Societal expectations, public land values, and management culture in the United States: the role of risk management in addressing a wicked problem.

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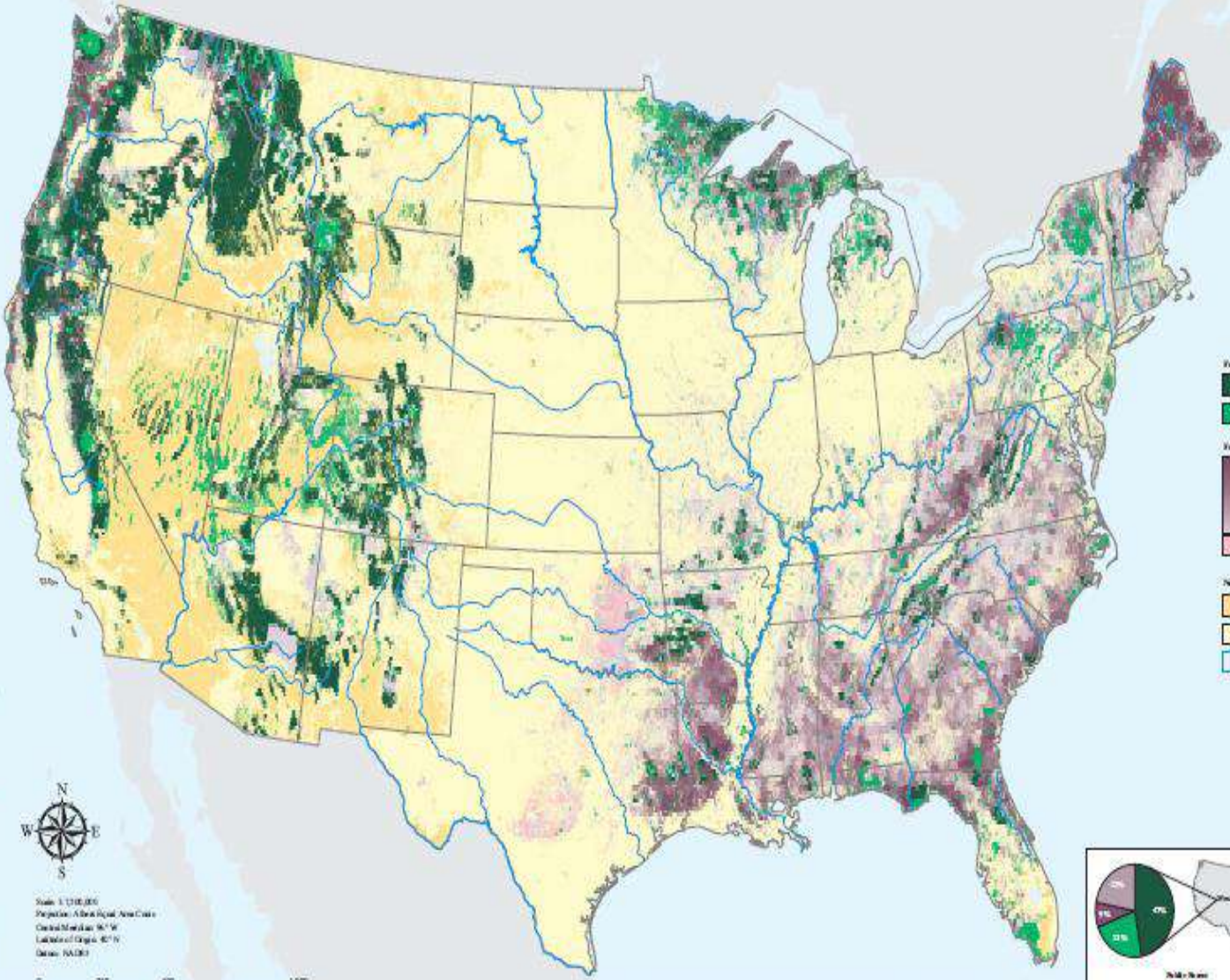
Photo: Kari Greer

Photo: Mary Lata

Forest Ownership in the Conterminous United States

Mark D. Nelson, Greg C. Liknes, and Brett J. Butler
U.S. Forest Service, Northern Research Station, Forest Inventory and Analysis



Map Description
This map depicts the spatial distribution of forest land across the conterminous United States (CONUS) in 2005, differentiated into public vs. private forest land, and the percentage of corporate ownership of private forest land.

Notable differences between eastern and western United States are evident in the map, as reported in Smith et al. (2009). Over two-thirds of western forest land is publicly owned, the majority of which is administered by the U.S. Forest Service as National Forests. In the East, more than 10 percent of forest land is privately owned.

Corporate forest land is privately owned by an incorporated business, e.g., forest industry, timber investment management organizations (TIMOs), or real estate investment trusts (REITs). Concentrations of corporate forest land are seen in Maine and in portions of the Southeast, South Central, Lake States, and the Pacific Northwest regions. No Data values represent private forest land where Forest Inventory and Analysis (FIA) plot data were insufficient to determine percentage corporate ownership.

Information displayed on the map was derived from multiple sources. Maps produced by FIA are for graphic display to meet general reporting requirements. Sources and intended uses of FIA data are available at: http://fia.fs.fed.us/data/default.asp

Suggested Citation
Nelson, Mark D.; Liknes, Greg C.; Butler, Brett J. 2010. Map of forest ownership in the conterminous United States. [Scale 1:7,500,000] Res. Map NRS-3. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Data Sources
The forest/nonforest land/water classification is derived from the U.S. Forest Service's CONUS forest/nonforest dataset. Public and private land ownership class is derived from the Protected Areas Database of the United States (PAD-US 1.1 (ESRI Shape) – last accessed: 9 June 2010).

Corporate ownership of private forest land is derived from the Forest Service's 2005 RPA dataset, summarized over the Environmental Protection Agency's original EMAP grid of 40 km² hexagons dataset. Political boundaries and basemap layers are from Environmental Systems Research Institute (ESRI) Data & Maps.

References
Nelson, Mark D.; Liknes, Greg C.; Butler, Brett J. 2010. Forest ownership in the conterminous United States. Forest Ownership [dataset] [Database] Version 1. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. Available at: http://fia.fs.fed.us/data/default.asp

Smith, W.B.; Miles, P.D.; Perry, C.H.; Pugh, S.A. 2009. Forest resources of the United States, 2007. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service. 336 p.

Publication date: July 2010

Associate Press

Camp Fire 2018: Paradise CA

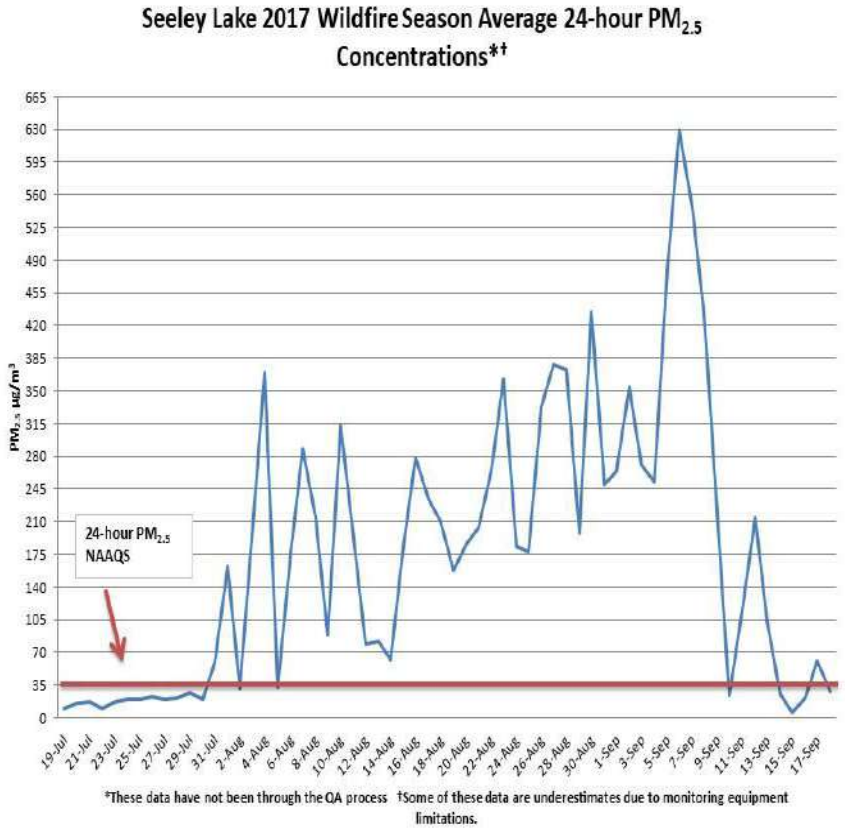
Tubbs Fire, 2017: Santa Rosa CA

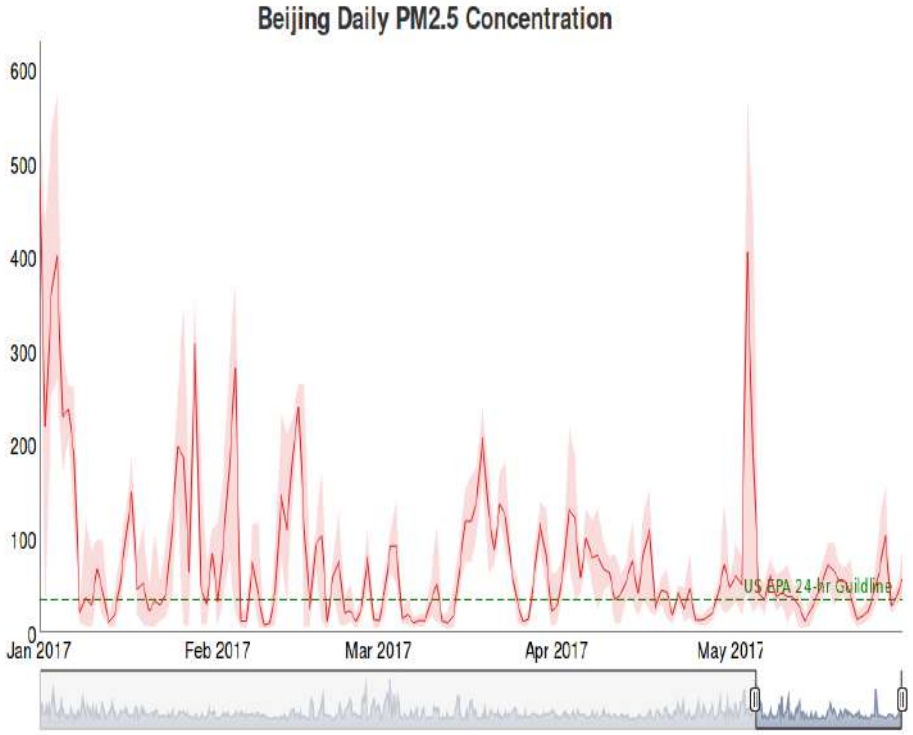
Getty Images

Washington Post

Mendocino Complex 2017: Mendocino, Lake, Colusa Counties CA

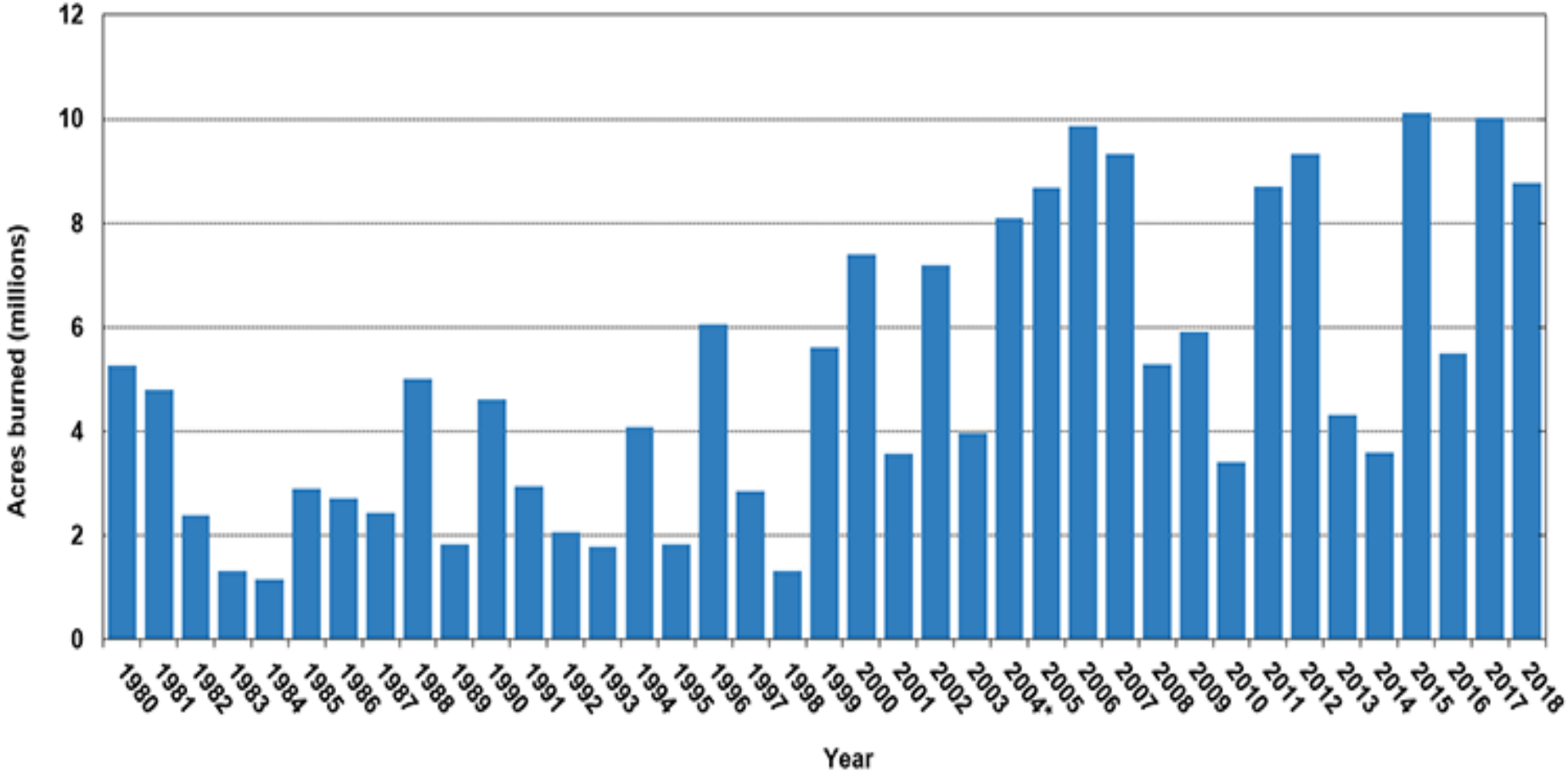
Chimney Tops 2, 2016 Gatlinburg Tenessee



