportion burn probability out to these four flame length classes.





Now apply weights to the likelihood of fire in different flame length (i.e., fire intensity) classes…

Underlying premise:

- Fires with higher flame lengths are “worse” (i.e., the potential hazard is greater because they require more effort to control, may have more ecological impact, etc.), so they should be weighted to come out higher on the wildfire potential output.
- Areas where crown fire is possible are even “worse” (i.e., potential hazard is greater still than areas only having surface fire) so they should be weighted to come out even higher on the wildfire potential output.

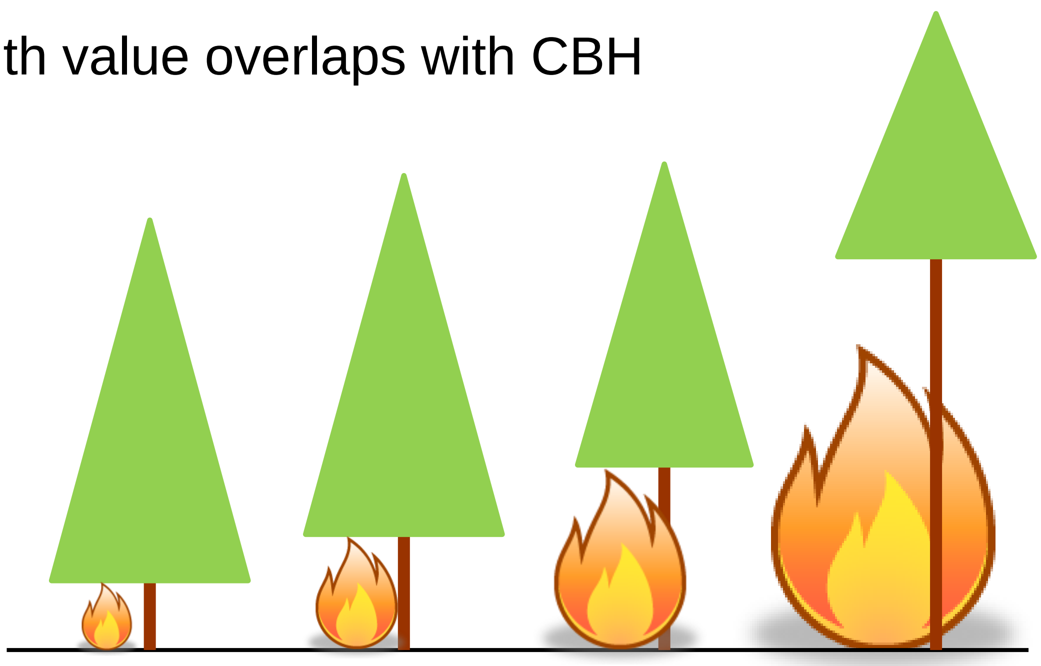
Defining Locations With Forest Crown Fire Potential

For each FSim flame length class above 4 ft., identify LANDFIRE 2008 pixels that meet the following criteria:

- Forest canopy height > 16 ft (5 m)
- Forest canopy cover > 50%

Basic closed forest criteria

- Flame length conditional probability > 0
- The upper flame length value overlaps with CBH



CBH:	<6 ft	<8 ft	<12 ft	<25 ft
FL:	4-6 ft	6-8 ft	8-12 ft	12+ ft

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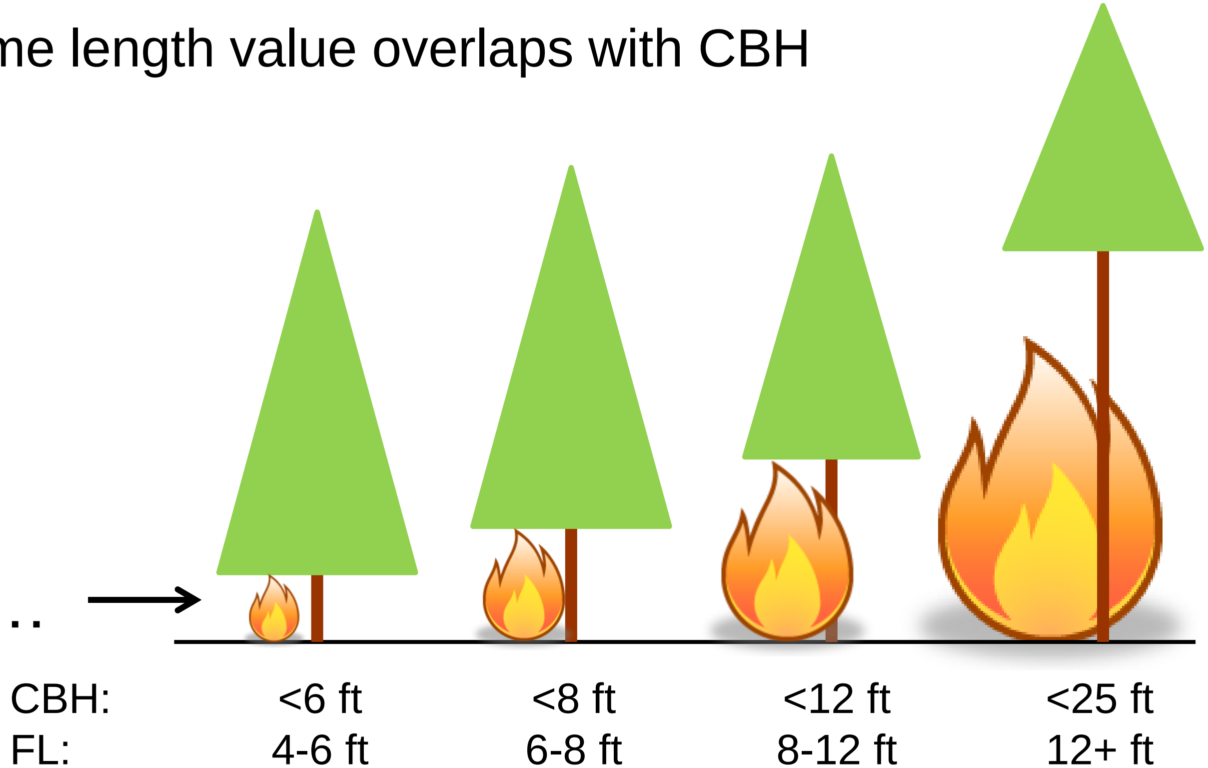
So, where can this…



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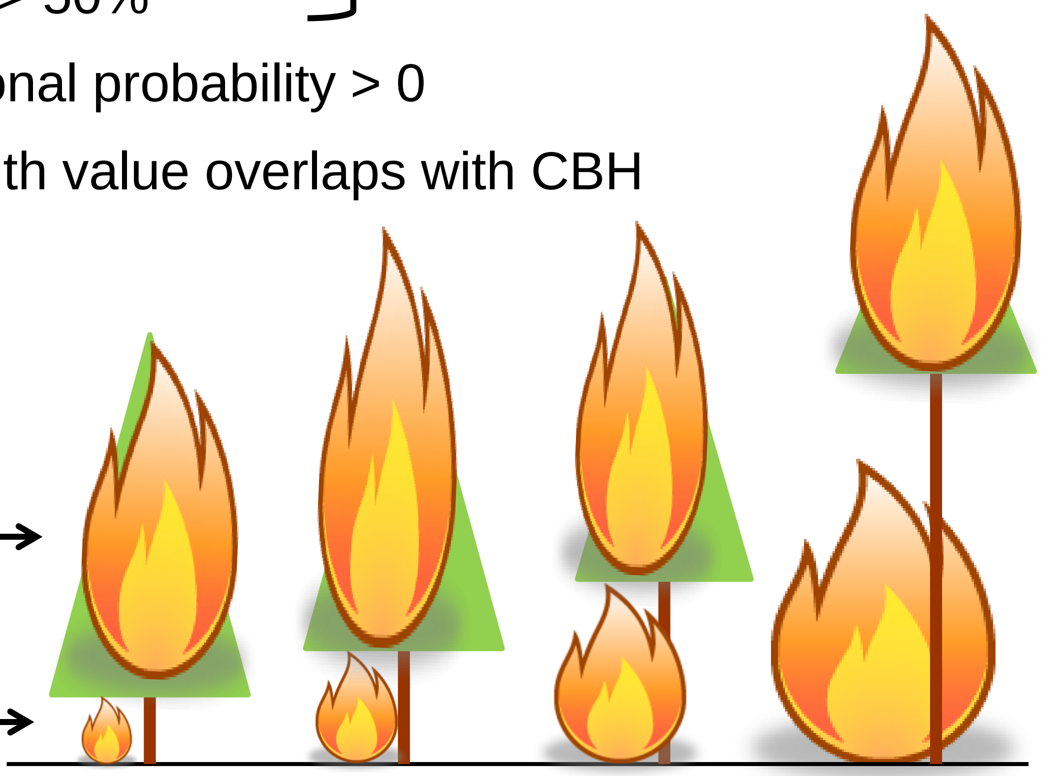
…lead to this?

