National Park Service

Rocky Mountain National Park

Drought, Wildfire, and Climate Change: From Scenarios to Real Life through the Eyes of a Scientist-Land Manager

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Rocky Mountain National Park

NC-CASC Webinar
Feb 11, 2021

Where my Lessons Come From

Mountain Studies Institute
SAN JUAN MOUNTAINS COLORADO

2004-2010

Sequoia & Kings Canyon National Parks (SEKI)

2010-2018

Rocky Mountain National Park (ROMO)

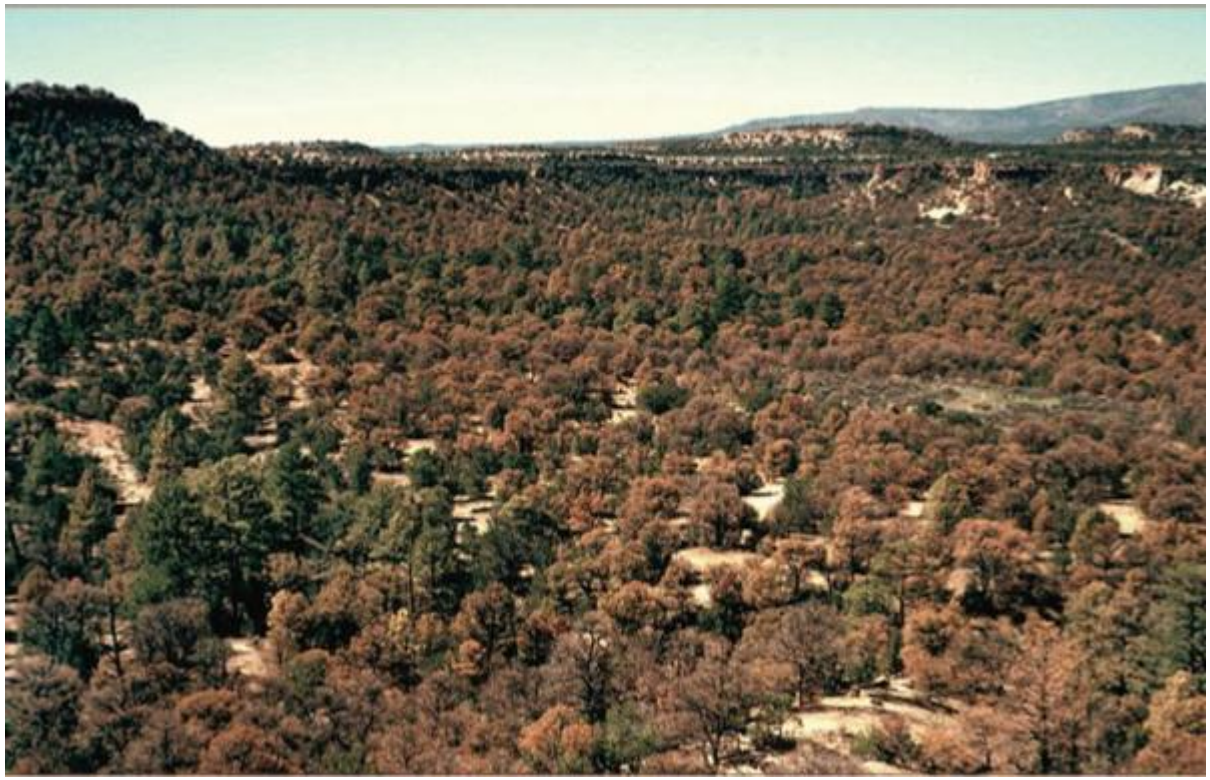
2018-2021

Road Map

- Background Key Science
- SEKI Story & Lessons
- ROMO Story & Lessons
- Conclusions

2002: Global Change-Type Drought

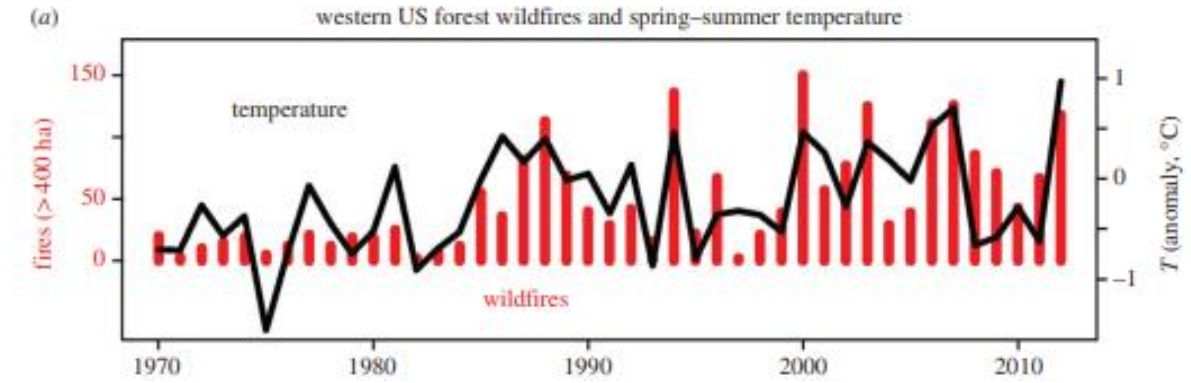
- Forest die-off
- Emerging climate change risk for forests globally



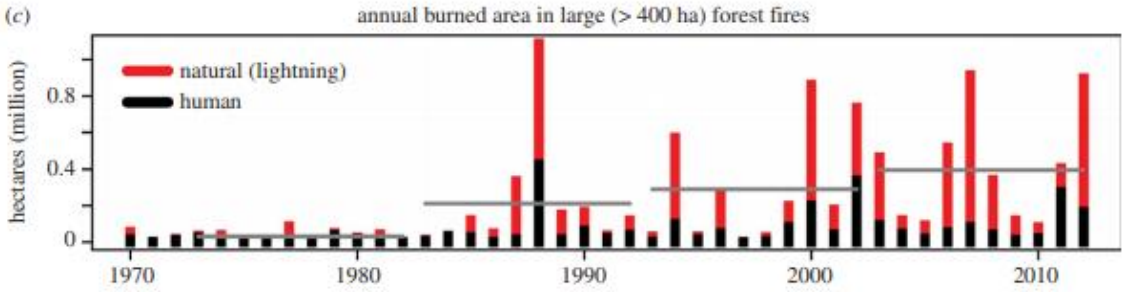
Breshears et al 2005. Regional vegetation die-off in response to global change-type-drought. Proceedings of the National Academy of Sciences

Allen et al. 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management.

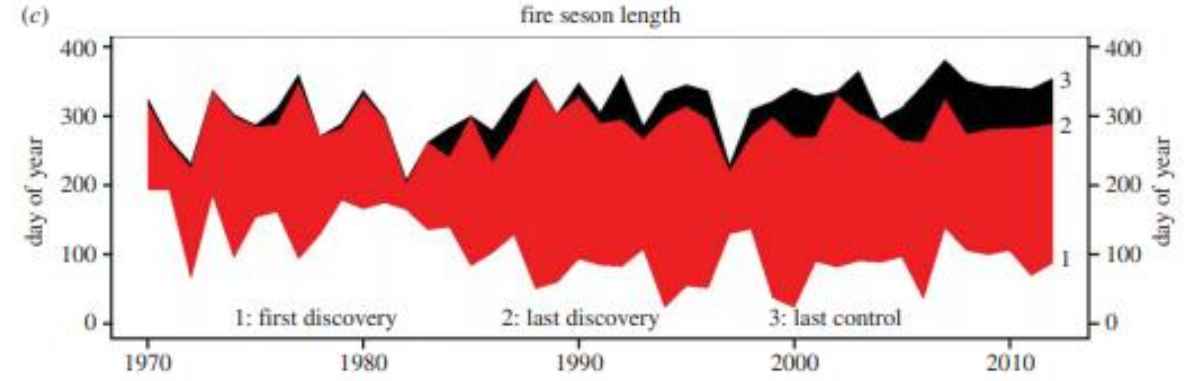
Western US Fire Trends 1970-2012



Wildfire frequency linked to temperature



Increasing wildfire frequency & area burned in large fires



Lengthening wildfire season

Westerling. 2016 Phil. Trans. R. Soc. B

SEKI – Giant sequoia mixed conifer forest

Within ponderosa pine mixed conifer forest

Grow in wetter areas

Highly fire adapted – short fire return interval (FRI), low/mixed severity fire

Sequoia seedlings depend on fire

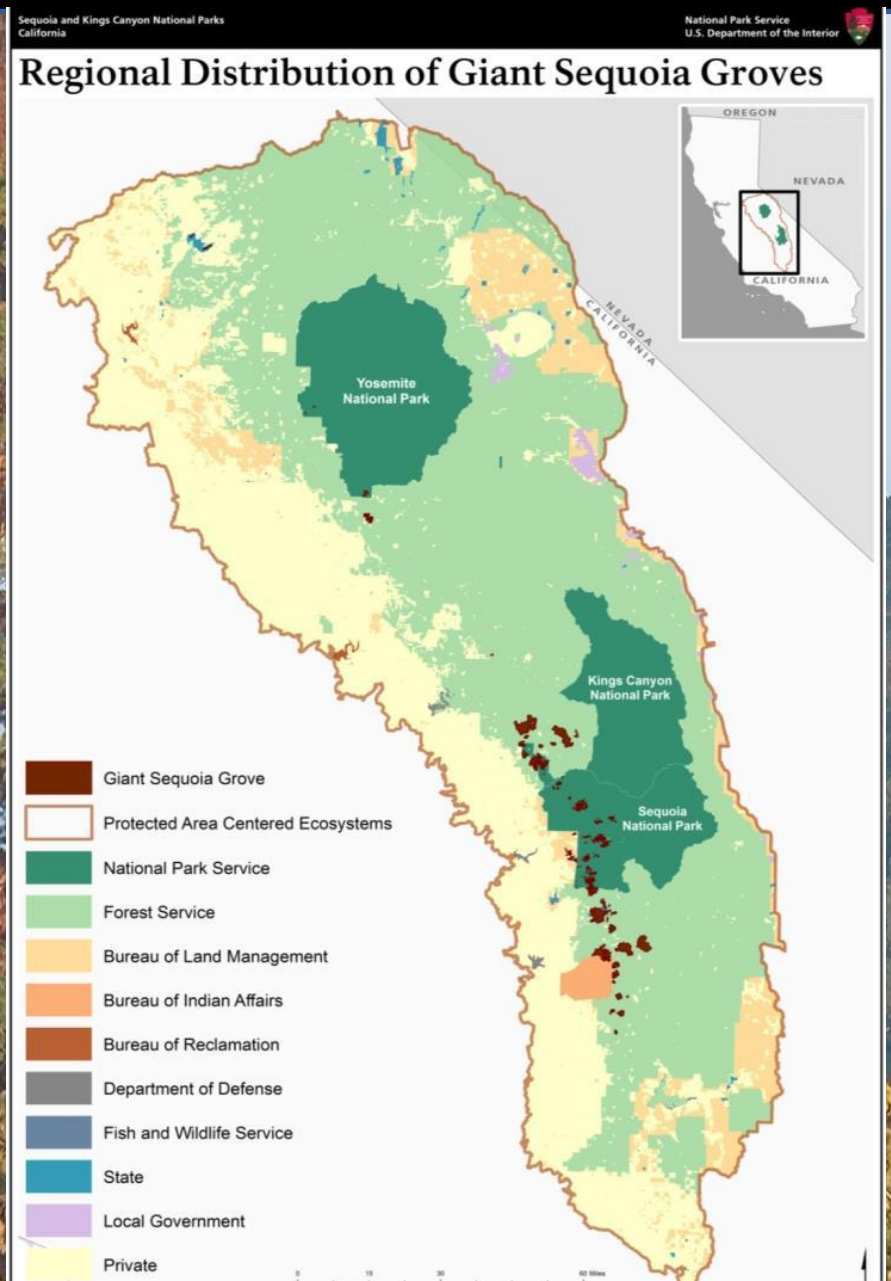
Mature sequoia trees highly resistant to fire & beetles

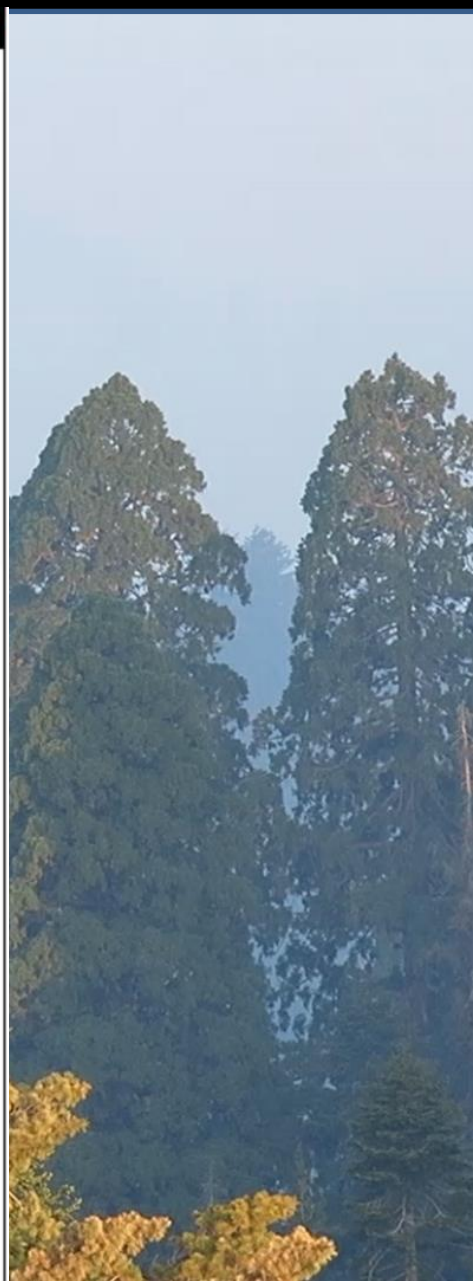
Fire suppression/fuel loading

Can live up to ~3000 yrs

Huge, old, awe-inspiring

Sequoia Grove Distribution





2011-2014 CC Adaptation Planning Projects

Alternative Fire Futures

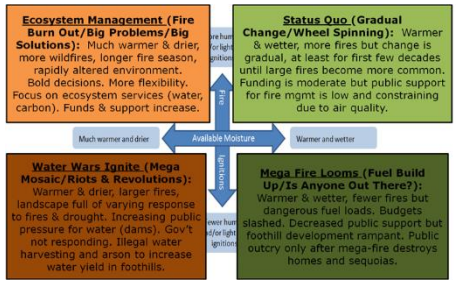
- Re-examine fire management in the face of climate change
- Tools, processes, collaborations for implementing changed approach
- Interagency/landscape scale