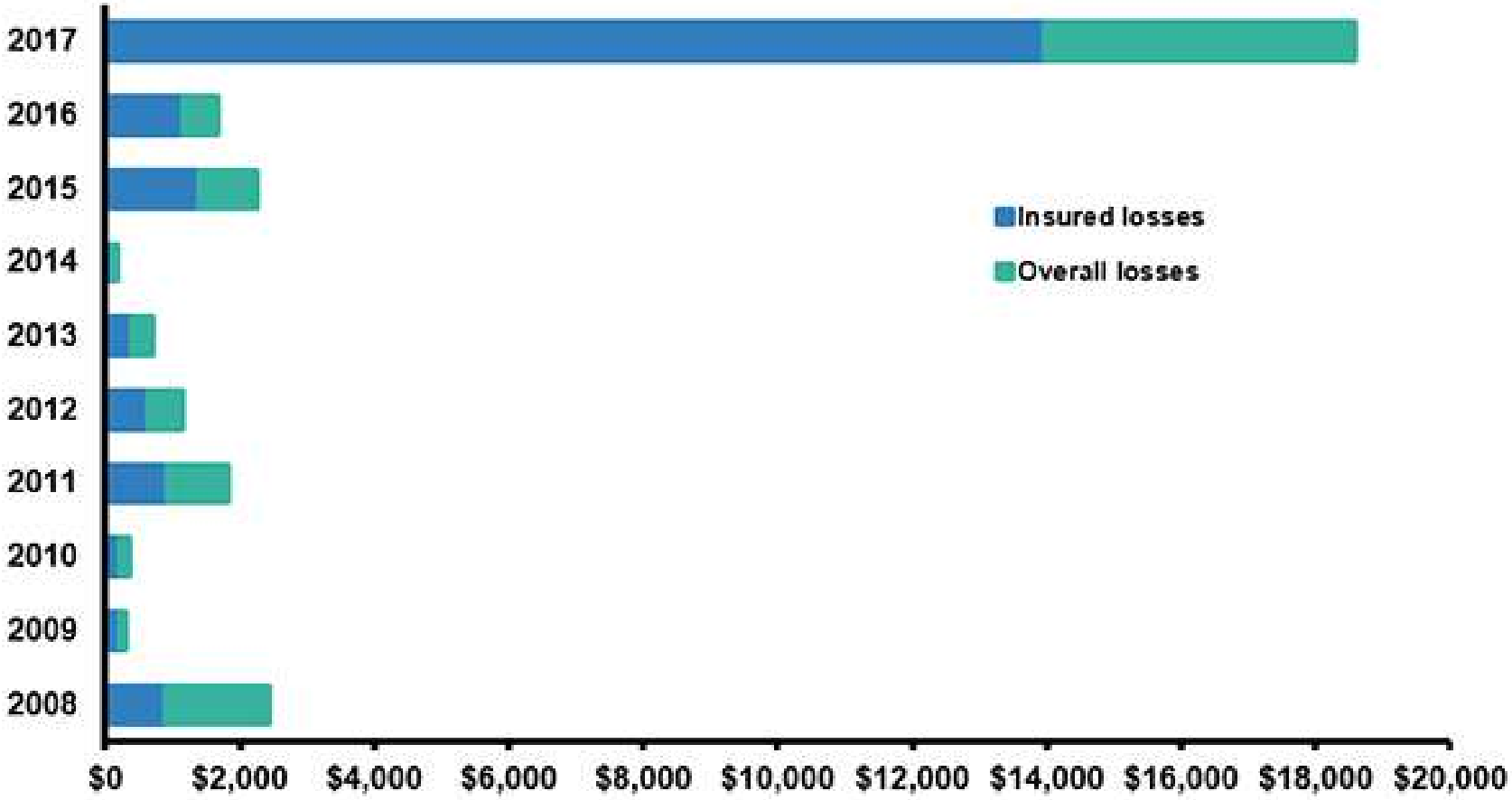


Rice Ridge Fire, 2018: Seeley Lake, MT

Recent US Wildfire Activity

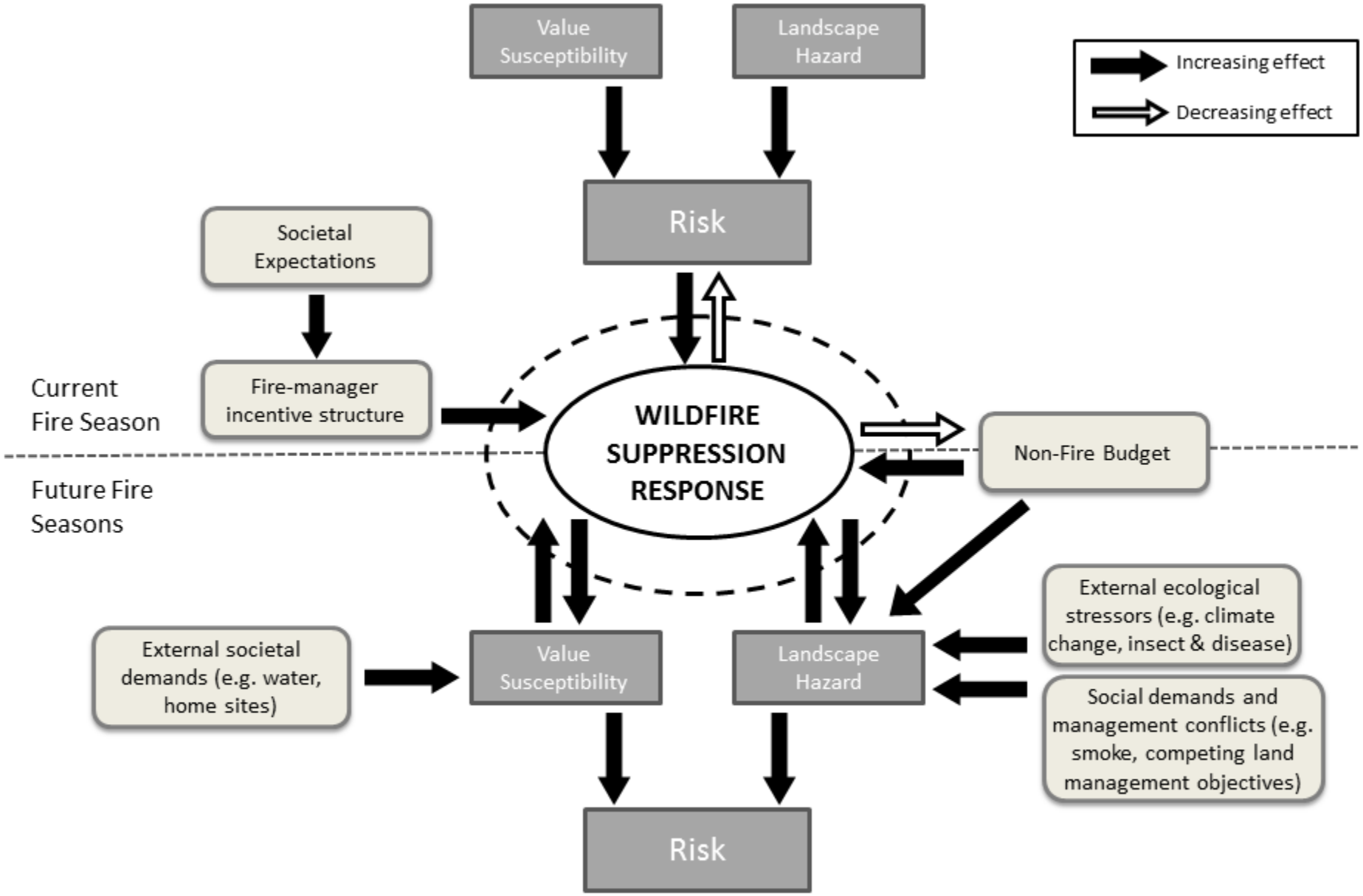


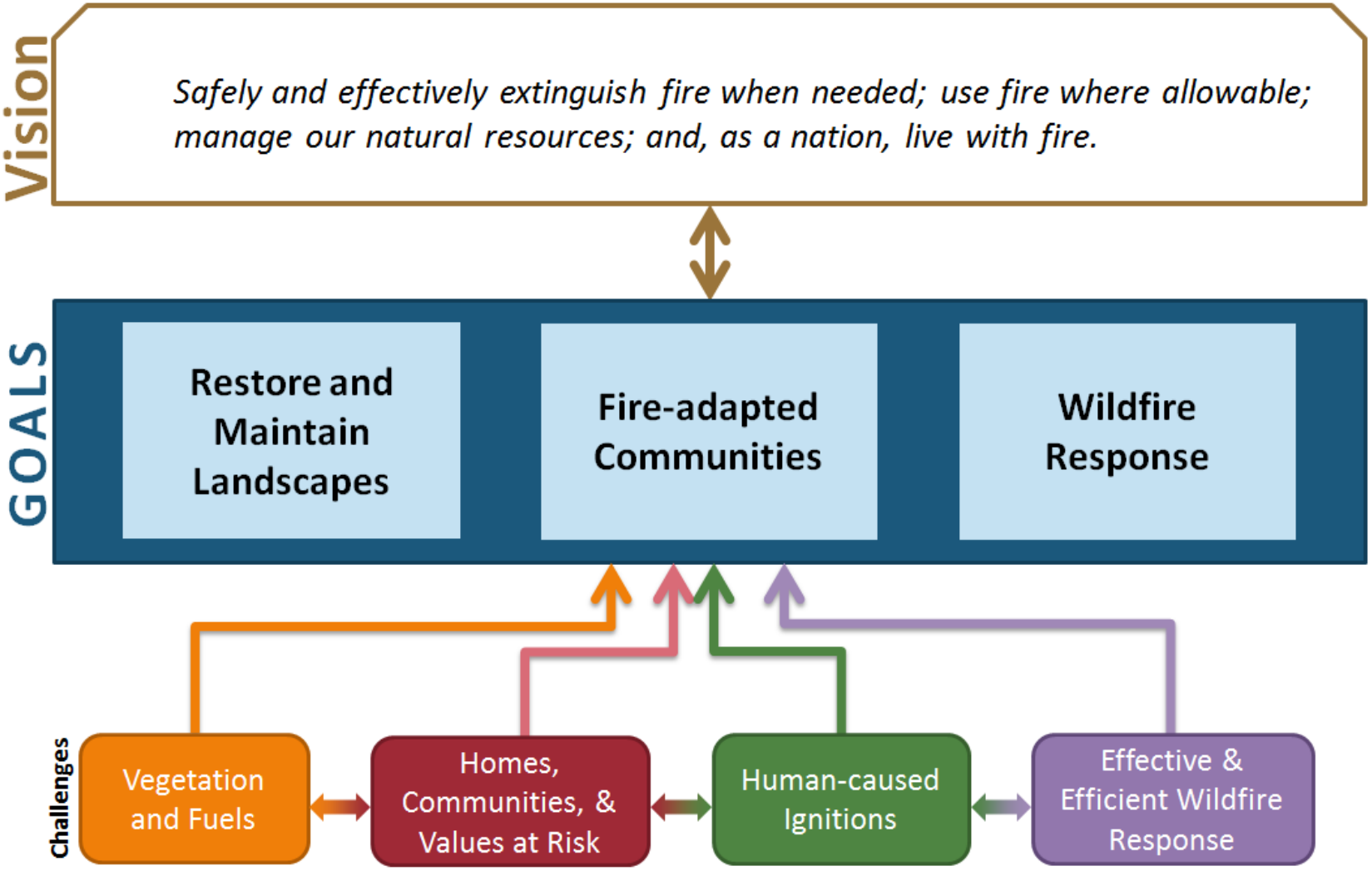
Wildfire Insured Loss

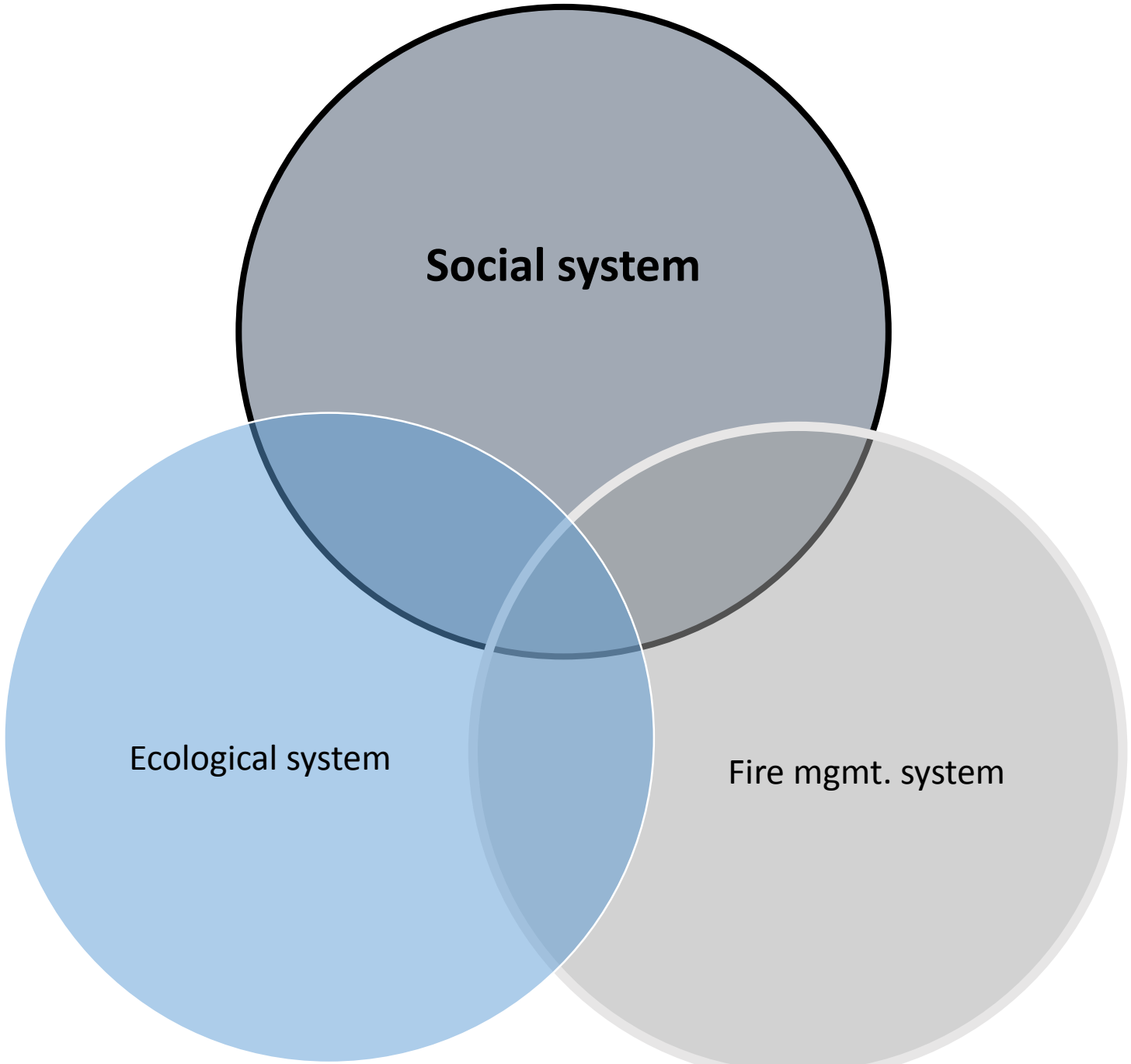


Wicked Problems

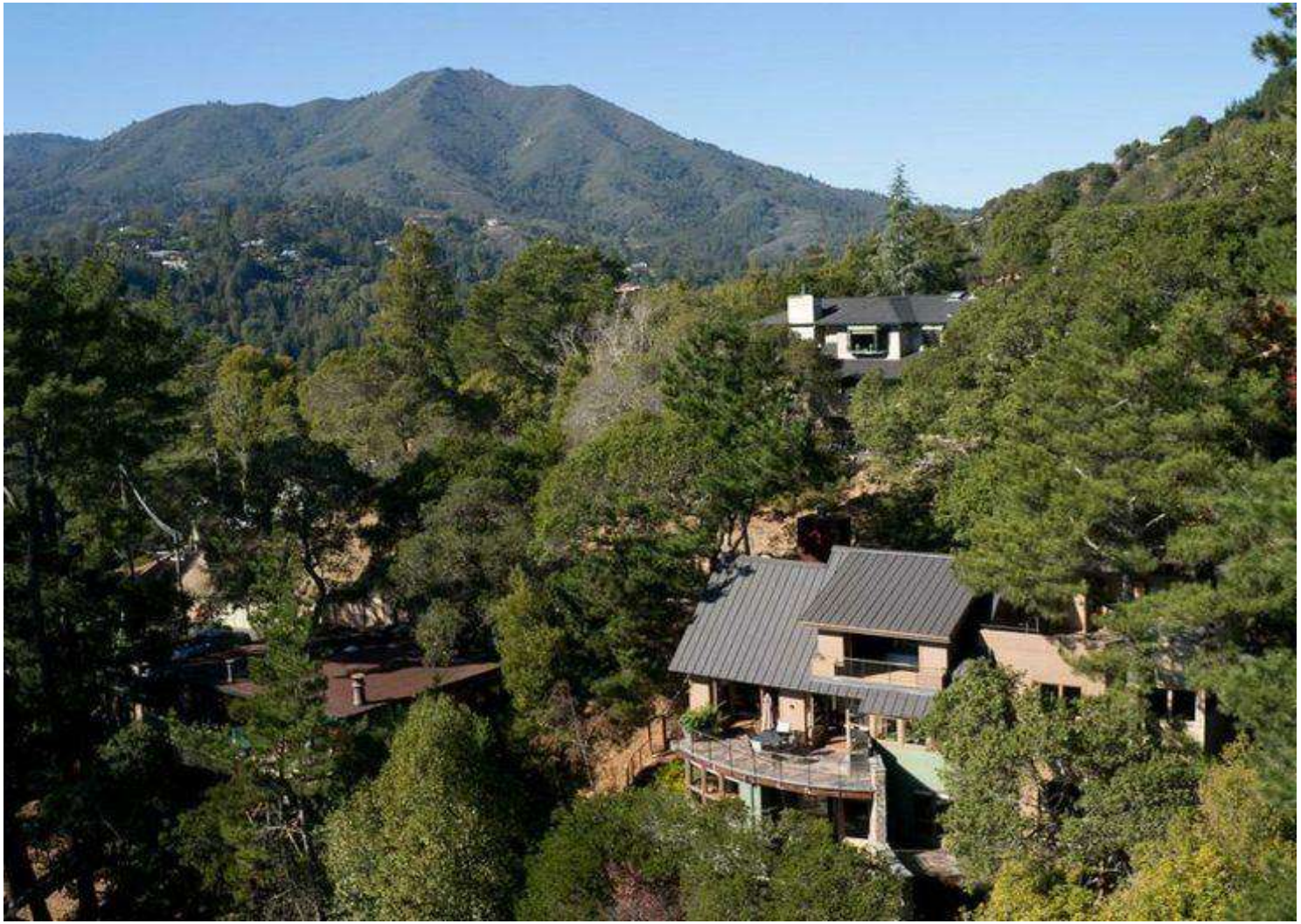
- A social or cultural problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.
- “The search for scientific bases for confronting problems of social policy is bound to fail because of the nature of these problems... Policy problems cannot be definitively described…there is nothing like the indisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions”. (Rittel and Webber 1973)


Value Susceptibility
Landscape Hazard
Increasing effect
Decreasing effect
Risk
Societal Expectations
Current Fire Season
Fire-manager incentive structure
WILDFIRE SUPPRESSION RESPONSE
Non-Fire Budget
Future Fire Seasons
External ecological stressors (e.g. climate change, insect & disease)
External societal demands (e.g. water, home sites)
Value Susceptibility
Landscape Hazard
Social demands and management conflicts (e.g. smoke, competing land management objectives)
