

# Analyzing fire suppression crew production, efficiency, and composition on large wildland fires

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May 19, 2014

# Outline

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## Background

- Wildfire activity
- Fire suppression and management
- Handcrews

## Data

- Painting the management picture

## Approach

- Objective 1: Crew productivity
- Objective 2: Daily fireline factors
- Objective 3: Do we dig it?

## Current Status

- Specification search

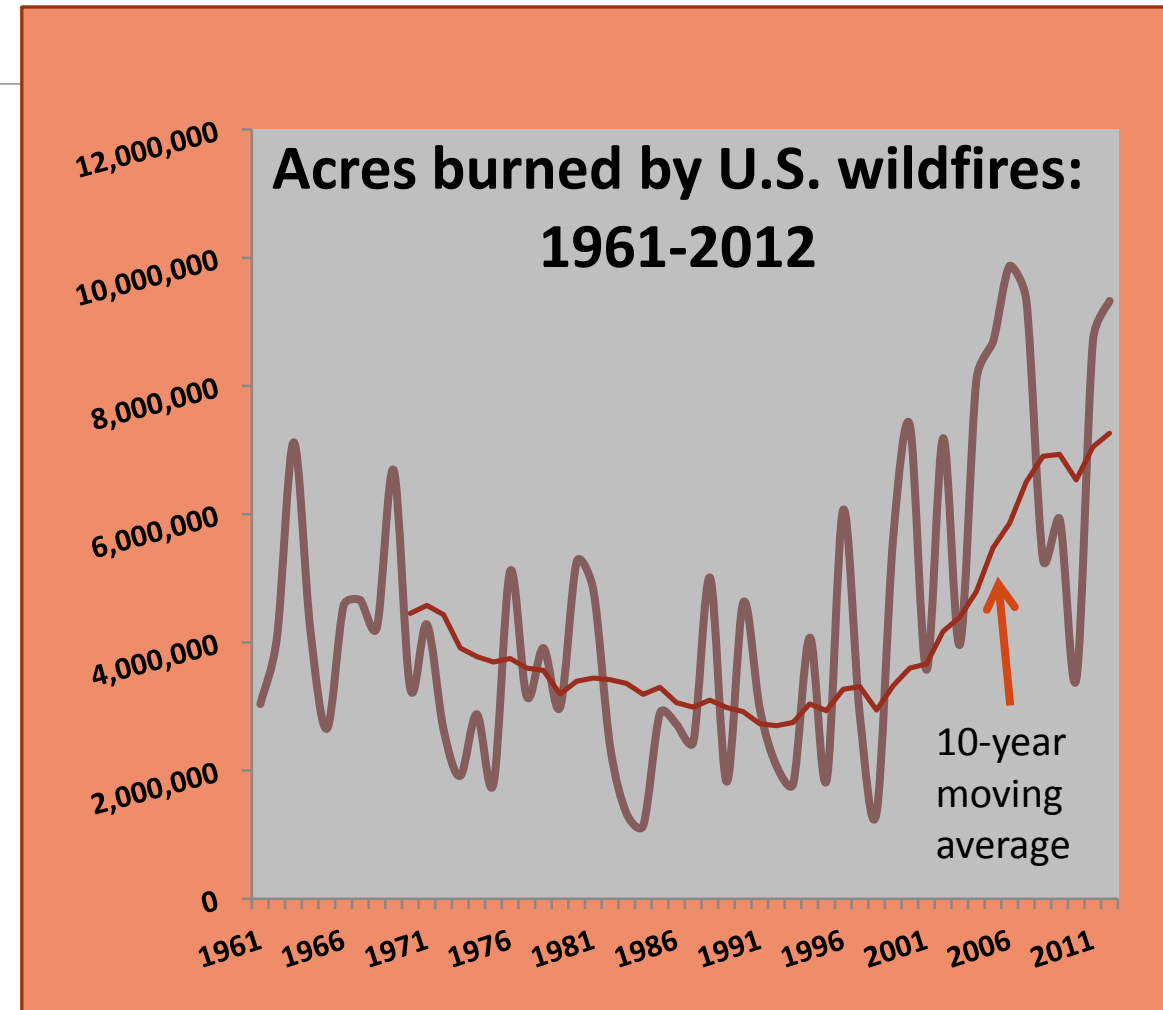
## Moving Forward

- Substitutes?
- Improving modeling approaches



# Wildfire activity

- Increase in fire size and duration
- Higher severity and intensity across the landscape
- More interaction with Wildland Urban Interface (WUI)
- Heightened societal awareness of values at risk