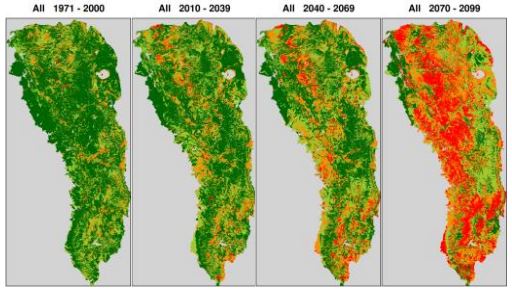
Giant Sequoia Forest Pilot

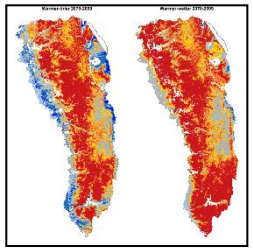
- Integrate climate change into resource stewardship planning
- Climate-Smart Resource Stewardship Strategy (RSS) Pilot
- Geospatial decision support tools

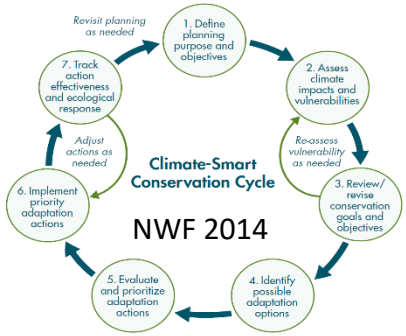
Smorgasbord of Methods

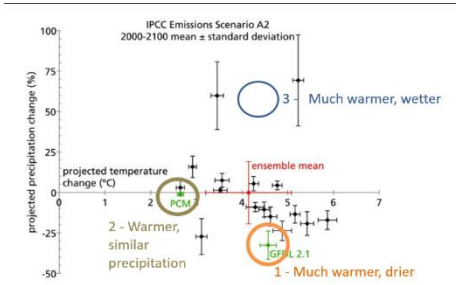
- Scenarios
- Climate Change Effects Modeling
- Vulnerability Assessments
- Values & Feasibility Assessments
- Geospatial Mapping
- Expert Input Workshops
- Prioritization/Triggers: what, when, where
- Re-examining goals as well as actions

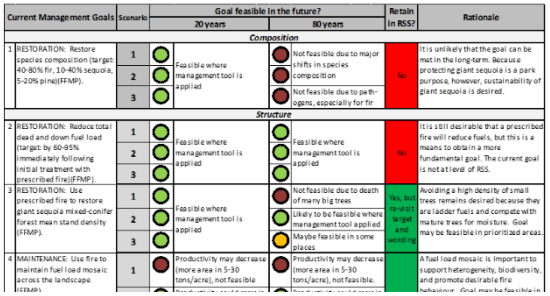


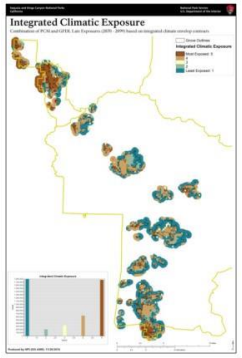


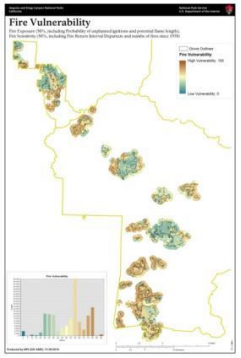












Key Question: Prescribed Fire - Where?

- 2-3 treatments to restore forest structure
- Promotes growth and survival of sequoia seedlings
- Reduces fuels that increase severity of wildfires
- Reduces risk of tree mortality from drought…maybe??
  (Van Mantgem et al. 2016. Fire Ecology)

Key Question: Prescribed Fire?

Expert workshops applying decision support maps to prioritization

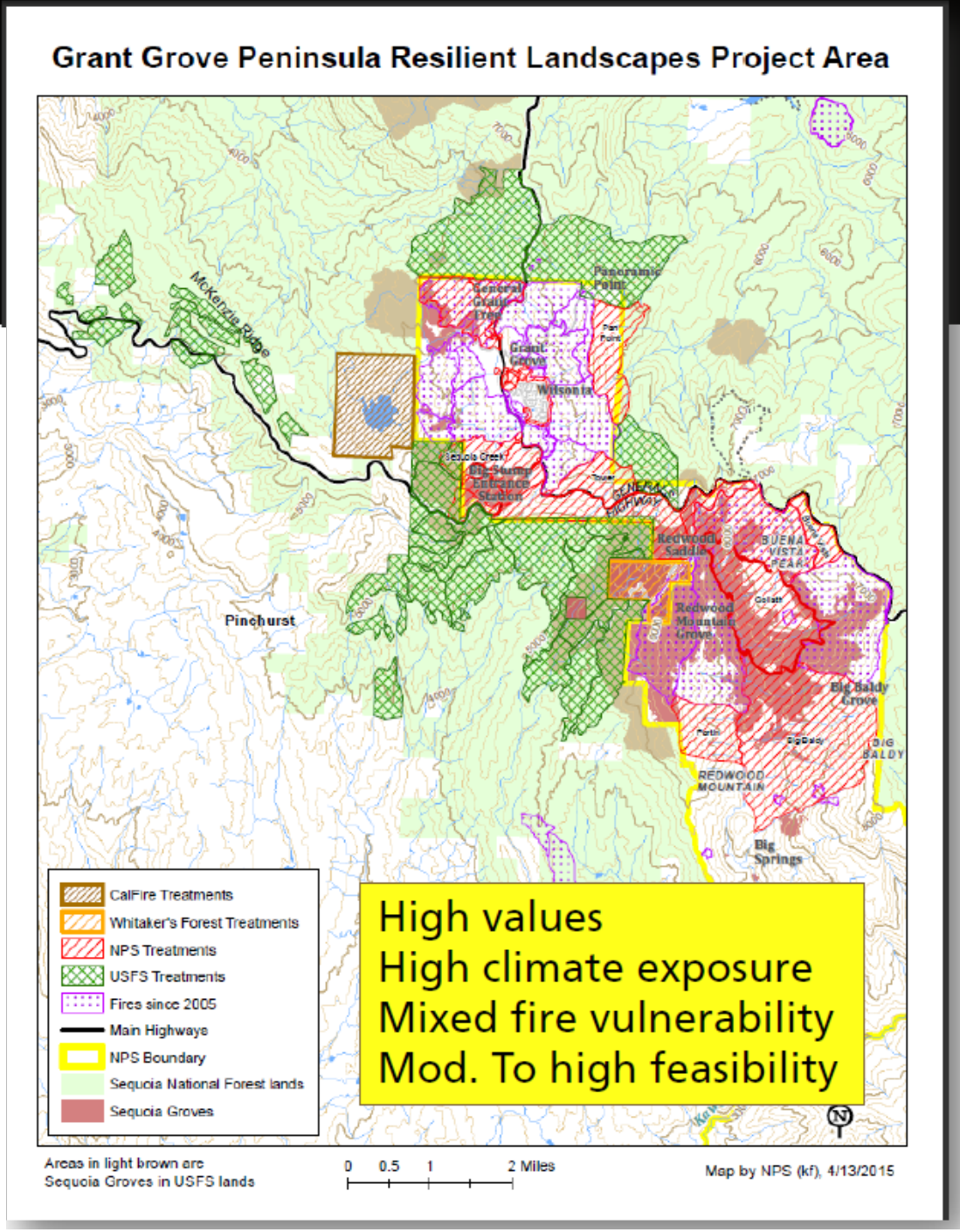
LESSONS – Useful in real decisions

SEKI applied this prioritization framework and was selected for:

DOI Resilient Landscapes Project

Multi-agency Effort

$1.5 M up to 7 years



Scenario Outlooks

20-30 years

Moderate changes climate & forest

Impacts to sequoia regeneration

Mature giant sequoias persist similarly to today

80 years

Severe changes climate & forest

Impacts to sequoia regeneration and mature trees

Scenario Extreme Events: Wildcards

Drought-Wildfire

…fire burns 200,000 acres in/around the parks…burns through a variety of vegetation, including giant sequoia groves and destroys structures…

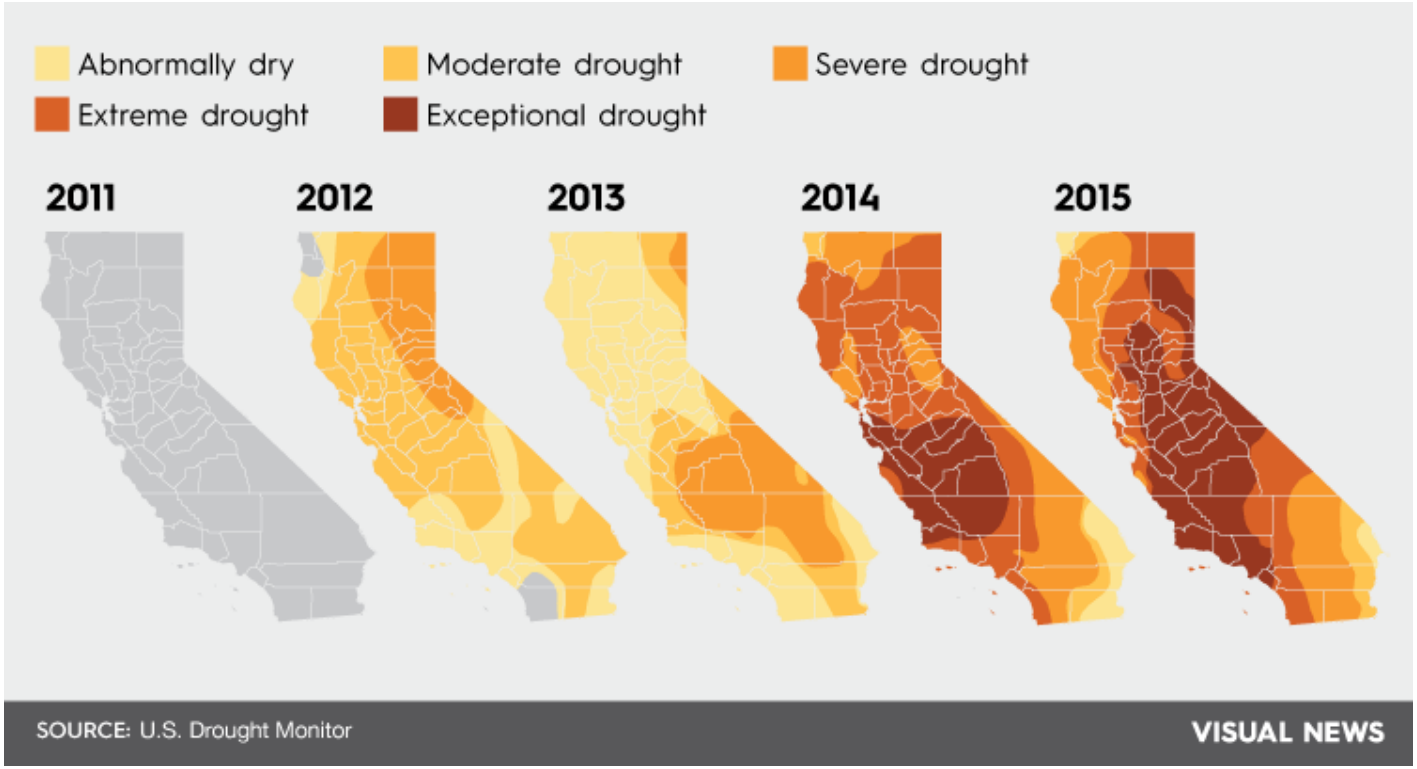
Drought- Insect Outbreak

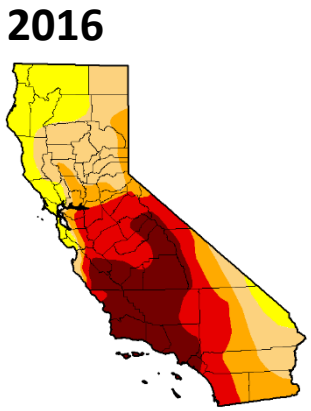
…insects and disease to spread into multiple giant sequoia groves, especially lower-elevation groves, weakening healthy trees and killing drought-stressed trees. Incidences of western cedar bark beetle increase in both incense cedar and giant sequoia…

Flood

…December-January storm brings 25" rain in 30 days. Flows on major rivers increase 5 times. Smaller streams see even larger increases. Vegetation is uprooted and washed downstream. A major landslide takes out portions of a sequoia grove and road…

Then...Record Breaking "Hot Drought"

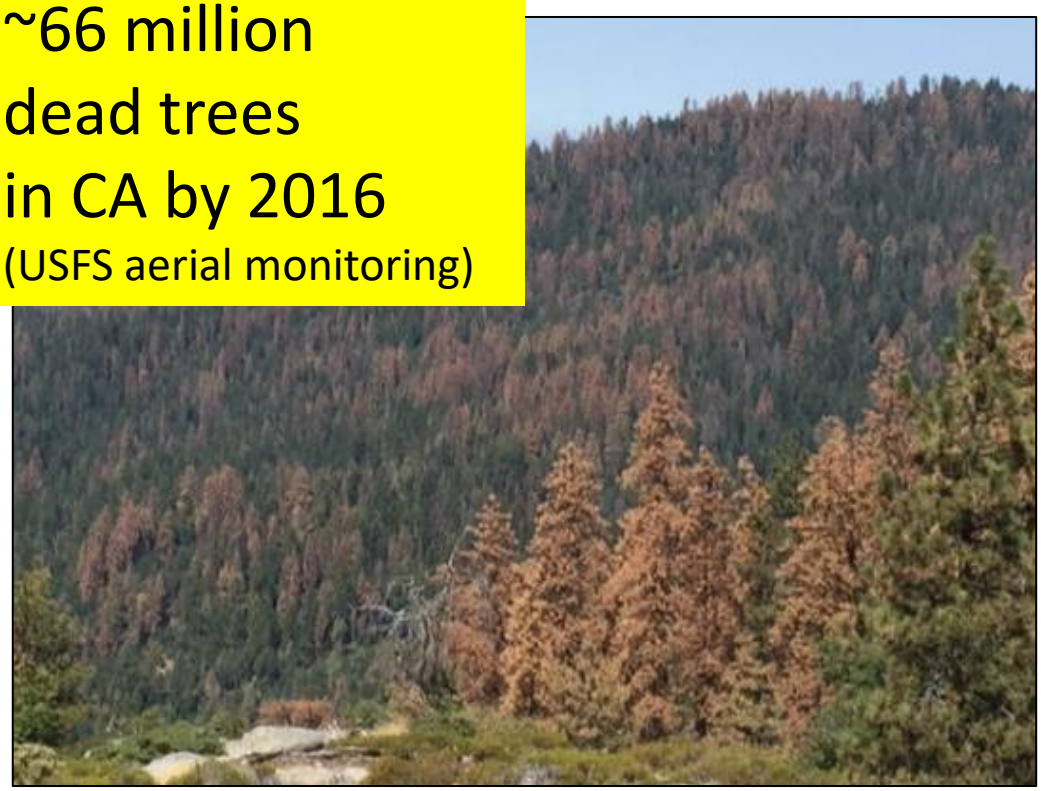




Anthropogenic warming increased drought severity
(Williams et al. 2015)