So, where can this…



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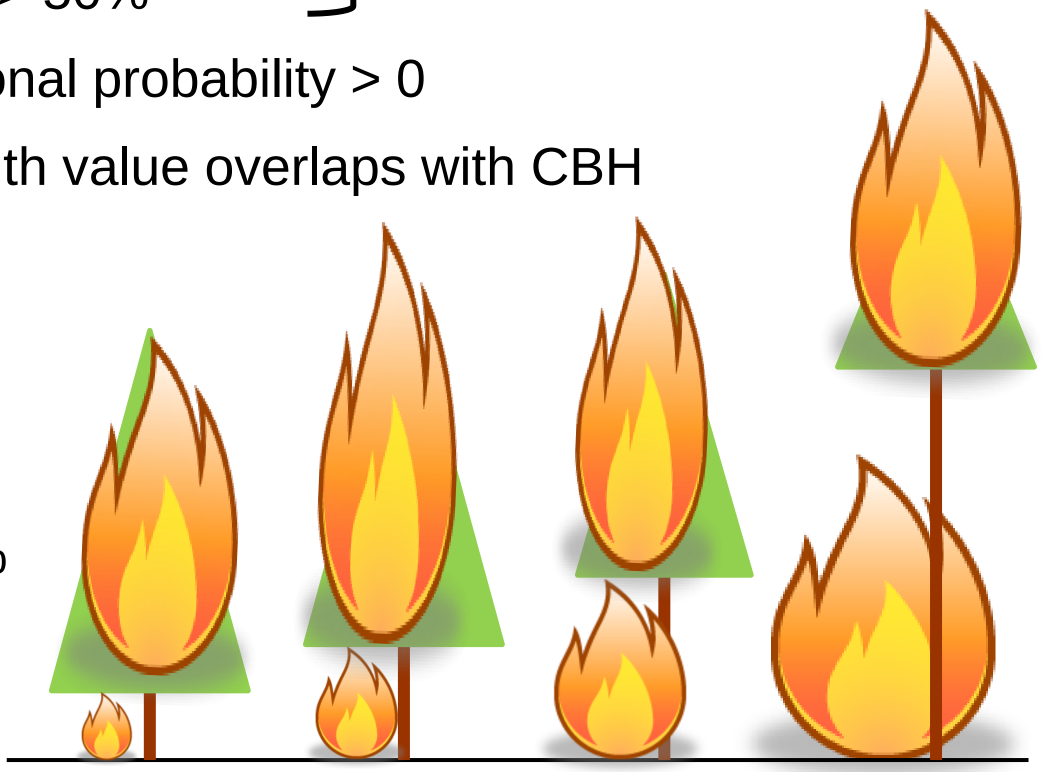
Also chaparral:

- LANDFIRE EVT
- LANDFIRE Shrub Canopy Cover > 30%



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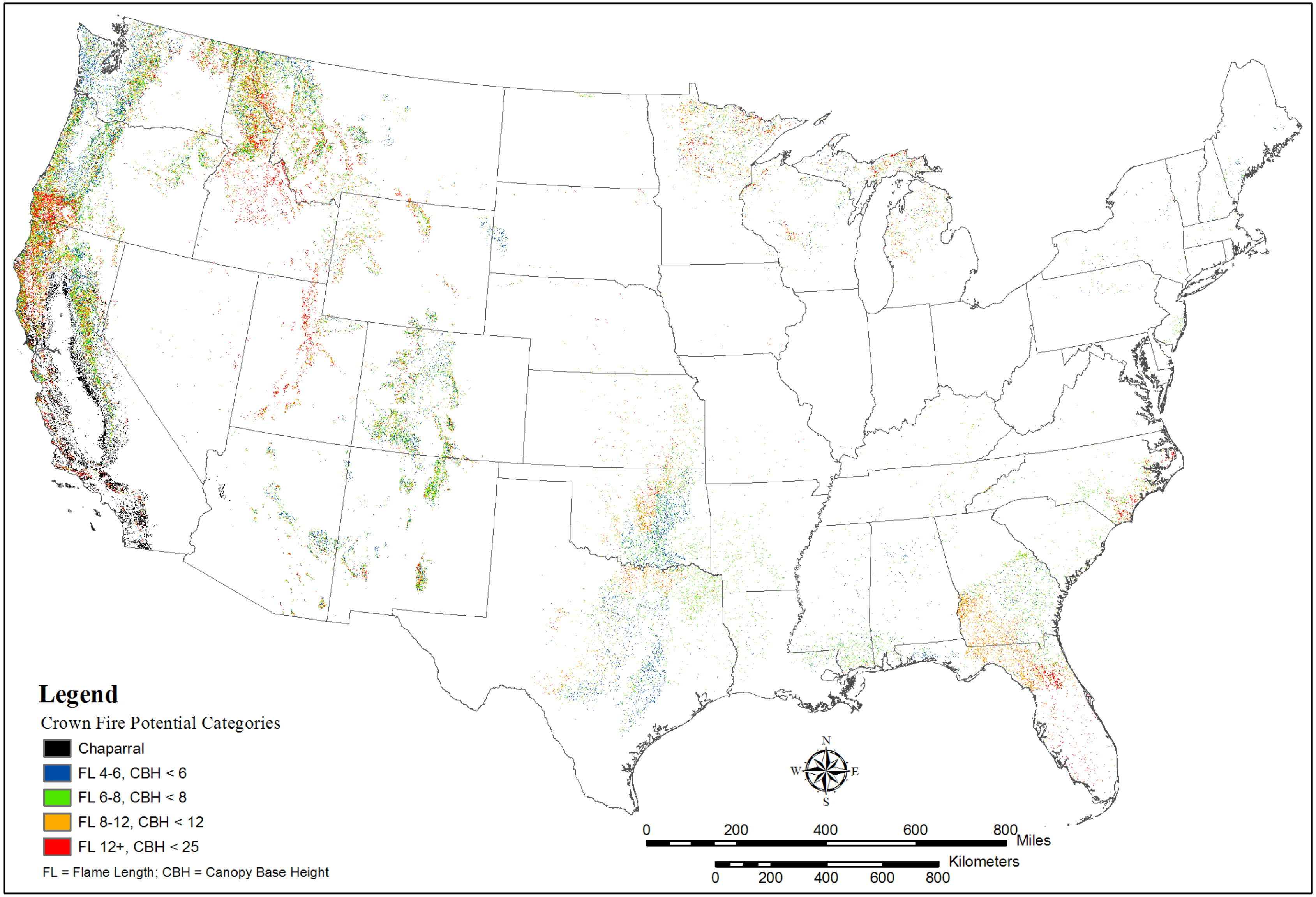
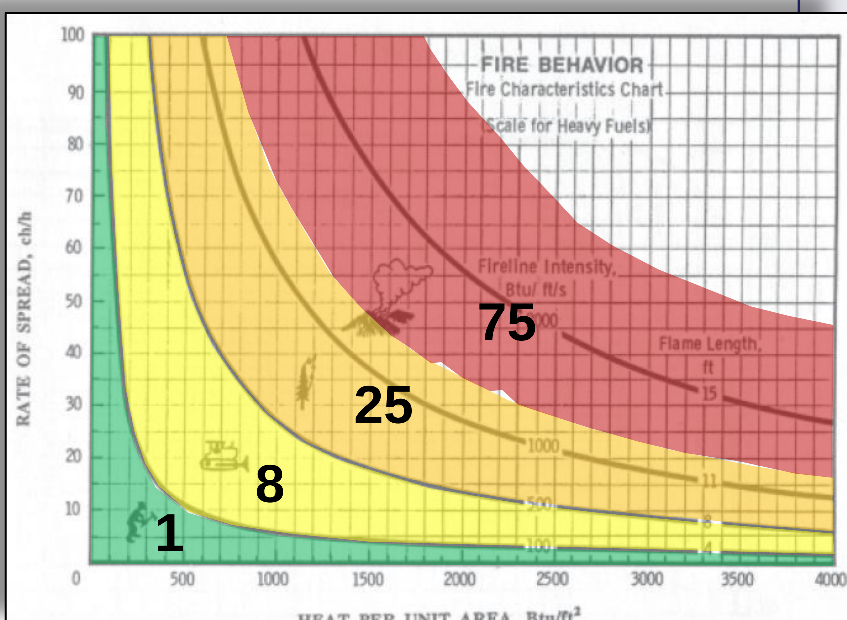


Weighting: No Crown Fire Potential

- To explain how weights were derived, we'll start by describing the logic used in all the areas where we did NOT identify the potential for crown fire (white space on the previous map).

flame length (ft)	fireline intesity (Btu/ft/s)	average intensity	How many "times as intense" as < 4 ft flames?	Weighting used for WFP
1	5.67			
2	25.60			
3	61.82	31.03	1.0	1
4	115.53			
5	187.67			
6	278.95			
7	389.99	243.03	7.8	8
8	521.34			
9	673.48			
10	846.84			
11	1,041.80	770.86	24.8	25
12	1,258.73			
13	1,497.97			
14	1,759.82			
15	2,044.59			
16	2,352.55			
17	2,683.95			
18	3,039.06			
19	3,418.10			
20	3,821.31	2,430.67	78.3	75

Equation relating surface fire flame length to fireline intensity from Byram (1959).



Weighting: No Crown Fire Potential

- As flame lengths (and fireline intensities) increase, fires become increasingly difficult to control.
- We chose to base our weights off of the mathematical relationship between flame length and fireline intensity.

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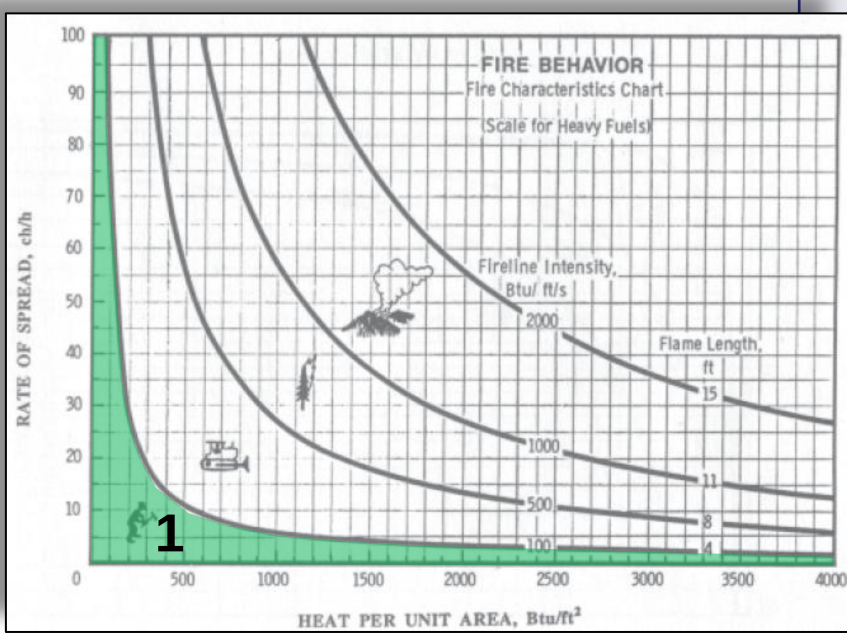
Starting with the 0 to <4ft flame length class, we can calculate the average fireline intensity and that becomes our base for all other weights.

Equation relating surface fire flame length to fireline intensity from Byram (1959).



