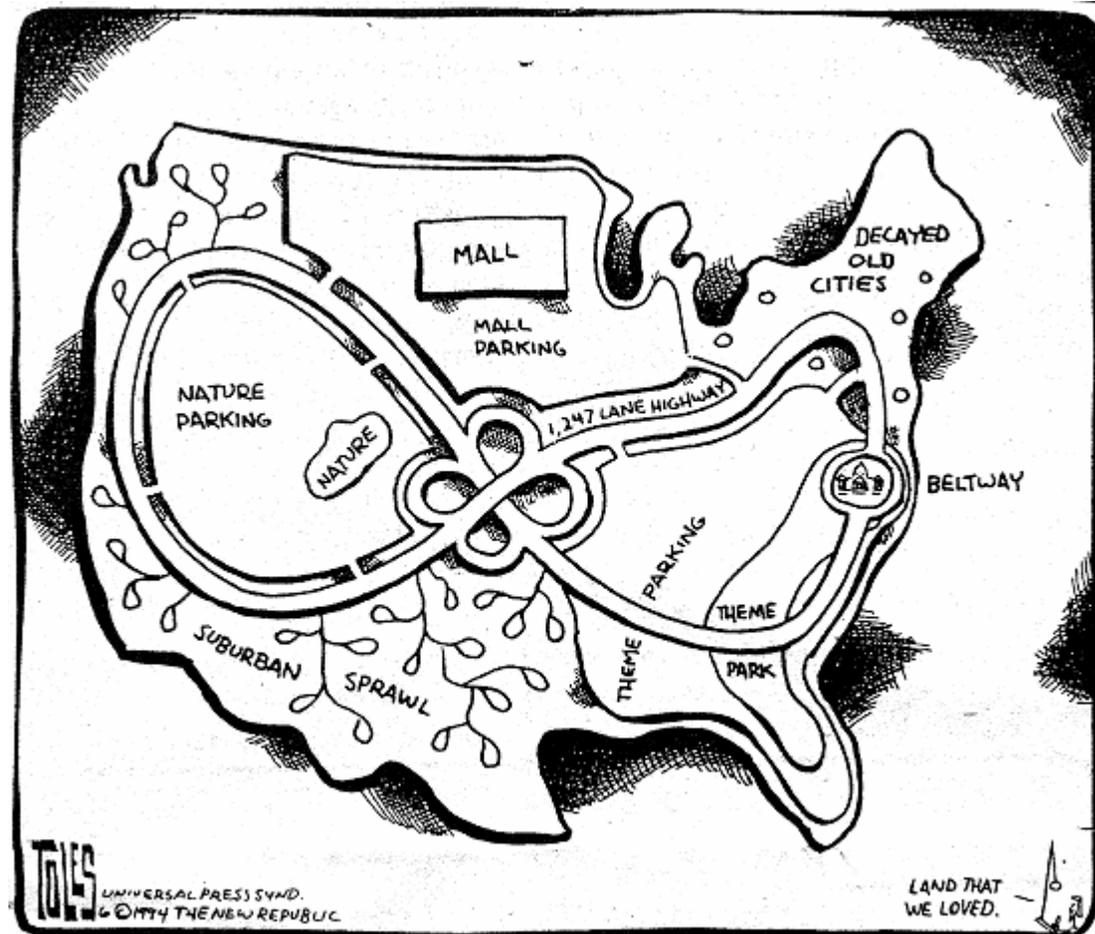


# Land use changes and socio-economic drivers



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*David M. Theobald, Ph.D.*

Natural Resource Ecology Lab and

Human Dimensions of Natural Resources

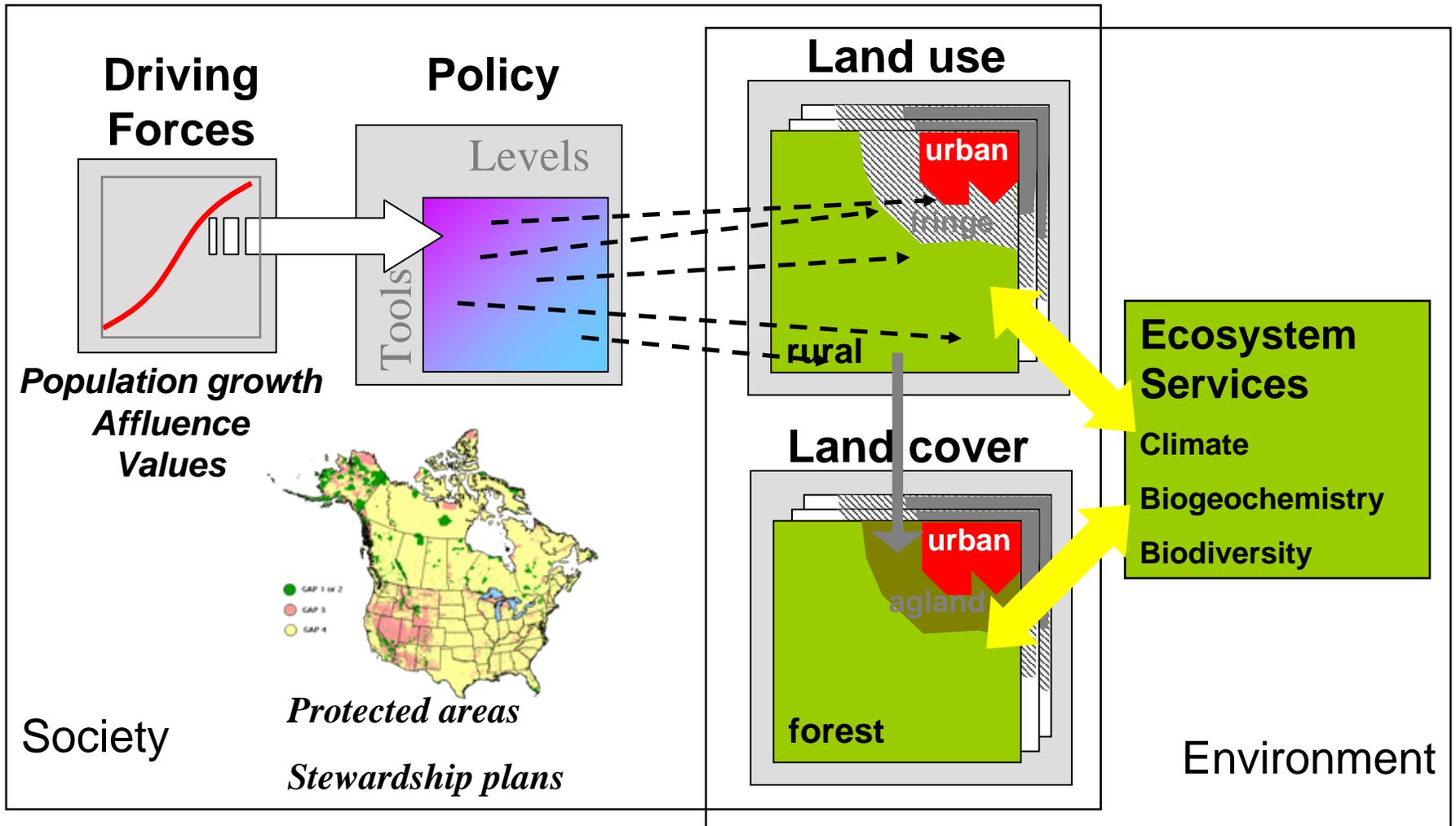
Warner College of Natural Resources

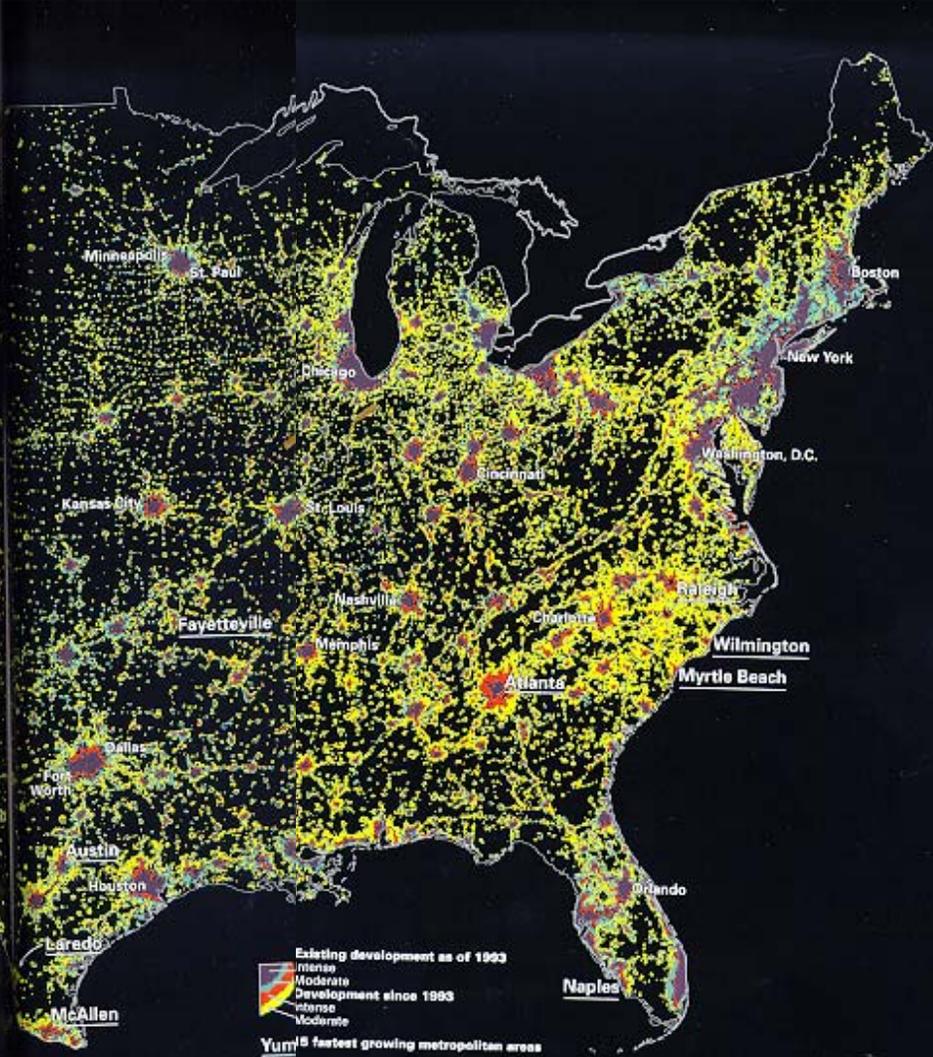
Colorado State University, Fort Collins, CO 80523

# Road map

- Landscape change framework
- Socio-economic drivers
- Land use changes
- Planning and geospatial science

# Land Use Change Framework

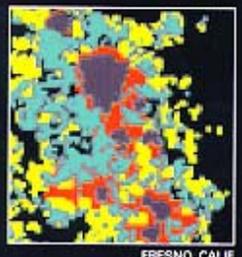




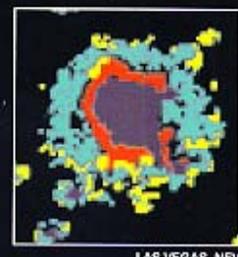
Galaxies of light across the United States illuminate the scope of sprawl; yellow and red reveal its radiating creep just since 1993. People have migrated to the periphery of cities "to find more housing for less money," says Alex Krieger of Harvard University. "Until this advantage is neutralized, sprawl will remain in our future."

# SPRAWL AT NIGHT: SEEING THE LIGHT

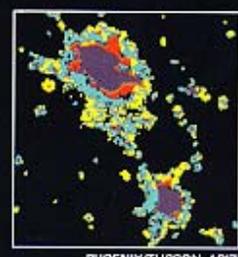
Existing development as of 1993  
 Intense  
 Moderate  
 Development since 1993  
 Intense  
 Moderate  
 Yum! fastest growing metropolitan areas



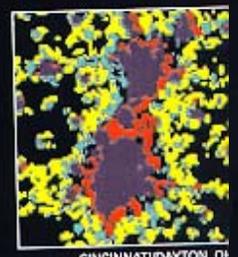
FRESNO, CALIF.



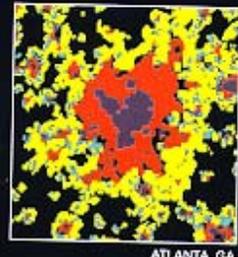
LAS VEGAS, NEV.



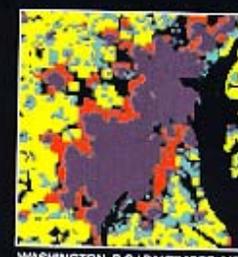
PHOENIX/TUCSON, ARIZ.



CINCINNATI/DAYTON, OH



ATLANTA, GA.



WASHINGTON, D.C./BALTIMORE, MD.

