Transforming Earth observations (EO) into Societally Valuable Information for Assessment of Forest Policies and Wildfire Loss Minimization

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Integrating Remote Sensing Data for Land Management Decision-Making

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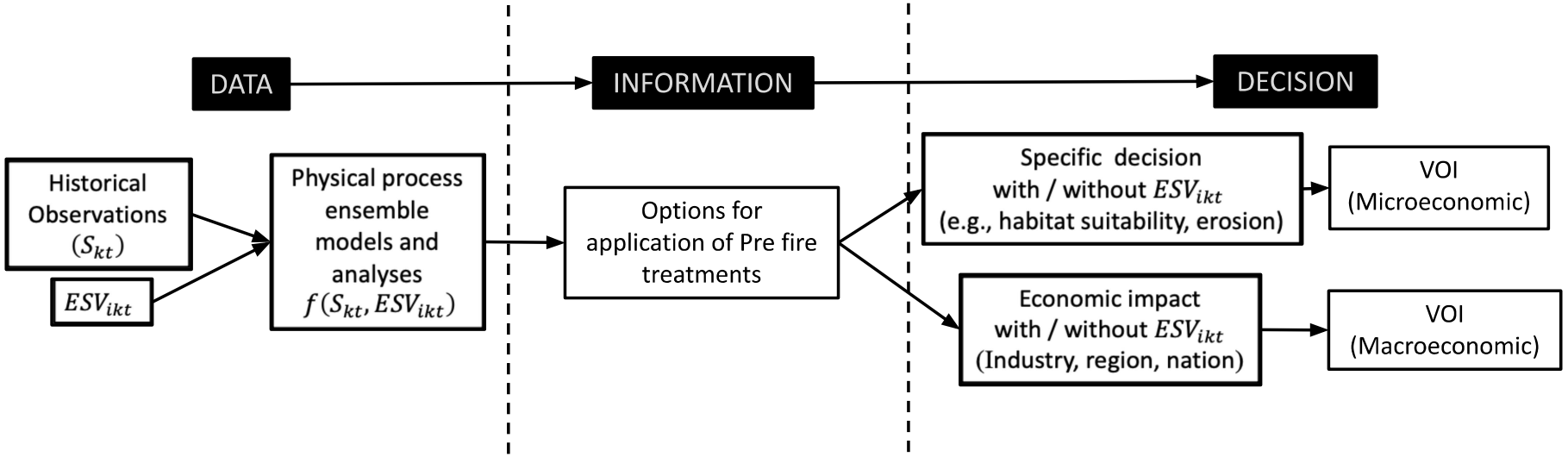
Value in Use Conceptual Framework: Who owns the arrow?



S_{kt}= State of the environment in location k at time t

ESV_{ikt}= Essential science variable i in location k at time t

Value in Use of EO for wildfire loss reduction and avoidance

- Goal: Transform useful science data into useable management information at local and regional resolutions for private and public sector decisions via monitoring and prediction (DATA).

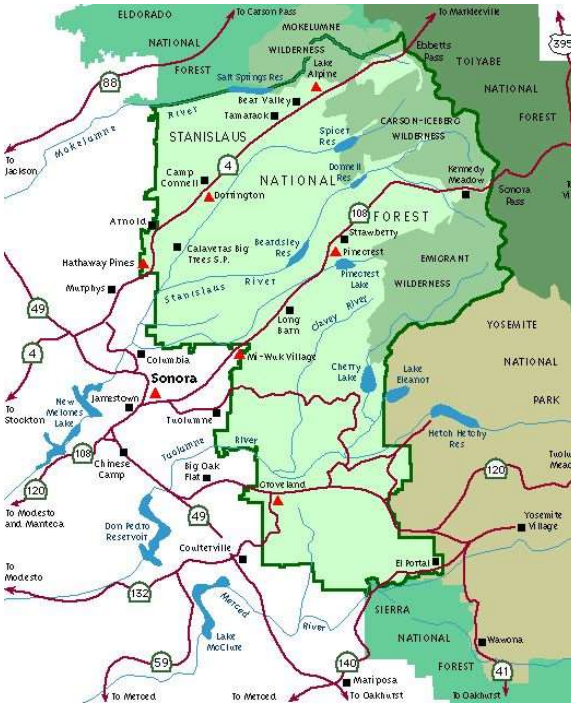
- Objective: Assign Essential Science Variables (*ESV*) to help reduce the uncertainty of applying pre fire mitigation. Insert *ESV*s into a decision process that is used to prioritize the societal benefits of protecting forest critical resources (INFORMATION

- Approach: Estimate the joint production of market goods and ecosystem services from forests in a regional economic analysis. Evaluate forest stewardship management benefits (outputs) and implementation costs (mitigation inputs) with and without *ESV*s (DECISION).