Risk


Vision
Safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and, as a nation, live with fire.
GOALS
Restore and Maintain Landscapes
Fire-adapted Communities
Wildfire Response
Challenges
Vegetation and Fuels
Homes, Communities, & Values at Risk
Human-caused Ignitions
Effective & Efficient Wildfire Response


Social system
Ecological system
Fire mgmt. system

WUI Development



Expectations of Response and the Role of the Media

Fireaviation.com

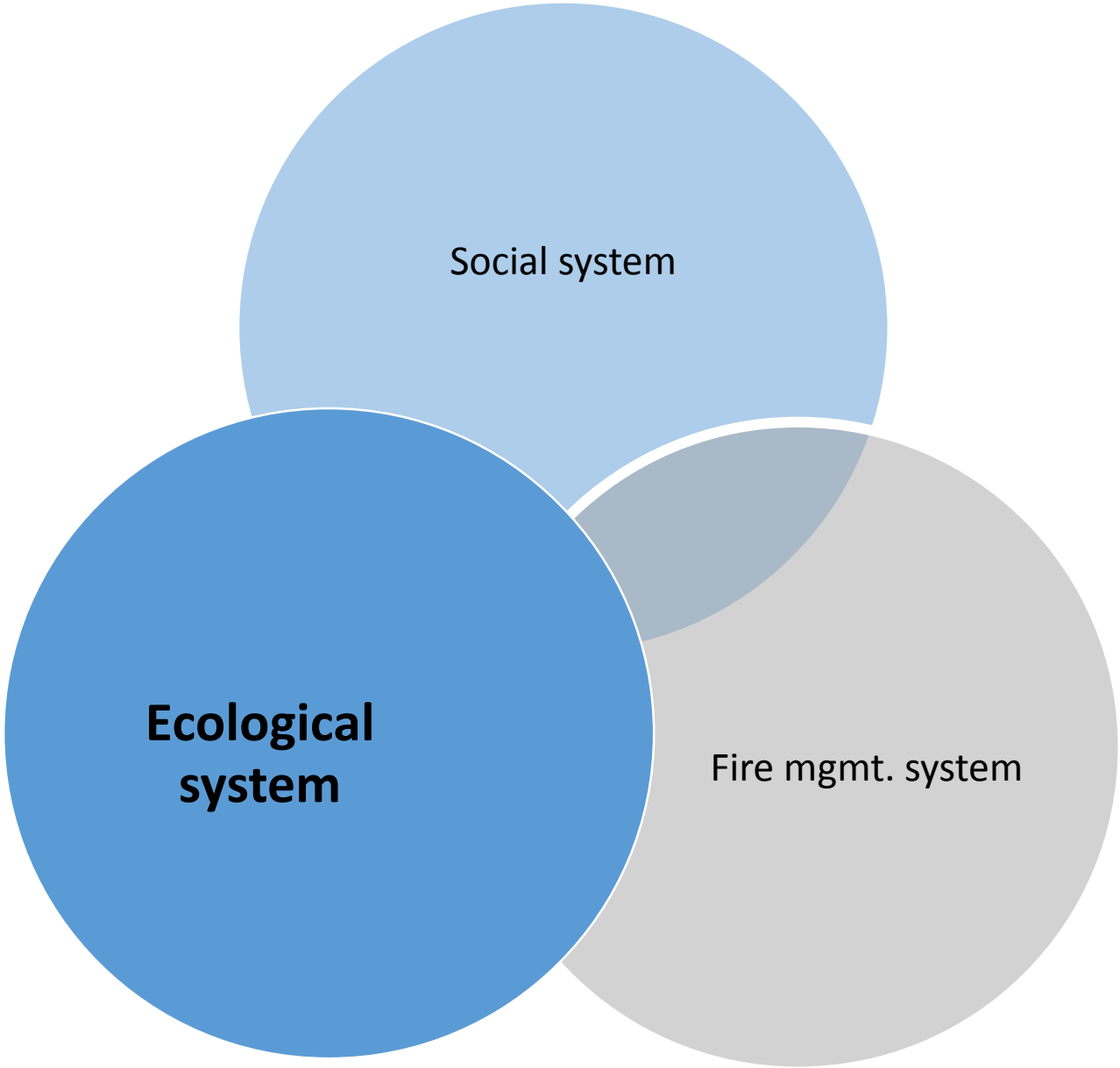
Public Perception: A complicated story

Alaska Public Media

Hero Culture

The Firefighting Trap and Political Influence

- A shortsighted cycle of problem-solving where you are trapped responding to emerging problems while failing to address the underlying cause
- Wildfire suppression has become a big business in US (~ $5 billion US) with a number of large contractors and suppliers.
- Mitigation is typically small scale and timber revenue from many fuel reduction activities typically don’t cover cost.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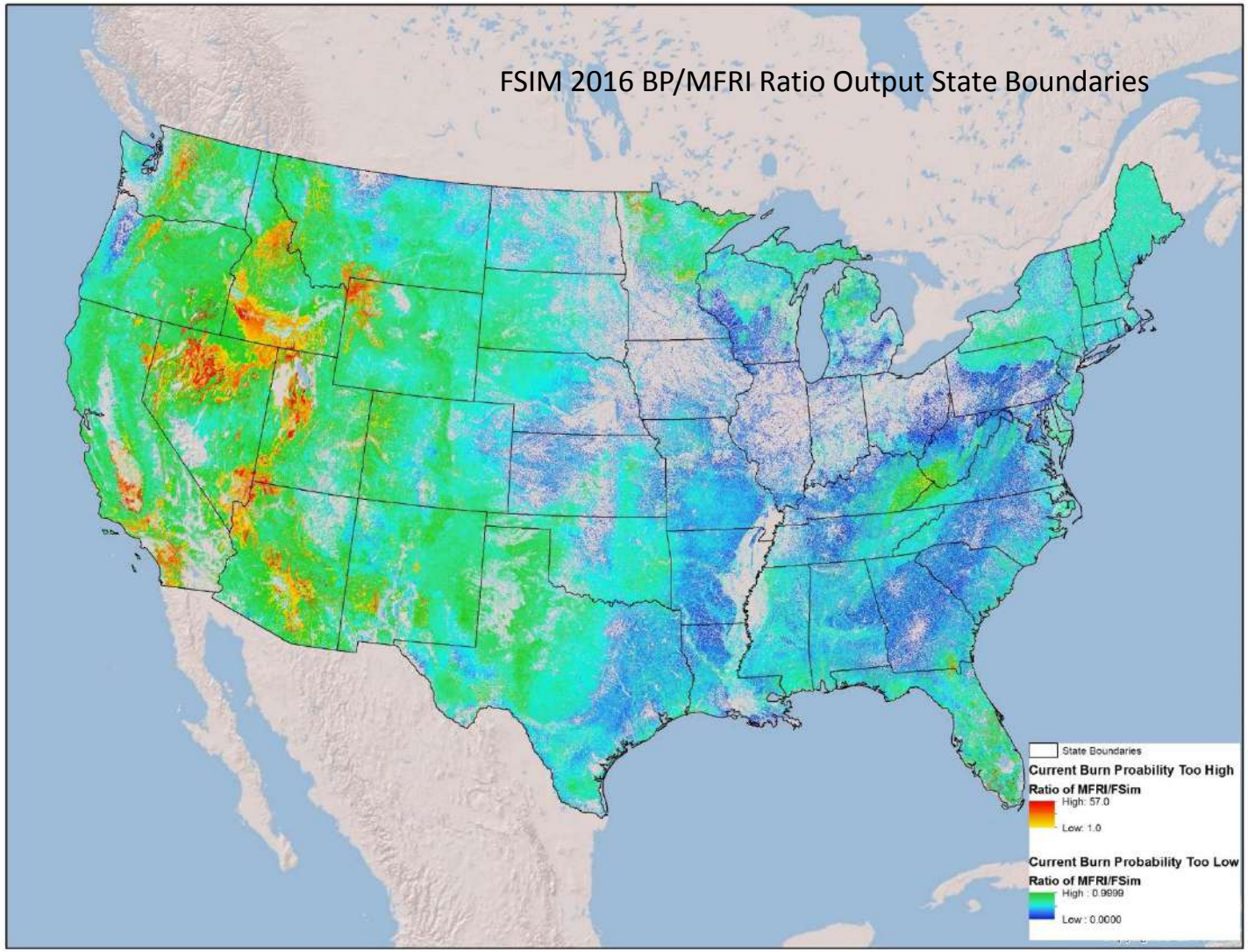
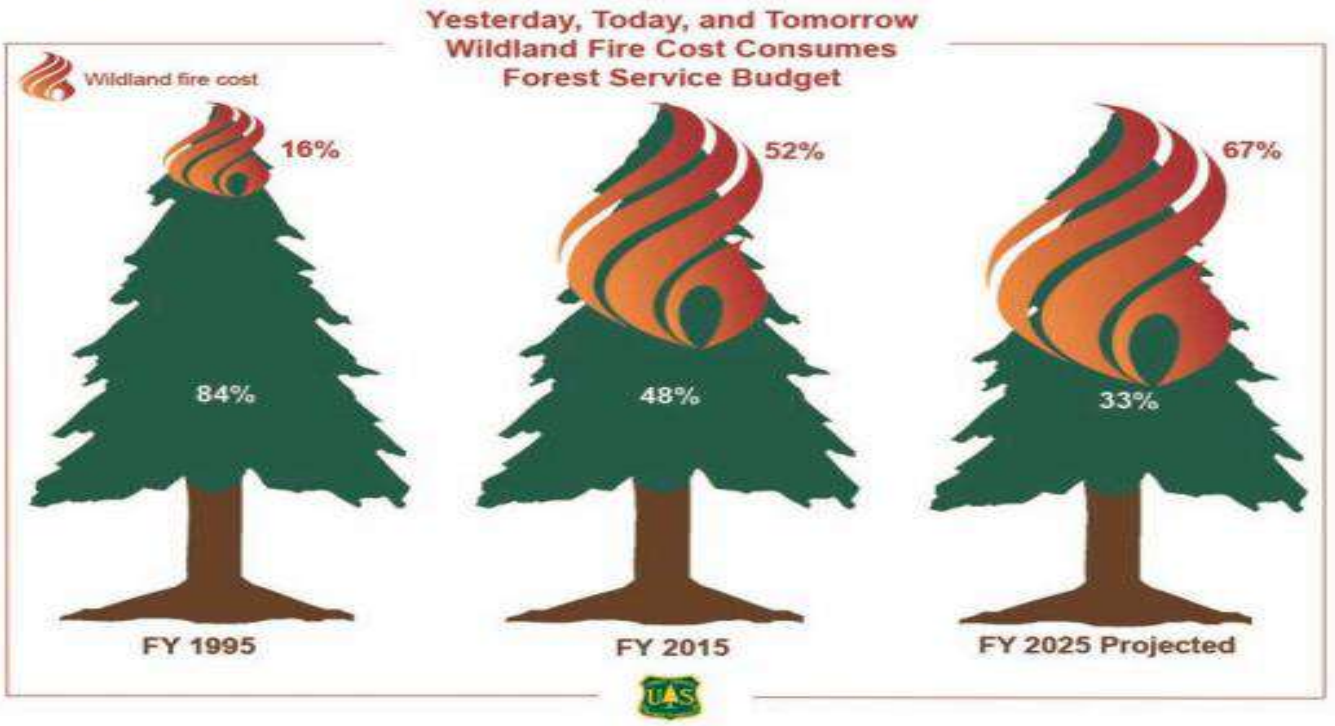
Ecological system
Fire mgmt. system