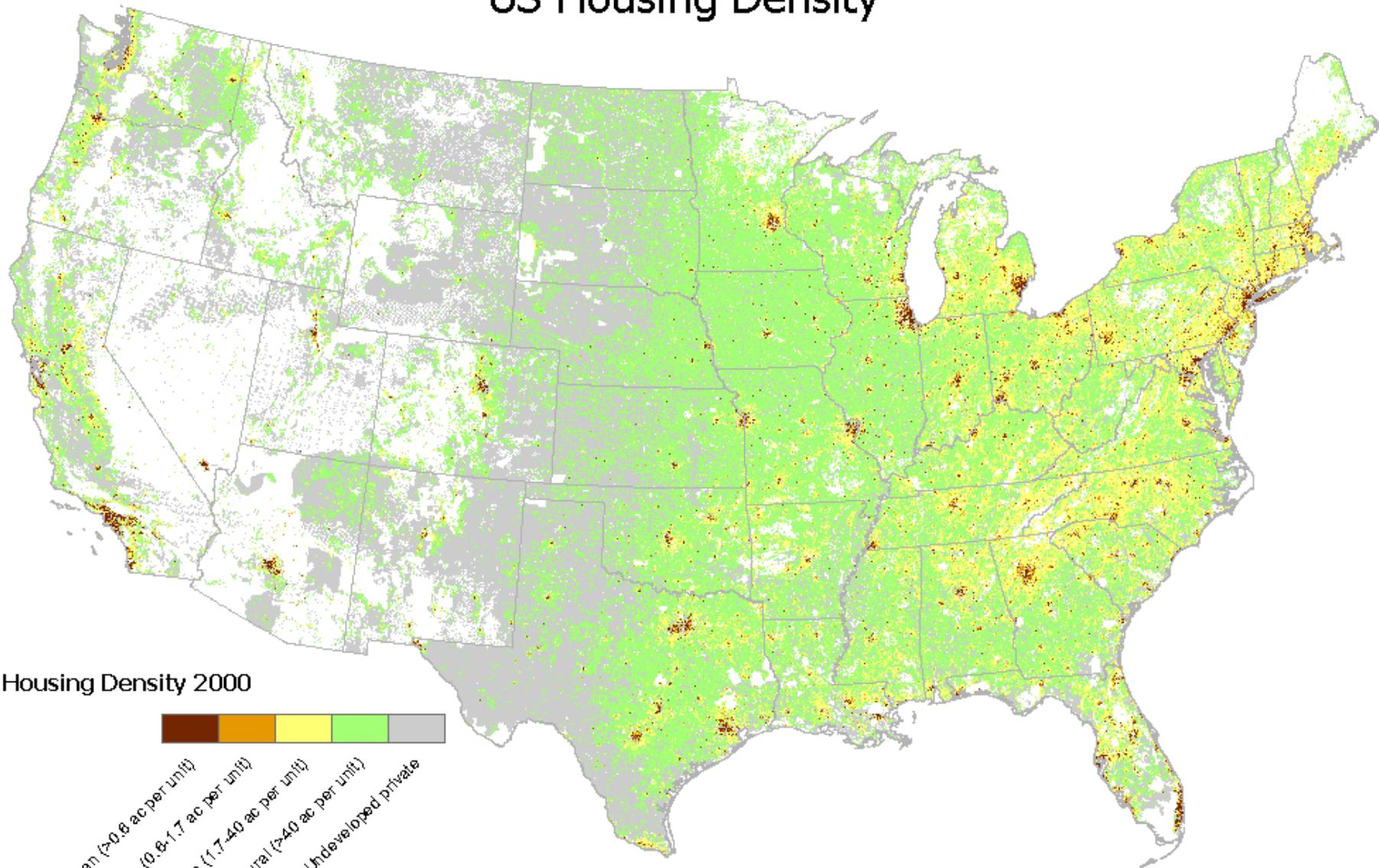
COMPOSITE IMAGE: NATIONAL GEOPHYSICAL DATA CENTER, NOAA, RHYM SATELLITE DATA: U.S. AIR FORCE DEFENSE METEOROLOGICAL SATELLITE PROGRAM, NATIONAL GEOGRAPHIC MAPS

# Urban sprawl

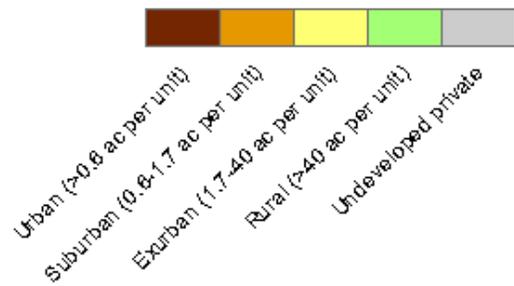
**Population Growth Versus Land Development: 1982–1997<sup>12</sup>**

U.S. Regions	Change in Population	Change in Urbanized Land
Midwest	7.06%	32.23%
Northeast	6.91%	39.10%
South	22.23%	59.61%
West	32.21%	48.94%
United States	17.02%	47.14%

# US Housing Density



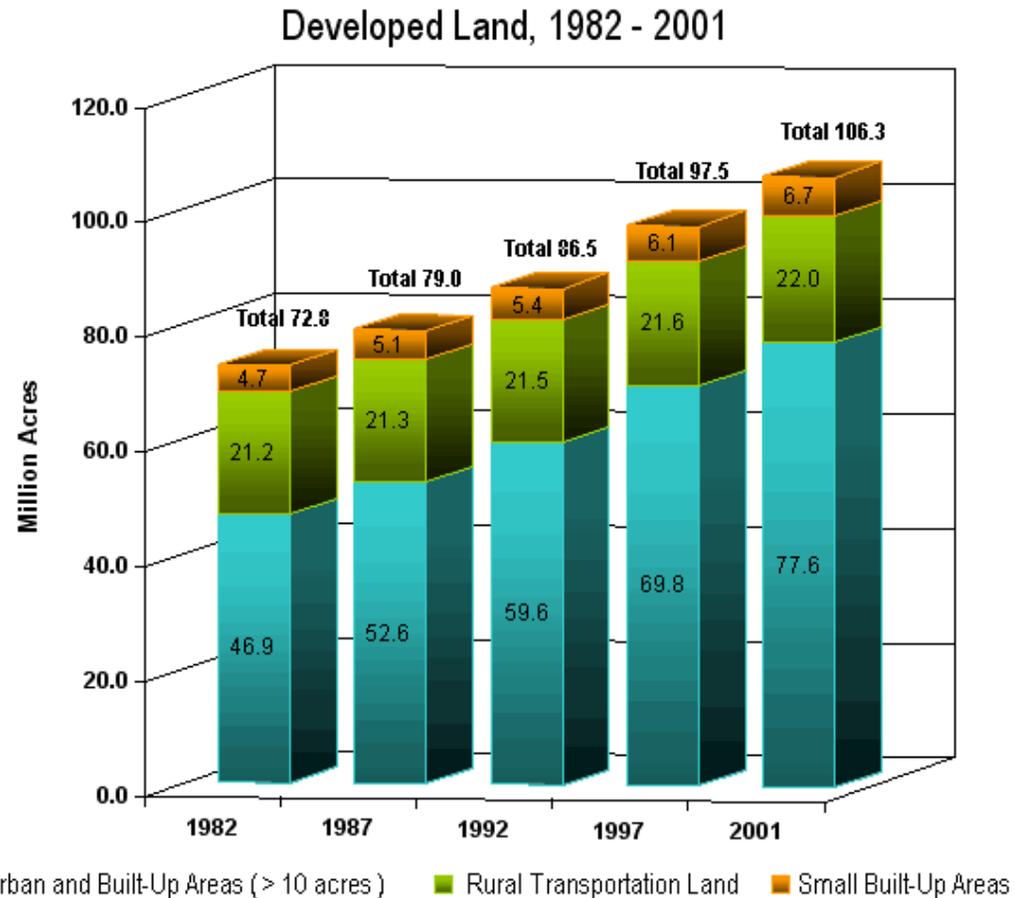
Housing Density 2000



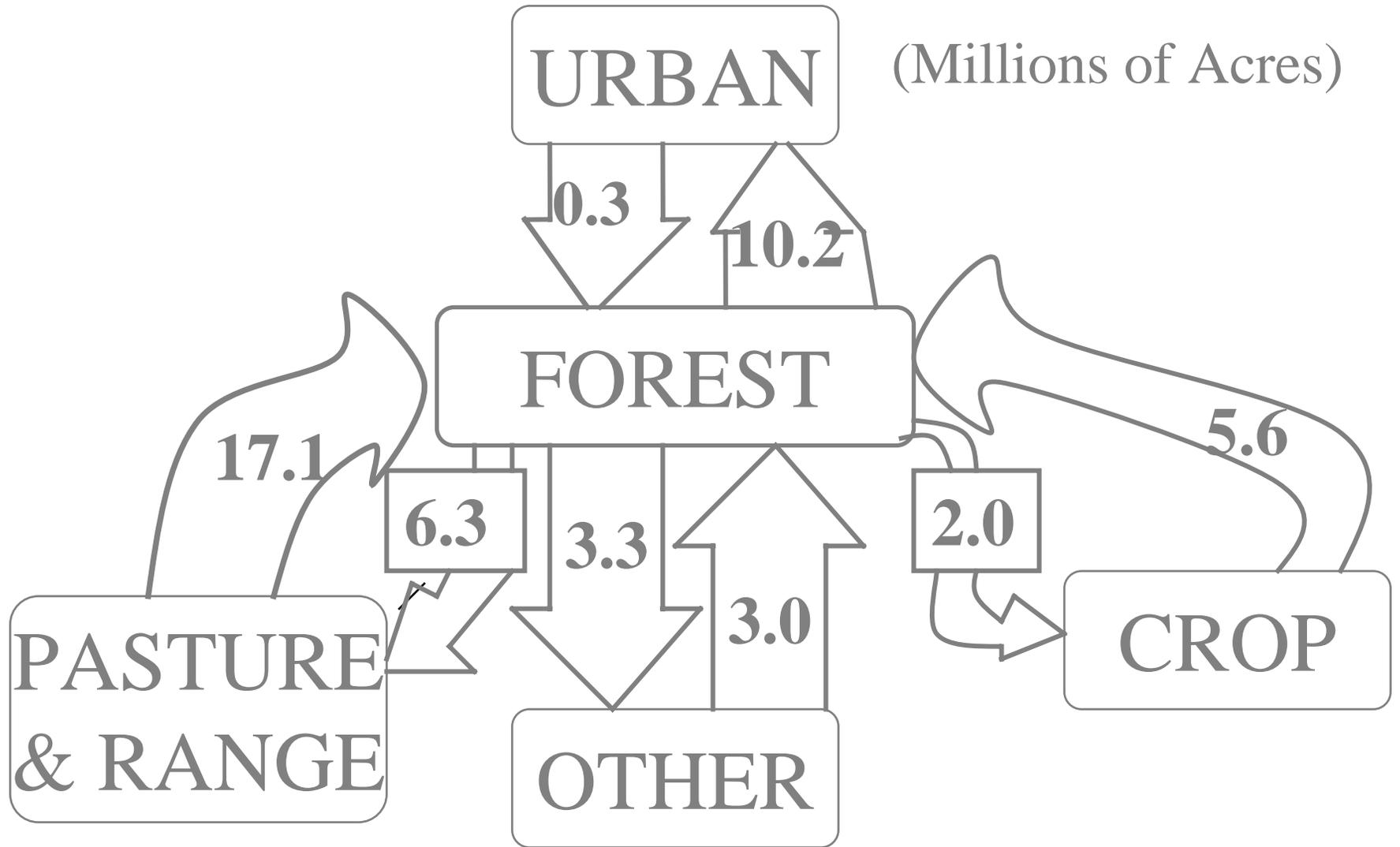
# Rural sprawl

- Re-analysis of NRCS NRI data (separating “small” from “large” built-up):
  - Large (>10 acre, low-density) 60% higher growth rate
  - 48.8% vs. 29.8% expansion (large vs. small)
  - Footprint 10x (77.6 vs. 6.7 MACs)
- Similar results in Theobald 2001; 2005

	Urb/Sub	Exurban
1982-87	8.5%	12.2%
1987-92	5.9%	13.3%
1992-97	13.0%	17.1%
1992-01	9.8%	11.2%



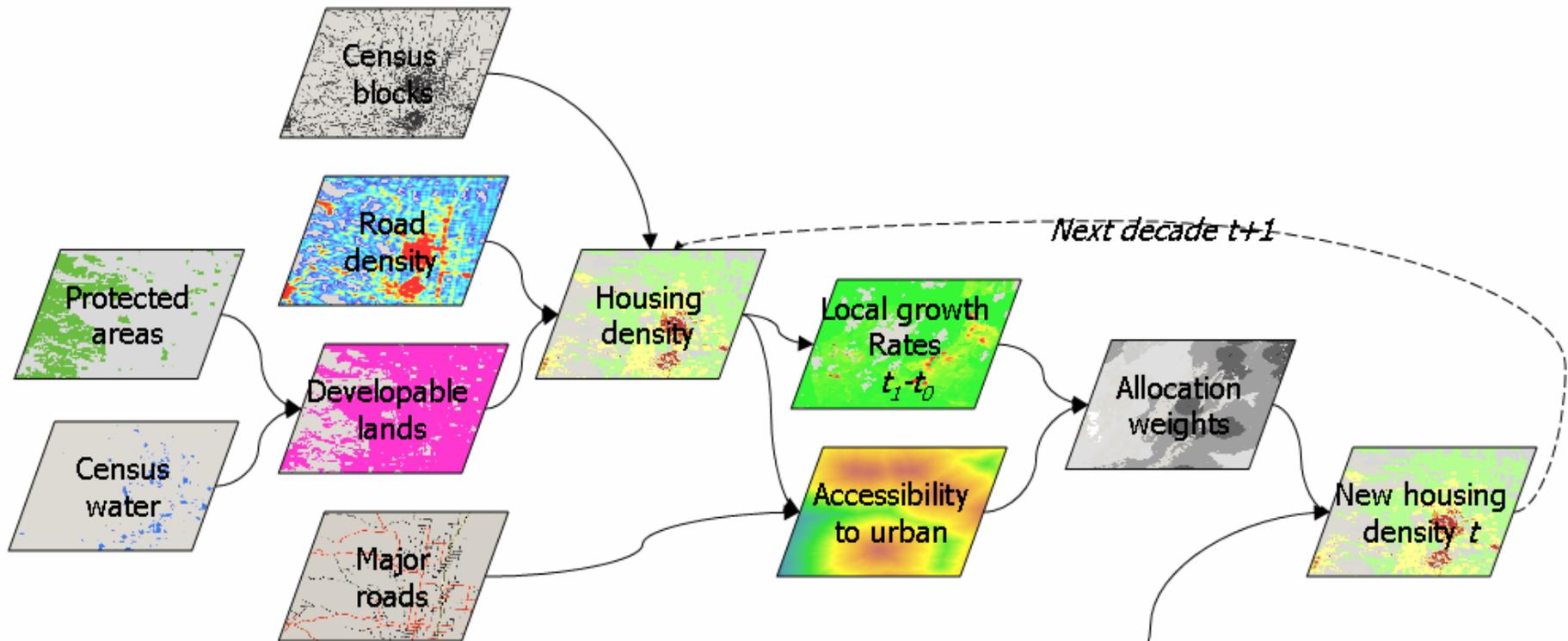
# Sources and Sinks of U.S. Forestland, 1982-1997



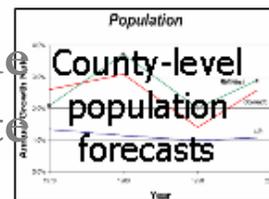
Source: USDA NRCS, NRI (from Alig 2006)