- Valuation: Estimate the value of the science information in the application (**VOI**).

Example: Assessing wildfire risk management tradeoffs on public lands*

- Create analytical tool for policy analysis and management decisions
- Apply Bayesian network (probabilistic causal model)
  - Utilize EO: Landsat and Monitoring Trends in Burn Severity (MTBS) transitions
  - Statistical approach for estimating habitat suitability: spotted owl and black bear
  - Modeled forecast of post fire natural hazards: impacts of the fire on erosion and sedimentation
  - Estimate economic benefits and costs of pre fire forest mitigation choices
- Example: Rim fire: 8/17/2013 - 10/24/2013
- Burned 154,530 acres in Stanislaus NF, 257,314 acres on all lands
- Cost: $127M for fire suppression
- Losses: Commercial buildings and 11 residences in SNF, $8.5 million for emergency road, trail, and watershed stabilization, $49.7M - $265M private property, 3 hydroelectric powerhouses taken offline, $102M - $797M carbon storage, $100M - $736M nonmarket ecosystem services (Headwaters Economics 2018)



Central Sierra National Forests and Yosemite National Park

Science Impact Laboratory for Policy and Economics

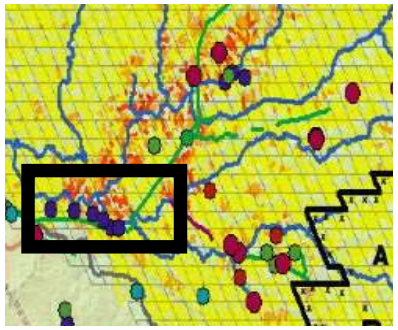
*These data are preliminary and are subject to revision. They are being provided to meet the need for timely 'best science' information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.

Inputs for better informed choices: Rim fire

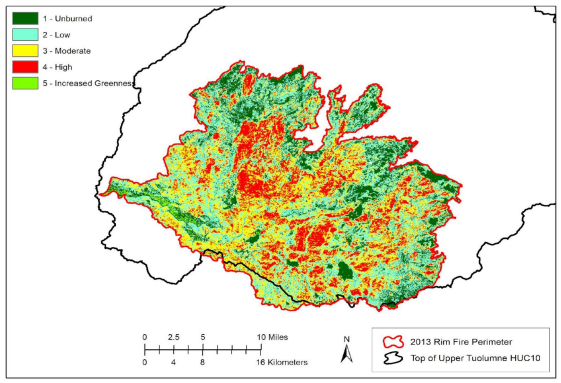
DATA → INFORMATION

Stanislaus Forest Critical Resources

Habitat suitability



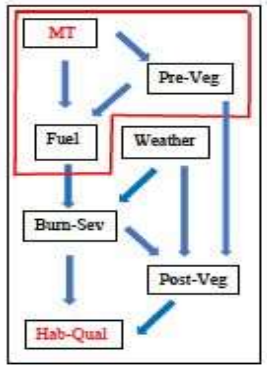
Culture and other infrastructure; Impacts to powerhouse and transmission lines



