
Pacific Wildland Fire Sciences Laboratory
Seattle

Climate Change and Wildland Fire Management - Management of New Fire Regimes in the : The challenge of Climate Change

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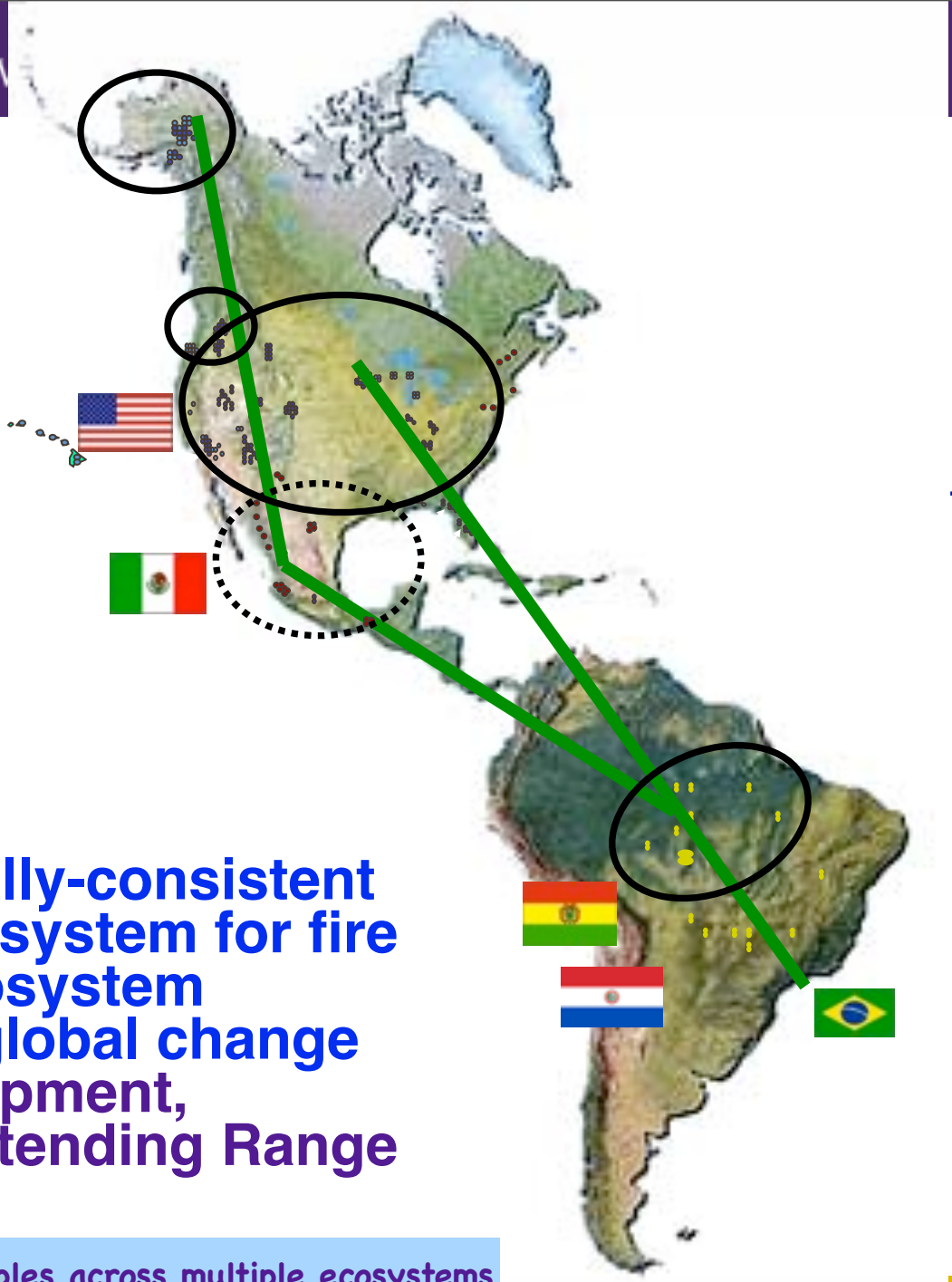
Wildland Fire Management and Ecology Laboratory, Seattle, Washington

5th South American Forest Fire Symposium. Campinas, SP, Brasil. Abril 11-12, 2011

Transect of the Americas 1970+ US 1991+ Global

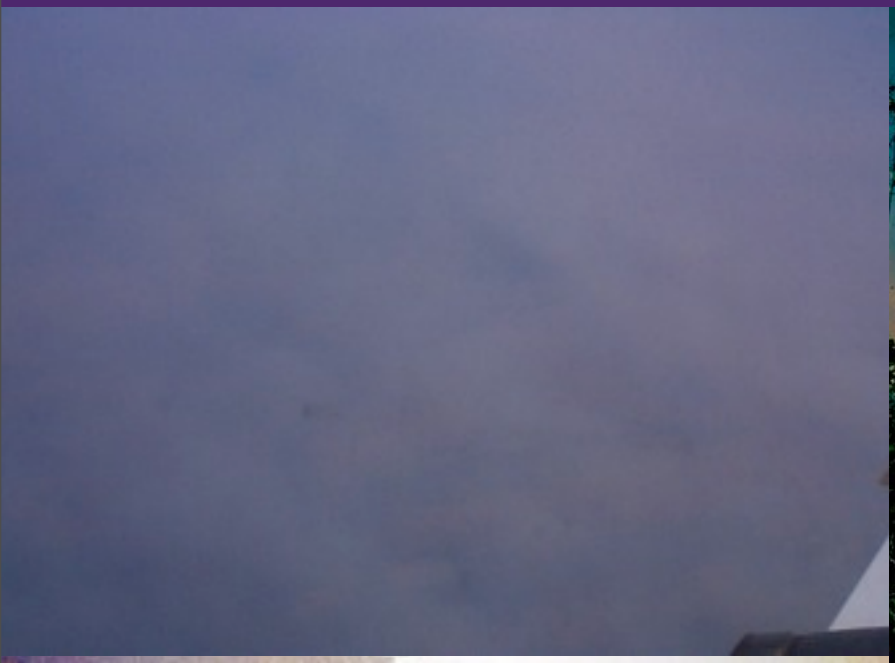


Biomass Burning, flammability, fire effects in mountain, temperate and tropical forests. Alaska, USA, Amazonia. Mexico and Bolivia

Providing a globally-consistent decision support system for fire management, ecosystem restoration, and global change response (Development, Validation and Extending Range of Applicability)

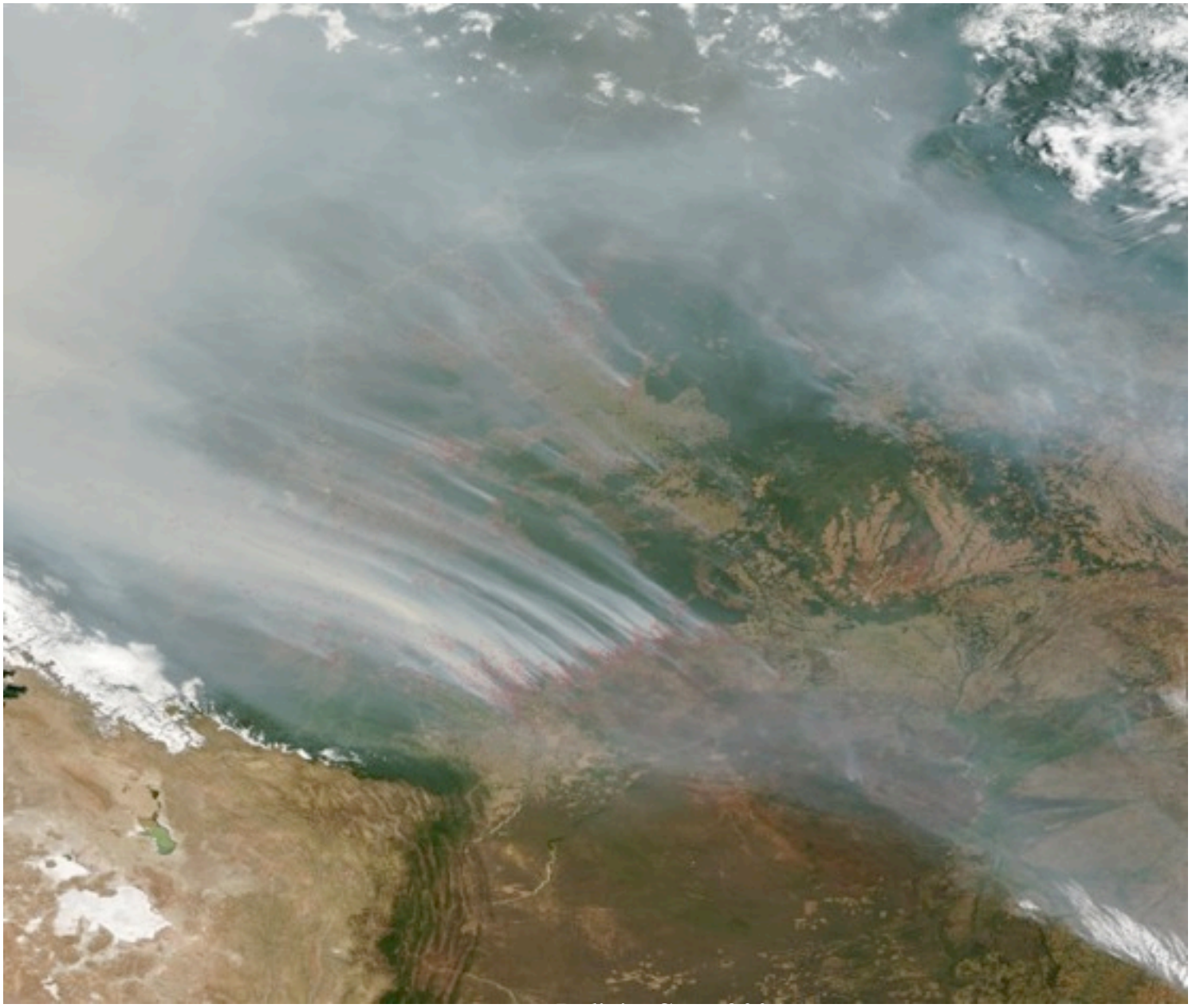
Physical and ecological principles across multiple ecosystems

First Impression - 1991: Smoke, fire, deforestation, and people



Increased land use change, use of fire, flammability, reduced impact harvesting, traditional knowledge

Fires in PanAmazonia



Bolivia, Sept. 2004

Wildfires and Climate Change
The Times They Are a-Changin'

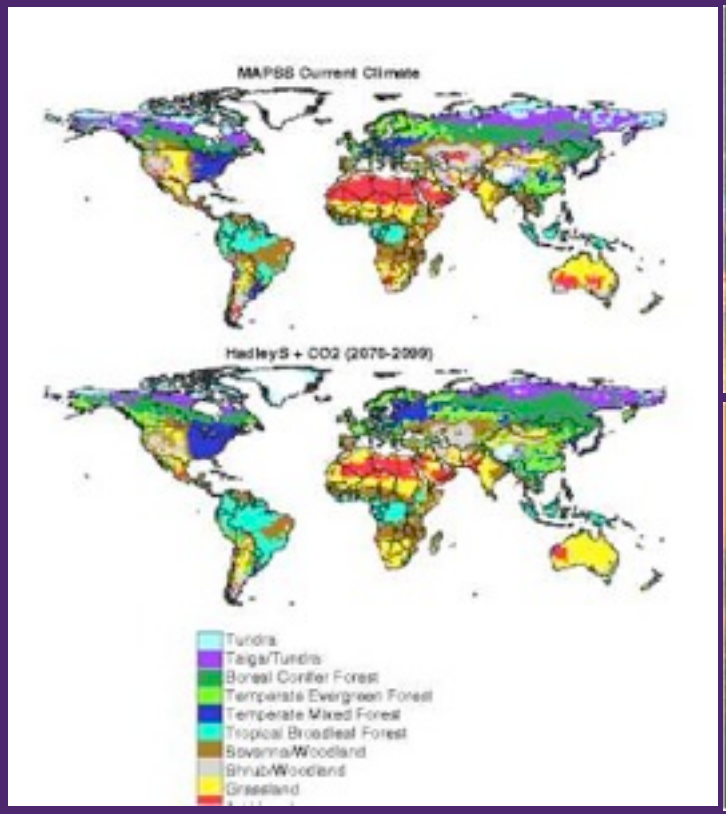
- Frequency and intensity of wildfires are strongly sensitive to climate change and variability, and land use practices
- Every year, fires burn an area equivalent to half of China or the US) (approx 500 millions has)
- Wildfires (savannas and forests) oxidize 1.7 to 4.1 GtC yr-1, or 3-8% of total terrestrial NPP (excluding fuelwood, deforestation, and tropical agricultural development)
- There is a great potential of alteration of terrestrial carbon balance due to change of fire regimes
- Many forests ecosystems need fire to maintain health, diversity, and productivity
- Fire use is an ancient land use practice by indigenous communities

2010: Seculo de uma guerra que ainda não termina

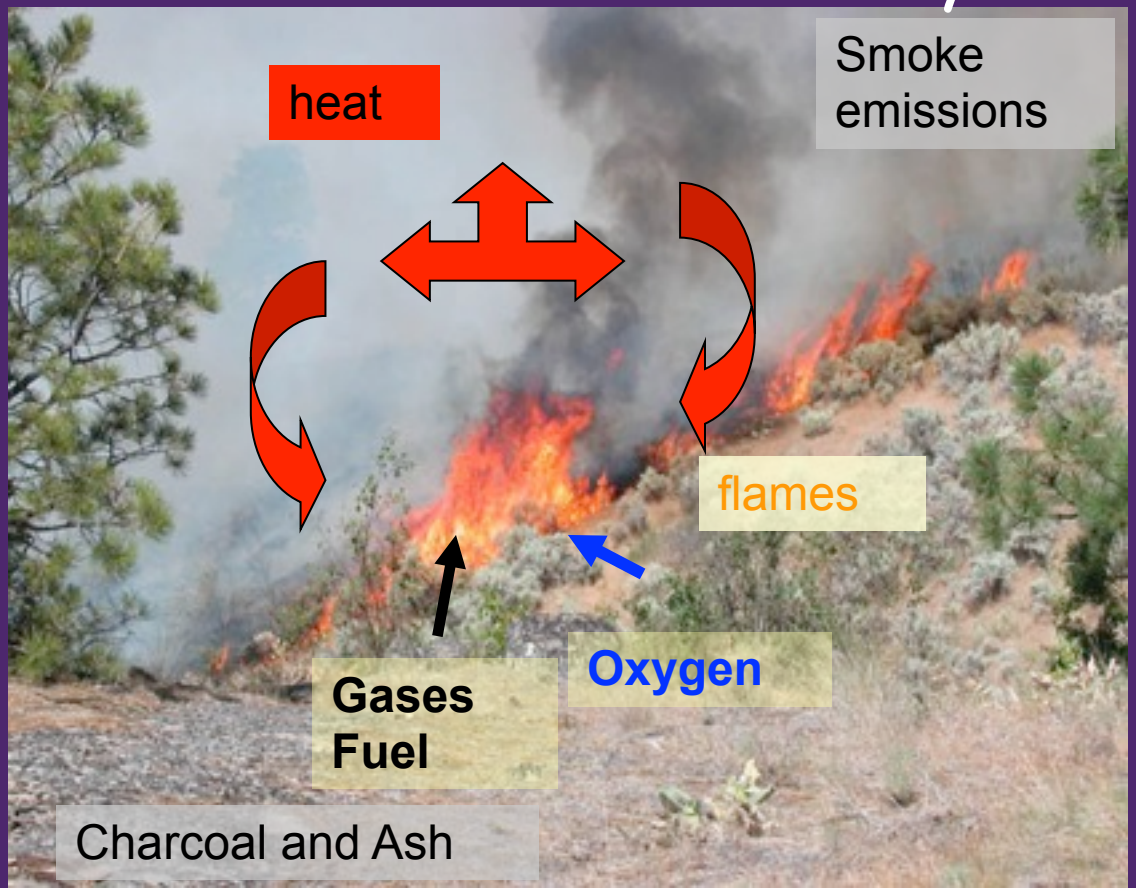
- 1910 - Centenario del incendio mas grande registrado en los EUA
- The Big Burn of 1910, the Big Blowup
- Area quemada 1.2 millones de hectareas (12,000 km2, 3,000,000 acres), la mayoria entre el 20-21 de Agosto.
- Evento que cambio la historia de los incendios forestales en los EUA, con repercusiones mundiales
- Perdida estimada $1 million USD (calculado en 1910)

★1998/1999: Incendios do tropico Mexicano e Central America, Roraima - Brasil, outros paises tropicais

Lecciones: 1. Los ecosistemas son una expresion del clima, suelo, perturbaciones y patrones de uso del suelo - El fuego ha estado presente en todos lados?