FSIM 2016 BP/MFRI Ratio Output State Boundaries
State Boundaries
Current Burn Proability Too High
Ratio of MFRI/FSim
High: 57.0
Low: 1.0
Current Burn Probability Too Low
Ratio of MFRI/FSim
High : 0.9999
Low : 0.0000

Budget Impacts

Figure 1: The Cost of Wildland Fire (Preparedness, Suppression, FLAME, and related programs) as a Percentage of the Forest Service's Annual Budget



Effect on other USFS programs (2000-2015)

Veg management	**-22%**
Facilities	**-67%**
Roads	**-46%**
Deferred maintenance	**-95%**

Water and the Western US

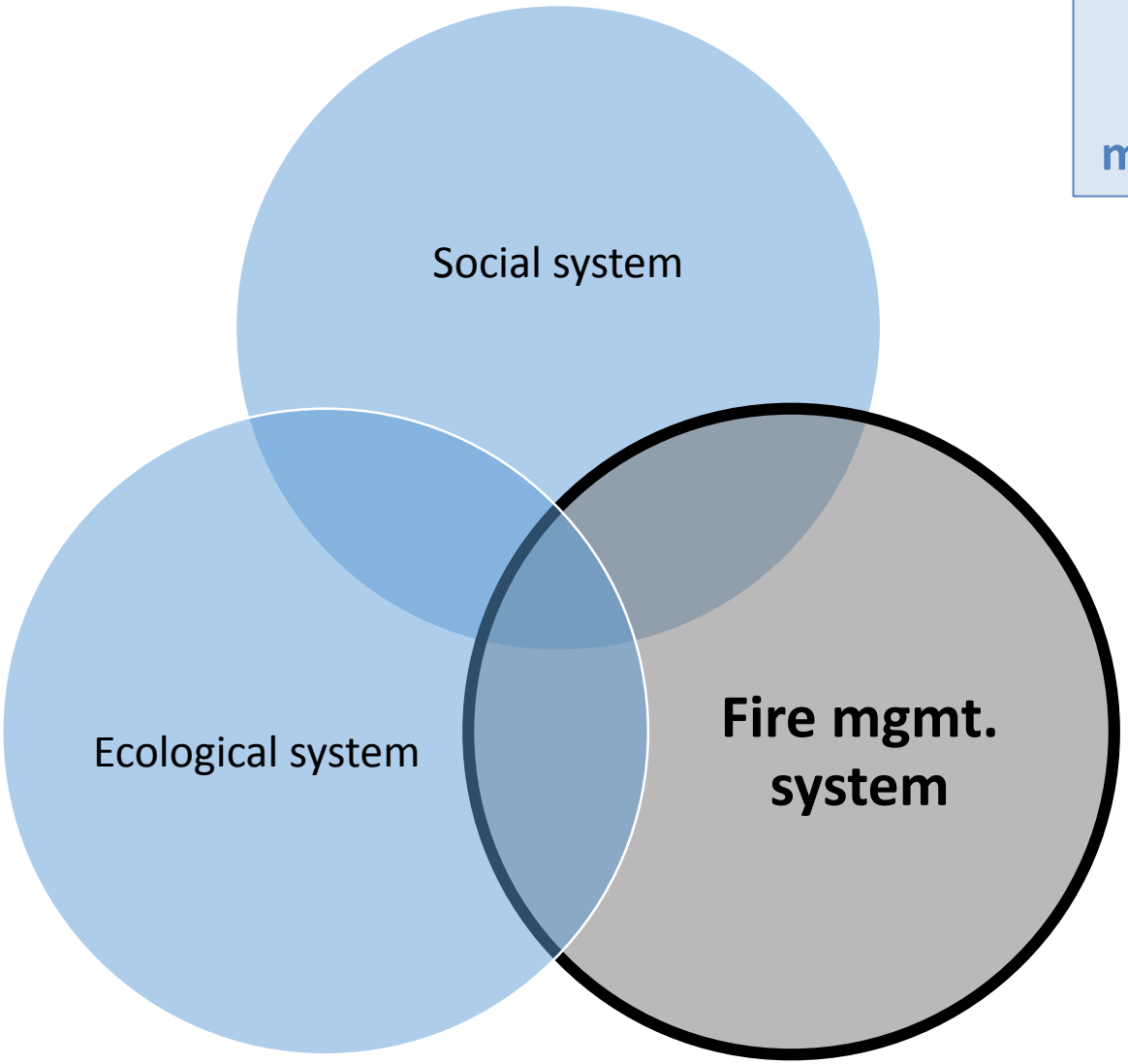
Wildfire Effects – Spatial and Temporal Influences

Issues with Monetization

- Natural resource values, particularly non-use are notoriously difficult to value in monetary terms.
- Individuals' valuation vary greatly.
- Existing research in US has provided little guidance and occasionally contradictory evidence.
- Equity issues abound when considering use values or privately owned assets.

Changes to social and ecological systems necessary but insufficient

Need change in the fire management system as well



Organizational Culture

Great Burn of 1910

Paiute Forestry - Prescribed Fire Debate

What we know about how large fires are managed?

- Data limitations inhibit knowledge and understanding
- Human factors dominate – strategies and associated cost vary considerably across regions and incident teams
- Production rate studies show considerable ‘inefficiency’ and even contradictory results
- Extensive experiential based requirements have limited participation and many IMTs are staffed by non-federal employees (particularly retirees)

Managerial Incentives and Decision Biases

- Decentralized decision making and a lack of control over suppression resource ordering on large fires creates a classic ‘tragedy of the commons’ where individual managers are incentivized to order resources beyond the level of marginal economic effectiveness increasing fire budget at the expense of funding for non-fire programs.
- A range of classic decision biases such as status quo bias, excessive discounting of future consequences, and loss aversion further promote excessive suppression resource use.

Suppression Effectiveness

- Finney et al. 2009 demonstrated quiescent period critical to fire containment
- Holmes and Calkin 2013 showed suppression resources approximately 15-30 percent efficient relative to reported production rates
- Katuwal et al. 2016 showed hand crews had a negative relationship on the production of final fire perimeter

Limits of Professional Intuition

<u>Conditions for intuitive expertise</u>:

"evaluating the likely quality of an intuitive judgment requires an assessment of the predictability of the environment in which the judgment is made and of the individual's opportunity to learn the regularities of that environment. **Subjective experience is not a reliable indicator of judgment accuracy.**"

Kahneman, D. and Klein, G., 2009. Conditions for intuitive expertise: a failure to disagree. *American psychologist*, *64*(6), p.515.

Competence in expert decision makers

Good Performance

- Static Stimuli
- Decisions About Things
- Experts Agree on Stimuli
- More Predictable Problems
- Feedback Available
- Objective Analysis Available
- Problem Decomposable

Poor Performance

- Dynamic (Changeable) Stimuli
- Decisions About Behavior
- Experts Disagree on Stimuli
- Less Predictable Problems
- Feedback Largely Unavailable
- Reliance on Subjective

Analyses

- Problem Not Decomposable

Adapted from Shanteau (1992)

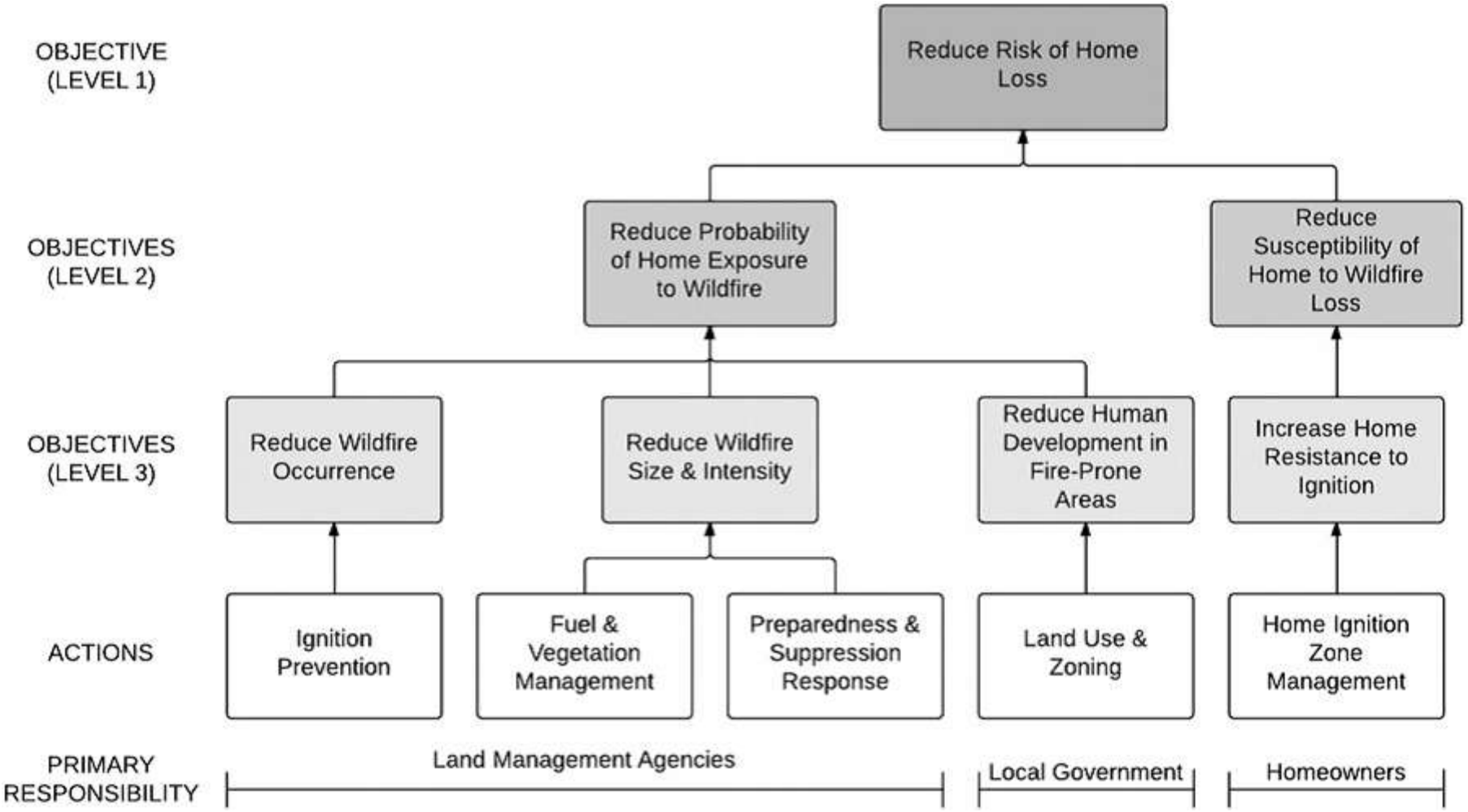
Risk Management

- Risk (ISO 31000): “effect of uncertainty on objectives”
  - Given some objective, “distribution of outcomes”
  - Not just one outcome – probability distribution
  - May include good and bad outcomes

- Risk governance should be inclusive, transparent, adaptable and reflexive in the future, particularly given the increasing prominence today of such multi-dimensional ‘wicked’ problems (Palmer 2011)

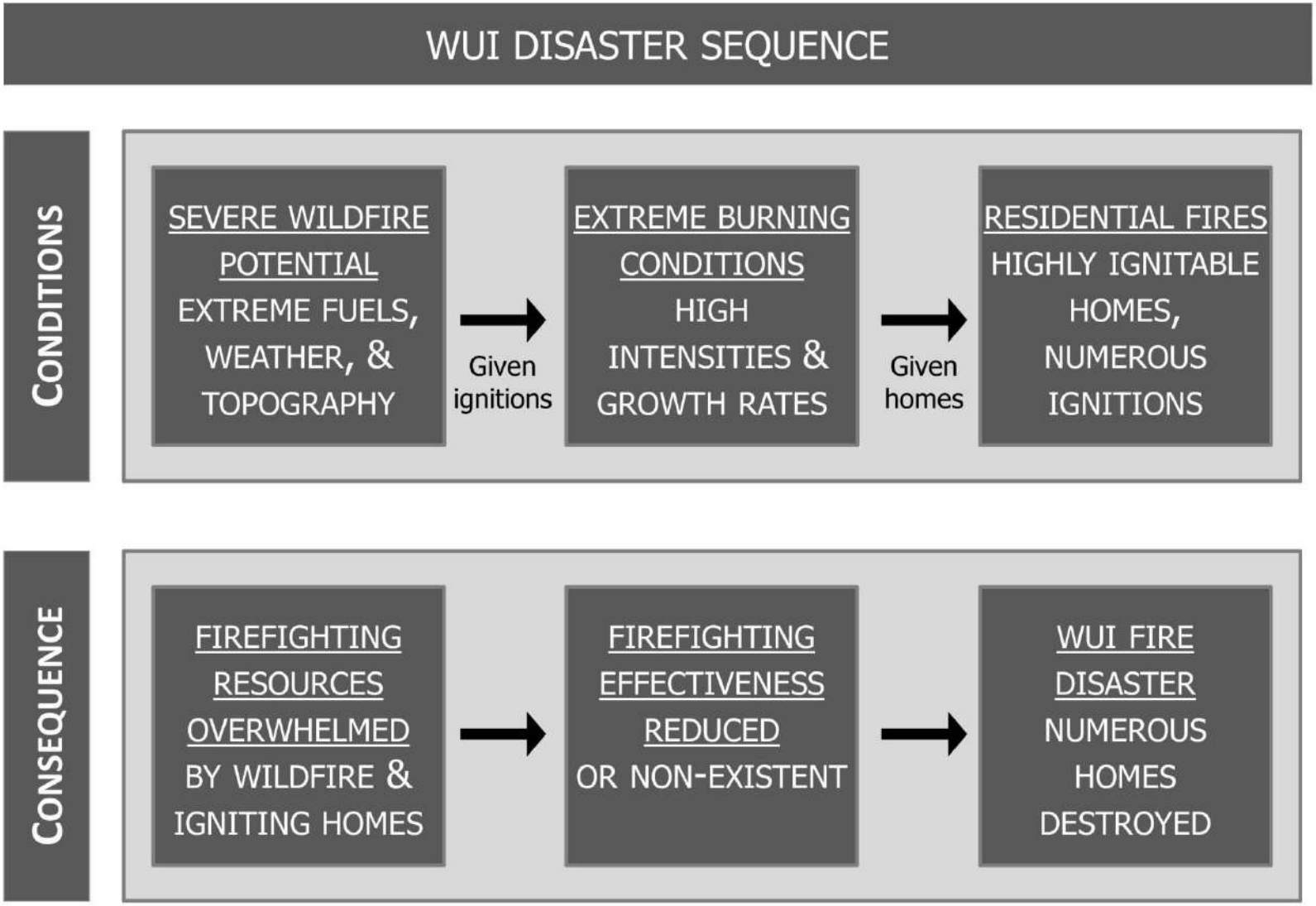
Levels of Risk Management

Structured Risk Mitigation Model



Wildfire risk and right tails

- Wildfire size has been shown to follow a power law.
- Extreme events dominate losses
- Mitigation are often designed for less than extreme conditions.