# Fire Suppression: Costs and losses

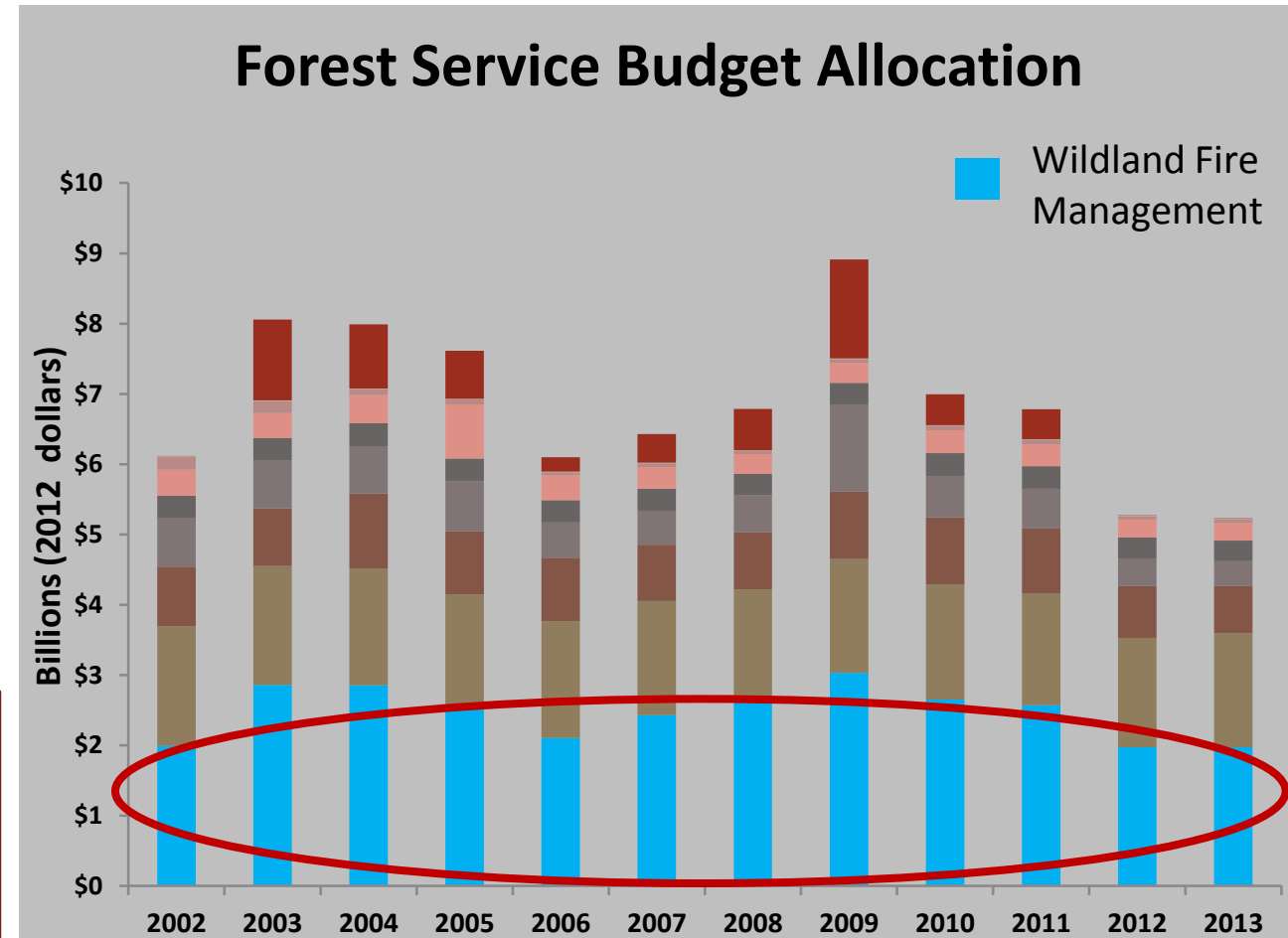
## Increasing cost of fire suppression

- Over one billion in emergency suppression expenditures
- Huge portion of USDA Forest Service budget

## Greater loss


- Risk to ecological and other resource values
- WUI expansion and conflicts

**The financial impact of wildfire management challenges the ability of the Forest Service to meet societal demands and achieve forest health objectives.**



# Federal fire management decisions

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- GENERAL**  
**DECISION-MAKING CHALLENGES**  **WILDLAND FIRE**  
**DECISION-MAKING CHALLENGES**
- Uncertainty
  - Risk attitudes and preference
  - Safety and exposure
  - Multiple objectives
- Lack of incentives
  - Open checkbook
  - Liability
  - Socio-political pressures

All these factors complicate the process of making cost-effective management decisions.

# On-the-ground operations

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## Improving decision-making space

- Better information
- Detailed and specific data
- Reassess current approaches and understanding

## Improving fire management

- Where are resources being deployed?
- When are they being used?
- What types of resources are utilized each day?

# Handcrews: Boots on the ground

Career and temporary wildland firefighters

Agency and privately contracted

Multi-level types

- Type I Interagency Hotshot Crews (IHCs)
- Type II
- Type II Initial Attack (IA)

Assigned an array of tasks and responsibilities by division

- Direct, indirect, mop-up, rehab, point protection

What are crews accomplishing on the ground?



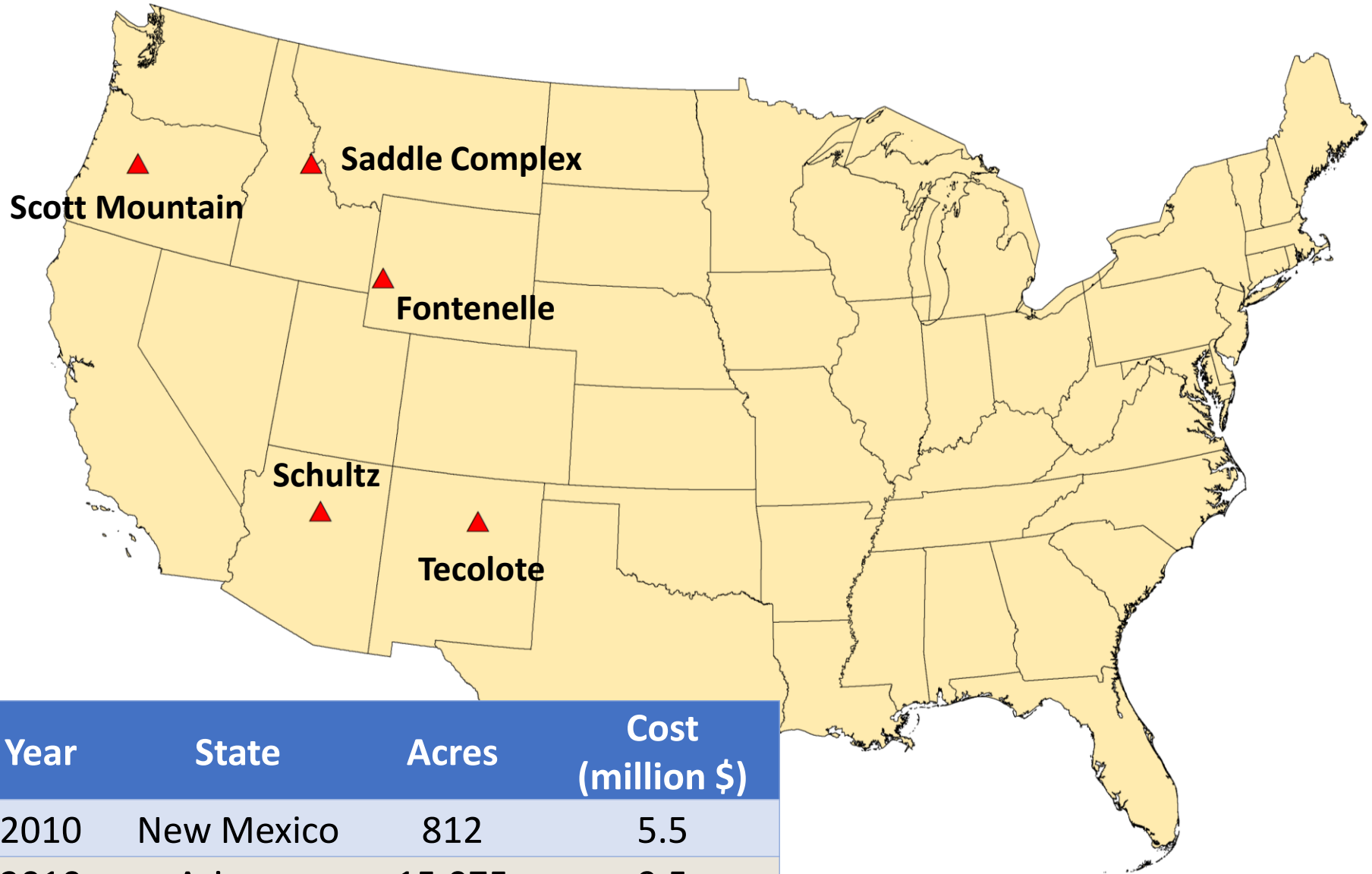
# Estimating resource productivity

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*“...collection of **more precise operational data** could help reduce uncertainty regarding the relative importance of factors that contribute to productivity shortfalls.”*