2014-2015 Drought Observations

~66 million
dead trees
in CA by 2016
(USFS aerial monitoring)



Pines, firs, cedars dying from drought + beetles, starting 2014

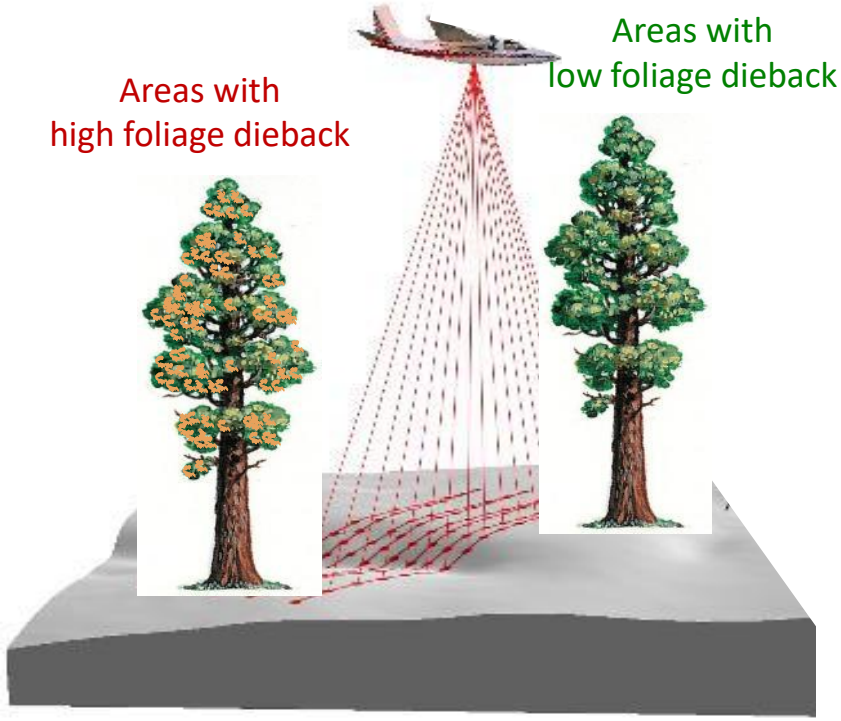
Giant sequoia foliage dieback in 2014

2015: Drought Vulnerability from Leaf to Landscape

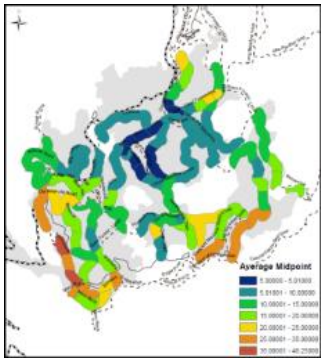
Ask the trees themselves how stressed they are to hot drought

Remote sensing

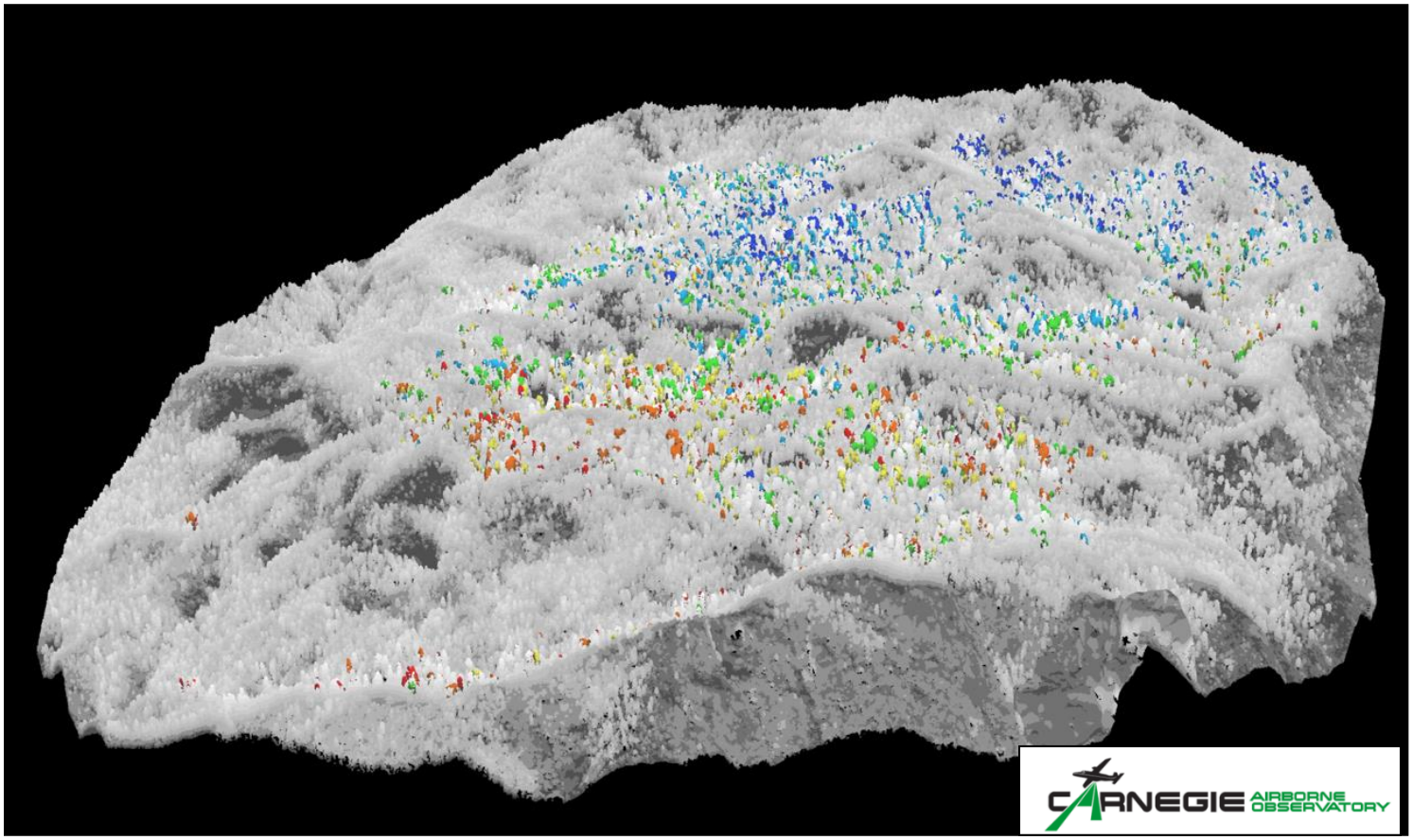
- LiDAR + hyperspectral



Field Work: direct measurements



Sequoia Canopy Water Content (CWC)
Giant Forest, Summer 2015

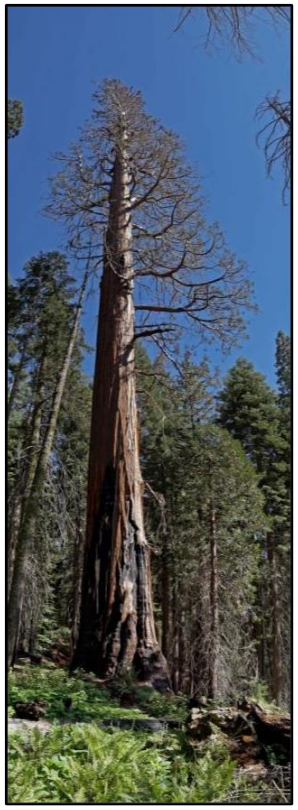


Nydick et al. 2018. Forest Ecology and Management (series of 5 Leaf to Landscape papers)

2017 – Beetles Killing Sequoias?

Phloeosinus galleries

Beetles Killing Sequoias



33 beetle-killed sequoias found in SEKI to date

Complex Interactions:

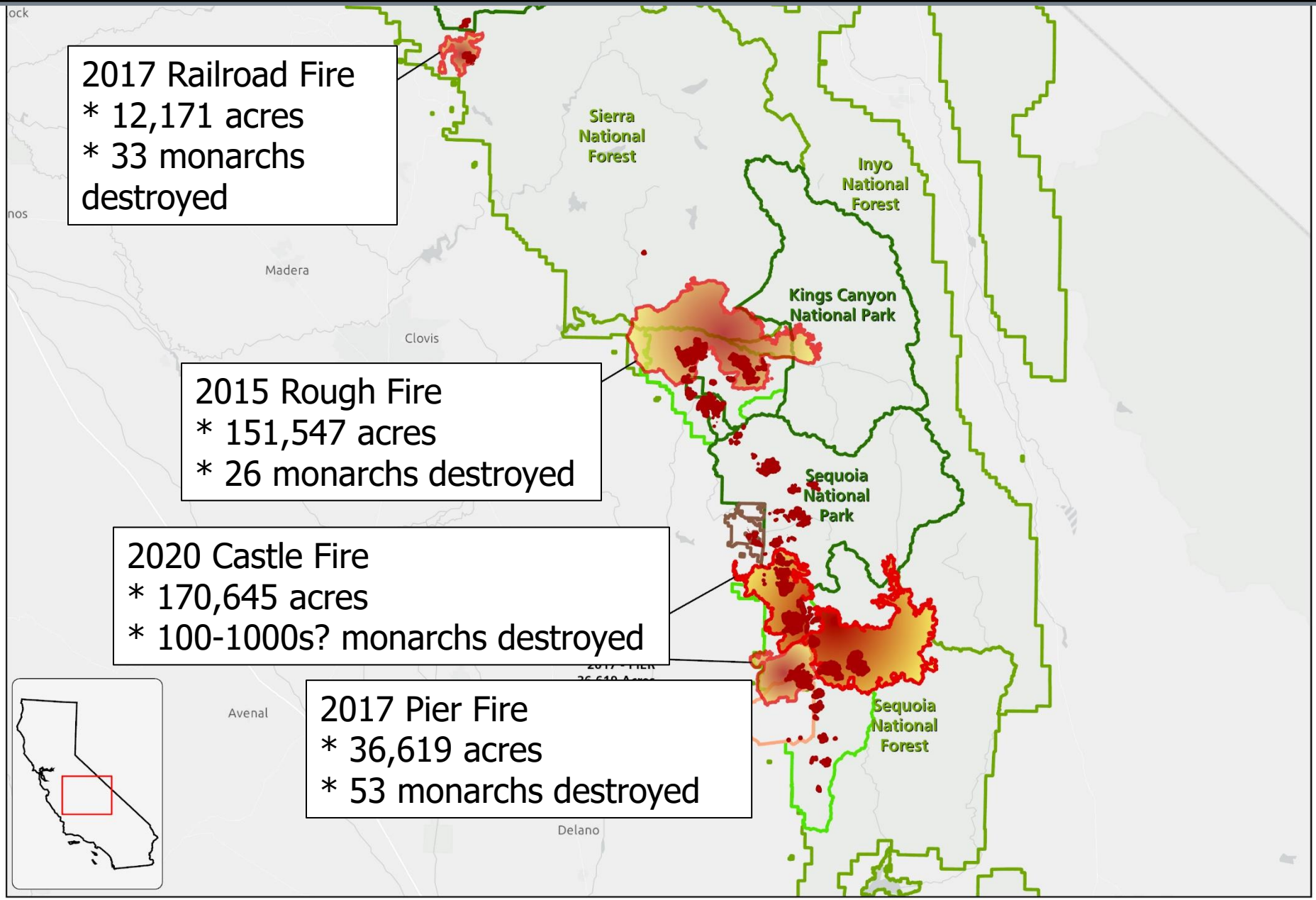
- Drought x environmental factors = stress
- Add in *Phloeosinus* x extensive fire damage = mortality
    - Lower elevation, drier areas
    - Higher elevation, wetter areas

"Spoiled Tree Hypothesis"

Baeza et al. In Press. Mapping the Vulnerability of Giant Sequoias after Extreme Drought in California using Remote Sensing. Ecological Applications

Research ongoing

2015-2020 – Fires Killing Large "monarch" Sequoias



2020 Castle Fire – 22 sequoia groves burned (12 SEKI)

<u>High Severity Effects</u>

- warmer, drier south-facing
- AND no recent fire
- 13% grove area in park
- ~hundreds of large sequoias destroyed

<u>Mixed/Moderate Severity or Limited Fire Spread</u>

- Cooler, more moist north-facing
- OR recent fire

PRIORITIZATION EVEN MORE URGENT: Lack of Treatment Has Consequences!

Understanding vulnerability doesn't tell you what to do where

- Protect higher value areas regardless of vulnerability?
- Protect lower vulnerability (refugia?) as insurance policy?
- Do most feasible so the most acres can be accomplished?

Place-Based Expert Decision-Making
(both ecological and social consequences)

Lessons

URGENT, INTERACTIVE, COMPLEX

Climate change interacts with other stressors…producing accelerated, amplified & highly complex and sometimes unprecedented effects…breaks your assumptions.

ADAPTIVE MANAGEMENT ON STEROIDS

Demands nimble and robust science, innovative multi-prong methods & thoughtful decision making.

