A use of risk analysis to support wilderness fire decisions

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Research Themes

Wilderness management

- Suppression
- Fire as a stewardship tool
- Unplanned ignitions

Fuel treatment benefits of fire

- Moderate fire severity
- Mitigate fire spread
- Shift fire size distributions

Manager decision-space

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Risk analysis

- Likelihood, intensity, and effects of fire

Manager decision-space

- Quantitative, probabilistc metrics
- Spatially-explicit

Wilderness fire management

Wildland fire as a fuel treatment

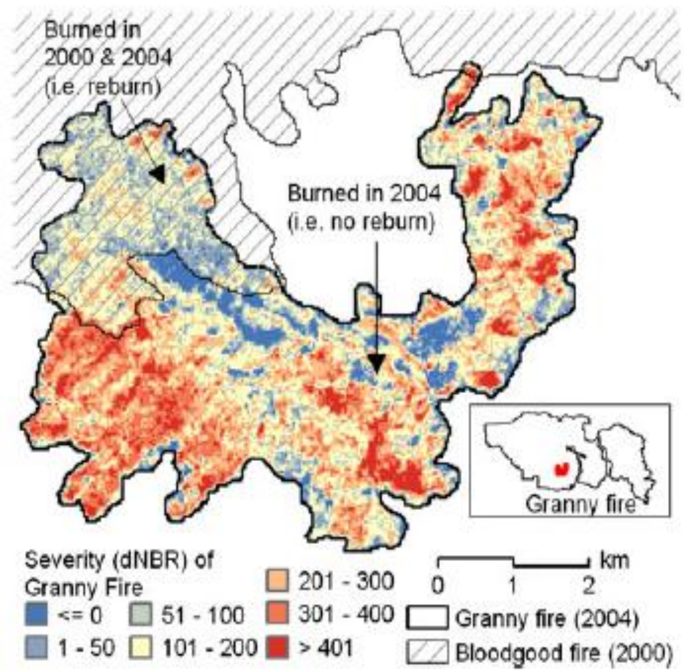
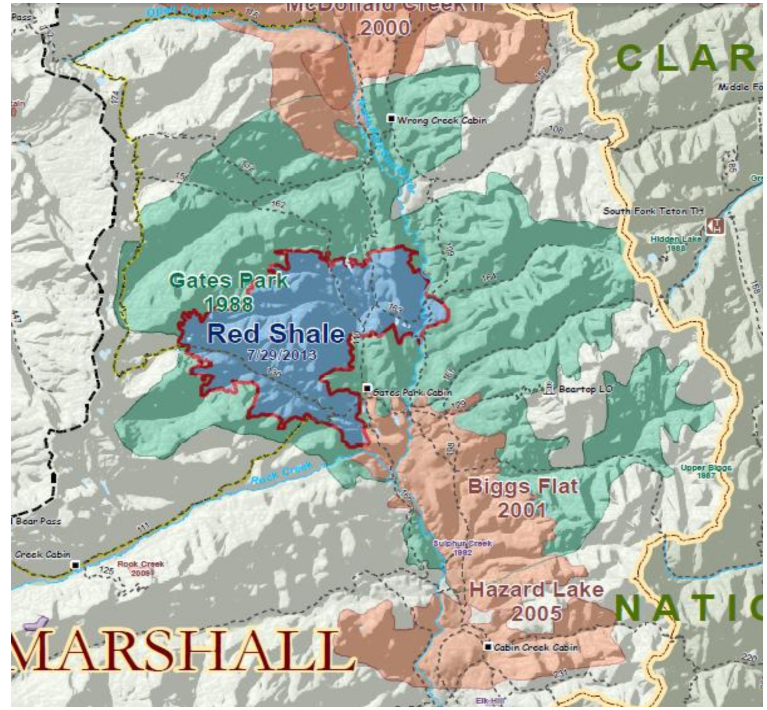


Figure 2. Burn severity (dNBR) for the 2004 Granny fire in GAL. The *thick black line* represents the Granny fire perimeter; the *hatched area* represents the perimeter of the 2000 Bloodgood fire. Qualitatively, areas that had previously burned in 2000 appear to have lower dNBR than areas that had not. The *inset* shows the location of the Granny fire within GAL.

Parks et al. (2013) *Ecosystems*



- Moderate severity of future fires
- Serve as fuelbreaks
  - Alter fire growth, spread rates
  - Expand manager decision-space

Risk analysis

- Framework guiding fire and fuels management

$$E(NVC_j) = \sum_i p(f_i)RF_j(f_i)$$

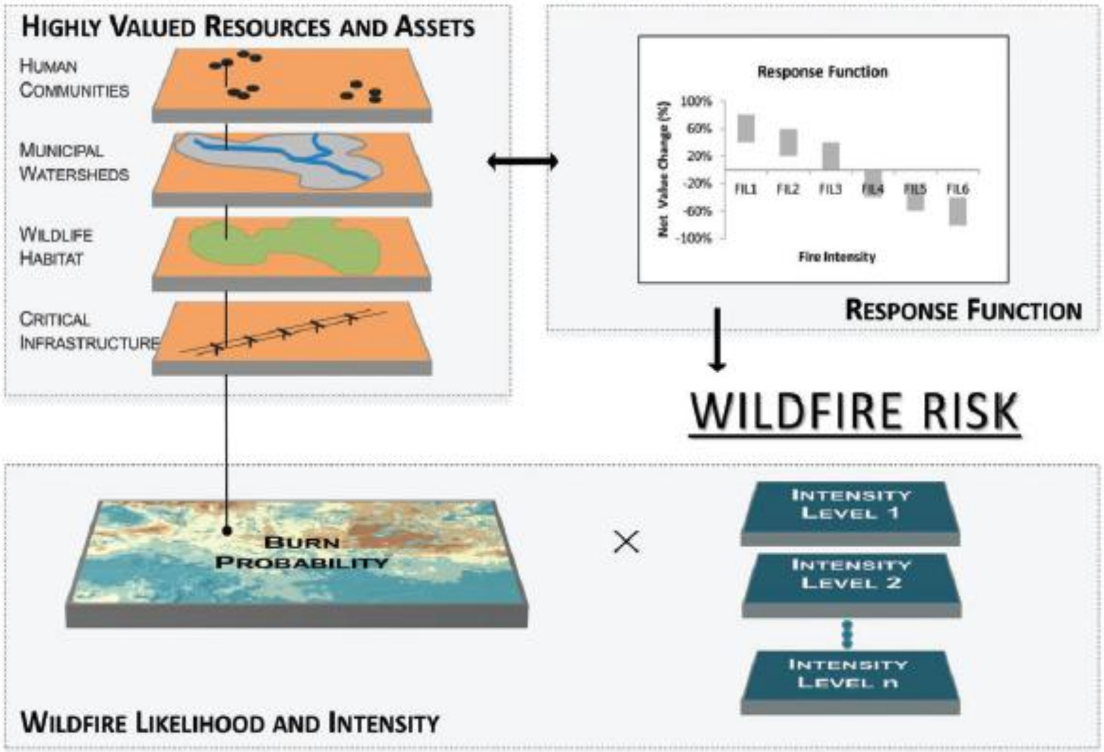
j = resource at risk

i = fire intensity level

RF = response function

p(f) = probability of fire

- Exposure vs effects analysis
- Fuel treatments
  - Effectiveness
  - Prioritization
    - Mitigate/minimize risk