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				5
18	3,039.06			
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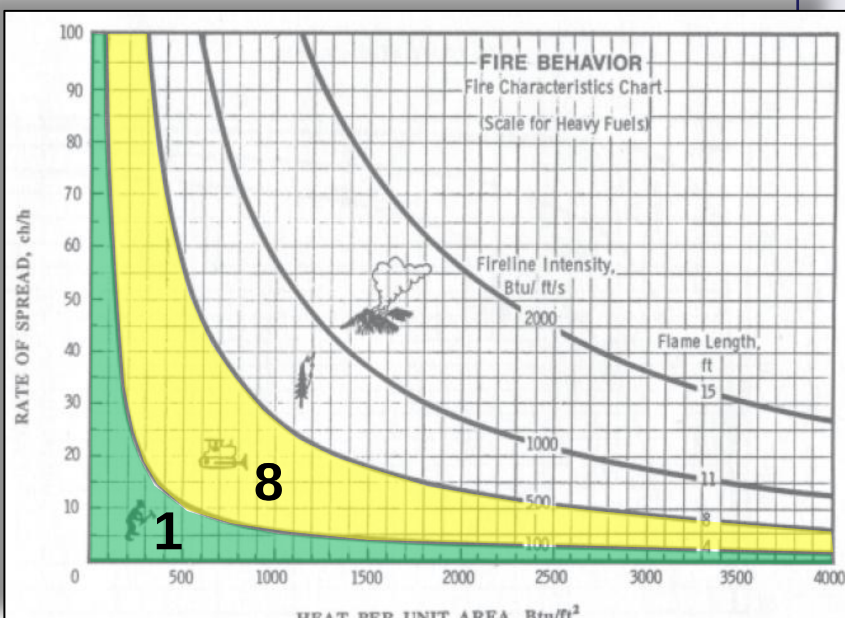
20	3,821.31	2,430.67	78.3	75

Next, we calculate the average fireline intensity for 4 to <8ft flame lengths, and see that it's 8 times our base. Burn probability values in this flame length class are therefore multiplied by 8.

Equation relating surface fire flame length to fireline intensity from Byram (1959).



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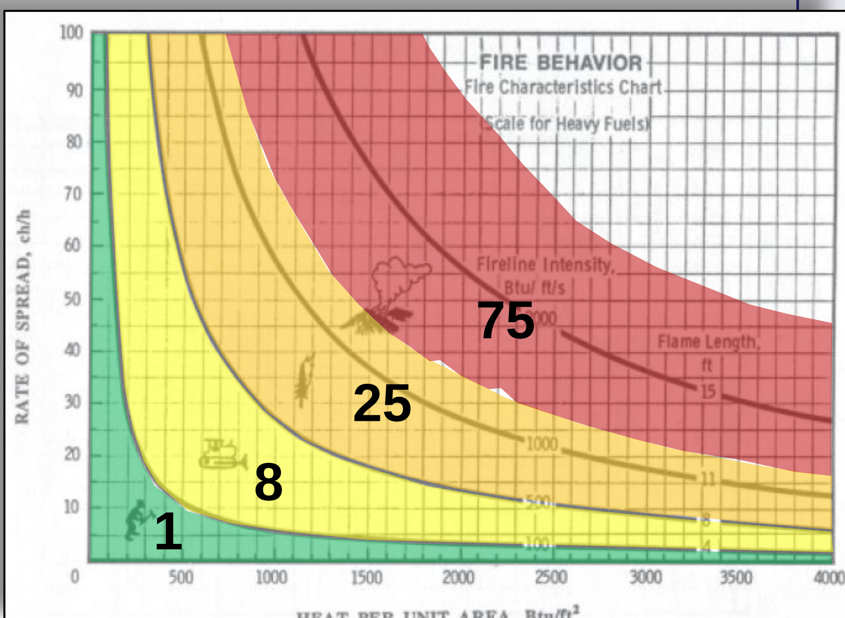
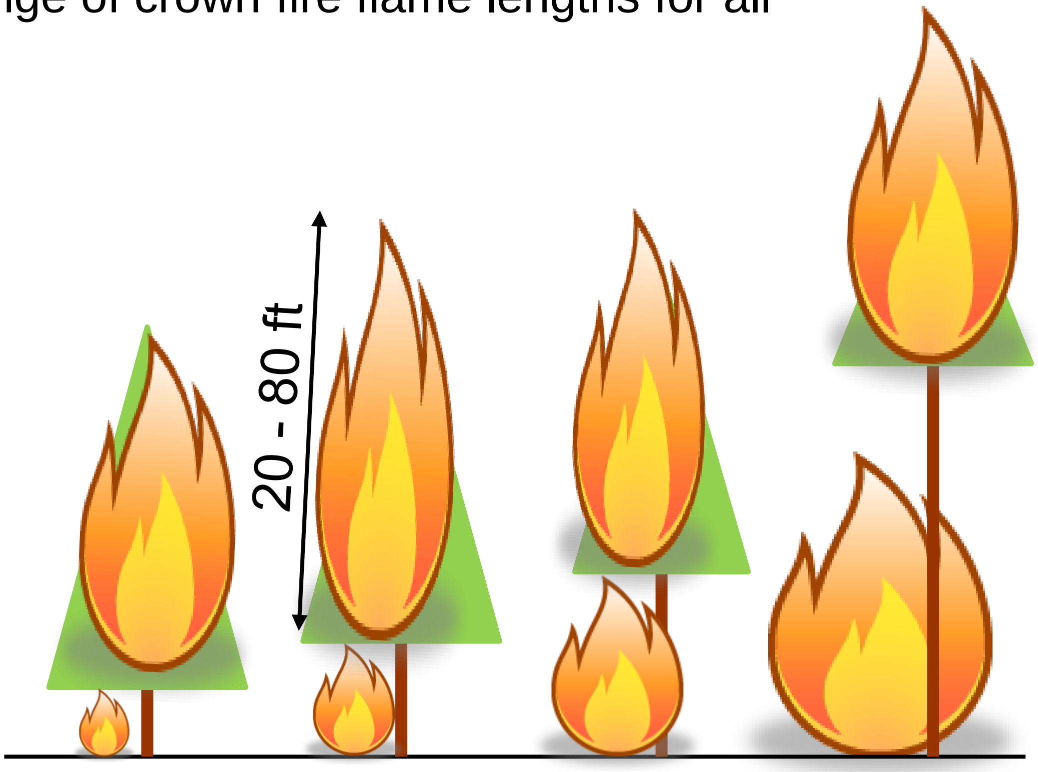


We can apply the same logic to all flame length classes. For 12+ft class, we chose an upper bound at 20ft flame lengths.

Weighting: Crown Fire Potential

- Again, use established relationships between flame length and fireline intensity
- Use equation for crown fire intensity from Thomas (1963)
- Have to assume the same range of crown fire flame lengths for all FSim flame length classes
- Experimented with different ranges… found 20 to 80 feet to produce reasonable results
- Average fireline intensity = 4,075 Btu/ft/s
- Approx. 130 times greater than <4 ft surface flames
- Weight = 130



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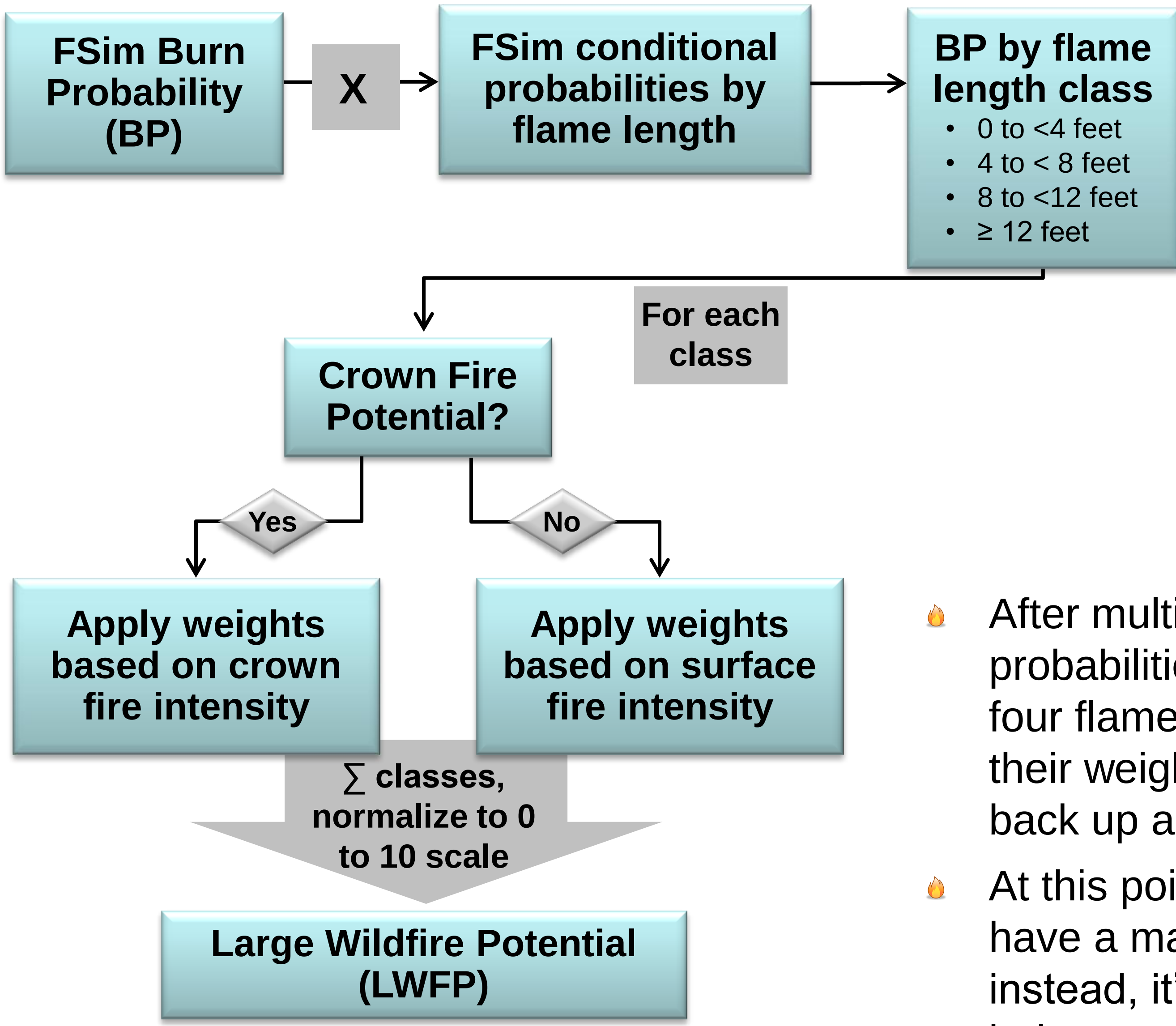


- After multiplying burn probabilities in each of our four flame length classes by their weights, we stack them back up and add them.
- At this point, we no longer have a map of probabilities; instead, it's simply a relative index combining likelihood and intensity of large fires.