NEVER ENOUGH RESOURCES TO DO IT ALL

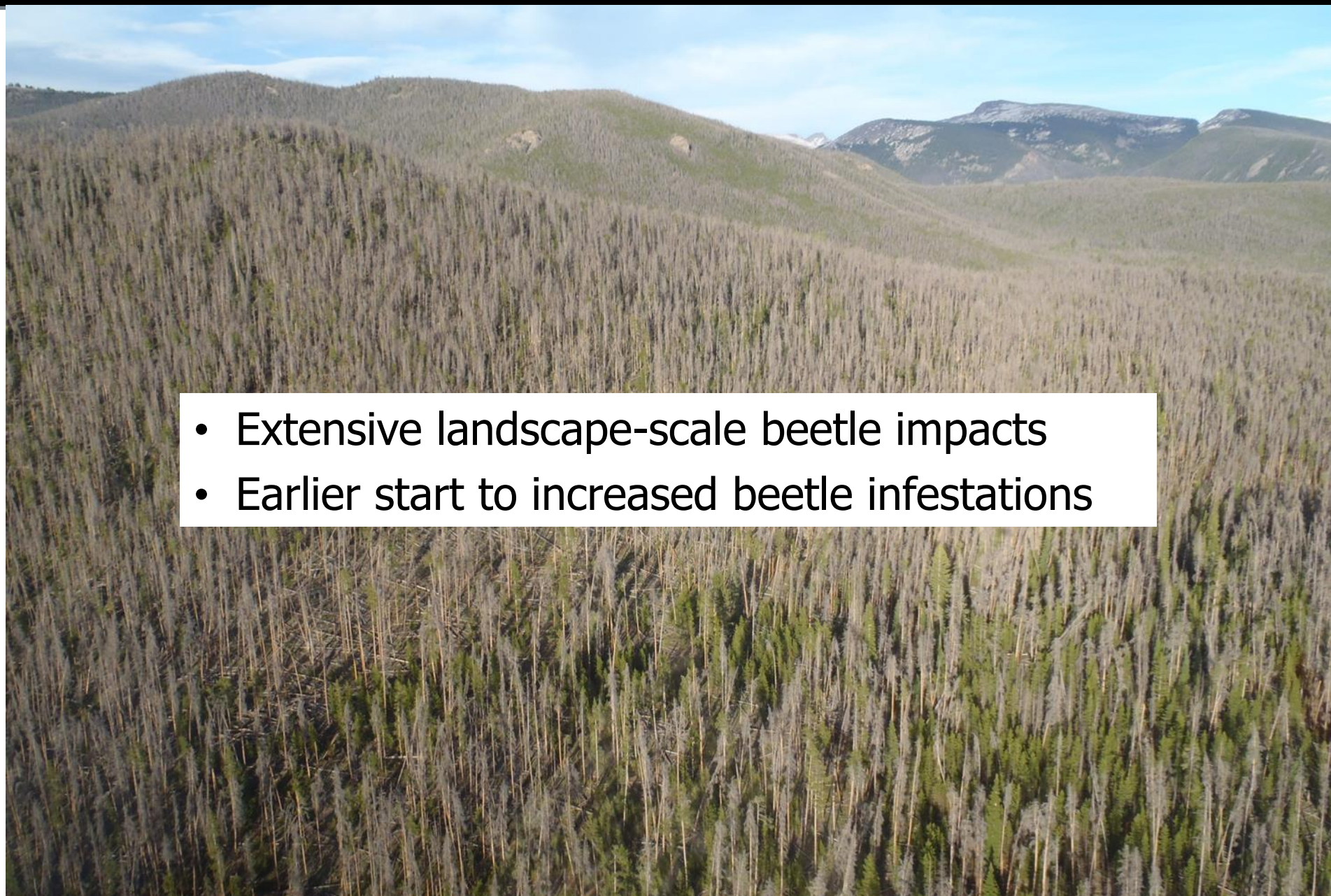
Takes you back to…prioritization

ROMO – Same, But Different, Forest Story

- Forest mostly subalpine
- Long fire-return intervals (150-300 years)
- Stand replacing fires during major droughts (4000-9000 acres)

- Small amount of ponderosa woodlands along WUI with Estes Park
- Shorter FRI, lower severity

ROMO Subalpine Forests = Beetle Kill



- Extensive landscape-scale beetle impacts
- Earlier start to increased beetle infestations

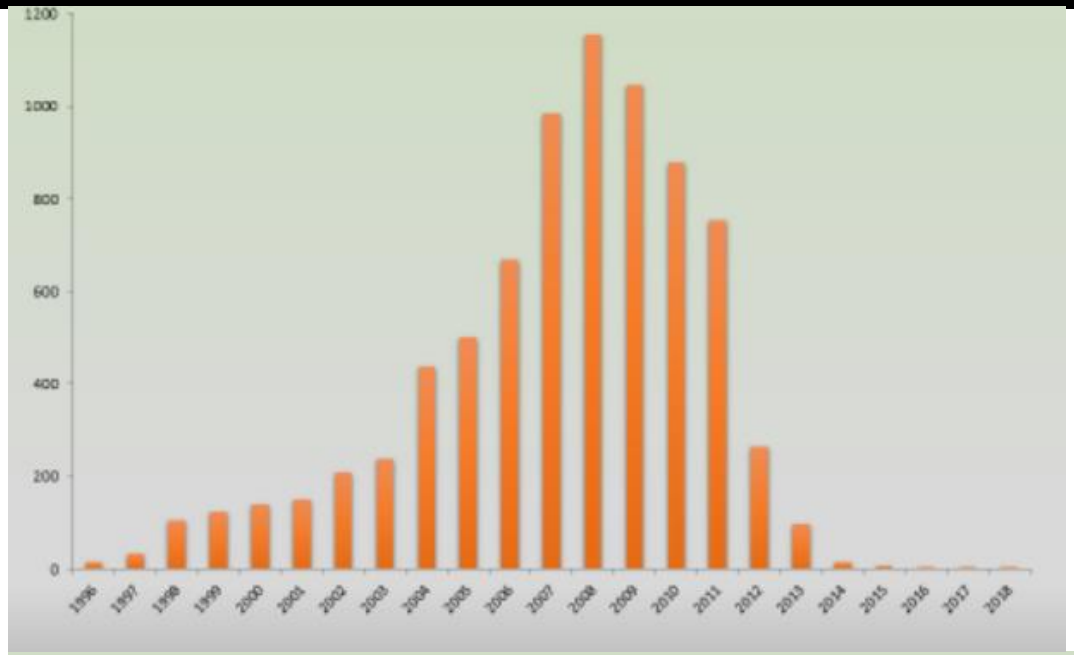
Beetle Outbreaks Over Time

USFS-R2. Aerial Survey Highlights for CO 2018
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd615371.pdf

Mtn Pine Beetle in CO

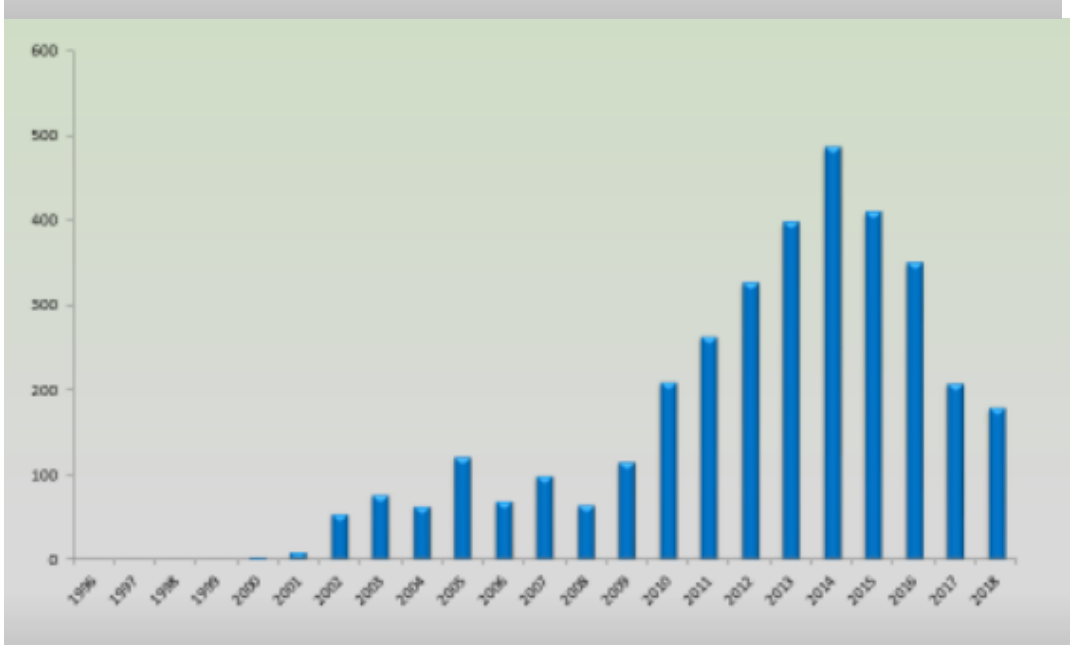
Acres Per Yr 1996-2018

ROMO:
mainly lodgepole pine
limber pine
(not ponderosa pine)