Scott et al. (2013) GTR-315

Challenges of applying wildfire risk framework to wilderness fire management

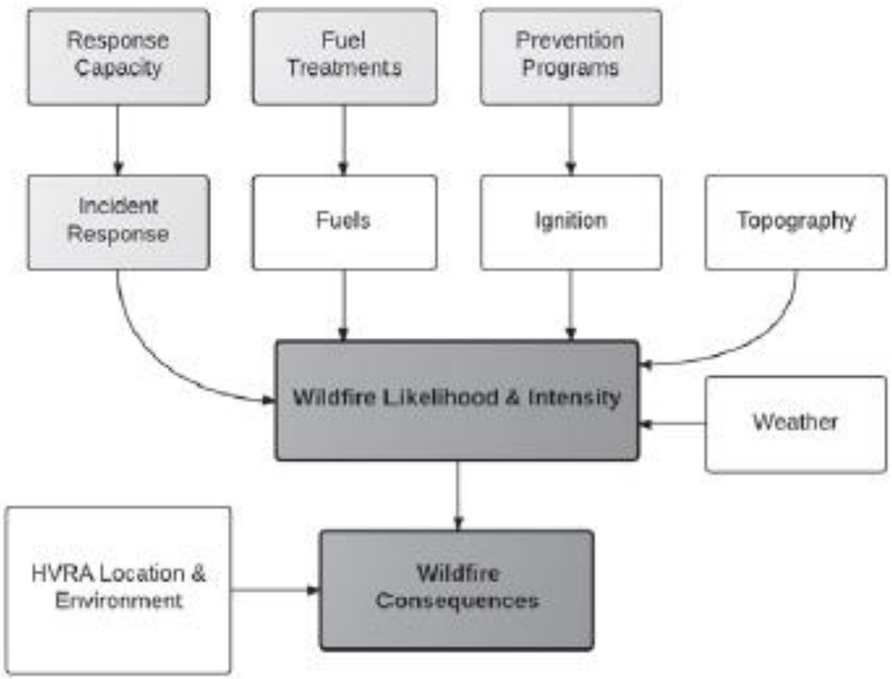


Figure 34—Conceptual model of wildfire management actions and their relation to primary factors driving wildfire risk. Boxes in light gray are management actions, and boxes in dark grey are assessment outputs. Figure modified from Calkin and others (2011a).

- Disconnect between ignitions and fuels
  - Interwoven, interdependent
- Constraints on reducing wildfire risk in wilderness areas
  - Ignitions
- Effects analysis
  - Mapping and quantifying wilderness character, access, solitude, restoration of fire regimes
  - Uncertainty in effects parameters
- Minimizing risk *inside* wilderness
  - Resources at risk outside wilderness

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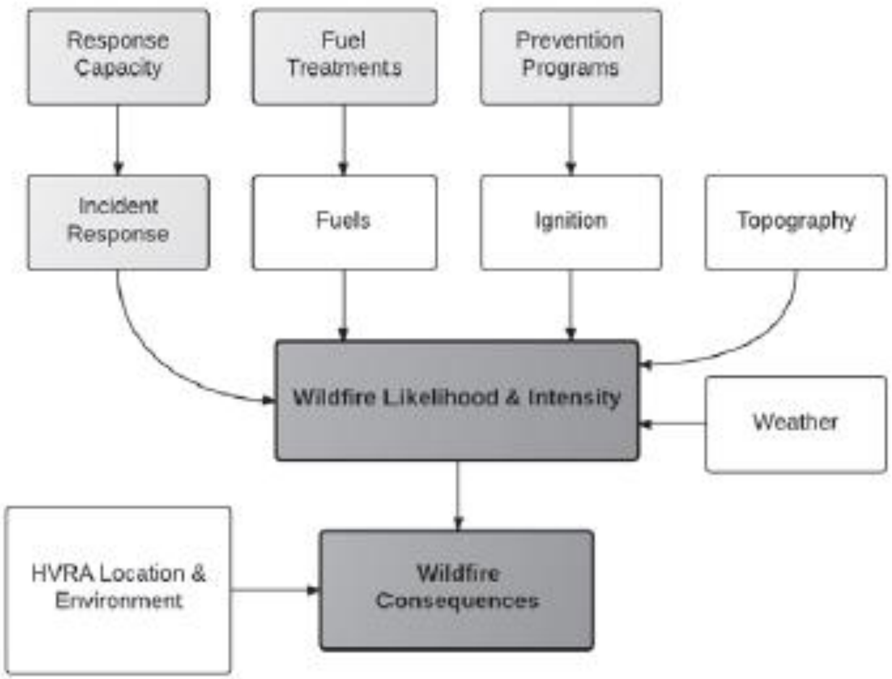

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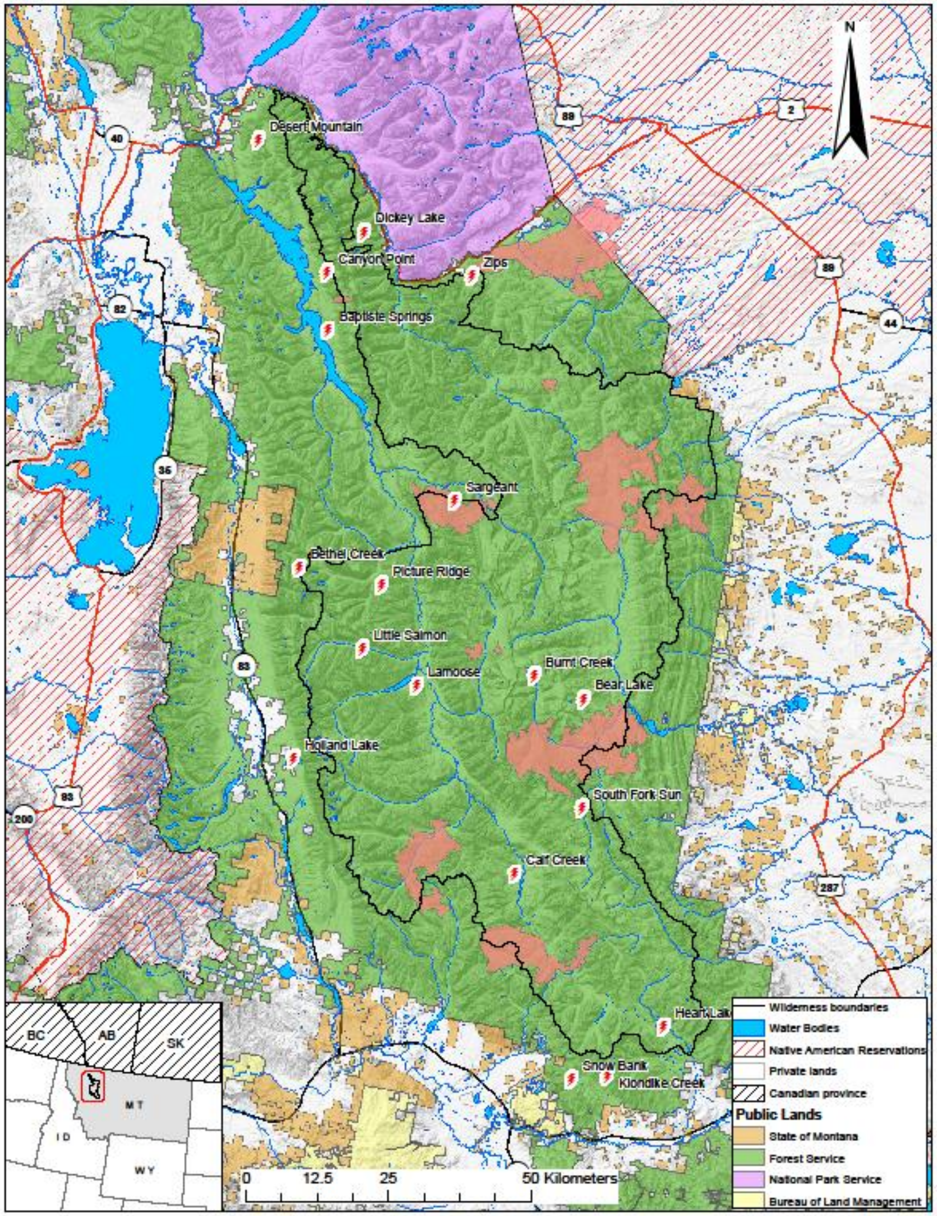
- **Quantify benefits of fire in terms of manager decision-space?**

