Scientific Basis for Modeling Wildland Fire Management:
Phase II Report of the National Science and Analysis Team
Tasks Assigned to NSAT

• Assemble credible scientific information, data, and preexisting models that can be used by all teams working on the Cohesive Strategy.

• Develop a conceptual framework that describes the relative effectiveness of proposed actions and activities on managing risks associated with wildland fire.

• Construct an analytical system using the products developed in Tasks 1 and 2 to quantitatively analyze regional and national alternatives.
Organization by Topics

• Landscape resilience
• Wildfire ignitions and preventions
• Fuels management, wildfire extent and intensity
• Wildfire response and suppression effectiveness
• Fire adapted human communities
• Firefighter safety
• Smoke management and impacts
• Public acceptance and policy effectiveness
Basic CRAFT Process

Phase 2

- Specify Objectives
- Design Alternatives
- Managers & Stakeholders

Phase 3

- Analysts & Scientists
- Model Effects
- Synthesize Results
General Analysis Process

1. Qualitative, Textual Descriptions
2. Conceptual, Box and Arrow Model(s)
3. Quantitative Analytical Model
Overall Conceptual Diagram

Management Actions, Policies, and Activities (Alternatives)

- Fuel Treatments (non-fire)
- Prescribed Fire
- Prevention Programs
- Response Capacity and Tactics
- Community Planning

Vegetation Composition and Structure

Wildfire Extent and Intensity

Response to Wildfire

Community Preparedness & Resiliency

Marketable Products

Ecological Services

Wildfire Ignitions

Smoke

Firefighter Safety

Public Safety

Property Losses
*Landscape Resilience* is the ability of a landscape to absorb the effects of fire by regaining or maintaining its characteristic structural, compositional and functional attributes. The amount of resilience a landscape possesses is proportional to the magnitude of fire effects required to fundamentally change the system.
Considerations with Resiliency

• Resiliency is contextual, not absolute
  – Is the system likely to change under the fire regime that it will experience?
  – Conceptually straightforward, difficult to quantify

• Resiliency is not inherently normative
  – Generally a positive attribute, but not always

• Two ways to affect resiliency
  – Change the fire regime (climatic shifts or through human activities)
  – Change the nature of the system to make it more or less consistent with existing fire regime.
Wildfire Data from USDOI and FS Lands, 2000-2008

Number of Ignitions

- Natural/Lightning
- Campfire
- Smoking
- Fire Use/Debris Burning
- Incendiary/Arson
- Equipment (Use)
- Railroad
- Juveniles/Children
- Miscellaneous and unknown

Area Burned

- Natural/Lightning
- Campfire
- Smoking
- Fire Use/Debris Burning
- Incendiary/Arson
- Equipment (Use)
- Railroad
- Juveniles/Children
- Miscellaneous and unknown
Cohesive Strategy Wildfire Ignitions and Prevention Conceptual Model

Social drivers
- Income
- Development
- Demographics
- Culture

Wildfire ignitions
- Natural
- Accidental
- Arson

Wildfire spread and behavior

Biophysical drivers
- Topography
- Weather
- Vegetation & fuels

Fire management
- Prescribed fires
- Fuel treatments
- Suppression

Wildfire impacts
- Civilian and firefighter health and safety
- Damaged resources and structures
- Future ecological conditions

Processes and patterns that can be altered
- Biophysical drivers
- Social drivers

Processes and patterns that cannot be altered
- Wildfire ignitions
- Wildfire spread and behavior
- Wildfire impacts
Strategic fuel treatment taxonomy, with illustrative examples of optimally placed treatments given variable motivation, fire regime, spatial pattern of values, and ultimate treatment strategy/system (Credit: Alan Ager and Nicole Vaillant)