*Holmes and Calkin (2013)*





Fire	Year	State	Acres	Cost (million \$)
Tecolote	2010	New Mexico	812	5.5
Schultz	2010	Arizona	15,075	9.5
Scott Mountain	2010	Oregon	3,464	4.6
Saddle Complex	2011	Montana	15,866	4.5
Fontenelle	2012	Wyoming	65,220	12.65

# Data crosswalk

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## **Rocky Mountain Research Station operational data**

- daily fireline constructed
- line by resource type
- assignment categorization
  - Direct, indirect, mop-up, rehab, point protection

## **Daily Incident Action Plans (IAPs)**

- crew name
- division crew composition
- daily division assignment
- daily weather data
- daily fire behavior information

## **Resource Ordering Status System (ROSS)**

- mobilization and demobilization dates
- quantity of each resource assigned
- crew level (Type I, II, IA)
- agency or contract crew (link to IAPs)

## **Incident Command System daily reports (ICS-209)**

- Incident Management Team type
- fire size in acres to date
- estimated costs to date
- daily percentage of fire containment (DPC)

# Objective 1: Productivity

Mimic Holmes and Calkin (2013) production model

- handcrews only
- observed daily fireline

$DFL_{it} = f(\text{handcrews, cumulative ERC, max windspeed, IMT dummy})$

$HDiFL_{it} = f(\text{handcrews, cumulative ERC, max windspeed, IMT dummy})$



# Objective 2: Daily fire line factors

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## Crew composition

- contract vs. agency

## Daily fire assignments

- predominant daily assignment: direct, indirect, mop-up, rehab

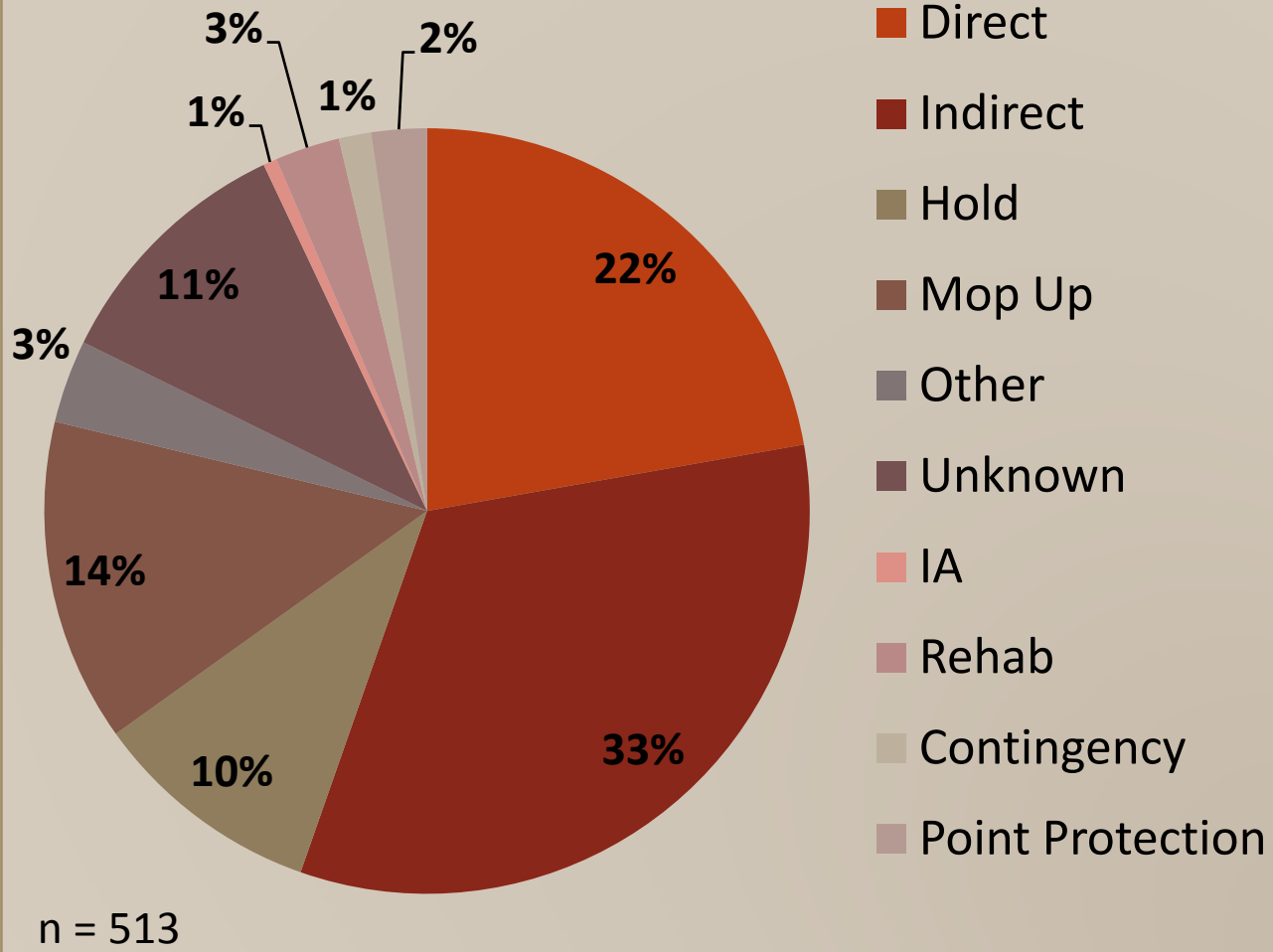
$DFL_{it} = f(\# \text{ of agency crews, total crews, mission type, ERC, maxwind, maxtemp, minhumid, IMT})$

$HDiFL_{it} = f(\# \text{ of agency crews, total crews, mission type, ERC, maxwind, maxtemp, minhumid, IMT})$

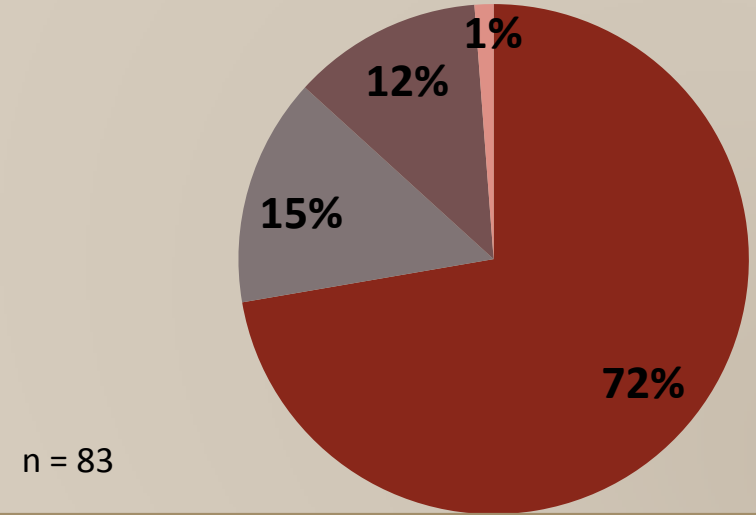
- a) How productive are different resource mixes at constructing line?
- b) How does the mix of mission types impact the daily fireline constructed?



