

**WESTCARB Technical Review and Planning**  
**Portland, Oregon**  
**October 28, 2004**

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**Status Report: Baselines and  
Carbon Supply for the West  
Coast Region**



John Kadyszewski, Aaron Dushku,  
& Sandra Brown

Winrock International  
[jkadyszewski@winrock.org](mailto:jkadyszewski@winrock.org)

# Acknowledgements

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# Summary

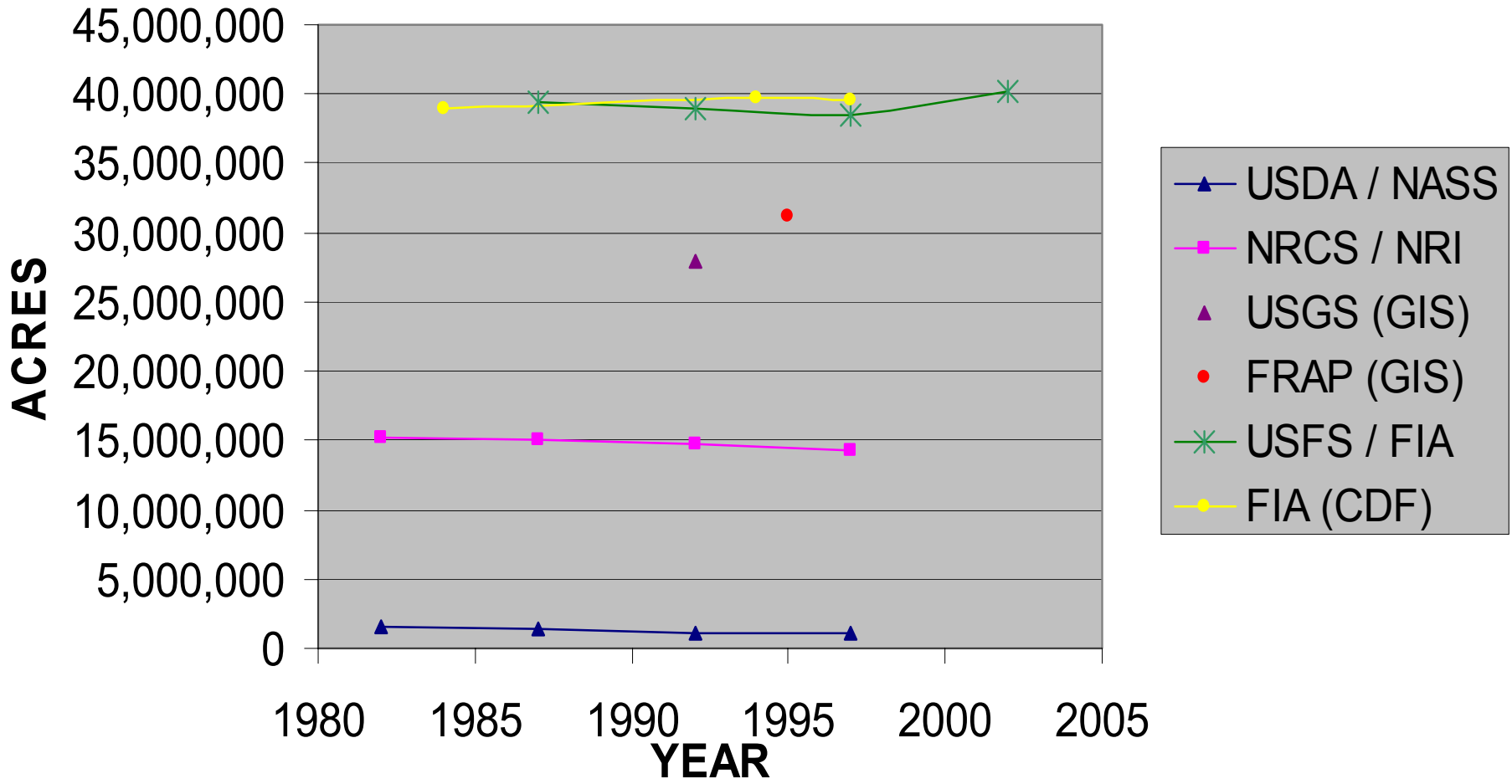
- **Baselines**
  - California complete
  - Status of Oregon, Washington and Arizona
- **Carbon Supply**
  - California
  - Oregon
- **Pilot Project Example**
  - Fire Management

# Baseline:

- Has two components:
  - Land-use change between two points in time
  - Corresponding changes in carbon stocks
- To obtain a trend need at least three points in time and two time intervals

# California Forest Area by Different Sources

## Woodland / Forest



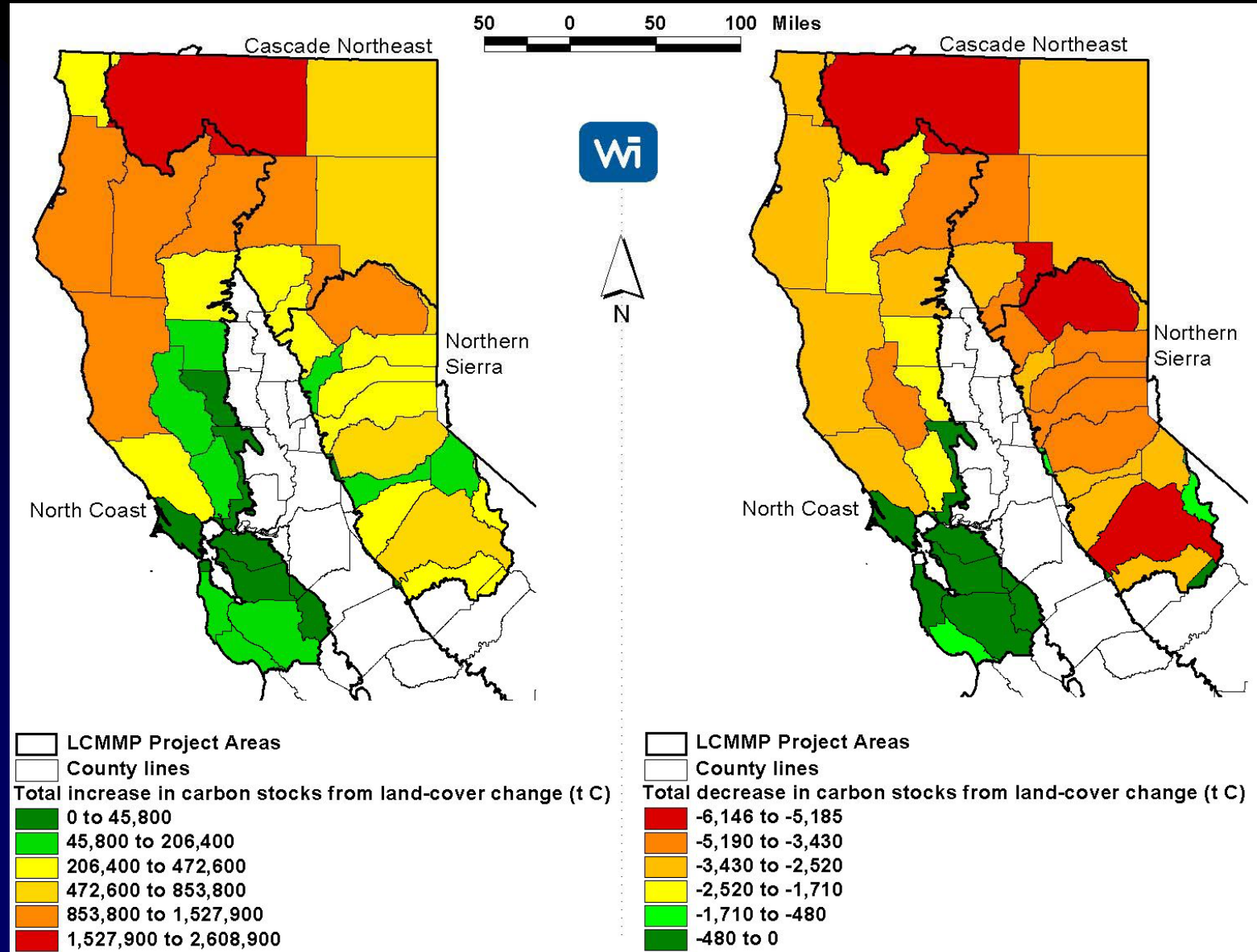
# Emissions and Removals by Cause of Change

MMTCO2/yr	Forests	Rangelands
Fire	-1.55	-0.14
Harvest	-1.40	-0.03
Development	-0.01	-0.004
Other/Unverified	-0.79	-0.10
Regrowth	+10.96	+0.46

# Approach for California

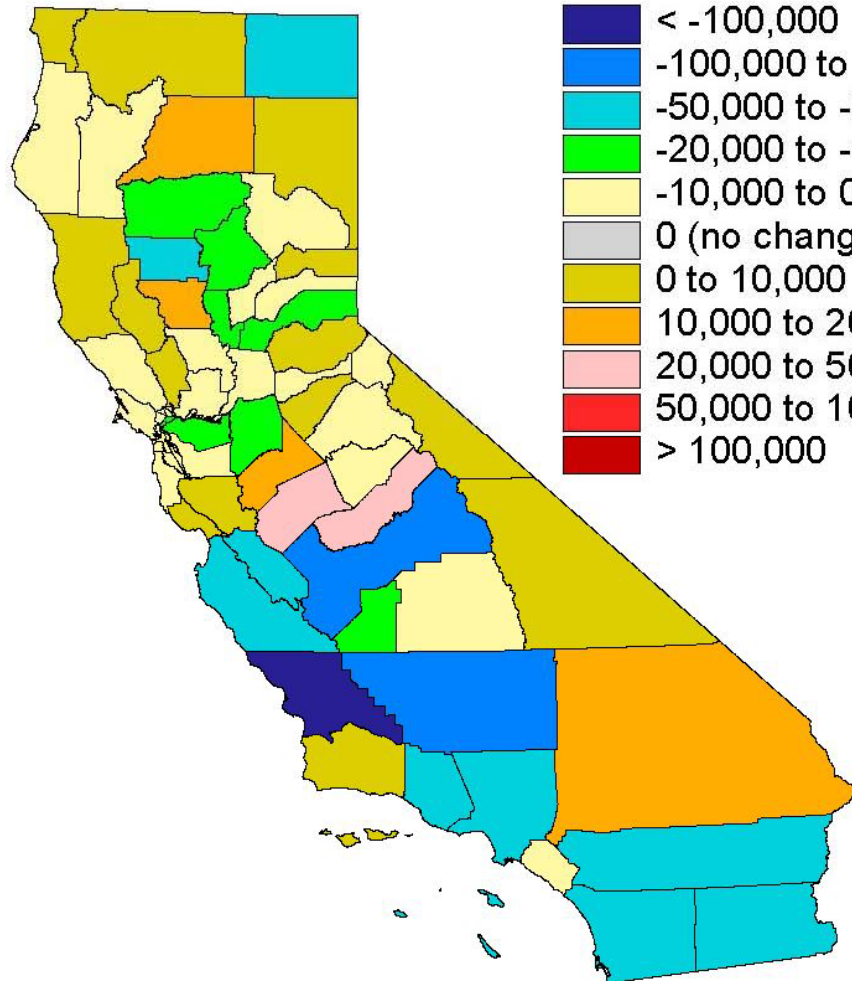
- **Land-use change:**
  - Forests and rangelands: GIS-based analysis in five regions
    - Obtain degree of change in canopy (at 1 hectare resolution)
  - Agriculture: USDA-NRI land-use survey analysis for entire state at county & hydrological units resolution
- **Carbon stocks:**
  - For forests from CDF, FIADB and literature
  - For agriculture from literature

# Carbon Stock Changes for Forest Land

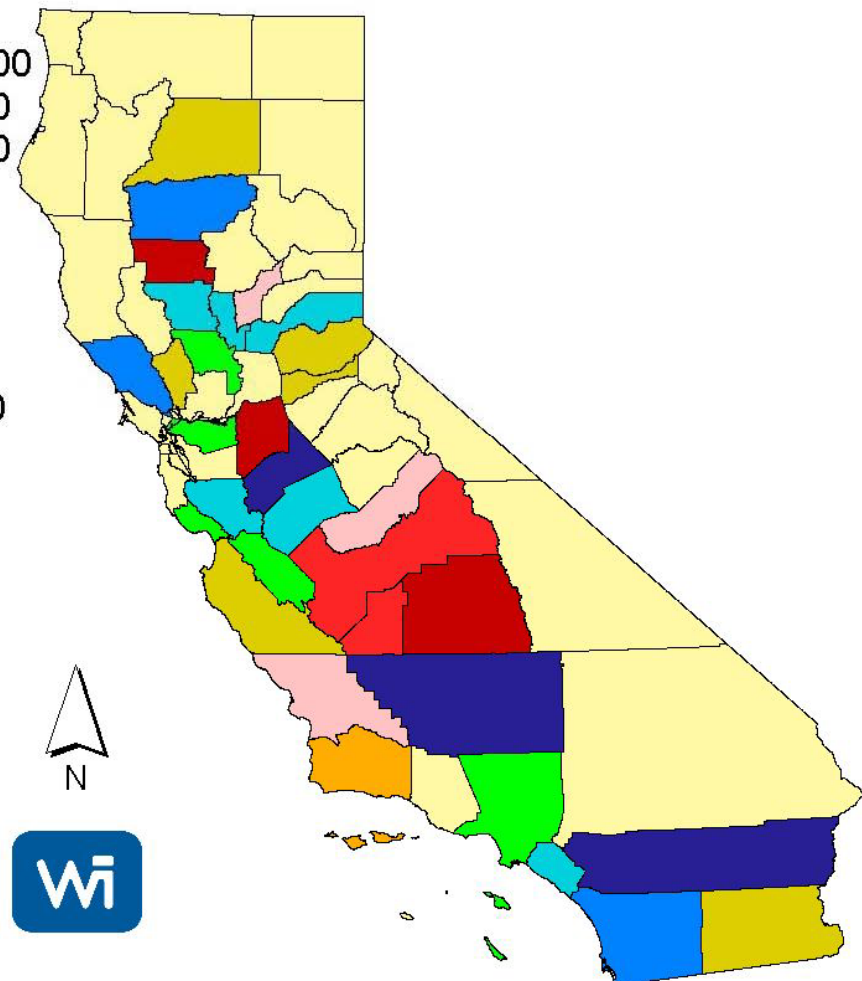


# Carbon Stock Changes in Agricultural Land for California

Change in Non-Woody Cropland



Change in Woody Cropland



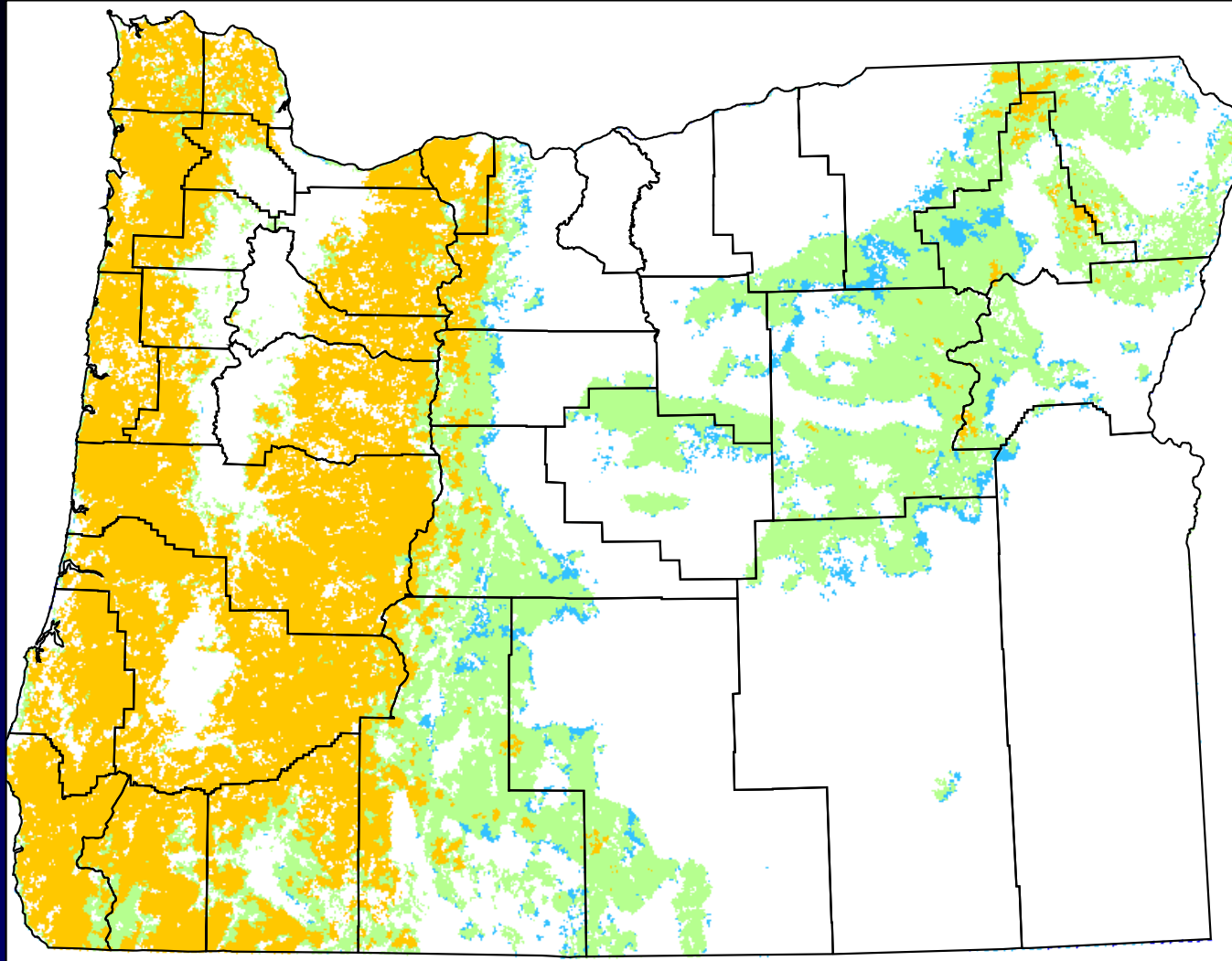
tC



# Baselines for Oregon and Washington

- **Forest and Rangelands**
  - Datasets used for California not available
  - Will use combination of FIA and available spatial data for fire and harvest
- **Agricultural Lands**
  - Same methods as California