Better understanding of basic fire concepts: What is fire? Physical process



Flaming × Smoldering

Flaming → **HOMOGENEOUS Gas Phase Reactions**

$$C_xH_y + \nu_1O_2 \rightarrow \nu_2CO + \nu_3CO_2 + \nu_4H_2O + \ldots$$

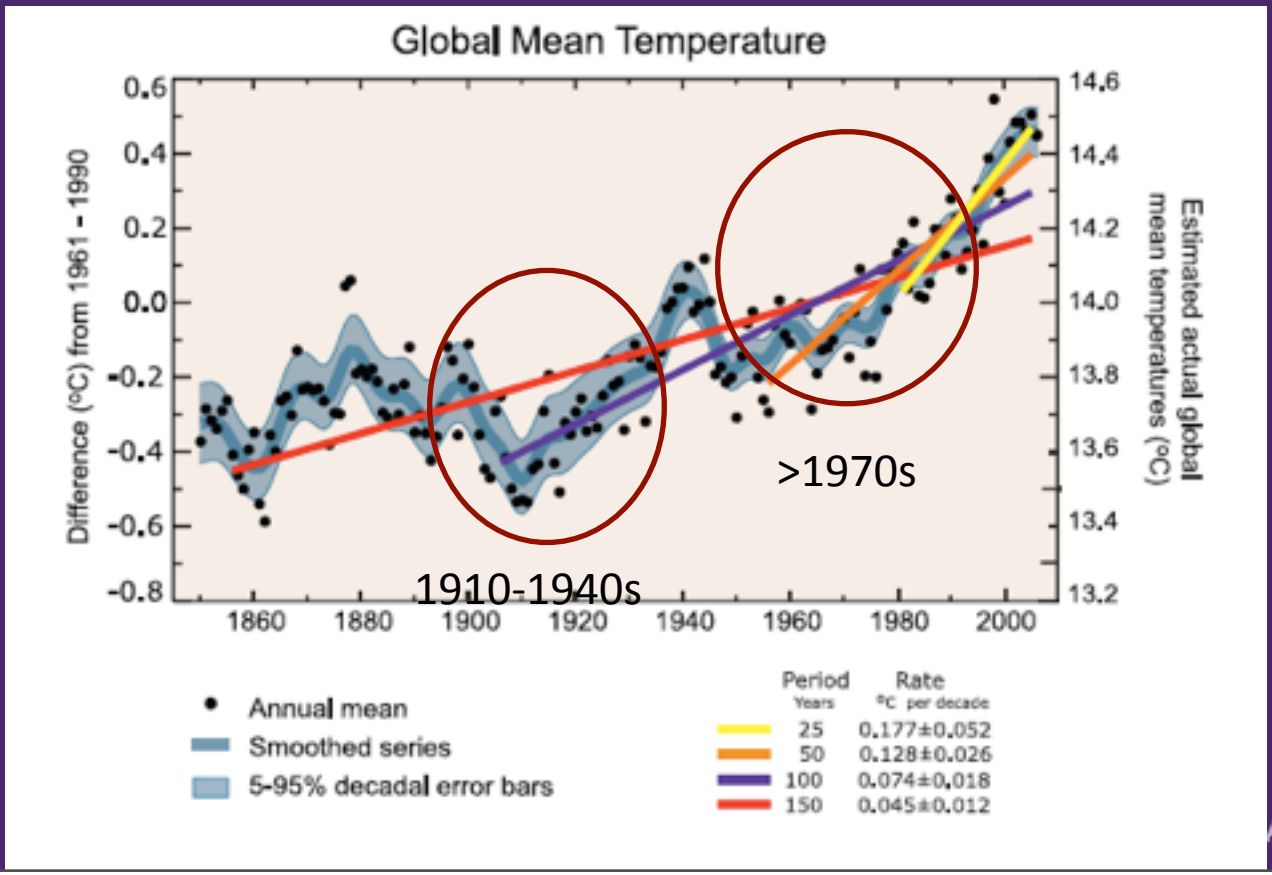
Emissions and heat release

UNIVERSITY of WASHINGTON

Threat to Fire Regimes? Climate Change

Global Annual Mean Temperatures

- Instrumental observations in the last 157 years show global temperature increases.
- Warming in the last century occurred in two phases, from 1910s to 1940s (0.35°C), and more strongly from 1970s to the present (0.55°C).



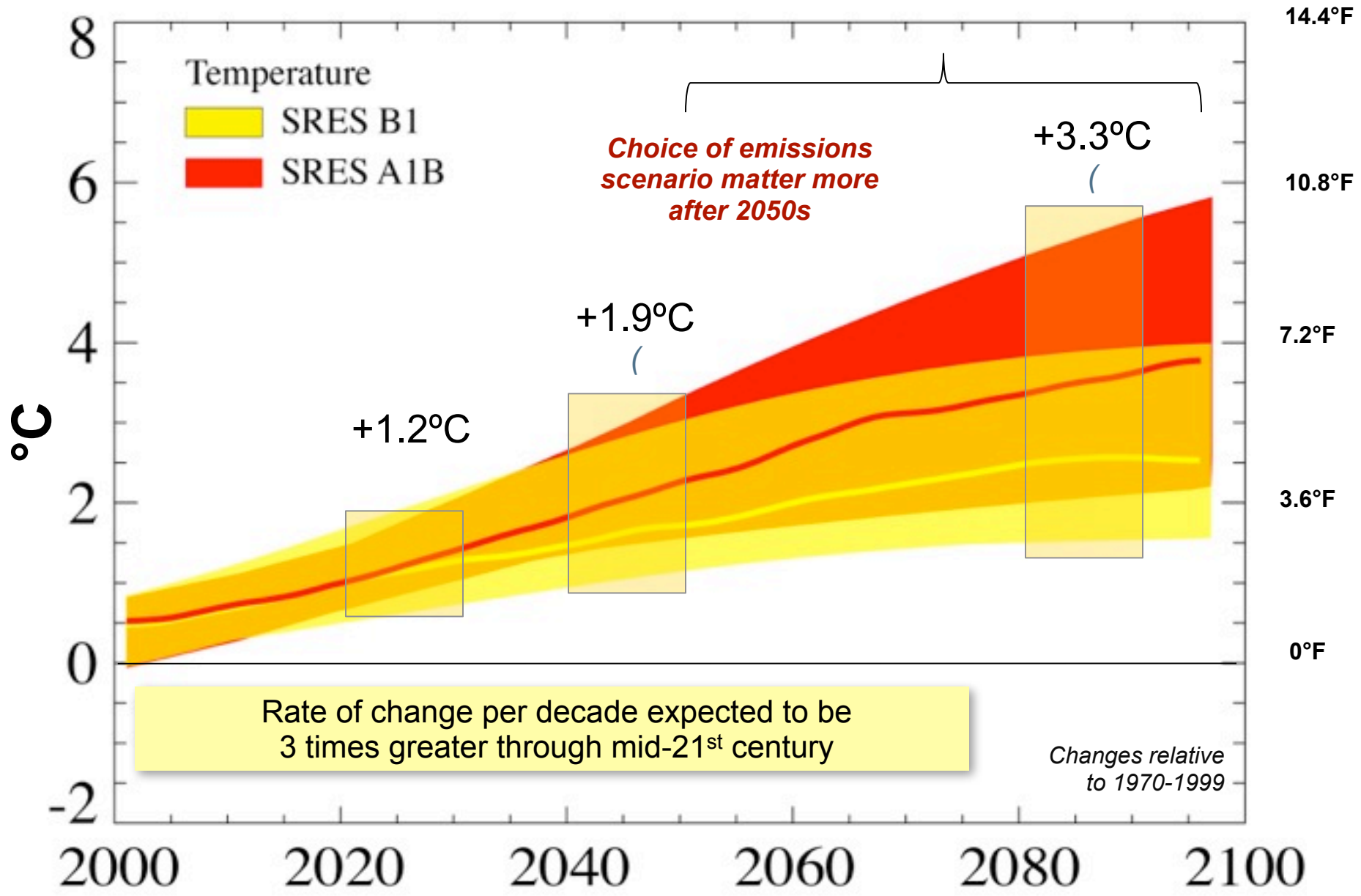
ASHINGTON

Climate Change and Wildland Fire Management

Climate Change and Fire Projections in the Western US: Why the Science Should Matter to Managers

Managing uncertainty in a changing climate ***

Projected Temperature in US Northwest

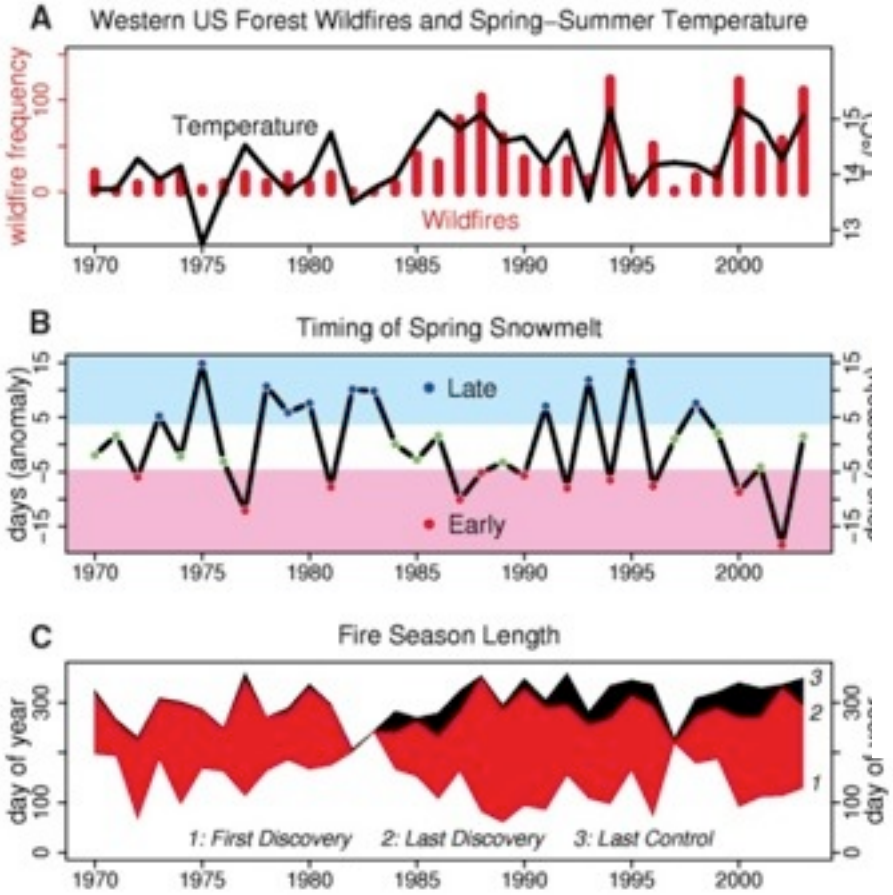


What do we know? supported by fire history and modern fire studies:

- Fire frequency and the area burned by fire are controlled by **climate**, not just weather and not just fuels.
- Fire regimes are NOT static - they are transient in space and time
- Fire regimes often are plastic even *within* a vegetation type or place
- Terms like catastrophic fire, forest health, historic/natural range of variability refer to equilibria that are inconsistent with the dynamic nature of the relationship between fire, climate, vegetation, and fuels

Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

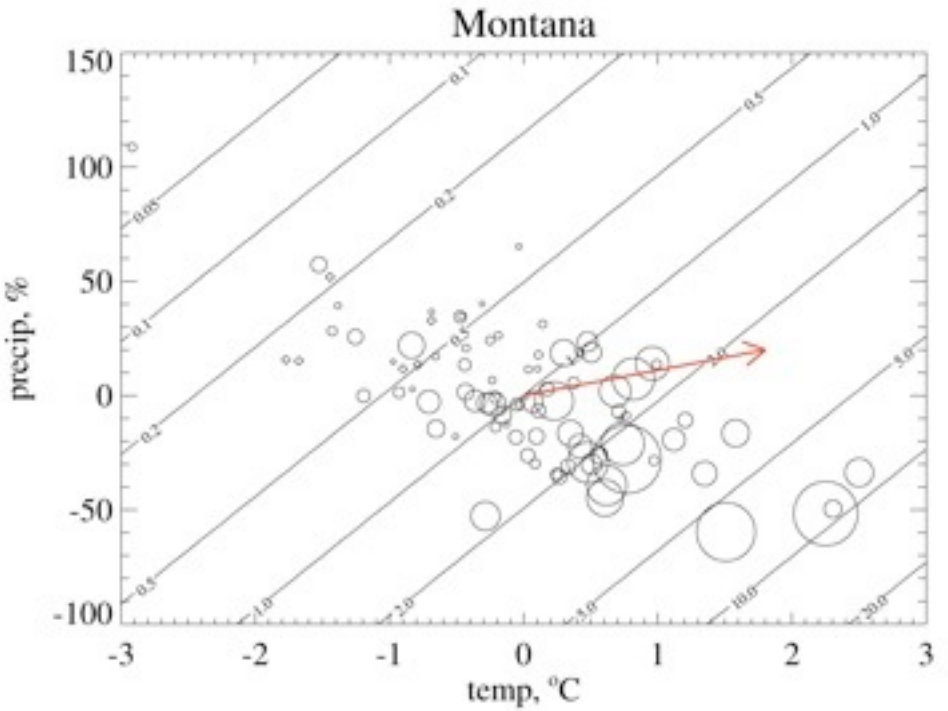
A. L. Westerling,[1,2]* H. G. Hidalgo,[3] D. R. Cayan,[1,3] T. W. Swetnam[4]



Westerling et al. 2006
Science 313. no. 5789, pp. 940 - 943

Climatic Change, Wildfire, and Conservation

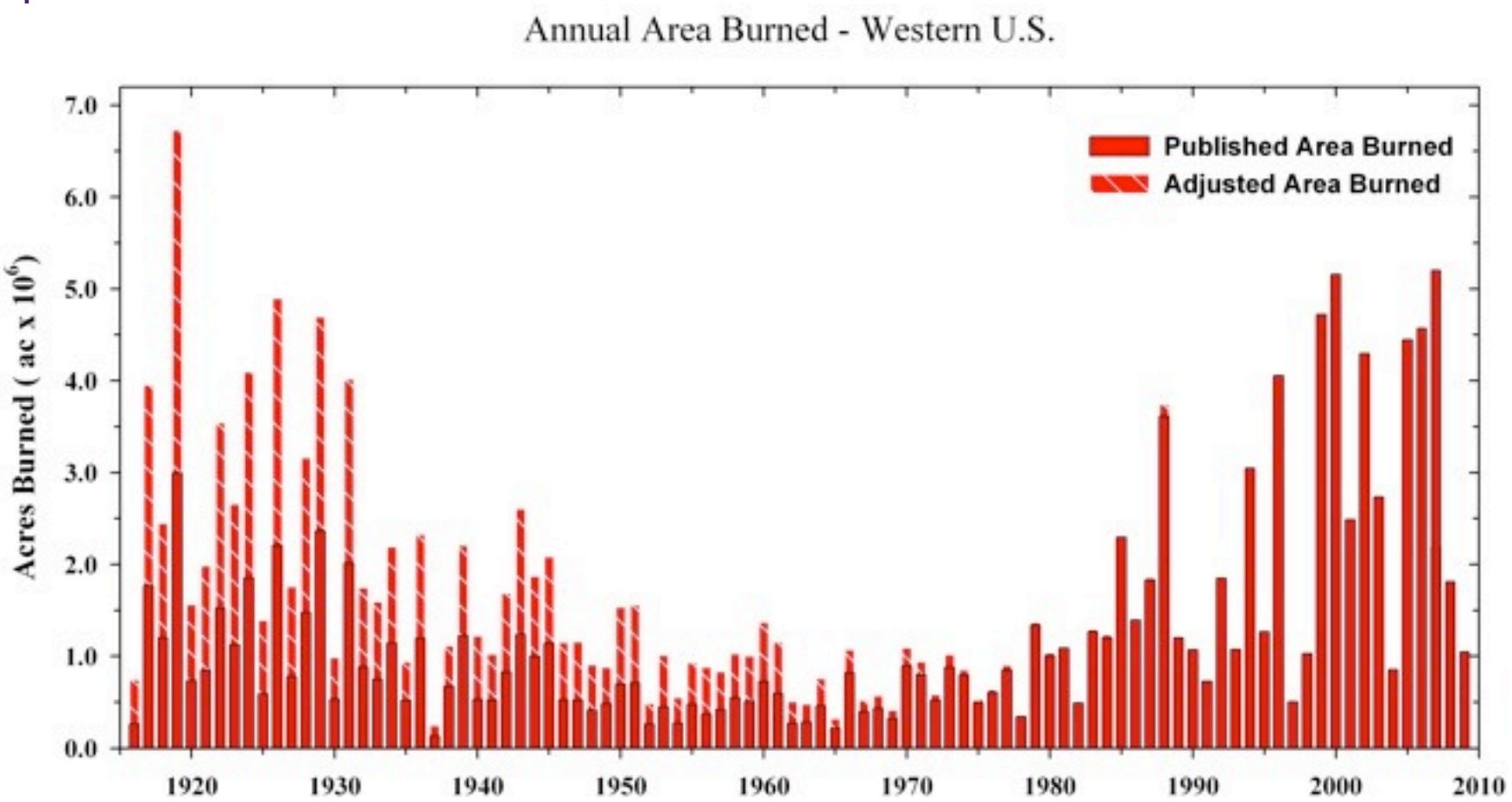
DONALD McKENZIE,*§ ZE'EV GEDALOF,† DAVID L. PETERSON,* AND PHILIP MOTE‡
*U.S. Department of Agriculture Forest Service, Pacific Wildland Fire Sciences Lab, 400 N 34th Street #201, Seattle, WA 98103, U.S.A.
†University of Victoria Tree-Ring Laboratory, Box 3050, Station CSC, Victoria, British Columbia, V8W 3P5, Canada
‡JISAO/SMA Climate Impacts Group, University of Washington, Seattle, WA 98195, U.S.A.



McKenzie et al. 2004
Conservation Biology 18, Issue 4, pp. 890–902

Analysis of wildfire data since 1916 for the 11 contiguous Western states shows that *for a 2.0°C increase* that *annual area burned will be 2-3 times higher*.