Research questions

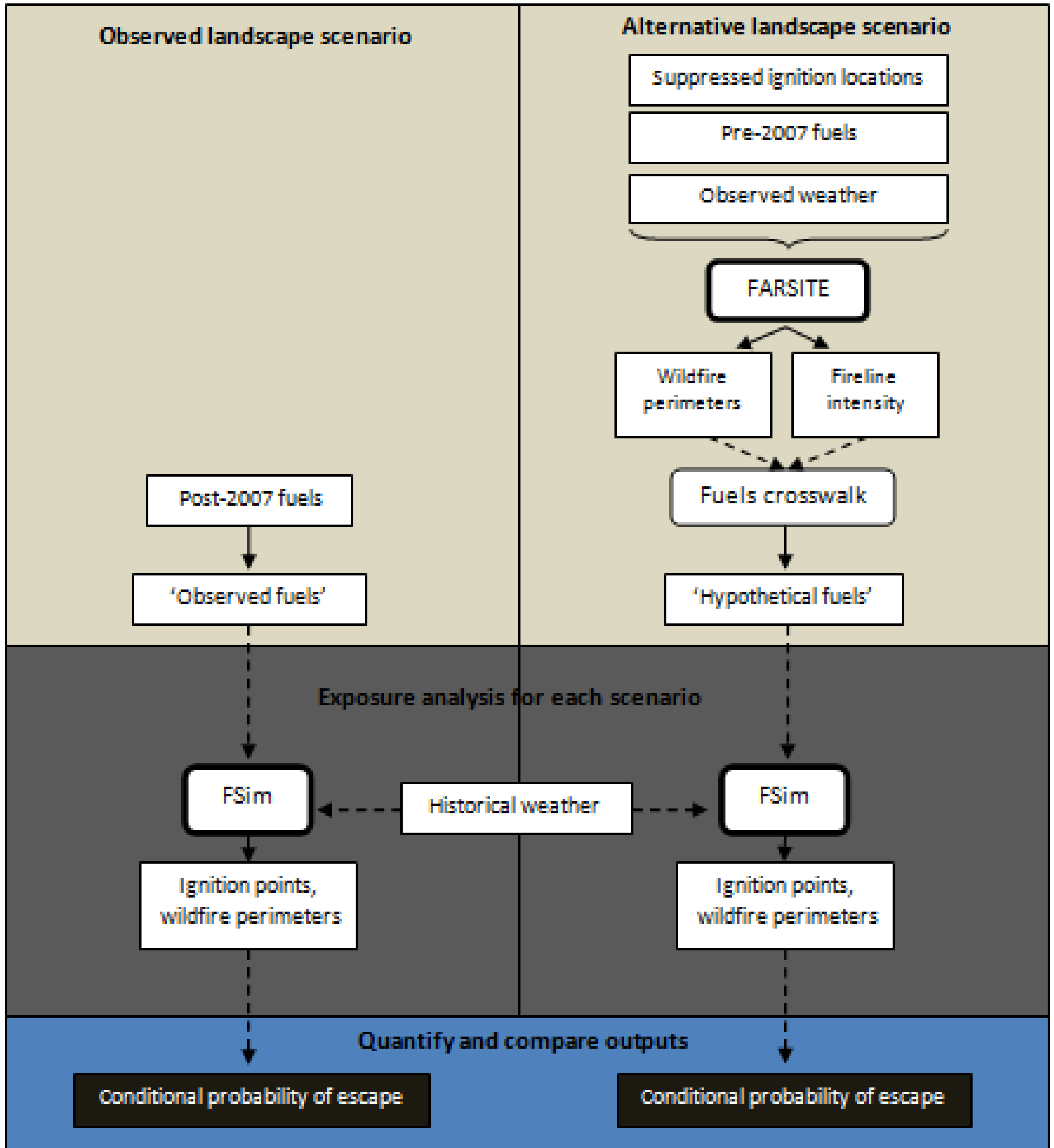
- How can wildfire risk analysis tools be used to quantify wilderness manager decision-space?
- How might allowing previously suppressed ignitions to burn have affected future manager decision-space?
- What properties of a fire contribute to their effectiveness at altering future manager decision-space?
  - Within versus outside fire perimeter

Case study area, year

- Bob Marshall Wilderness Complex
  - 625,000 hectares
  - Rich history of fire use
- Fire season of 2007
  - Active across northern Rockies
  - Aggressive implementation of Appropriate Management Response (AMR)
    - Full spectrum of response strategies
  - Numerous suppressed ignitions in BMWC