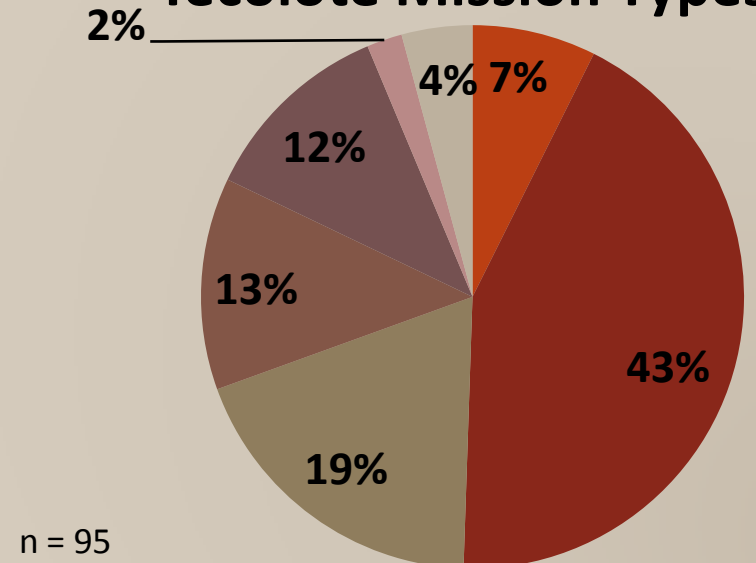
### Mission Type for All Fires



### Scott Mtn Mission Types



### Tecolote Mission Types



# Current Status

## Specification search

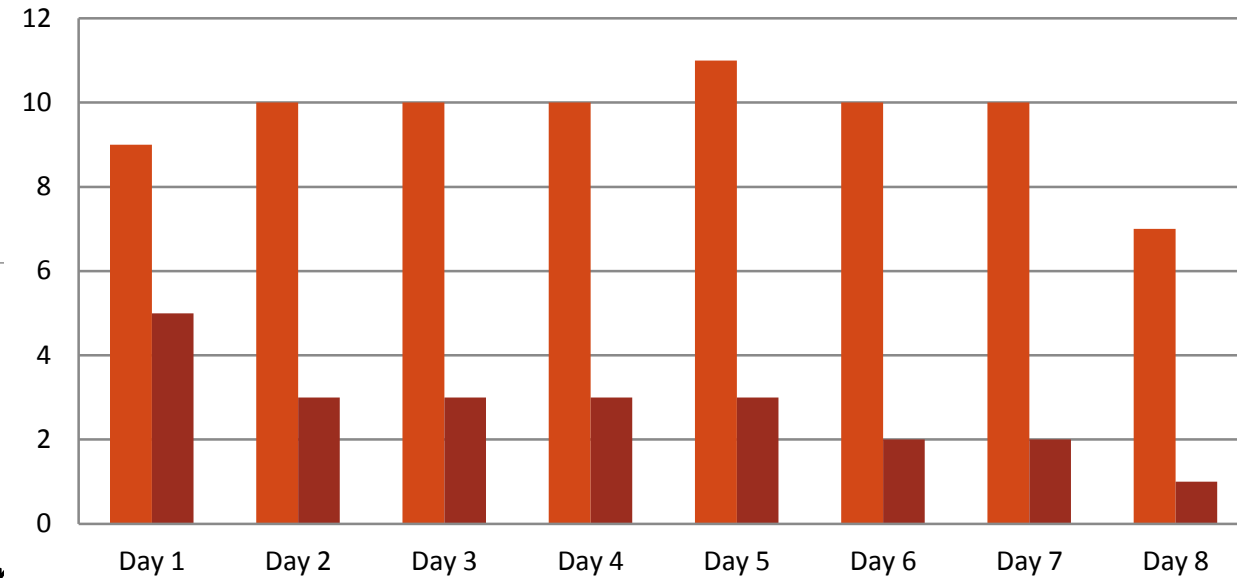
- econometric analysis
- regression exercise
  - Which model specifications are inter
  - comparing variables across specifica