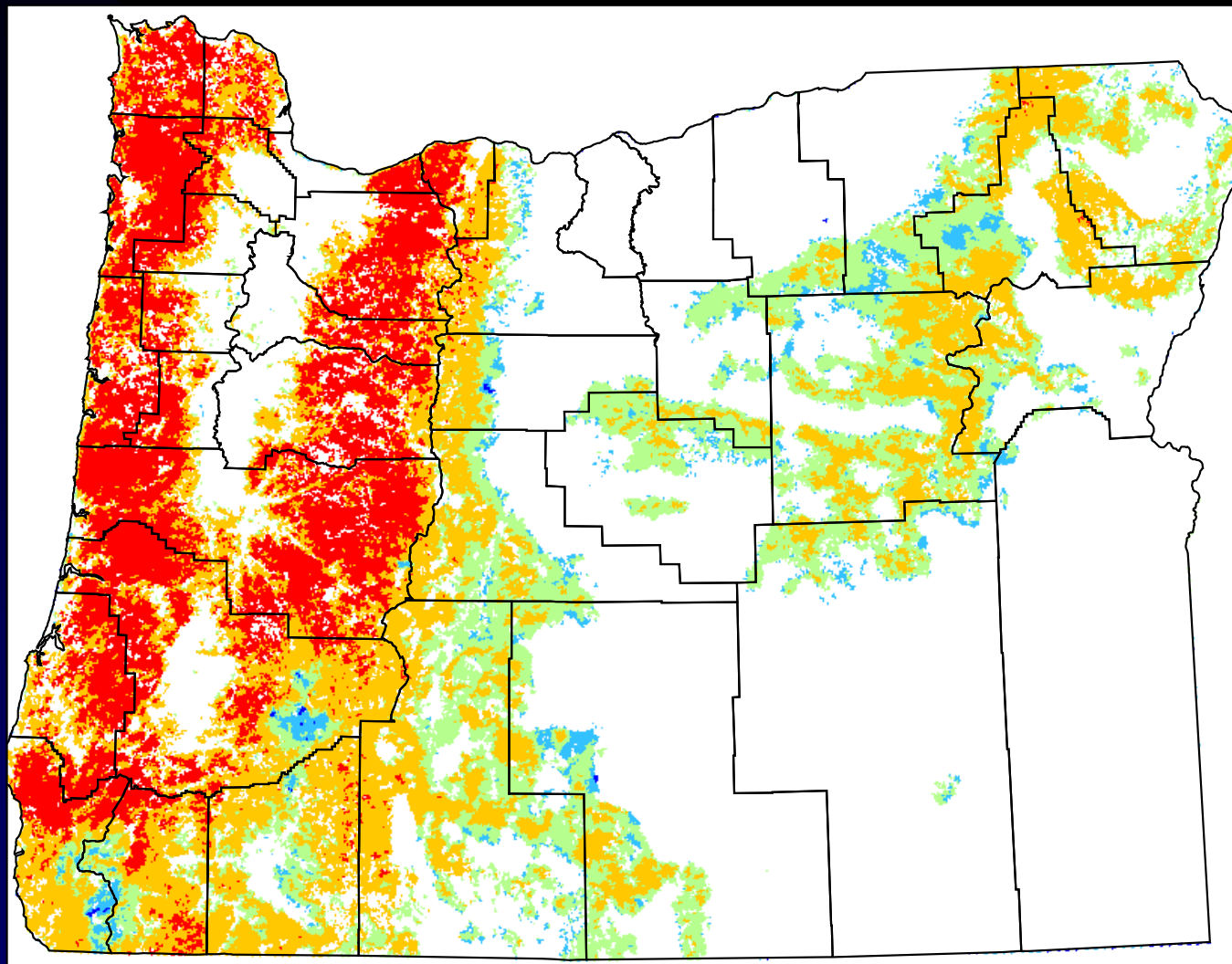
# Baseline for Fire



Forest Areas

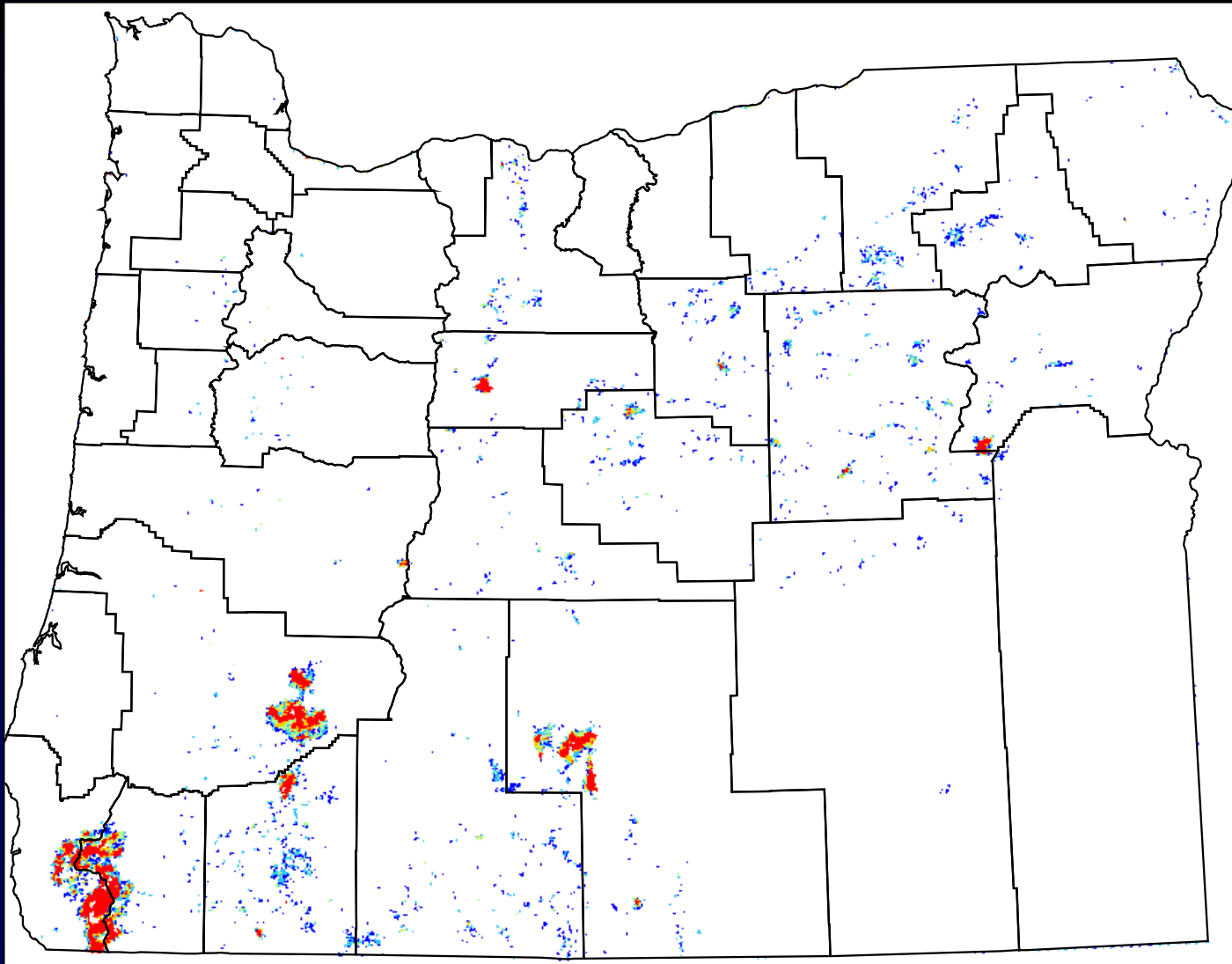
Mean Sept.  
NDVI 1990 –  
2003





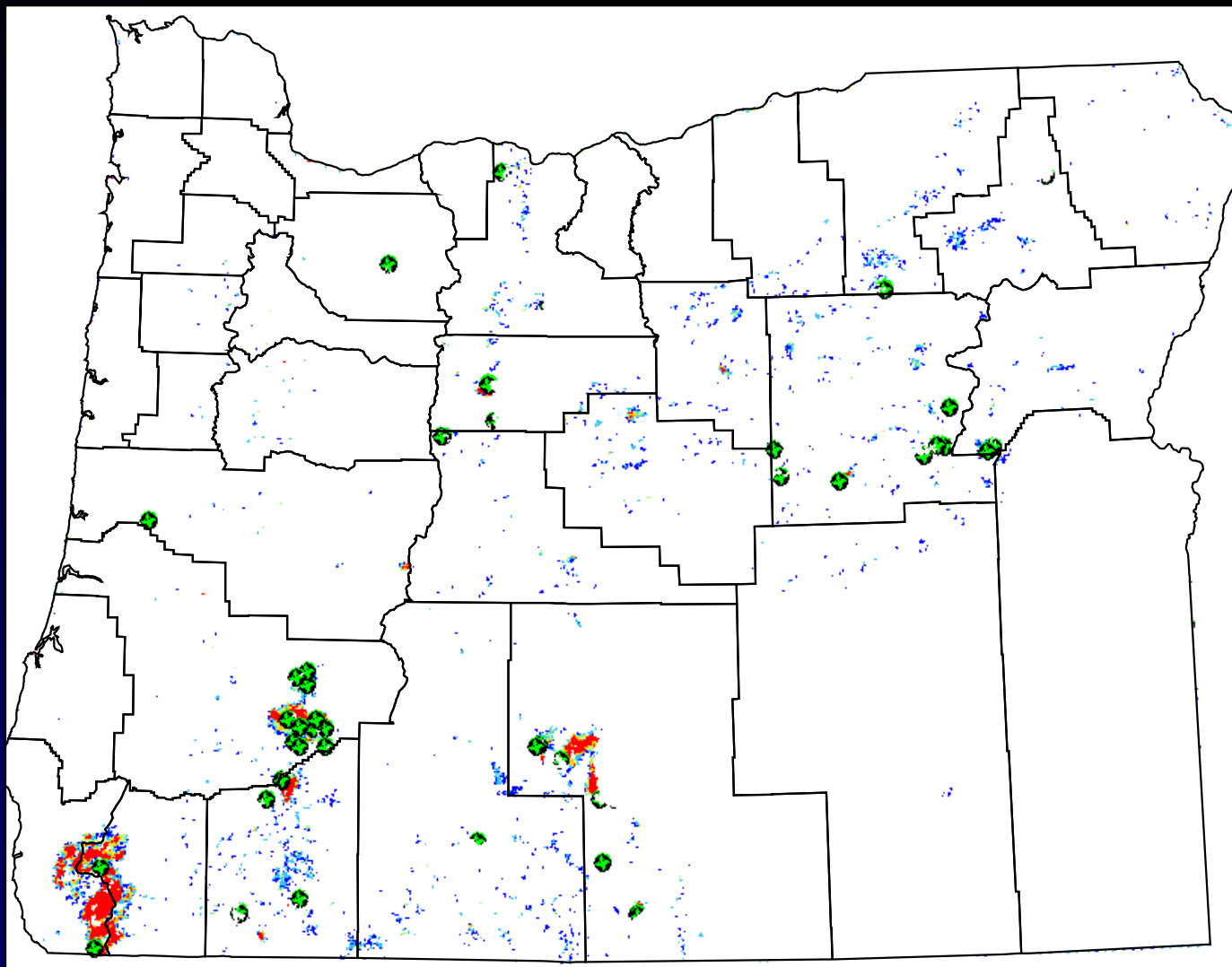
Forest Area

NDVI  
Sept.2002  
from max.  
values



Negative  
Change in  
Forest Areas  
between  
Mean & 2002  
NDVIs

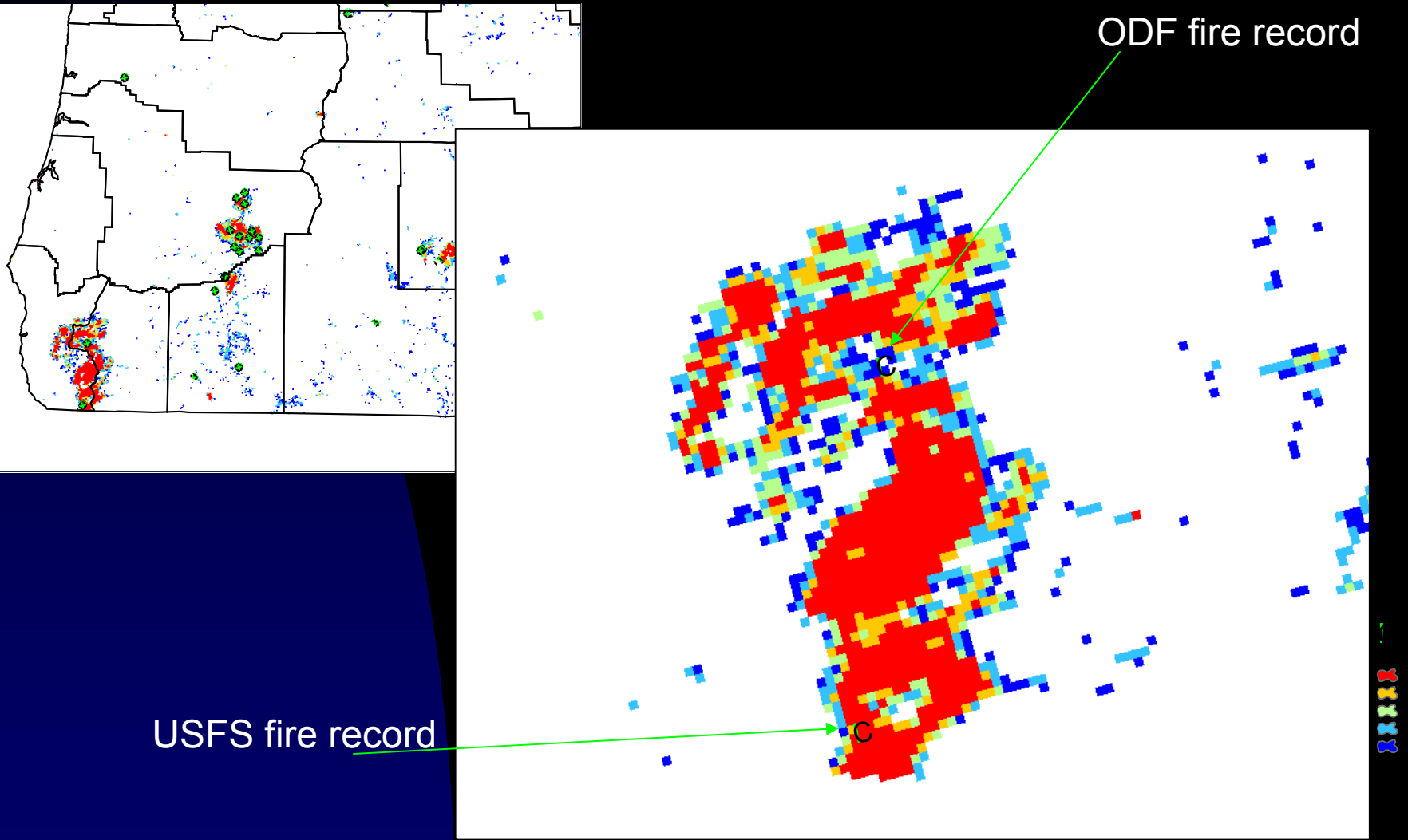




Negative  
Change in  
Forest Areas  
between Mean  
& 2002 NDVIs

Fire records  
come from  
ODF and  
USFS. There  
are a few  
overlapping  
points such  
as the Biscuit  
fire.

ODF and USFS list the Biscuit fire damage total acres as 499,945. We measured ~369,352 acres of change.



# General approach for carbon supply

- Divide lands into three main categories:
  - Rangelands
  - Forests
  - Agriculture
- Identify options for enhancing carbon sequestration for each category
- Estimate:
  - Area available—how much and where
    - Spatial modeling and FIA data base
  - Amount of carbon sequestration over 20, 40, and 80 year periods
  - Costs (opportunity costs, conversion costs, maintenance costs, and measuring costs)

# Carbon Supply Summary:

Afforestation of grazing lands provides the most carbon and at the least cost

Activity	Quantity of C—MMT CO <sub>2</sub>			Area available—M acres		
	20 yr	40 yr	80 yr	20 yr	40 yr	80 yr
<b>Forest management</b>						
Lengthen rotation <\$13.6	<b>2.2-3.5</b>	--	--	0.31	--	--
Increase riparian buffer-width <\$13.6	<b>3.91 (permanent)</b>			0.044		
<b>Grazing lands</b>						
Afforestation <\$13.6	<b>887</b>	3,256	5,639	12.03	17.79	20.76
<\$2.7	33	1,610	4,569	0.20	5.68	13.34



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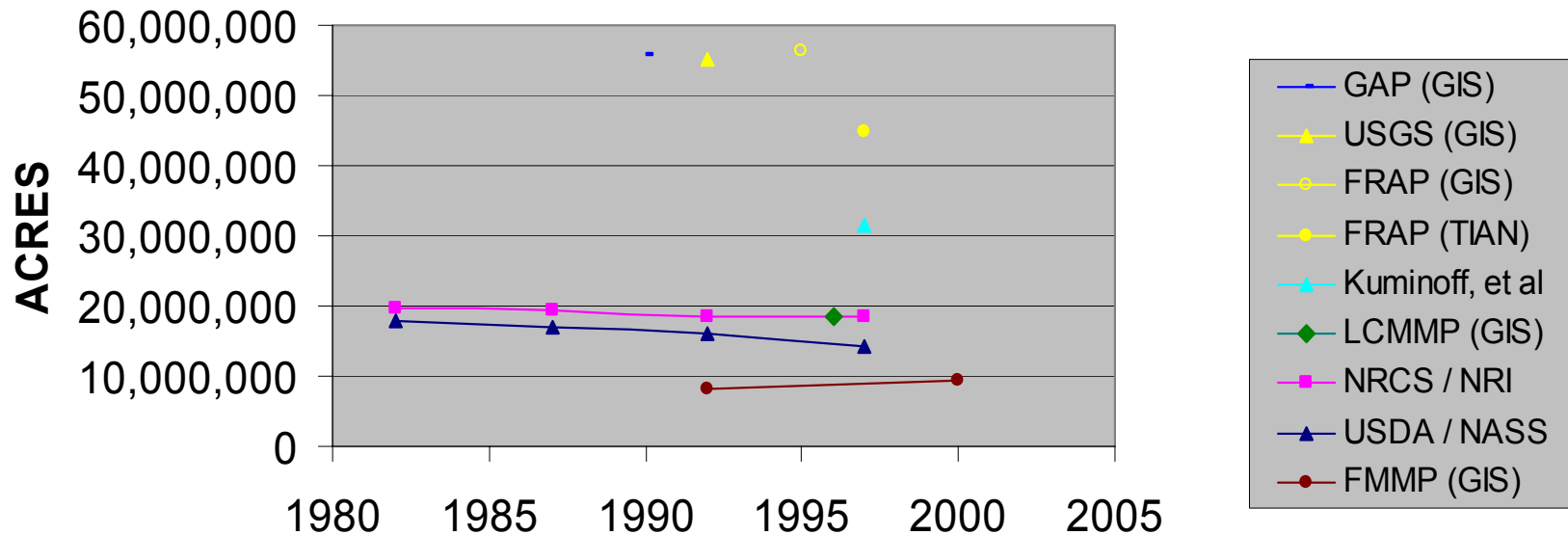
# *Rangelands*

# Convert rangelands to forests

- Determine which rangelands could support forests—suitability analysis
  - Land-use suitability analysis based on
    - I. Biophysical factor-dependent suitability for forest habitats
    - II. STATSGO production map-based models to map suitability for forage and biomass production
- Analysis of rates of carbon accumulation
- Economic analysis



## Areas of rangelands vary by source



Source	Data used	lands included
GAP (GIS)	UCal-SB's GAP analysis veg map reclassified using Melvin George's criteria for rangelands	all California
USGS (GIS)	National Land Cover Data (NLCD) aggregation of herbaceous and shrub classes	all California lands
<u>FRAP (GIS)</u>	CDF-FRAP multisource veg map reclassified using Melvin George's criteria for rangelands	all California
FRAP (TIAN)	statistics taken from Tian-Ting Shih's "Land Base of CA's forests" (1998)	all California
<i>Kuminoff, et al (AIC)</i>	aggregation of USDA/NASS, FMMP, FS and BLM data	all California lands
LCMMP (GIS)	LCMMP vegetation maps aggregation of herbaceous and shrub classes	for 5 LCMMP study areas
NRCS/NRI	sample points	private lands only -mostly rural
USDA/NASS	mailed census from farmers	private and BLM leased lands- agricultural counties predominate
FMMP (GIS)	FMMP maps of California agricultural areas	limited coverage of California's prime farmland counties



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***Suitability analysis for  
rangelands***

# Identify rangelands suitable for conversion to forests

- Analyze the relationship between existing forests and several biophysical factors using GEOMOD =“suitability for forest map”
- Cross-reference suitability map to areas of current rangelands to select areas with afforestation potential.