Area burned in 11 Western states, 1916-2010



Littell et al. 2009, Ecological Applications

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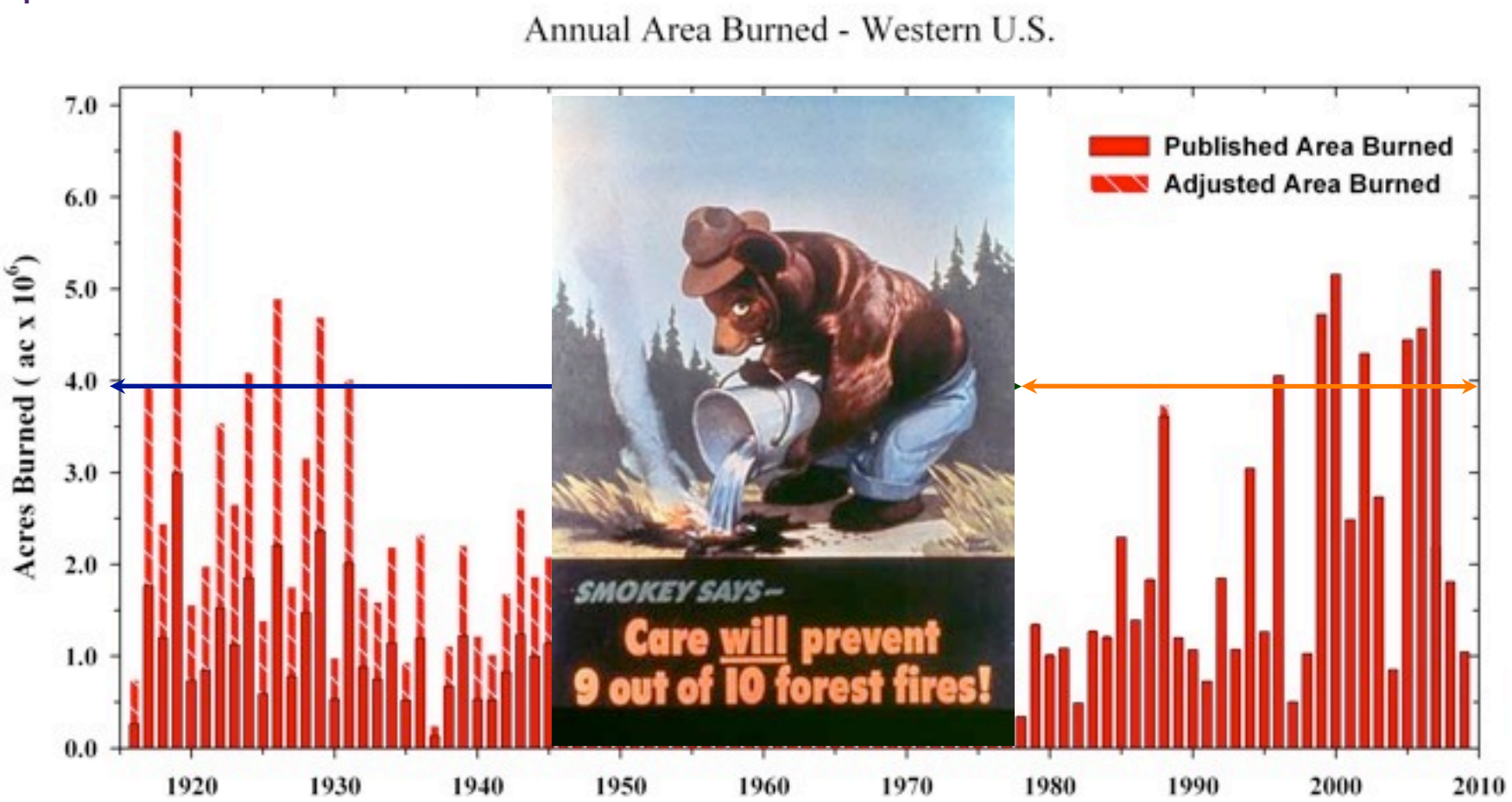

Period of post-settlement fire

Period of active fire suppression and fuel accumulation

Period of fire increase

Littell et al. 2009, Ecological Applications

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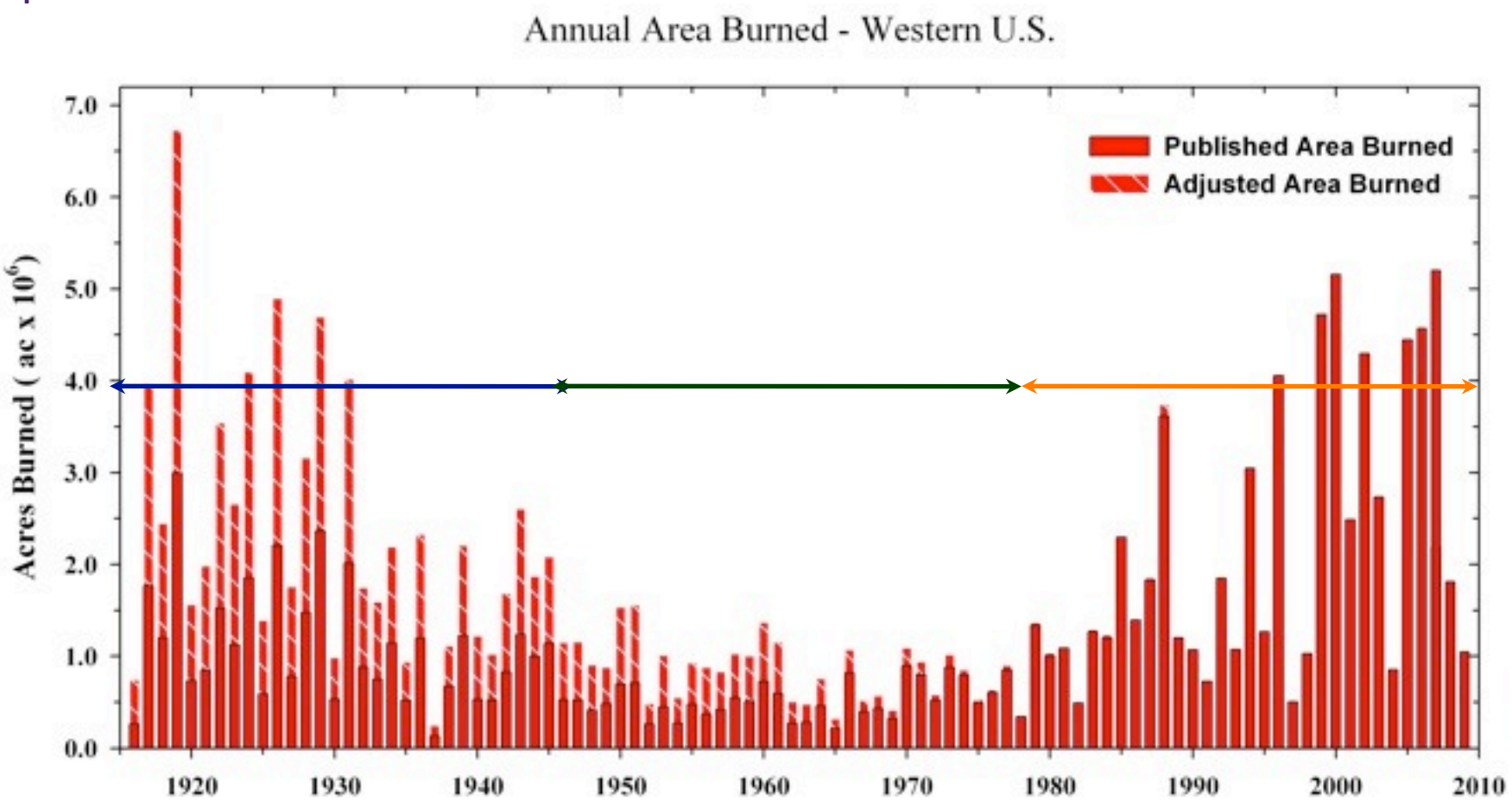

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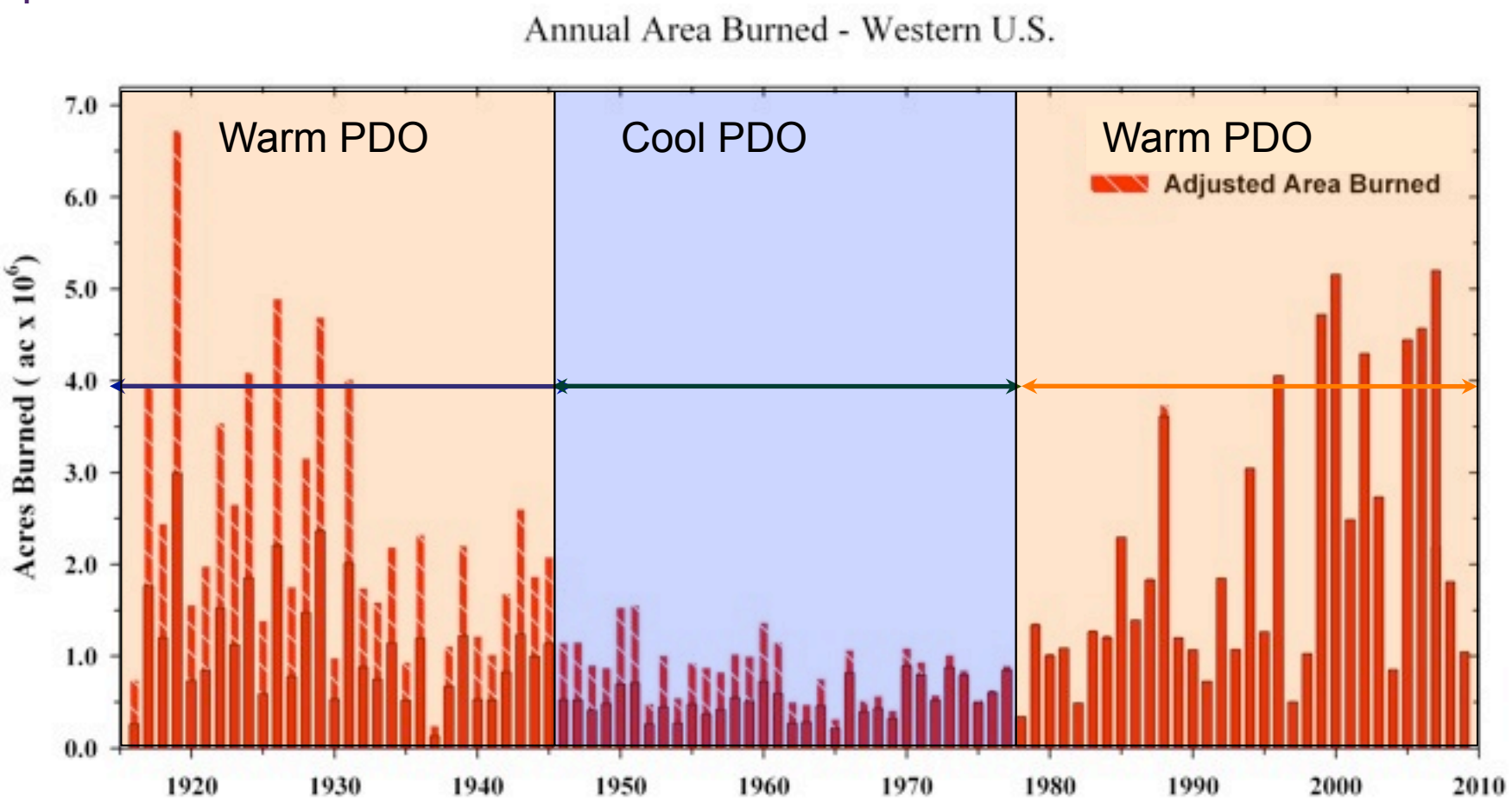

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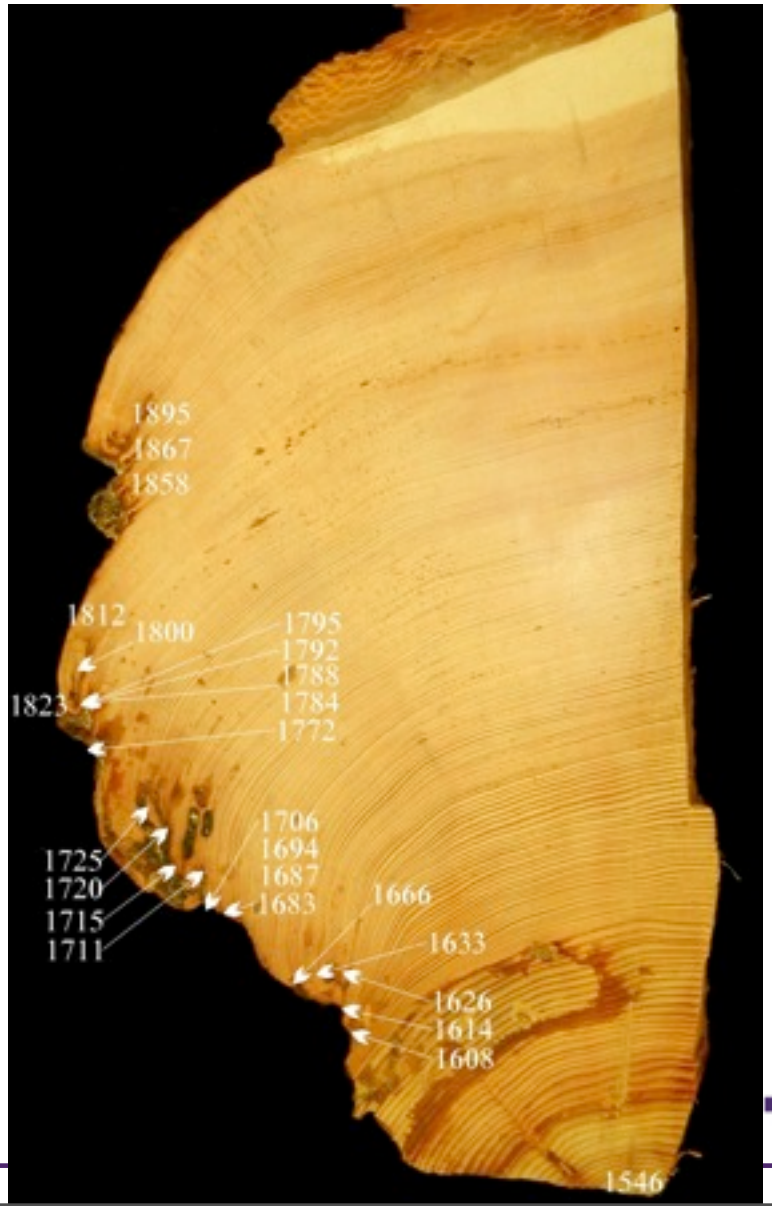
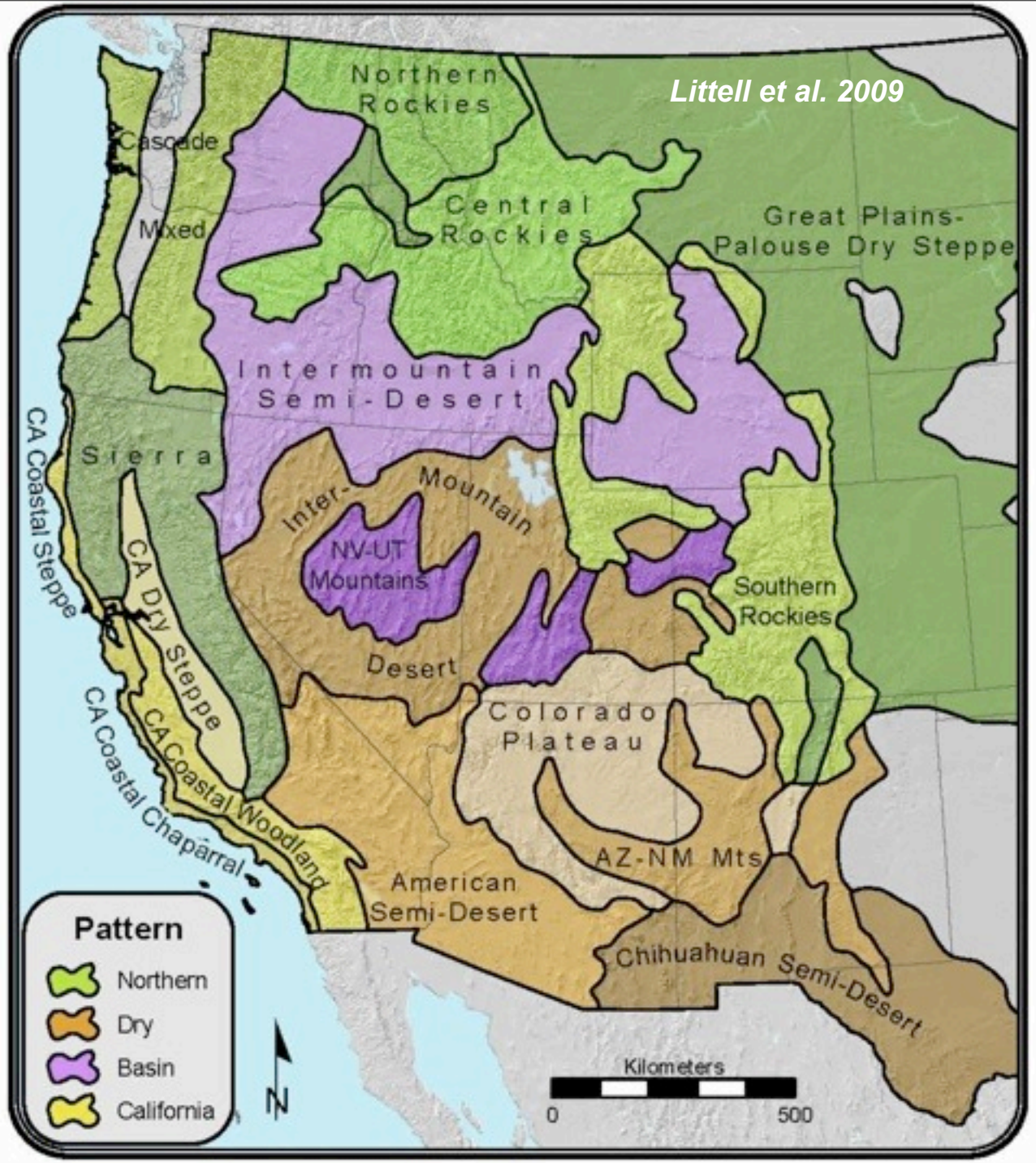
Littell et al. 2009, Ecological Applications

Climate drivers of fire area burned: evidence from 20th C. and pre-settlement fire history

- Increasing temperature (cool and warm season) appears related to increasing area burned trend (1970-2000s).
- Antecedent climate (drought in forests, but also wetter, cooler climate, especially in the SW).
- Combination of long-term soil → fuel moisture ("climatic set-up") and short term extreme weather implicated