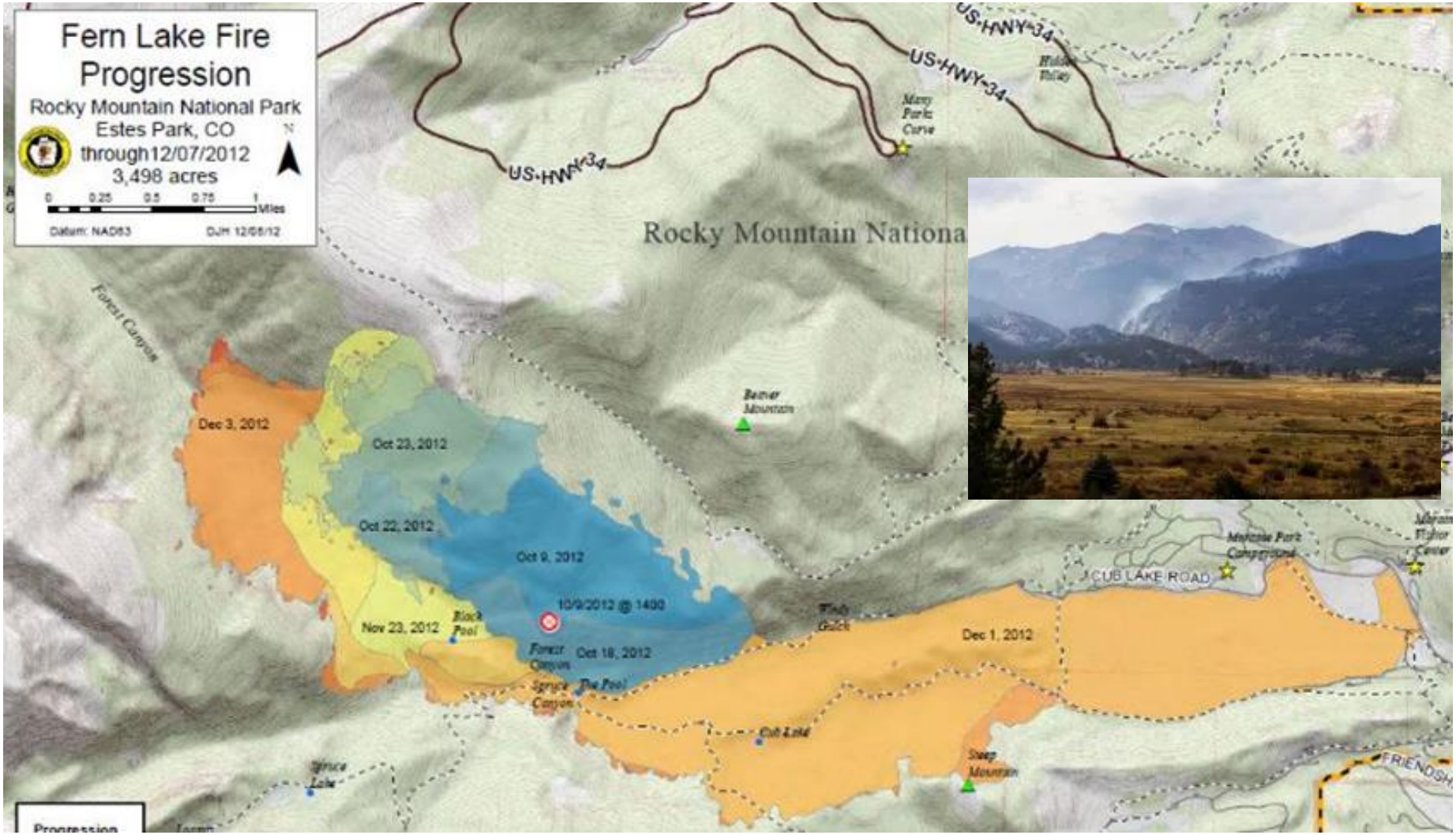


Spruce Beetle in CO

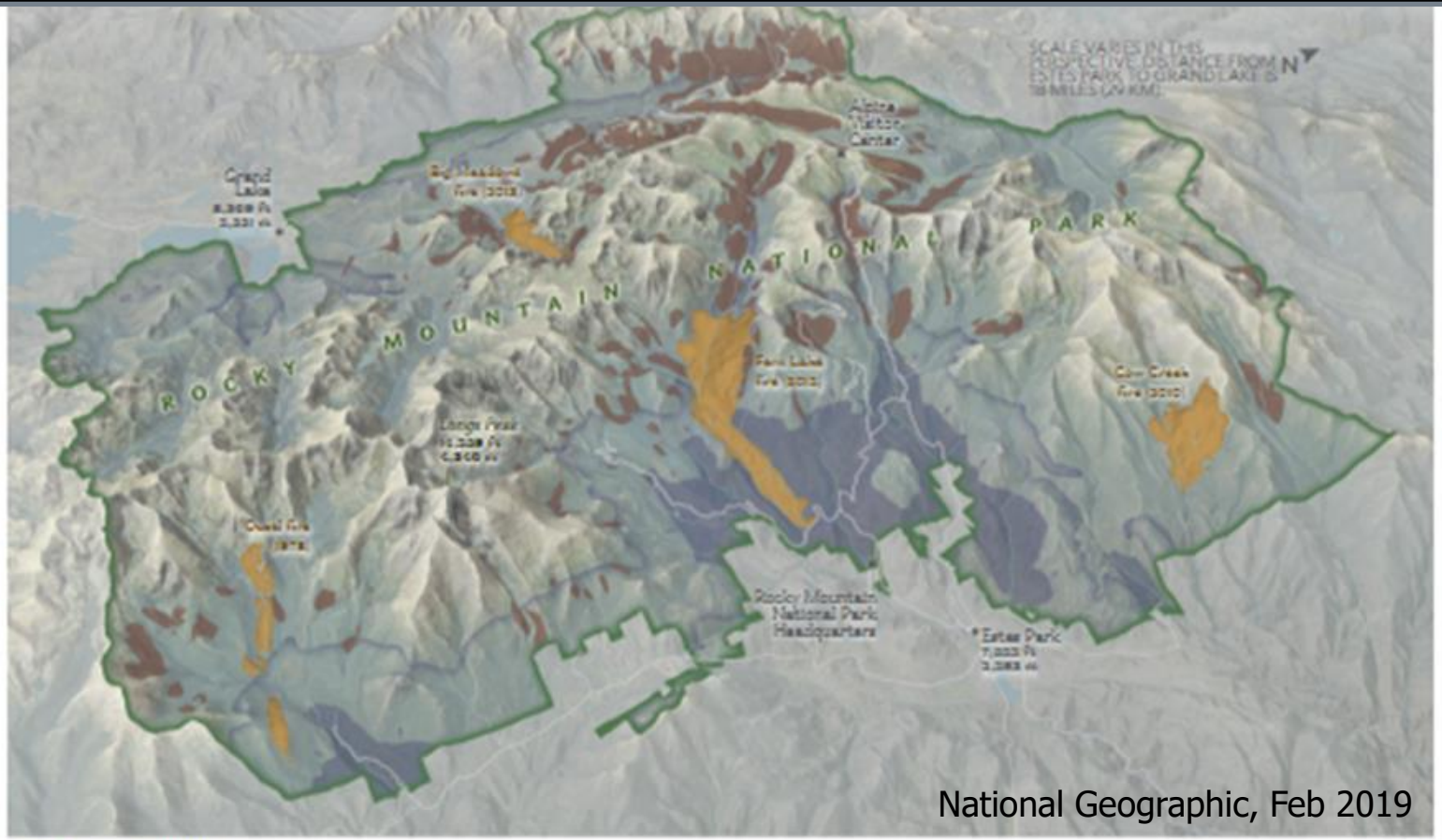
Acres Per Yr 1996-2018



2012 Fern Lake Fire…a winter story!



The ROMO Landscape…



National Geographic, Feb 2019

Projected suitable cheatgrass habitat in 2050

Current suitable cheatgrass (*Bromus tectorum*) habitat

Wildfire over 50 acres since 1970

Severe bark beetle damage, 2012-18

INVADING GRASSES
Non-native cheatgrass, once limited to the park's lowest elevations, is now spreading above 9,500 feet, moving more than 2,000 feet in elevation in just 10 years.

WILDER WILDFIRES
More acreage has burned here in the past eight years than in the previous century. The 2012 Fern Lake fire, caused by humans and fed by dry conditions, burned for months and over snow.

DESTRUCTIVE BEETLES
Dense stands of conifers are like a banquet for bark beetles. Mountain pine beetles infest 90 percent of the park's pine forests, and spruce beetle populations are rising fast.

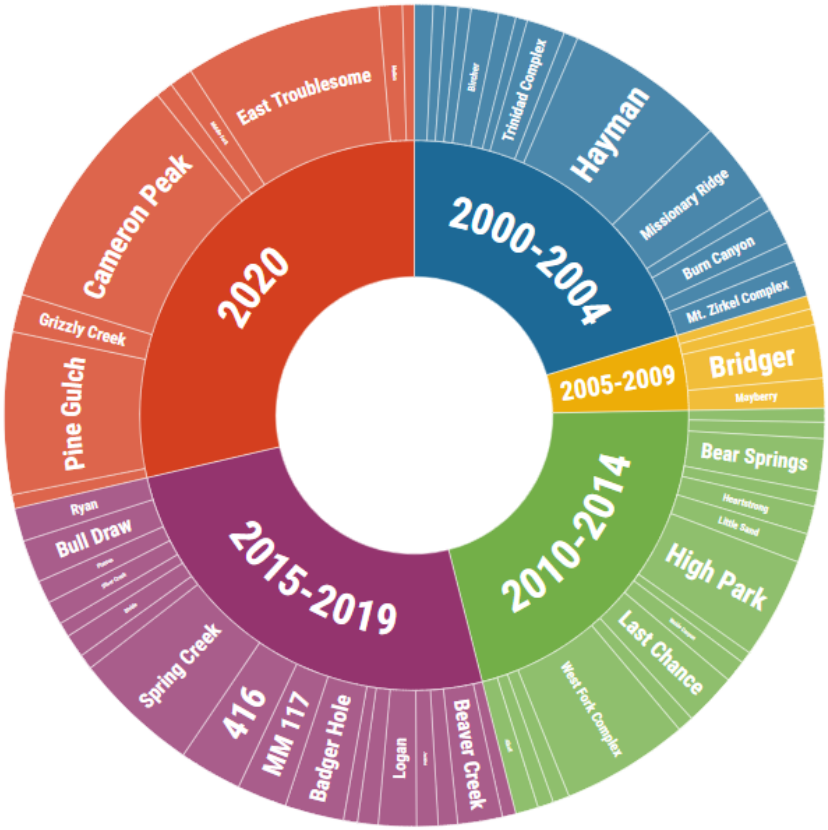
CLARE TRAINOR, NGM STAFF
SOURCES: COLORADO STATE FOREST SERVICE; USDA FOREST SERVICE; NATIONAL PARK SERVICE; JASON SIBOLD AND AMANDA WEST, COLORADO STATE UNIVERSITY; GEOMAC, USGS

Then came 2020

For large fires, 2020 is its own epoch

Colorado's largest wildfires since 2000

The 60 fires that have burned more than 10,000 acres in Colorado in the last two decades



Source: Rocky Mountain Area Coordination Center
Acreage totals for 2020 fires are current as of Oct. 19. This chart includes the more than 20,000 acres that the Mullen Fire , which started in Wyoming, has burned so far in Colorado.

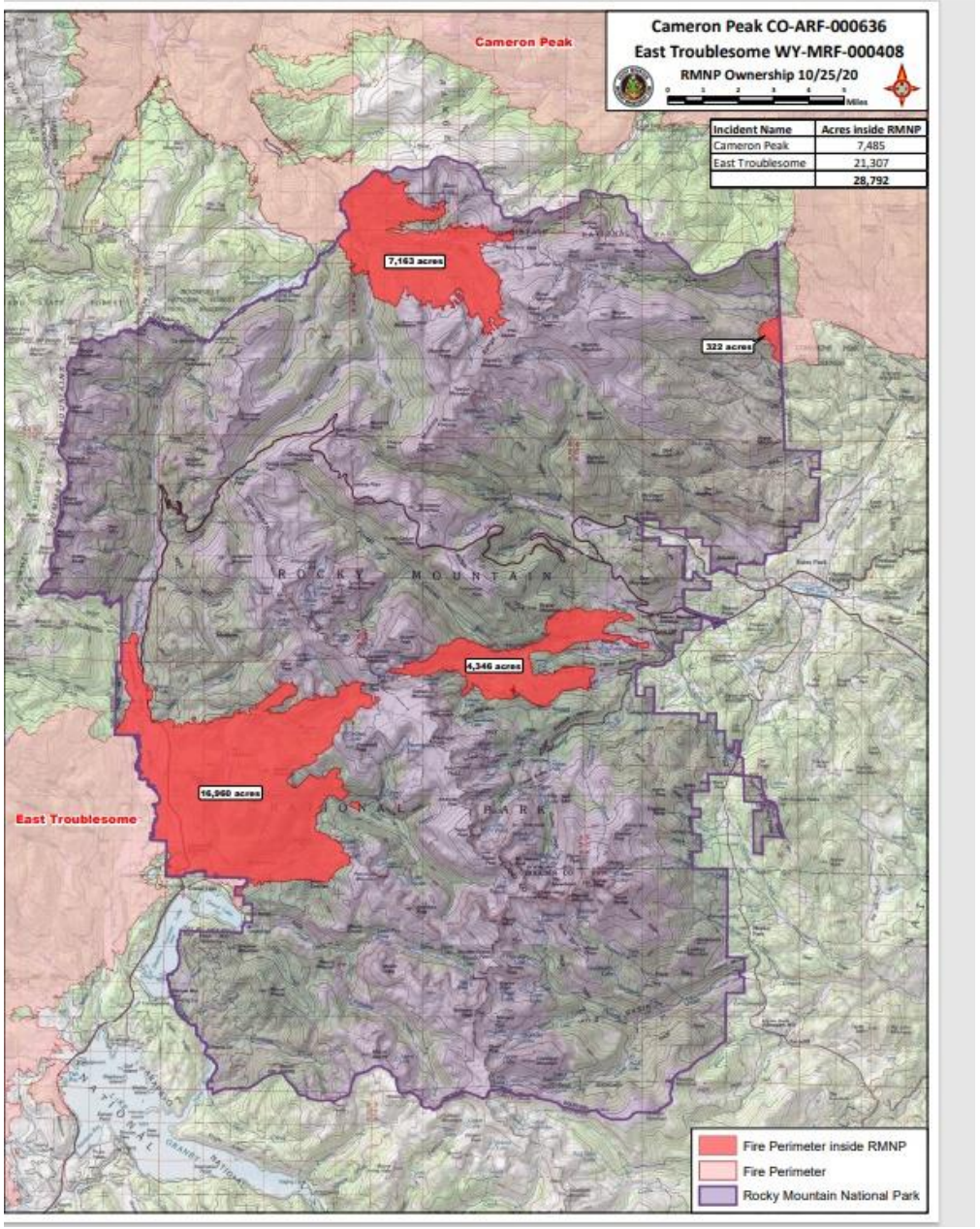
The Colorado Sun

Then came 2020

Cameron Peak Fire
- 208,913 acres
- 7,485 acres in ROMO
- 8/12 start -12/2 contained

East Troublesome Fire
- 193,812 acres
- 21,307 acres in ROMO
- 10/4 start -11/30 contained

9.2 % of ROMO burned

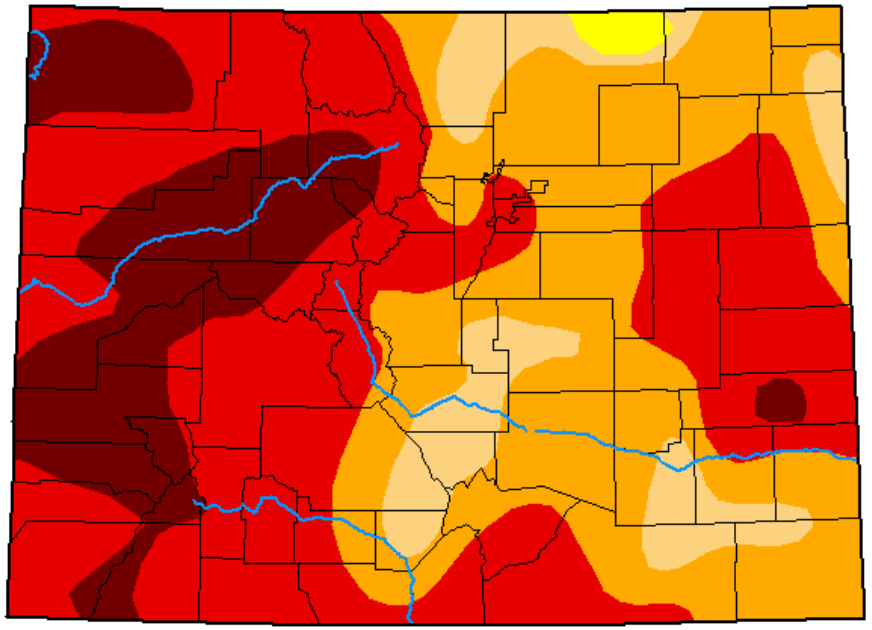


East Troublesome Fire

- Evacuations of Grand Lake and Estes Park communities
- Hundreds structures lost in Grand Lake
- 26 ROMO structures destroyed (mostly historic); cemetery damaged
- 18 miles roads, 47 miles trails, and 32 wilderness campsites burned
- Lots of hazard trees
- Hundreds of archaeological sites burned over
- Burned wildlife exclosures, limber pine stands, and wetlands
- Fish kills
- Potential/likely flooding, debris flow, exotic plant spread, and wildlife habitat changes expected.

Wide-spread, severe drought

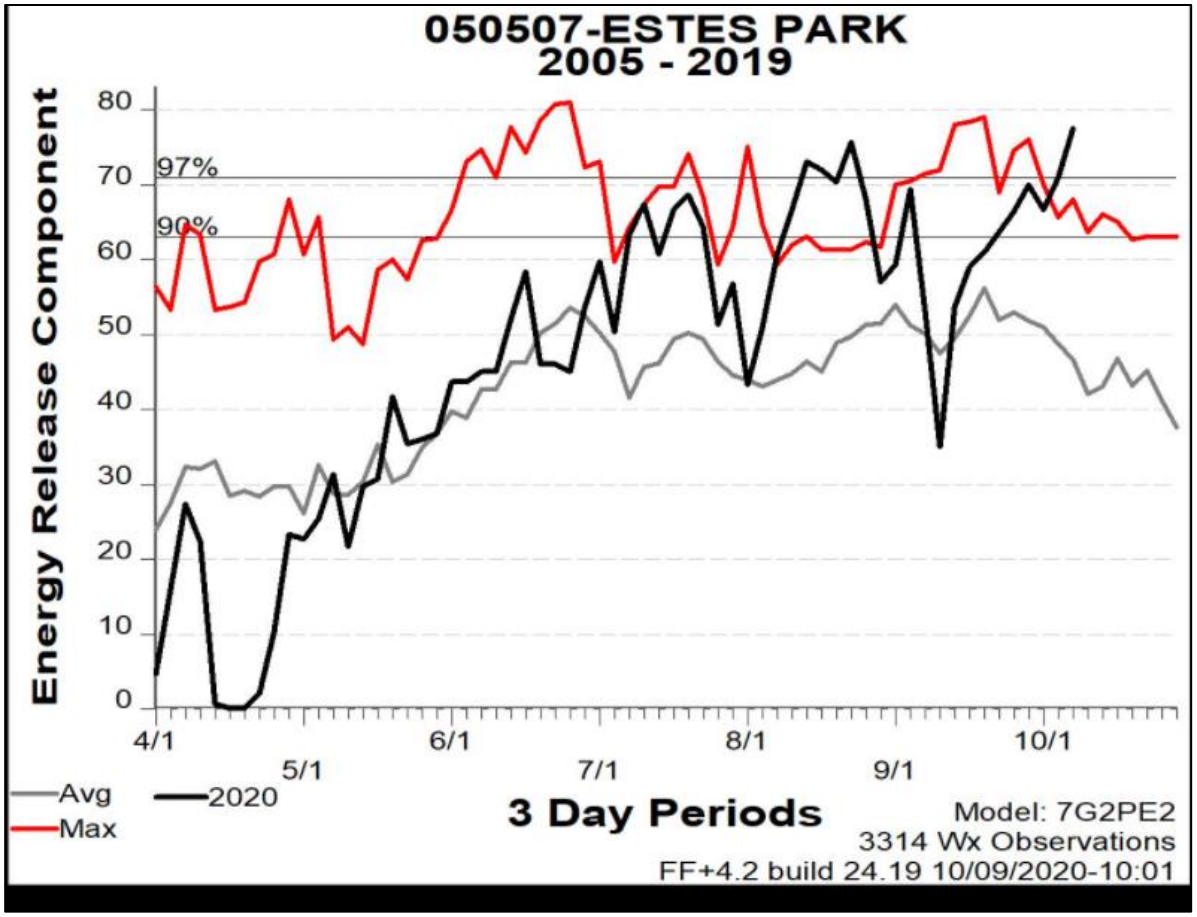
Severe drought due to hot & dry summer/fall