***Product = map of rangeland areas suitable to support forests***

- Carbon sequestration in forest biomass derived from FIA and literature

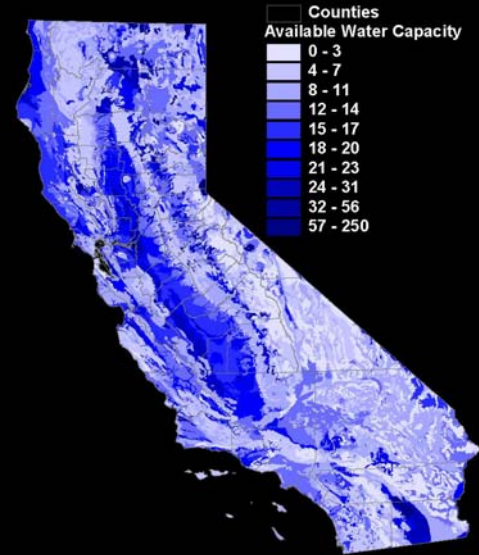
***Product = map of carbon accumulation for afforesting rangelands***

# Prepare factor maps

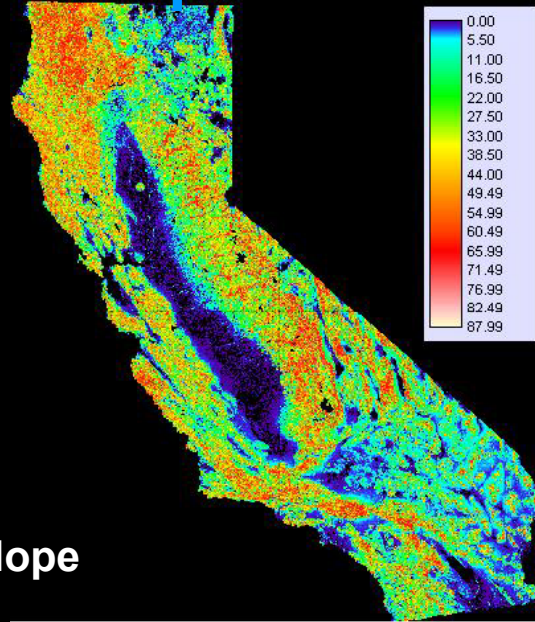
Combine factor maps to determine suitability for afforestation

## Available Water Capacity

(STATSGO interpretation by Miller, D.A. and R.A. White, 1998)

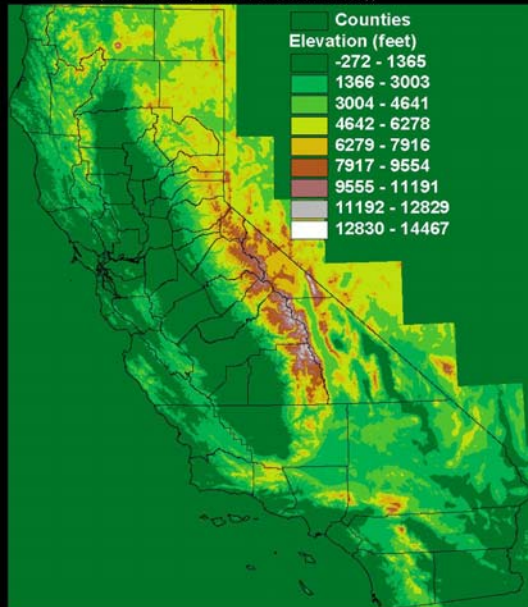


## Slope



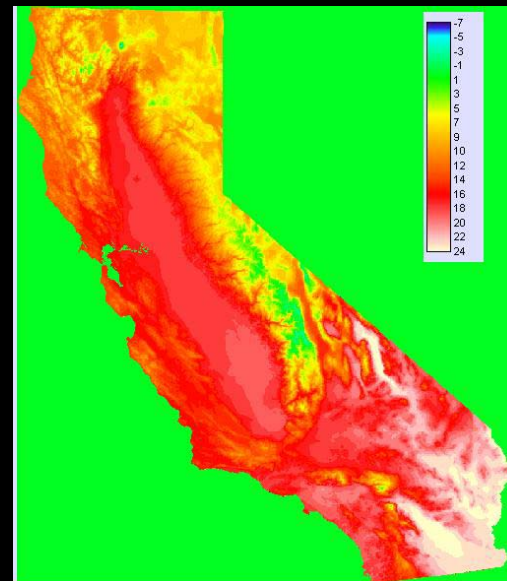
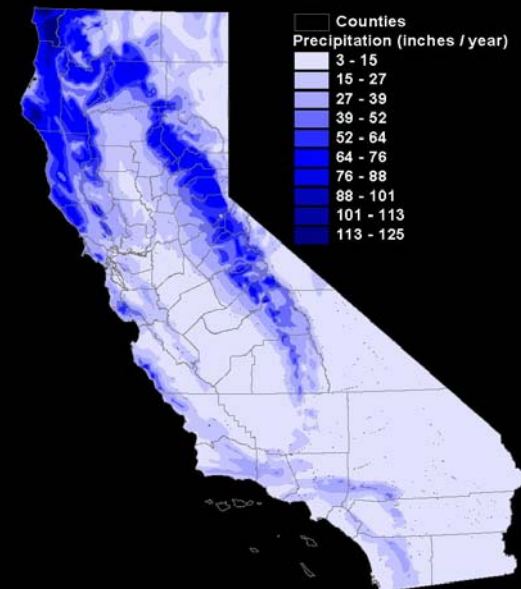
## Elevation

(California Spatial Information Library)



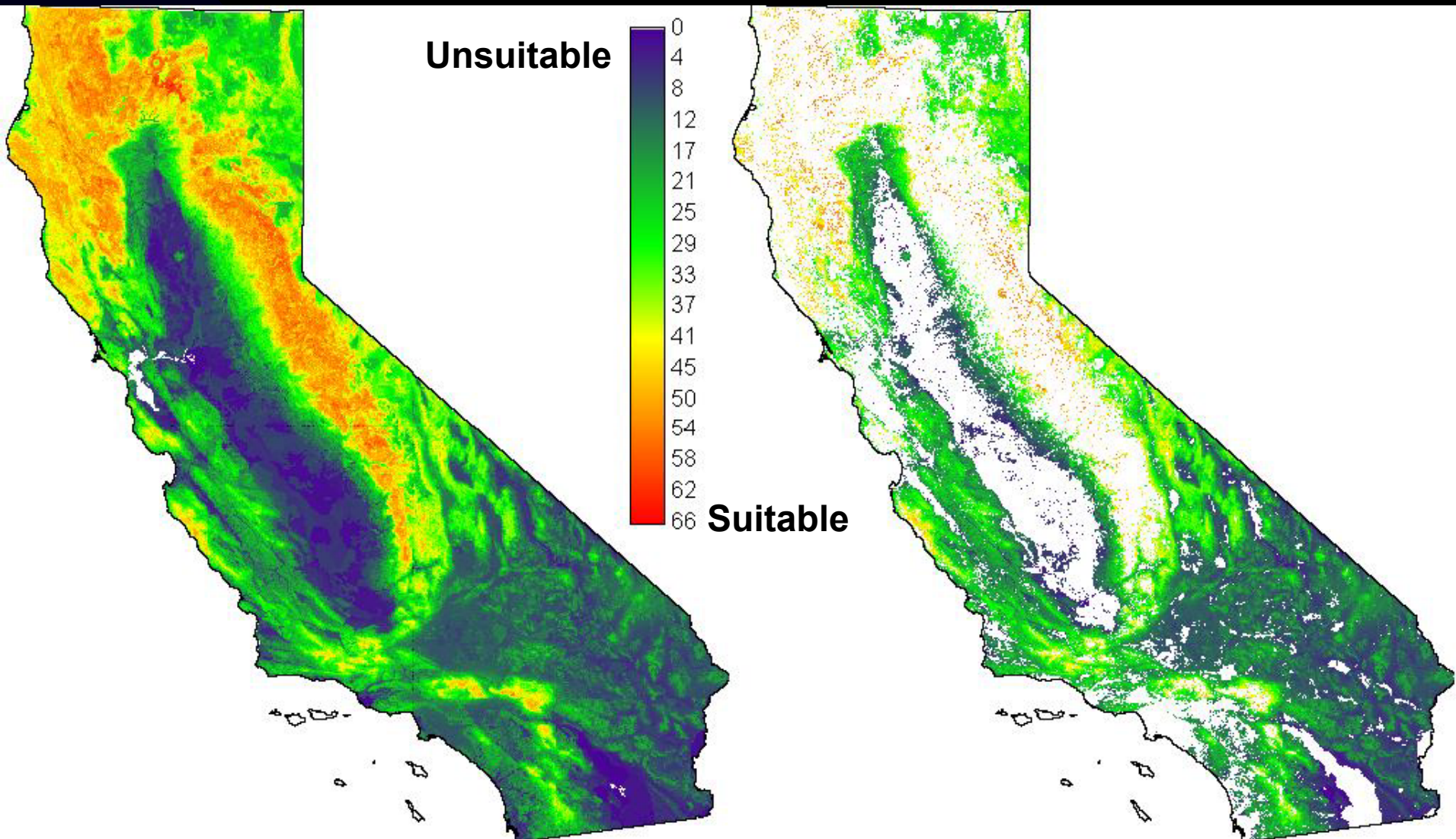
## Mean annual precipitation

(California Spatial Information Library / USGS)



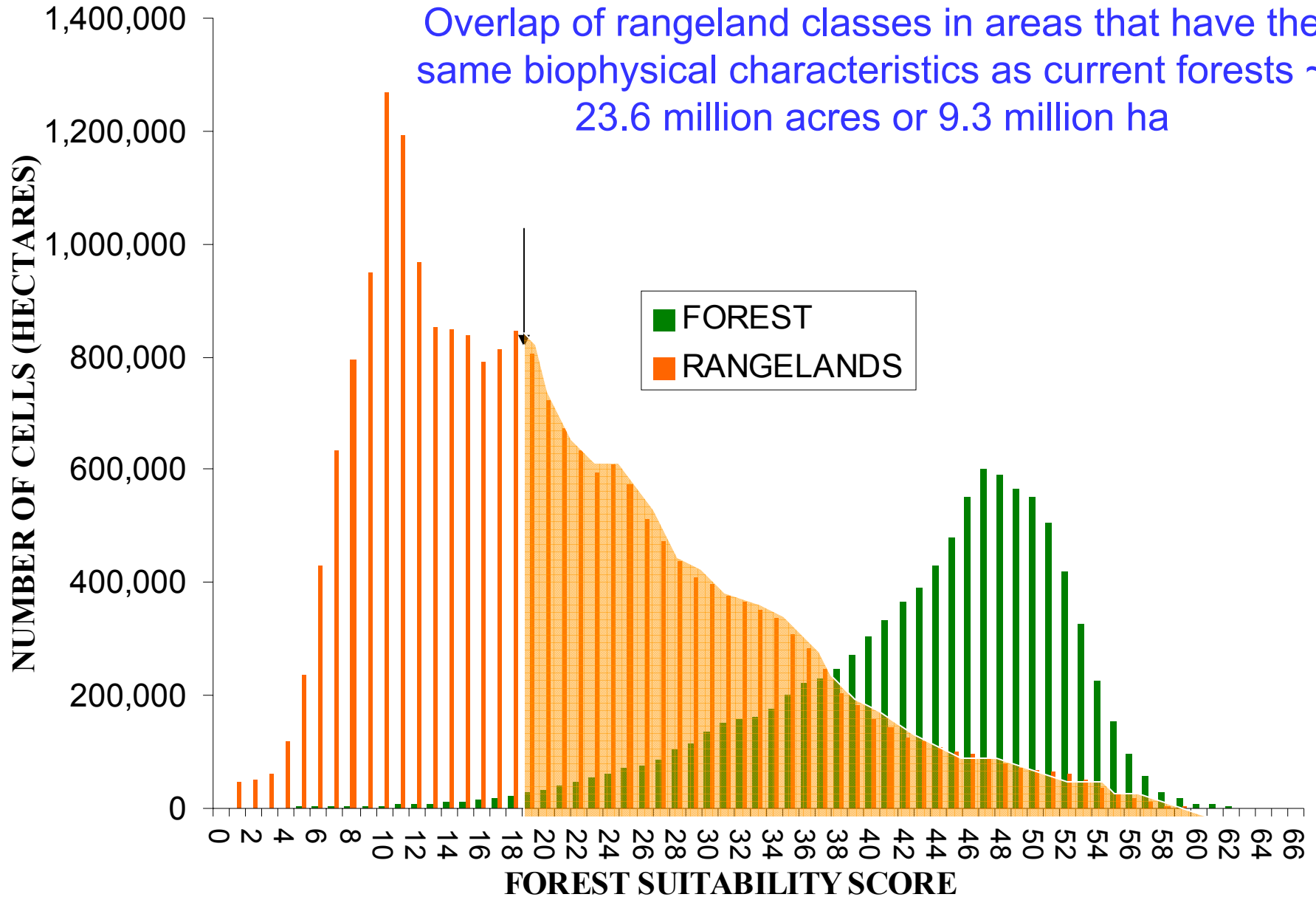
## Mean annual temperature

# All areas suitable for forest growth (left) and rangeland areas suitable for forest growth (right)

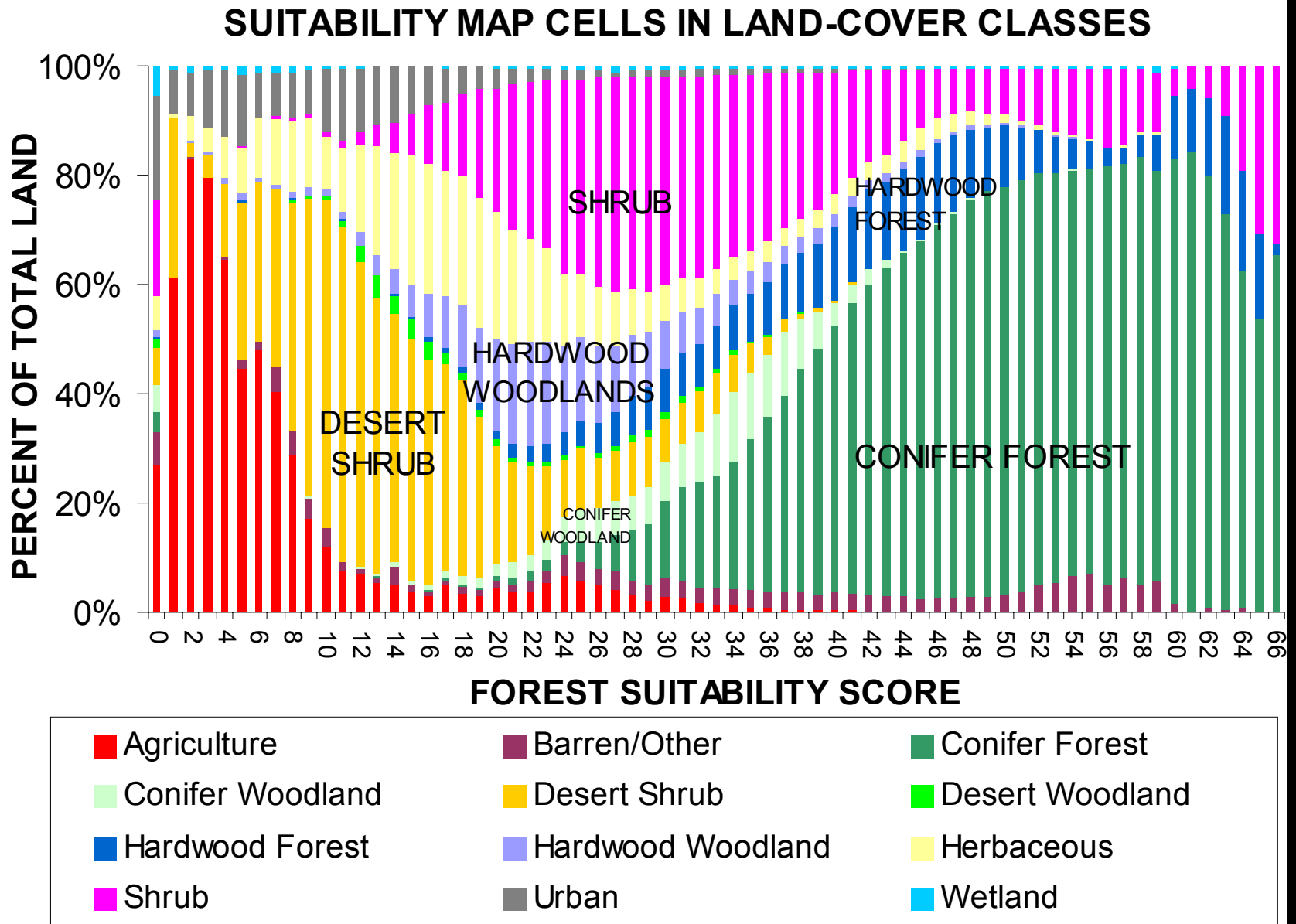


# Area of existing rangelands suitable for forest growth

Overlap of rangeland classes in areas that have the same biophysical characteristics as current forests ~ 23.6 million acres or 9.3 million ha