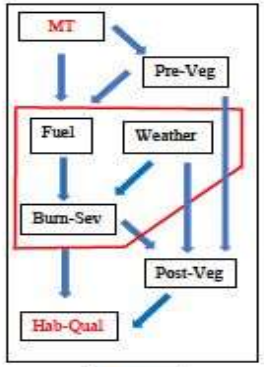
Rim fire burn severity

Normalize input values to 0 -1

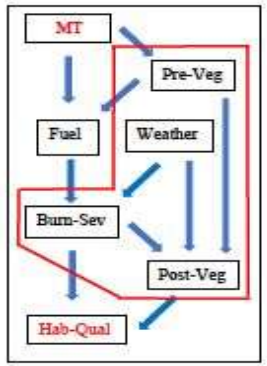
Simulation steps



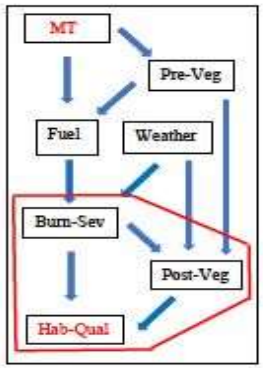
STEP 1



STEP 2



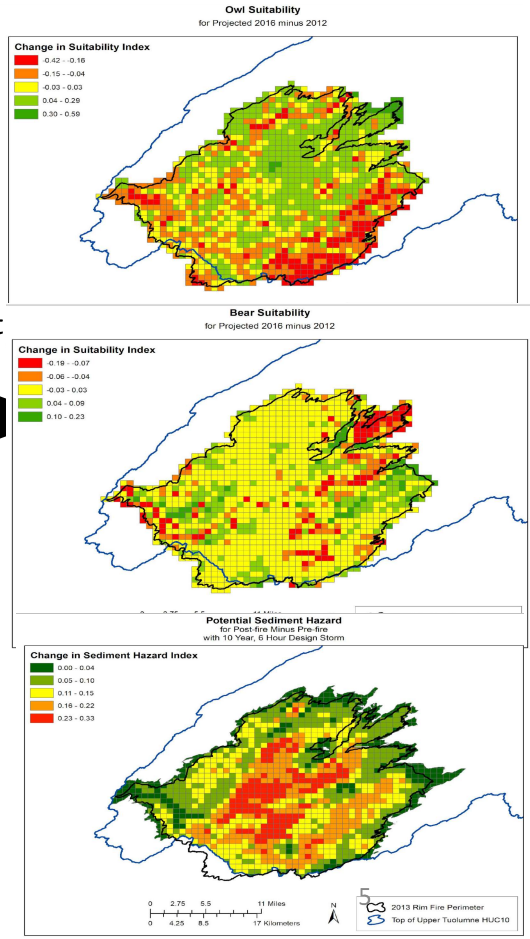
STEP 3



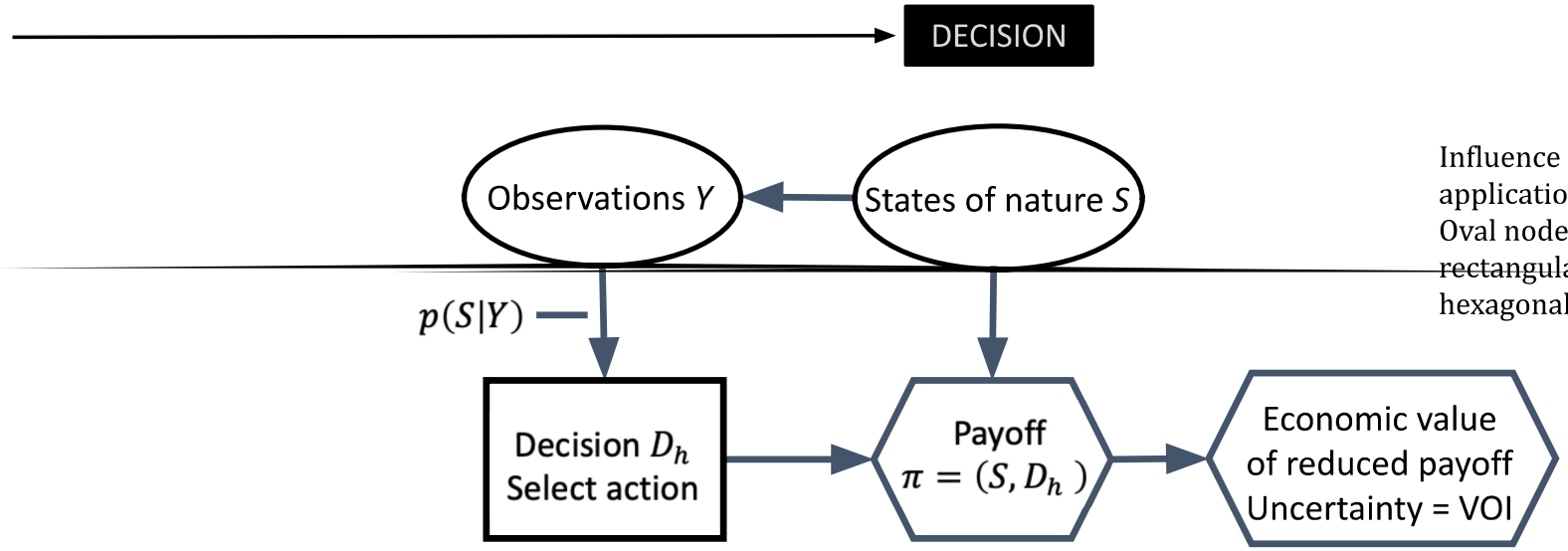
STEP 4

Pre -Post

Post fire forecast



A Bayesian Approach to prioritizing decisions



Influence diagram describing a decision application.
Oval nodes indicate uncertain quantities, rectangular node relates to decisions and hexagonal nodes relate to outcomes