- Different fuel types respond differently to climate (T, P, PDSI)
- Two mechanisms:
  - *drying* of fuels
  - *production* of fuels
- Fuel (moisture) - limited systems
- Climate (energy) - limited systems
- At scale of eco-provinces, both represented – hybrid models common

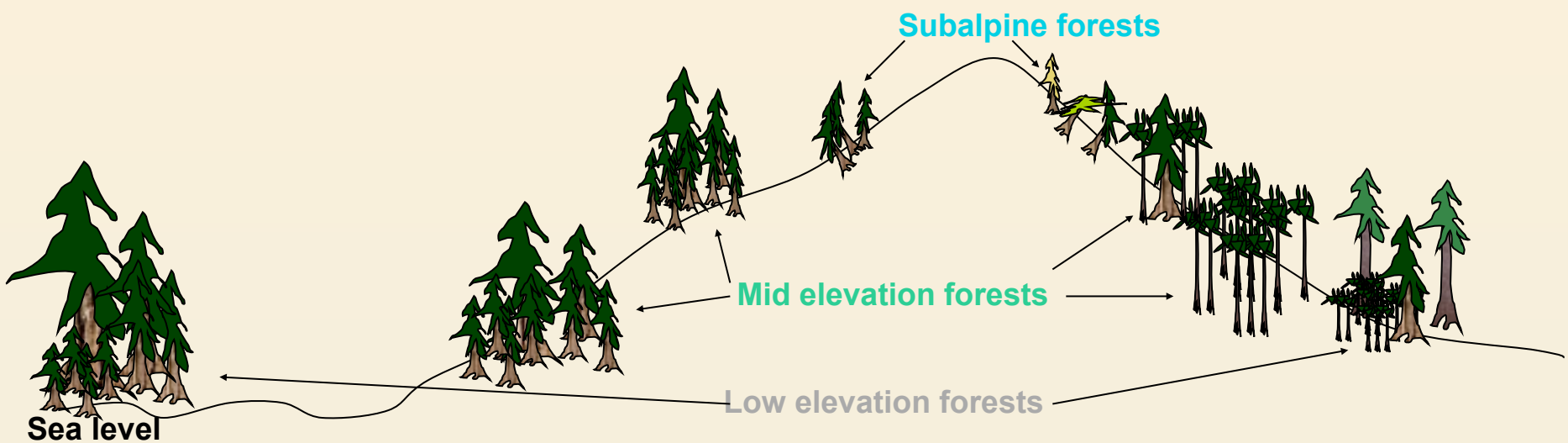
Map: R. Norheim

Climate change and tree growth

Subalpine forests: less snowpack duration; longer, warmer growing seasons = **growth increase**

Mid elevation forests: warmer summers, less snow pack = **growth depends on precipitation**

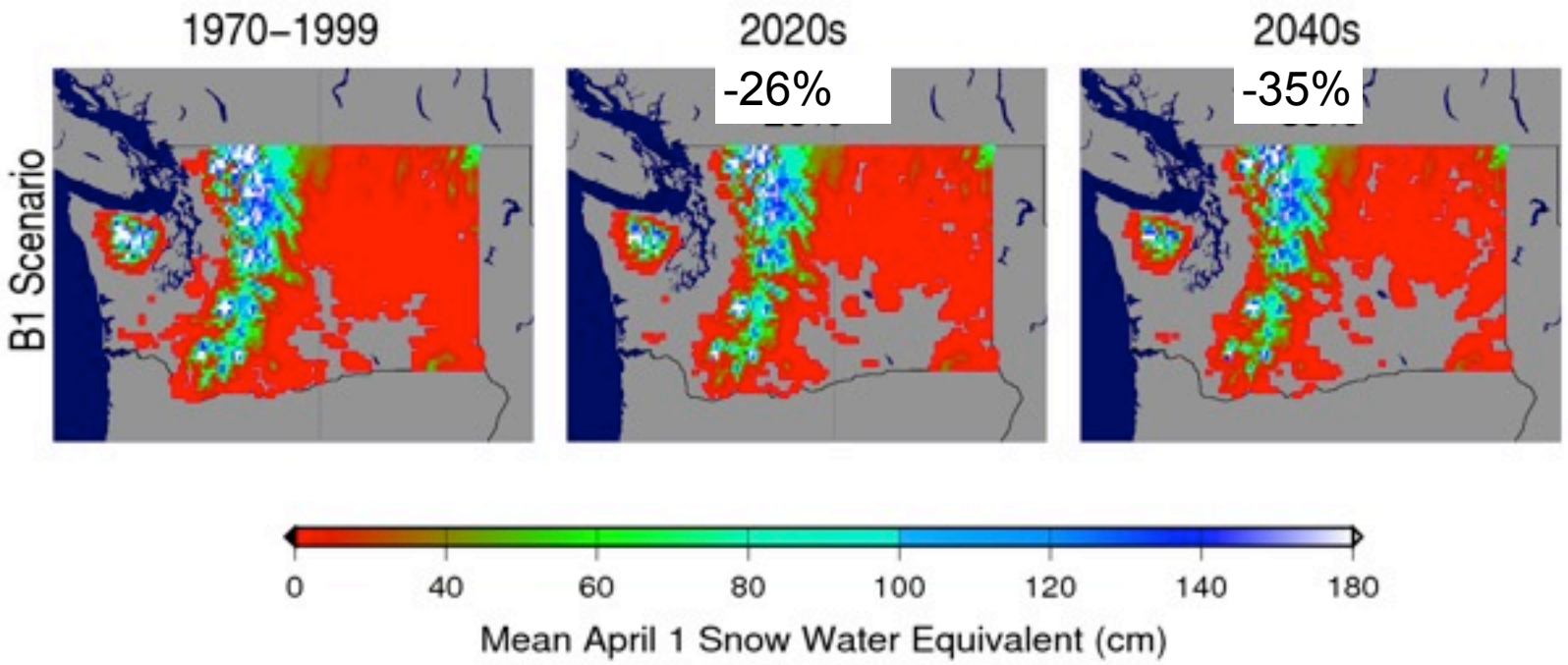
Low elevation forests: warmer summers, less snow pack = **large growth decrease**



Main Impact (I): Less Snow

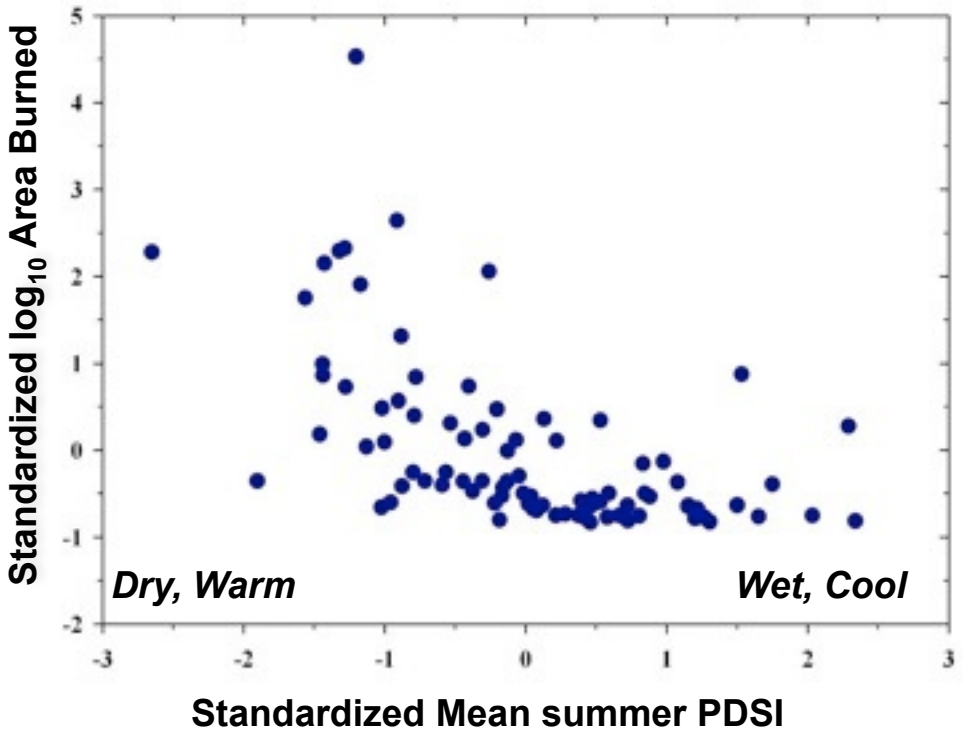
Warmer temperatures contribute to more winter precipitation falling as rain rather than snow, *particularly in transient (mid-elevation) basins.*

Changes in Simulated April 1 Snowpack for Washington



Implications: Area Burned

Increased temperature without increased precipitation will lead to **more summers with fuel moisture favorable for fire spread**, higher fire frequency, and more area burned.



Littell (2006)

Estrategias de Adaptacion al Cambio Global de Clima

General adaptation strategies

Implement adaptive management

Incorporate uncertainty in science and management

View fire disturbance (and ecological disturbance in general) as an opportunity

Work with your neighbors – collaborate with other organizations

General adaptation strategies

Strategy #1: **Increase landscape diversity**

Strategy #2: **Maintain biological diversity**

Strategy #3: **Plan for post-disturbance management**

Strategy #4: **Implement early detection / rapid response**

Strategy #5: **Manage for realistic outcomes**

Strategy #6: **Incorporate climate change in restoration**

Strategy #7: **Develop climate-smart regulations, policies**

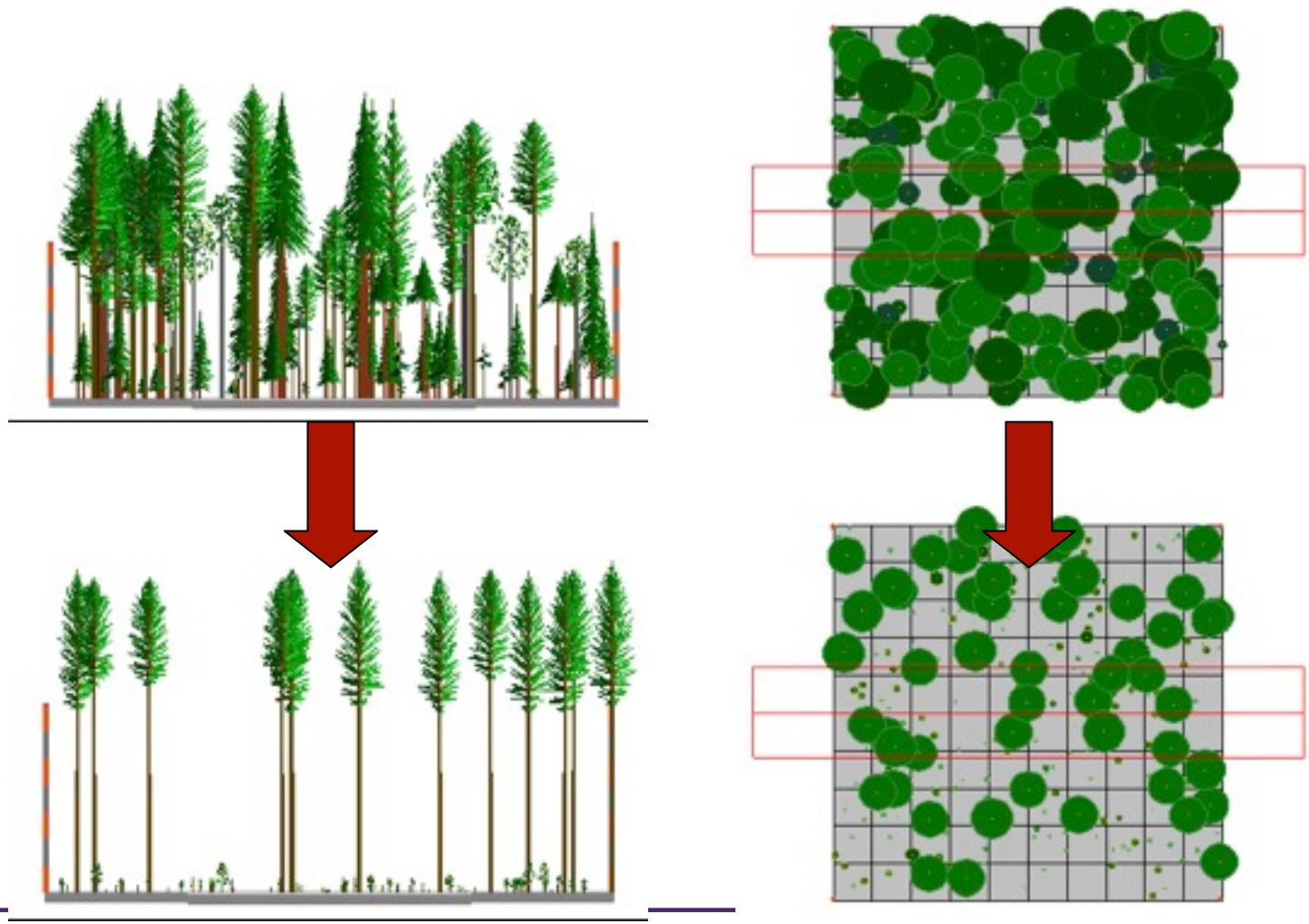
Strategy #8: **Anticipate big surprises**

Tools for Assessing Fire Behavior, Effects and Development of Adaptation Strategies for Climate Change

USFS/UW PWFSL Fire Seattle Group's 40+ years of Field Experience

Almost 20 Years of Research on Biomass Burning and Developing Tools for Fire Management with Brazilian Cooperators

Forest Management and Silvicultural Alternatives: How can forest structure be modified to reduce crown fire hazard?



Silviculture meets Fire Science

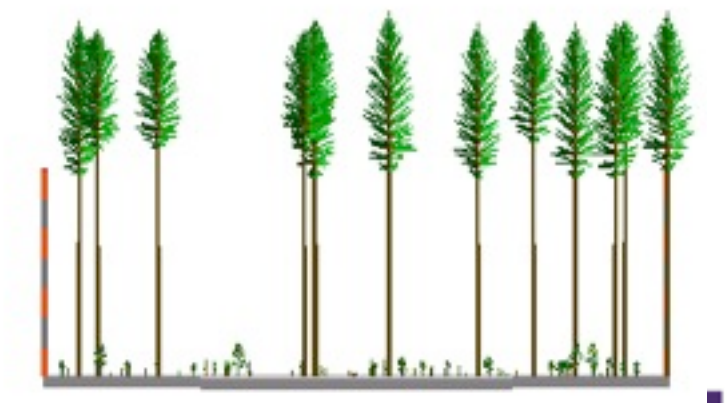
Reduce crown fire hazard by:

Raising canopy base height

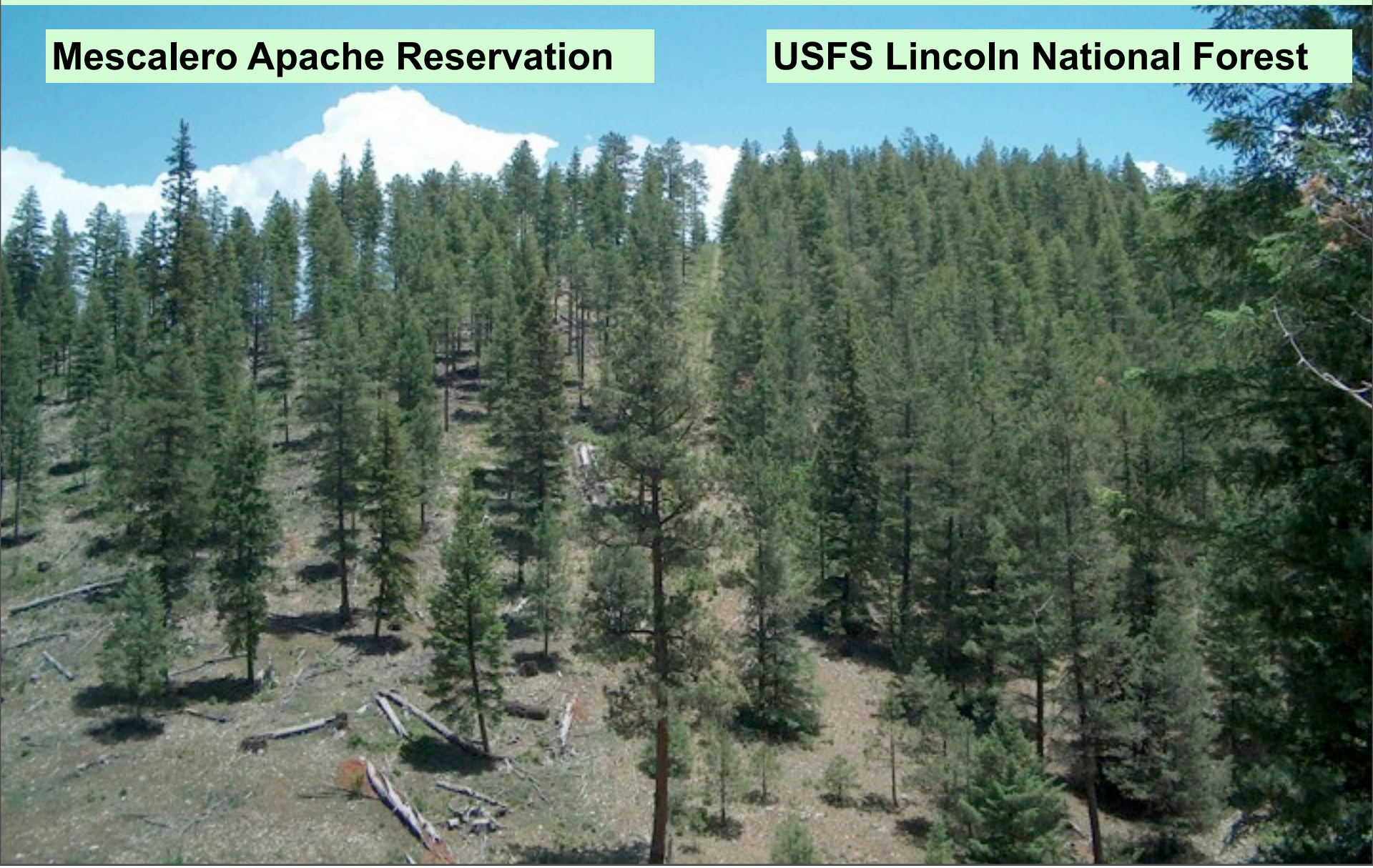
Reducing canopy bulk density

Reducing crown continuity

Reducing fire vulnerability through forest management



Effect of active forest and fuel management on fire severity: Comparative analysis between federal, state, and tribal lands: Yakama (WA) and Flathead Reservations (MT) - EUA