10/6/20 US Drought Monitor

Wide-spread, severe drought

Severe drought due to hot & dry summer/fall *despite average snowpack.*



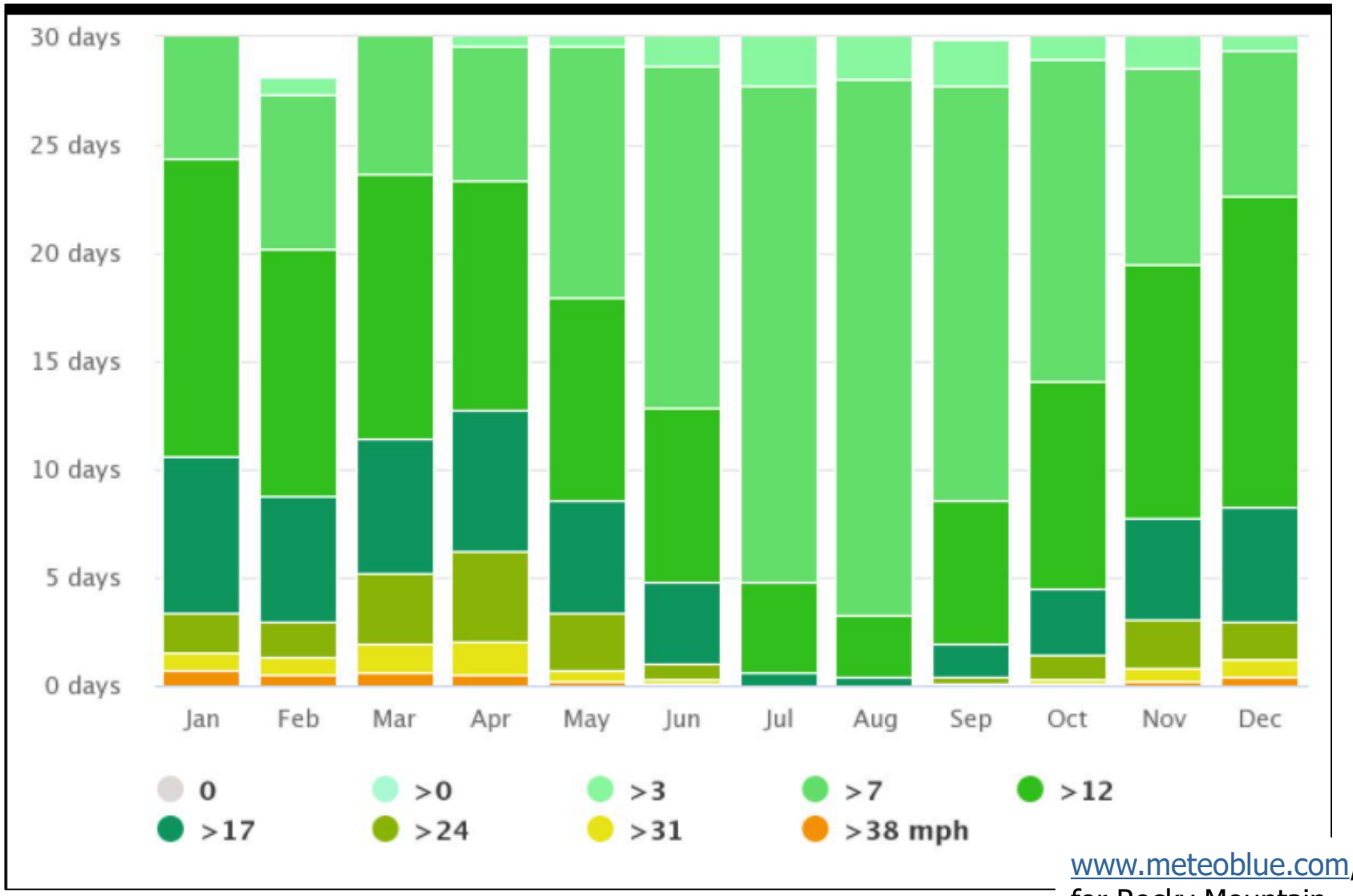
Beetle-Kill Fuel Regime

Extreme Wind

- Gusts up to 60 mph
- Grew more than 120,000 acres and traveled 18+ miles in a day (Oct 21)

Jumped the Divide 1.5 miles

Seasonal Distribution of Wind Speeds

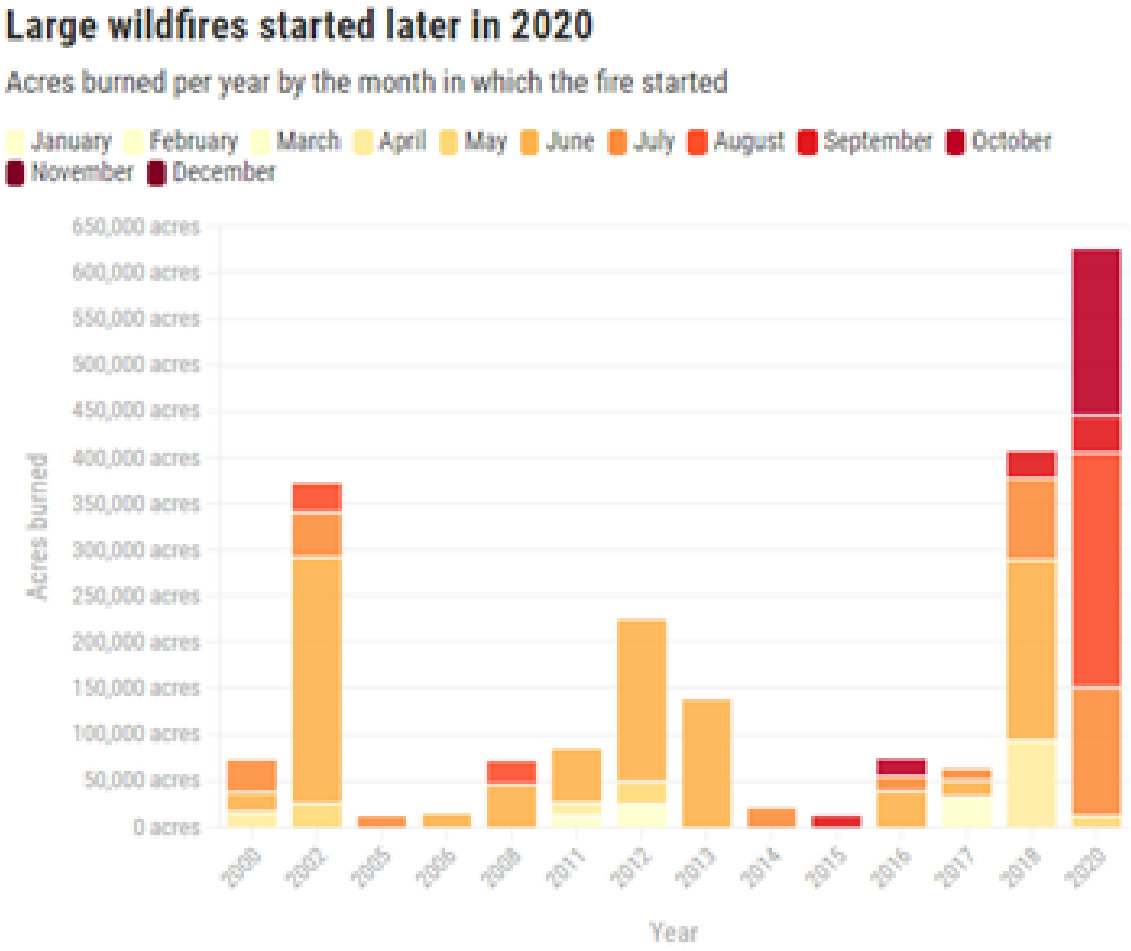


www.meteoblue.com, for Rocky Mountain National Park

Will climate change alter wind regime?

Late fire season = more wind

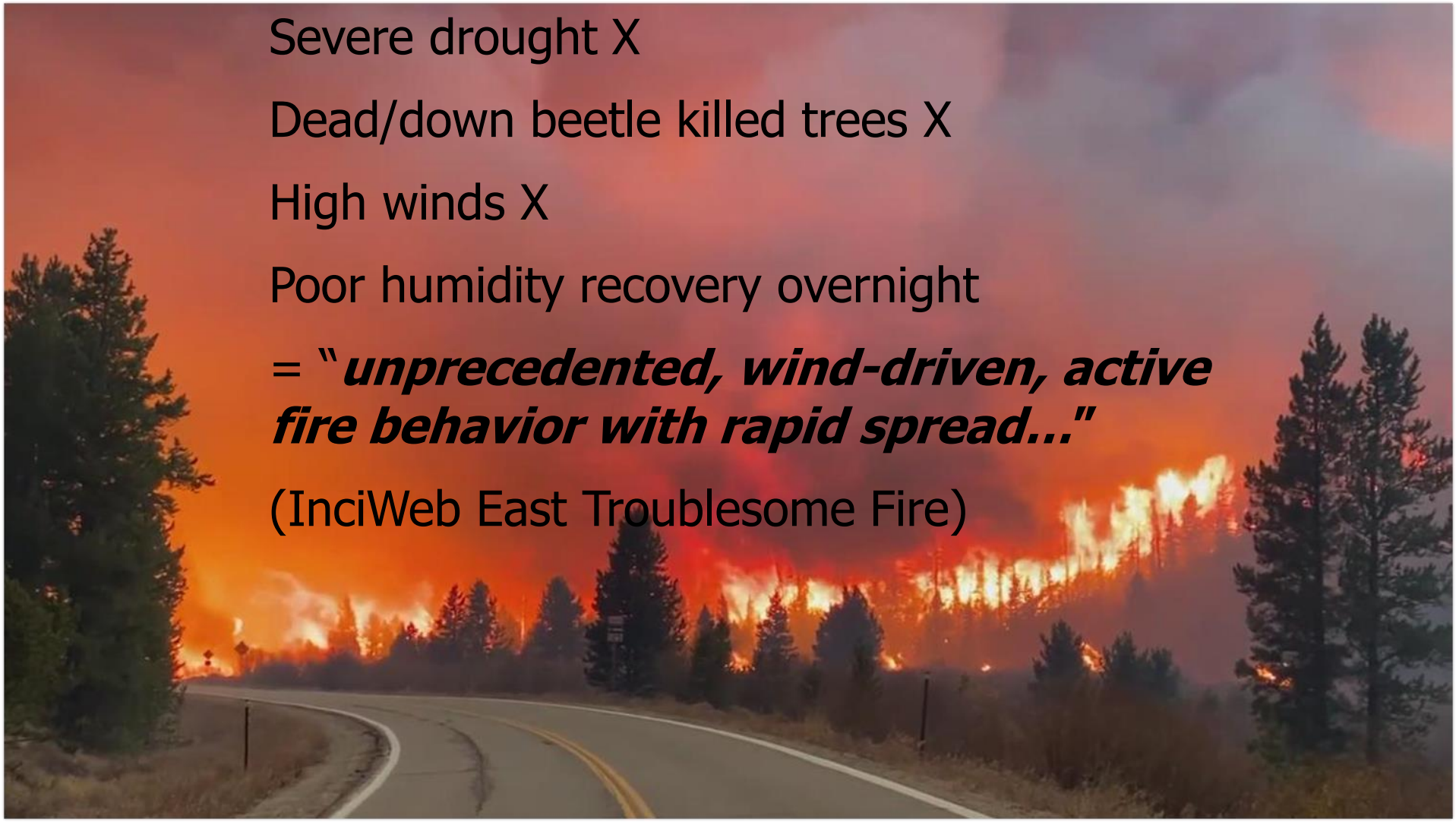
The 2020 fire season is unusually late



Source: Rocky Mountain Area Coordination Center

https://coloradosun.com/2020/10/20/colorado-largest-wildfire-history/

A Perfect Storm



Severe drought X

Dead/down beetle killed trees X

High winds X

Poor humidity recovery overnight

= "***unprecedented, wind-driven, active fire behavior with rapid spread…***"

(InciWeb East Troublesome Fire)