FSim Burn Probability (BP)

X

FSim conditional probabilities by flame length

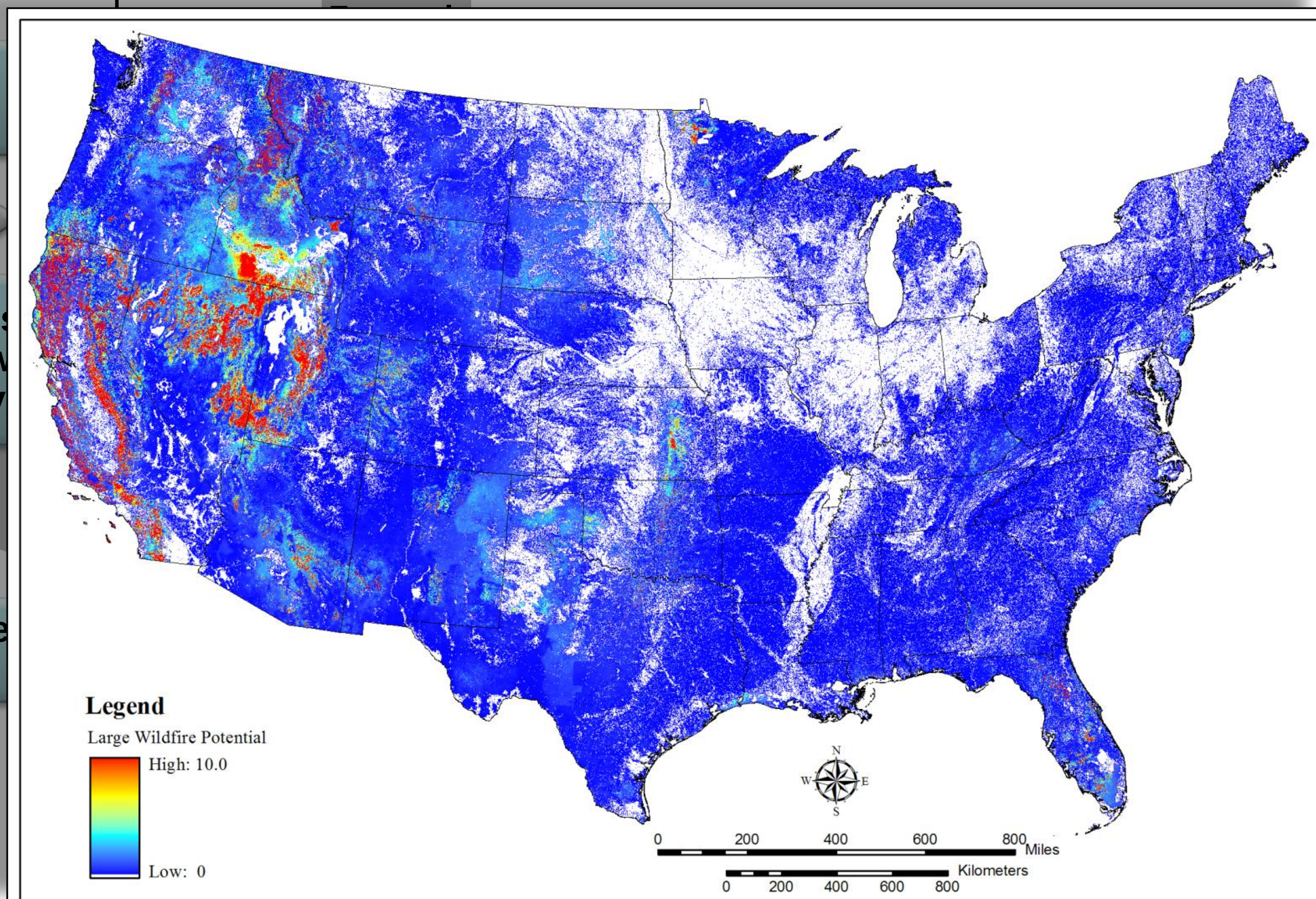
BP by flame length class

- 0 to <4 feet
- 4 to < 8 feet
- 8 to <12 feet
- ≥ 12 feet

Yes

Apply weights based on crow fire intensity

Large

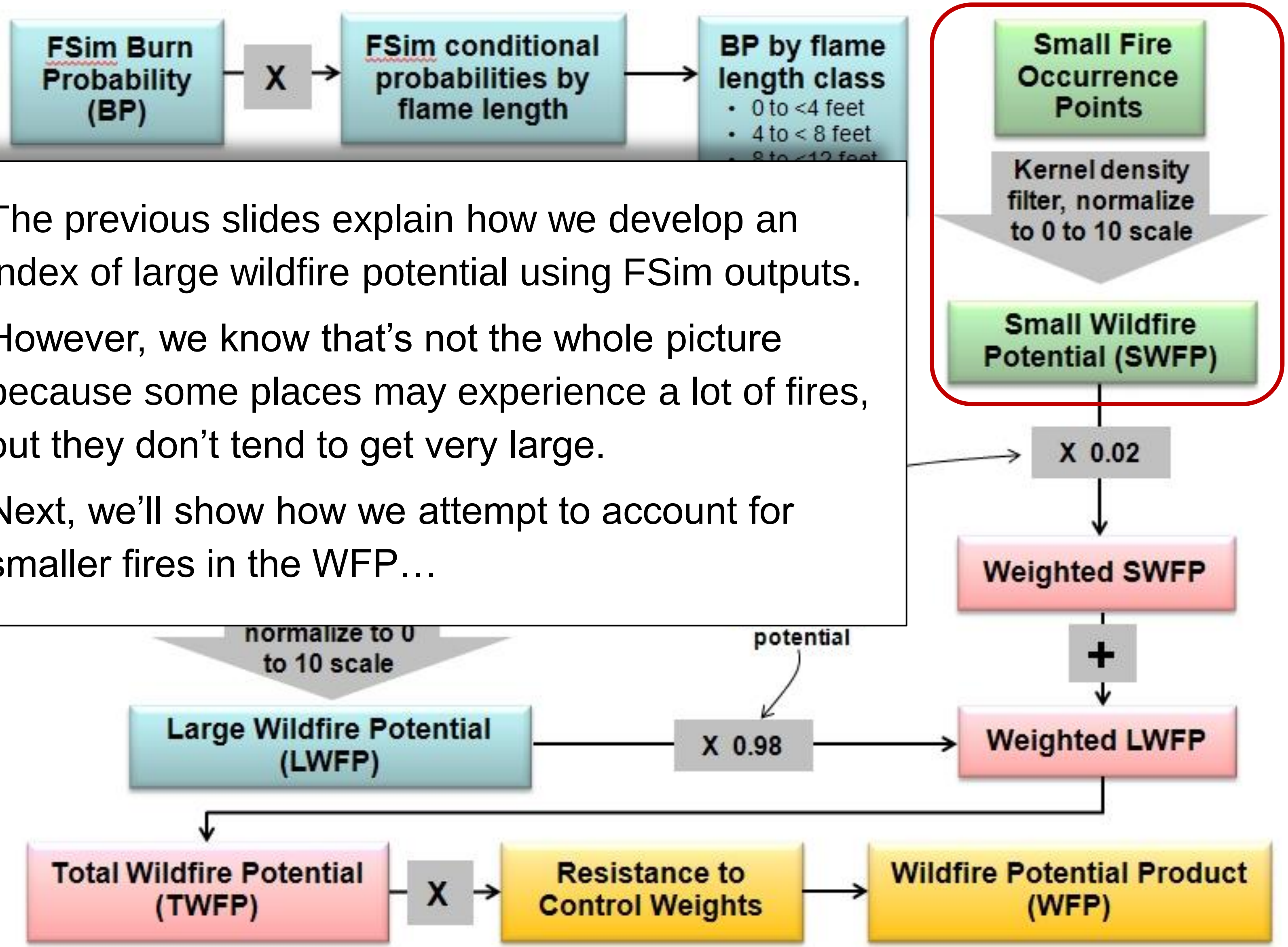


Wildland Fire Potential 2012: Methods

The previous slides explain how we develop an index of large wildfire potential using FSim outputs.

However, we know that's not the whole picture because some places may experience a lot of fires, but they don't tend to get very large.