# Forecast housing density

## SERGoM v1



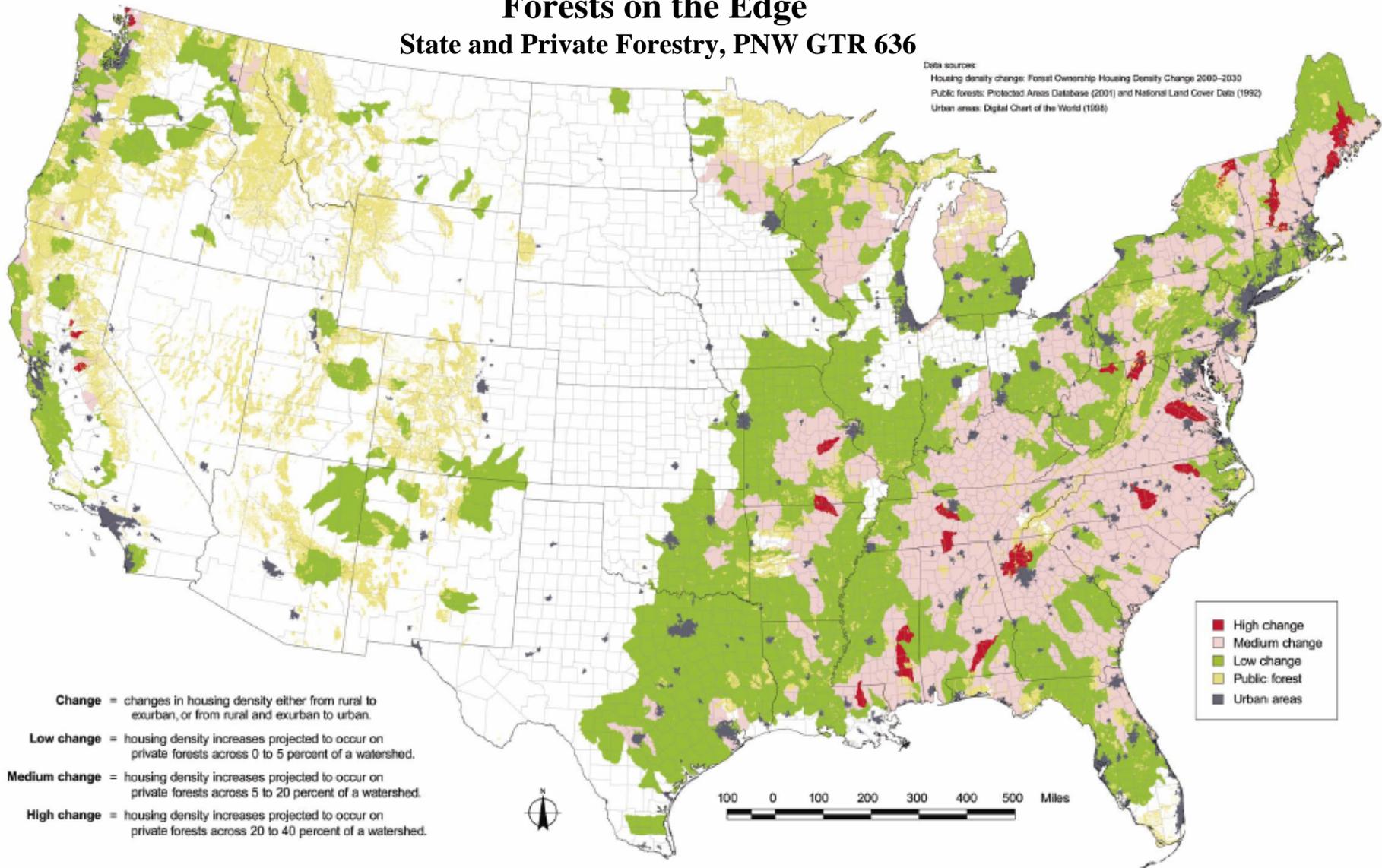
1. Pattern of growth from past decade
2. Average rates for 16 classes by state
3. Travel time to urban areas



# Forests on the Edge

## State and Private Forestry, PNW GTR 636

Data sources:  
Housing density change: Forest Ownership Housing Density Change 2000-2030  
Public forests: Protected Areas Database (2001) and National Land Cover Data (1992)  
Urban areas: Digital Chart of the World (1998)



**Change** = changes in housing density either from rural to exurban, or from rural and exurban to urban.

**Low change** = housing density increases projected to occur on private forests across 0 to 5 percent of a watershed.

**Medium change** = housing density increases projected to occur on private forests across 5 to 20 percent of a watershed.

**High change** = housing density increases projected to occur on private forests across 20 to 40 percent of a watershed.



United States  
Department of  
Agriculture

Forest Service

FS-861

August 2006



# COOPERATING ACROSS BOUNDARIES

## PARTNERSHIPS TO CONSERVE OPEN SPACE IN RURAL AMERICA

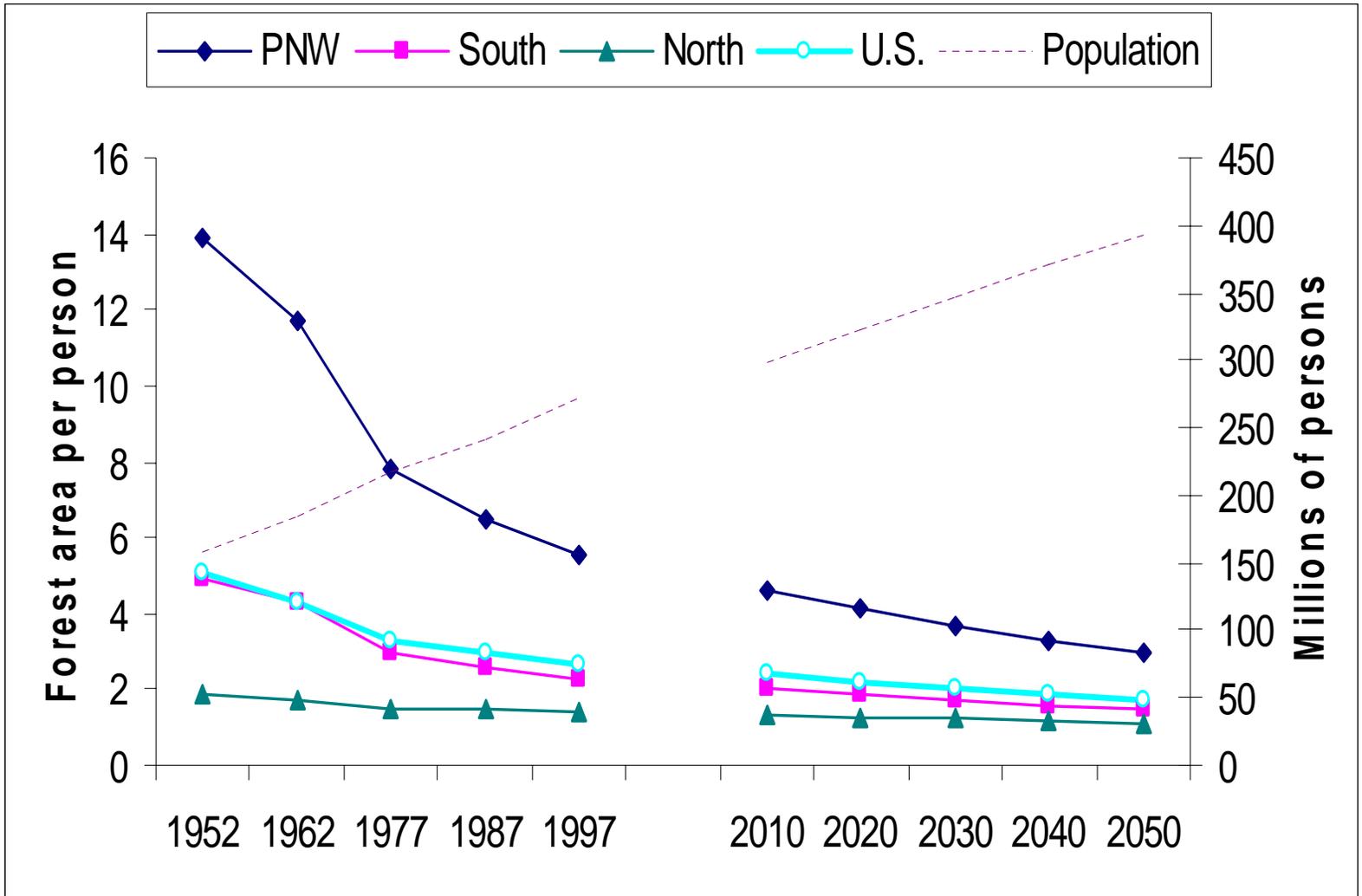


# Top Issues (Threats)

- Land-use/ownership changes
  - Fragmentation, isolation, and perforation
  - Landowner values and interests
- Insects and pathogens
  - Native, within home range
  - Invasive, native or exotic
- Severe weather or climatic changes
- Invasive species
- Wildland fire
- Other anthropogenic stresses

# Socio-economic Drivers

- Population growth (& baby boomers)
- Amenity migration
- “New Ruralism”?
- The Rural Rebound

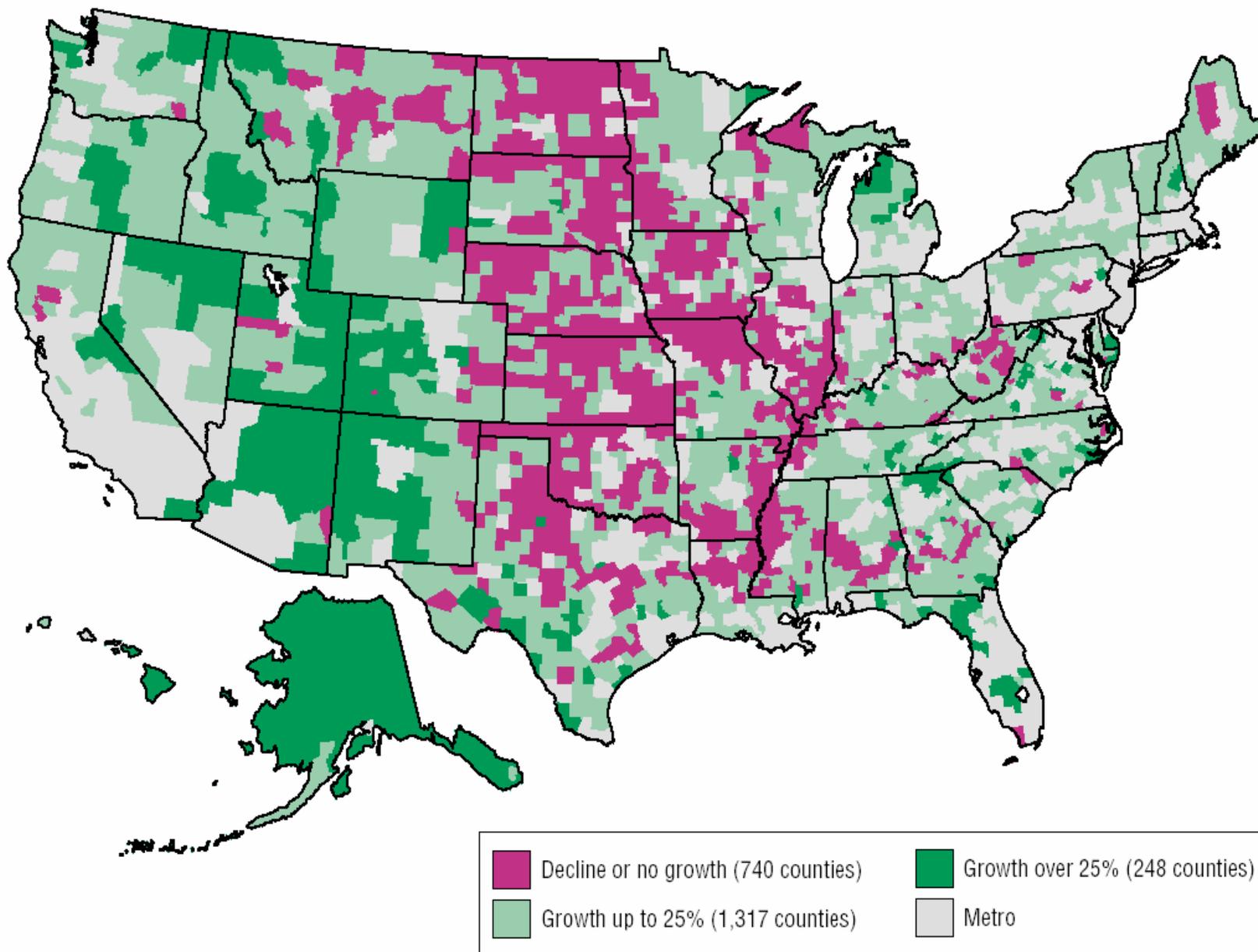


Source: Alig et al. 2004

Figure 4

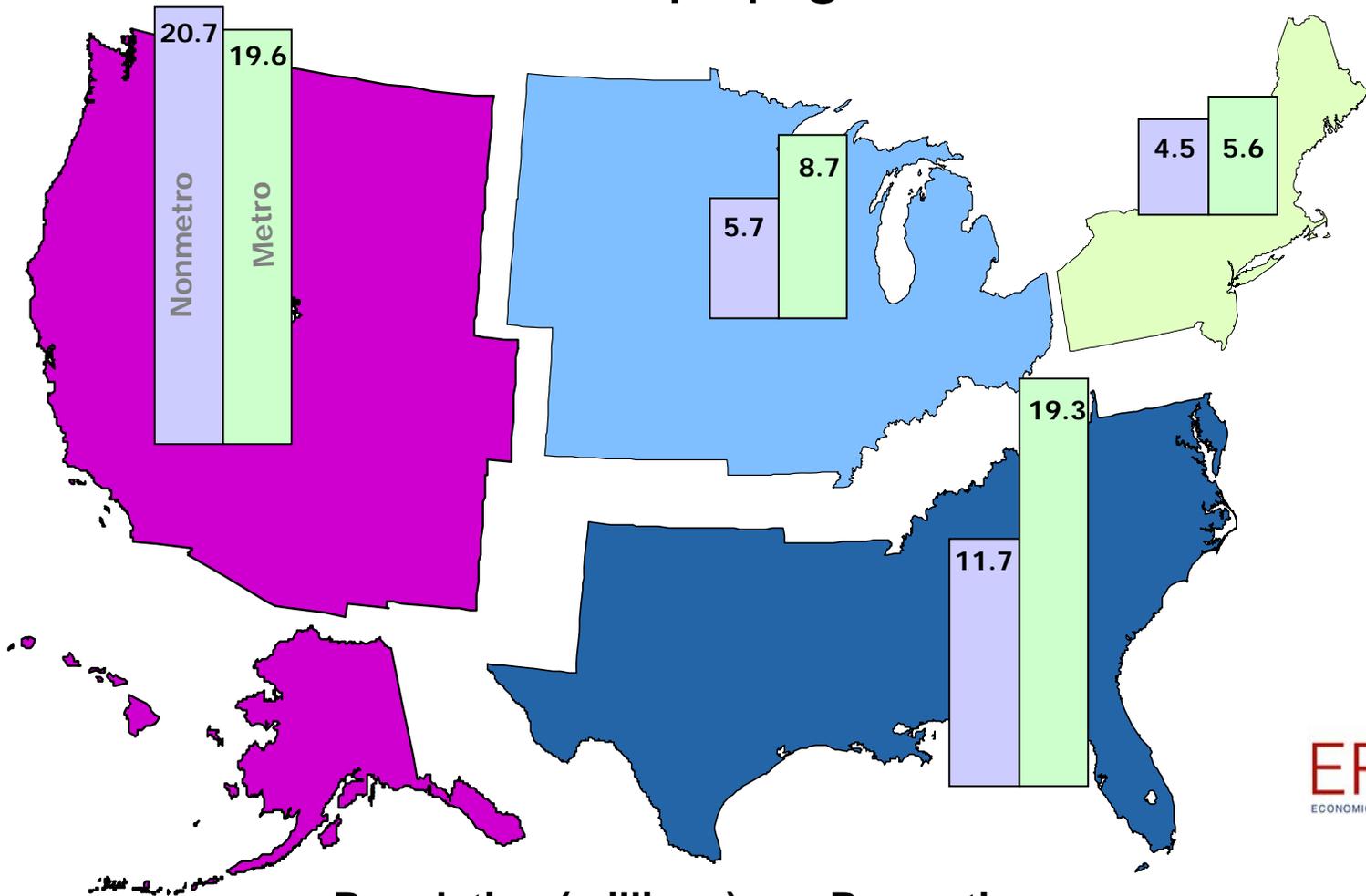
### Change in the nonmetro population age 65 and over, 1990-2000

*The number of nonmetro counties with declining elderly population increased sharply in the 1990s*



Source: Prepared by ERS using data from the Census Bureau.