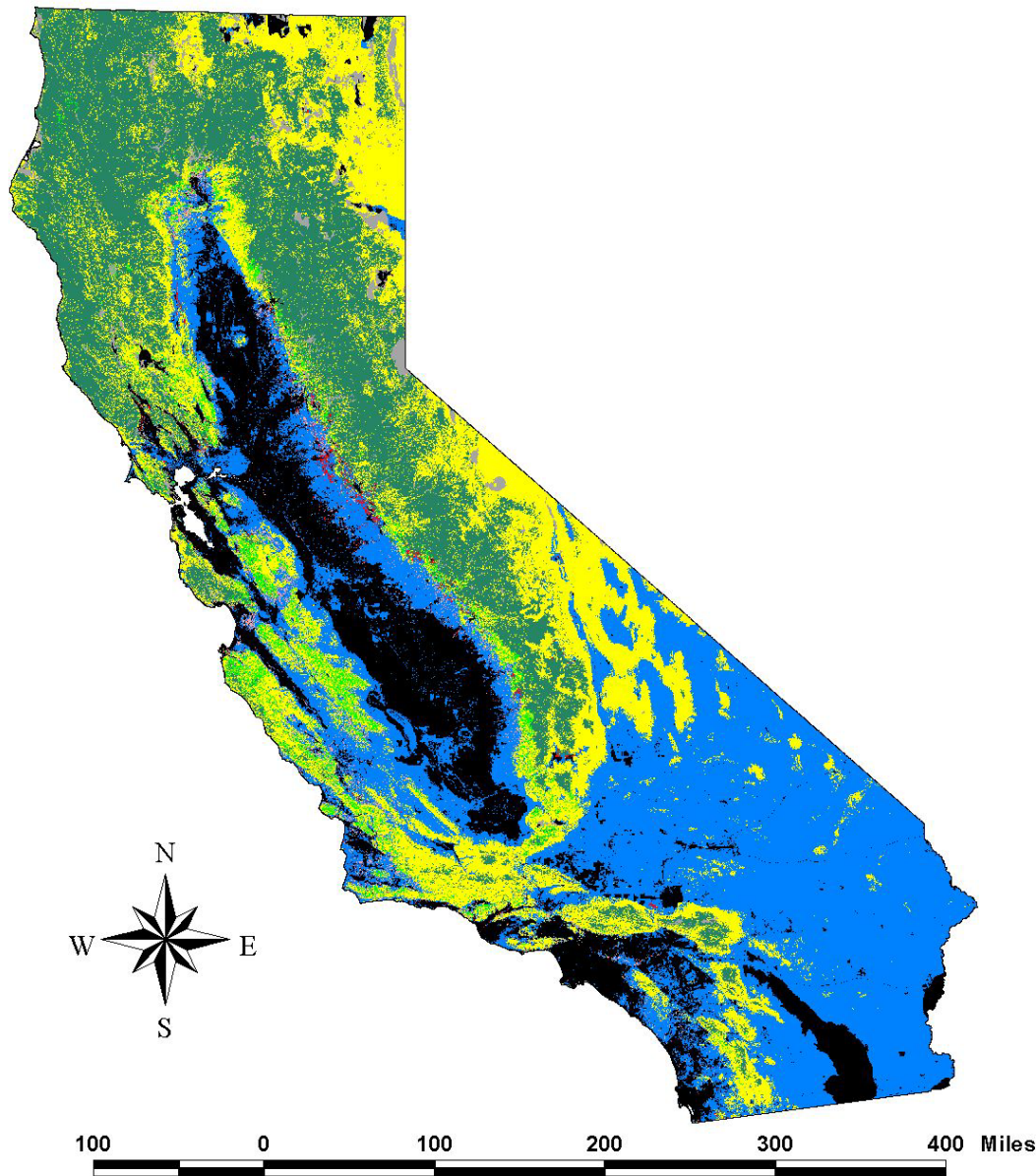


# What type of forests are suitable?



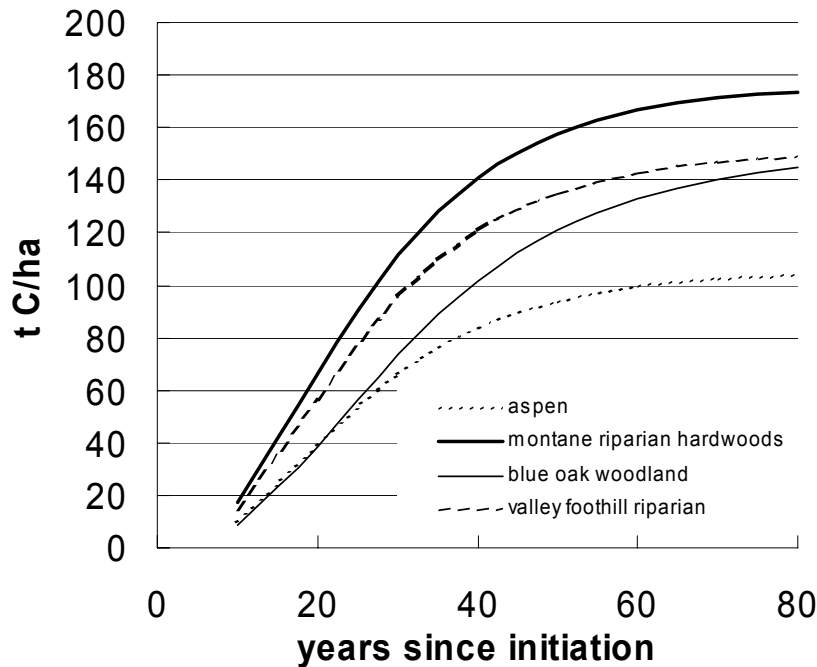
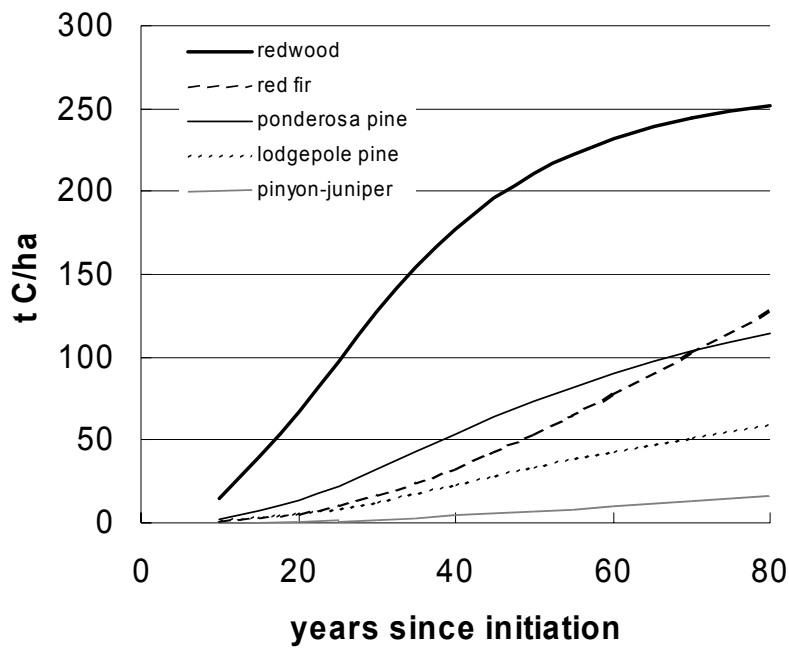
# Map of rangeland areas (in yellow) suitable for afforestation

• *Represent about 24 million acres or 23% of State area*

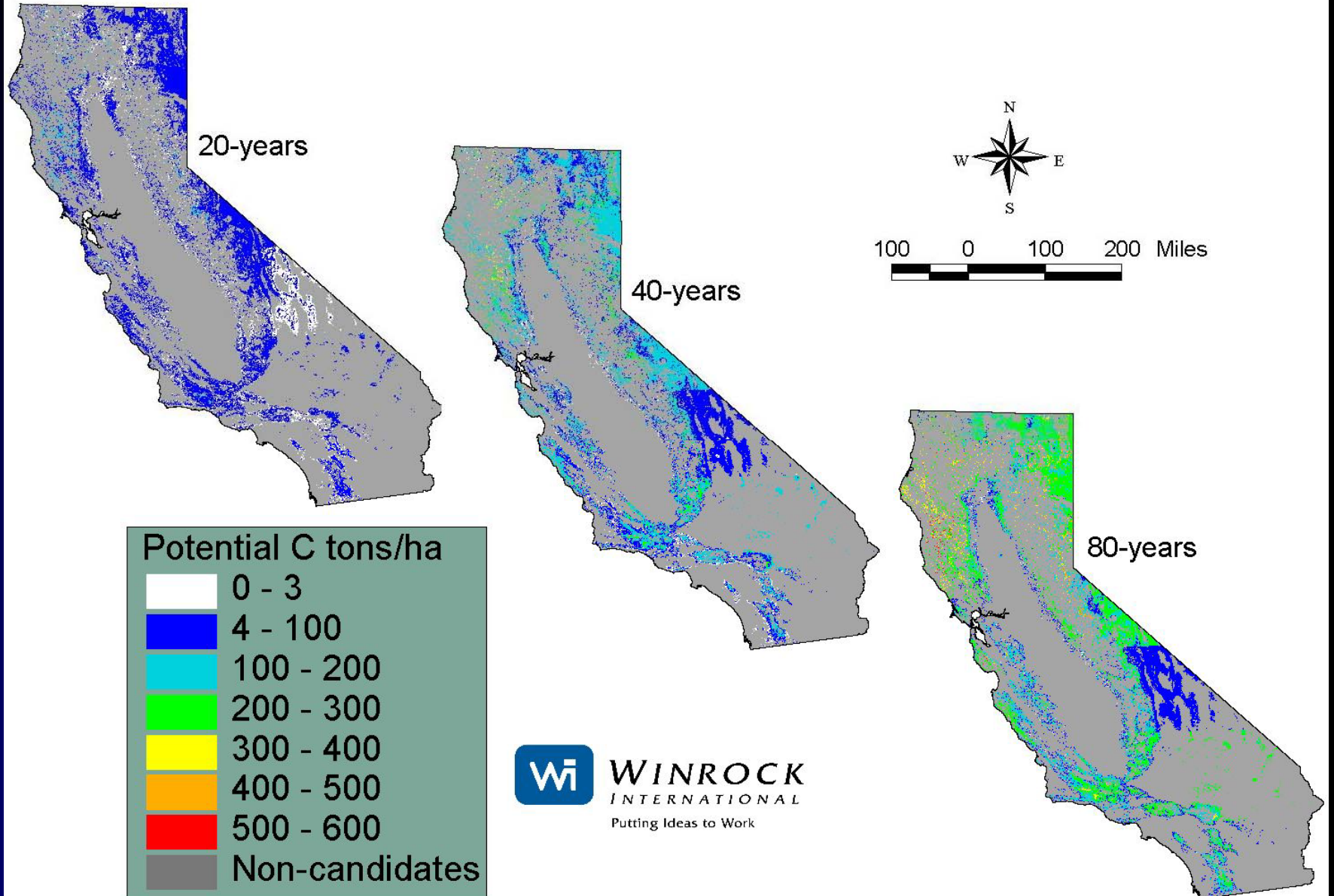


■	non-suitable Ag / Urb / Aquatic:	6,429,000 hectares
■	non-suitable forestlands:	124,000 hectares
■	non-suitable rangelands with CC > 40%:	378,000 hectares
■	non-suitable rangelands with CC < 40%:	13,477,000 hectares
■	suitable Ag / Urb / Aquatic:	790,000 hectares
■	suitable forestlands:	9,472,000 hectares
■	suitable rangelands with CC > 40%:	813,000 hectares
■	suitable rangelands with CC < 40%:	9,364,000 hectares

# Potential biomass-carbon accumulation in conifer and hardwood forests



# Net carbon accumulation applied to potential woody-species distributions over three time periods



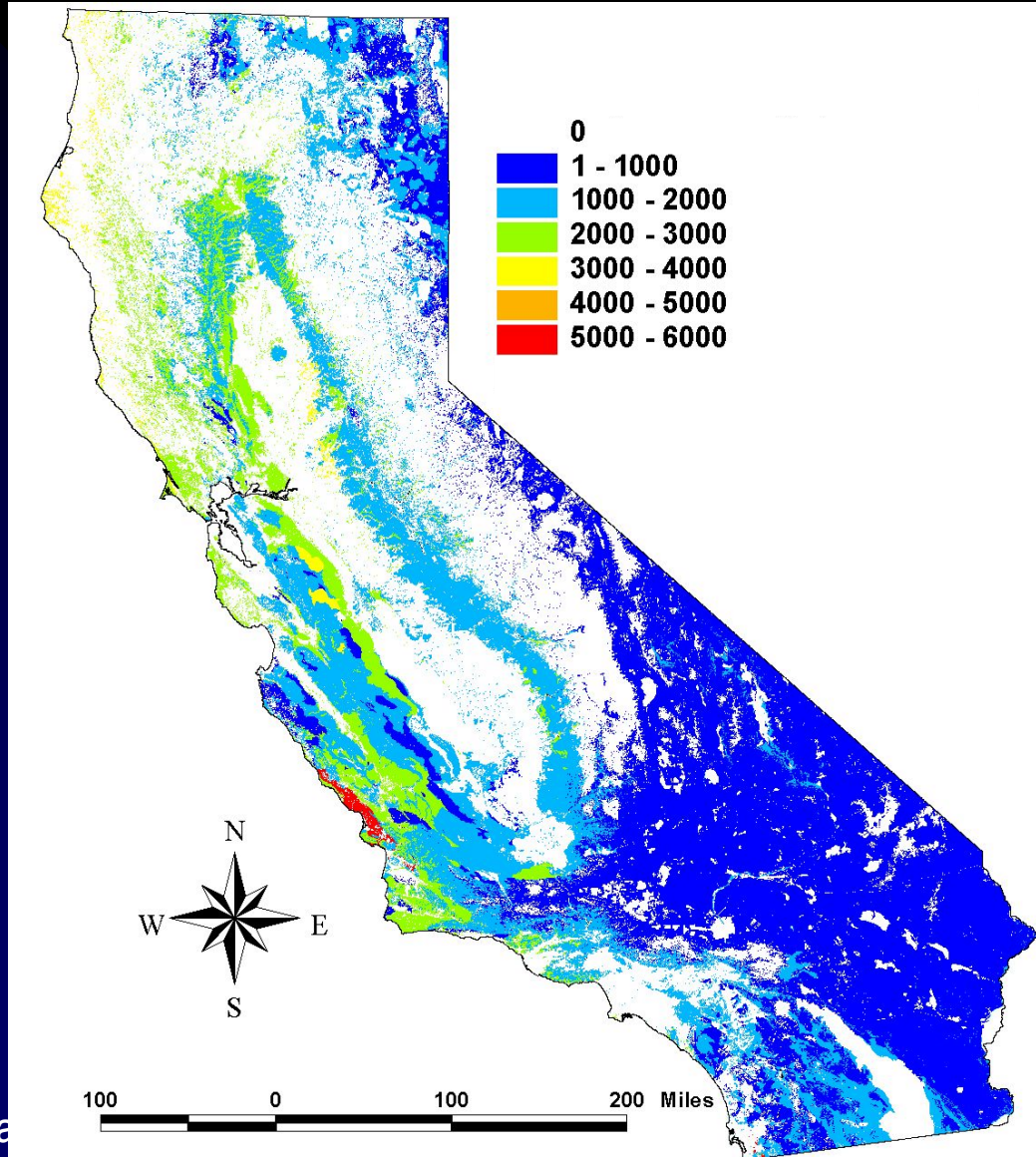
# Opportunity Cost

- Using the same biophysical factors, a model was used to extrapolate STATSGO forage productivity data samples to a state-wide coverage.

*Product = map forage production*

- Economic analysis of forage value derived from national databases and field interviews
  - Mean annual profit/cow
  - Number of cows supported based strongly on forage production (1 animal unit month for CA = 791 lbs)

# Estimated forage productivity across rangeland classes (lbs per acre per year)

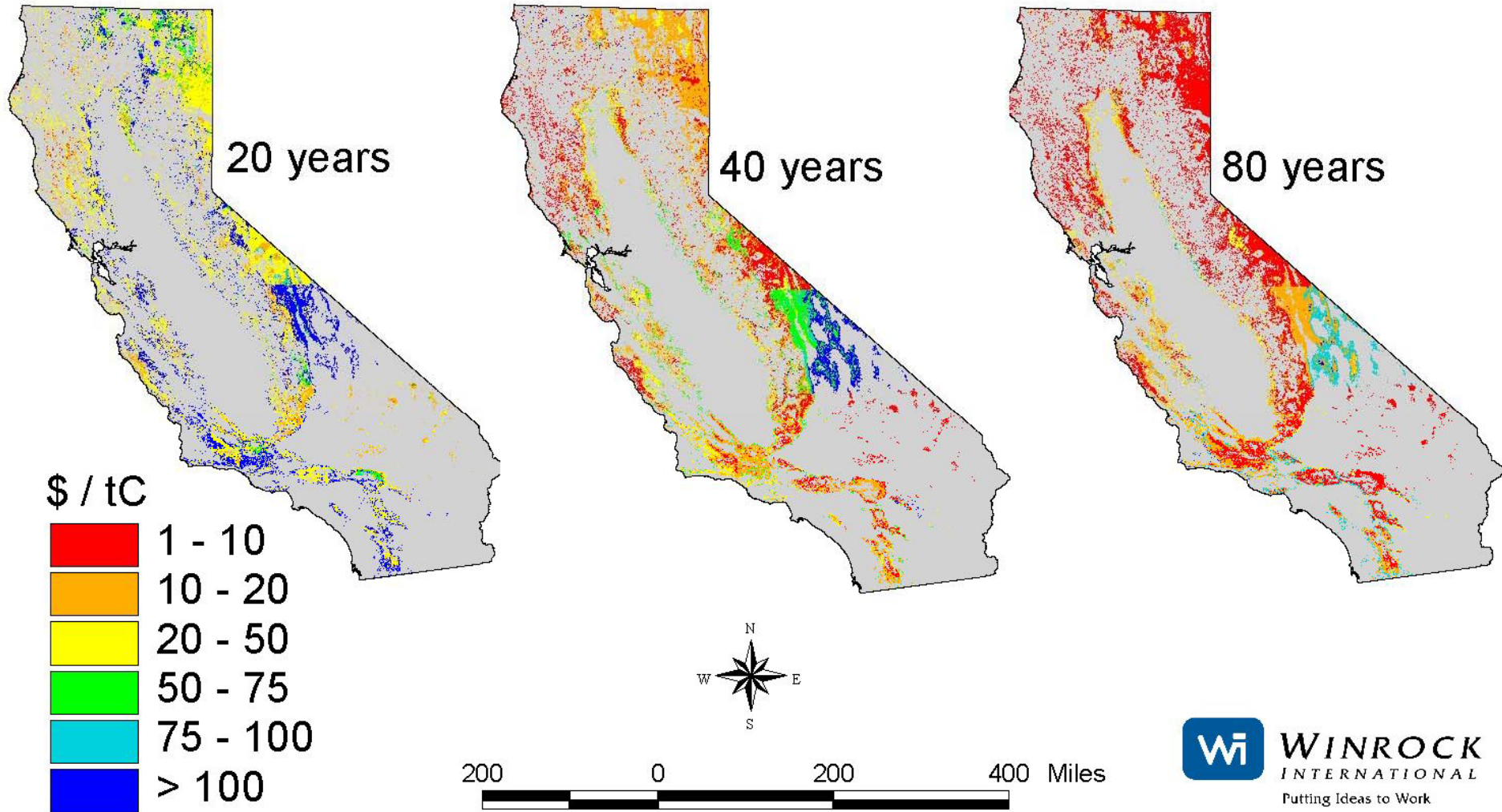


This map used to estimate number of cows per acre based on need for 9,492 lbs of forage per year for range-fed cattle and opportunity cost based on profitability per cow