Next, we'll show how we attempt to account for smaller fires in the WFP…

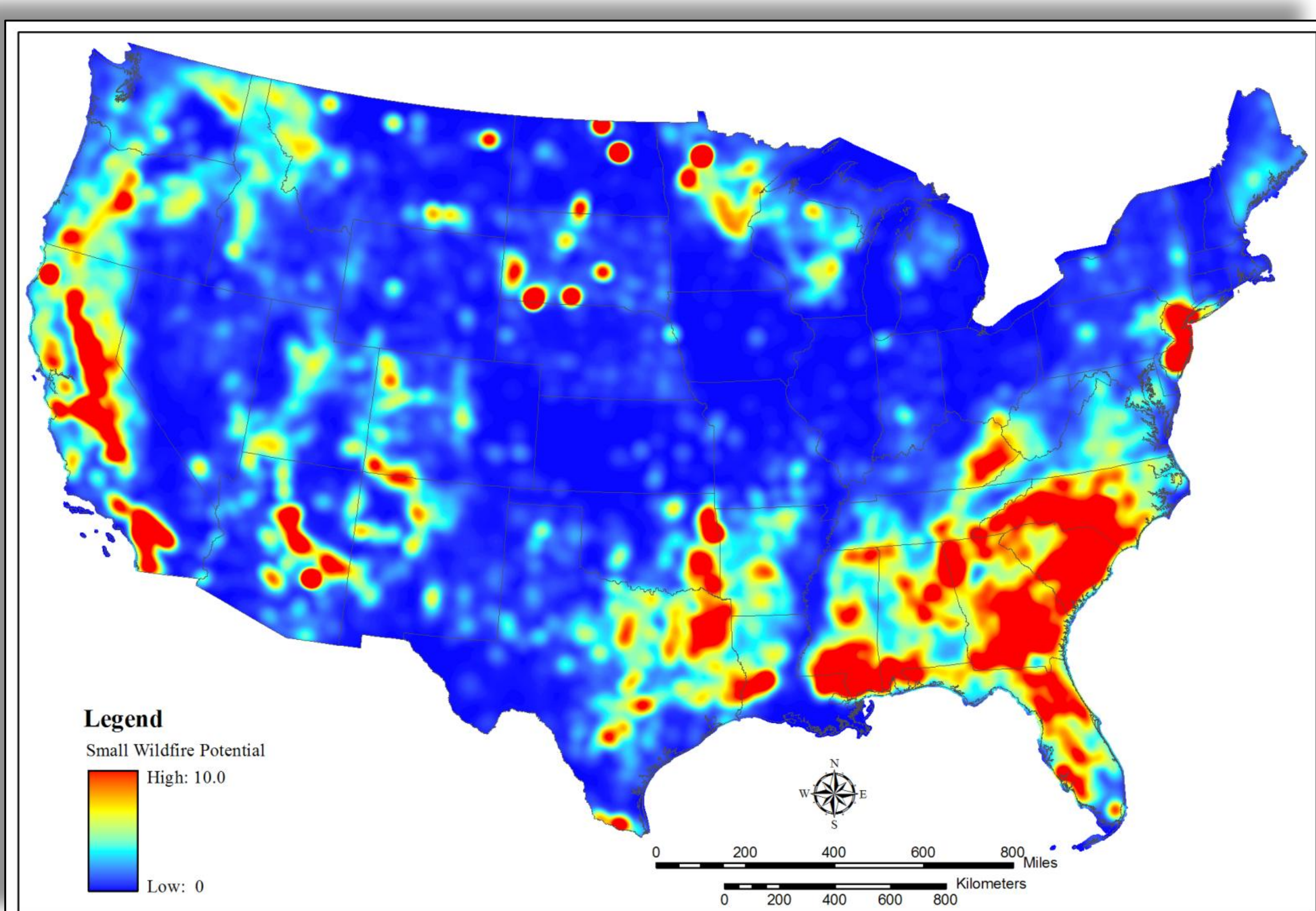


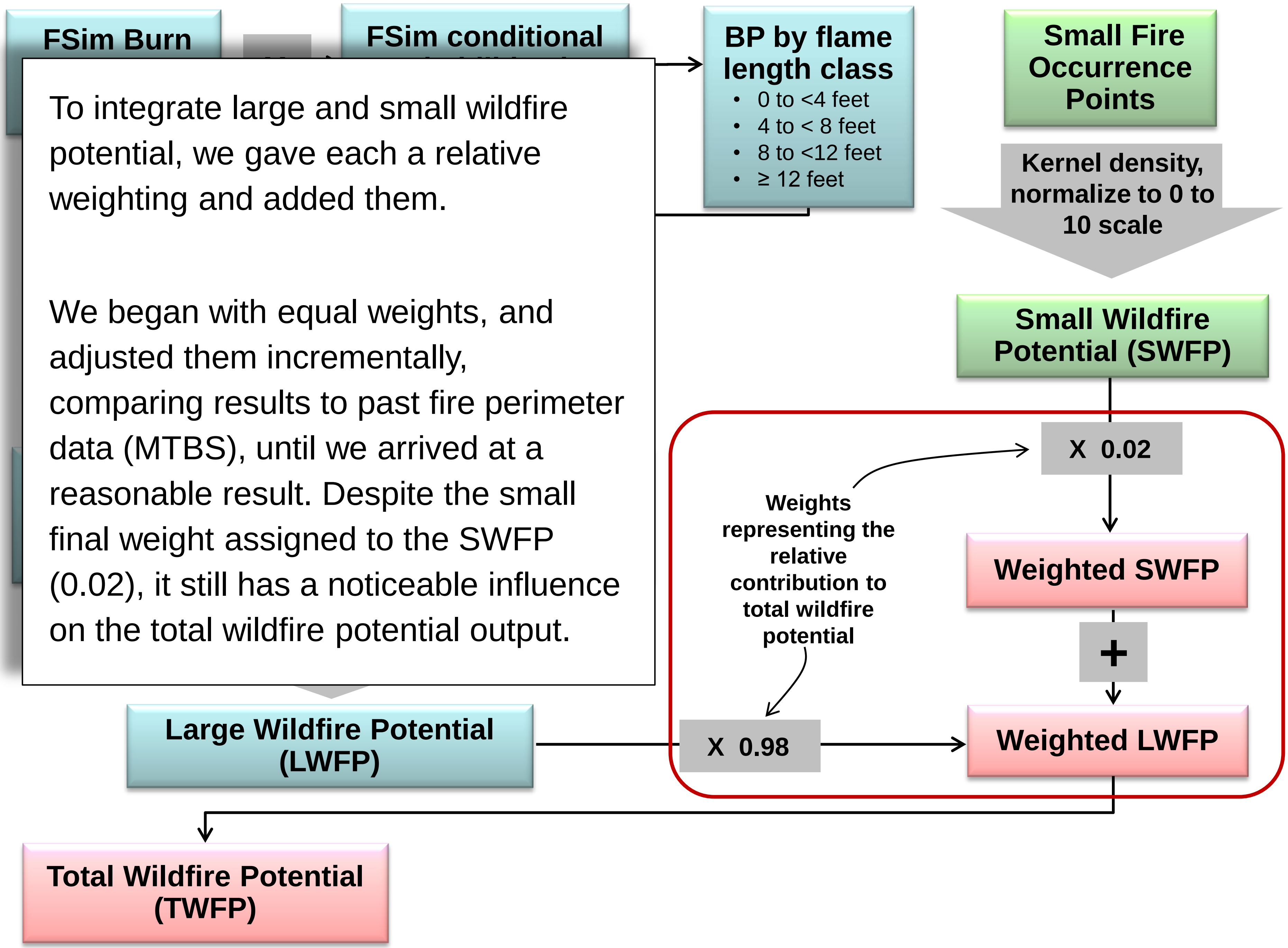
- First, select points from FPA Fire Occurrence Database (FOD) with final fire size < 300 acres. The FOD includes records from 1992 – 2010.
- Next, run a kernel density function in ArcGIS with 50km radius.
- The result is an ignition density surface for small fires, which we rescale to match the scale of the large wildfire potential index.

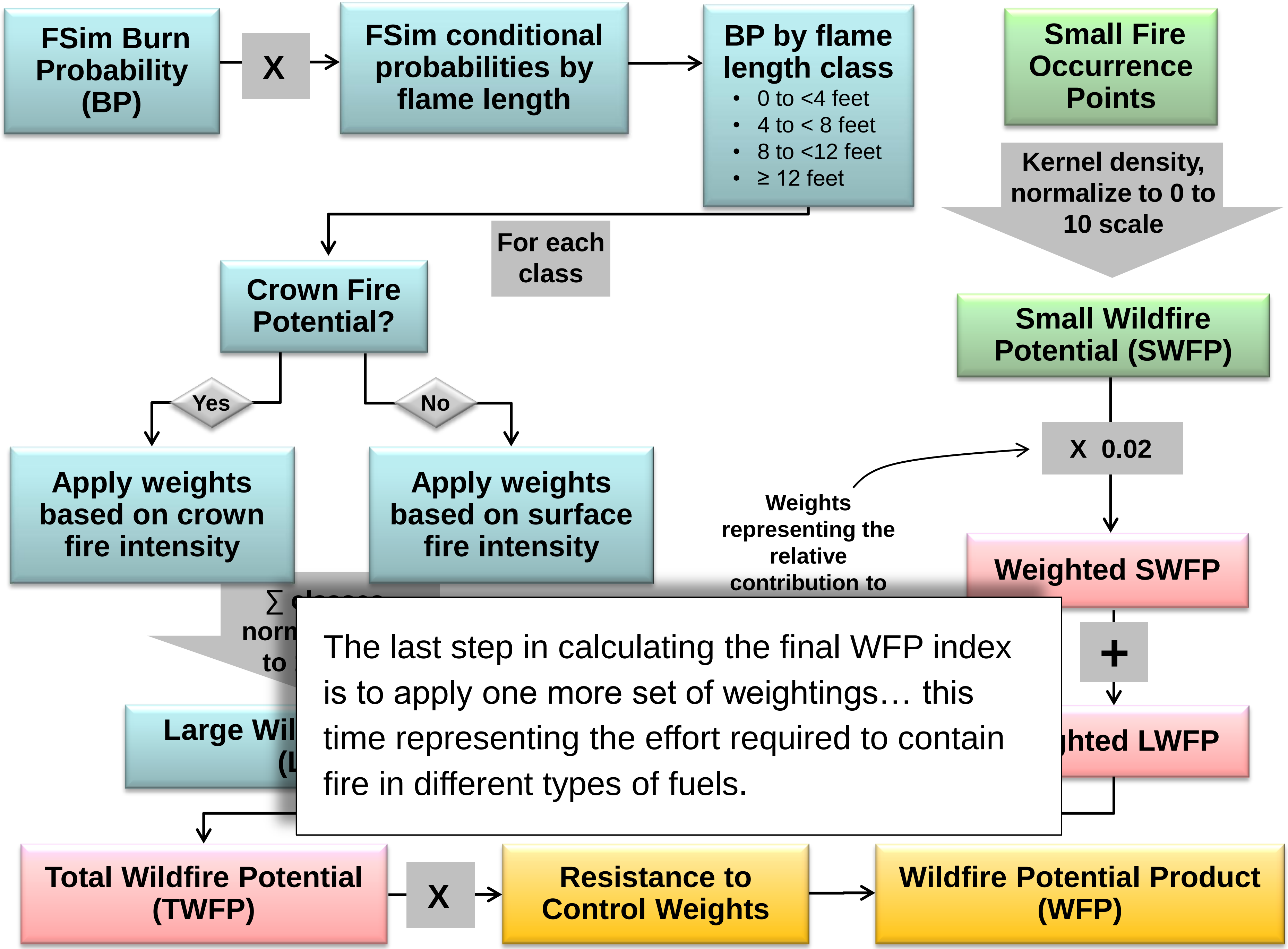
Small Fire Occurrence Points

Kernel density, normalize to 0 to 10 scale

Small Wildfire Potential (SWFP)