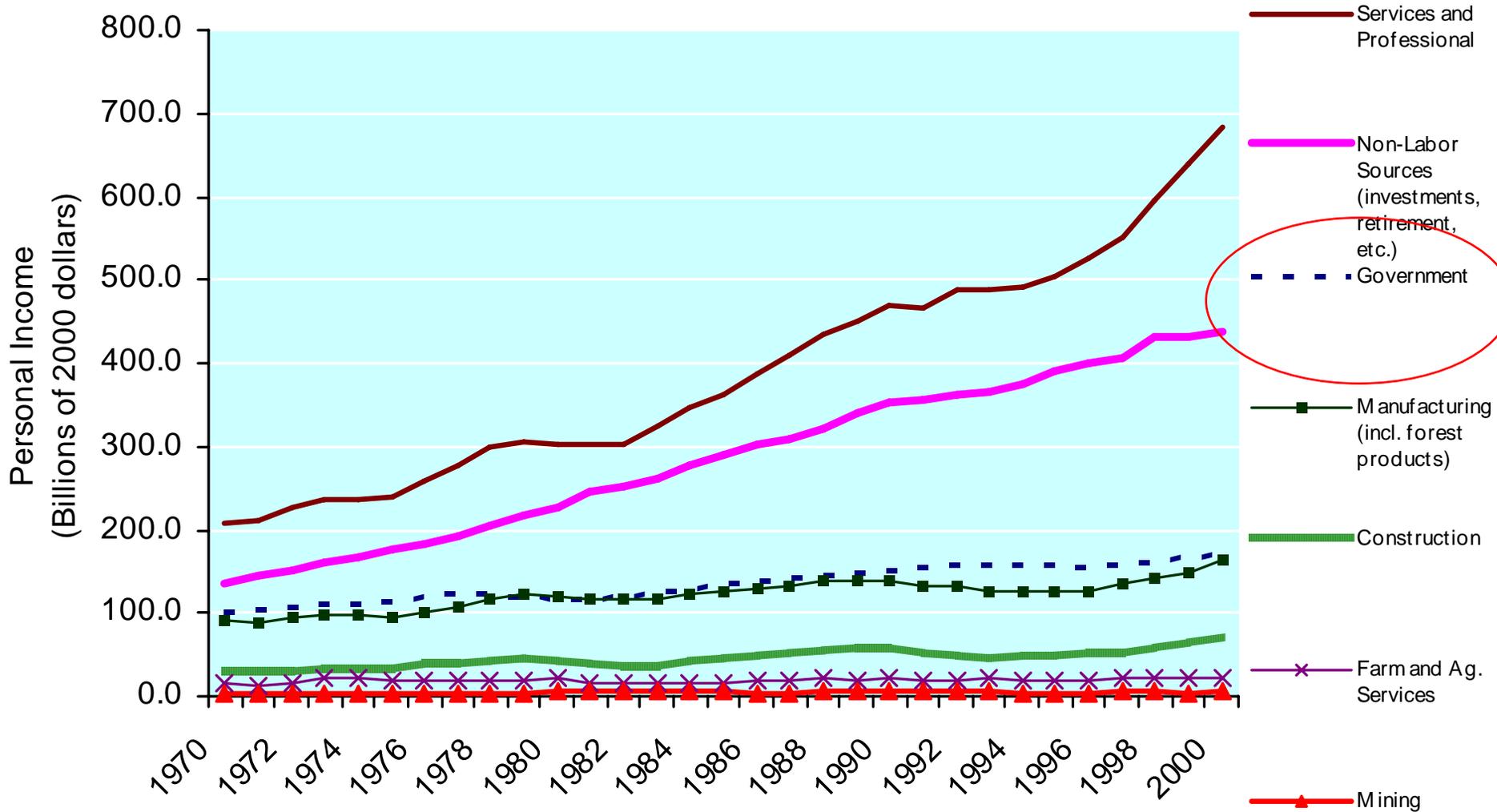
# Non-metro vs. metro pop growth 1990-2000



	Population (millions)		Proportion	
	Urban	Rural	Urban	Rural
<b>Western US</b>	43.2	18.1	70.5%	29.5%
<b>Eastern US</b>	122.5	95.6	56.2%	43.8%
<b>Nationwide</b>	165.8	113.7	59.4%	40.7%

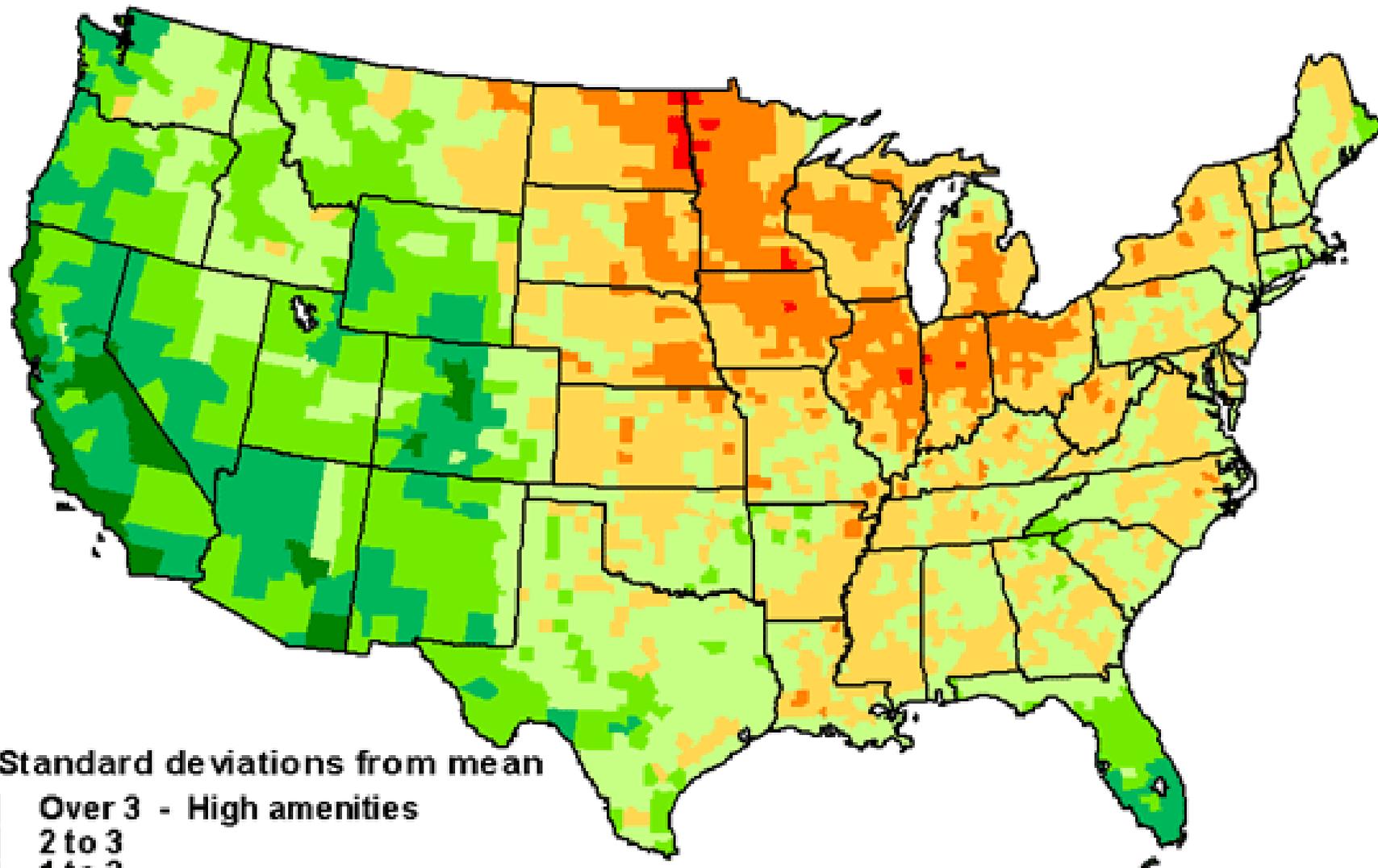
# Far West Region (AK, CA HI, NV, OR, WA)

## Personal Income by Industry, 1970 – 2000

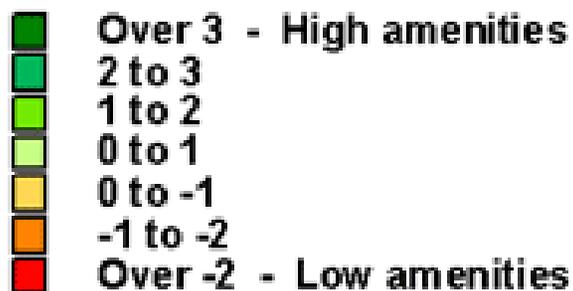


Source: Sonoran Institute, based on US Bureau of Economic Analysis data

# Natural amenities scale



Standard deviations from mean



Source: USDA, Economic Research Service.

# “New Ruralism”

## A CALL FOR NEW RURALISM

by Sibella Kraus



Published since 1886

# The PROGRESSIVE FARMER

WE HELP YOU LIVE YOUR AMERICAN DREAM.

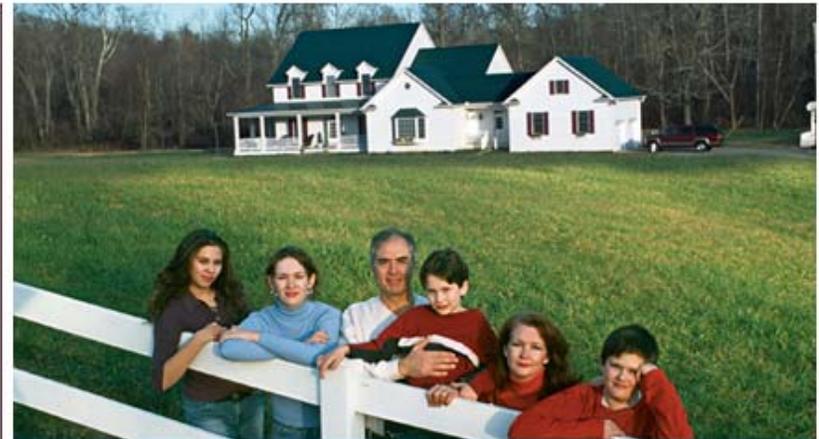


YOUR COUNTRY HOME & FAMILY | HORSES & FARM ANIMALS | FARM FRESH GARDENS | OUTDOORS & WILDLIFE | YOU CAN DO IT PROJECTS | LA K

## YOUR AMERICAN DREAM

### New Ruralism

Moving to the country is a trend that's sweeping across America with half a million people moving last year alone. Rural areas are experiencing population growth as all walks of people move to the country for many of the same reasons. They're searching for a simpler life in a place where they can reconnect to the land. They have a desire and passion to live on land and enjoy the pleasures that come from a life in the country. We call this aspiration *New Ruralism* and it's the driving force behind the population rebound



### New Faces of Rural America

For Gustavo and Michelle Huerta, the decision was not all that difficult. They could either stay in Miami and raise their four children in an increasingly violent environment, or they could live their dream and move to the country.

Raised in the city, the Huertas didn't like what they were seeing. One day it was a huge shootout involving 17 U.S. marshals just a few blocks from their home. Another time it was a car abandoned at their doorstep. The driver said he would be back, but the Huertas later learned the car

# “New Ruralism”

## The Rural Rebound

- The 1990's saw a rural population rebound; which totally reversed the outmigration of the 1980's. 70% of rural counties grew in population from 1990 to 1999.
- Between 1990 and 1999, 2.2 million more Americans moved from the city to the country, than the reverse.

## Rural – not just for Agriculture anymore

- 6.3% of rural Americans live on farms.
- Farming accounts for 7.6% of rural employment.
- 0.39% of the US population is engaged in farming as a primary occupation.
- 1.8% of the US rural population is engaged in farming as a primary occupation.

Technology has changed our choices in residential location, in our home we can have:

- bank, office, newspaper, bookstore, brokerage, factory, investment firm, school

# Planning

- Conference theme: Leading social change through forest planning

## Approaches

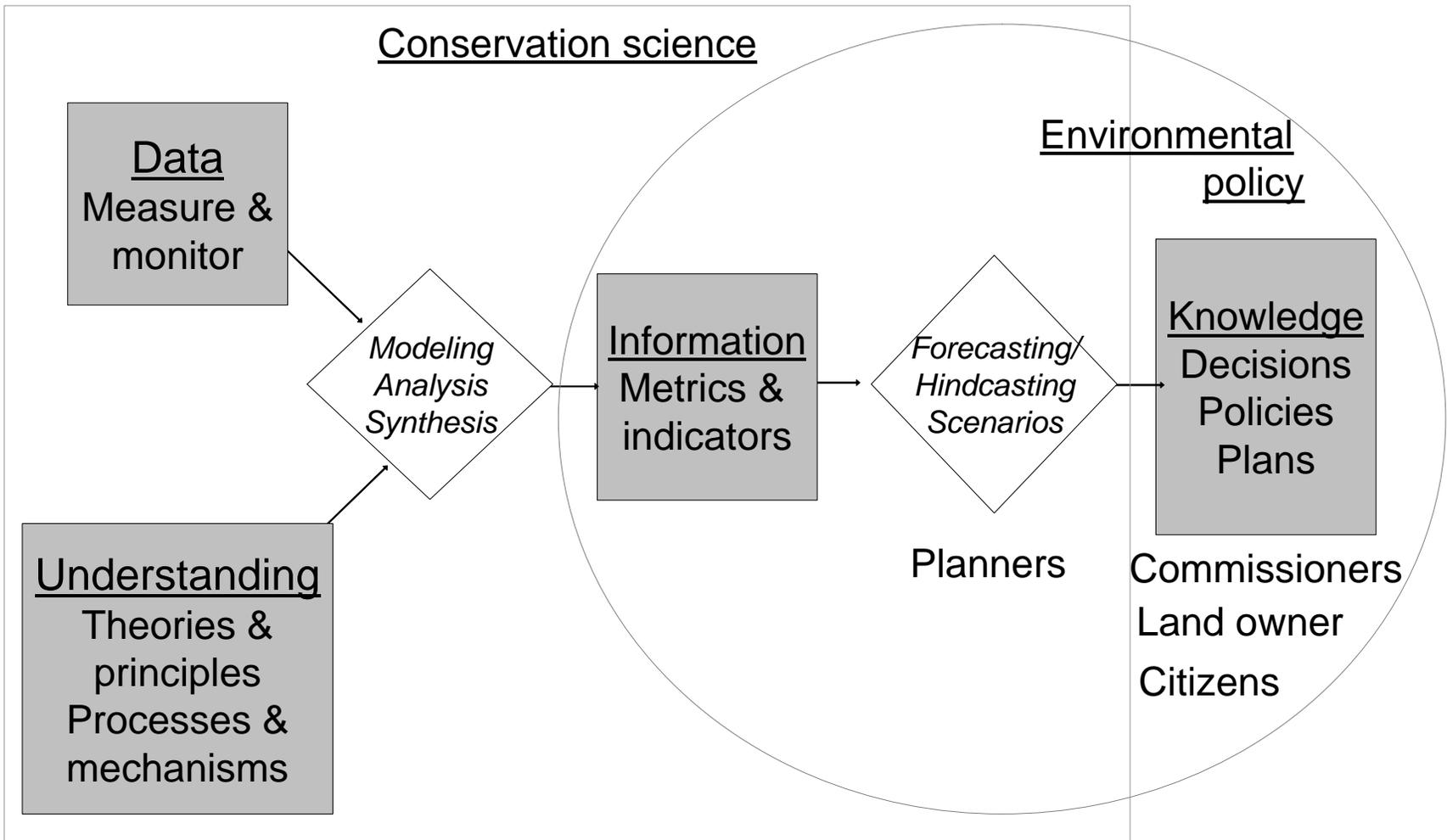
(national to regional to landscape to site scale):

WUI

Green infrastructure

Build-out analysis

Conservation subdivision/clustered development



# Wildland-urban interface



[Click Here to sign up](#)

## Siren song of the forest st: Explosive growth being forecast for fire-prone risk

By [Mark P. Couchand Kristi Arellano](#)  
Denver Post Business Writers

**Sunday, June 30, 2002** - Homeowners flock to the Rocky around a flickering flame, but each new house adds fuel to

For thousands of people, a home in the woods is a primal ur and luxury, a refuge from the buzz of city life.