WUI DISASTER SEQUENCE
CONDITIONS
SEVERE WILDFIRE POTENTIAL
EXTREME FUELS, WEATHER, & TOPOGRAPHY
Given ignitions
EXTREME BURNING CONDITIONS
HIGH INTENSITIES & GROWTH RATES
Given homes
RESIDENTIAL FIRES
HIGHLY IGNITABLE HOMES, NUMEROUS IGNITIONS
CONSEQUENCE
FIREFIGHTING RESOURCES OVERWHELMED
BY WILDFIRE & IGNITING HOMES
FIREFIGHTING EFFECTIVENESS REDUCED
OR NON-EXISTENT
WUI FIRE DISASTER
NUMEROUS HOMES DESTROYED

Community Exposure to Wildfire WA & OR

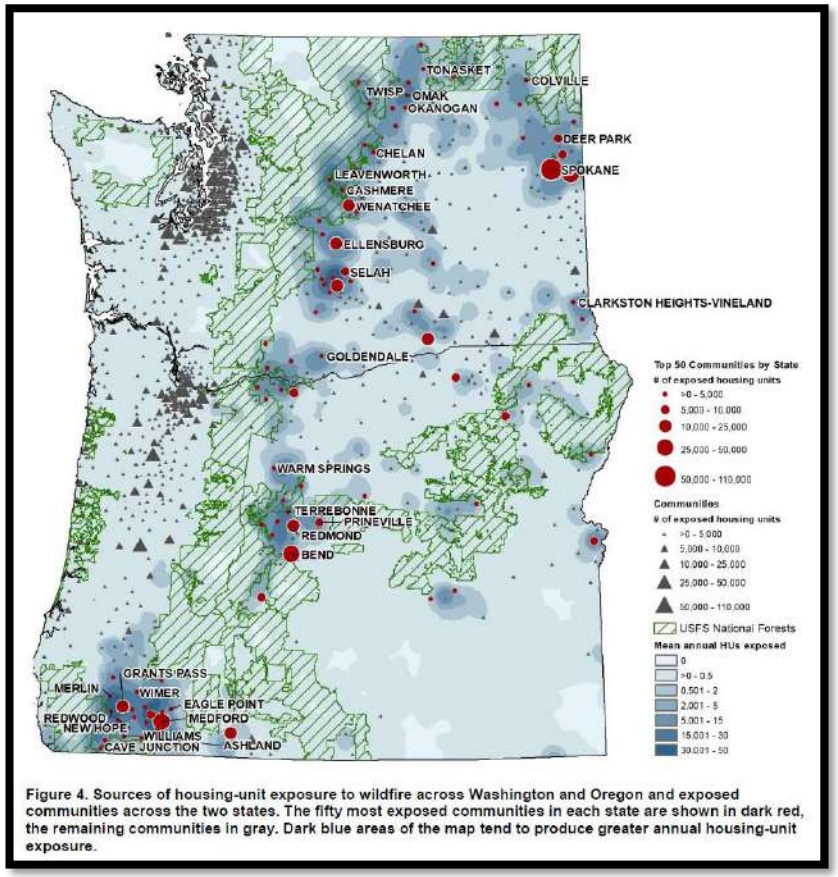


Figure 4. Sources of housing-unit exposure to wildfire across Washington and Oregon and exposed communities across the two states. The fifty most exposed communities in each state are shown in dark red, the remaining communities in gray. Dark blue areas of the map tend to produce greater annual housing-unit exposure.

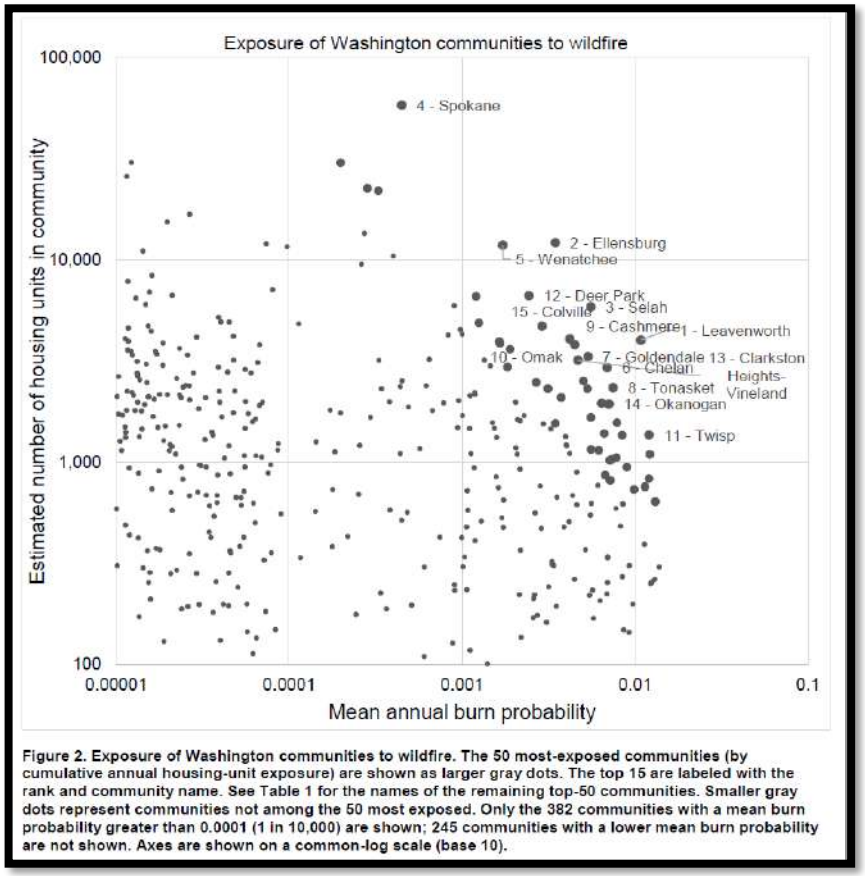
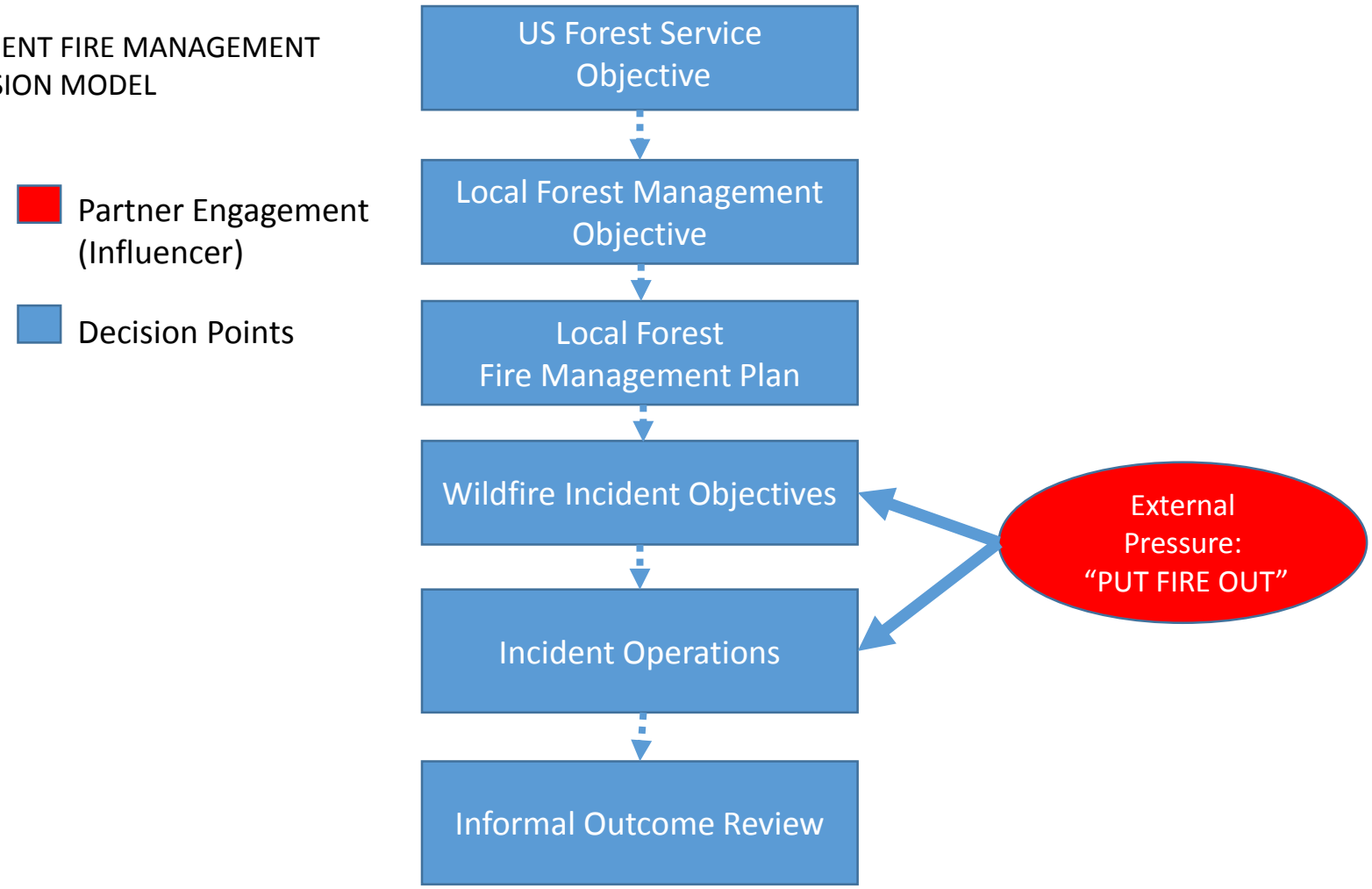
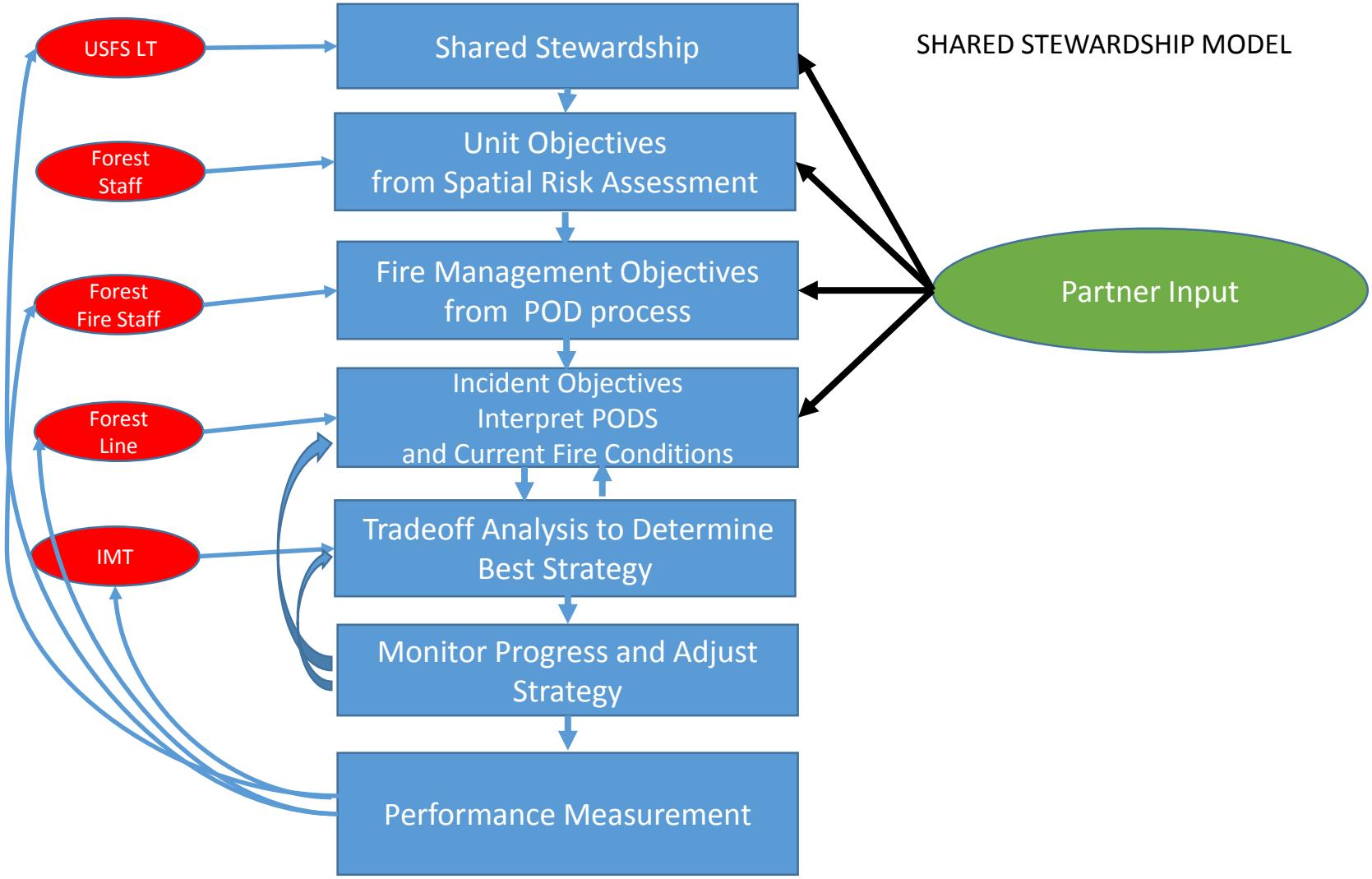


Figure 2. Exposure of Washington communities to wildfire. The 50 most-exposed communities (by cumulative annual housing-unit exposure) are shown as larger gray dots. The top 15 are labeled with the rank and community name. See Table 1 for the names of the remaining top-50 communities. Smaller gray dots represent communities not among the 50 most exposed. Only the 382 communities with a mean burn probability greater than 0.0001 (1 in 10,000) are shown; 245 communities with a lower mean burn probability are not shown. Axes are shown on a common-log scale (base 10).