Management for Forest Health

Before

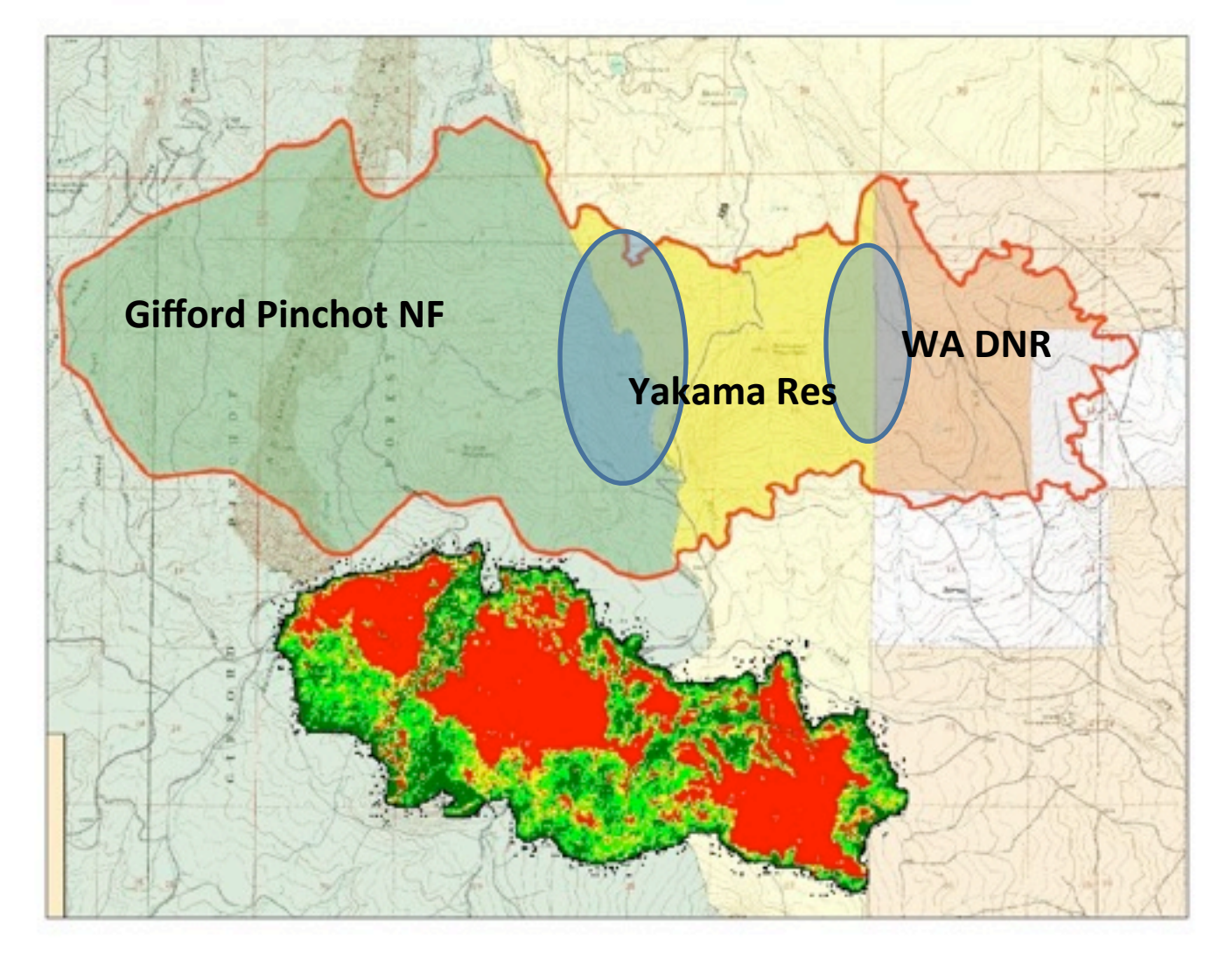
After

"Tribal lands demonstrate creative approaches in meeting forest health strategies. Tribal management procedures include tribal community consensus and a focus on both biological and economic goals."

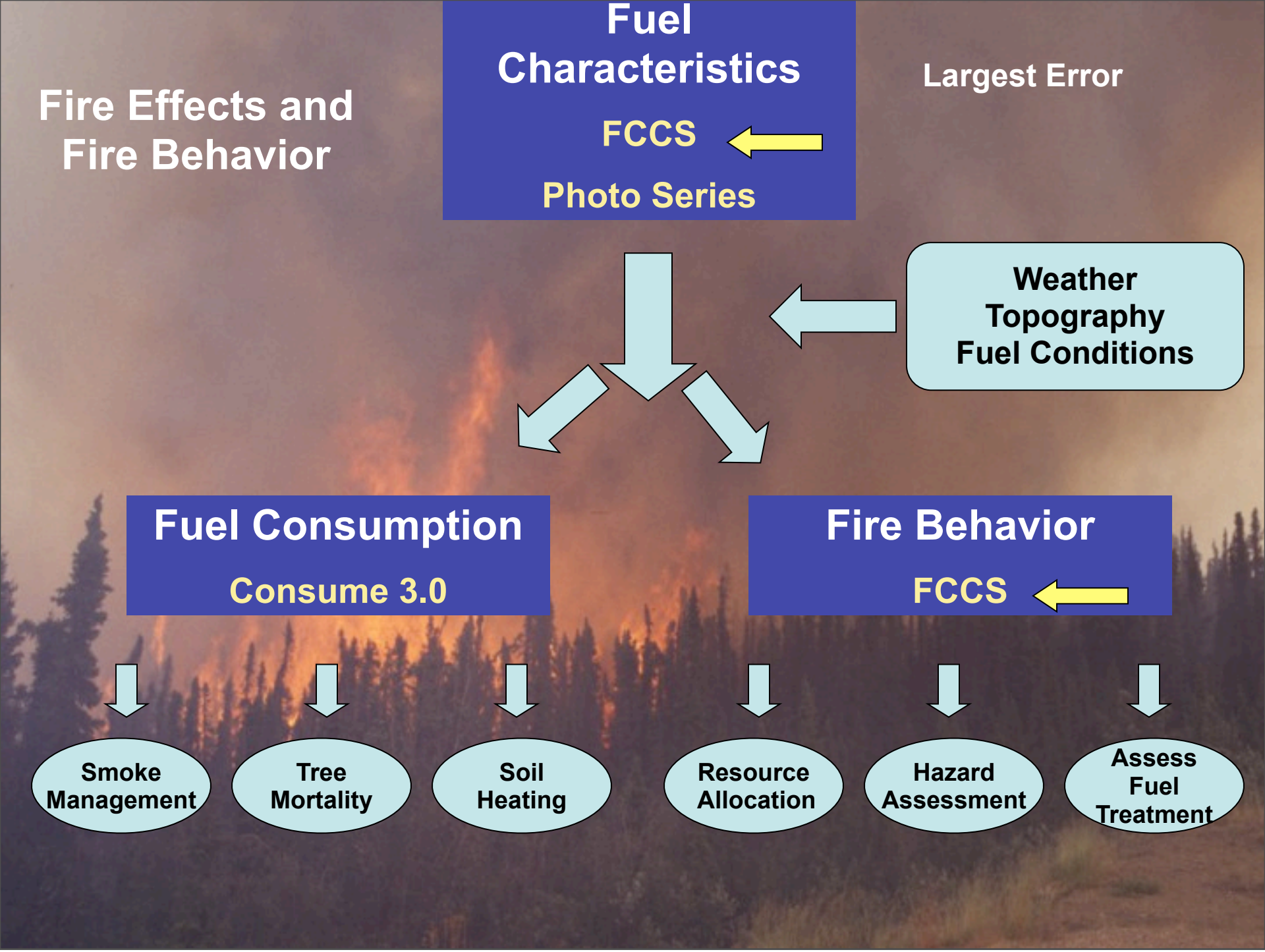
- A Desirable Forest Health Program for WA Forests

Yakama, WA

Fire severity and land ownerships: Cold Springs Fire (Gifford Pinchot NFP, Yakama Res and DNR 2007)



Integration of Traditional Ecological Knowledge and Western Science in Fire Management: A Collaborative Project UW-USFS-BIA-ITC √


Fire Effects and Fire Behavior
Fuel Characteristics
FCCS
Photo Series
Largest Error
Weather
Topography
Fuel Conditions
Fuel Consumption
Consume 3.0
Fire Behavior
FCCS
Smoke Management
Tree Mortality
Soil Heating
Resource Allocation
Hazard Assessment
Assess Fuel Treatment

















The Fuel Characteristic Classification

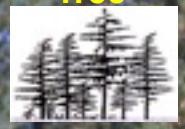
A nationally consistent, durable system to build and characterize all components of a fuelbed and to classify the fuelbed for its potential flammability and fire hazard.

Fuel Characteristic Classification System

6 strata divided into categories and subcategories:

- **Canopy Stratum**
- **Shrub Stratum**
- **Nonwoody Vegetation Stratum**
- **Woody Fuel Stratum**
- **Moss, Lichen, Litter Stratum**
- **Ground Fuel Stratum**

Snag Tree



Ladder Fuels

Crown Fire

Shrubs

Needle Drape

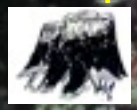
Graminoids

Herbs

Surface Fire

Piles and Jackpots

Stumps



Sound Wood

Rotten Wood

Lichen

Moss

Litter

Smoldering, Residual Effects

Duff

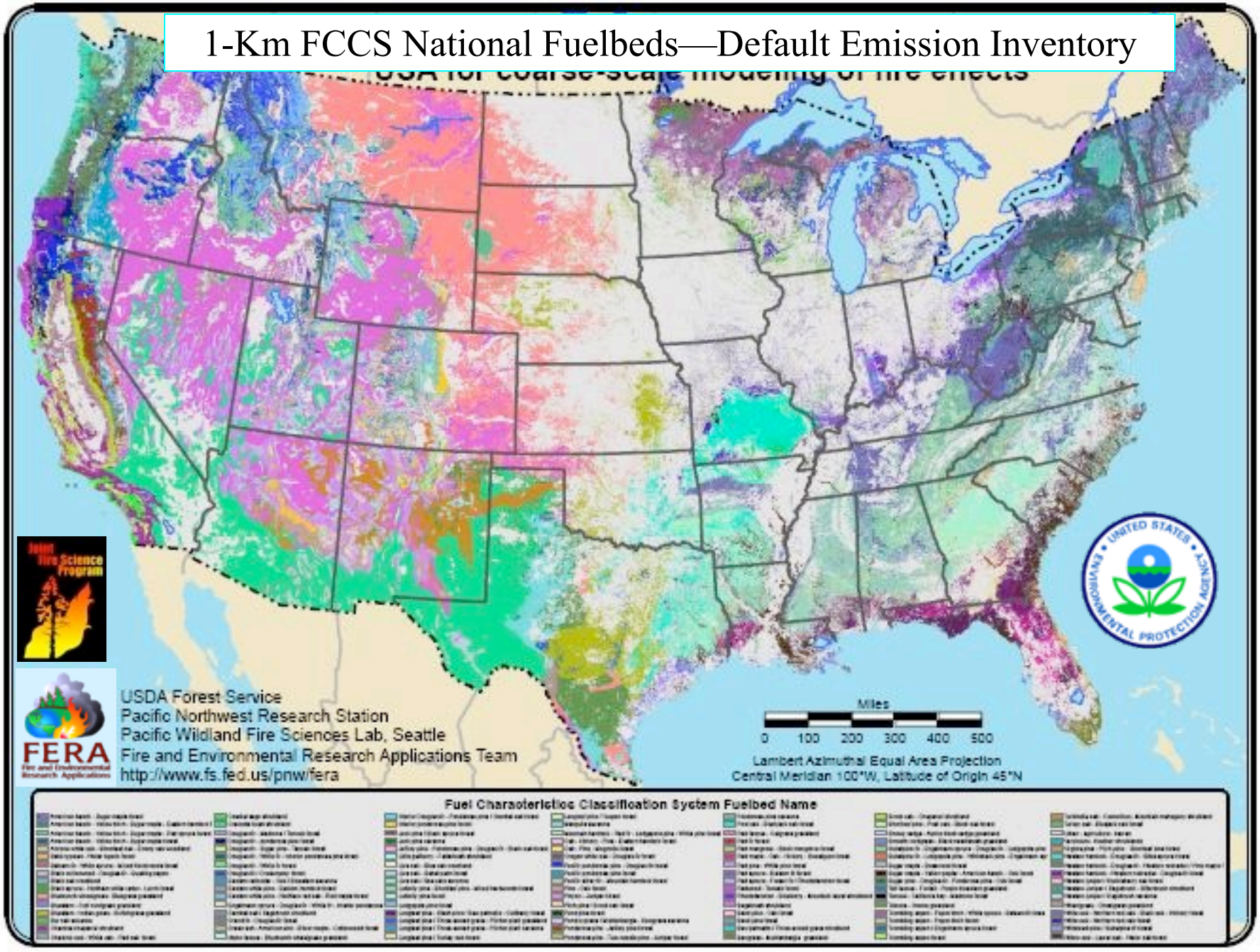
Squirrel Midden

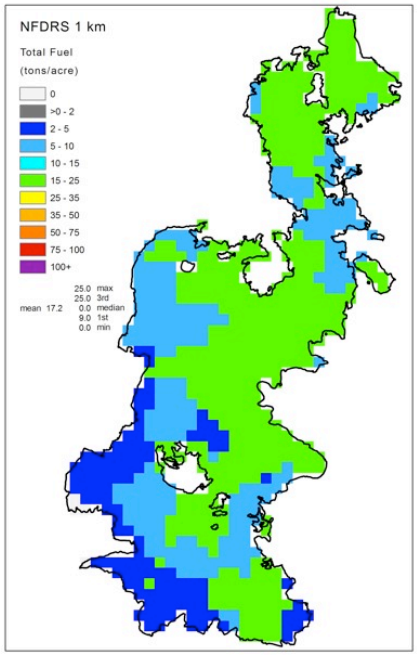
Basal Accumulation

FCCS Fuelbeds

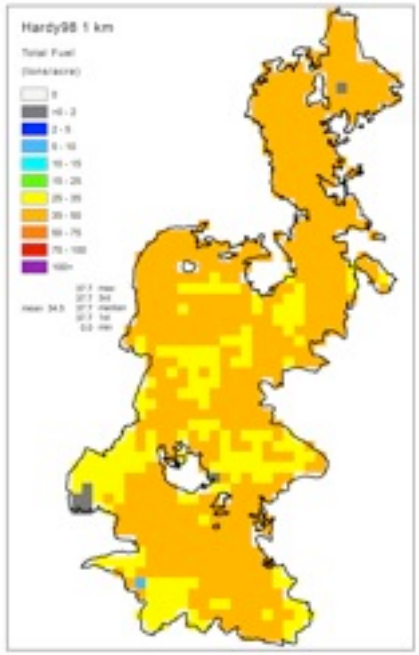
- **FCCS data base contains approximately 216 Fuelbeds**
  - **Represent a broad variety of common vegetation types**
  - **Associated change agents (e.g. fire, disease, insects, harvest, etc.)**
- **Several hundred additional FCCS fuelbeds are being added.**

1-Km FCCS National Fuelbeds—Default Emission Inventory

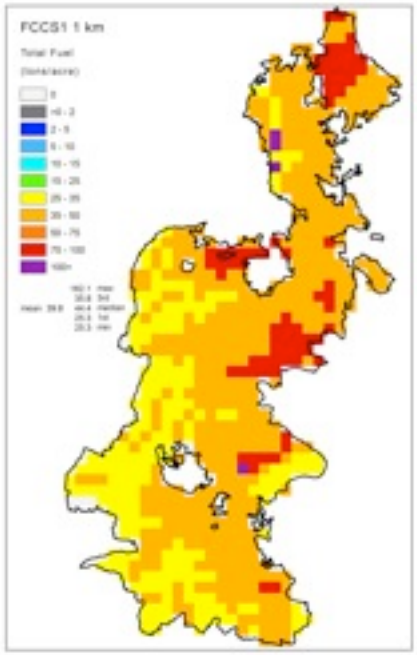




NFDRS 1km



NFFL HARDY 1km



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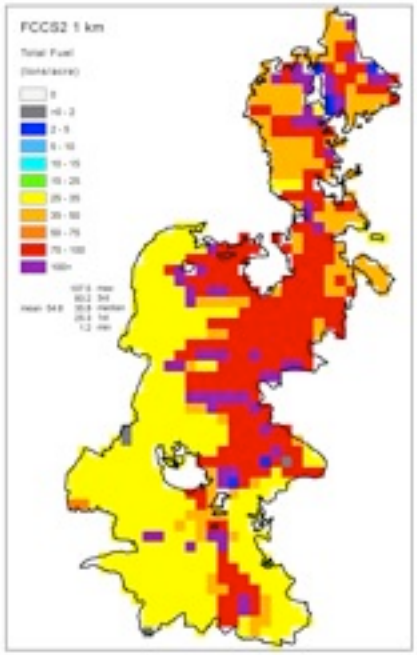