*What relationships can be extracted?*

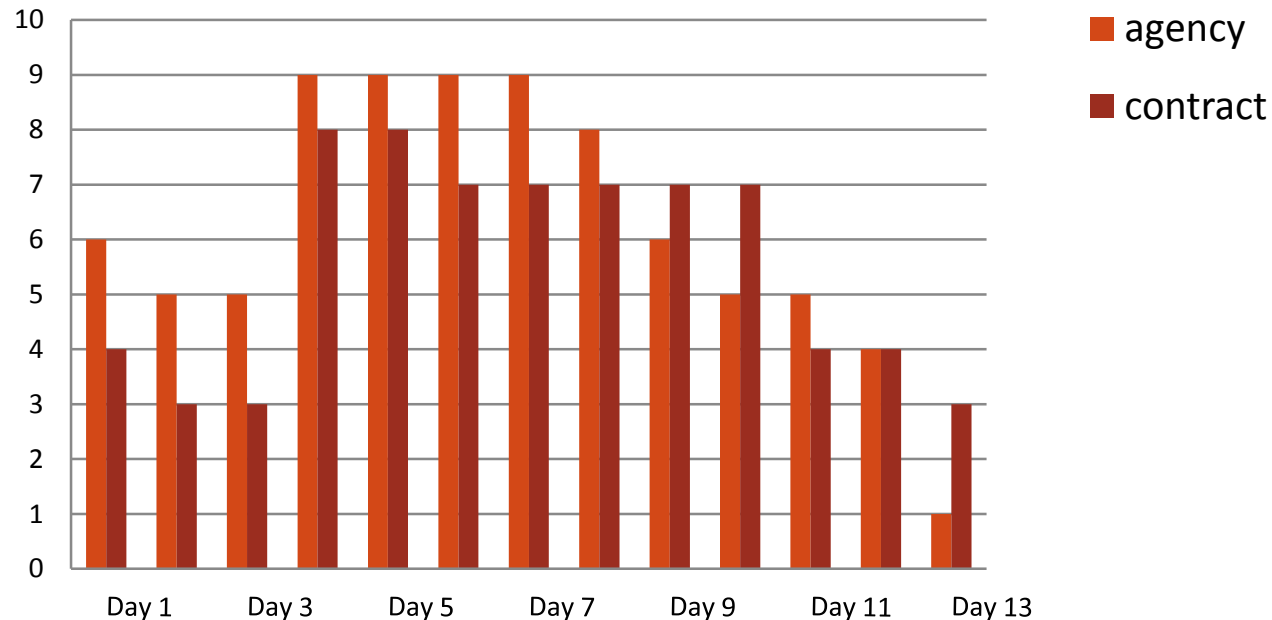
## Case study approach

- Agency hotshot crew vs. Type II contr
- location, assignment, accomplishmen

### Tecolote Fire Assignments by Crew Type



### Fontenelle Fire Assignments by Crew Type



# Moving Forward

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## Scale

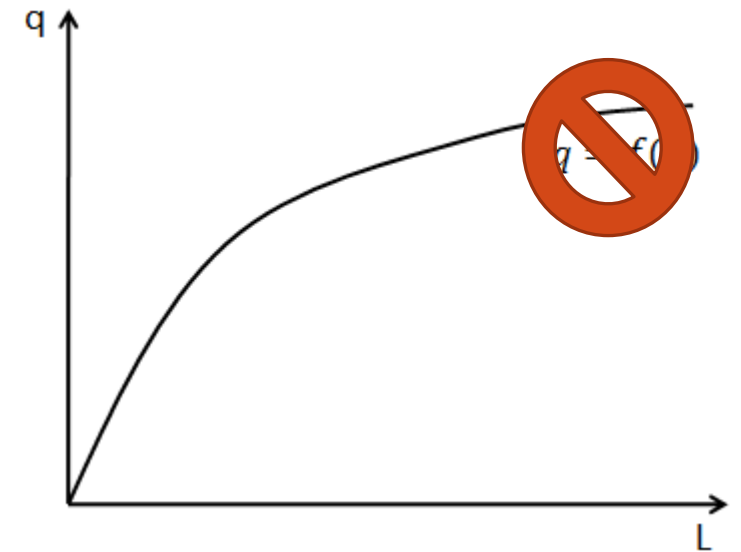
- Is analyzing daily aggregate suppression resources enough?
- Resource placement and probability of success

## Spatially explicit data

- Better understanding of where resources are deployed
- Amount of fireline built that engages final fire perimeter
- Enhanced evaluation of firefighter exposure

## Substitutes?

- Can we demonstrate that agency and contract crews are not substitutes?
- Modeling mop-up activities vs. initial attack – how do we get better?



# Improving wildfire management

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- Reduce potential resource loss
- Decrease unnecessary exposure of wildland firefighters
- Reduce management costs



# Acknowledgments

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**Dr. Claire Montgomery**, OSU College of Forestry, FERM Department, Corvallis, OR

**Dr. Dave Calkin**, Rocky Mountain Research Station, Human Dimensions Program, Missoula, MT

**Dr. Matthew Thompson**, Rocky Mountain Research Station, Human Dimensions Program, Missoula, MT

**Jon Rieck**, Rocky Mountain Research Station, Human Dimensions Program, Missoula, MT

Rick Strachan Graduate Fellowship 2011-2012

Rocky Mountain Research Station Joint Venture Agreement 2013-2014



# Thank you!

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*Mount Sentinel burning at night in July 2008*

*Photo Credit: Chad Harder*

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## ECONOMIC PRODUCTION MODELS BASED ON SPATIALLY EXPLICIT DATA

Improve understanding of the relative effectiveness of resources in producing fireline

Amount of fireline that engages the final fire perimeters

Other activities that suppression resources engage in other than fireline production

Enhancing evaluation of exposure of firefighters to fireline dangers

# Optimal mix of agency and contract crews

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Are contract crews a fundamentally different type of firefighting resource?

Donovan (2006)

Periods of low demand (rather than high) determine the optimal number of agency crews

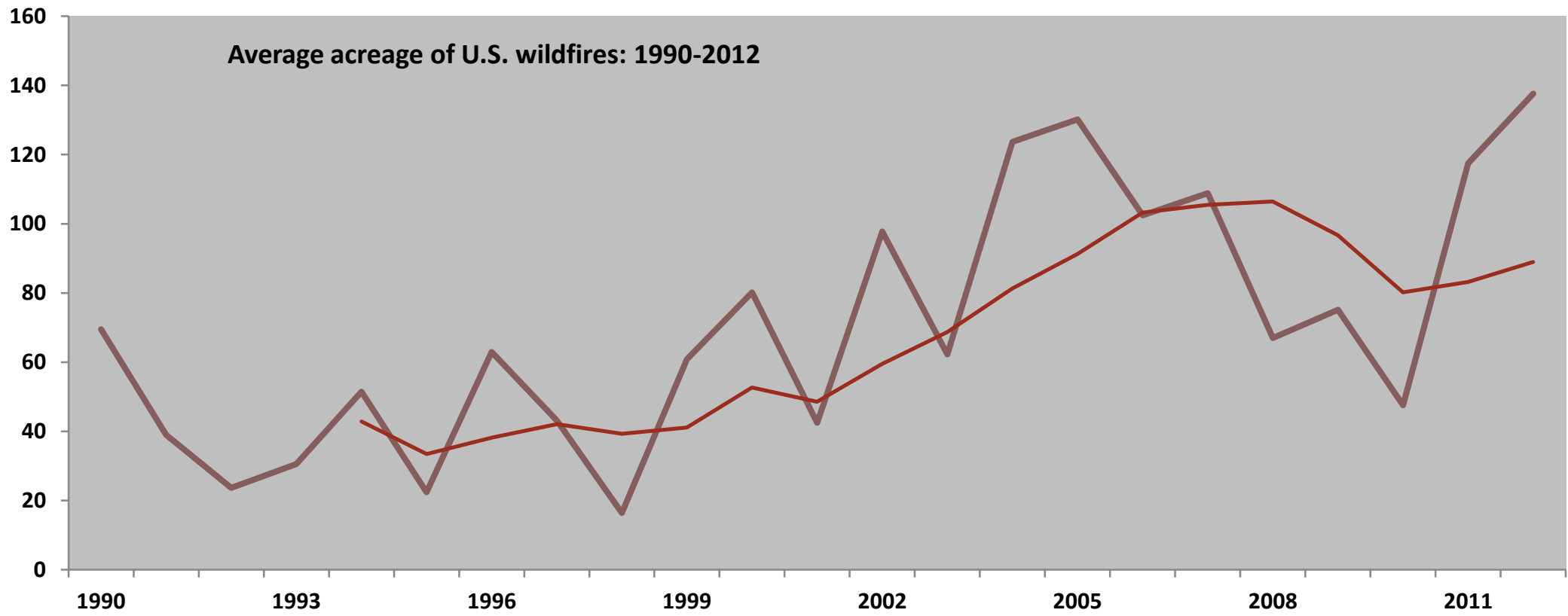
Availability of alternative work is **at least** as important as fire season severity

Model is a framework for considering the tradeoffs between agency & contract crews (only one of potentially many tools)