This year's record fires will not stop people from building, sa executive officer for Home Builders Association of Metropolit

"Will what we are seeing curtail demand? Absolutely not in t jurisdictions move to limit development in those areas? No. from themselves."

By 2030, nearly 2.2 million residences will stand in fire-prone Rocky Mountain West - a 40 percent jump from current leve

Colorado sets the pace in forest construction. Nearly one-ti the Rocky Mountain woodlands will be built in Colorado, and there in 2030, according to a recent study.

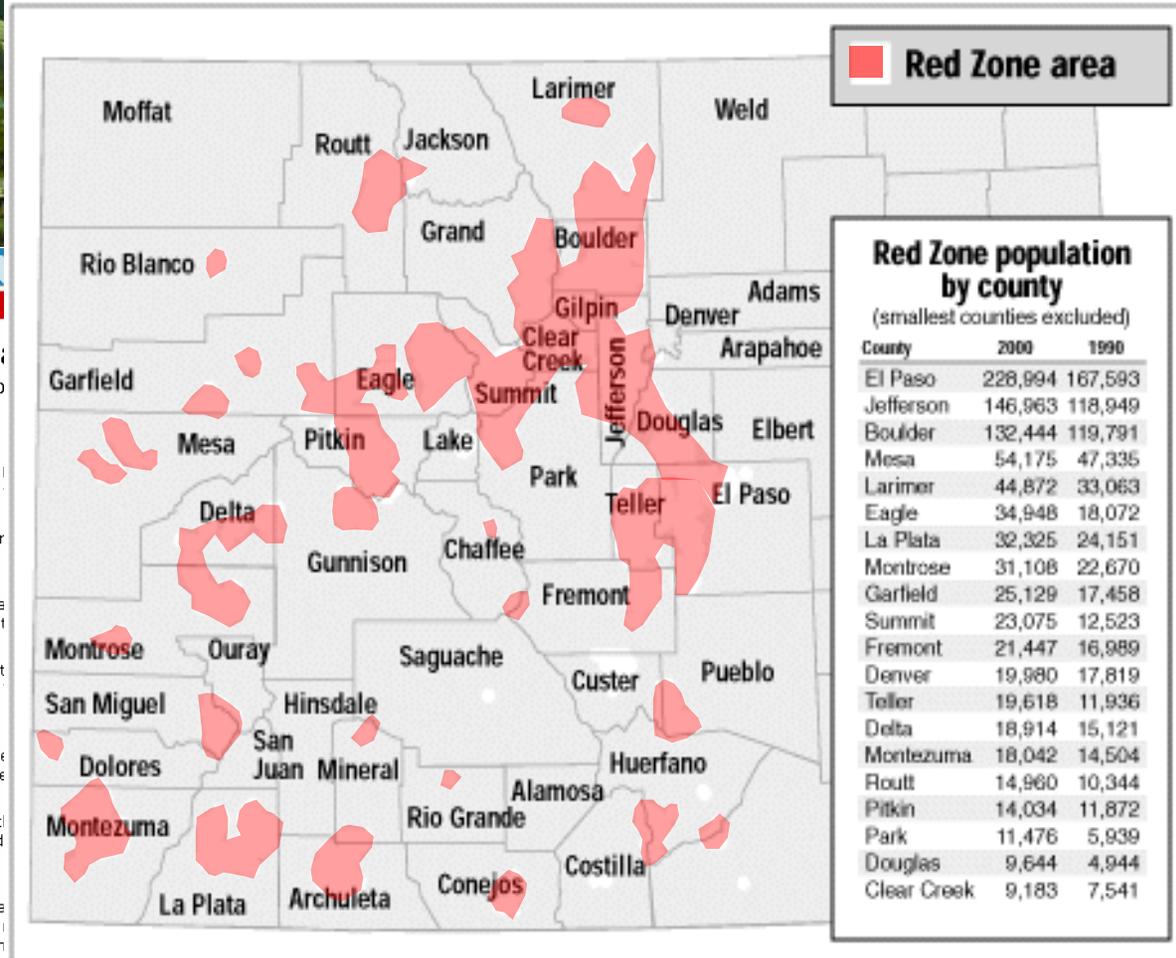
"It's a conflict of lifestyle versus risk," said Ron Brave, a fire Eagle County, home to Vail and Beaver Creek. "People who i don't think a lot about wildland fire because there's no such from. They haven't experienced it; they haven't seen fire ju air."

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[T-REX](#)  
[Wasting Disease](#)  
[World/Nation](#)

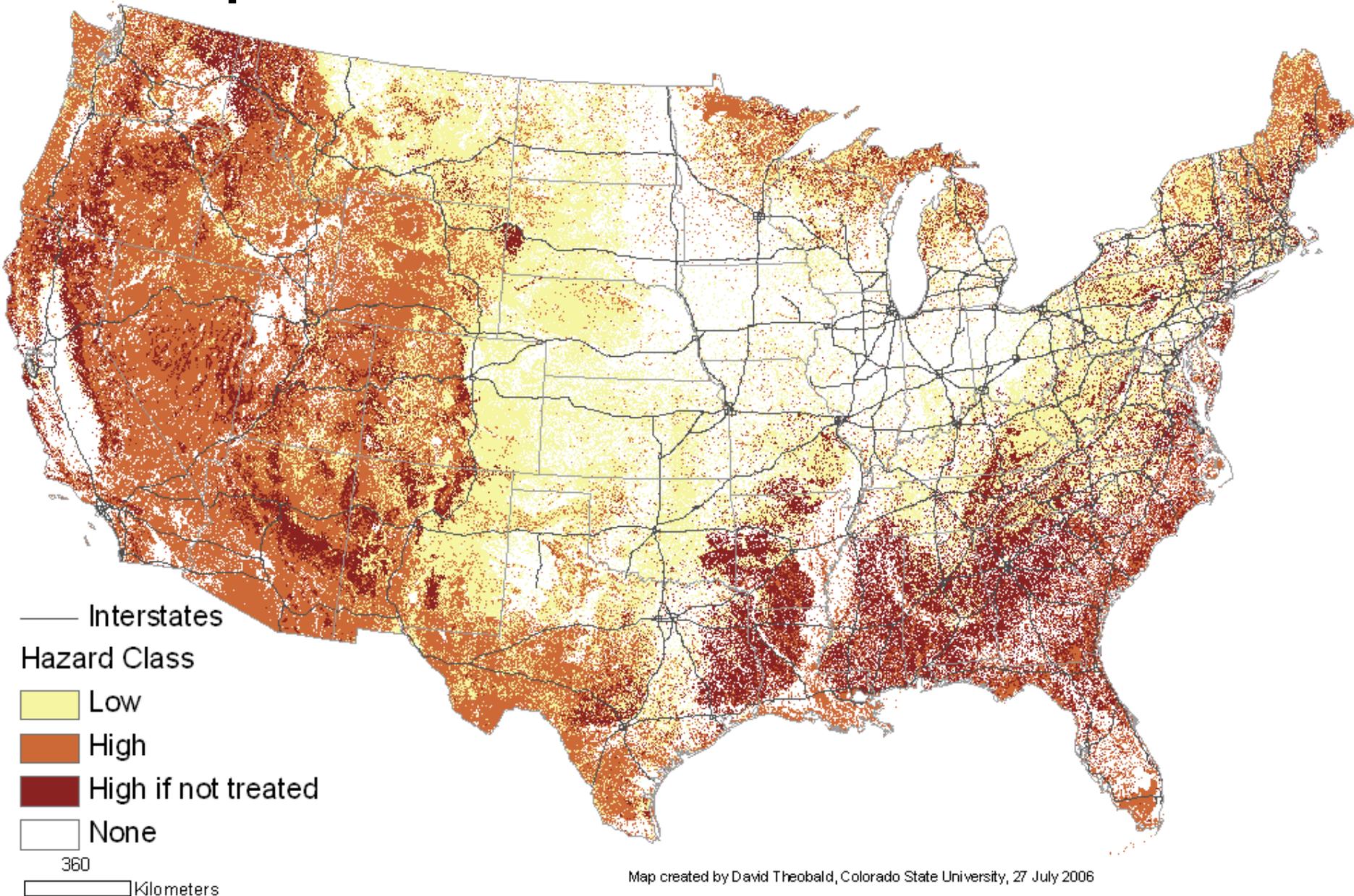
## Living in the 'Red Zone'

About 979,851 people live in Colorado's wildfire danger zone, up from an estimated 748,350 in 1990, according to a Denver Post analysis of U.S. Census Bureau data. Defined by the Colorado State Forest Service, the "Red Zone" represents areas where fuels — primarily trees — and population combine to create a threat of "highly destructive" wildfires. There are about 474,000 homes in the zone, up from about 370,000 in 1990, the Post analysis also found.



Source: Denver Post analysis of data from the U.S. Census Bureau, Colorado State Forest Service and CSU Natural Resources Ecology Lab

# Expansion of the Wildland-urban interface



Source: Theobald & Romme. *in review*

## Federal Register

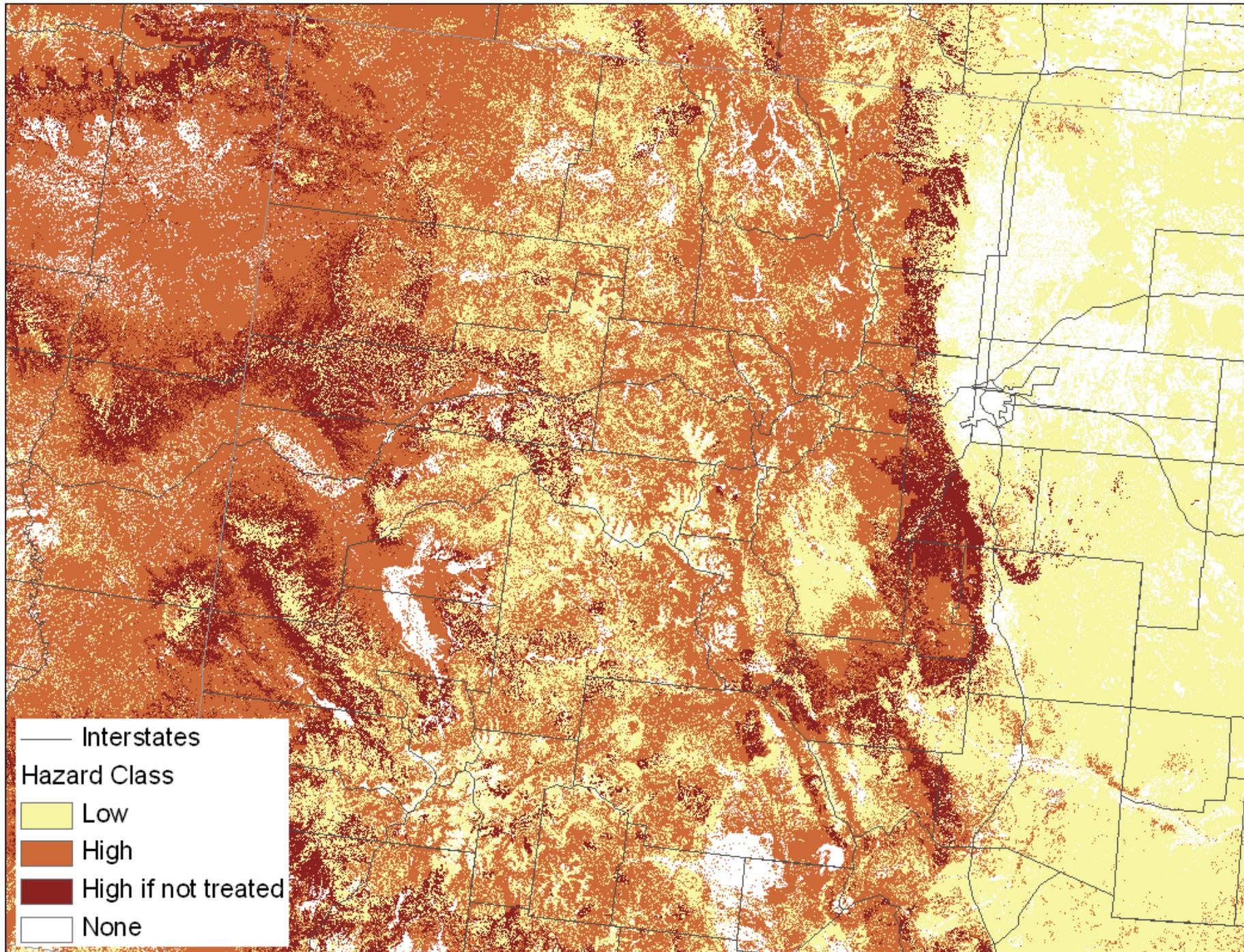
<b>Class</b>	<b>description</b>	<b>definition</b>	<b>Our definition</b>	<b>Other definitions</b>
Interface (WUI)	Clear line of demarcation between structures & fuels	>1 structure per 0.3 ac (>3 units/ac <i>or</i> >250 people/mi <sup>2</sup> )	>1 unit per 2.4 ac (based on 250 people/mi <sup>2</sup> ) <i>and</i> >25 ac patch	>1 unit per 40 ac & <50% wildland vegetation (Stewart et al. 2003)
Intermix (WIX)	Structures scattered throughout, fuels continuous	1 unit per 0.3 to 40 ac	1 unit per 2.4 to 40 ac <i>and</i> % of WIX using 100 m treatment;	>1 unit per 40 ac & >50% wildland vegetation (Stewart et al. 2003)
Occluded	Structures abut “island” of fuels, often in city,	<1,000 acres	-	-
Community fire planning zone	0.5-2.0 mi from boundary of at-risk community		0.5, 1.0, 2.0 mi from WUI; 1 ha cells	1.5 mi buffer from WUI; blocks are units
Wildland vegetation	?	Forest & shrublands	Forest types from FUELMAN, location from NLCD, filtered	FUELMAN (1 km; Schmidt et al. 2002) NLCD (30 m; Radeloff et al. 2004)