FSim Burn
FSim conditional
BP by flame length class
0 to <4 feet
4 to < 8 feet
8 to <12 feet
≥ 12 feet
Small Fire Occurrence Points
Kernel density, normalize to 0 to 10 scale
Small Wildfire Potential (SWFP)
To integrate large and small wildfire potential, we gave each a relative weighting and added them.
We began with equal weights, and adjusted them incrementally, comparing results to past fire perimeter data (MTBS), until we arrived at a reasonable result. Despite the small final weight assigned to the SWFP (0.02), it still has a noticeable influence on the total wildfire potential output.
X 0.02
Weights representing the relative contribution to total wildfire potential
Weighted SWFP
+
Large Wildfire Potential (LWFP)
X 0.98
Weighted LWFP
Total Wildfire Potential (TWFP)


FSim Burn Probability (BP)
X
FSim conditional probabilities by flame length
BP by flame length class
0 to <4 feet
4 to < 8 feet
8 to <12 feet
≥ 12 feet
Small Fire Occurrence Points
Kernel density, normalize to 0 to 10 scale
For each class
Crown Fire Potential?
Small Wildfire Potential (SWFP)
Yes
No
X 0.02
Apply weights based on crown fire intensity
Apply weights based on surface fire intensity
Weights representing the relative contribution to
Weighted SWFP
+
The last step in calculating the final WFP index is to apply one more set of weightings… this time representing the effort required to contain fire in different types of fuels.
Total Wildfire Potential (TWFP)
X
Resistance to Control Weights
Wildfire Potential Product (WFP)

Resistance to Control Weights

- Basic premise: fires are easier to contain in some fuel types than others
- Fireline handbook lists fireline production rates (ch/hr) for initial attack by hand crews for Anderson 13 fuel models

Resistance to Control Weights

- Basic premise: fires are easier to contain in some fuel types than others
- Fireline handbook lists fireline production rates (ch/hr) for initial attack by hand crews for Anderson 13 fuel models
- FPA updated rates to the Scott/Burgan 40 fuel models, most recently in 2010
- We only applied weights where rate > 1

Fuel Model	Line construction rate, Published by FPA 4/27/10 (ch/hr)	RTC Weight Based on 4/27/10 rates	RTC Weight Adjusted for WFP v2012
GR1 (101) Short, Sparse Dry Climate Grass (Grass)	4	0.25	0.25
GR2 (102) Low Load, Dry Climate Grass (Grass)	3	0.33	0.33
GR3 (103) Low Load, Very Coarse, Humid Climate Grass	2.49	0.40	0.40
GR4 (104) Moderate Load, Dry Climate Grass	2.49	0.40	0.40
GR5 (105) Low Load, Humid Climate Grass	3	0.33	0.33
GR6 (106) Moderate Load, Humid Climate Grass	2.49	0.40	0.40
GS1 (121) Low Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS2 (122) Moderate Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS3 (123) Moderate Load, Humid Climate Grass-Shrub	2.7	0.37	0.37
TU1 (161) Low Load Dry Climate Timber-Grass-Shrub (Hardwood)	10	0.10	0.10
TU2 (162) Moderate Load, Humid Climate Timber-Shrub	1.8	0.56	0.56
TL2 (182) Low Load Broadleaf Litter	8	0.13	0.13
TL6 (186) Moderate Load Broadleaf Litter	10	0.10	0.10
TL9 (189) Very High Load Broadleaf Litter	2	0.50	0.50
TU1 (161) Low Load Dry Climate Timber-Grass-Shrub (Conifer)	2	0.50	1.00
TL1 (181) Low Load Compact Conifer Litter	2	0.50	1.00
TL3 (183) Moderate Load Conifer Litter	1.8	0.56	1.00
TL8 (188) Long-Needle Litter	2	0.50	1.00

Resistance to Control Weights

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- Fireline handbook lists fireline production rates (ch/hr) for initial attack by hand crews for Anderson 13 fuel models
- FPA updated rates to the Scott/Burgan 40 fuel models, most recently in 2010
- We only applied weights where rate > 1
- 1/rate = RTC weight
- Applied spatially using LANDFIRE 2008 data

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GR5 (105) Low Load, Humid Climate Grass	3	0.33	0.33
GR6 (106) Moderate Load, Humid Climate Grass	2.49	0.40	0.40
GS1 (121) Low Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS2 (122) Moderate Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS3 (123) Moderate Load, Humid Climate Grass-Shrub	2.7	0.37	0.37
TU1 (161) Low Load Dry Climate Timber-Grass-Shrub (Hardwood)	10	0.10	0.10
TU2 (162) Moderate Load, Humid Climate Timber-Shrub	1.8	0.56	0.56
TL2 (182) Low Load Broadleaf Litter	8	0.13	0.13
TL6 (186) Moderate Load Broadleaf Litter	10	0.10	0.10
TL9 (189) Very High Load Broadleaf Litter	2	0.50	0.50
TU1 (161) Low Load Dry Climate Timber-Grass-Shrub (Conifer)	2	0.50	1.00
TL1 (181) Low Load Compact Conifer Litter	2	0.50	1.00
TL3 (183) Moderate Load Conifer Litter	1.8	0.56	1.00
TL8 (188) Long-Needle Litter	2	0.50	1.00

Resistance to Control Weights

- Basic premise: fires are easier to contain in some fuel types than others
- Fireline handbook lists fireline production rates (ch/hr) for initial attack by hand crews for Anderson 13 fuel models
- FPA updated rates to the Scott/Burgan 40 fuel models, most recently in 2010
- We only applied weights where rate > 1
- 1/rate = RTC weight
- Applied spatially using LANDFIRE 2008 data
- Manually adjusted some weights based on initial mapping tests