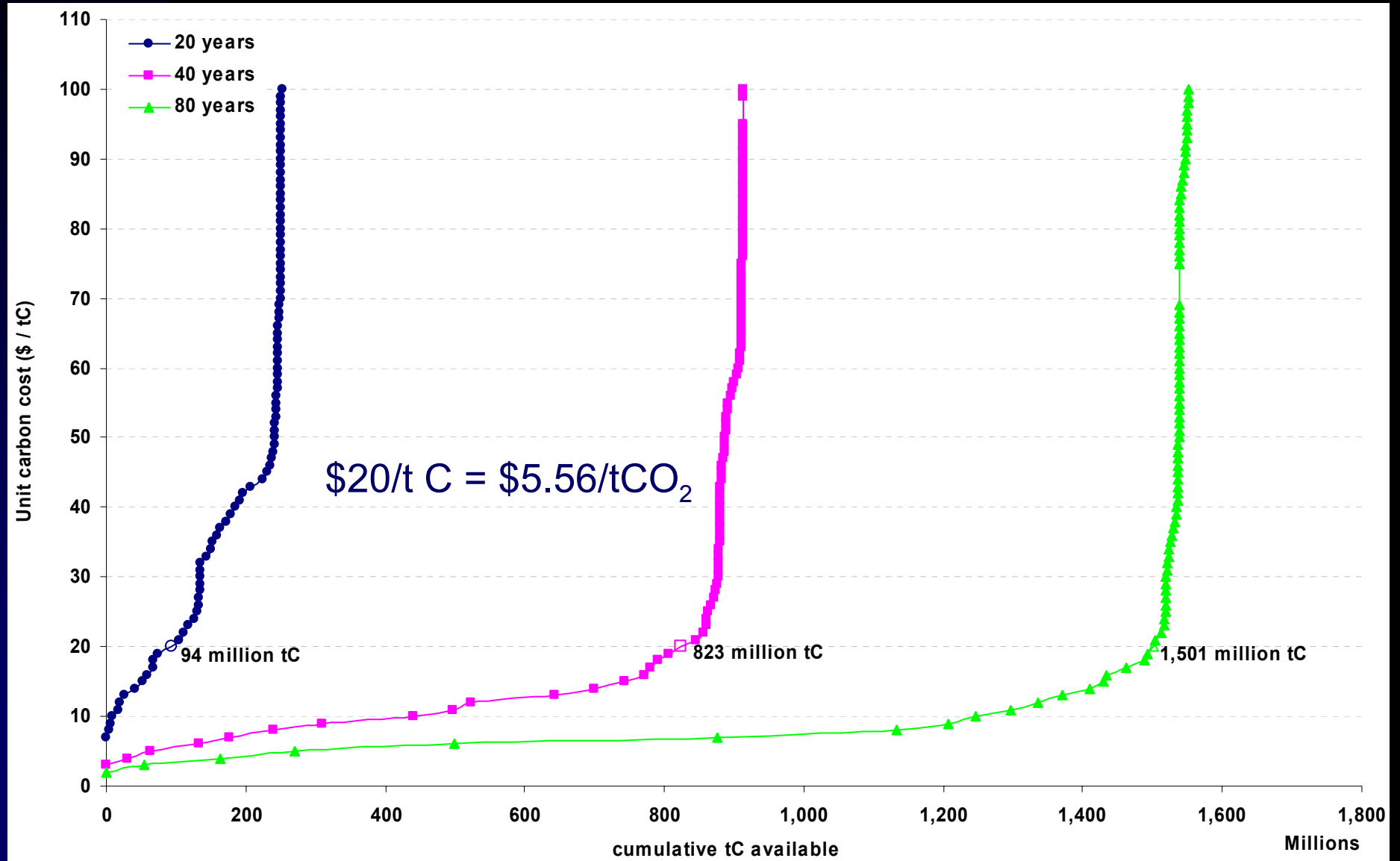
# Cost of Carbon Sequestration

- Total cost, as net present value over life of duration of activity = opportunity cost + conversion cost + measuring&monitoring cost + maintenance cost
  - Conversion costs—one time cost for planting trees (about \$450/ha)
  - Measuring and monitoring costs over life of activity (about \$2.5/ha annually)
  - Maintenance costs—replanting, fencing, chemical additions (about \$20/ha annually for 5 years)

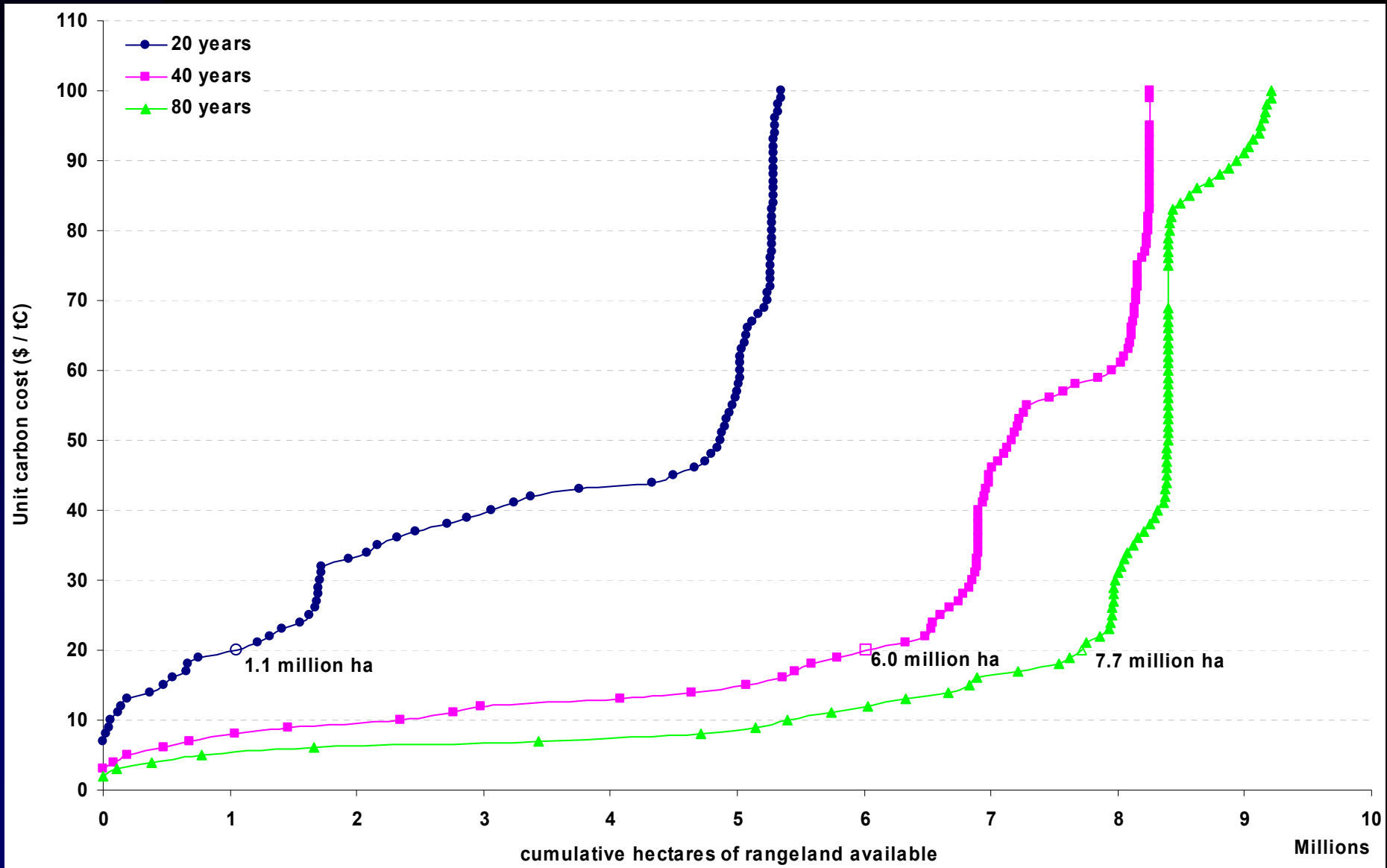
# Cost of carbon sequestration through afforestation of California rangelands



# Carbon supply curves for afforestation activities for 20, 40 and 80 years



# Area of rangelands for afforestation activities at different price points

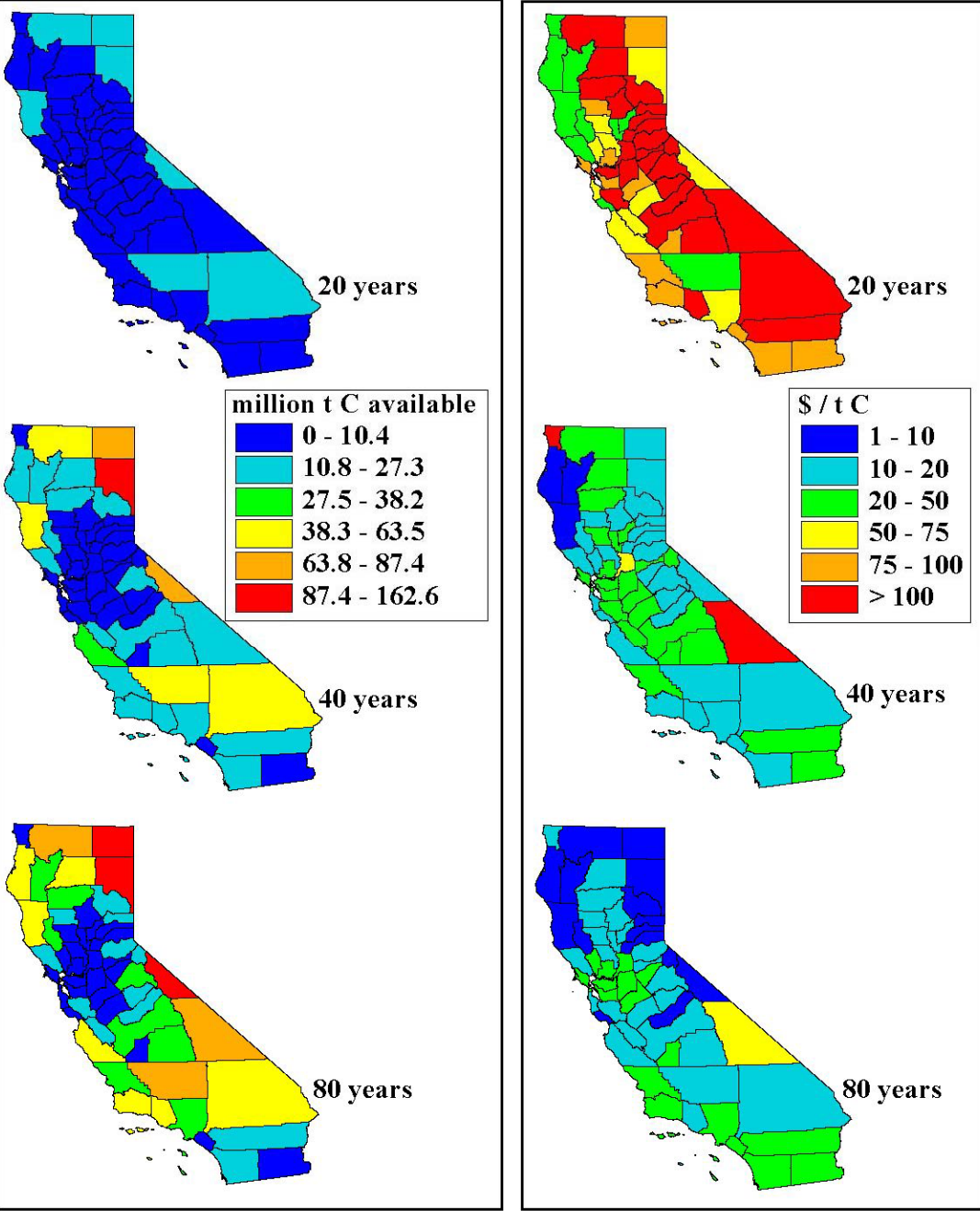


# Quantity of CO<sub>2</sub> and area of rangeland for cost of up to \$5.5/t CO<sub>2</sub>(\$20/t C)

<b>Life of Activity</b>	<b>Carbon Supplied (million tons CO<sub>2</sub>)</b>	<b>Rangeland (million ac)</b>	<b>Percentage of Suitable Rangeland</b>
20	338	2.72	14%
40	3,018	14.8	68%
80	5,504	19.0	83%

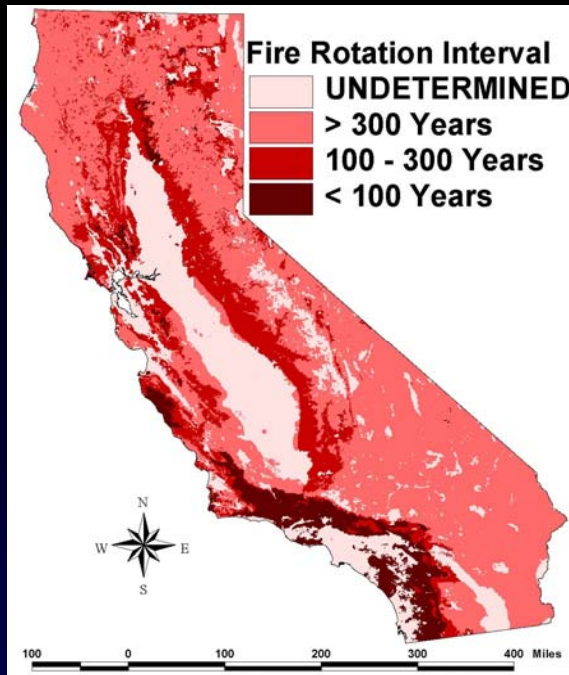
# Total carbon sequestered by afforestation of rangelands and area-weighted average cost \$/t C and after 20, 40 and 80 years

To convert to \$/ metric t CO<sub>2</sub>, divide by 3.6



200 0 200 400 Miles

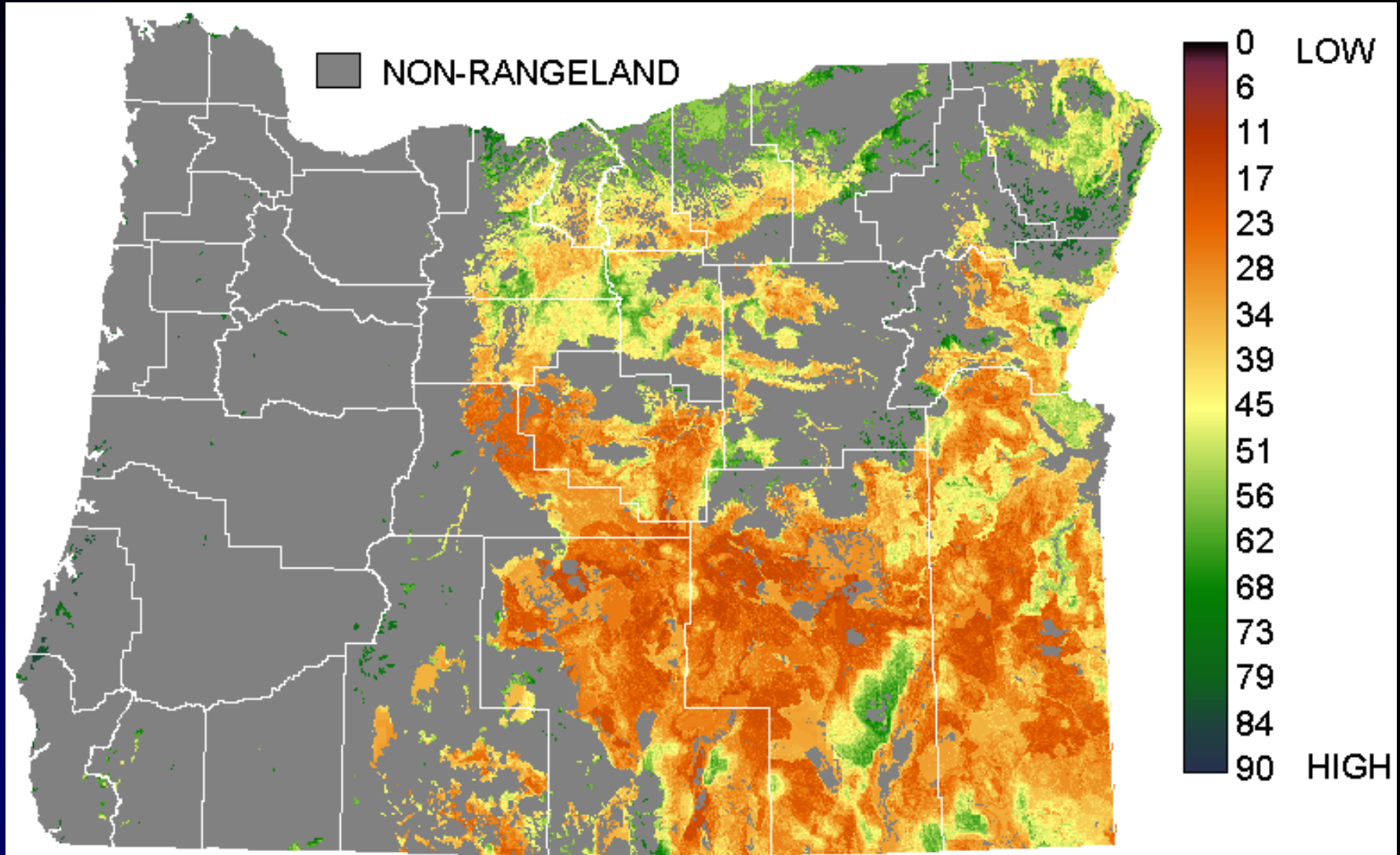




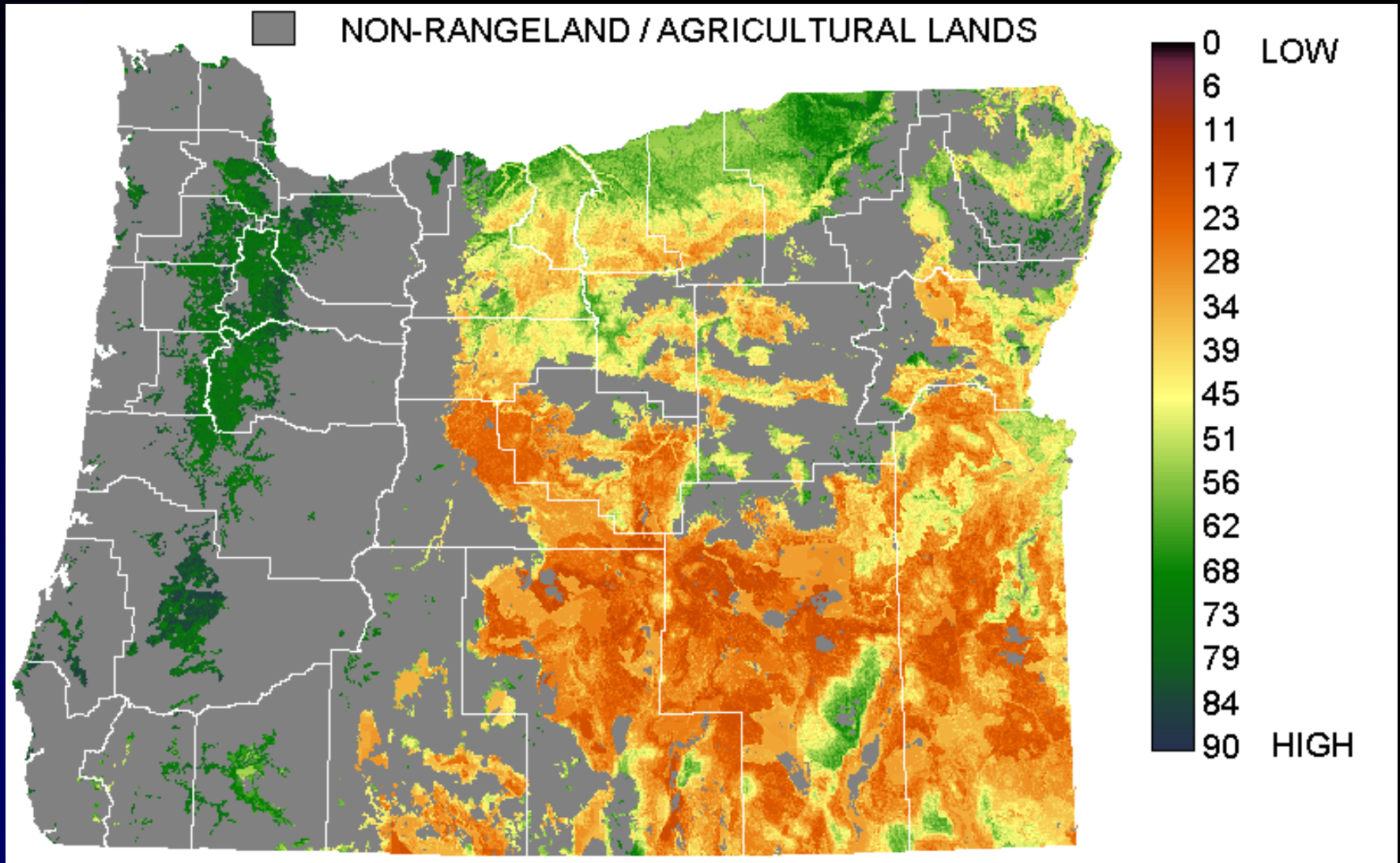
# Percentage of rangelands suitable for afforestation at various levels of fire risk