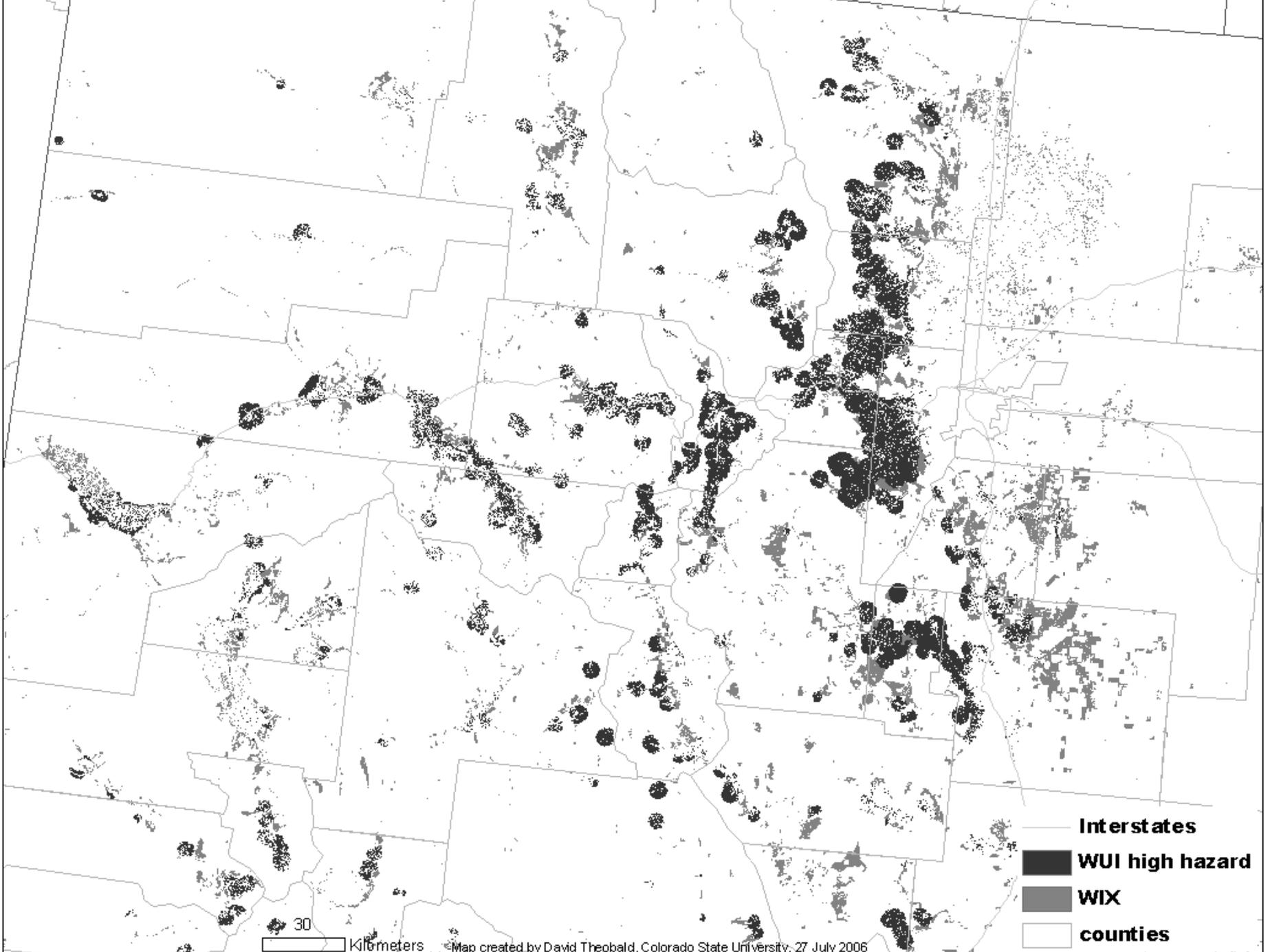


# Forest vegetation types

<i>NLCD Cover type</i>	<i>FUELMAN Vegetation Type*</i>	<i>Km<sup>2</sup></i>	<i>% US</i>
Water		1,925	5.05%
Dev. Low resl		82,083	1.02%
Dev. High res		21,041	0.26%
Dev. Comm..		45,462	0.56%
Transitional		166,781	2.07%
Forest – Conifero us or Mixed	White/red/j pine	106,564	1.32%
	E. spruce-fir	61,062	0.76%
	Longl. pine	104,047	1.29%
	Loblolly pine	352,732	4.38%
	Ponderosa Pine	208,266	2.59%
	Douglas-fir	124,956	1.55%
	Larch	9,787	0.12%
	W. White Pine	9,094	0.11%
	Lodgepole Pine	107,453	1.33%
	Heml. S. Spruce	8,072	0.10%
	Fir – Spruce	79,719	0.99%
	Redwood	15,127	0.19%
	P-Juniper	157,536	1.96%
Oak-pine	120,638	1.50%	

Forest - Deciduo us	Oak-hickory	439,203	5.45%
	Oak-cypress	45,756	0.57%
	Elm As Cotton.	30,783	0.38%
	Mpl-Bch-Brch	182,110	2.26%
	Aspen-Birch	83,507	1.04%
	W. Hardwoods	30,025	0.37%
	Juniper – Pinyon	14,848	0.18%
Shrubland	Juniper Steppe	467	0.01%
	Mesquite bosques	568,588	7.06%
	Sagebrush	83,948	1.04%
	Chaparral	306,872	3.81%
	SW shrub steppe	441,221	5.48%
	Desert shrub	14,848	0.18%
	Annual (CA))	72,092	0.89%
Grassland	Mountain	104,733	1.30%
	Plains	701,698	8.71%
	Prairie	155,534	1.93%
	Desert	112,563	1.40%
	Texas savanna	40,473	0.50%
	Alpine tundra	42,391	0.53%
	Wetl. Wdy	221,272	2.75%
Wet.Herb.	98,360.7	1.22%	



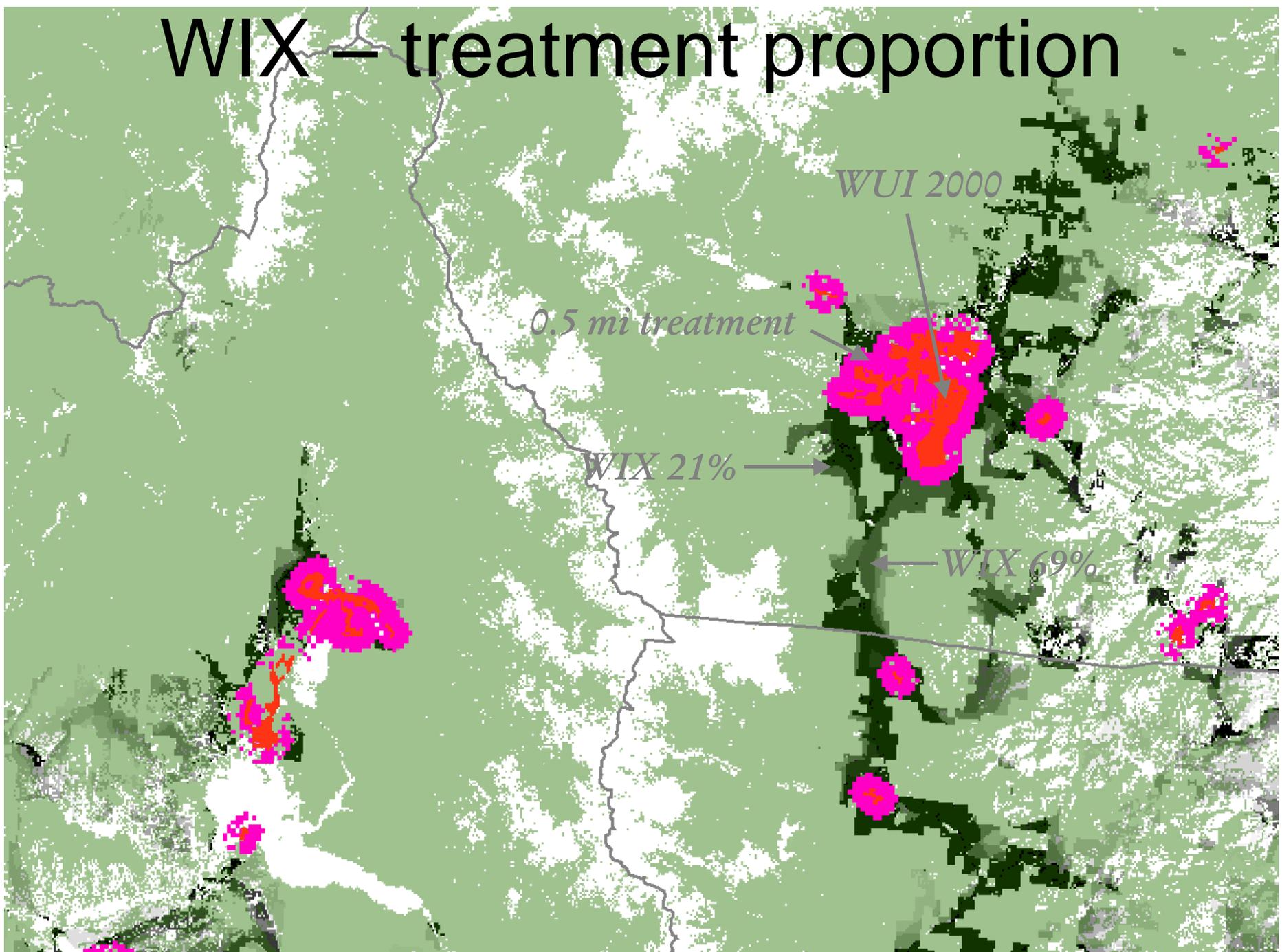


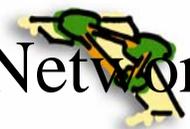
30  
Kilometers

Map created by David Theobald, Colorado State University, 27 July 2006

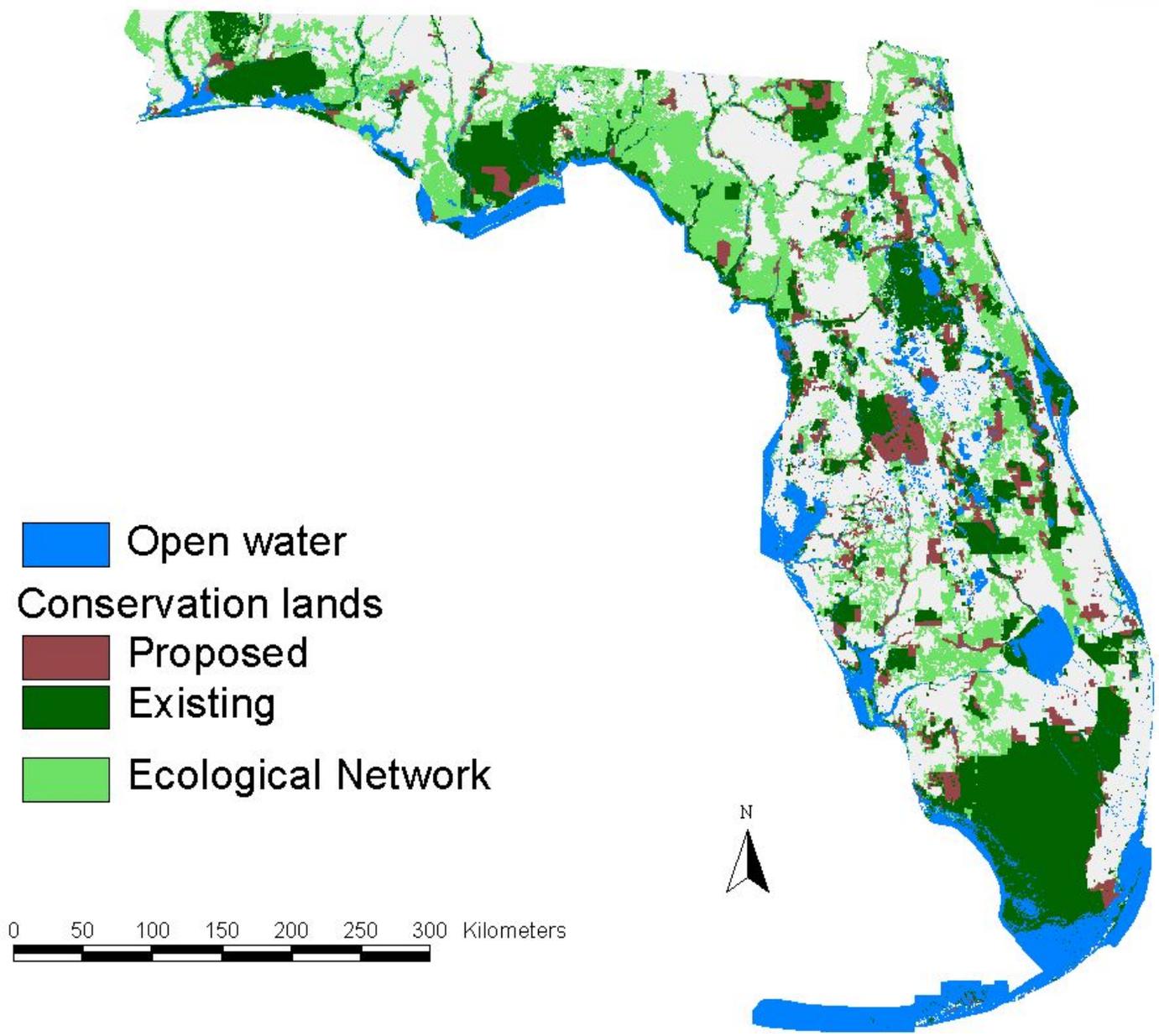
- Interstates
- WUI high hazard
- WIX
- counties