FCCS-LF - 1km

SEMIP Smoke and Emissions Model Intercomparison Project

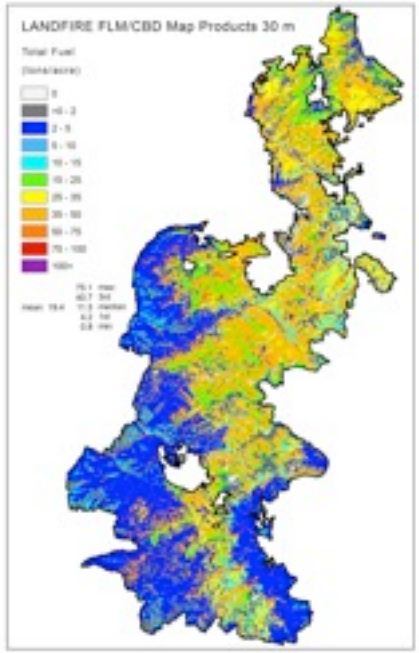
TRIPOD FIRE CASE

TOTAL FUELS

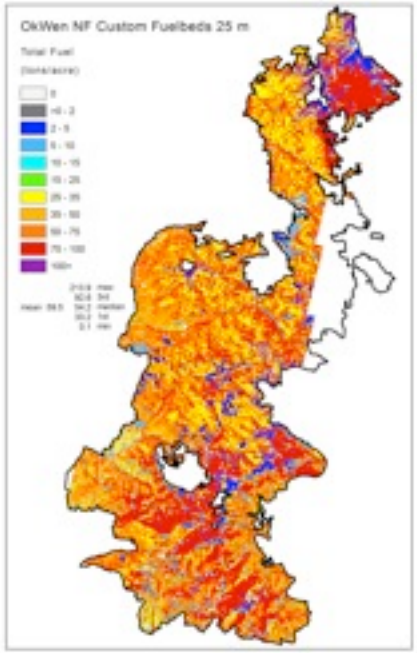
Top: 1-km maps

Bot: High-res maps

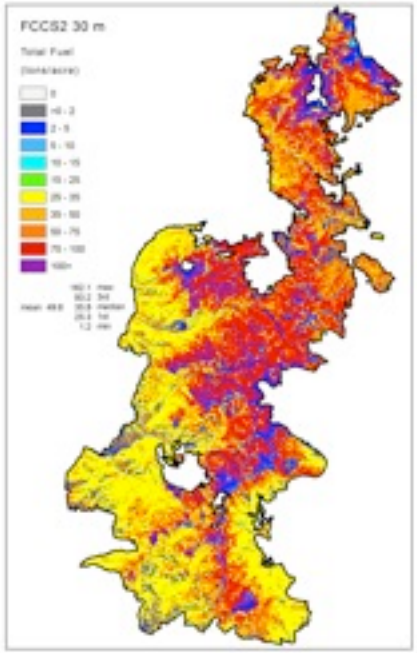
FCCS Landscape



LANDFIRE 30m (NFFL 13+40)



FCCS OK-WEN FOREST 30m



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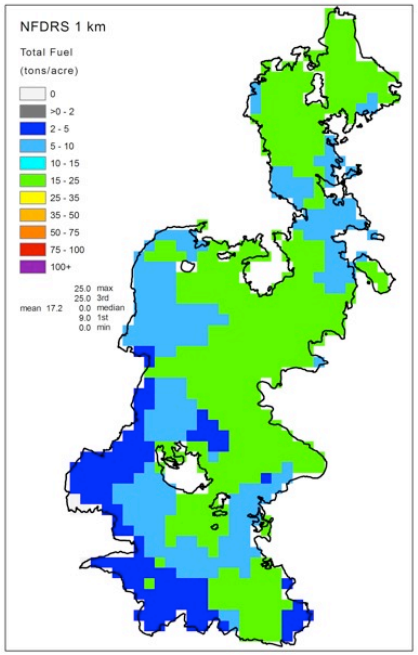
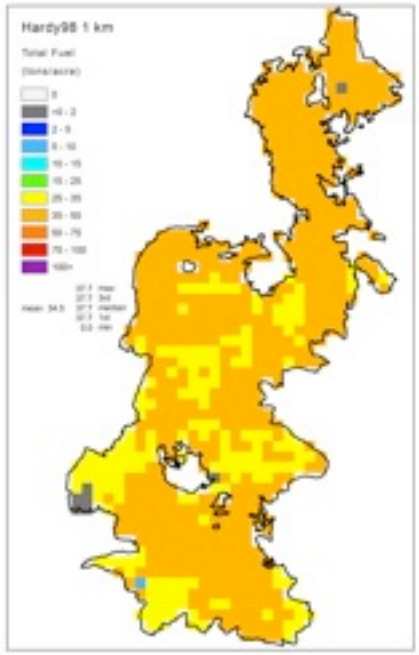
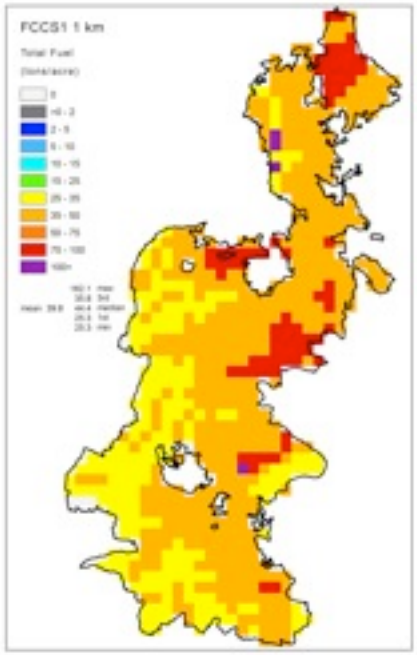


NFDRS 1km



NFFL HARDY 1km



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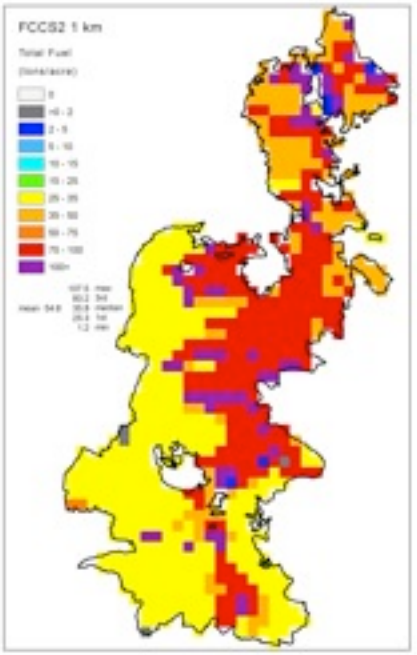

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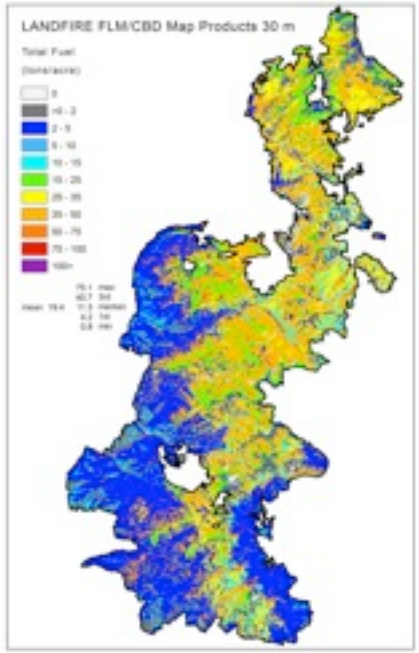

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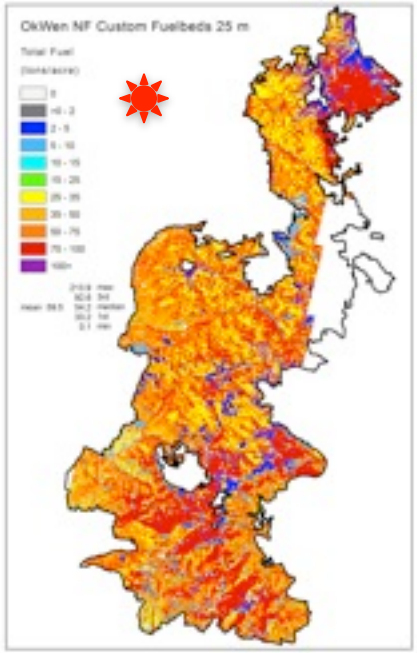
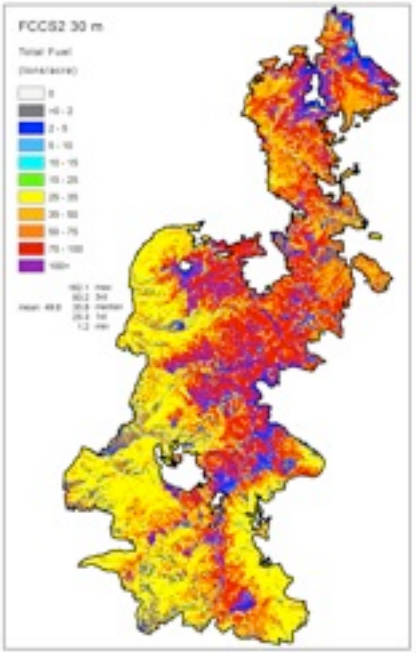


FCCS OK-WEN FOREST 30m



FCCS-LF - 30m

Assessment of Effectiveness of Fuel Treatments: Increasing Resiliency

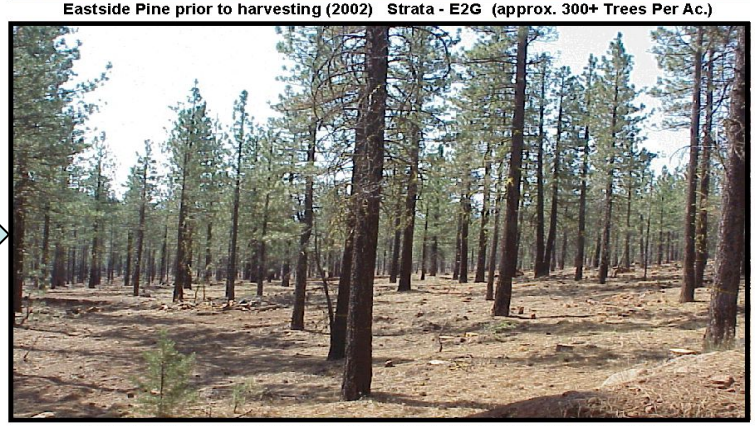
From this

TO

This

Signal Thin DFPZ Timber Sale (HFQLG)
1,189 ac.

Eastside Pine prior to harvesting (2002) Strata - E2G (approx. 300+ Trees Per Ac.)



Eastside Pine after harvesting (2002) Strata - E3N (approx. 90-110 Trees Per Ac.)

- Removed 28.5 green tons/ac., which was 40% sawlogs and 60% chips and biomass
- Generated $74,183.00 or $124.67/ac. in revenues for the portion of the sale which is harvested
- The objectives were to develope a DFPZ and improve stand health and vigor.
- CASPO Prescription

FCCS Fire Potential:
657

FCCS Fire Potential:
213

FCCS at the Stand Level √


“Survival of the world depends on our sharing what we have, and working together. If we don’t, the whole world will die. First the planet, and next the people.”
Fools Crow
Lakota Sioux
THE BEGINNING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THE BEGINNING
THANKS, OBRIGADO, GRACIAS

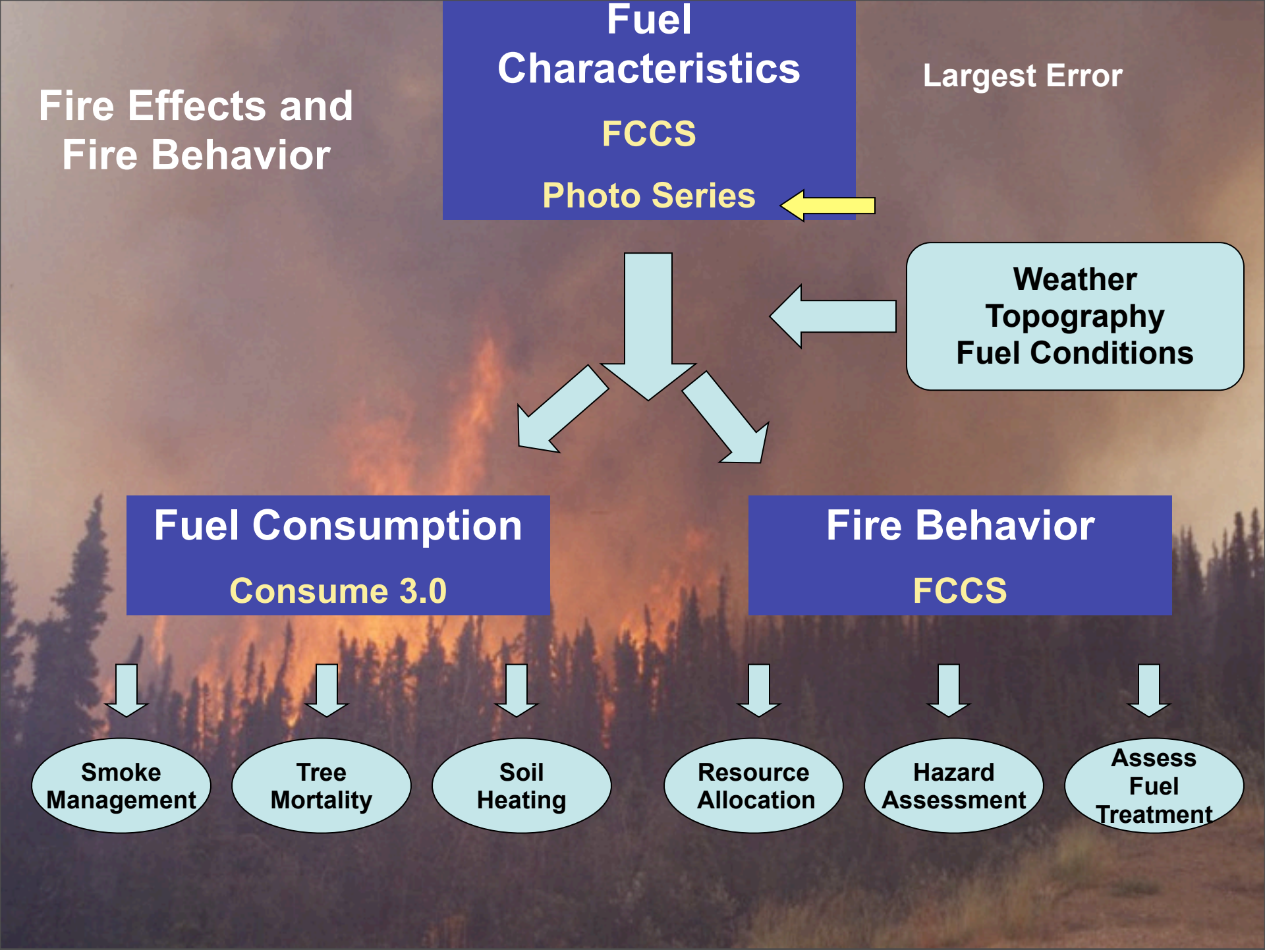
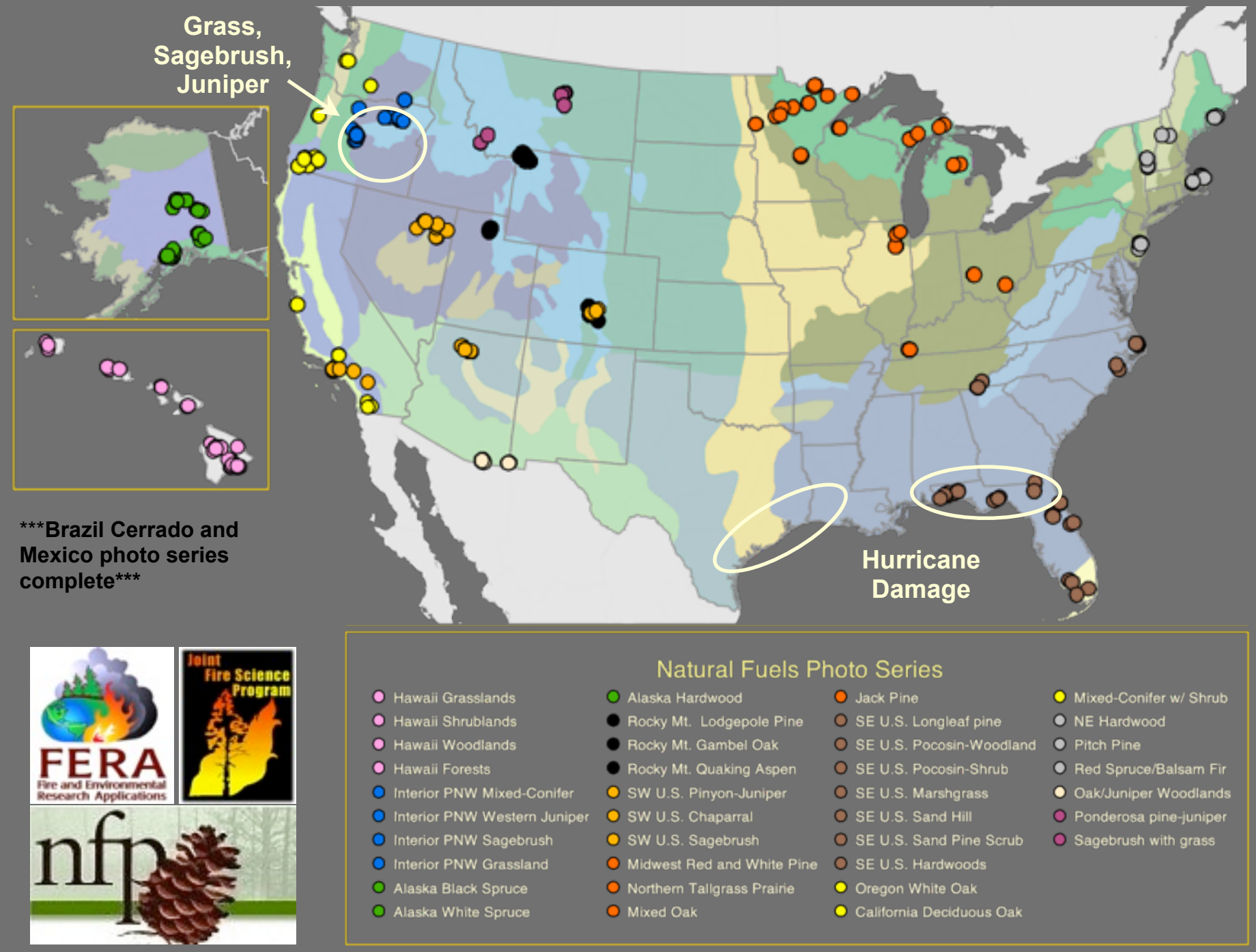

Fire Effects and Fire Behavior
Fuel Characteristics
FCCS
Photo Series
Largest Error
Weather
Topography
Fuel Conditions
Fuel Consumption
Consume 3.0
Fire Behavior
FCCS
Smoke Management
Tree Mortality
Soil Heating
Resource Allocation
Hazard Assessment
Assess Fuel Treatment

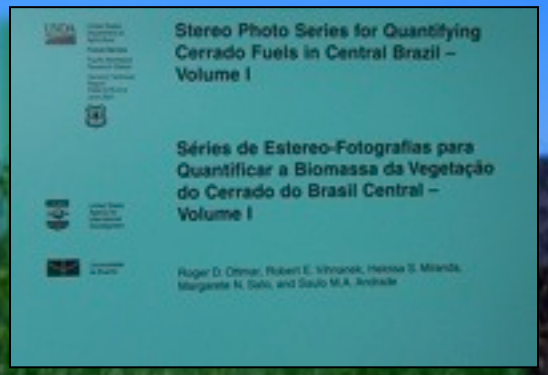
Photo Series—A Tool to Assess Fuelbed Characteristics

- To easily and quickly assess fuelbed characteristics across landscapes through the appraisal of living and dead woody material and vegetation characteristics.