Fire rotation interval	% of area	20-year	40-year	80-year
UNDETERMINED	8%	\$107.53	\$28.14	\$14.32
MODERATE	49%	\$120.01	\$59.53	\$20.25
HIGH	29%	\$111.65	\$23.16	\$15.24
VERY HIGH	15%	\$122.07	\$15.97	\$22.91

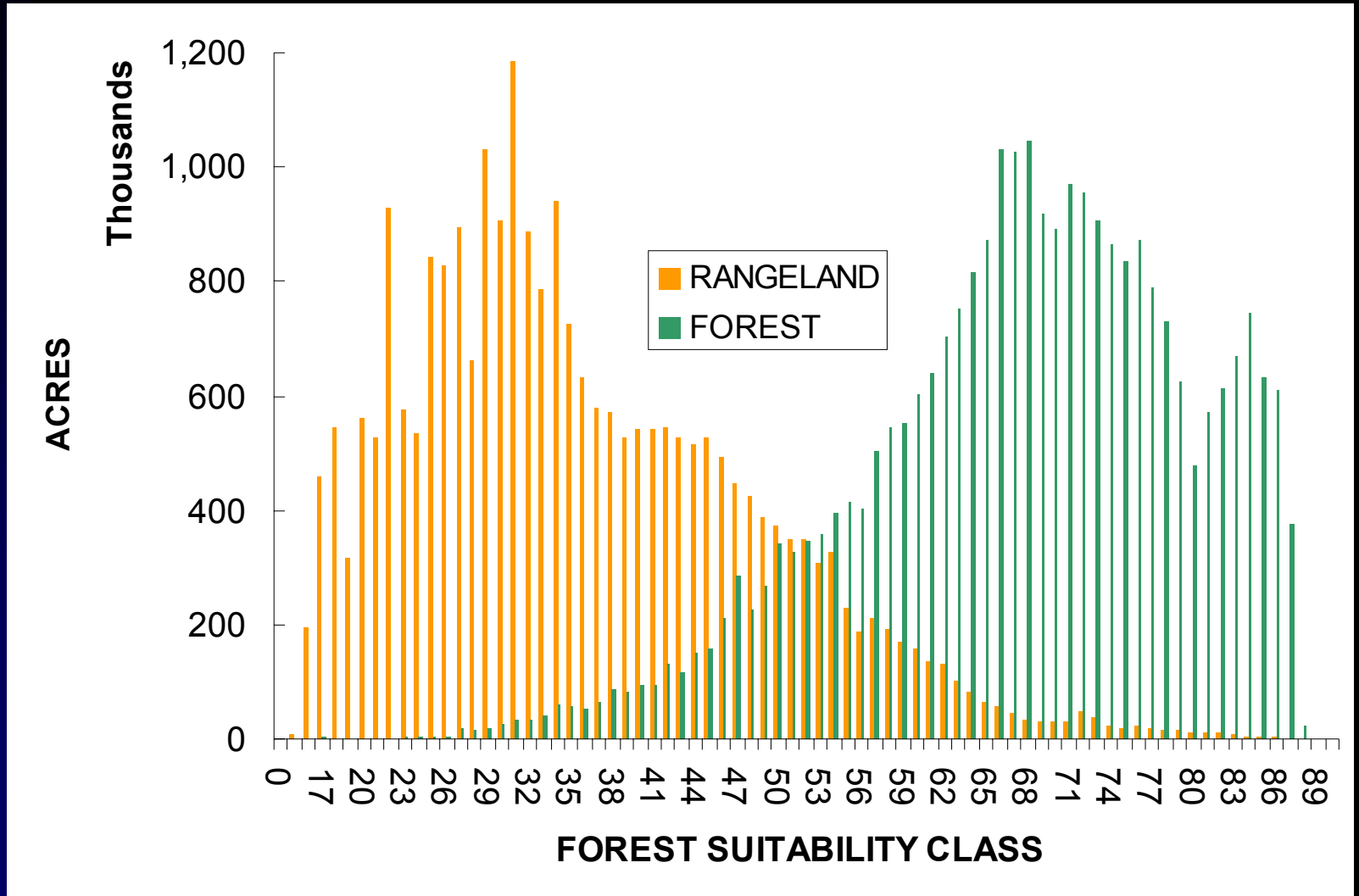
# Oregon Grazing Lands Suitable for Afforestation



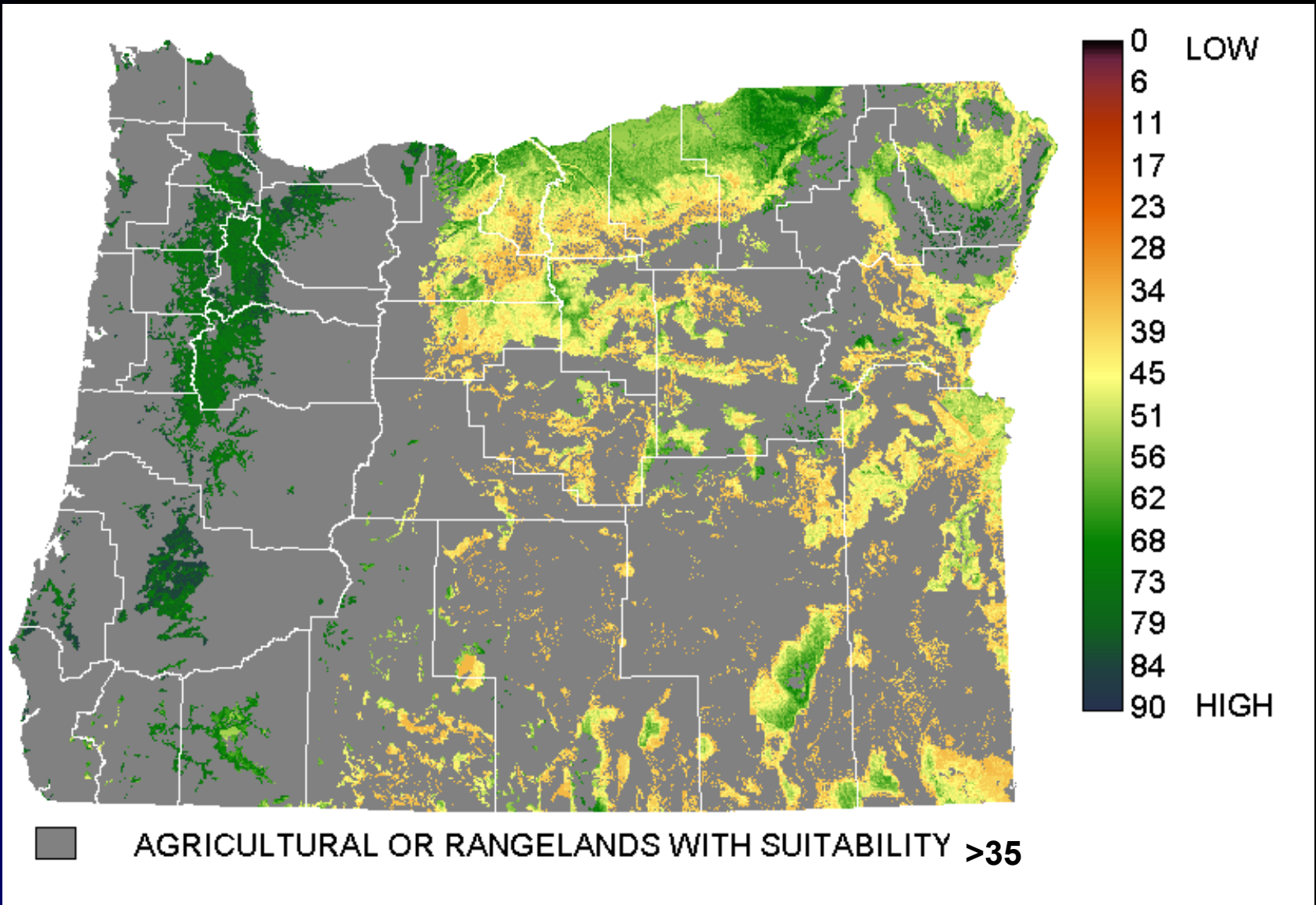
# Oregon Agricultural and Grazing Lands Suitable for Afforestation