# WIX – treatment proportion

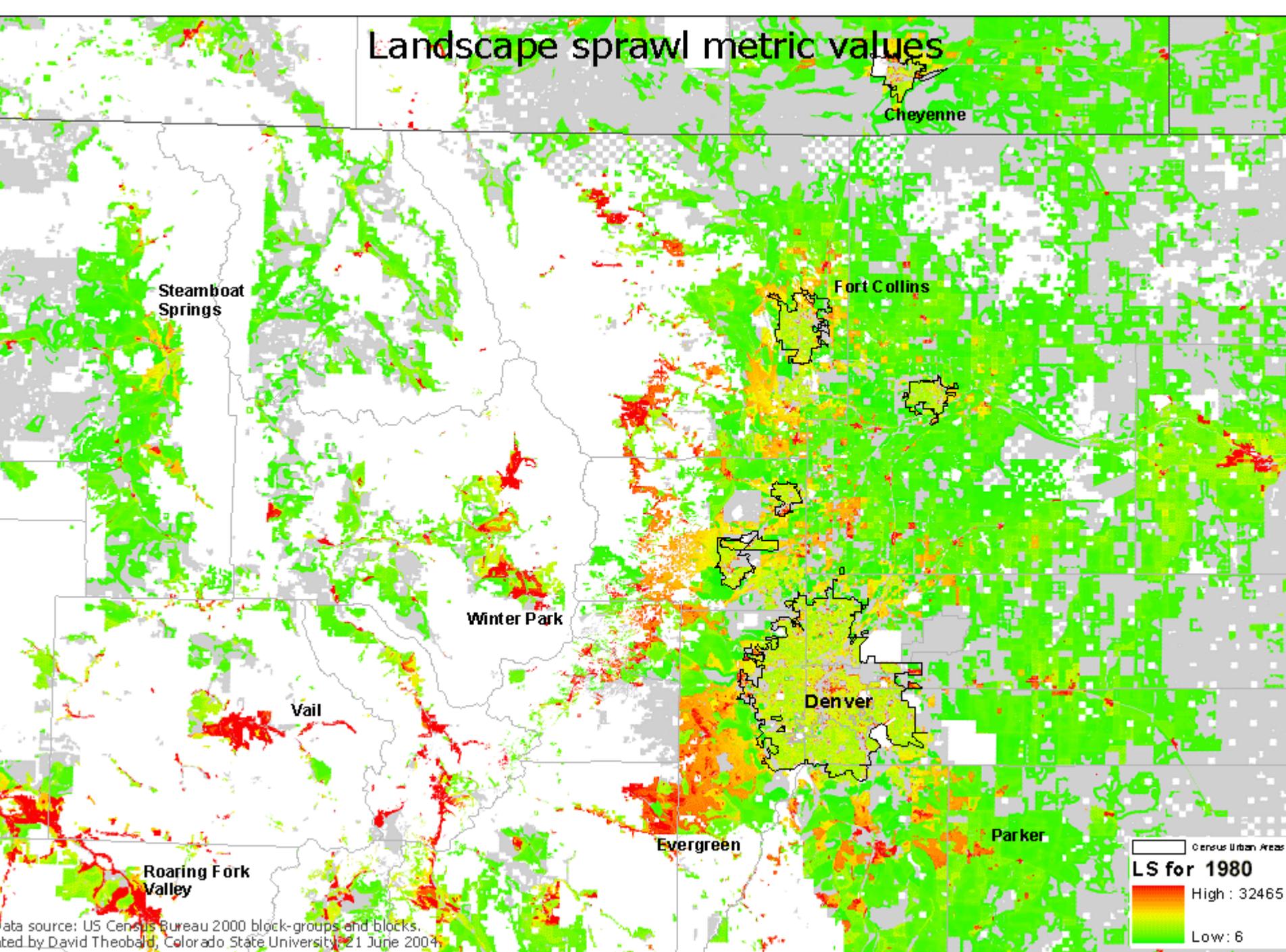




# Green infrastructure e.g., Florida Ecological Network



# Landscape sprawl metric values

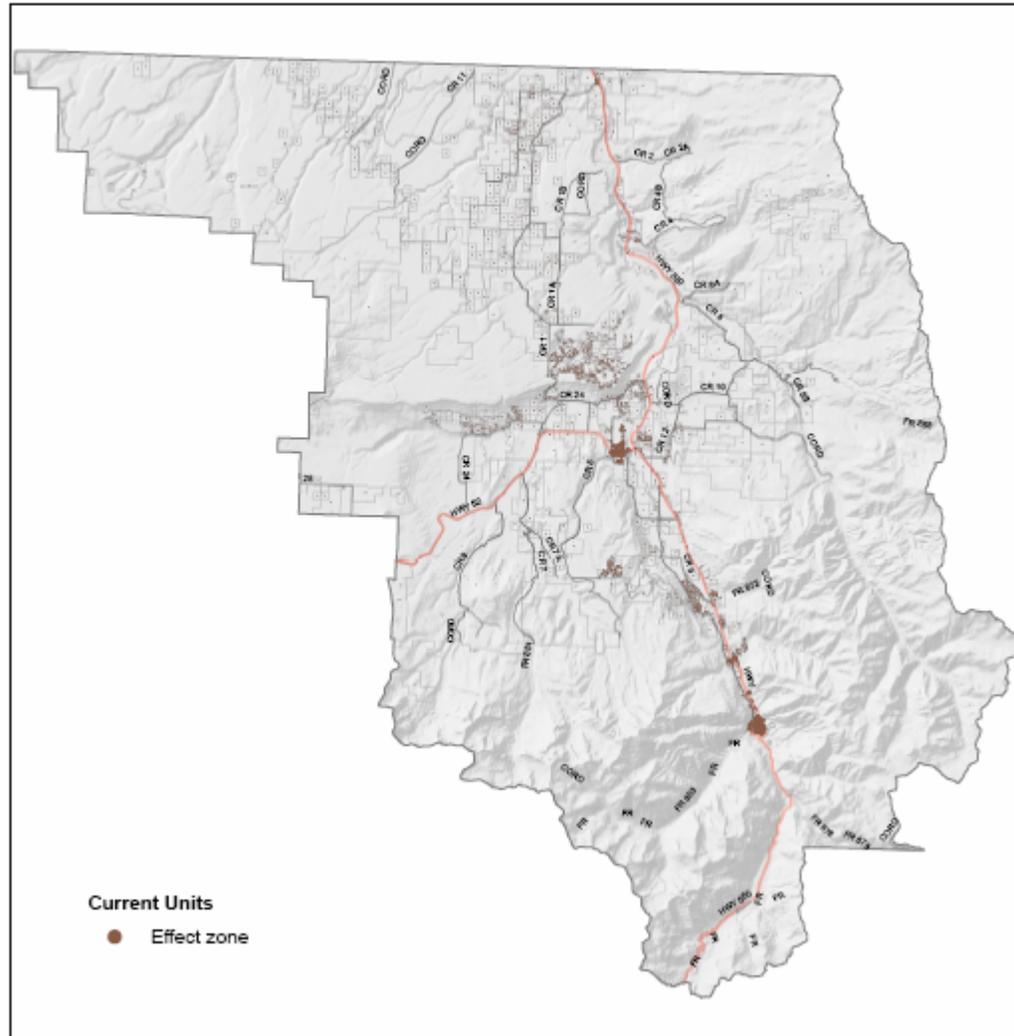


Data source: US Census Bureau 2000 block-groups and blocks.  
Map created by David Theobald, Colorado State University, 21 June 2004.