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Restoration</th>
<th>Protection</th>
<th>Protection</th>
<th>Protection</th>
<th>Restoration</th>
<th>Protection</th>
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</thead>
<tbody>
<tr>
<td>Fire regime</td>
<td>Low severity (+ fire)</td>
<td>Mixed severity (+/- fire)</td>
<td>Mixed severity (+/- fire)</td>
<td>High severity (- fire)</td>
<td>High severity (- fire)</td>
<td>High severity (- fire)</td>
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<tr>
<td>Pattern of values</td>
<td>Dispersed (large trees)</td>
<td>Dispersed and prevalent (low density WUI, T&amp;E)</td>
<td>One clump</td>
<td>Clumpy</td>
<td>Any</td>
<td>Low or none</td>
</tr>
<tr>
<td>Treatment Strategy</td>
<td>Create large contiguous areas of low hazard (minimum treatment for maximum area)</td>
<td>Strategic (SPLATS/SPOTs)</td>
<td>Localized protection (targeted treatments)</td>
<td>Localized protection (targeted treatments)</td>
<td>Restore natural fire barriers</td>
<td>Defensible fuel breaks along roads and other barriers</td>
</tr>
<tr>
<td>Treatment system</td>
<td>Low hazard fire containers</td>
<td>Treatment optimization model (FlamMap; TOM)</td>
<td>Defensible fuel breaks</td>
<td>Defensible fuel breaks</td>
<td>Strategic restoration</td>
<td>High hazard fire containers</td>
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<tr>
<td>Spatial treatment pattern</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
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<td><img src="image5.png" alt="Image" /></td>
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Wildfire Suppression Response

- Experience and knowledge
- Location and topography
- Fuels management
- Prevention and law enforcement
- Ignitions
- Weather and climate
- Fuels
- Fire intensity and extent
- Suppression response
- Suppression capacity and placement
- Expected consequences
- Training
- Actual consequences (e.g., smoke, safety, property loss, landscape resilience)
- Funding: operational
- Funding: capacity investment
- Transport network
- Socioeconomics and policy
- Actual consequences (e.g., smoke, safety, property loss, landscape resilience)
Cohesive Strategy FAHC Conceptual Model
Range of Activities by Wildfire Timeframe

Pre Wildfire
- Pre-Event Coordination Planning
- Outreach Programs: Firewise & Read Set-Go, etc, education
- Land Use Planning and Codes
- Fuel Treatments (private & public lands)
- Stay and defend preparation and planning
- Identify all values at risk

During Wildfire
- Communication & Information mgmt
- Evacuation/Closure Orders
- Evacuate (RSG) or Stay and Defend
- Interagency Event Coordination

Post Wildfire
- Post-fire Assessments
- Rebuilding- Land Use Planning and Codes
- Outreach Programs: Firewise & Ready Set-Go
- Fuel Treatments (private & public lands)
- Education and Communication
- Pre-Event Coordination Planning
- BAER, Landscape Restoration & Rehabilitation
- Community Recovery

Measureable Characteristics

Action/Program
- Metric

Goals
- Preserve life, protect health, and insure safety
- Protect property and infrastructure
- Encourage community and individual ownership & responsibility for maintaining fire-safe conditions
- Foster a fire resilient landscape
Preserve life, protect health, and insure safety
Protect property and infrastructure
Encourage community and individual ownership & responsibility for maintaining fire-safe conditions
Foster a fire resilient landscape
Conceptual Model for FAHC before and after wildfire event

**Individual/Household Elements**
- **Social Vulnerability**
  - Household Size & Composition
  - Length of Residence; Renter/Owner
  - Education & Occupation
  - Age
  - Physical Health

- **Household Preparedness**
  - Residents Knowledge & Actions
  - Residents land Ignition behavior
  - Response Plan: Evacuation/Stay & Defend
  - Tourist or Nonresident Evacuation

**Community Elements**
- **Community Vulnerability & Resilience**
  - Social Vulnerability
  - Economic Resilience
  - Insurance

- **Institutions & Governance**
  - Land Use Planning & Building Codes
  - Local Suppression Resources
  - Good Horizontal & Vertical Relationships

**Physical/Environmental Elements**
- **Neighborhood & Structure Characteristics**
  - Neighborhood Structure Density & Configuration
  - Structure Composition
  - Defensible Space & Landscaping
  - Road Network or Accessibility
  - Internal Safety Zones
  - Fire Breaks & Fuel Treatments

- **Ecosystem Services**
  - Composition & Configuration
  - Supply & Demand

**Measurable Characteristics**
- Processes, patterns, or characteristics that can be altered
  - Processes, patterns, or characteristics that cannot be altered