# Oregon Suitability for Forest versus Rangeland



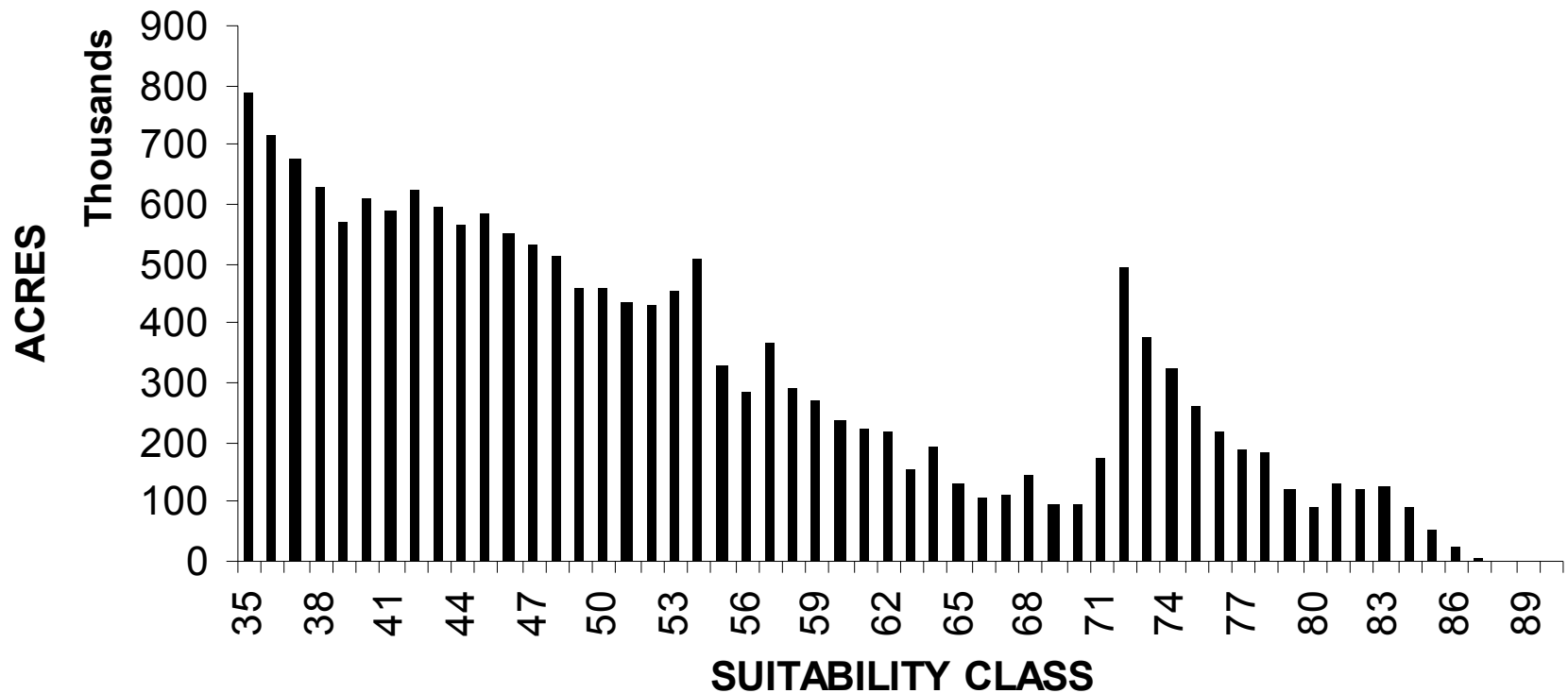
# Suitability Greater Than 35



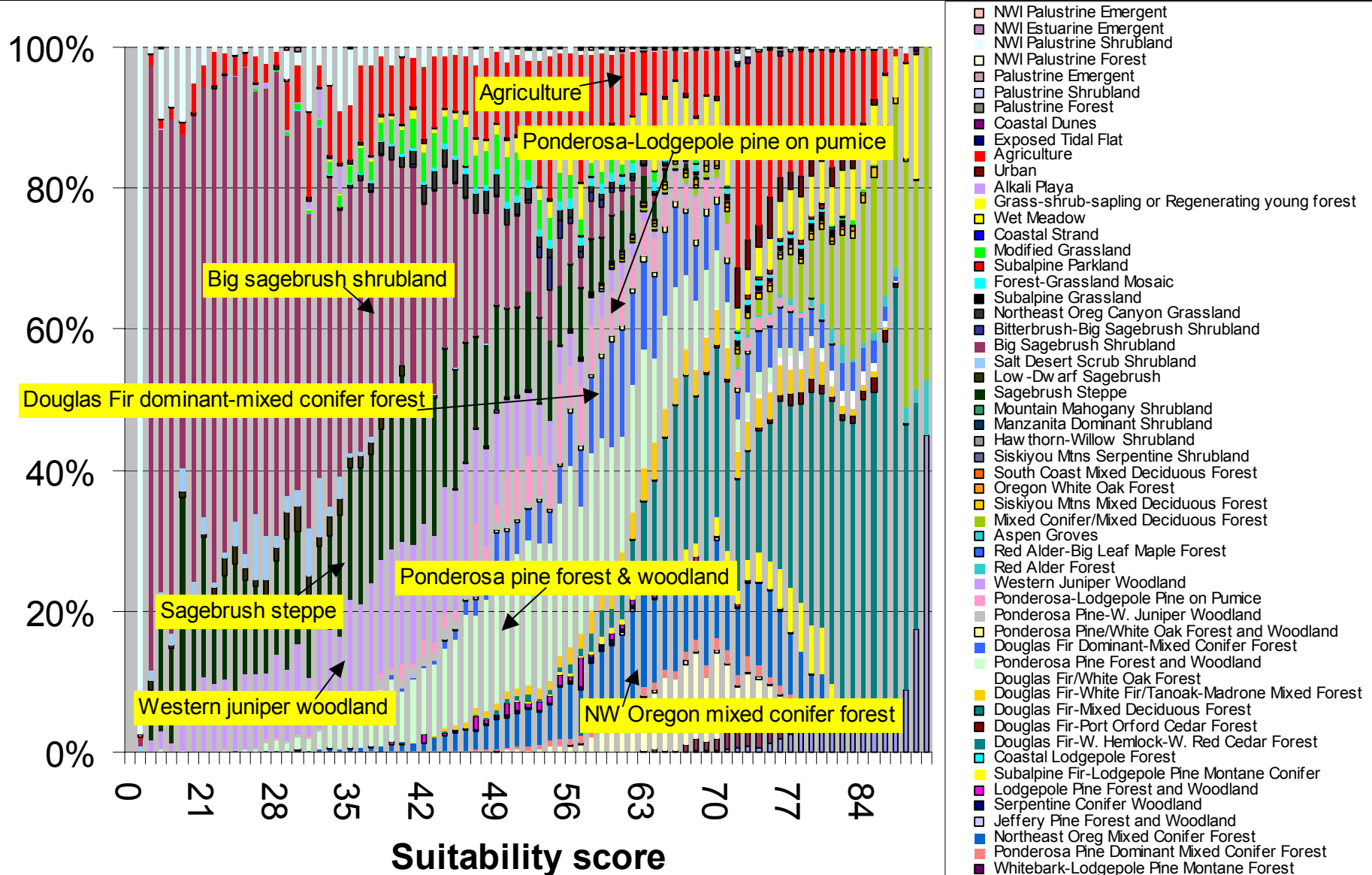
# Oregon Potential Afforestation Area

## CANDIDATES FOR AFFORESTATION

17,539,369 acres



# Species Mix for Various Suitability Scores



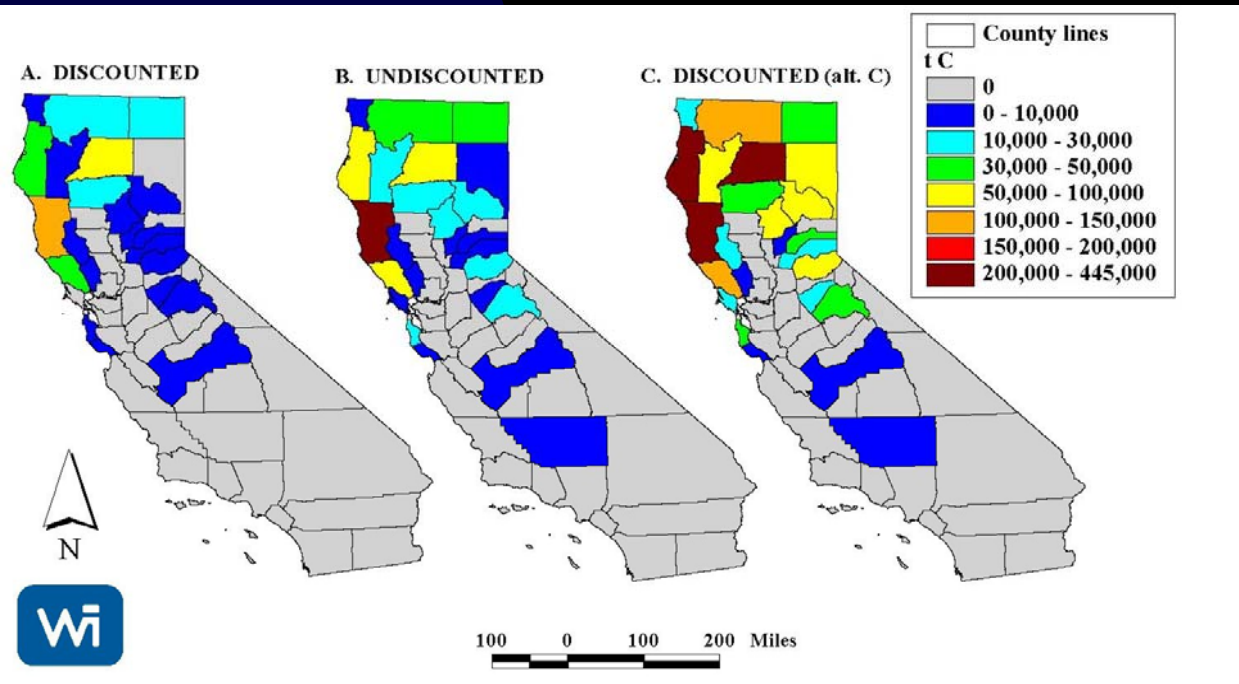
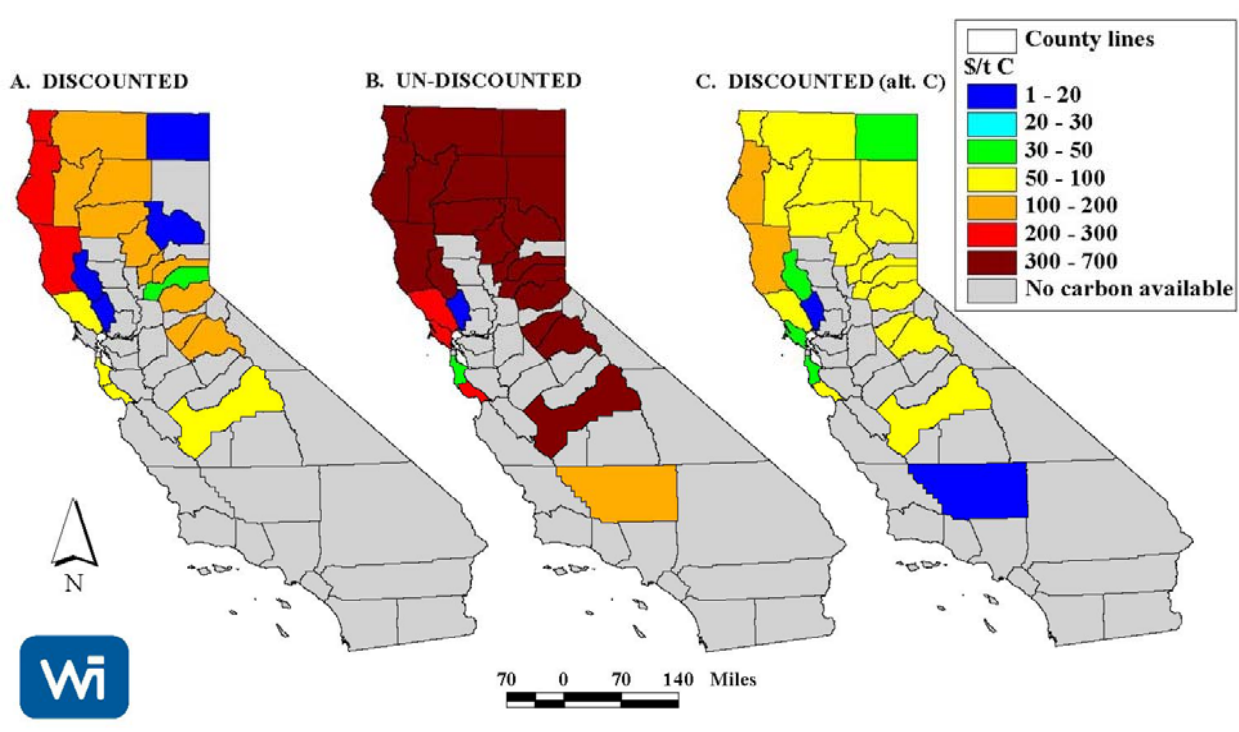


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# *Forests*

# Four alternatives analyzed:

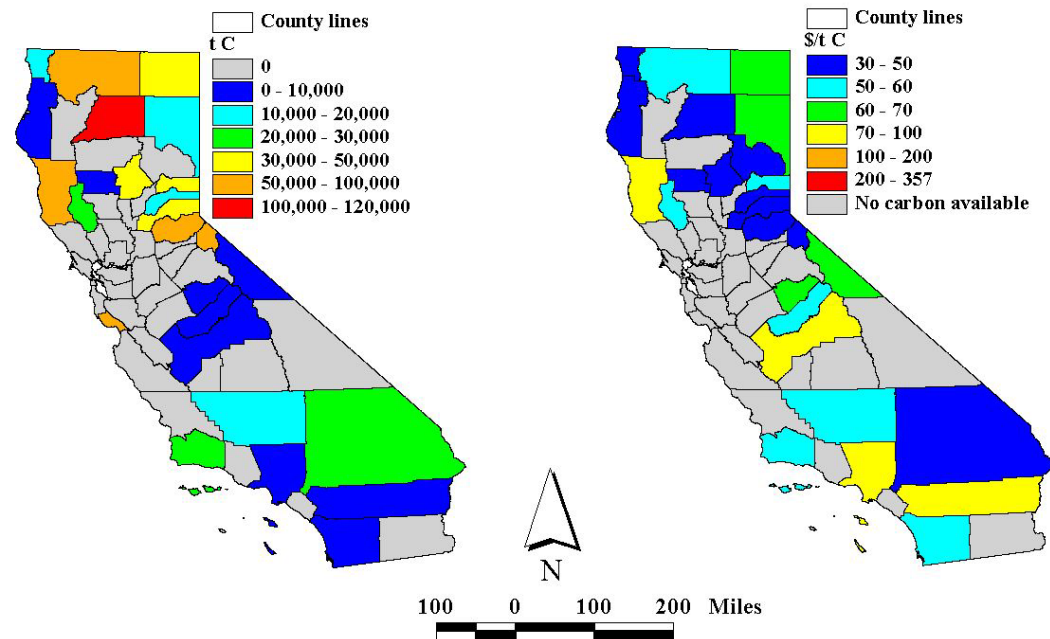
- Estimates were derived for 20 year and/or permanent contract periods:
  - ✓ (1) allowing timber to age, i.e. lengthening rotation time;
  - ✓ (2) increasing the riparian buffer zone by an additional 200 feet;
  - (3) changing traditional clear cuts to group selection cuts—*little to no increase in carbon sequestration*;
  - (4) forest fuel reduction to reduce hazard of catastrophic fires, and subsequent use of biomass in power plants



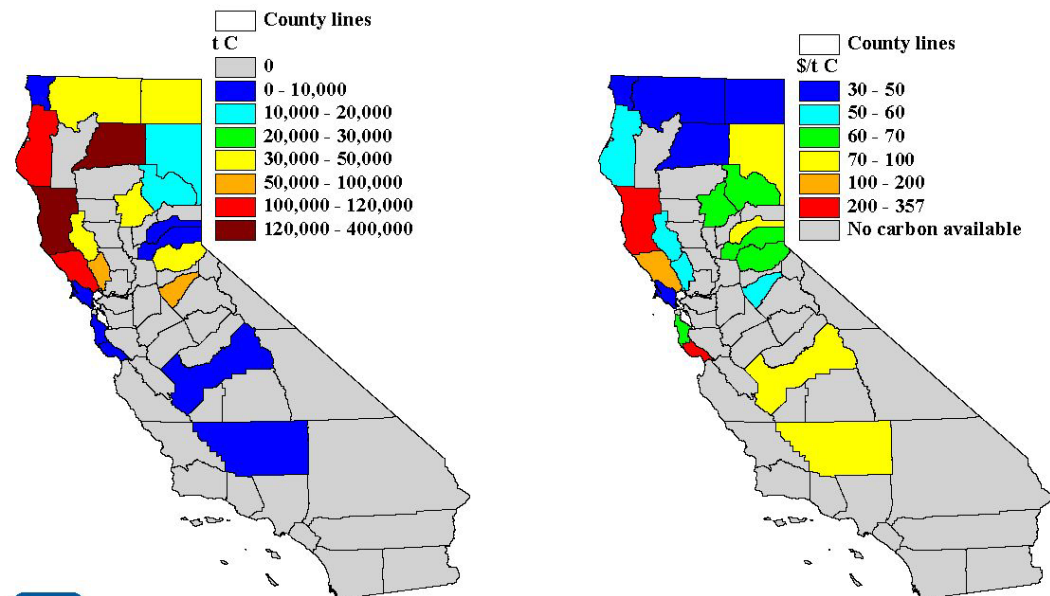
# Alternative 1: County level costs and quantities of carbon for lengthening the forest rotation time by 5 years

The two methods of discounting carbon (A. and C.) are related to how the emissions from the initial harvest are counted.

## A. PUBLIC LANDS



## B. PRIVATE LANDS

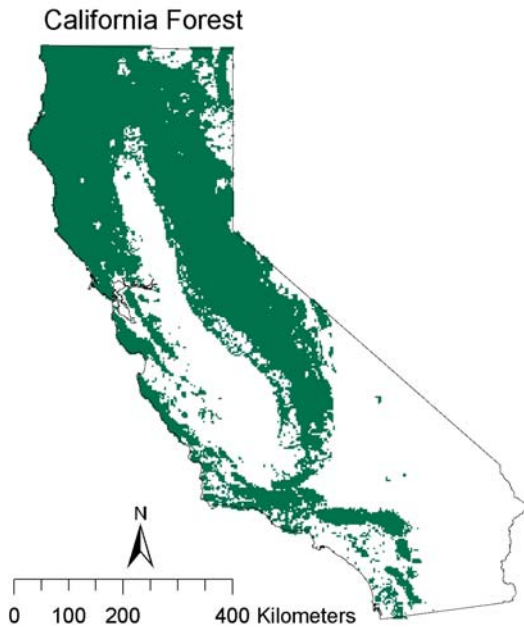


**Alternative 2:**  
County level quantity  
of carbon and cost by  
extending riparian  
buffers 100 feet on  
both sides of  
perennial streams on  
public and private  
lands.

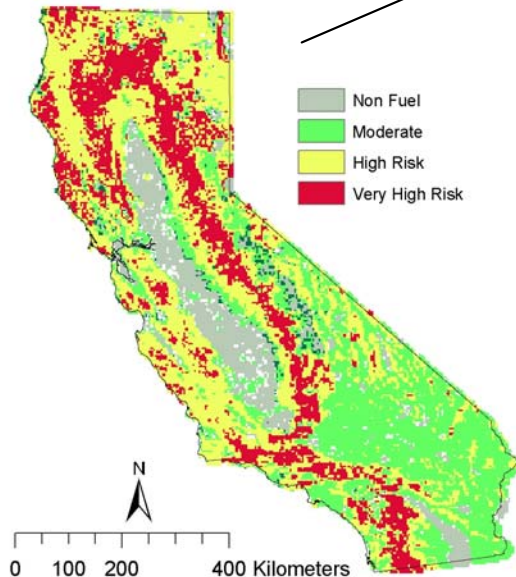
# Alternative 3: forest fuel reduction

- Estimate the areas and carbon stocks of forests suitable for fuel reduction to reduce their fire risk and their location relative to existing power plants
- Develops a “Suitability for Potential Fuel Reduction (SPFR)” score for high fire risk forests based on slope, distance to biomass plants, and distance from roads
- SPFR scores rank areas feasible for transporting the removed fuels to biomass power generating plants

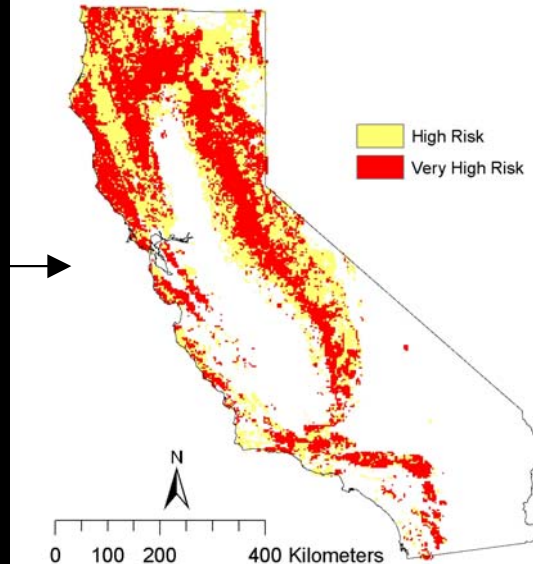
# Distribution of California's forests at high and very high risk for catastrophic fire



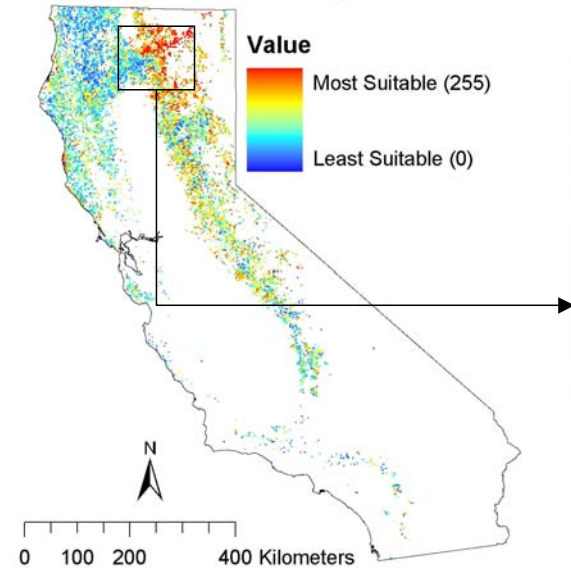
California Fuel Rank



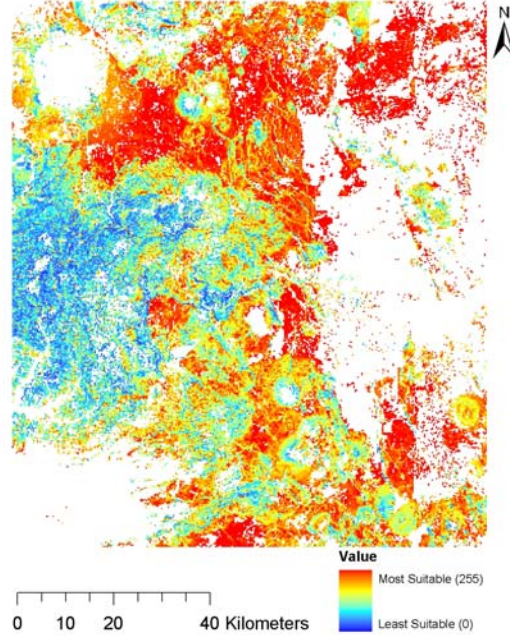
California High Risk Forest



Factor Image for Suitable Slopes

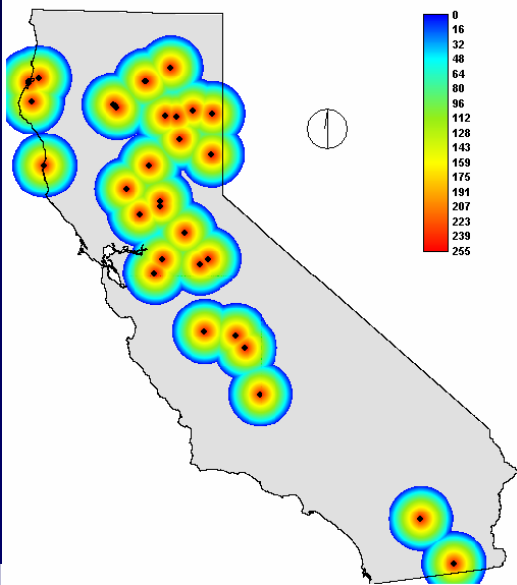


Windowed Image Detailing Suitable Slopes

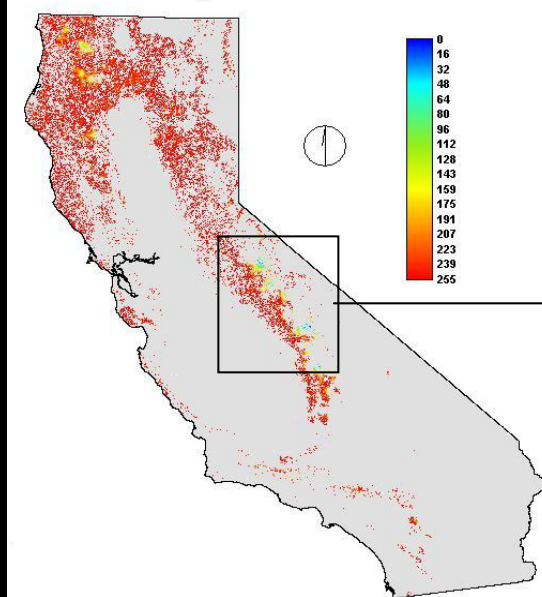


Factors used to develop index of suitability for fuel reduction

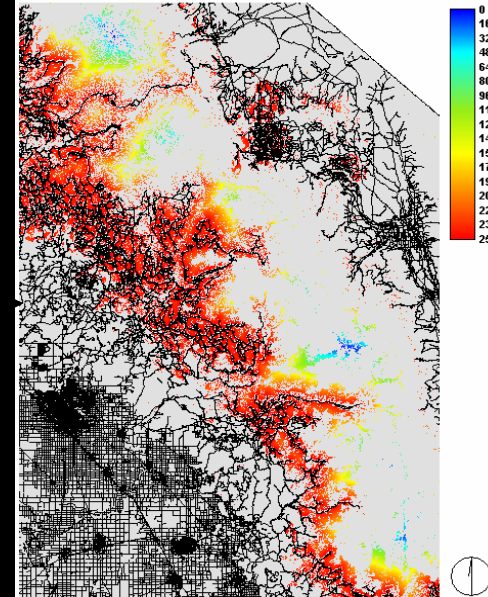
Factor image for distance from biomass plants