CURRENT FIRE MANAGEMENT DECISION MODEL




SHARED STEWARDSHIP MODEL
USFS LT
Forest Staff
Forest Fire Staff
Forest Line
IMT
Shared Stewardship
Unit Objectives from Spatial Risk Assessment
Fire Management Objectives from POD process
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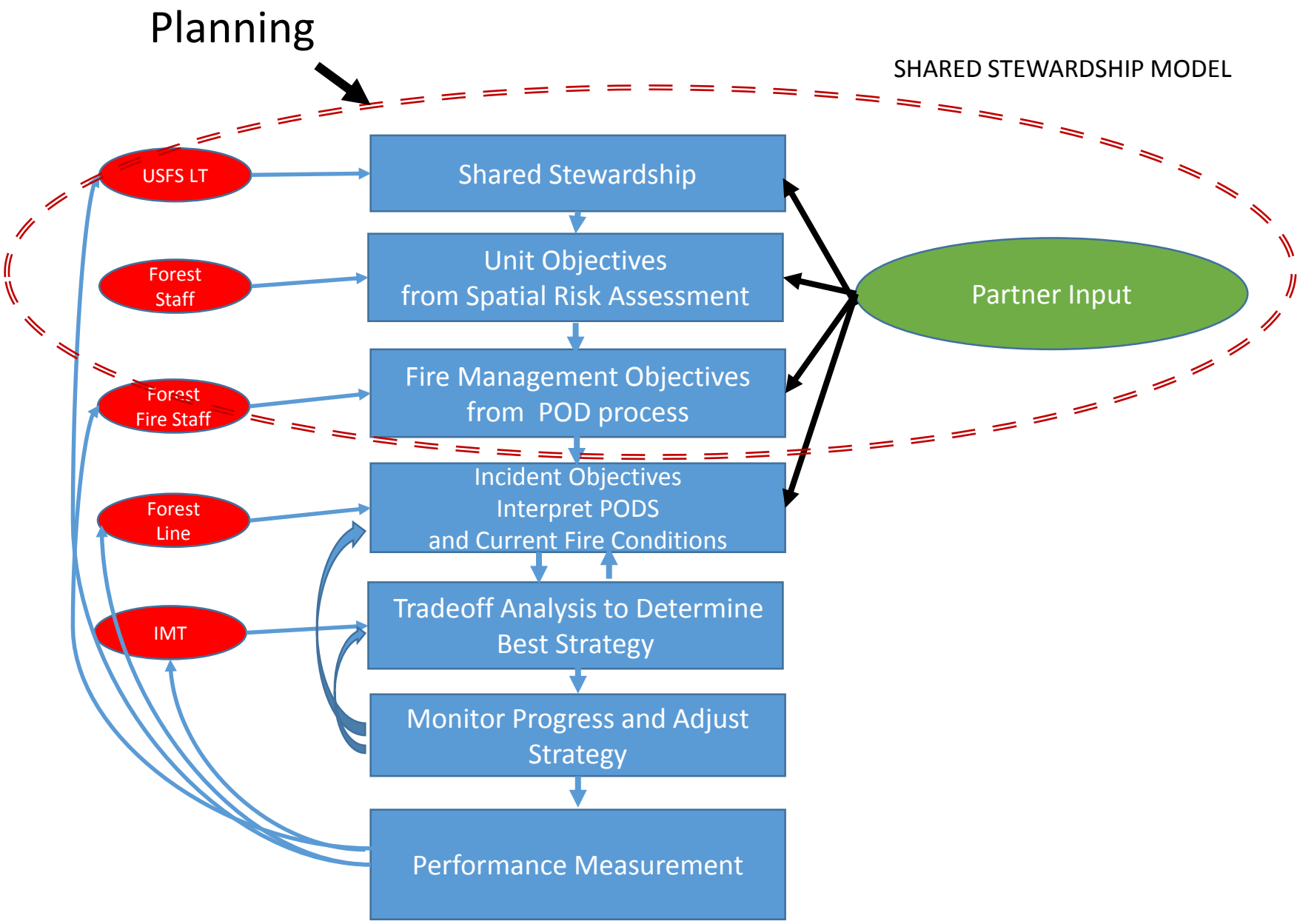
Tradeoff Analysis to Determine Best Strategy
Monitor Progress and Adjust Strategy
Performance Measurement
Partner Input


Planning
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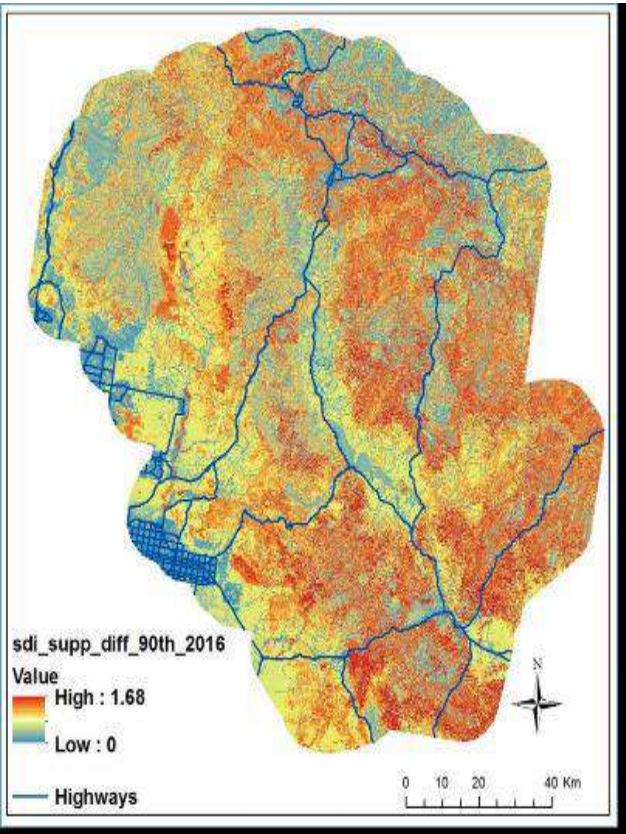
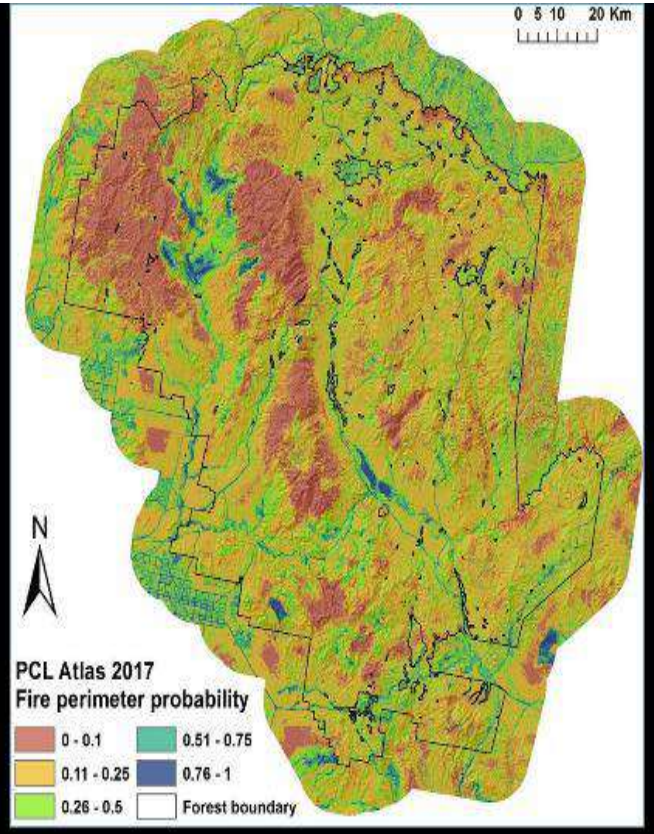
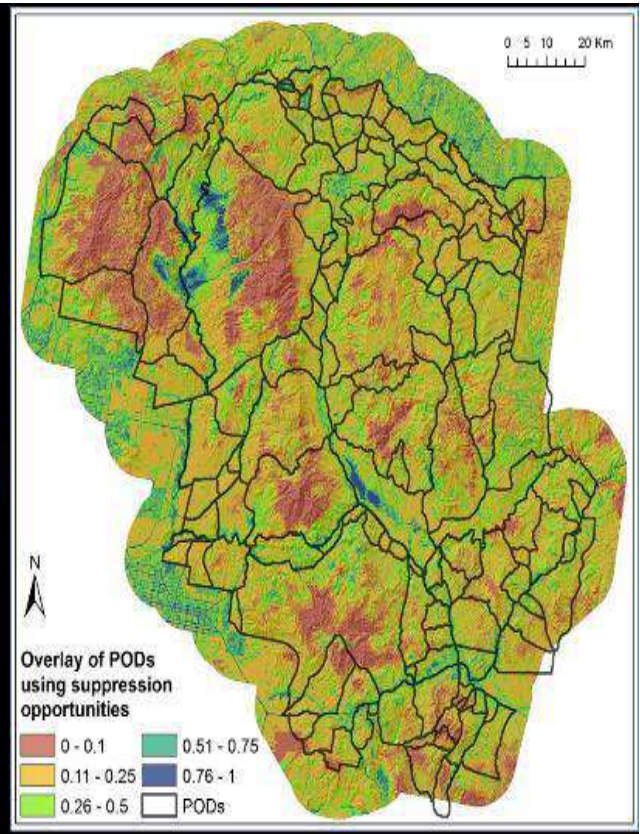
Wildfire Suppression Models

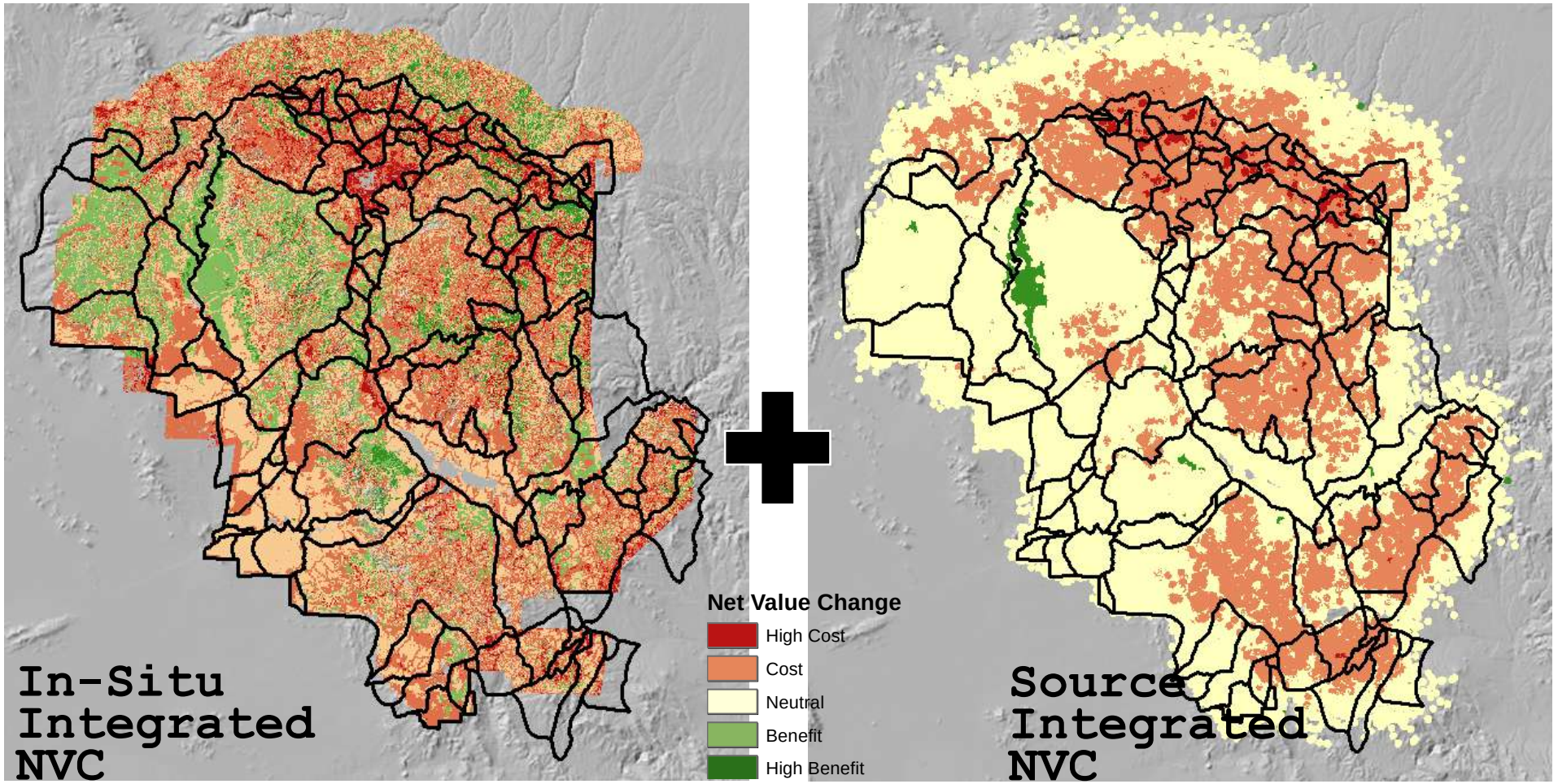






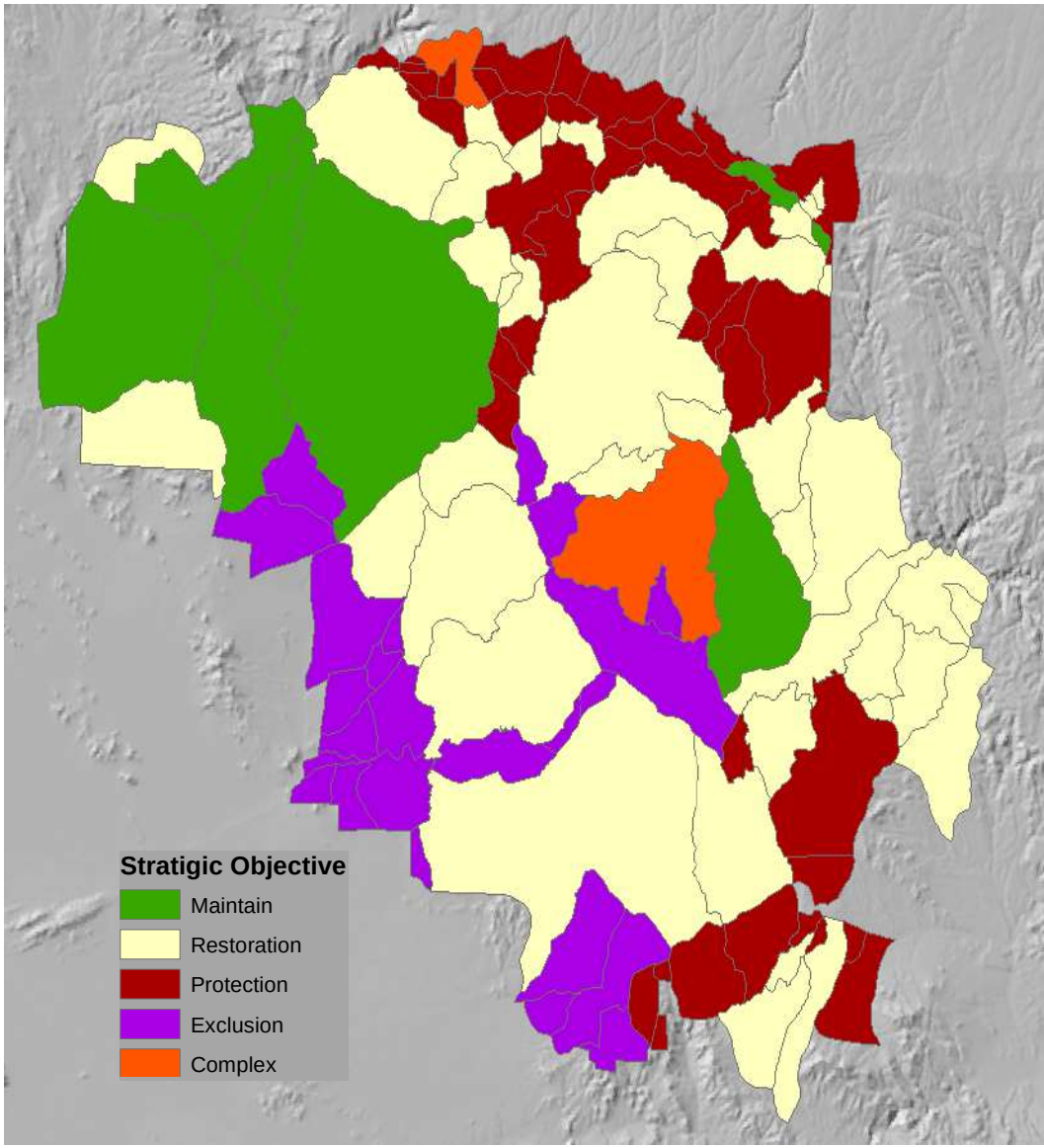
Suppression Difficulty → Potential Control Locations → PODS