- Managers and scientists will find these fuelbed assessments a key element for:
  - ✓ land management planning
  - ✓ prescribed fire planning
  - ✓ developing suppression tactics
  - ✓ predicting fire effects
  - ✓ carbon assessment.


Grass, Sagebrush, Juniper
Brazil Cerrado and Mexico photo series complete
Hurricane Damage
Natural Fuels Photo Series
Hawaii Grasslands
Hawaii Shrublands
Hawaii Woodlands
Hawaii Forests
Interior PNW Mixed-Conifer
Interior PNW Western Juniper
Interior PNW Sagebrush
Interior PNW Grassland
Alaska Black Spruce
Alaska White Spruce
Alaska Hardwood
Rocky Mt. Lodgepole Pine
Rocky Mt. Gambel Oak
Rocky Mt. Quaking Aspen
SW U.S. Pinyon-Juniper
SW U.S. Chaparral
SW U.S. Sagebrush
Midwest Red and White Pine
Northern Tallgrass Prairie
Mixed Oak
Jack Pine
SE U.S. Longleaf pine
SE U.S. Pocosin-Woodland
SE U.S. Pocosin-Shrub
SE U.S. Marshgrass
SE U.S. Sand Hill
SE U.S. Sand Pine Scrub
SE U.S. Hardwoods
Oregon White Oak
California Deciduous Oak
Mixed-Conifer w/ Shrub
NE Hardwood
Pitch Pine
Red Spruce/Balsam Fir
Oak/Juniper Woodlands
Ponderosa pine-juniper
Sagebrush with grass
FERA
Fire and Environmental Research Applications
Joint Fire Science Program
nfp

Brazil Cerrado Photo Series



Principal Investigators:

Roger Ottmar, Robert Vihnanek, PNW Research Station, Seattle

Dr. Heloisa Miranda, University of Brasilia, Brasilia

Universidade de Brasília

FERA Fire and Environmental Research Applications

Support:

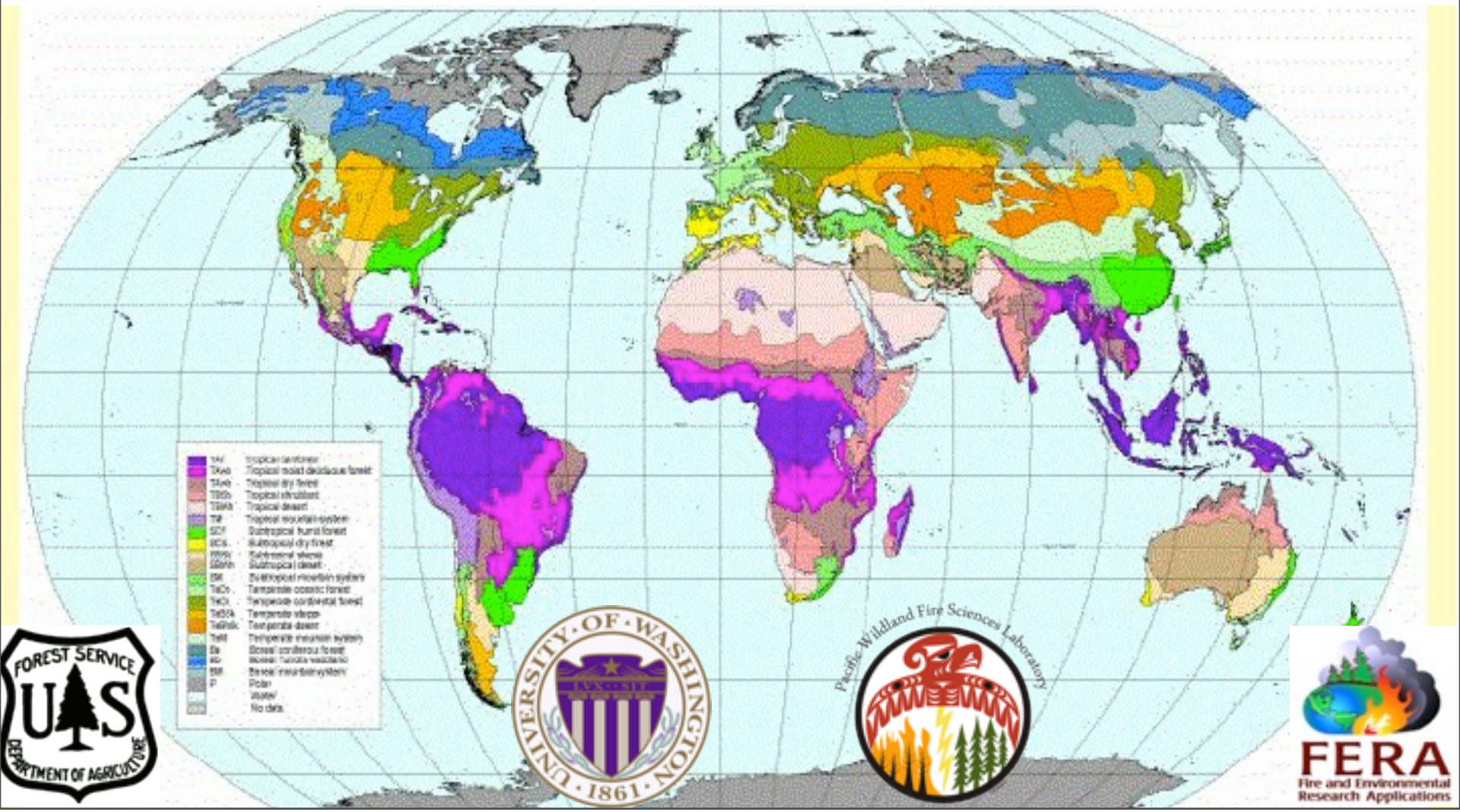
Michelle Zweede, International Programs, Washington D.C.

USAID
United States Agency for International Development

Photoseries and FCCS Fuebeds for the Brazilian Cerrado of Central Brazil

- Applications in Fire Management
- Fire Fighting Training
- Development of the New Brazil's Dynamic Vegetation Model (Deforestation and Fire)??

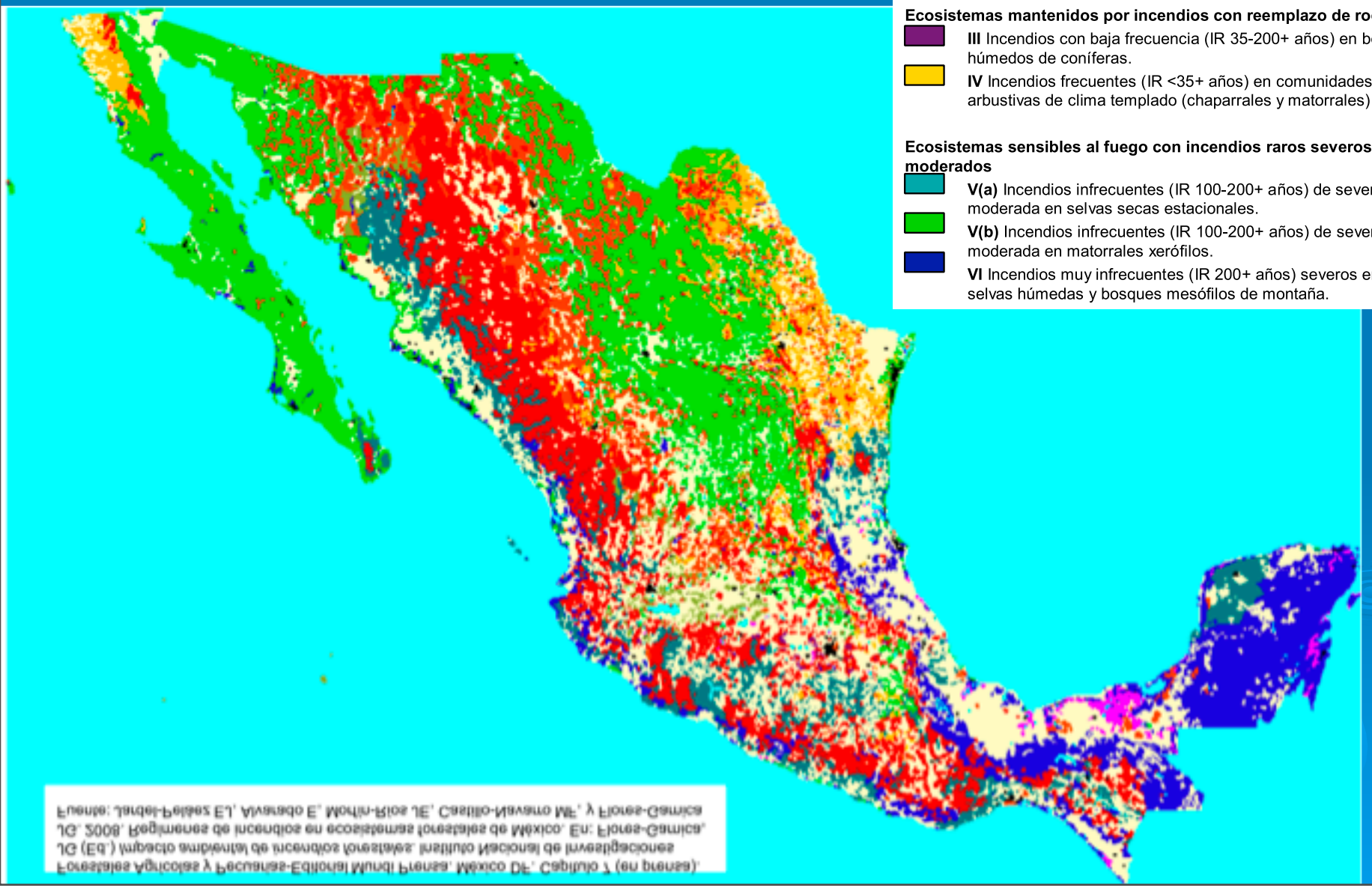
Global Applications of FERA Tools: Mexico's Natural Protected Areas and Cerrado of Central Brazil



Fuel Characterization for Natural Protected Areas of Mexico: From Deserts in the North to the Tropical Rainforest of the South (FCCS and Photo Series)

- Fire Management and Policy Applications
- Biodiversity Conservation
- REDD+: Assessment of Carbon Stocks
- Assessment of Carbon Emissions

POTENTIAL FIRE REGIMES IN MEXICO TO SUPPORT MEXICO'S NATIONAL FIRE STRATEGY



Ecosistemas mantenidos por incendios superficiales frecuentes

I(a) Incendios frecuentes (IR <35 años) en comunidades dominadas por herbáceas (pastizales y sabanas).

I(b) Incendios frecuentes (IR <35 años) en comunidades dominadas por herbáceas en terrenos inundables (tulares, popales).

II Incendios frecuentes (IR <35 años) de baja a moderada severidad en bosques subhúmedos (pinares, encinares)

Ecosistemas mantenidos por incendios con reemplazo de rodales

III Incendios con baja frecuencia (IR 35-200+ años) en bosques húmedos de coníferas.

IV Incendios frecuentes (IR <35+ años) en comunidades arbustivas de clima templado (chaparrales y matorrales)

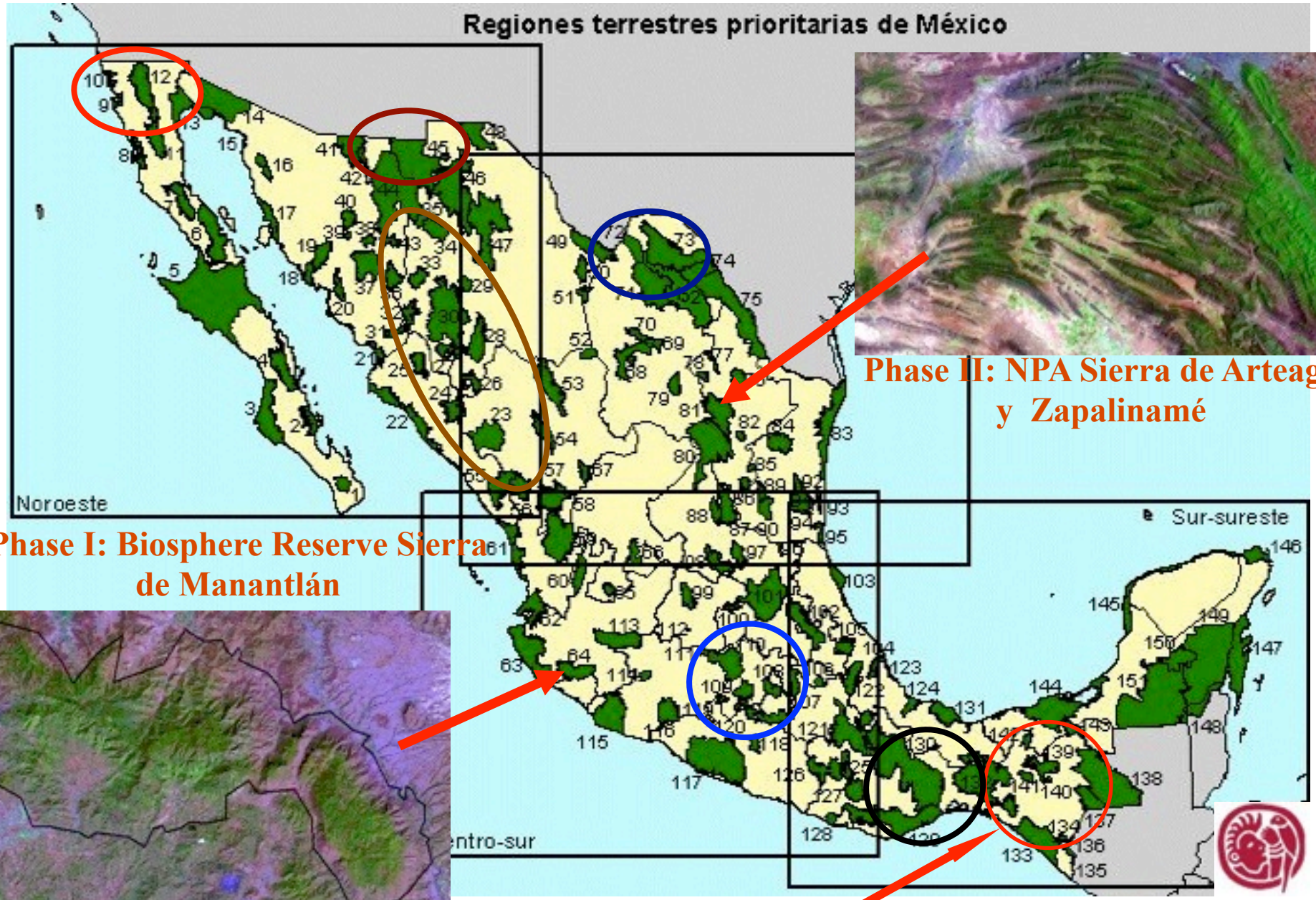
Ecosistemas sensibles al fuego con incendios raros severos a moderados

V(a) Incendios infrecuentes (IR 100-200+ años) de severidad moderada en selvas secas estacionales.

V(b) Incendios infrecuentes (IR 100-200+ años) de severidad moderada en matorrales xerófilos.

VI Incendios muy infrecuentes (IR 200+ años) severos en selvas húmedas y bosques mesófilos de montaña.

Fuente: Jardel-Peláez E.J., Alvarado E., Martín-Ríos J.E., Castillo-Navarro M.R. y Flores-Garnica J.G. 2008. Regímenes de incendios en ecosistemas forestales de México. En: Flores-Garnica J.G. (Ed.) Impacto ambiental de incendios forestales. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias-Editorial Mundi Prensa. México DF. Capítulo 7 (en prensa).