Fire Severity

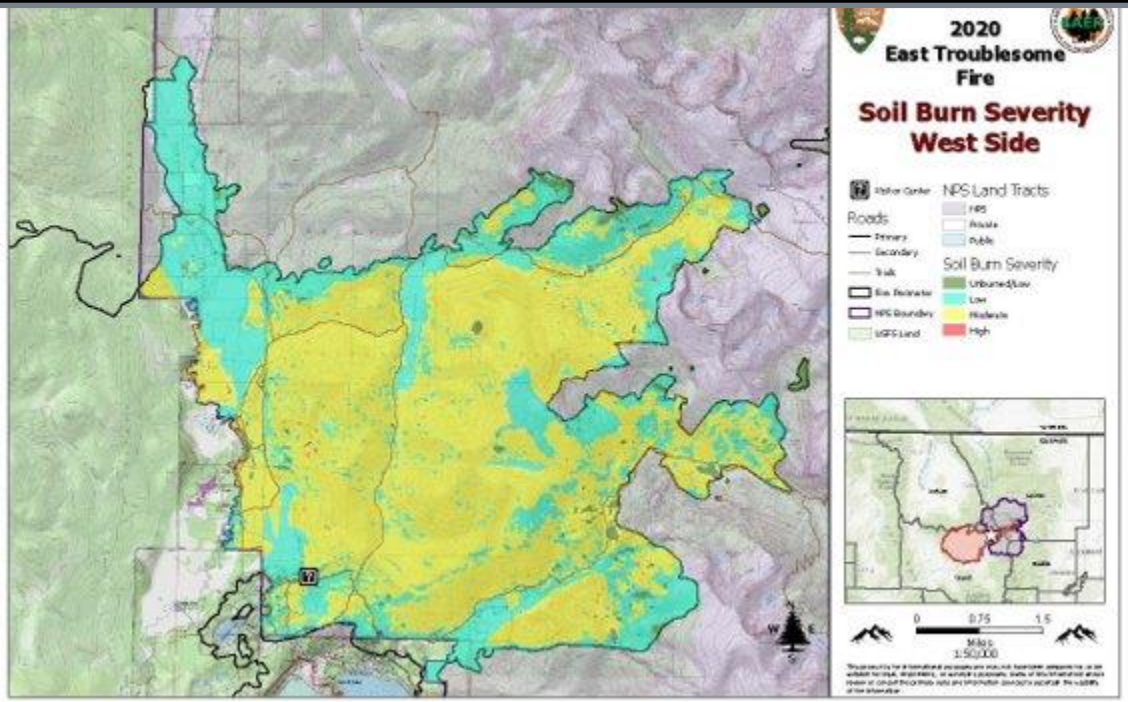
Big areas of high vegetation burn severity

Soil burn severity low to moderate

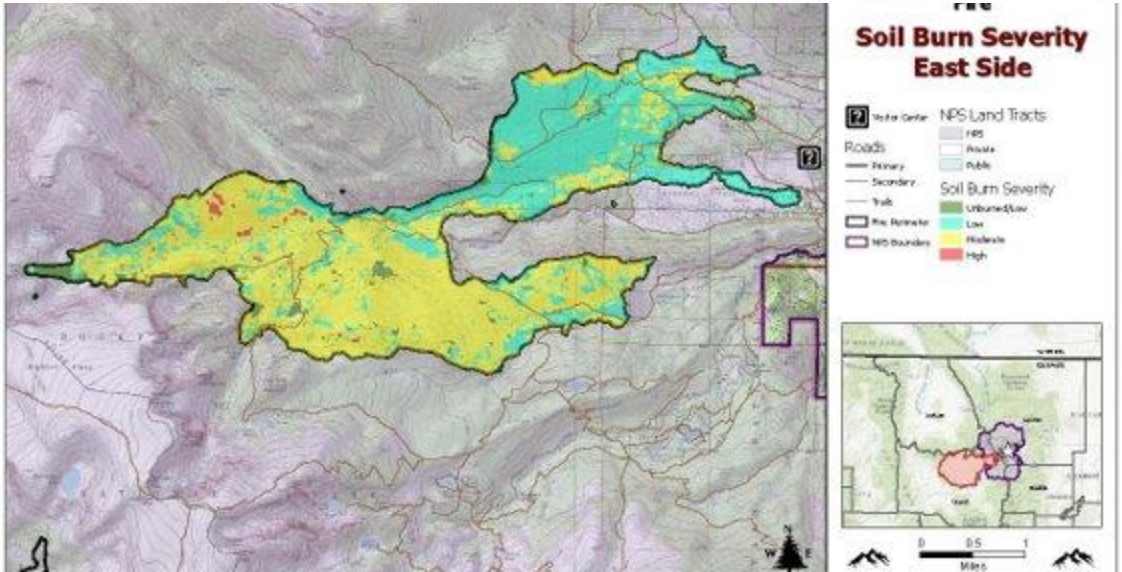
ROMO East Troublesome BAER Plan [DataStore - Plan - (Code: 2284055) (nps.gov)]

Soil Burn Severity Maps

West side

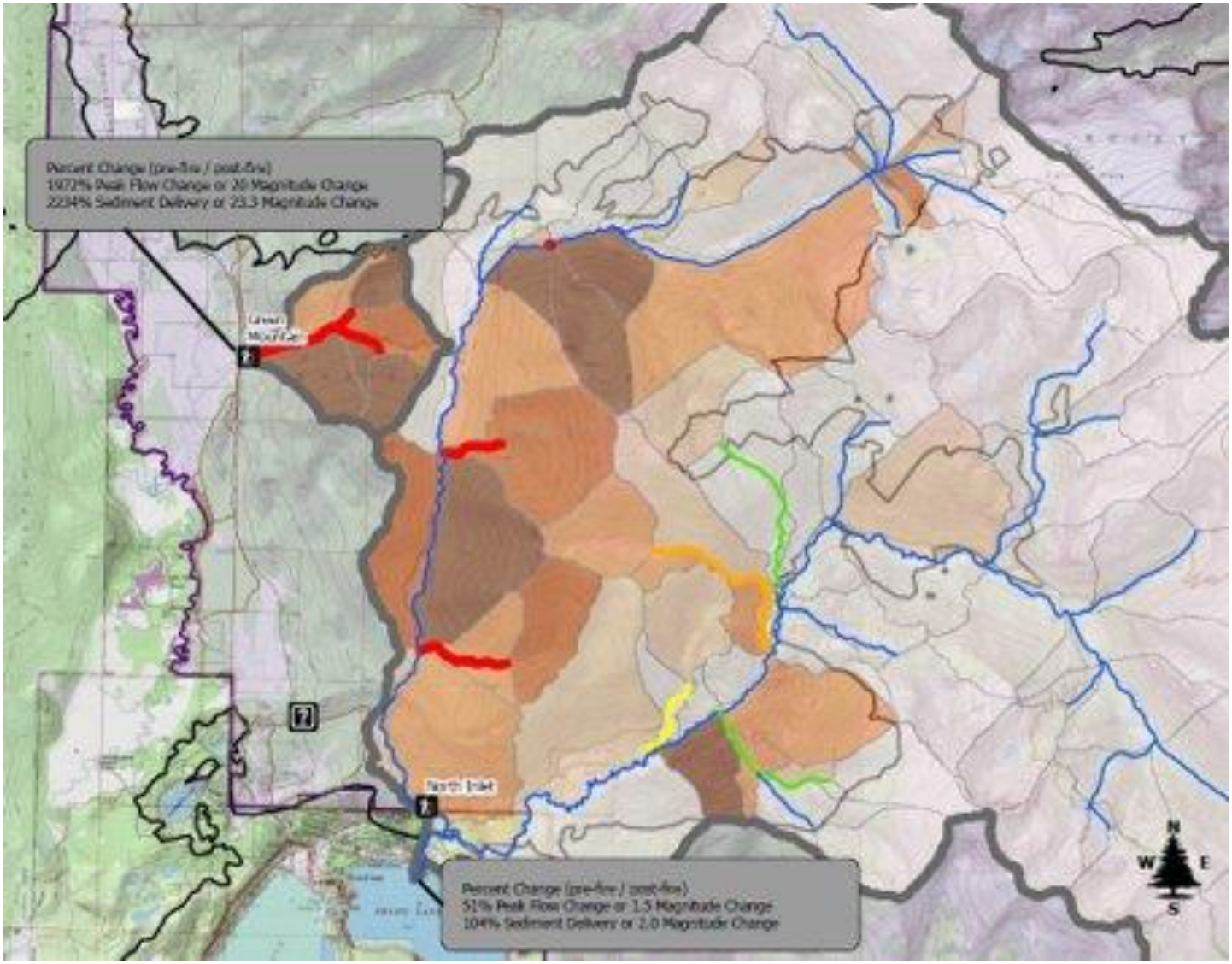


East side



Flooding and Sediment Modelling

West Side: Green Mountain, Tonahutu, and North Inlet



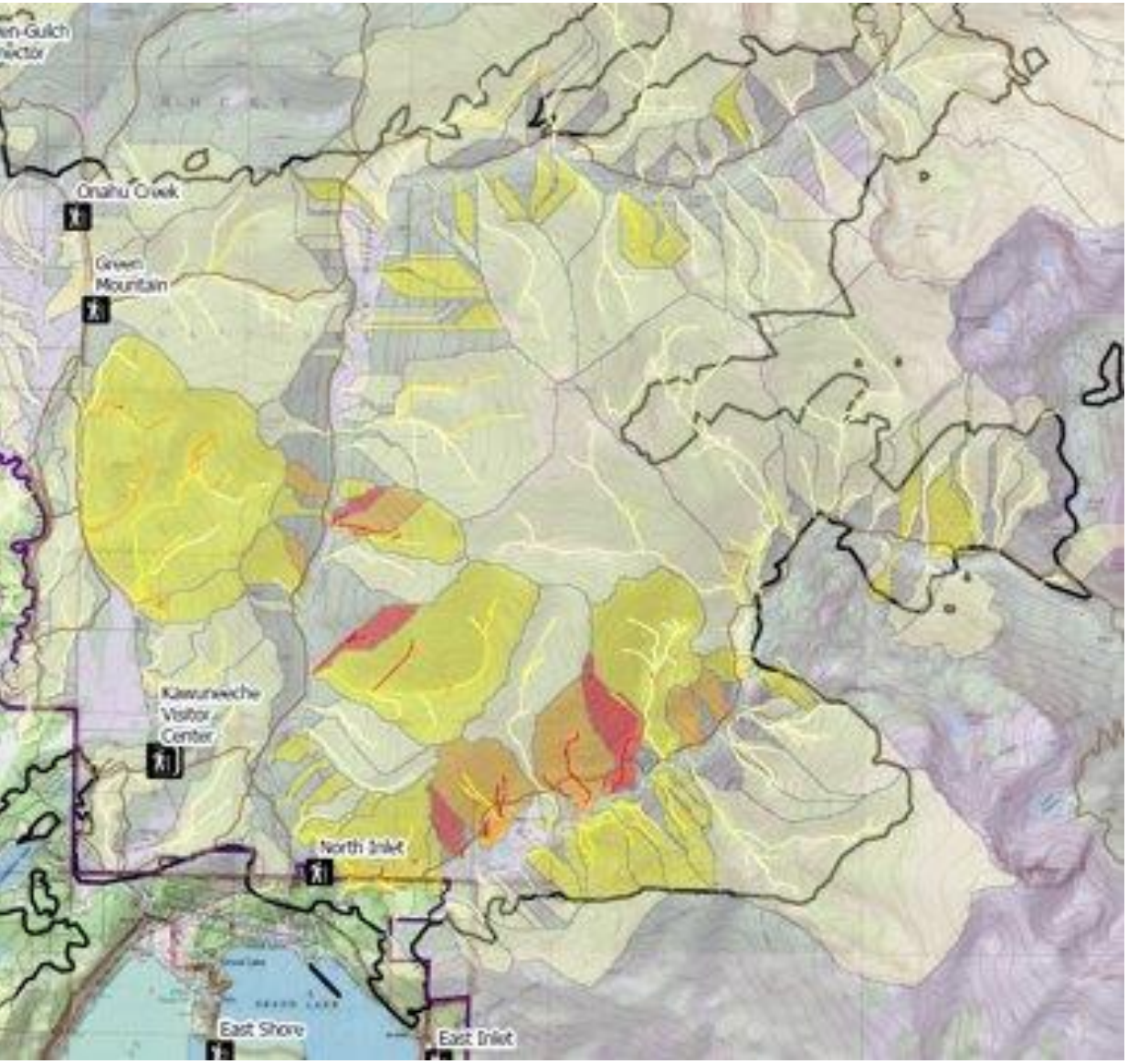
5-year, 1 hour storm event with 1.03” of precipitation

Percent Change
Peak Flow
- ≤100
- 100 - ≤300
- 300 ≤500
- 500 ≤1,000
- 1,000 ≤ 2,300

Percent Change
Sediment Delivery
- ≤1,000
- 1,000 ≤3,000
- 3,000 ≤10000
- 10,000 ≤20,000
- 20,0000 ≤ 36,000

USGS Debris Flow Estimates

West side: Green Mountain, Tonahutu, and North Inlet



DFE Segments - Probability
- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

DFE Basins - Probability
- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

Actual flooding, sediment delivery, and debris flow occurrence? Effects?

Fire Effects and Natural Recovery?