Wildfire Risk Assessment



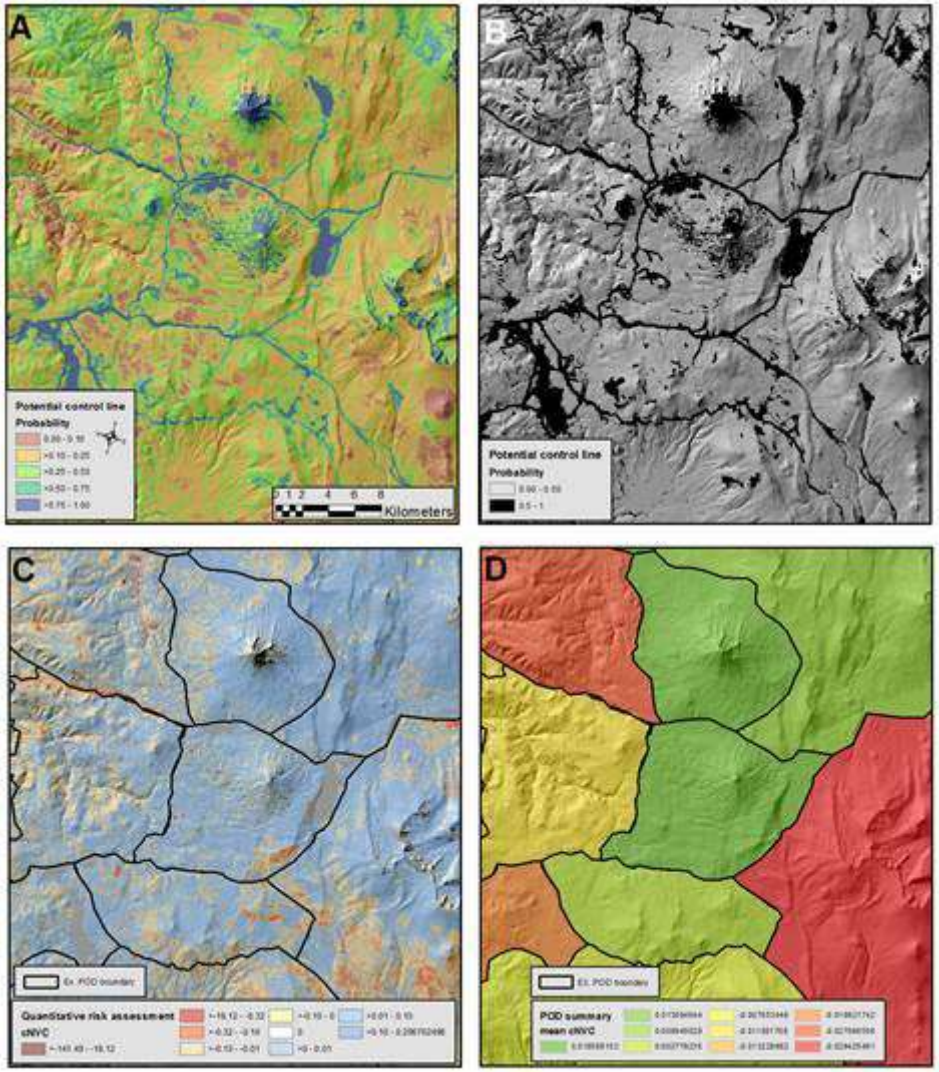
Strategic Response

- Maintain = risk metrics +
  - manage fire for resource benefit
- Restore = risk metrics +/-
  - resource benefits could exist, but values at risk are such that managing fires are difficult under some conditions
- Protect = risk metrics –
  - values at risk make it difficult to manage fires under most conditions. Fuels mitigation work needed
- Exclude = Sonoran desert
- High Complexity = difficult to mitigate risk, and mix of costs/benefits

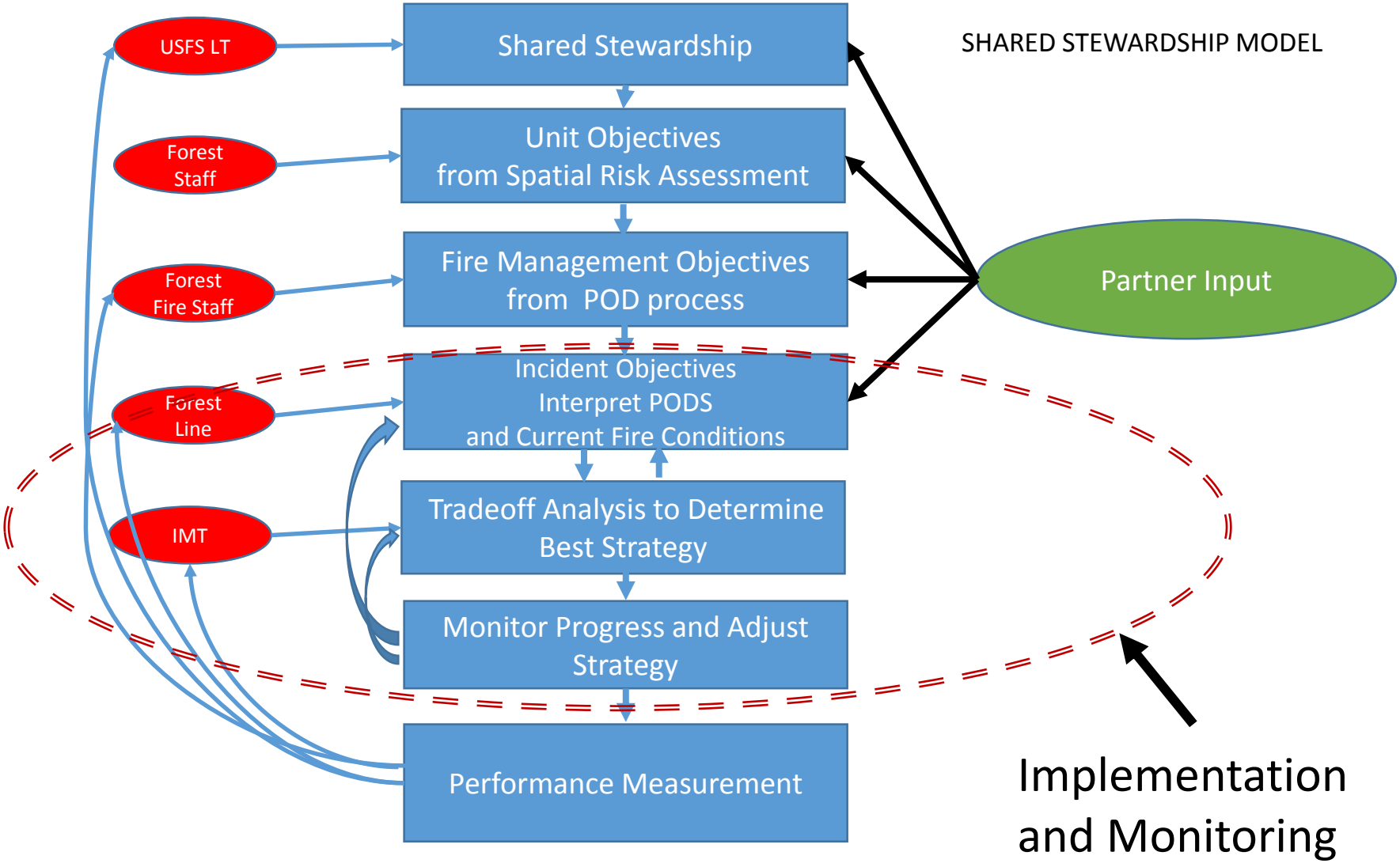


Infusing Analytics into Fire Planning

Photo credit: Mike Caggiano



O'Connor, C.D., Calkin, D.E. and Thompson, M.P., 2017. An empirical machine learning method for predicting potential fire control locations for pre-fire planning and operational fire management. *International journal of wildland fire*, *26*(7), pp.587-597.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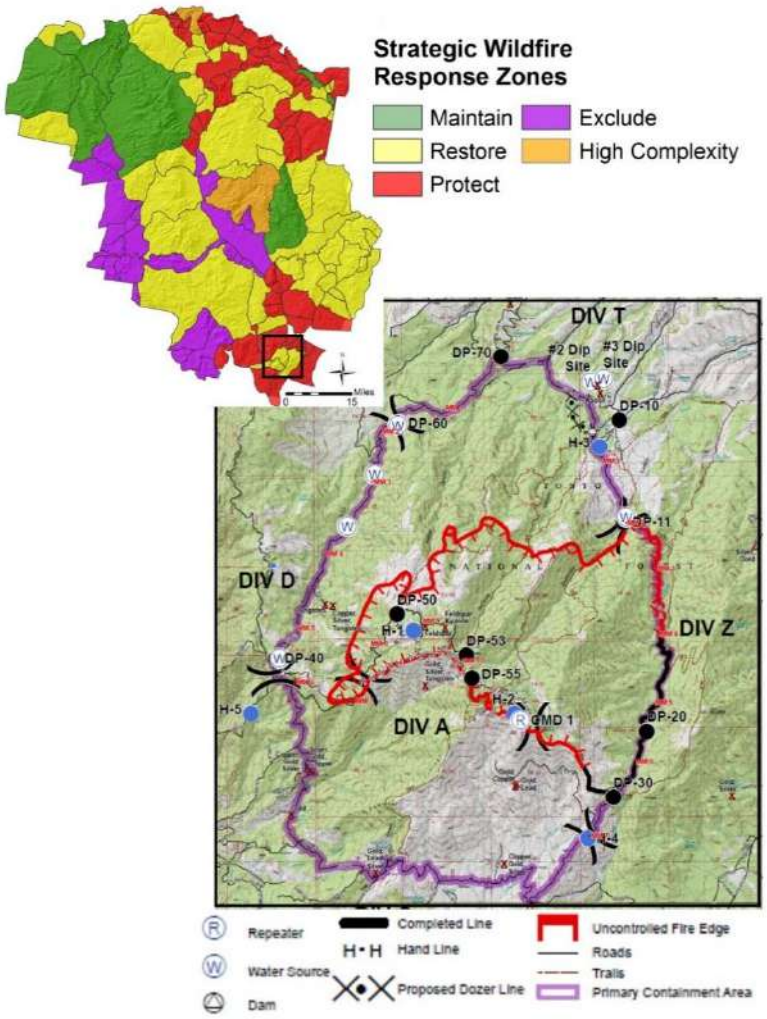
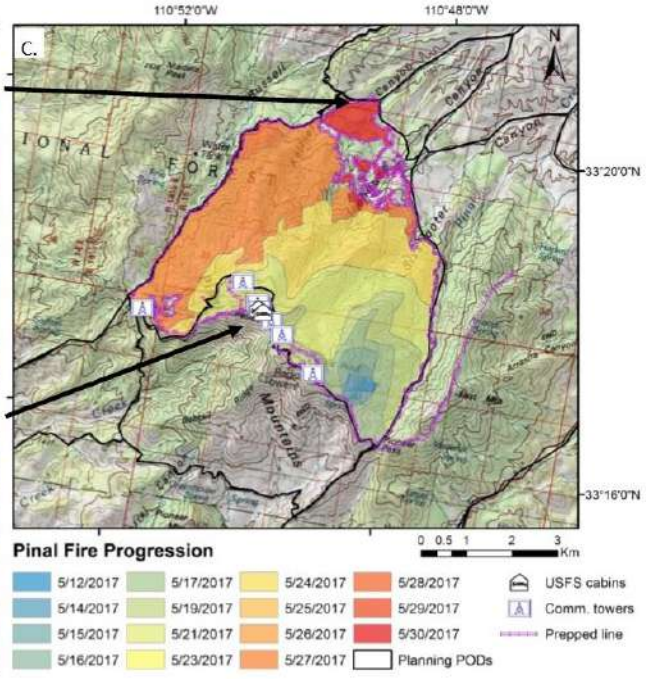
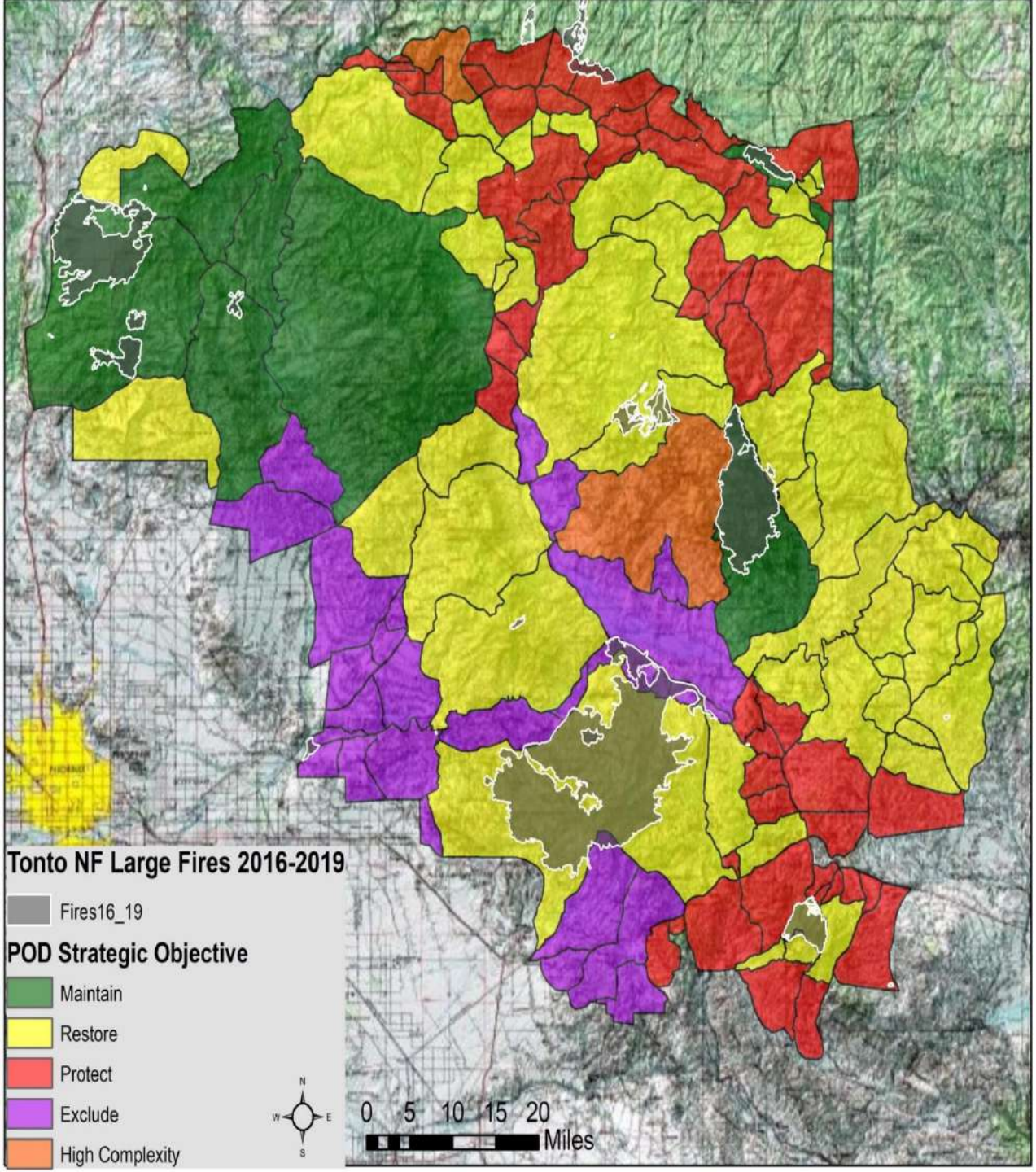
Implementation and Monitoring

Example from the 2017 Pinal Fire (Tonto NF)





Wei, Y., Thompson, M.P., Haas, J.R., Dillon, G.K. and O'Connor, C.D., 2018. Spatial optimization of operationally relevant large fire confine and point protection strategies: model development and test cases. *Canadian Journal of Forest Research*, *48*(5), pp.480-493.