Landscape scenarios



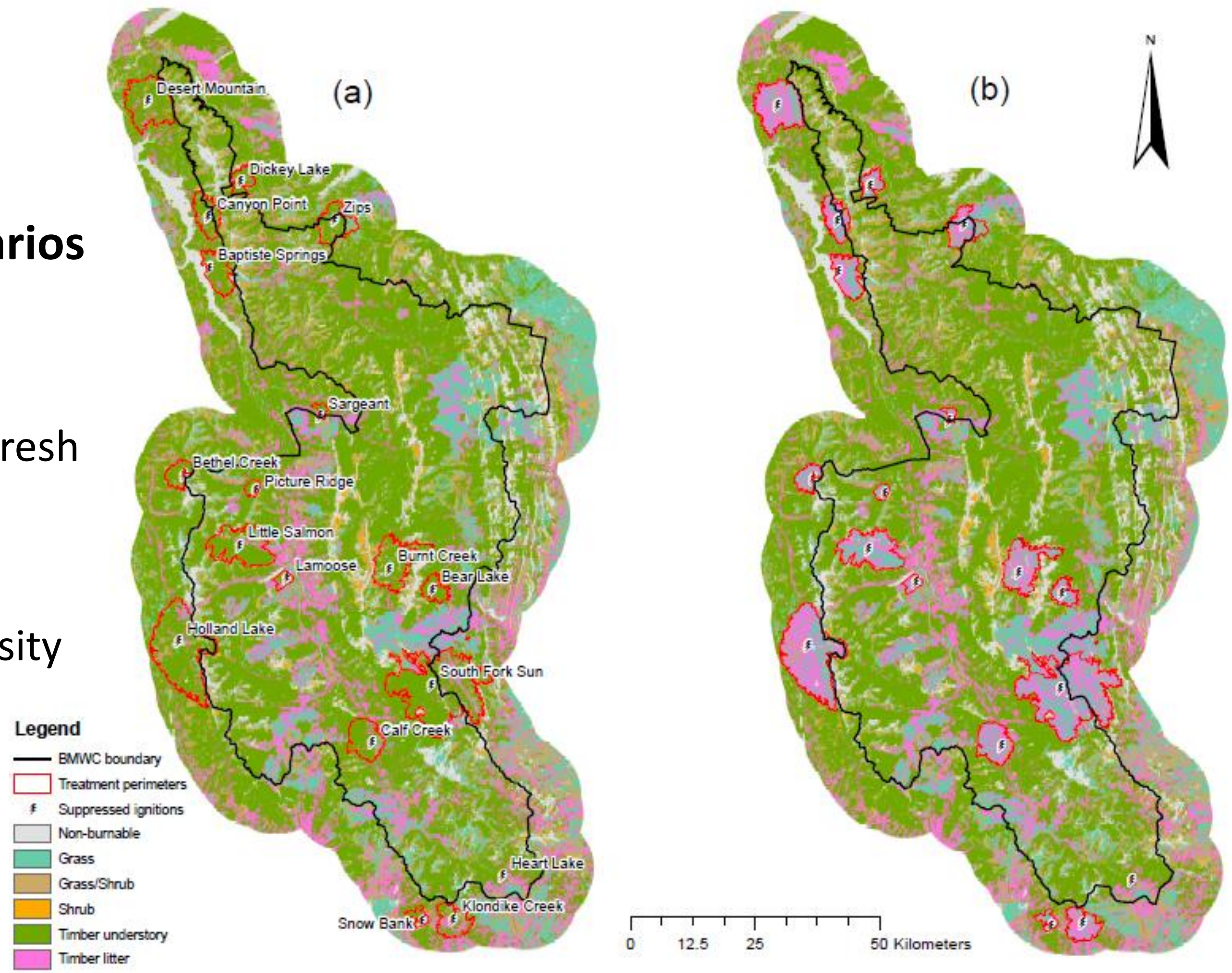
Developing landscape scenarios

Observed landscape scenario

- Post-2007 fuels
  - LANDFIRE Refresh

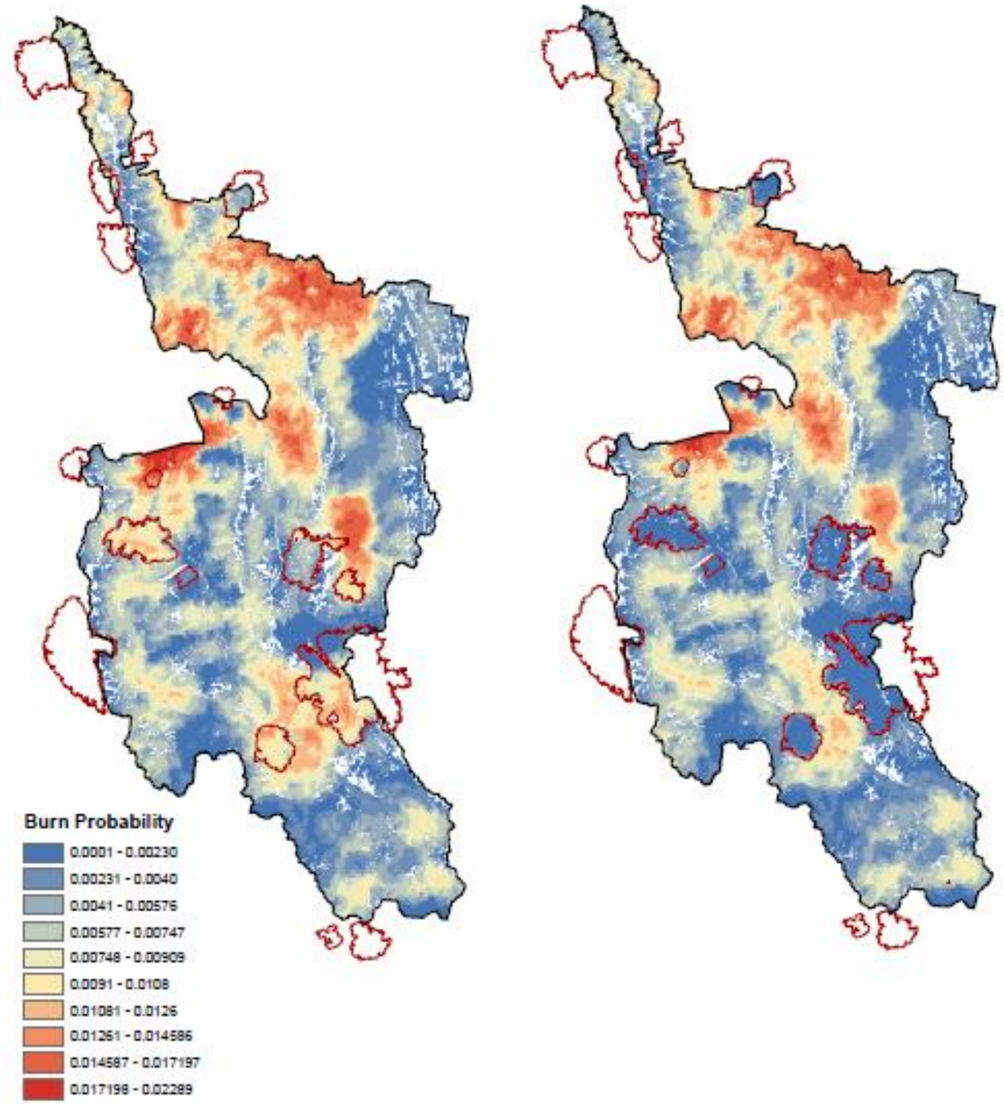
Alternative landscape scenarios

- Retrospective simulations
  - FARSITE (Finney, 1998)
  - Modified LANDFIRE Refresh
  - Observed weather
- Update fuels layers
  - Crosswalk fireline intensity into burn severity classes



Exposure analysis

- Large Fire Simulator (FSim, Finney et al., 2011)
- Simulates fire occurrence, growth, and behavior
  - 25,000 artificial fire seasons
    - Historic weather observations
  - Spatially-explicit burn probability, intensity
  - Ignition points, simulated fire perimeters
- Cumulative, individual alternative landscape scenarios
  - Hold weather, ignitions constant between scenarios