Fuel Model	Line construction rate, Published by FPA 4/27/10 (ch/hr)	RTC Weight Based on 4/27/10 rates	RTC Weight Adjusted for WFP v2012
GR1 (101) Short, Sparse Dry Climate Grass (Grass)	4	0.25	0.25
GR2 (102) Low Load, Dry Climate Grass (Grass)	3	0.33	0.33
GR3 (103) Low Load, Very Coarse, Humid Climate Grass	2.49	0.40	0.40
GR4 (104) Moderate Load, Dry Climate Grass	2.49	0.40	0.40
GR5 (105) Low Load, Humid Climate Grass	3	0.33	0.33
GR6 (106) Moderate Load, Humid Climate Grass	2.49	0.40	0.40
GS1 (121) Low Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS2 (122) Moderate Load, Dry Climate Grass-Shrub	2.7	0.37	0.37
GS3 (123) Moderate Load, Humid Climate Grass-Shrub	2.7	0.37	0.37
TU1 (161) Low Load Dry Climate Timber-Grass-Shrub (Hardwood)	10	0.10	0.10
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TL6 (186) Moderate Load Broadleaf Litter	10	0.10	0.10
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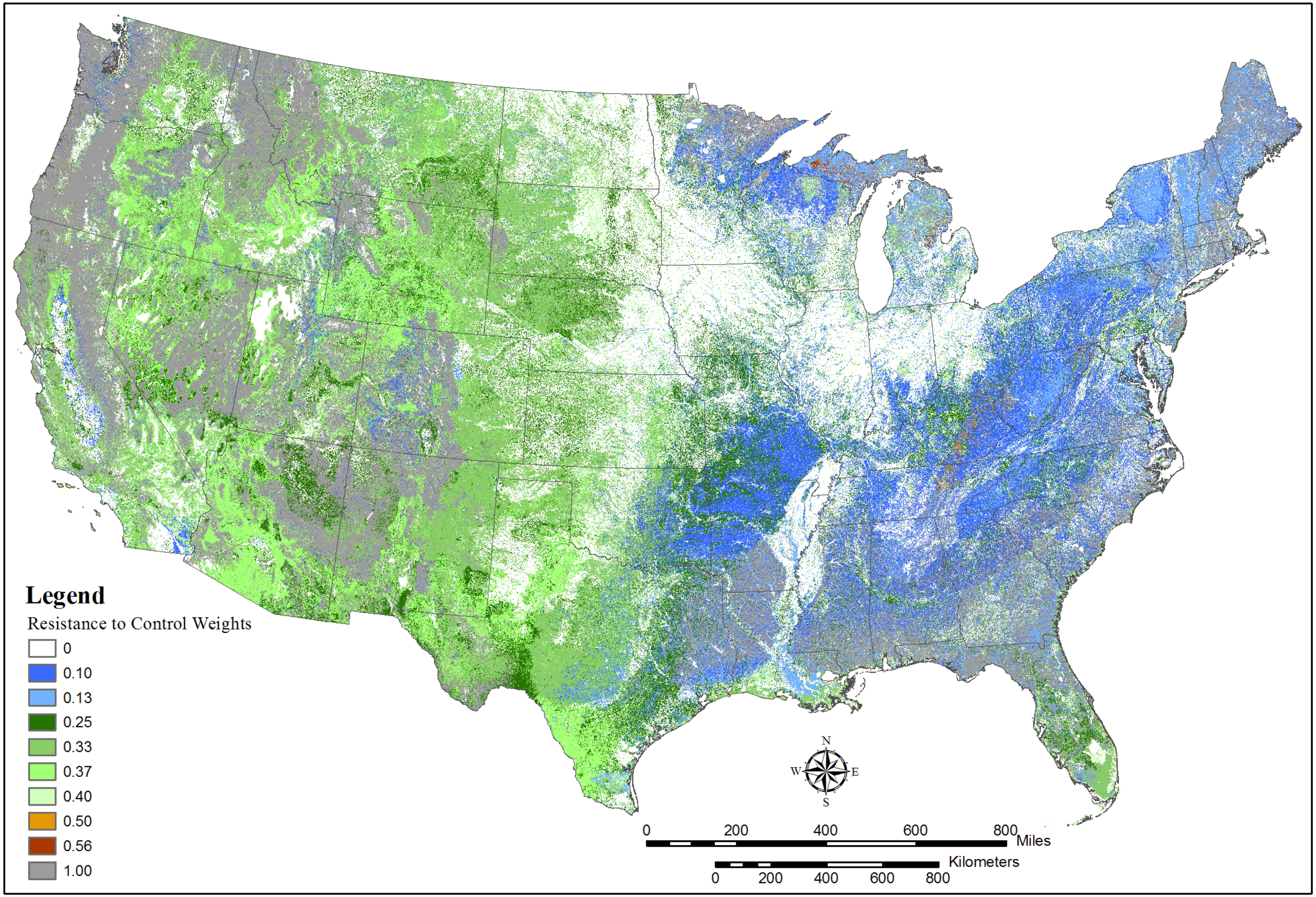
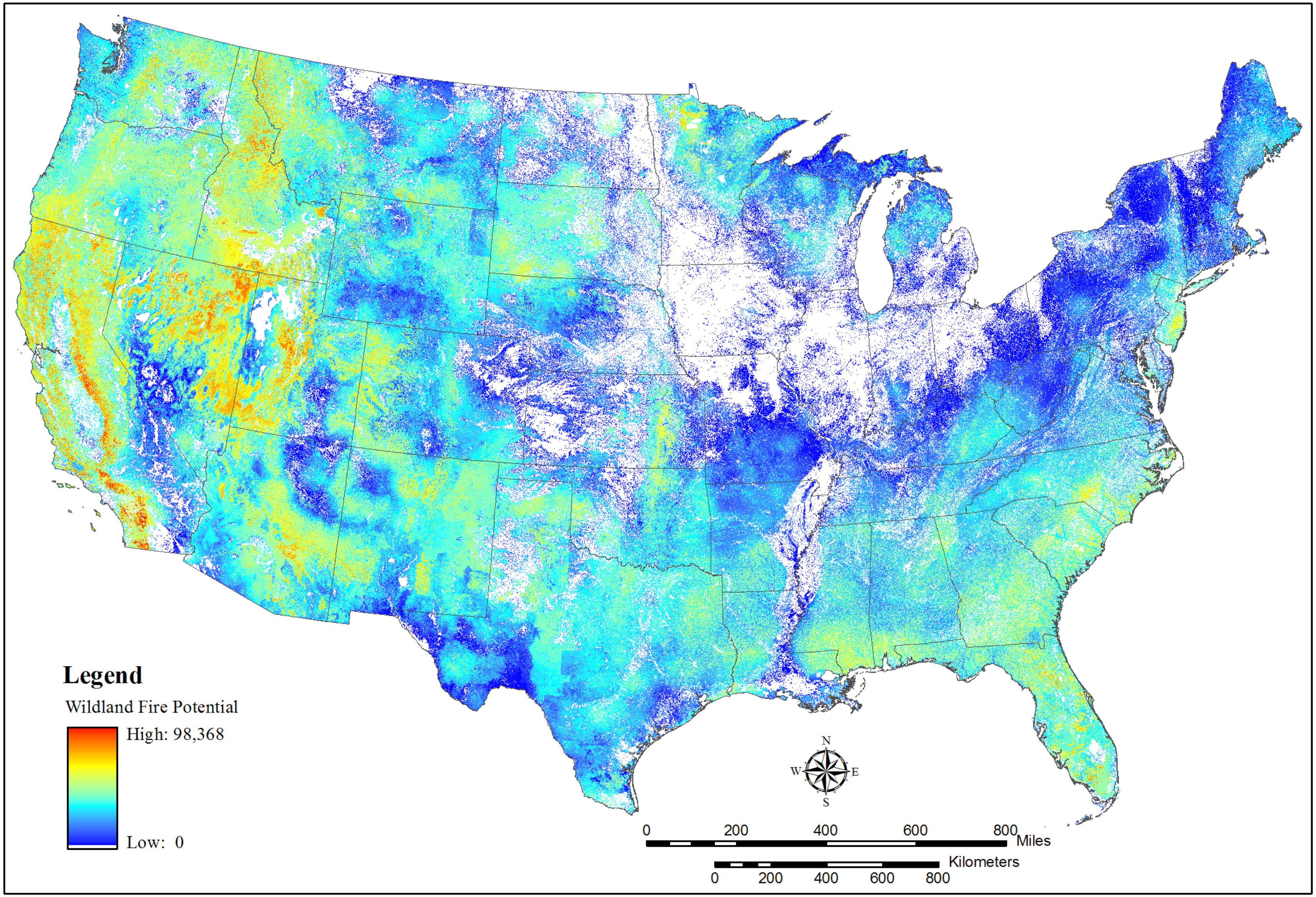
TL3 (183) Moderate Load Conifer Litter	1.8	0.56	1.00
TL8 (188) Long-Needle Litter	2	0.50	1.00