Tonto NF Large Fires 2016-2019
Fires16_19
POD Strategic Objective
Maintain
Restore
Protect
Exclude
High Complexity
N
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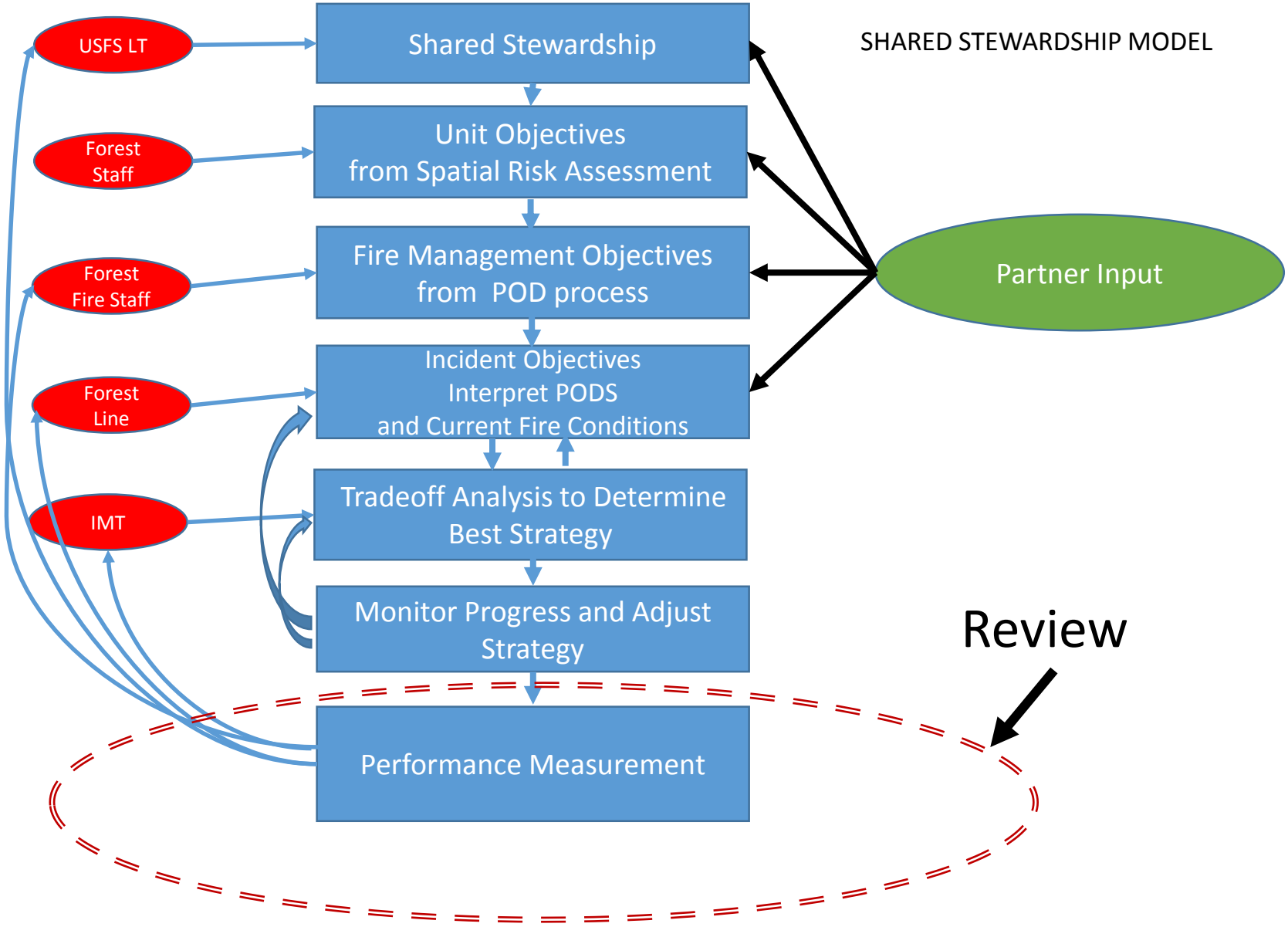
Miles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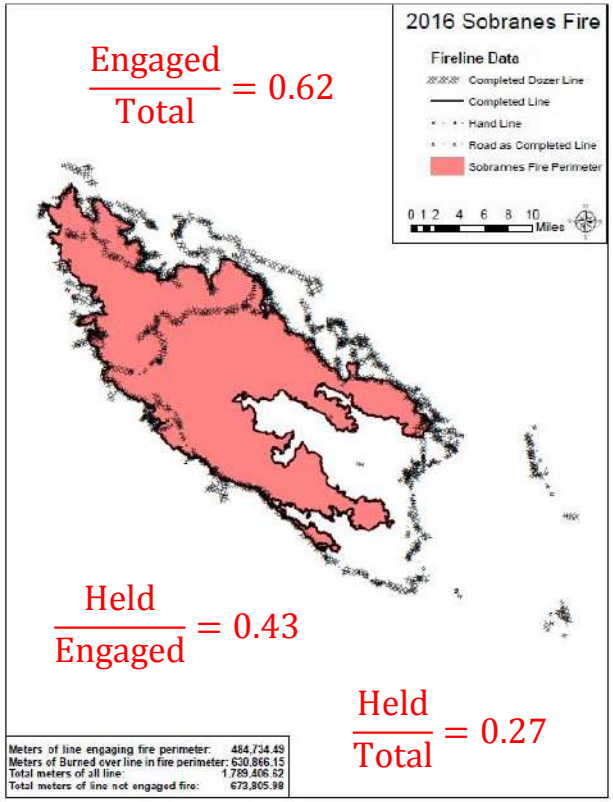
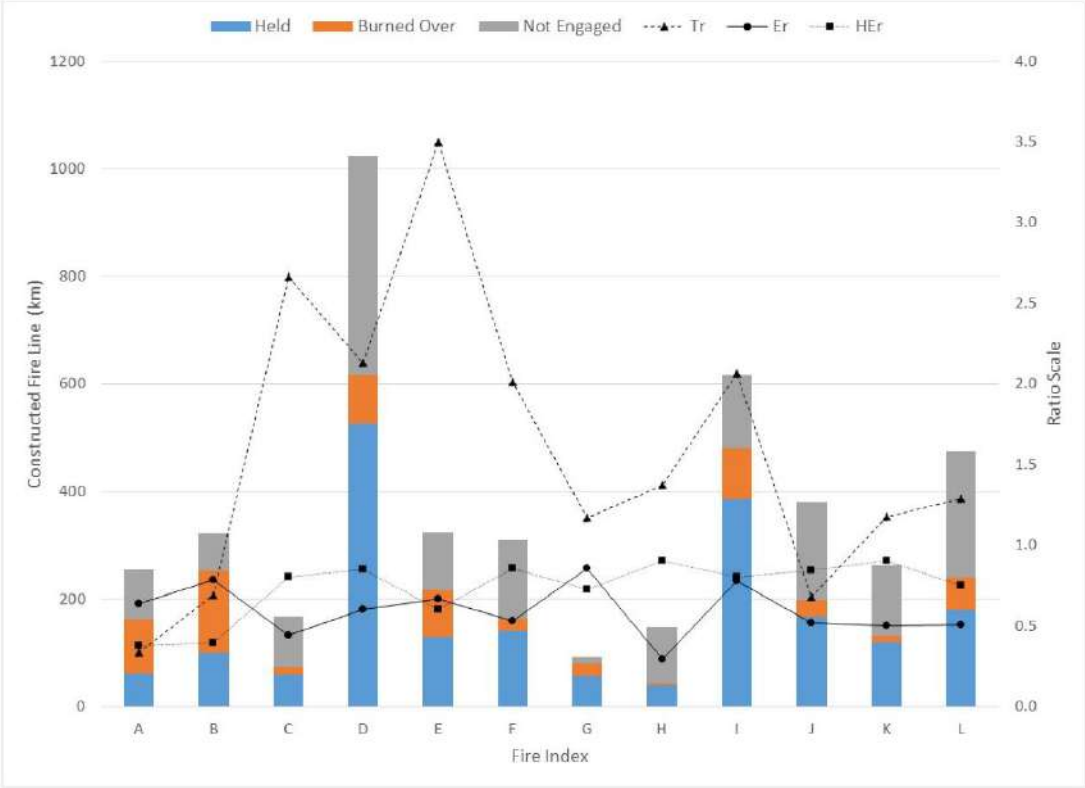
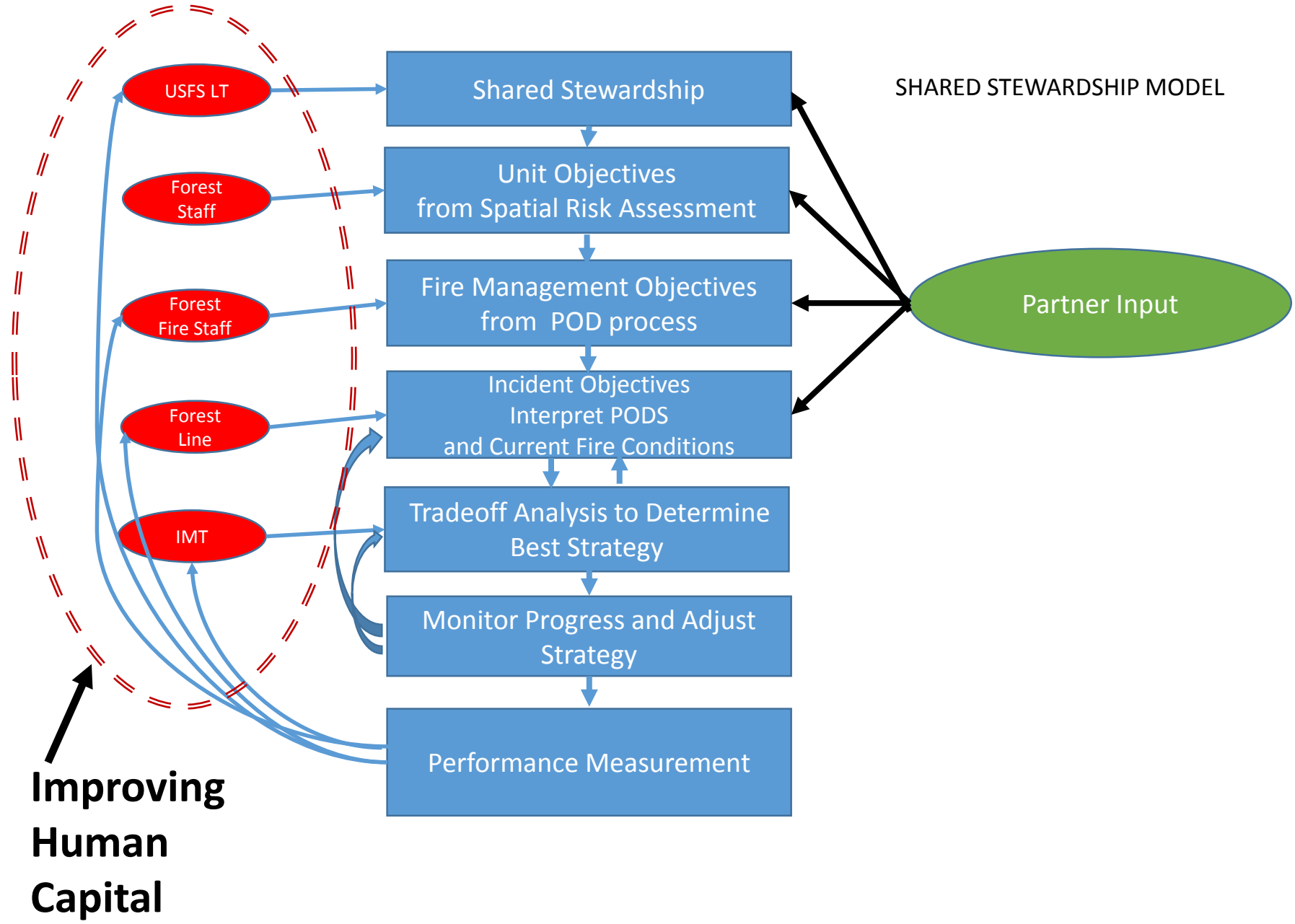
Planning → Implementing → Monitoring → **Review**



Fire Line Effectiveness Analysis



Thompson, M., Lauer, C., Calkin, D., Rieck, J., Stonesifer, C. and Hand, M., 2018. Wildfire Response Performance Measurement: Current and Future Directions. *Fire*, *1*(2), p.21.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Partner Input
Improving Human Capital

"To overcome the insight deficit, Big Data – no matter how comprehensive or well analyzed – needs to be complemented by Big Judgement"

"Investments in analytics can be useless, even harmful, unless employees can incorporate that data into complex decision making"

Develop **informed skeptics**:

- the employees best equipped to make good decisions
- effectively balance judgement and analysis
- possess strong analytic skills

US Experience

- Over 100 years of attempting to remove wildfire from many western forest have created increased fuel loading and wildfire hazard.
- Large diversity of human communities and ecological conditions (some highly impacted others relatively intact).
- Climate change increases the likelihood of high severity fire weather conditions.

US Experience

- Human development has greatly expanded into high hazard areas.
- Broad management strategy has not sufficiently evolved to address these issues.
- Government ability to control new development and require homeowner action is limited, private actions (insurance, power companies) will likely have an increasing impact.

Concluding Thoughts

- Societal and political recognition of the unwinnable war on fire.
- The complexity of the wildfire environment and increasing loss requires a more integrated approach using the best available science to inform mitigation, planning, response, and post-fire evaluation and learning.

Concluding Thoughts

- Mitigation and planning must consider the extreme conditions under which loss occurs.
- Active and passive management that increases landscape resilience is required at scales we are currently not organized to address.
- Solutions will need to be designed that recognize the diversity of ecological and human community conditions.
- Social issues will be more challenging than technical issues.