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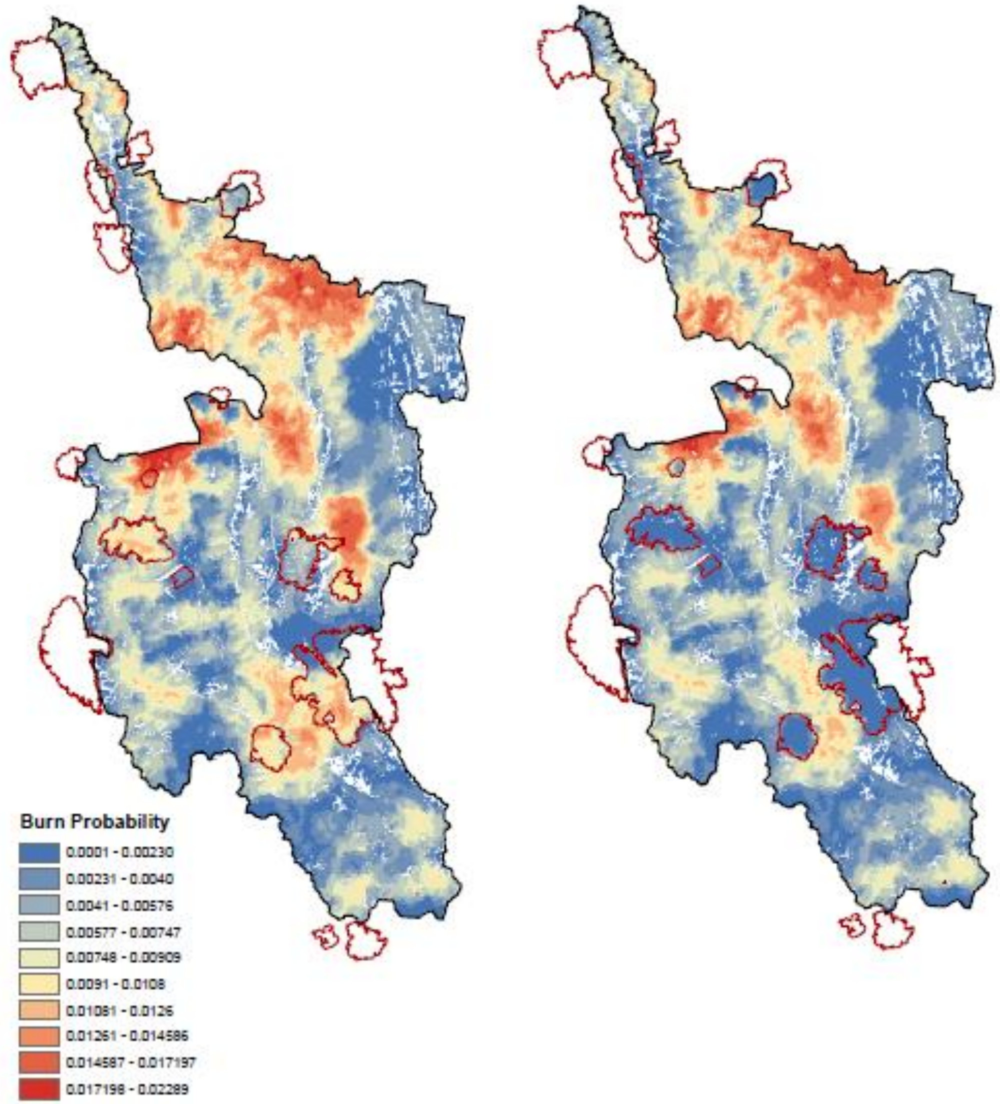
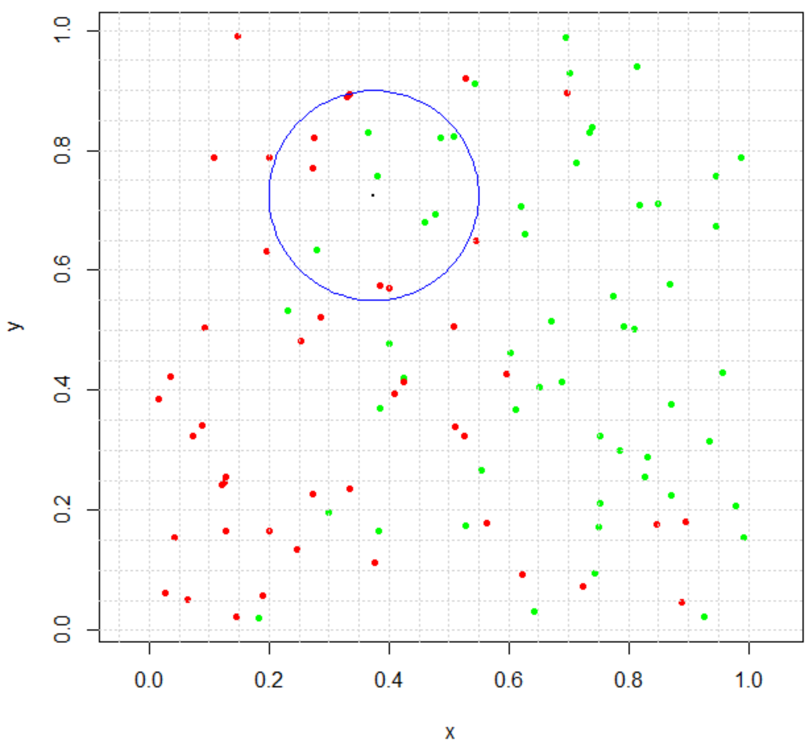
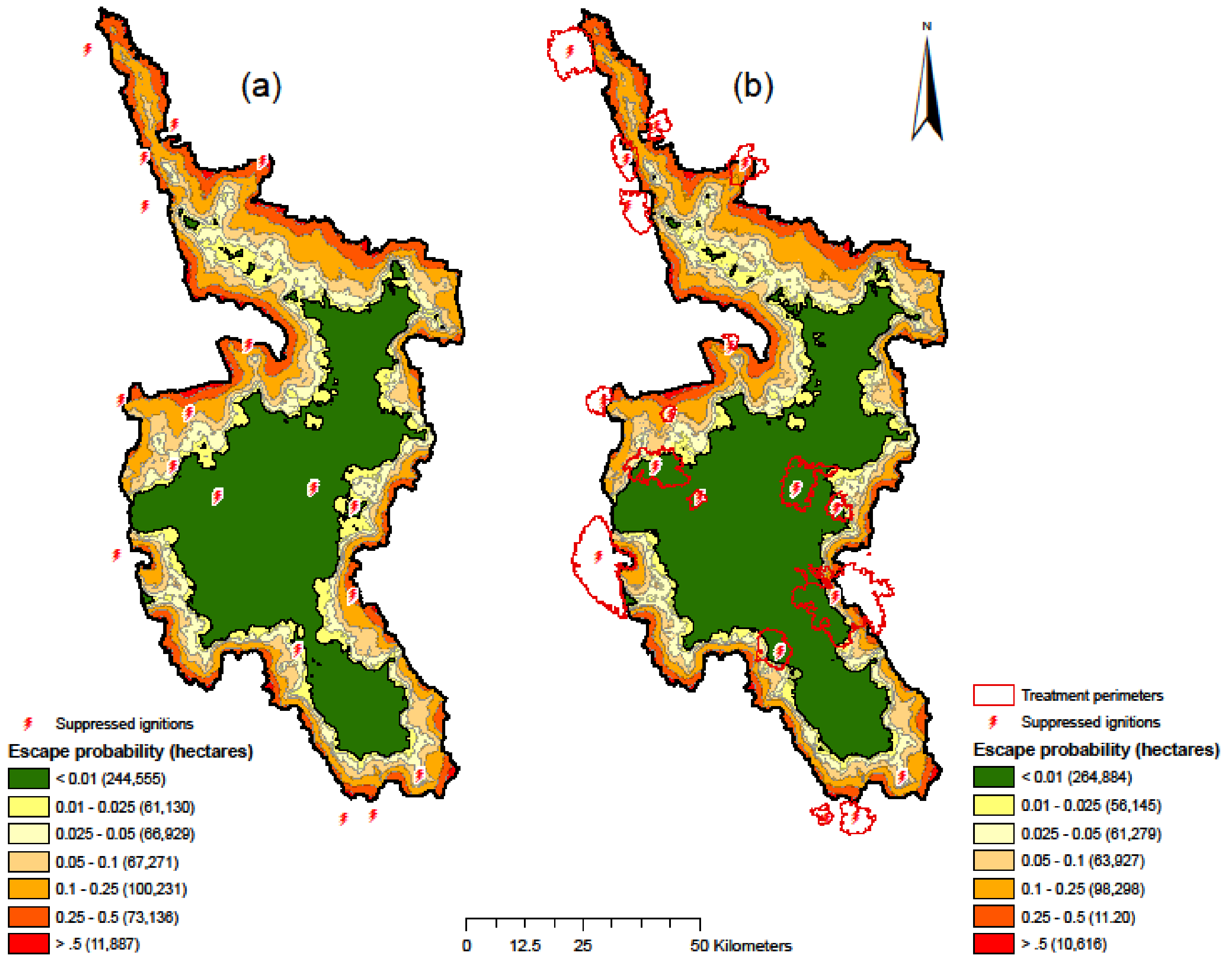


Conditional probability of escape

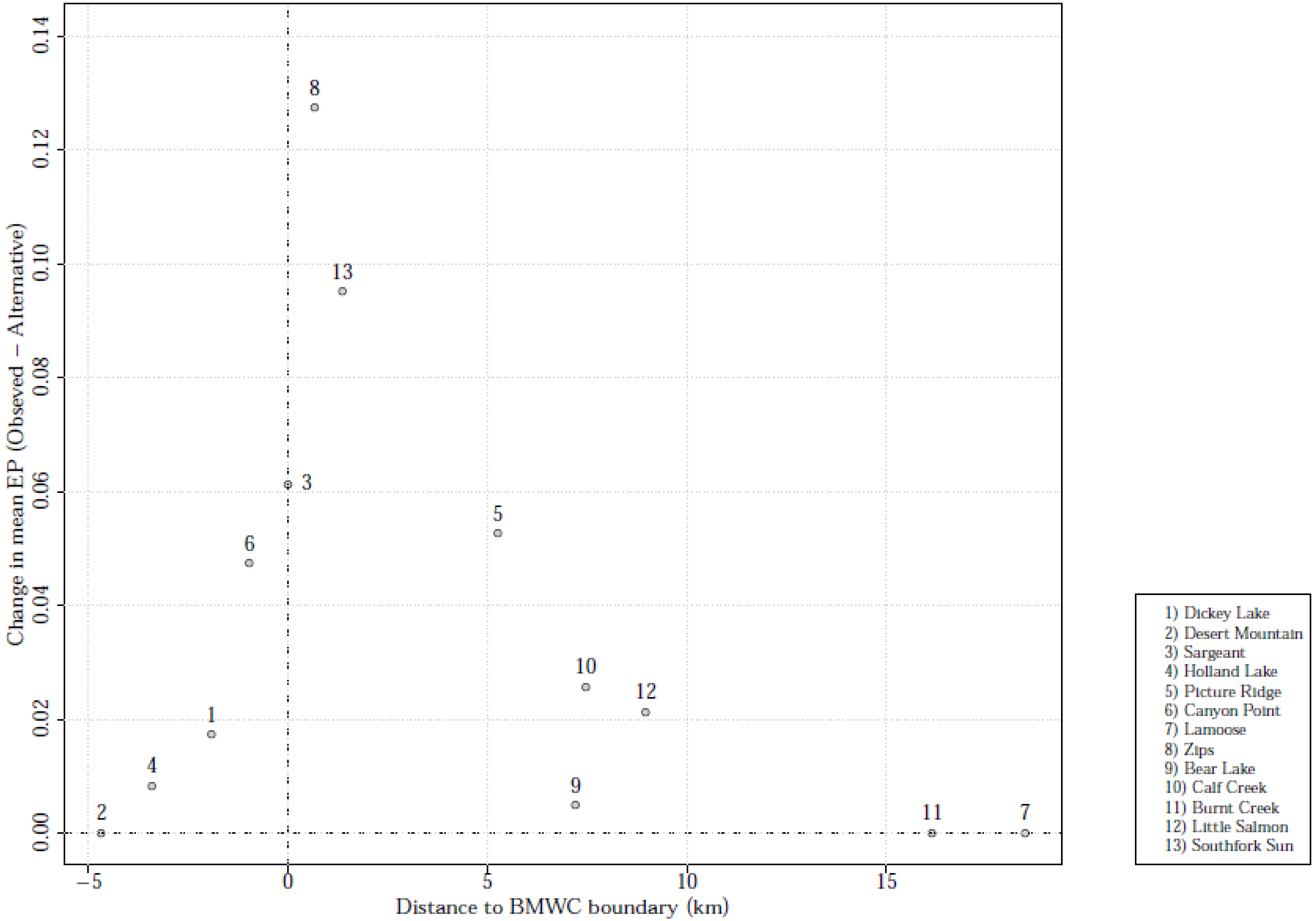
- Identify each ignition whose perimeter breached wilderness boundary
- Moving window analysis
  - 1,256 hectare circle
  - Proportion of escaped ignitions (0-1)