**FAHC**
- Preserve life, protect health, and insure safety
- Protect property and infrastructure
- Encourage community and individual ownership & responsibility for maintaining fire-safe conditions
- Foster a fire resilient landscape
Conceptual Model for FAHC during wildfire

**Individual /Household Elements**
- Social Vulnerability
  - Household Size & Composition
  - Length of Residence; Renter/Owner
  - Education & Occupation
  - Age
  - Physical Health

- Household Preparedness
  - Residents Knowledge & Actions
  - Residents land Ignition behavior
  - Response Plan: Evacuation/Stay & Defend
  - Tourist or Nonresident Evacuation

**Community Elements**
- Community Vulnerability & Resilience
  - Social Vulnerability
  - Economic Resilience
  - Insurance

- Community Preparedness
  - Community Wildfire Knowledge
  - Community Social Capital

- Institutions & Governance
  - Land Use Planning & Building Codes
  - Local Suppression Resources
  - Good Horizontal & Vertical Relationships

**Physical/Environmental Elements**
- Neighborhood & Structure Characteristics
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Cause of death for wildland firefighters 2000-2009 for all jurisdictions by the Cohesive Strategy Region in which the fatality occurred. Categories have been reclassified from the National Fire Administration’s Fallen Firefighters Database based on incident descriptions.
An integrated conceptual model for firefighter safety related to incidents.
Pathways to reducing firefighter deaths and injuries and associated strategic investments.

<table>
<thead>
<tr>
<th>Strategic investment</th>
<th>Workforce emphasis</th>
<th>Incident management emphasis</th>
<th>Fire attribute emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards, training, experience</td>
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<tr>
<td>Technology, equipment</td>
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<td></td>
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<tr>
<td>Communications</td>
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<td>Health monitoring</td>
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<tr>
<td>Personnel standards, screening efforts</td>
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<tr>
<td>Incident learning</td>
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<tr>
<td>Fire behavior and weather modeling</td>
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<td>Wildfire prevention efforts</td>
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<td>Fuels reduction</td>
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<tr>
<td>Forest and disease management</td>
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</tbody>
</table>

Position within Figure 2 shown by black and red:
A conceptual model for long-term fire-fighter health.
Conceptual Model of Smoke Management and Impacts

Decisions
Endpoints (values)
Nodes

Fuels Management

Prevention
Other causes
Unplanned Ignitions
Other
Planned Ignitions

Climate
Topography
Weather
Fire behavior
Emissions
Dispersion/transport

Regional haze
Visibility hazard

Smoke concentration
Individual sensitivity

Social acceptability

Air quality regulations

Ambient pollutants

Cultural expectations
Population density

Smoke outreach

Communication
Potential smoke impact from a fire in Montana illustrating the need for a transfer function.
Expectations for Phase III

1. Translate conceptual models developed in Phase II into quantitative models.
2. Compile and integrate appropriate data needed to quantify and validate the relationships presented in the models.
3. Identify performance measures that can be used across all regions and within a given region.
4. Identify geographic variations in the quantitative models to reflect appropriate differences across the regions.
5. Interact with the RSCs and WGs to validate the models.
6. Explore potential management options across the regions that reflect the decision space available for broad national and regional choices.
7. Interact with the regional committees to iteratively identify and refine regional strategies.
Conclusions

• Fine-scale processes tend to be better understood than broad-scale processes or strategic issues.

• There has been considerably more research focused on the biophysical aspects of wildland fire than has been directed at equally important socio-political issues.

• Integrated research efforts that focus on interactions among human and physical factors are becoming more common and are highly promising.

• Data from Federal agencies is decidedly more complete and accessible than from other entities.
Conclusions

• Collectively, the conceptual models create a rich tapestry that illustrates the extensiveness, complexity and interconnectedness of wildland fire. Along with the information summarized on existing analytical models and data sources, the conceptual models provide a strong foundation for building more rigorous models in Phase III.

• Moving forward and building models that can provide quantitative estimates of risk to social values will not be easy. Each of the subteams identified limitations in available data and understanding that will pose challenges to overcome.

• Finally, remember that the work of the NSAT does not occur in isolation. All of the governing committees and advisory groups within the Cohesive Strategy have a continuing role in ensuring that the analyses are matched to the most important questions, utilize the best available understanding and data, and provide results that can be understood by all.