Forest recovery

Exotic plant spread

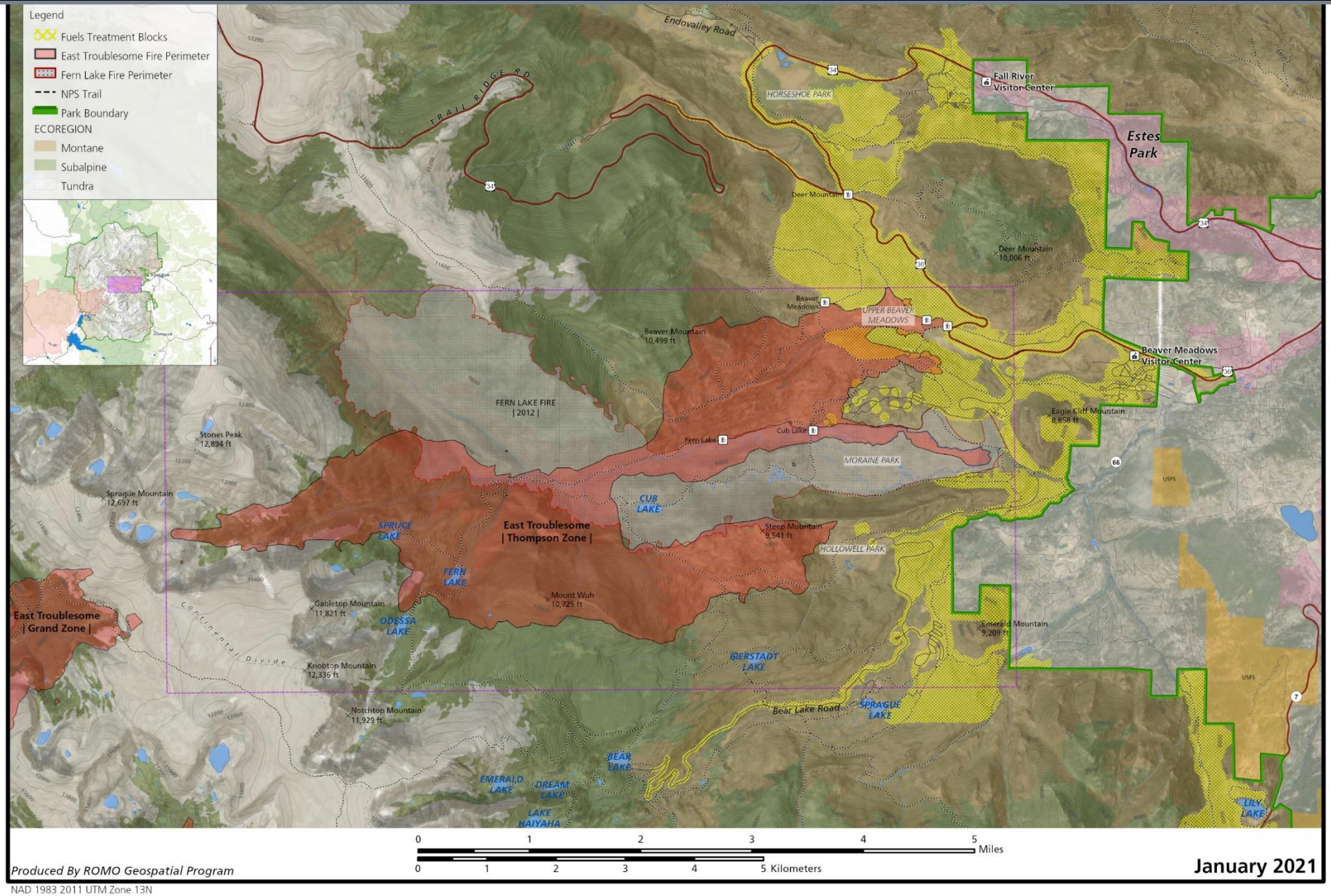
Limber pine recovery

Water quality, aquatic habitat, and fisheries

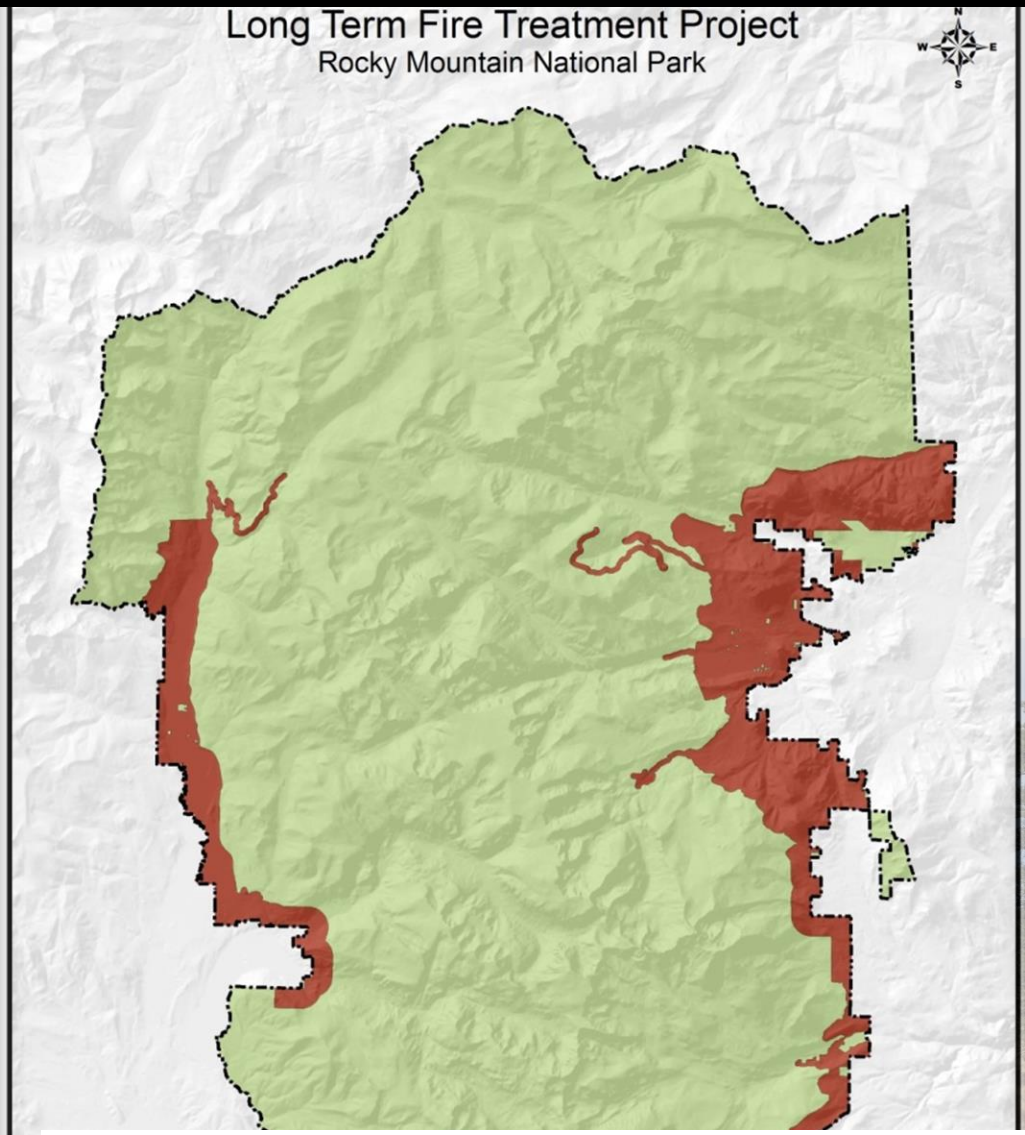
Willow recovery inside & outside of exclosures

- Wildlife habitat, forage & prey
- Effects on cultural sites

Fuel Treatments & East Troublesome Fire



ROMO Master Fuel Plan – Much More To Do



In past 10 years, 3000 acres treated with fuel reduction or prescribed fire? What is their efficacy? Do they work?

Rethinking Subalpine Fuel Treatments

- Thinning Lodgepole Pine and Spruce/Fir forests reduces fuels, but has no ecological surrogate

- Treatments designed to promote fuel transition to aspen?

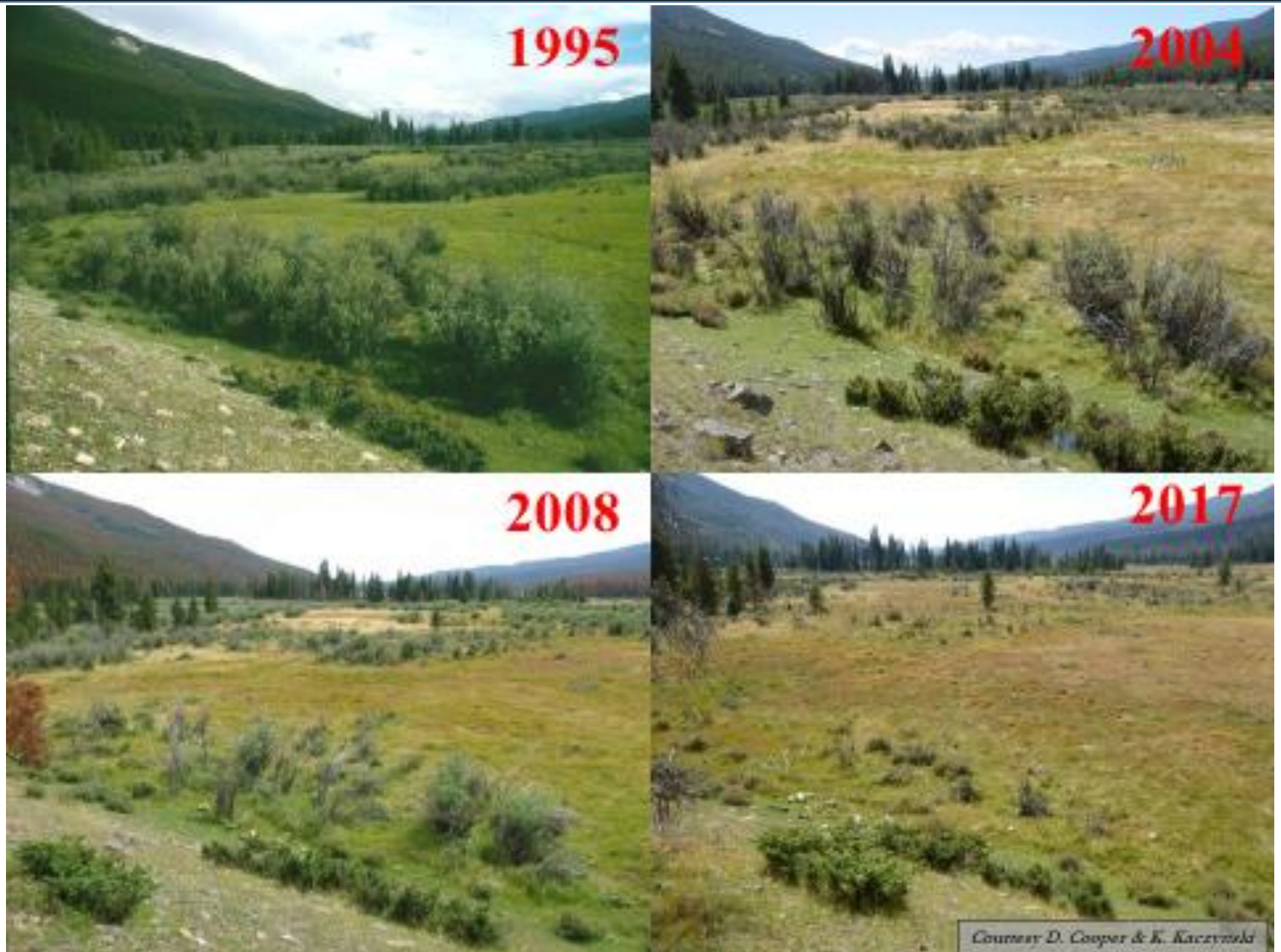
Aspen = lower flammability + high biodiversity & aesthetics

- How to overcome the challenge of elk browsing?

Riparian Areas as Fuel Breaks

Kawuneechee Valley, Oct 21

Riparian Areas – Loss of Wetland Functioning



Methods to Restore Riparian Wetland Already In Use

Wildlife exclosures to restore willows and aspen

(Elk and Vegetation Management Plan/EA)

Simulated beaver structures (SBS) to raise water table (& attract real beaver to do the job better)

Restoring Healthy Riparian Areas

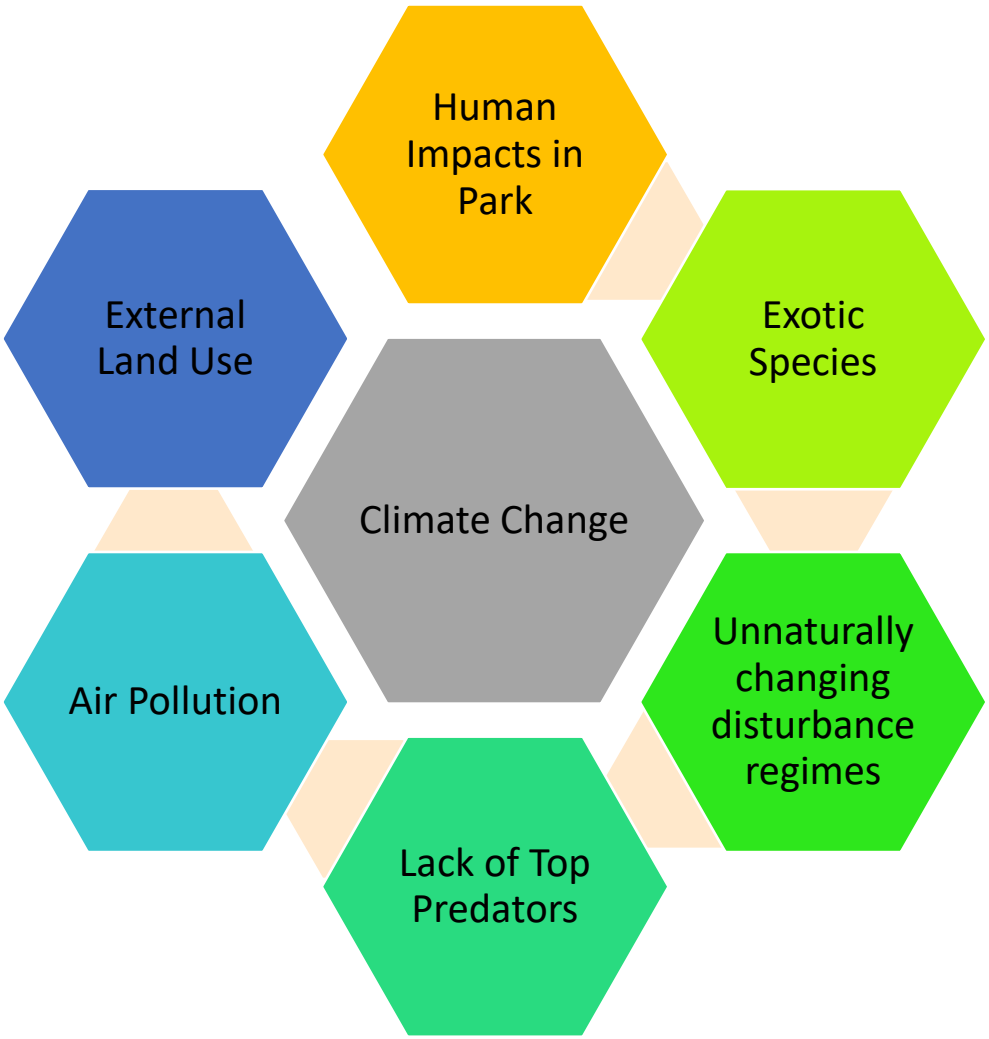
Achieve multiple goals

- Wetter conditions (drought resilience)
- Increased biodiversity
- Improved water quality
- Flood buffering
- Resist exotic plants
- Fuel break

Becoming much more urgent with climate change

…clock is ticking

Many Climate Change Interactions & Issues



- Increased Urgency to Act
- Understand, Resist/Increase Resilience, Accept Change
- Reduce Other Stressors/Restore ecosystem integrity
- Adaptive Management!
- Look for Multiple Benefits
- Prioritization: what, where, when

Collaboration and Partnerships are Essential

USGS

NATIONAL PARK SERVICE

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

COLORADO STATE UNIVERSITY

UCDAVIS
JOHN MUIR INSTITUTE
OF THE ENVIRONMENT

Berkeley

Rocky Mountain Conservancy

CARNEGIE AIRBORNE OBSERVATORY

Kawuneeche Valley Wetland Restoration Partnership (many partners)

And many others

Questions?