Factor image for distance from roads

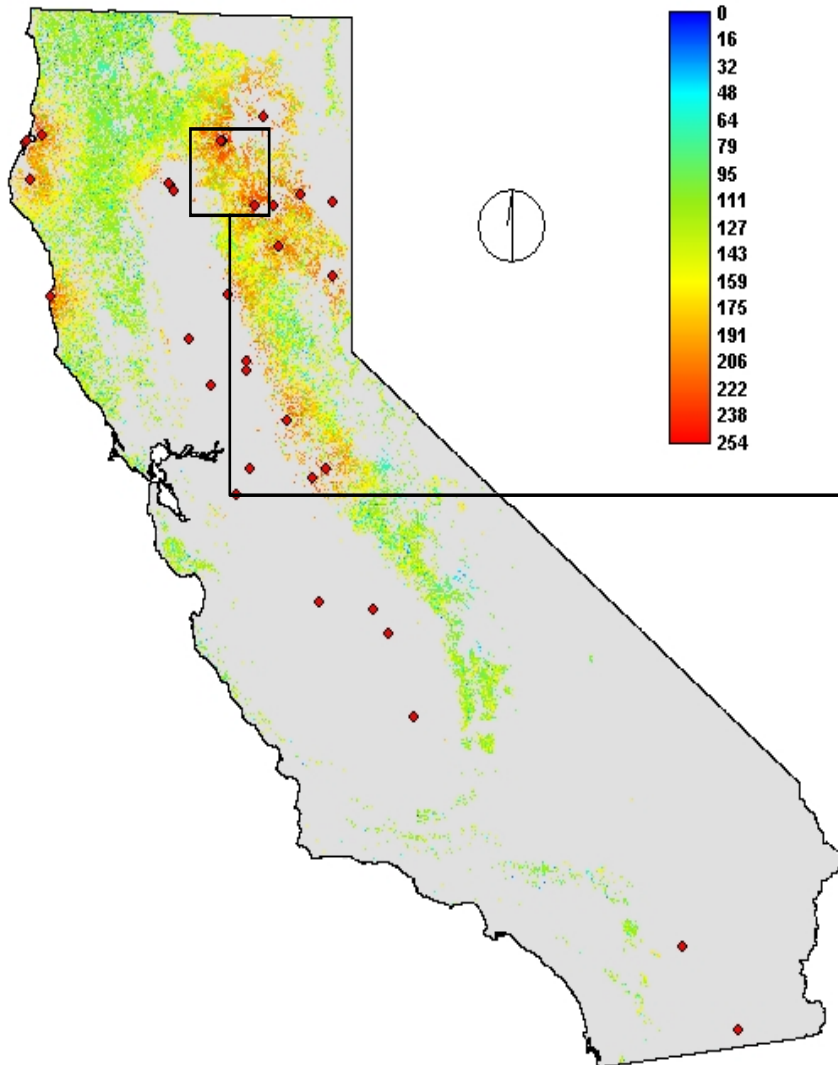


Zoomed image for distance from roads

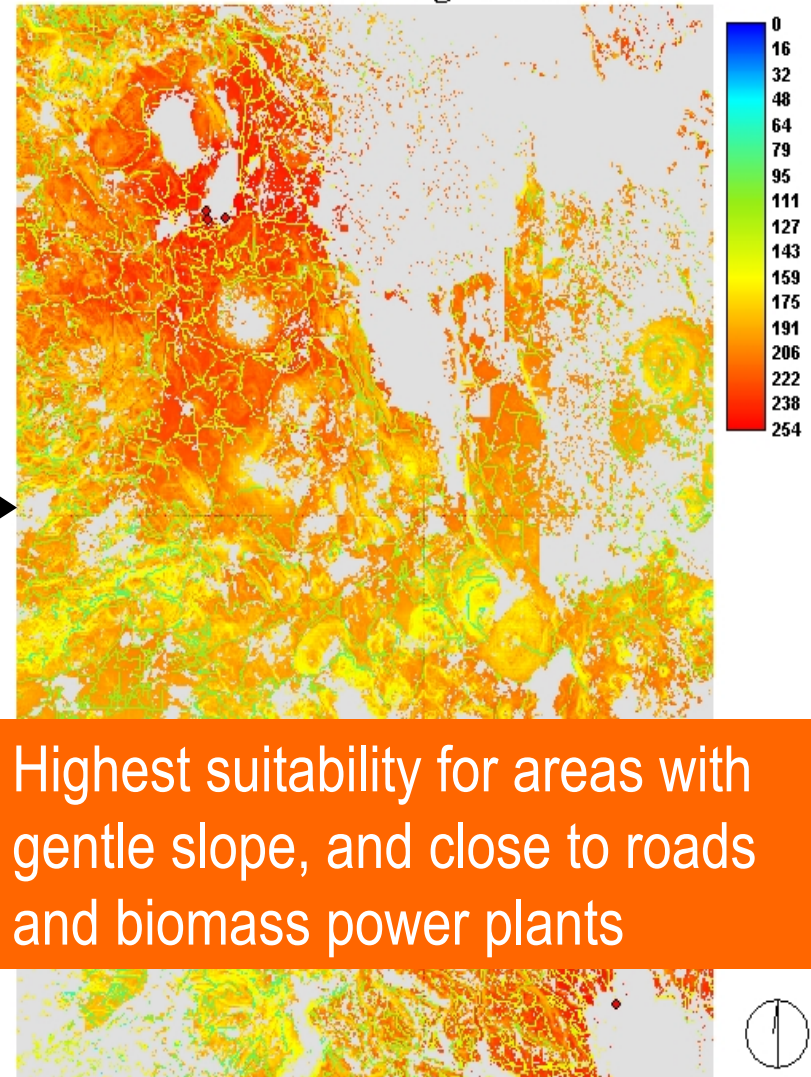


# Map of suitability scores for potential fuel reduction for California forests

Suitability Range for Potential Fuel Reduction

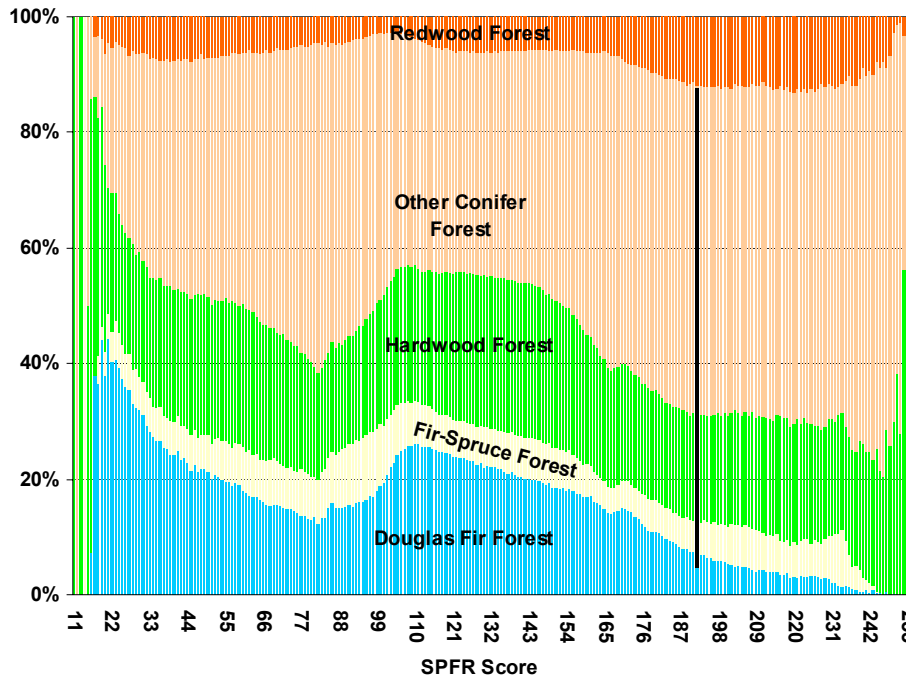
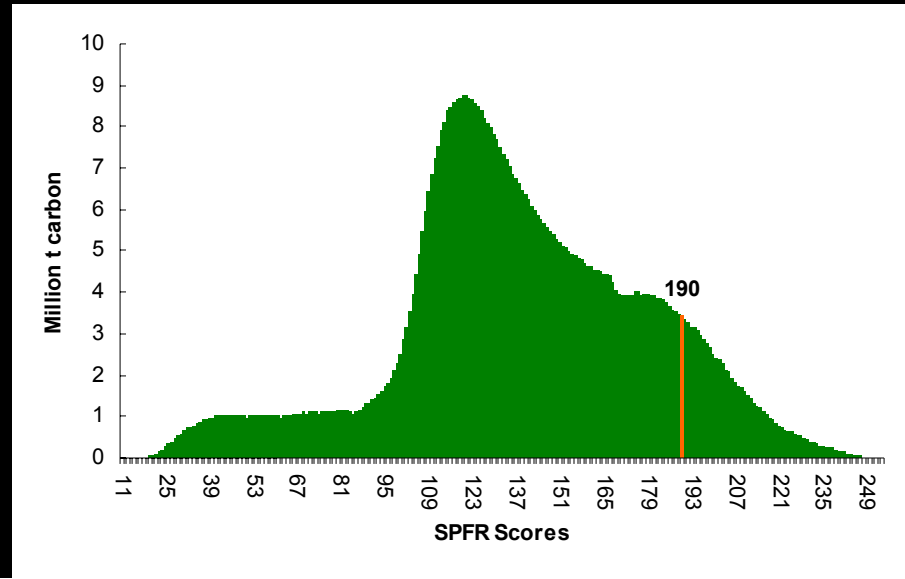
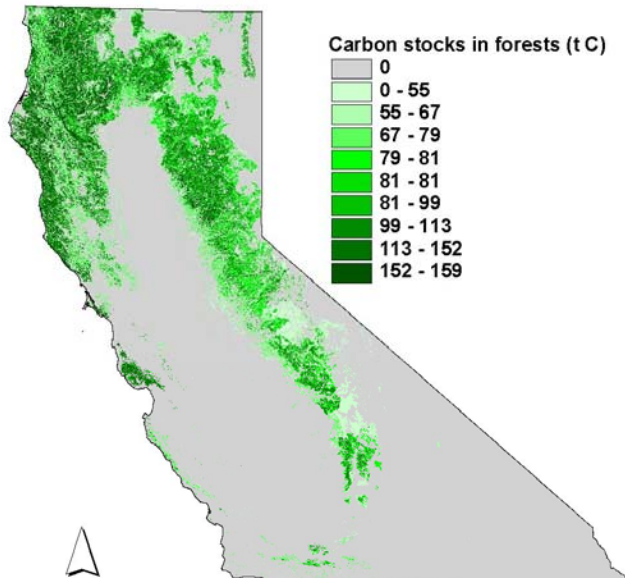


Window detailing SPFR scores



Highest suitability for areas with gentle slope, and close to roads and biomass power plants

# Carbon stocks in forests exposed to fire



Carbon stocks by SPFR classes for forests at high and very high risk for fire

Forest composition of the SPFR classes for areas at high and very high risk for fire.

# Potential Carbon Emissions from Fire

- Cumulative carbon stocks in forests at high and very high risk for fire with SPFR classes higher than the top 25% (score of 190) = 74.2 million t covering an area of approximately 775,000 hectares
- The estimated net emissions from these forests if they burned could be as much as 22 million t C (range for different forest classes =25-51 t C/ha)

# Project Example: Fire Management

- Remove fuel load from forests to reduce carbon emissions from fire
- Transport fuel to power plant
  - Account for emissions from transport

# Improve Understanding of Sequestration Benefits from Improved Fire Management



Source: Dr. Sam Sandberg, USDA Forest Service  
PacificWildland Fire Sciences Laboratory

- Change GHG emissions from combustion
- Reduce loss of carbon stocks from large trees
- Reduce loss of carbon stocks from duff
- Maintain carbon accumulation rates during recovery
- Avoid ecosystem-changing fires

# What changes can be made in fuels and fire management to reduce net GHG emissions?

- Continuous fuel management to keep fuel loads below prescribed levels
- Substitution of low severity prescribed fire for high severity wildland fire
- Substitution of low severity wildland fire for high severity wildland fire



Source: Dr. Sam Sandberg, USDA Forest Service  
PacificWildland Fire Sciences Laboratory

# Removing Fuel from the Forest



■ Typical forest thinning operation requires about \$1 Million investment

- 2 or more shears
- 2 skidders
- Chipper
- Road maintenance equip.
- Maintenance truck
- 6 or more employee



Source: Steve Jolley, Wheelabrator Shasta

# Production Rate from Thinning Operations



Source: Steve Jolley, Wheelabrator Shasta

- Production expectation for one operation:
  - Approximately 12-16 loads per day
  - Equals 150-200 BDT per day
  - Cost into the chip van about \$30/BDT
- Transportation costs additional
  - Based on \$55-\$60/hr.
  - Delivered price is \$39-\$45/BDT

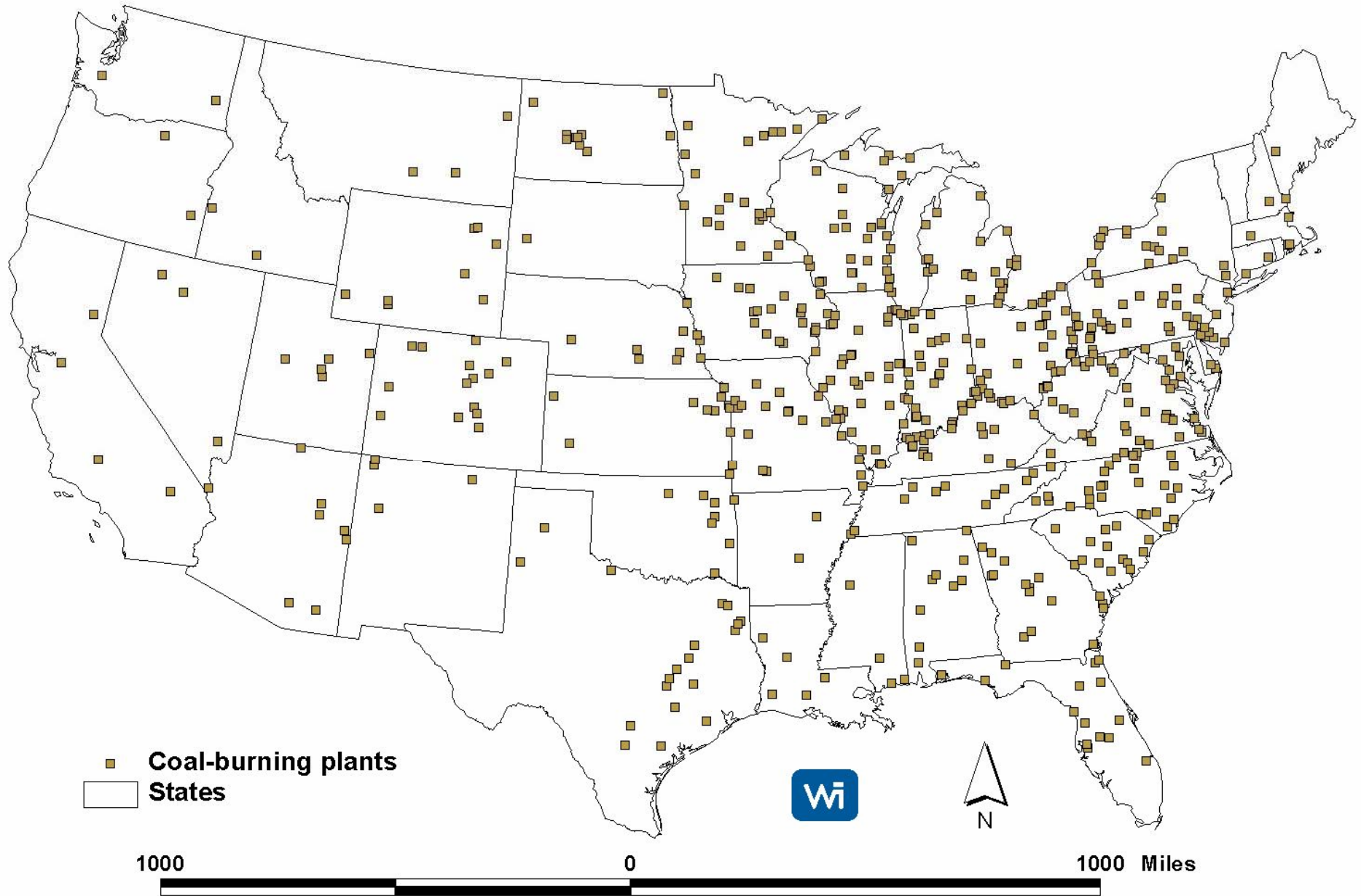
# How Far Can Fuel Be Transported?

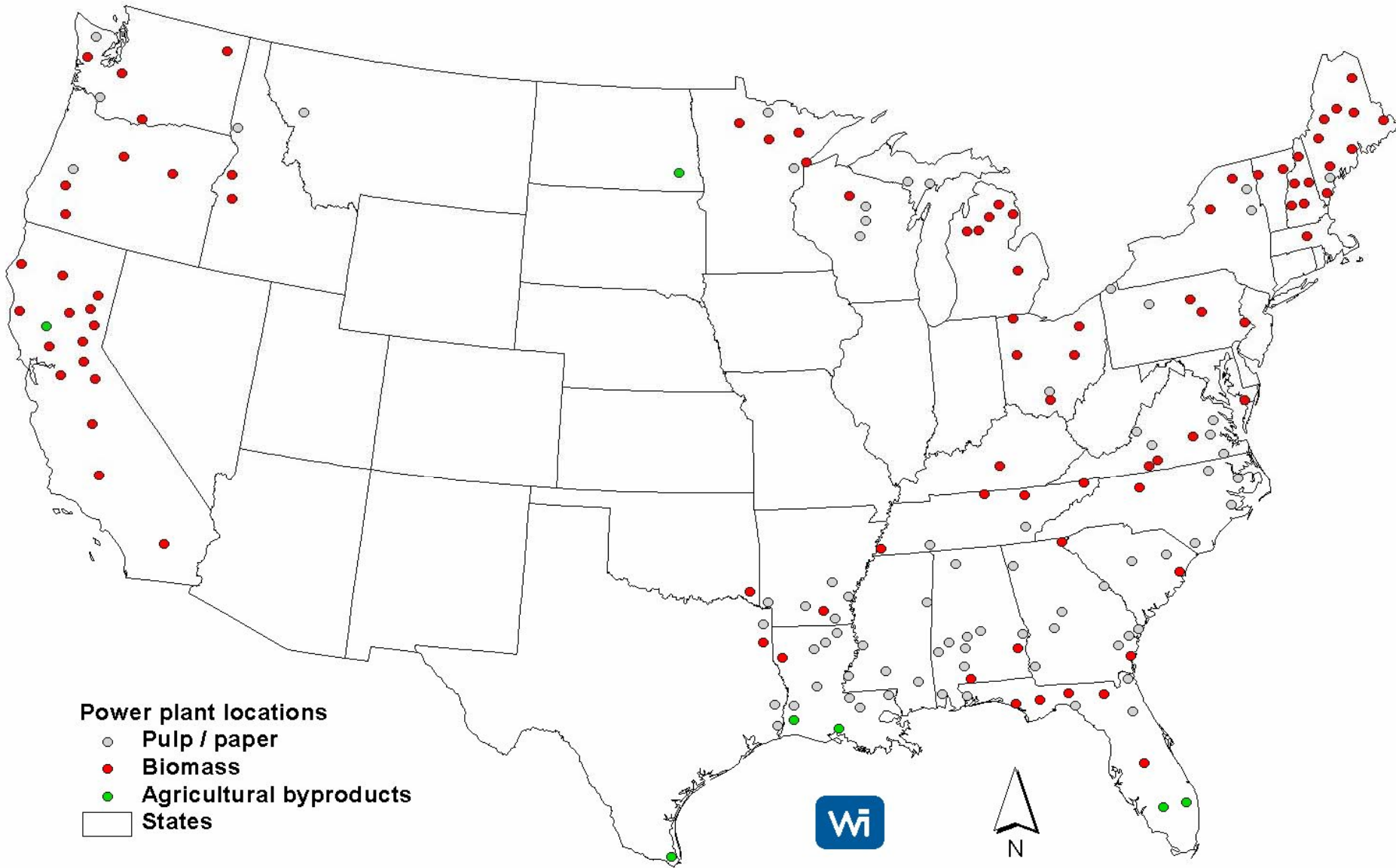
- Factors affecting transport costs:
  - Transport type
  - Fuel type and density
  - Distance from the plant
  - Season (affects availability of trucks)
  - Backhaul opportunities











**Power plant locations**

- Pulp / paper
- Biomass
- Agricultural byproducts
- States

1000

0

1000 Miles

# Example: Data Needed for Next Steps in Project Evaluation

- Refine fire baseline
- Review and collect field data on effect of fires on carbon stocks,
- Review pattern of recovery of carbon stocks after fire,
- Review available data and experience for gathering and transportation of fuel forest thinnings,
- Develop site selection criteria.

# Schedule

- **Carbon Supply**
  - California – complete
  - Oregon – December 31, 2004
  - Washington – February 15, 2004
  - Arizona – March 1, 2004
- **Baselines**
  - California – complete for 3 regions
  - Oregon – December 31, 2004
  - Washington – January 31, 2004
  - Arizona – March 1, 2004
- **Pilot Project Development**
  - ??????