Regiones terrestres prioritarias de México
Noroeste
Sur-sureste
ntro-sur
Phase I: Biosphere Reserve Sierra de Manantlán
Phase II: NPA Sierra de Arteaga y Zapalinamé
Phase III: Chiapas

Quercus forest

Conifer forest

Montane Tropical Cloud Forest

SM10 El Triguito, ECLJ, Cloud Forest, 1935 m

Submontane shrubland

Oak forest

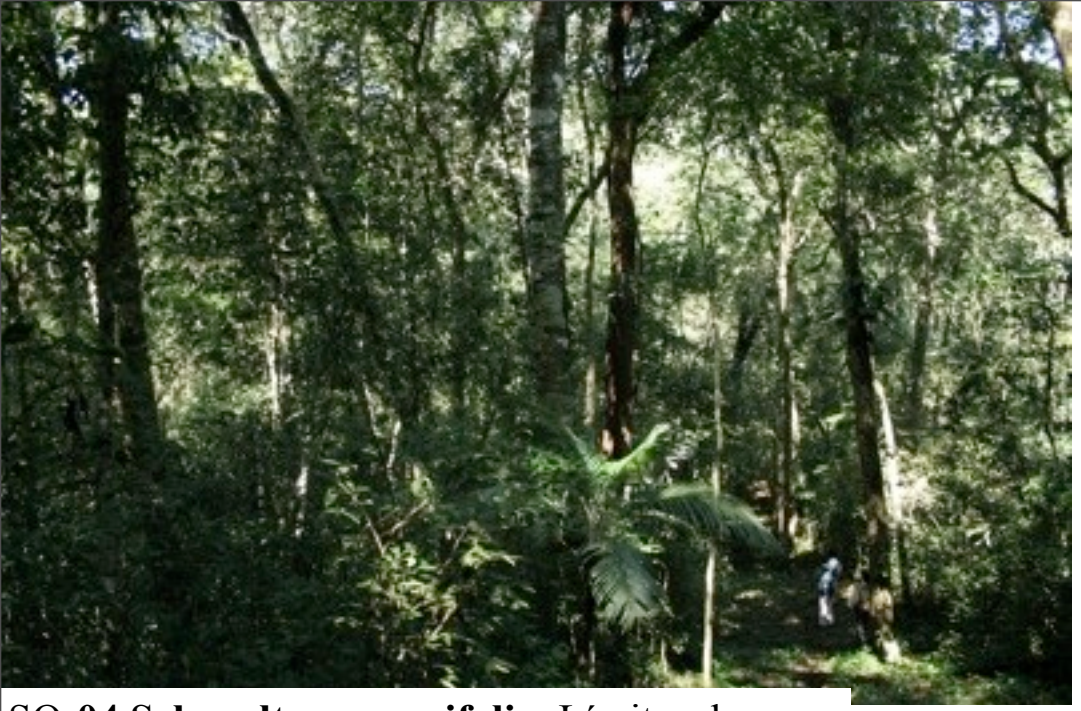
Pine forest

***Abies and Pseudotsuga* forest**

Fuel Characterization in Tropical Rain Forest

- Role of fire in tropical forests has been underestimated
- Rare event but has occurred historically
- Generally associated to droughts linked to El Niño/La Niña
- There is an increasing trend of wildfire occurrence on those ecosystems
- There is little information

Evergreen Tropical Rain Forest



SO-**04 Selva alta perennifolia**. Límites de Rabasa y El Cielito.(Foto EJP 18-Ene-2008).

Evergreen Tropical Rain Forest

2. Selva Mediana Perennifolia (Chiapas): Selva mediana perennifolia en el cañón del Río de la Venta, cerca de El Encajonado

Evergreen Tropical Rain Forest

SO-03 **Selva media subperennifolia abierta**. Camp El Ocote (Rabasa). 768 msnm. (Photo EJP 18-Ene-2008).

Evergreen Tropical Rain Forest

SO-07 **10-year old Secondary subperennifolious forest, burned in 1998** 774 m (Photo EJP 18-Ene-2008).

Evergreen Tropical Rain Forest

SO-02 **5-year old secondary forest of a medium subperennifolium tropical rainforest, burned in 1998 and 2003**, 793 m. (Photo EJP 17-Ene-2008).

Deciduous Tropical Forest

SM-05- **Deciduous tropical dry forest**. El Tepehuaje, 1208 m. (Photo EJP 26-Mar-2008).

Deciduous Tropical Forest

SM11 La Calera, Casimiro Castillo, **Sub deciduous tropical dry forest,** Alt 753 msnm

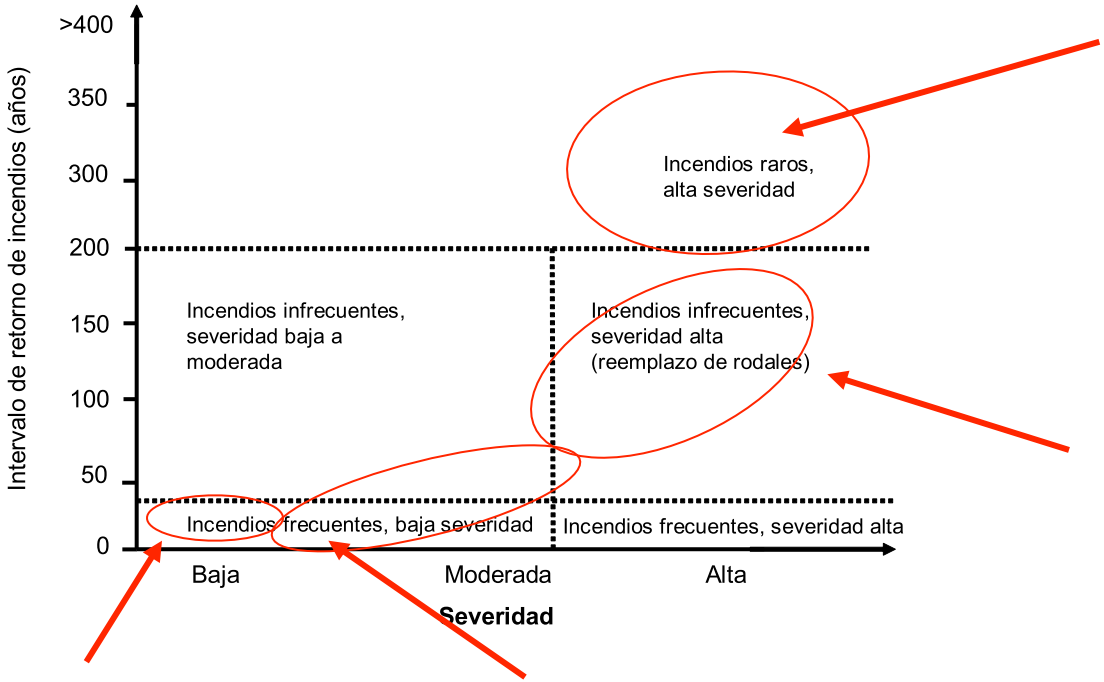
Deciduous Tropical Forest

SM13 Partida La Palmita, Casimiro Castillo, **Sub deciduous tropical dry forest,** 500 msnm

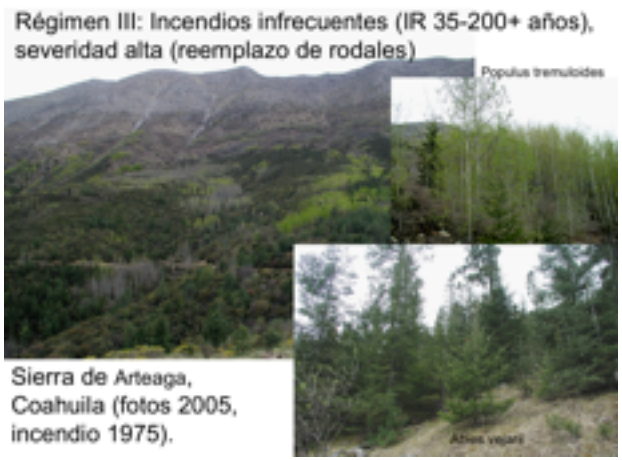
Deciduous Tropical Forest

SO-10 **Tropical dry forest**, 1006 m. (Photo EJP 19-Ene-2008).

FIRE REGIMES (HYPOTHESIS) FOR MEXICO'S TERRESTRIAL ECOSYSTEMS



Selva alta perennifolia, R.B. El Ocote, Chiapas.



Sierra de Arteaga, Coahuila (fotos 2005, incendio 1975).

Pastizal natural de *Bouteloa gracilis*, Llanos de Ojuelos, Jalisco.

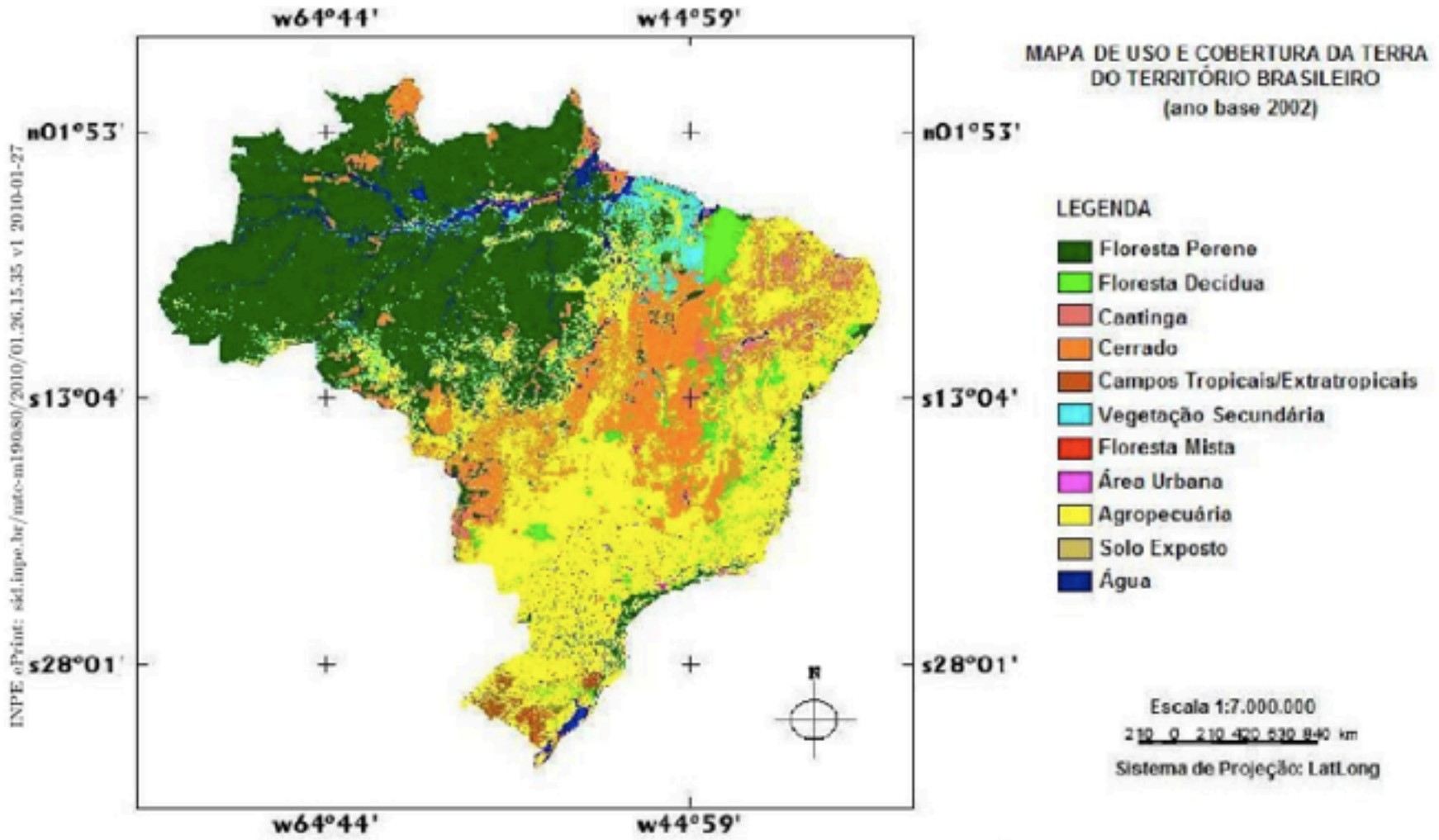
Bosque de pino, R.B. Sierra de Manantlán, Jalisco.

Initial FCCS Fuelbeds for Mexico

- 17 Sities at the Biosphere Reserve Manantlan
- 15 Sites at the Natural Protected Area of Arteaga
- 20+ sities from the US-Mexico borderlands, Arizona and Nuevo Mexico
- 10+ from the California-Mexico border
- 20+ from similar ecosystems from the United States (pines, oaks, chaparral, poplars)
- 5-10 from the Brazilian savannas
- Tropical forest from Chiapas and Oaxaca, Biosphere Reserve El Ocote 15
- 6 MILAGRO project (DOE, NSF, NASA)

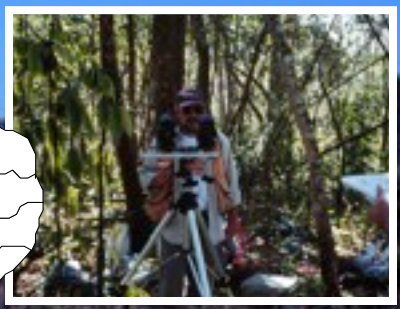
> 192 FCCS fuelbeds (2011)

Brasil? Possibility of Developing a National Fuel Characterization System? High-resolution (1km) vegetation map



Location of Photo Series Sites √

Sites were selected to show a range of conditions within selected physiognomic types.



Belem

Manaus

Chapada dos Veadeiros (2)

Chapada dos Guimaraes (3)

Salvador

Grande Sertao Veredas (8)

Basilia

Pirinopolis (2)

Aguas Emendadas (3)

IBGE & Botanical Gardens (15)

Emas (7)

IBAMA (2)

Rio De Janeiro

Sao Paulo

Brazil

Photo Series Sites

Sites

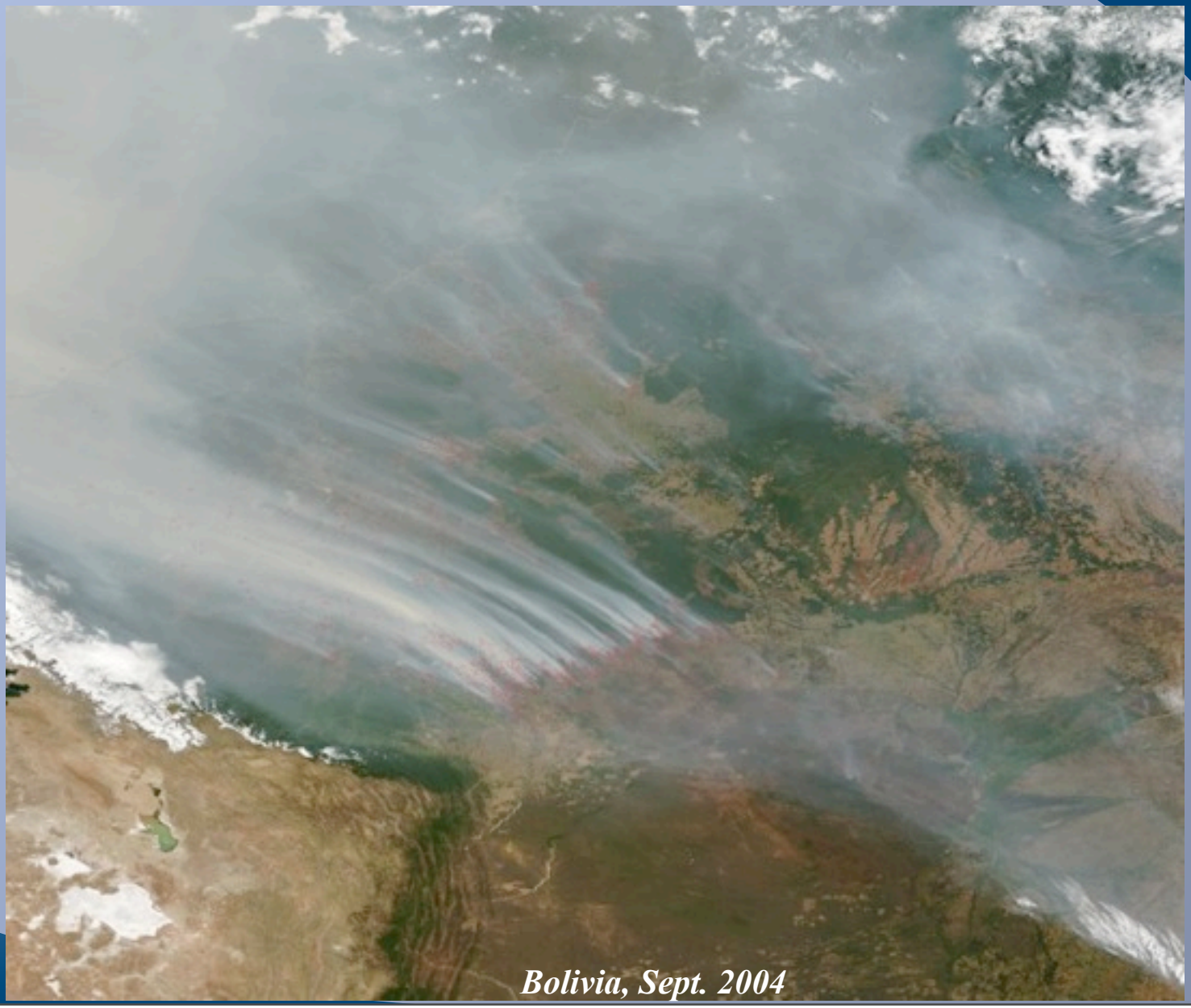
32 Number of sites Volume I

10 Number of sites Cerradao

Fire Management in Tropical Forests- Fire Regimes

- Characterization and systematization of fire regimes
- Development of fire management plans to reduce fire damage
- Fire management to support sustained sustainability of terrestrial ecosystems
- Restoration of degraded ecosystems
- Appropriate use of fire
- Develop strategies of fire management to mitigate and adapt to climate change

National Assessments and Reporting of Greenhouse Gases Emitted from Wildfires In Latin American Countries (REDD+): Mexico



Bolivia, Sept. 2004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