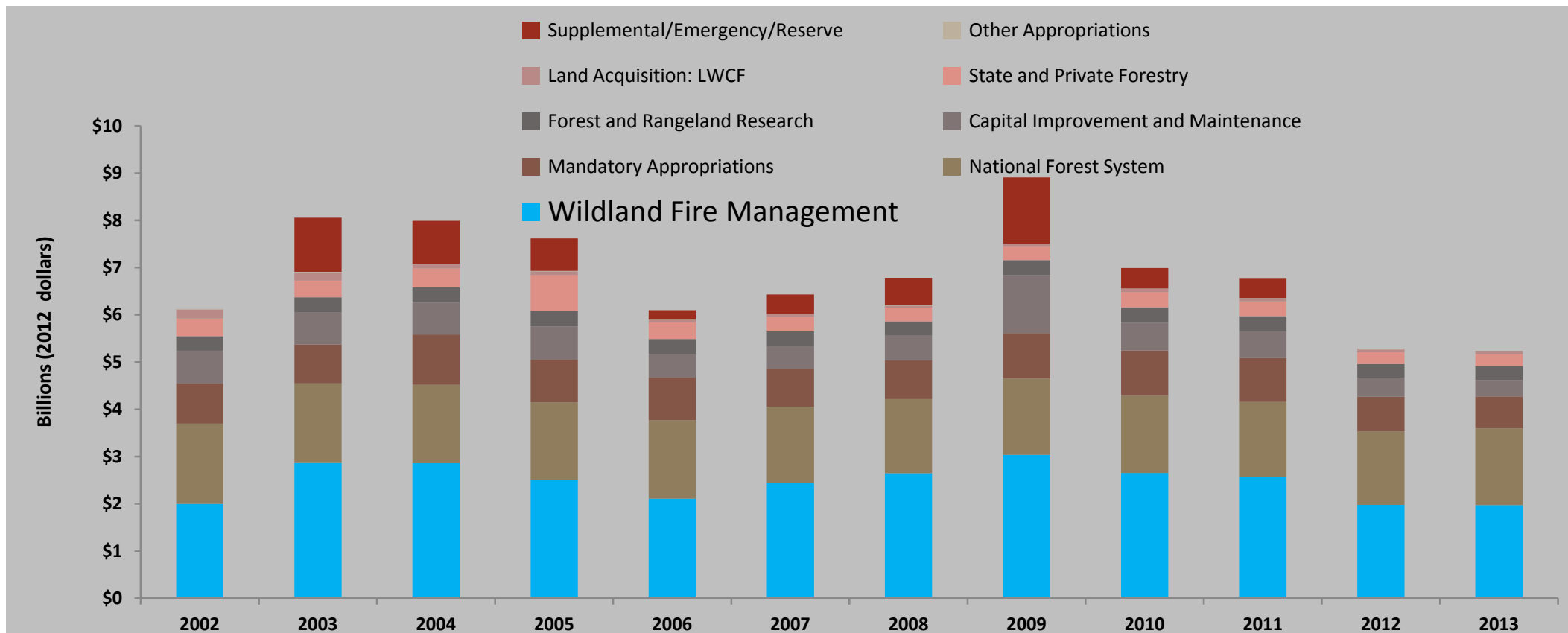
What about differences in productivity?

- Assumes equal productivity across crew types, across fires
- Need for combining productivity with uncertainty
- Anecdotally it seems that ICs don't think of contract crews as particularly high efficiency units

Hot to get contractors to lower their bids- what could the FS do to get their costs down at this level?



# US Forest Service Budget Breakdown



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**Fire days 72**

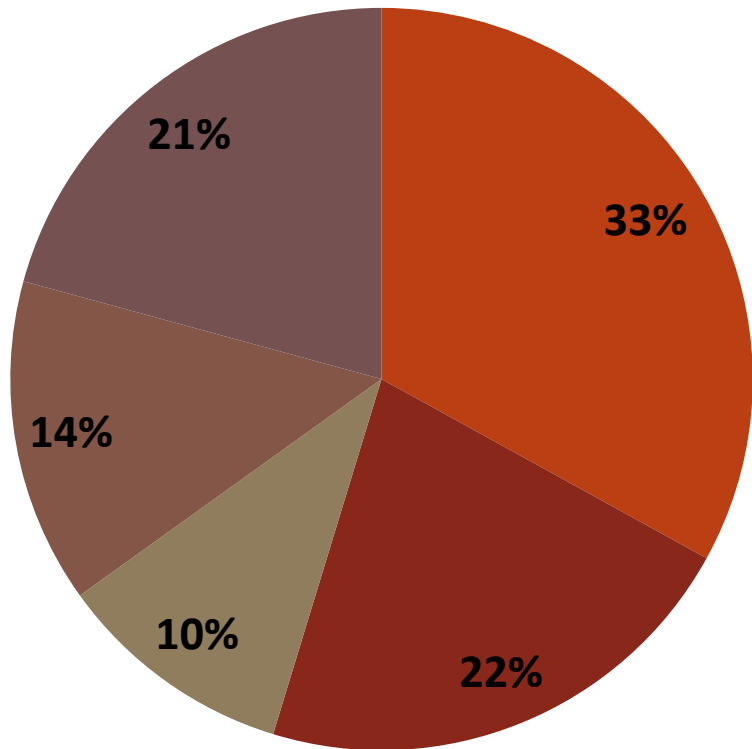
**Fire Assignments 513**

**Divisions (513)**

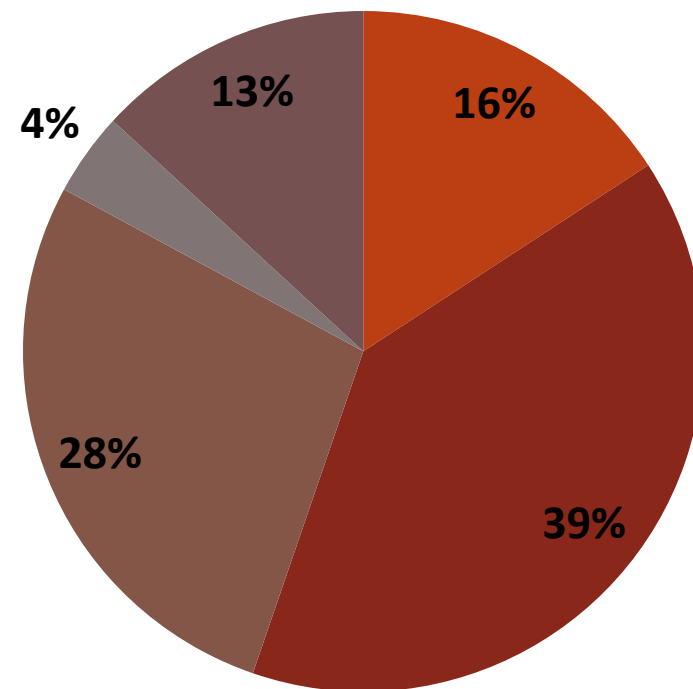
## Schultz Mission Types

## Saddle Complex Mission Types

- Direct
- Indirect
- Hold
- Mop Up
- Other
- Unknown
- IA
- Rehab
- Contingency
- Point Protection