Bayesian Decision model inputs and output:

(1) Probability $p(S)$ pre fire state of the forest environment
(2) Observations Y, where $Y = f(ESV_i)_t \;\; i = i = 1,..I, t = 0, \ldots, T$
(3) Conditional probability $p(S|Y)$ of states of the forest environment
(4) Decision D_h for a management action, where $h = \{1,2,3\}$; 1 is a critical forest value, 2 is a combination of 2 resources, 3 is all 3 resources combined in a mapped location
(5) Expected payoff $\pi = (S, D_h)$ associated with a specific combination of a state of the environment and a decision

Resources:
Buildings & infrastructure, Suitable habitats, Stable slope attributes, Cultural features

ESVs: Land cover, Land Use, Tree canopy, …

Analysis: $\max_h \pi$

Regional output and impacts of wildfires and loss mitigation with and without pre fire treatments

Critical Values (USFS 2018)

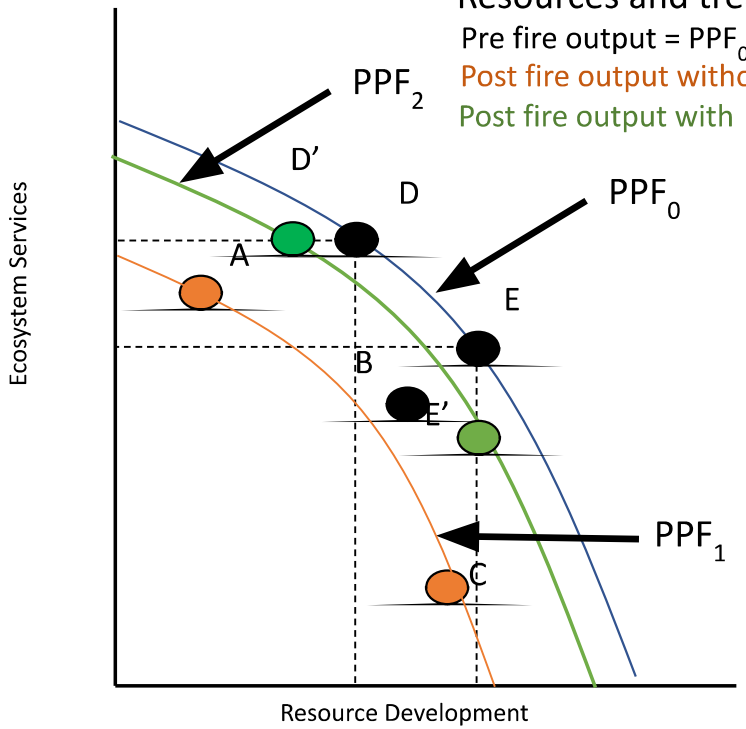
HUMAN LIFE AND SAFETY
Human life and safety on National Forest System (NFS) lands.

PROPERTY
Buildings, water systems, utility systems, road and trail prisms, dams, wells or other significant investments on NFS lands.

NATURAL RESOURCES
Water used for municipal, domestic, hydropower, or agricultural supply or waters with special Federal or State designations on NFS lands.
Soil productivity and hydrologic function on NFS lands.
Critical habitat or suitable occupied habitat for federally listed threatened or endangered terrestrial, aquatic animal, or plant species on NFS lands.
Native or naturalized communities on NFS lands where invasive species or noxious weeds are absent or present in only minor amounts.

CULTURAL AND HERITAGE RESOURCES
Cultural resources which are listed on or potentially eligible for the National Register of Historic Places, Traditional Cultural Properties, or Indian Sacred Sites on NFS lands.

Resources and treatments vary:
Pre fire output = PPF_0
Post fire output without pre fire treatment = PPF_1
Post fire output with pre fire treatment = PPF_2



Value of reducing wildfire burn severity:
PPF_0 - PPF_j = loss of forest resources, infrastructure, habitat

Summary

Status of Rim fire calibration and reforecast

Apply $(ESV_i)_t$ in a composite wildfire risk indicator based on physical process ensemble models

Identify the "best" match between useful, potentially operational EO information to applications and forecasts to estimate community impacts and environmental justice issues to underserved populations

Attract more natural scientists to get involved in societal applications of EO to help determine what is usable in the short run and what is possible in the longer term

Thank you

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