Results – cumulative scenario



Results – individual scenarios



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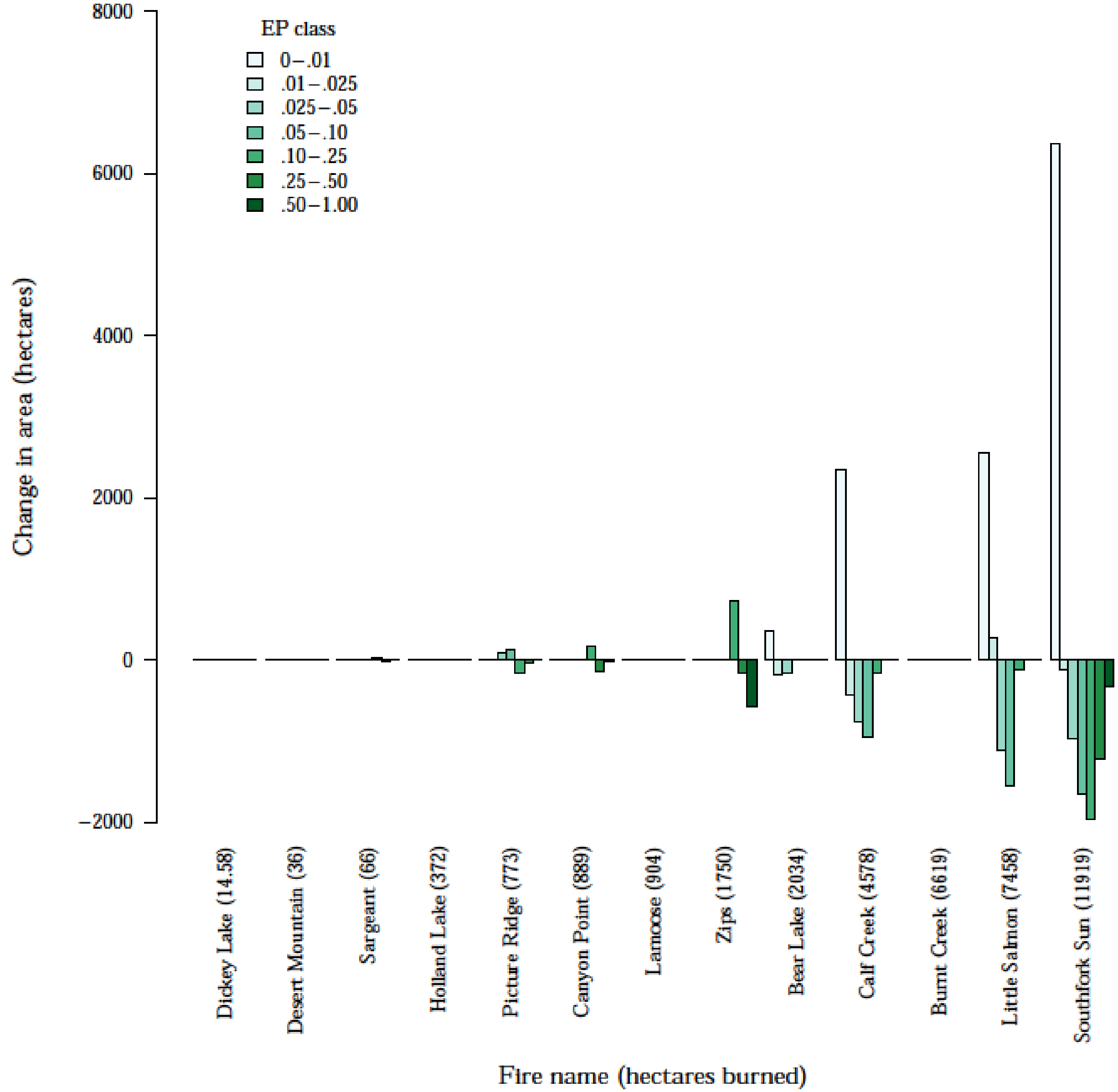
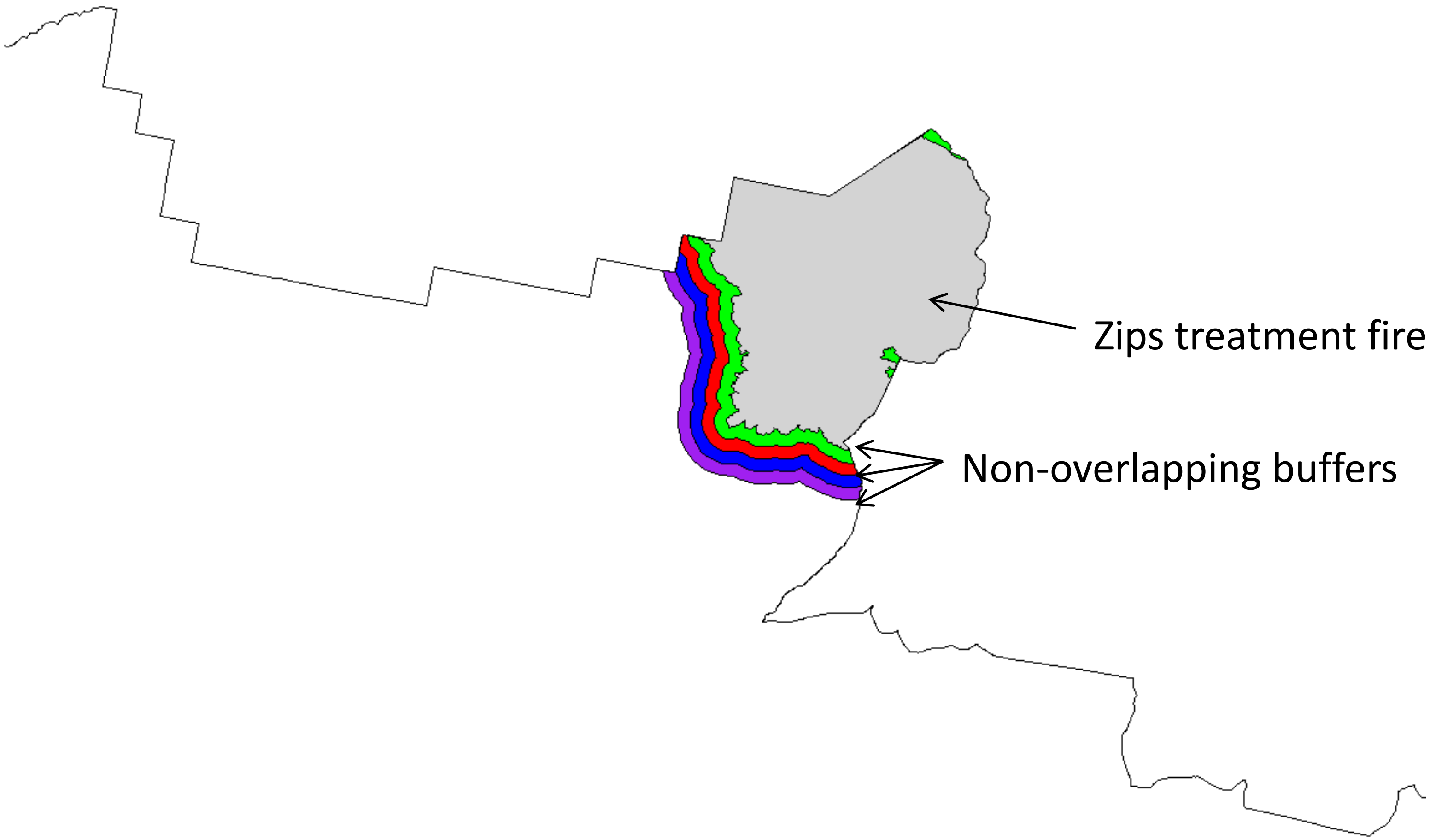