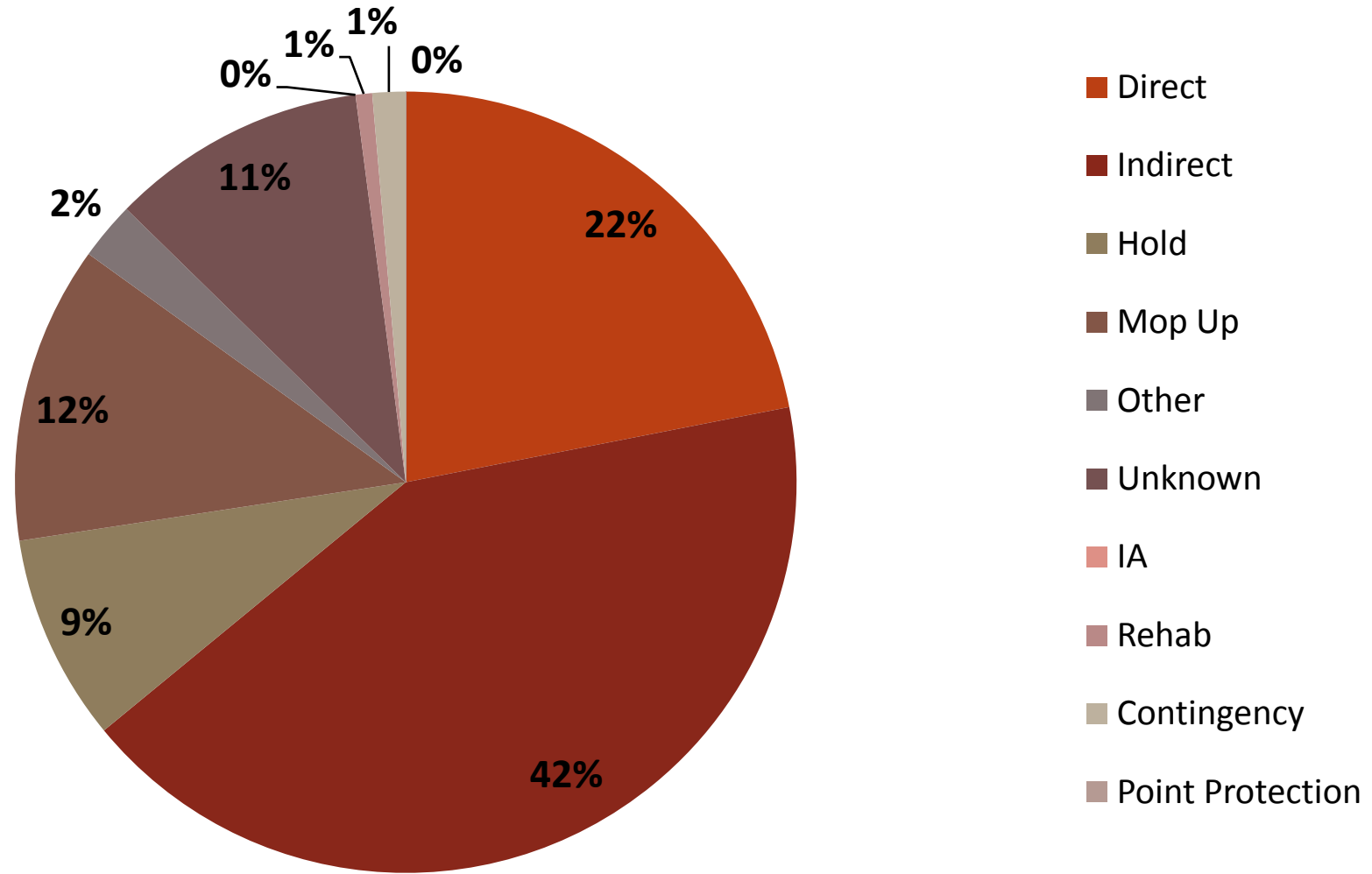
n = 106



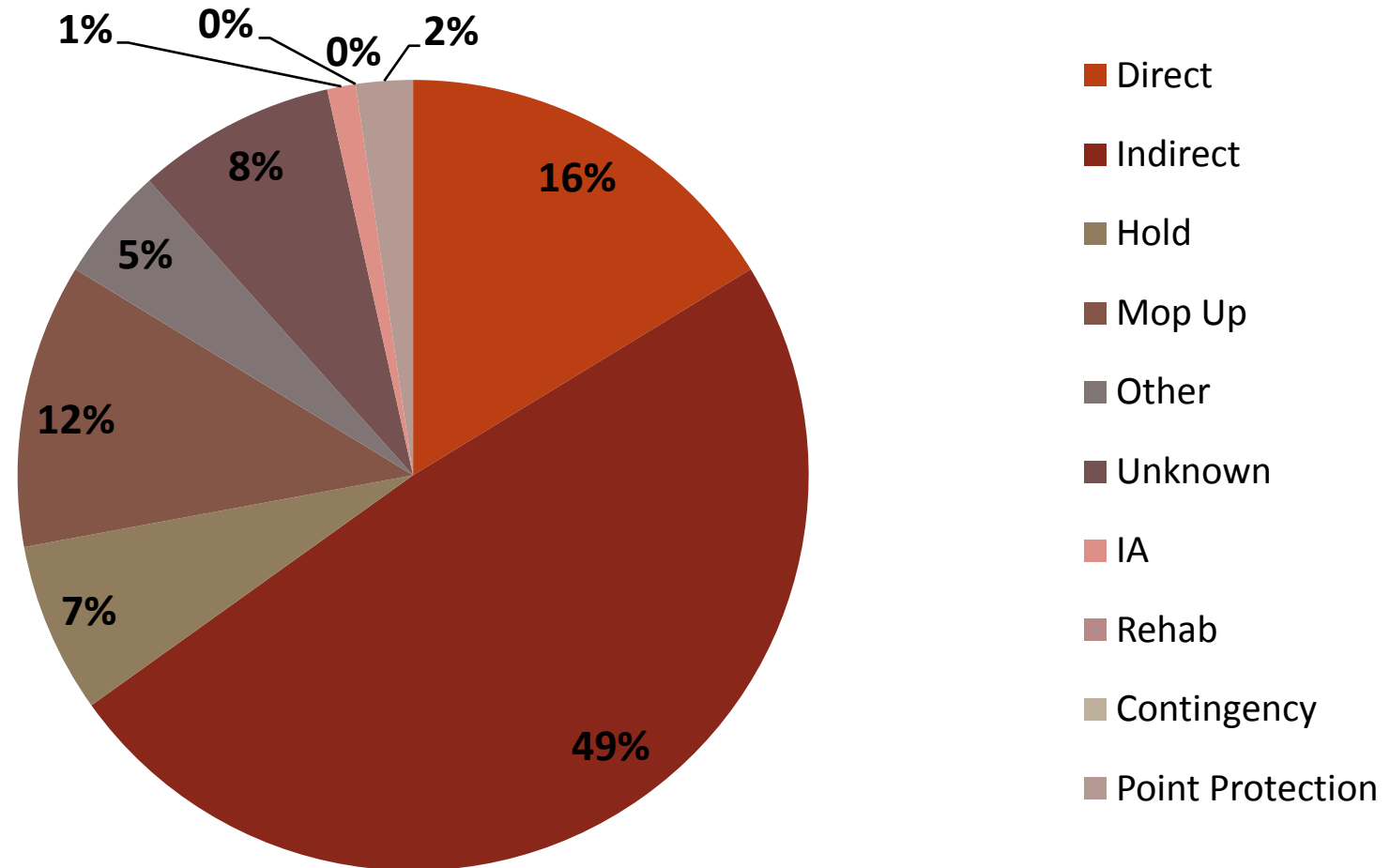
n = 76



# Agency Crew Fire Assignments

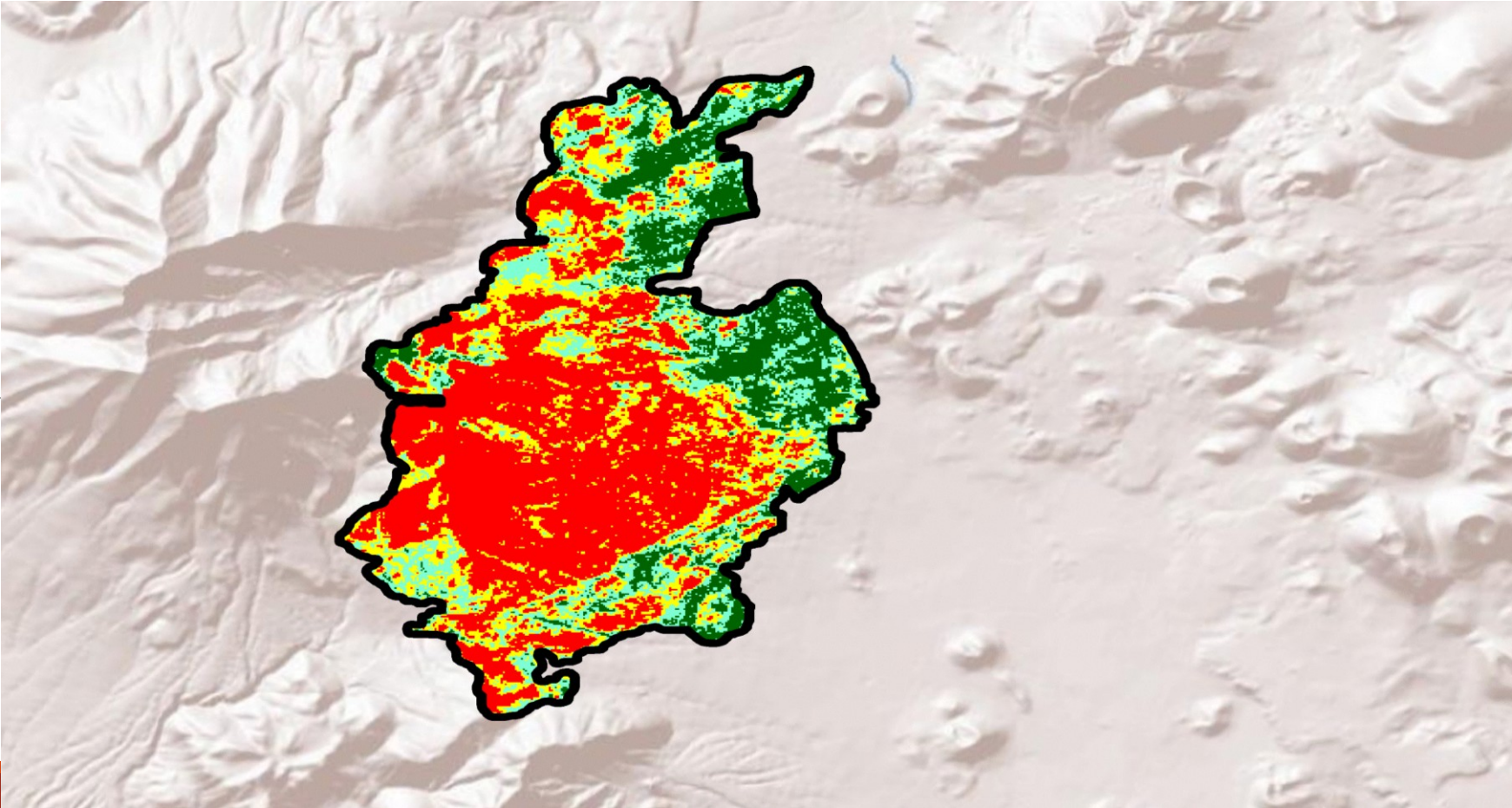