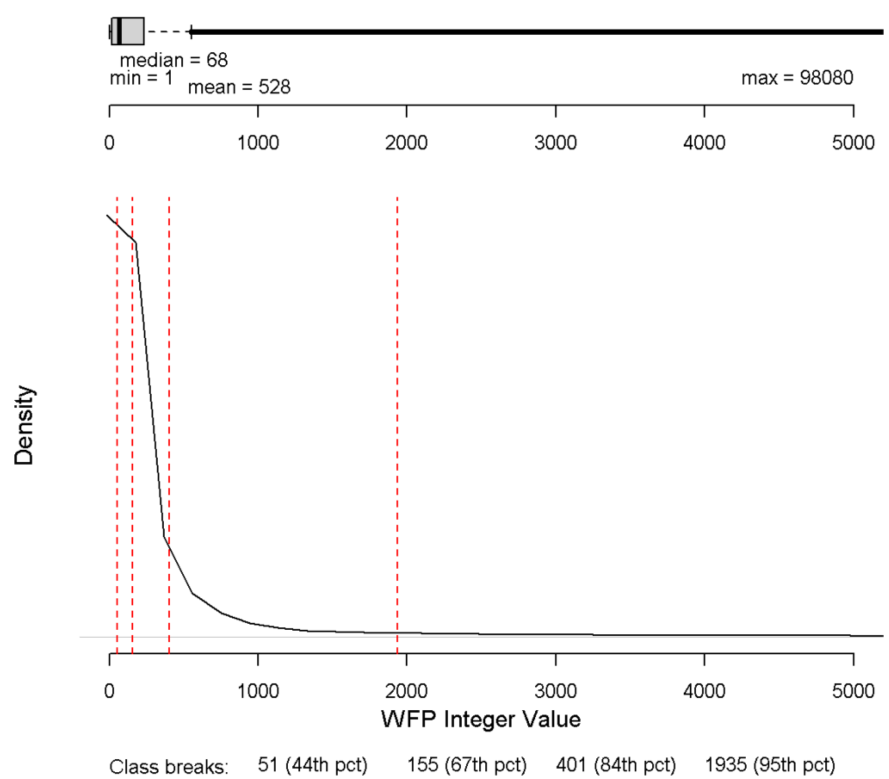
Resistance to Control Weights

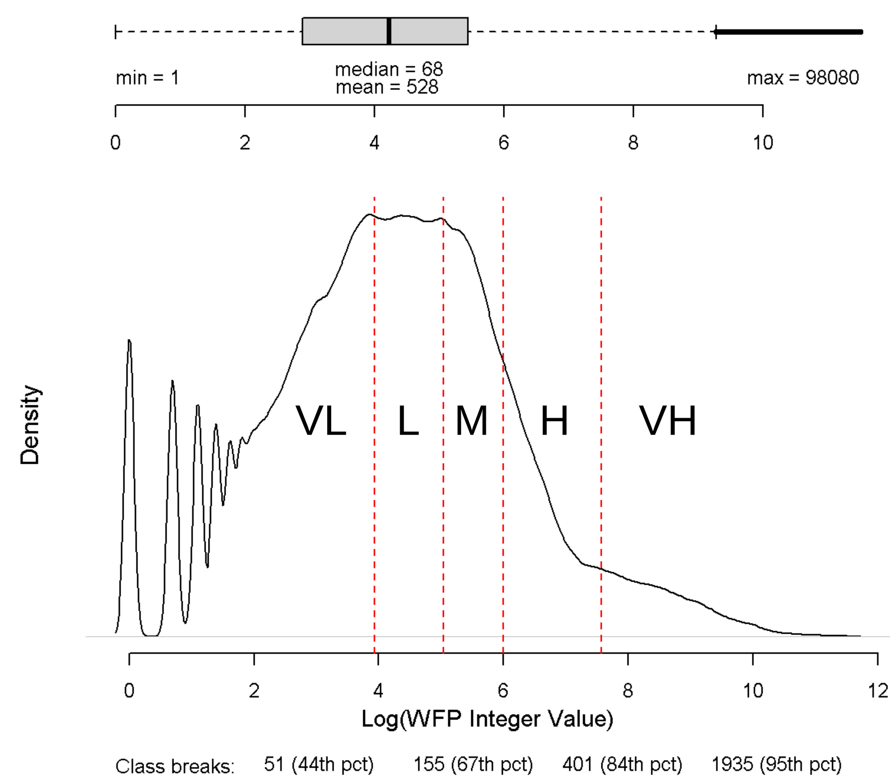


Final WFP Product - Continuous



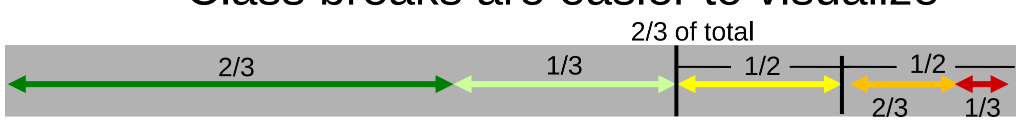
Creating Discrete WFP Classes



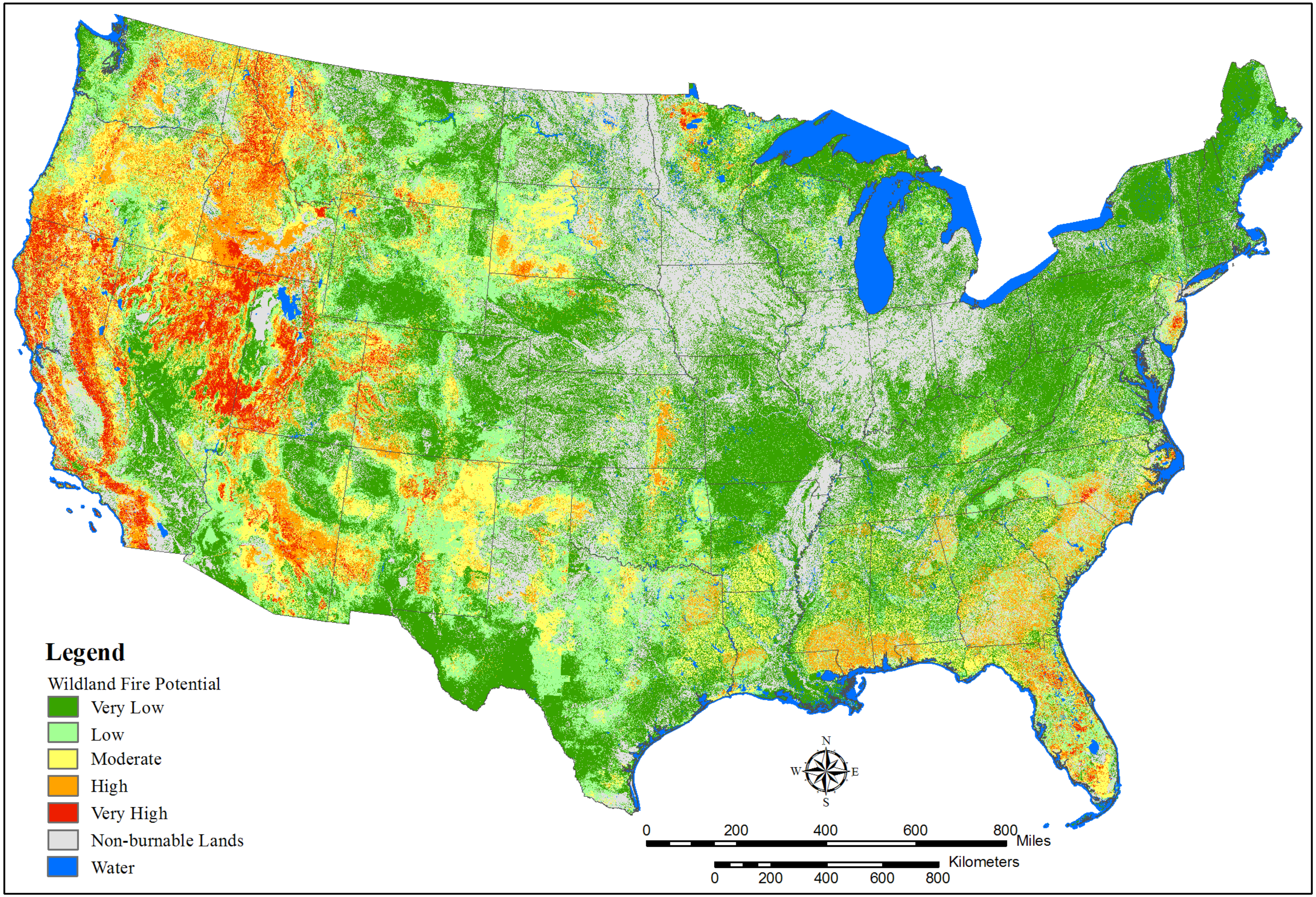


- WFP values are strongly skewed
- Over 95% of values < 2000
- Plots are truncated… right tail extends to over 98,000

- WFP values are much more normally distributed on a log scale
- Class breaks are easier to visualize

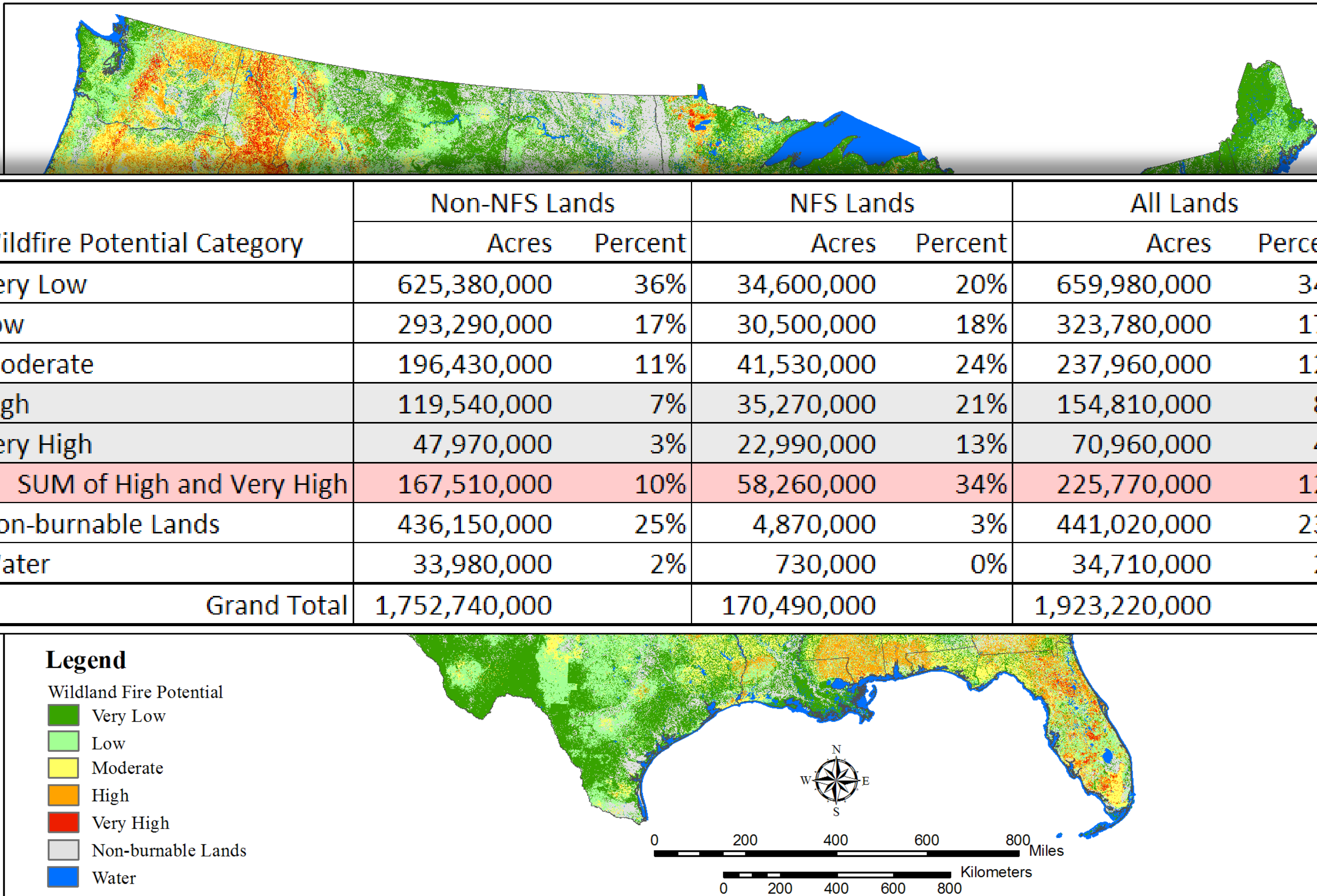


Final WFP Product - Classified



Final WFP Product - Classified

Wildfire Potential Category	Non-NFS Lands		NFS Lands		All Lands	
	Acres	Percent	Acres	Percent	Acres	Percent
Very Low	625,380,000	36%	34,600,000	20%	659,980,000	34%
Low	293,290,000	17%	30,500,000	18%	323,780,000	17%
Moderate	196,430,000	11%	41,530,000	24%	237,960,000	12%
High	119,540,000	7%	35,270,000	21%	154,810,000	8%
Very High	47,970,000	3%	22,990,000	13%	70,960,000	4%
SUM of High and Very High	167,510,000	10%	58,260,000	34%	225,770,000	12%
Non-burnable Lands	436,150,000	25%	4,870,000	3%	441,020,000	23%
Water	33,980,000	2%	730,000	0%	34,710,000	2%
Grand Total	1,752,740,000		170,490,000		1,923,220,000	



Wildland Fire Potential: Recap

- Intended uses of the WFP map:
  - Long-term strategic planning and fuels management.
  - Analyses of wildfire risk or hazardous fuels prioritization at large landscapes (100s of square miles) up through regional and national scales.
  - Can be used to create value-specific wildland fire risk maps, when paired with spatial data depicting highly valued resources.

Wildland Fire Potential: Recap

- What the WFP map *is*:
  - The WFP map is a raster geospatial product for the conterminous United States (CONUS) at 270m resolution.
  - The specific objective of the WFP is to depict the relative potential for wildfire that would be difficult for suppression resources to contain, based on past fire occurrence and estimates of wildfire likelihood.
  - Inputs are derived from simulation modeling with 2008 landscape fuel conditions.

Wildland Fire Potential: Recap

- What the WFP map *is not*:
  - On it's own WFP is not an explicit map of wildfire threat or risk; it includes no information on effects of wildfire on specific values.
  - The WFP map is not a forecast or seasonal outlook for any particular season. It does not incorporate any information on current or forecasted weather or fuel moisture conditions.
  - The 2012 WFP map is not a snapshot of landscape conditions in 2012, and any comparison to previous versions does not indicate changes in fuels conditions. Changes from 2007 and 2010 versions primarily reflect changes in inputs and methods.

Questions?

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