Quantifying offsite-effects



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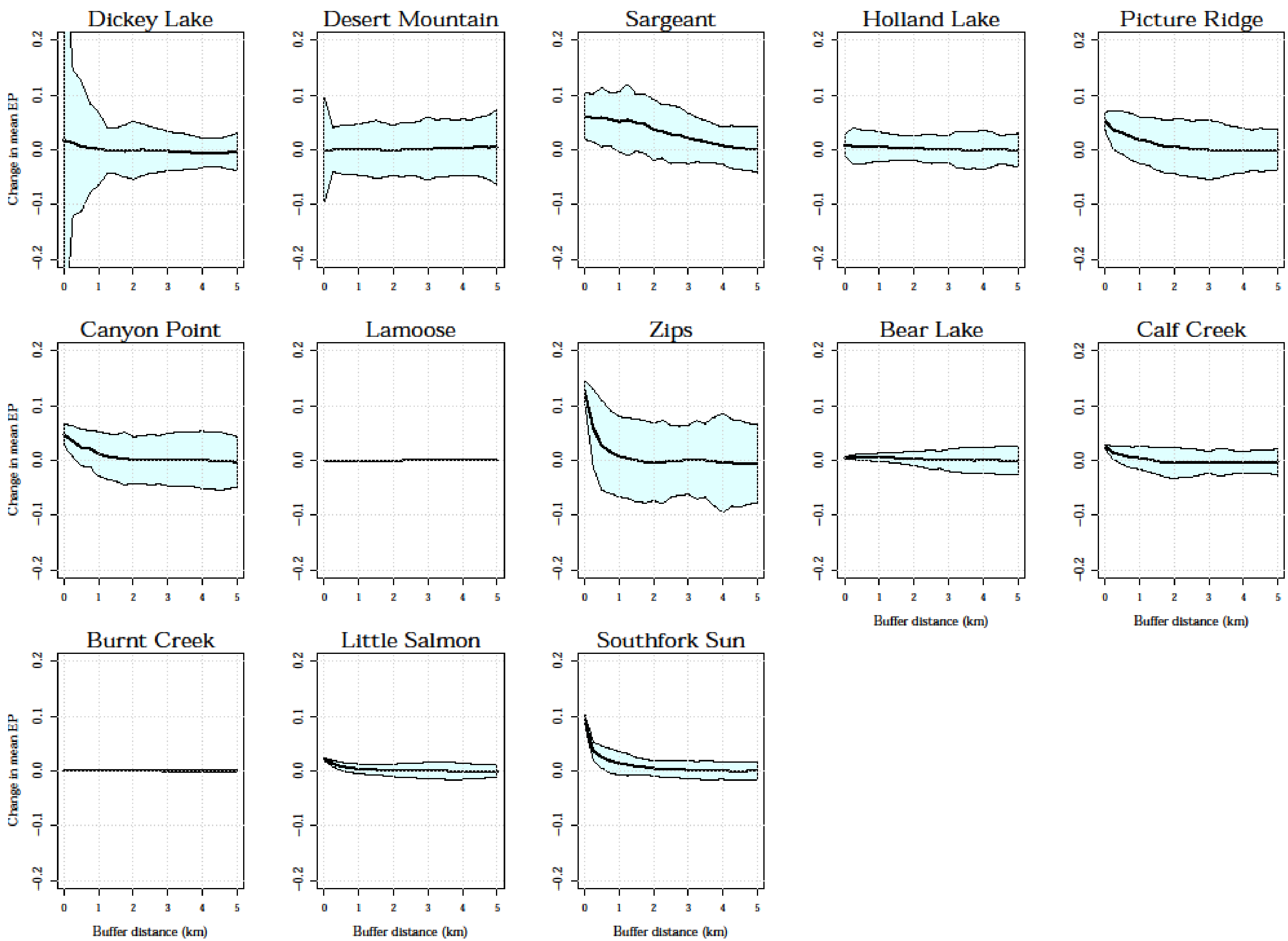


Discussion

Cumulative landscape scenario

- EP decreases as a function of distance to BMWC boundary
  - Non-uniform, variation
- Modest effects on reducing EP at landscape scale
  - 20,329 ha increase in EP < .01

Individual landscape scenarios

- Within-treatment effects
  - Fires closer to wilderness boundary had large effect on EP
  - Largest fires effective at expanding EP < .01
    - Burnt Creek
- Offsite-treatment effects
  - Both large and small fires effective at reducing EP
  - Fires closer to wilderness boundary had large effect on EP
  - Wide variation around estimates

Discussion

Relation to existing research

- Fire Spread Probability (FSPro, Finney et al., 2011)

- Extensions of FSim
  - Delineating 'firesheds'
    - Thompson et al. (2013)
    - No within fireshed variability
  - Fires reaching WUI
    - Scott et al. (2012)
    - Where at on the landscape?

- EP can compliment existing risk-based tools

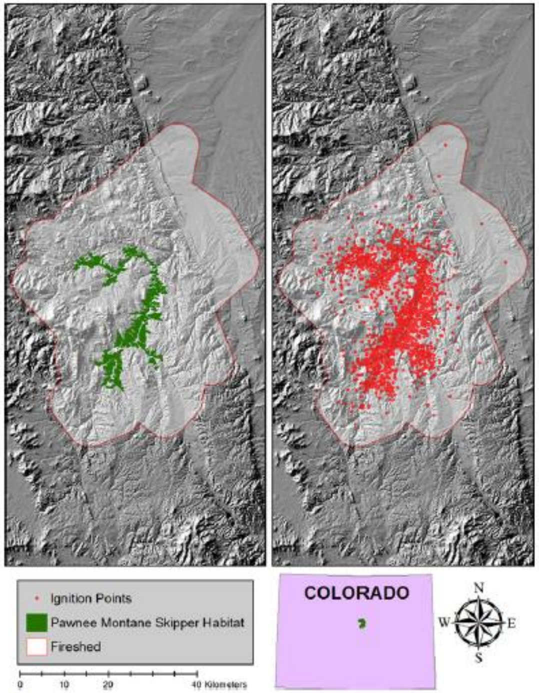


Fig. 4 Delineated fireshed for the Pawnee montane skipper habitat, including ignition locations for all simulated wildfires that reached habitat polygons. The delineated fireshed is a five km buffer around the concave hull of ignition locations of simulated wildfires that reached any part of the habitat

Table 5. Expected annual number of wildfires that reach the wildland-urban interface (WUI) defense zone (N_{WUI}), conditional WUI defense zone area burned per fire (A'_{WUI}, ha fire^{-1}), and expected annual WUI-area burned (A_{WUI}; ha yr^{-1}) for all fires and with application of RO rules by month of fire start. A'_{WUI} is assumed to be the same for RO fires as it is for all fires.

	All fires			RO fires	
	N_{WUI} (fires yr^{-1})	A'_{WUI} (ha fire^{-1})	A_{WUI} (ha yr^{-1})	N_{WUI} (fires yr^{-1})	A_{WUI} (ha yr^{-1})
May	0.004	550	2.4	0.000	0.0
Jun	0.014	488	6.8	0.001	0.7
Jul	0.032	362	11.5	0.008	2.9
Aug	0.030	289	8.7	0.014	3.9
Sep	0.003	90	0.3	0.002	0.2
Oct	0.000	168	0.1	0.000	0.1
Nov	0.000	279	0.0	0.000	0.0
Dec	0.000	0	0.0	0.000	0.0
Total	0.084	465	29.9	0.025	11.8