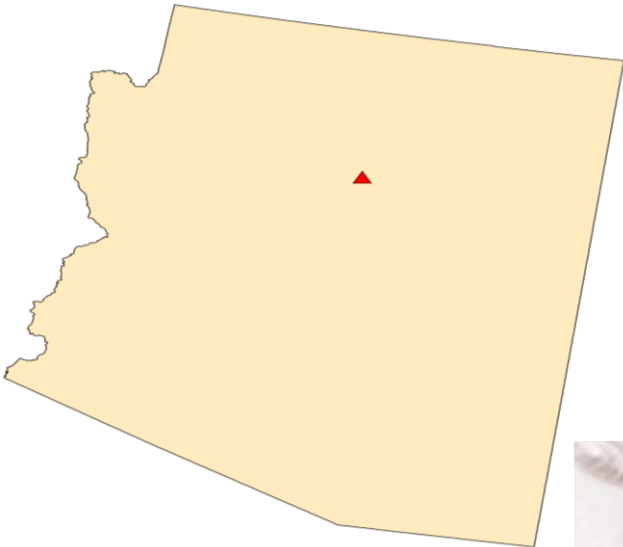


# Contract Crew Fire Assignments

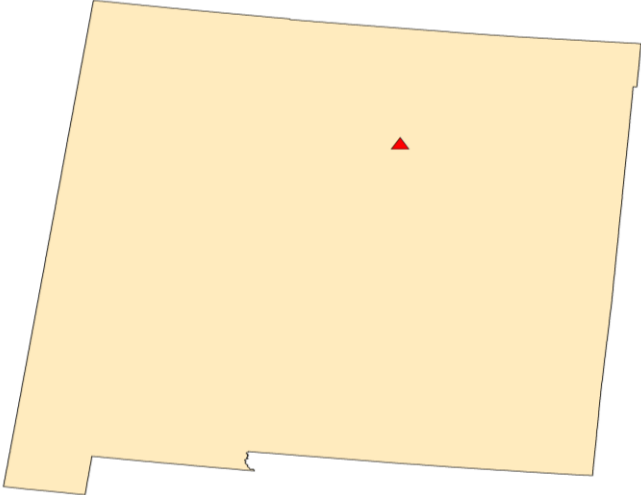


n = 86

Schultz 2010



Teclolote 2010



Saddle Complex 2011