Discussion

Management implications

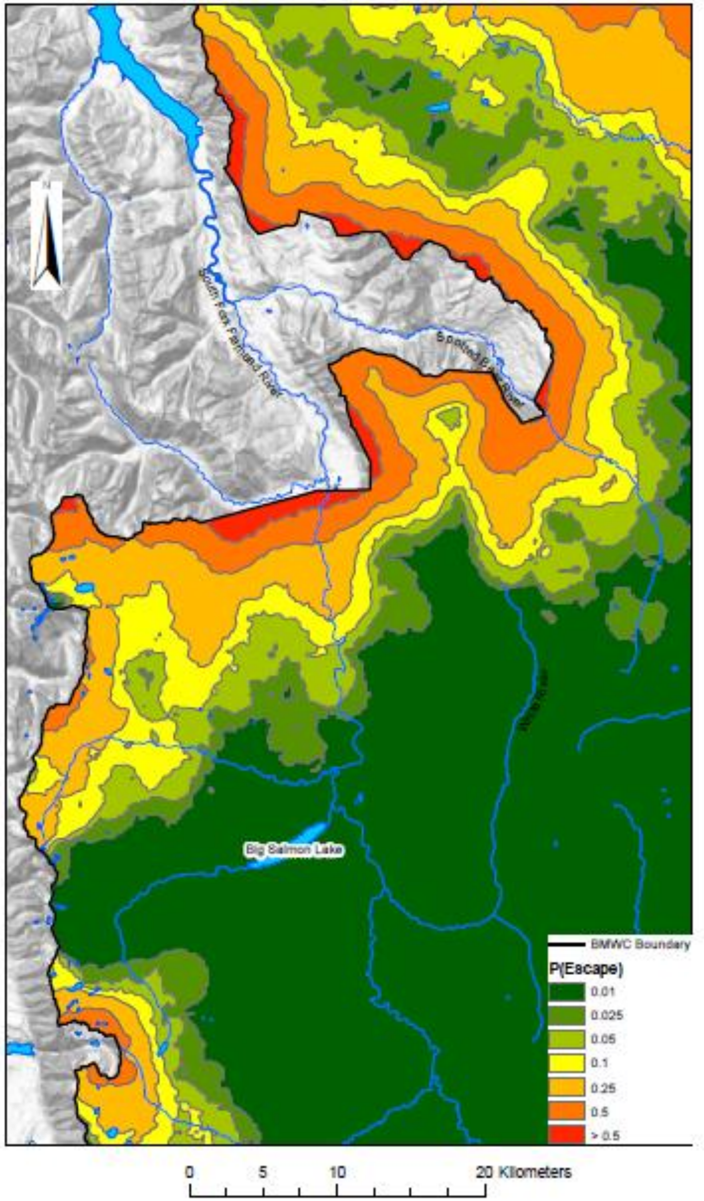
- Allowing fires to burn near the wilderness boundary can increase future decision-space
  - Paradox: Fires that start closer to the wilderness have high likelihoods of escape
  - Tradeoff between short term exposure versus longer term risk reductions
- Not all large treatment fires are effective fuel treatments
  - Small treatment fires were effective at reducing EP
  - Location appears to be important
- Outputs used to support strategic, long-term planning
  - Evaluate decisions taken/not taken
  - Monitor trends over time

Limitations and caveats

- Similar to burn probability studies
- Modeling post-fire effects on fuels
- Moving window size, shape
- Focus on 0.01

Extensions of EP approach

- Seasonality
  - Monthly, ERC percentiles
- Tease out drivers of EP
  - Biophysical, fuels, ignitions, burning conditions
  - Identify limiting factors, interactions
  - Other wilderness ecosystems
- Disentangle treatment fire size vs location interactions
  - Experimental design, simulation modeling
  - Simulate many treatment fires
    - Systematically varying orientation, size, location, burning conditions
- Effects of climate change on manager decision-space
  - Expand, contract
  - Fuels and fire management today can mitigate future effects



Conclusions

- Tools of risk analysis can be used to support and evaluate decisions to allow wilderness fires to burn
  - Reframing goals of fire and fuel management may be necessary
- Tradeoffs associated with suppression
  - Foregone benefits of wildland fire
- Quantify fuel treatment benefits of wilderness fire using tools of wildfire risk analysis
  - Consistent with principles of risk analysis

Acknowledgements

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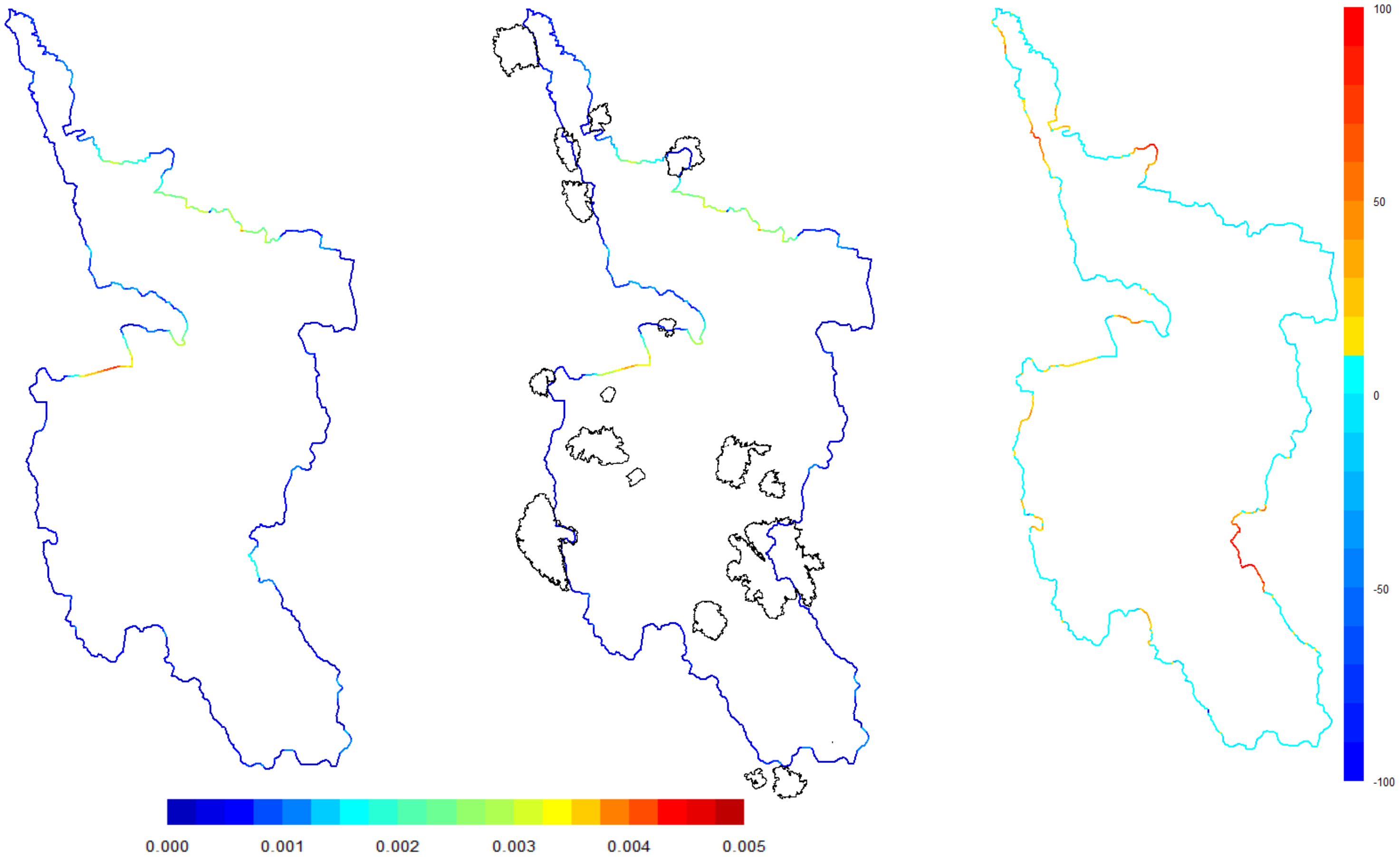
- Family and friends



Average annual escape probabilities for (a) the observed landscape scenario and (b) the alternative landscape scenario. The wilderness boundary was segmented into equidistant lines by distributing 1000 sample points along the boundary line and connecting the sample points with a straight line. Each line segment is roughly 725 meters long, or about .45 miles. The number of times each line segment intersected a simulated wildfire in FSim was tabulated and that value was assigned to its corresponding spatial line. The lines were plotted using a color ramp as a way to display the likelihood that wildfires igniting within the wilderness boundary would escape through different sections of the wilderness boundary. The percentage change between the two scenarios is presented in panel (c). The integrity of the wilderness boundary in terms of mitigating fire spread outside of the boundary is enhanced for segments of the boundary both inside and near the 2007 simulated wildfire perimeters.