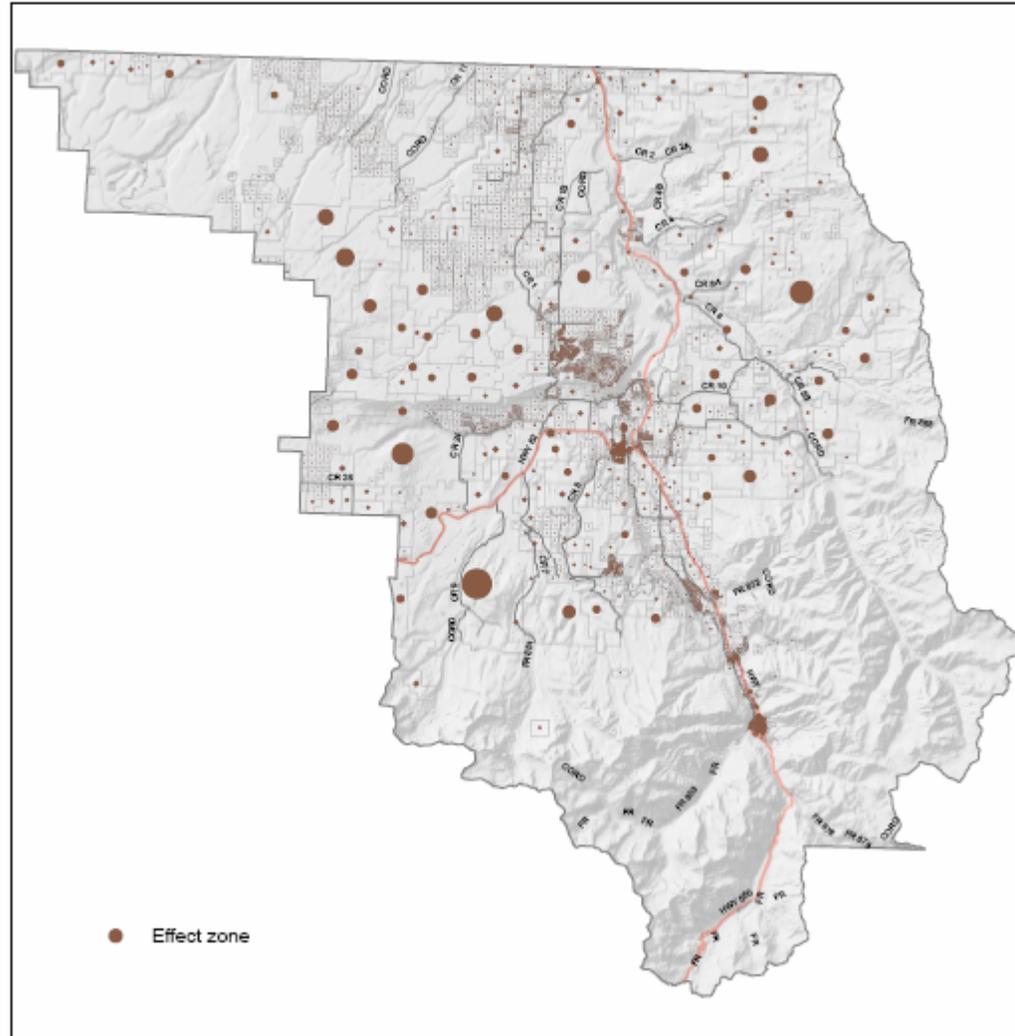
# Ouray County build-out

Scenario: Current conditions  
Ouray County Build-out Analysis



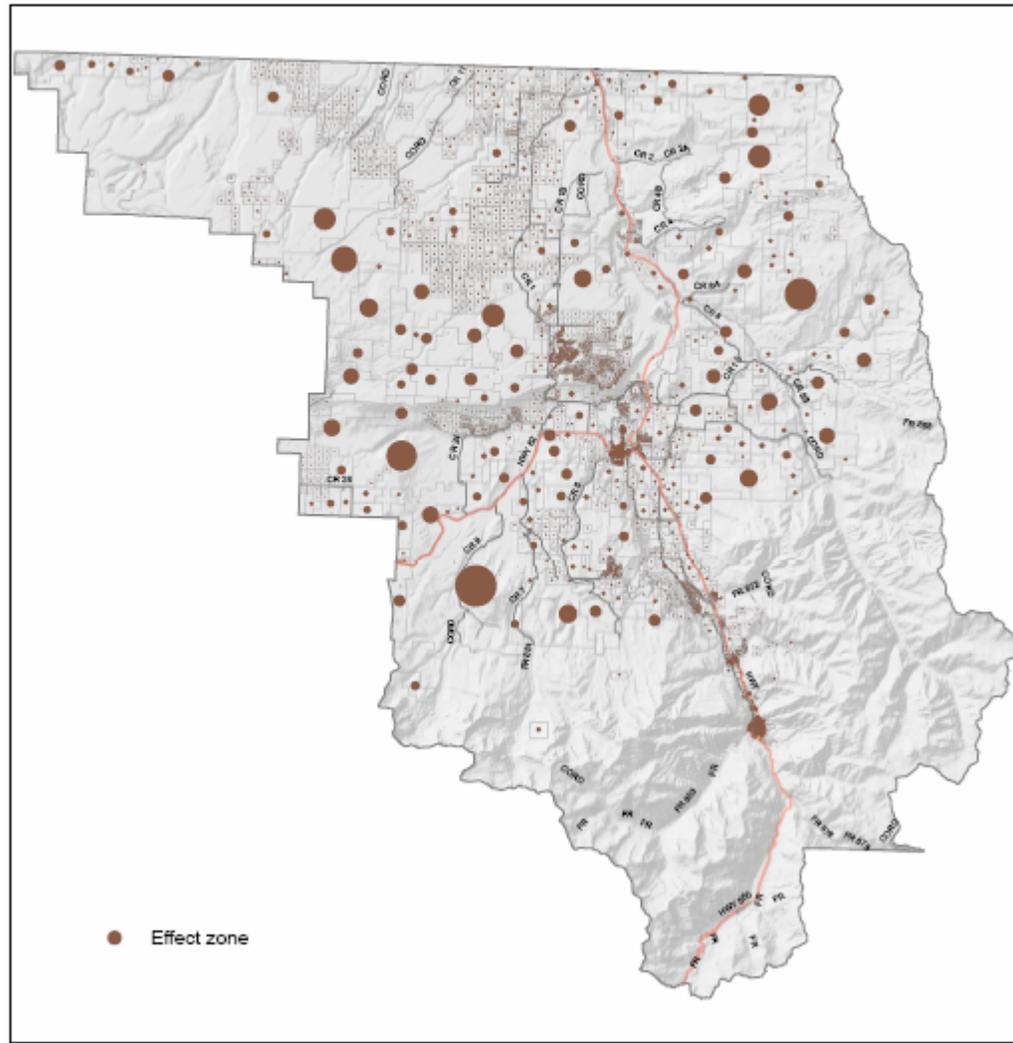
# Ouray County build-out

## Scenario A: Existing zoning Ouray County Build-out Analysis



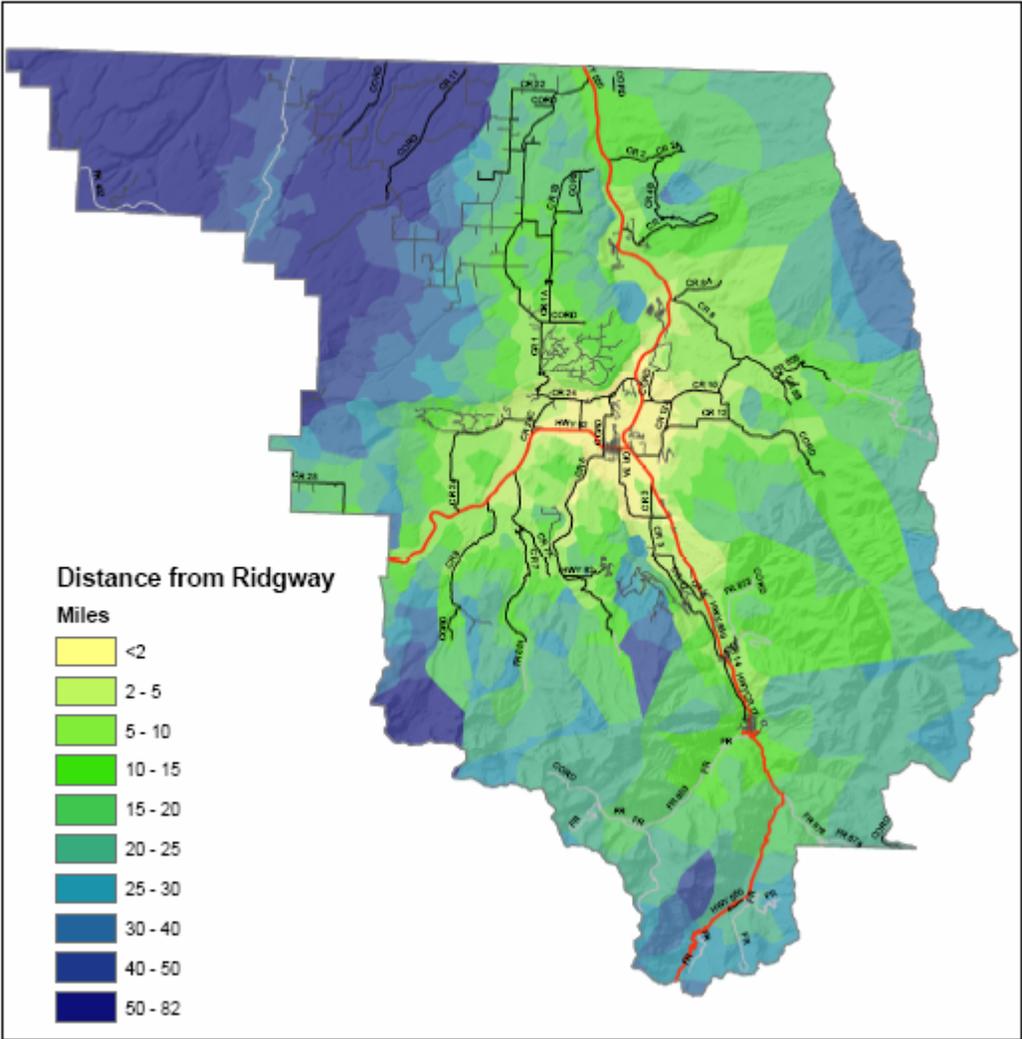
# Ouray County build-out

Scenario B: 35 acres at 17.5 per unit  
Ouray County Build-out Analysis



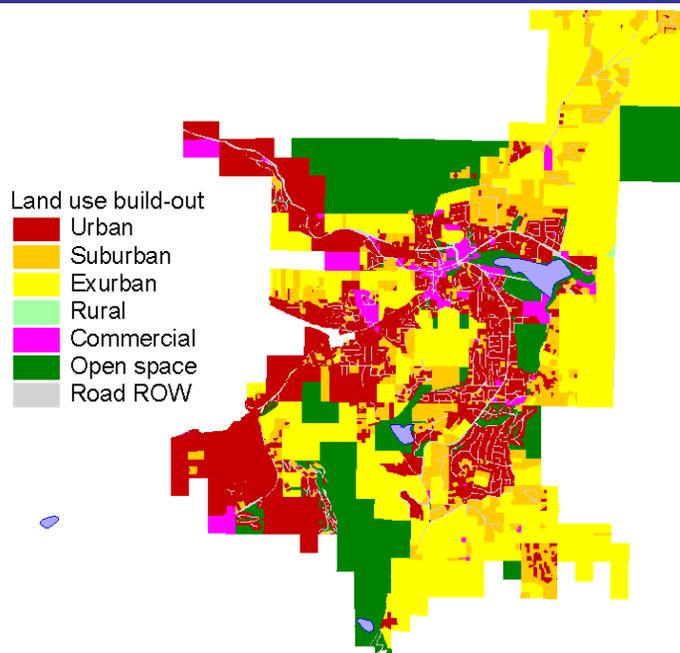
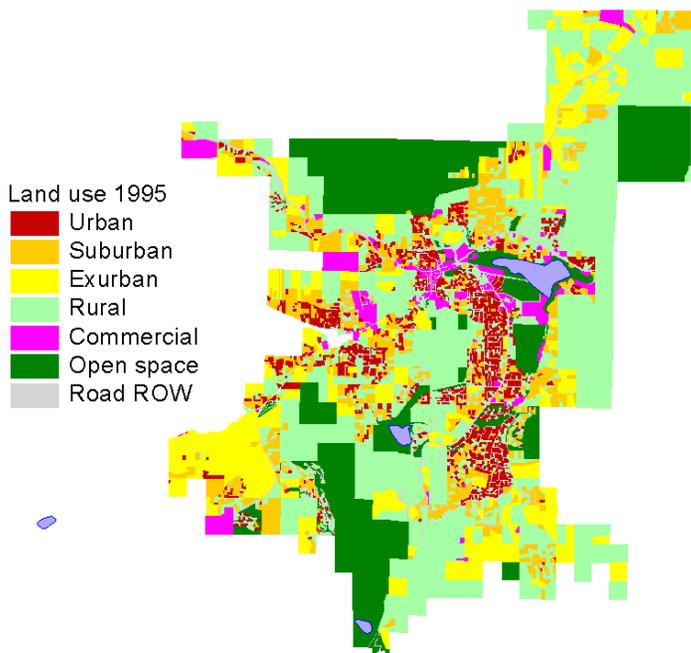
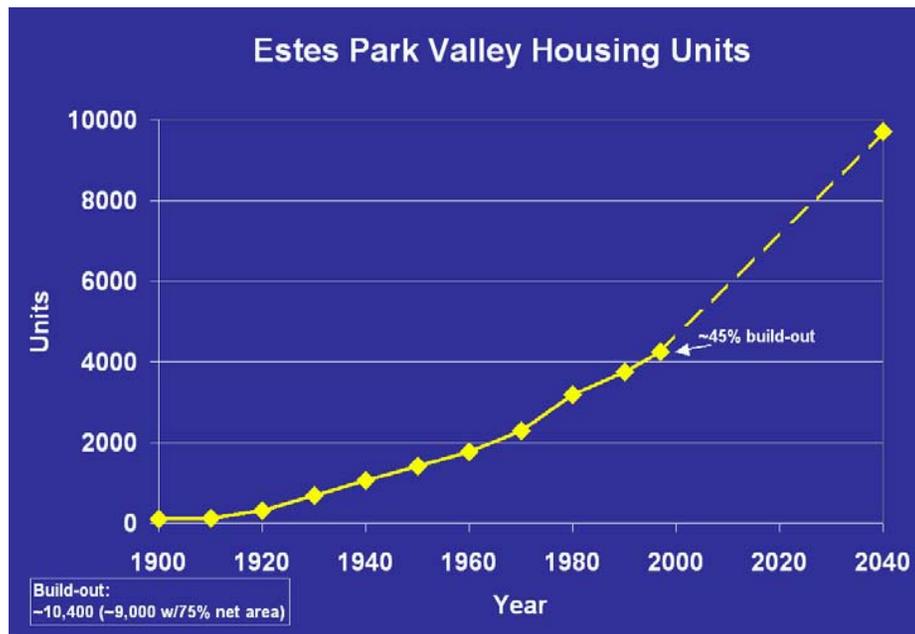
# Vehicle Miles Traveled

## Ouray County Build-out Analysis



# How to understand cumulative effects?

Forecasting growth patterns and the tyranny of small decisions

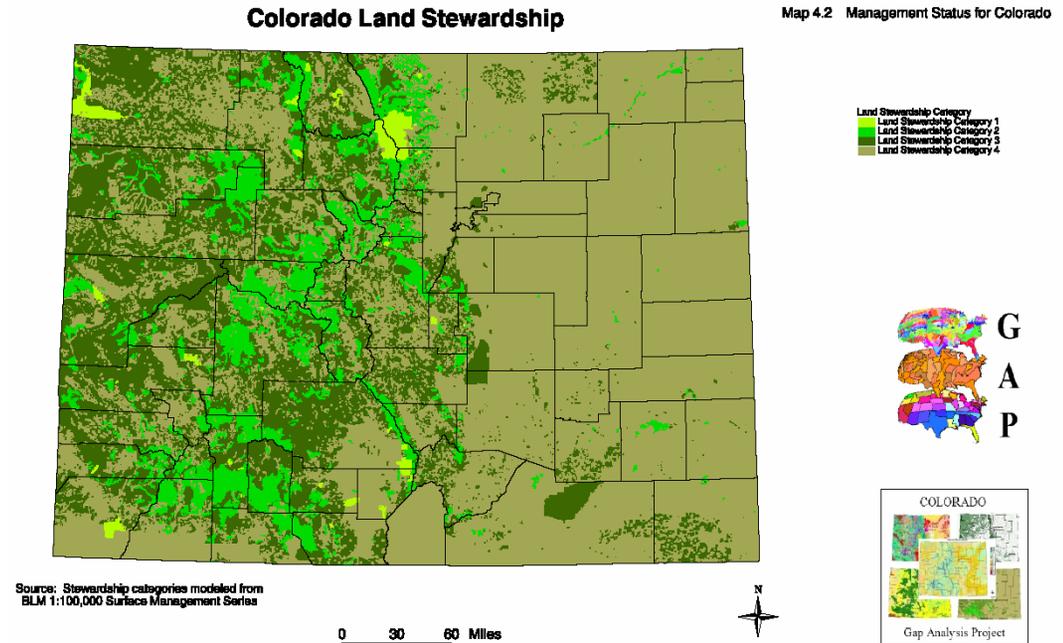


# Primary challenges

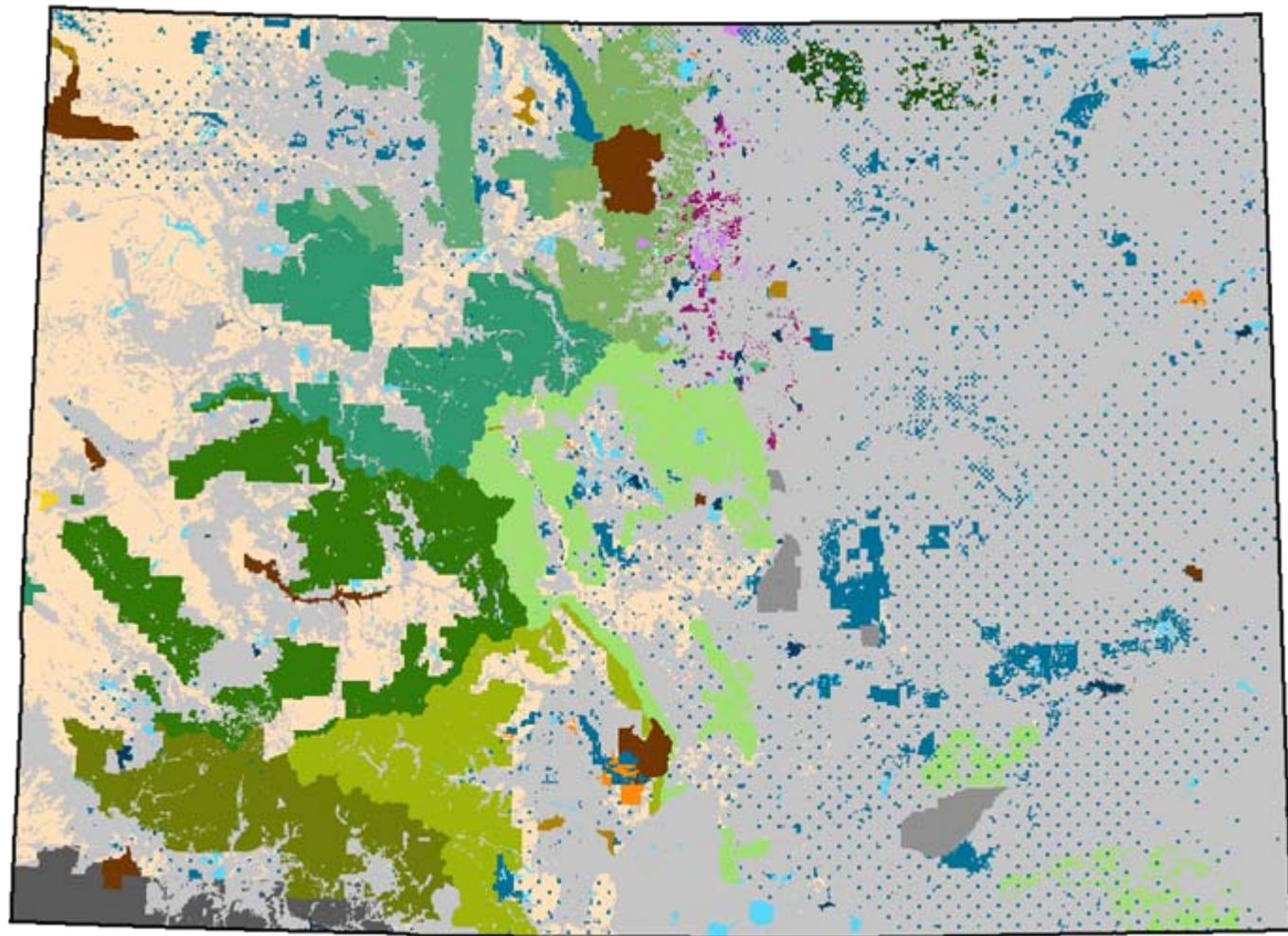
- Incorporating dynamics in policy
  - Institutionalizing a “red zone” map vs. dynamics (data, understanding, drivers)
  - Updating *Forests on the Edge*
- Better framework and data on stewardship, conservation uses

# Common approaches to STEWARDSHIP mapping

- IUCN (1994)
  - 8 categories
- USGS Gap



1. *Permanent protection from conversion of natural land cover with natural processes:* National park, wildlife refuge, etc.
2. *Permanent protection but degradation of quality (e.g., Suppression):* State wildlife area, wilderness, etc.
3. *Protection but some extractive uses:* Recreation area, military reservation, national forest, grassland, etc.
4. *No restrictions of conversion:*  
State forest, state land board, Federal Center, **private**



COMaP:

Colorado Ownership  
Management  
and  
Protection

*Mapping the status and trends of Colorado's protected areas*

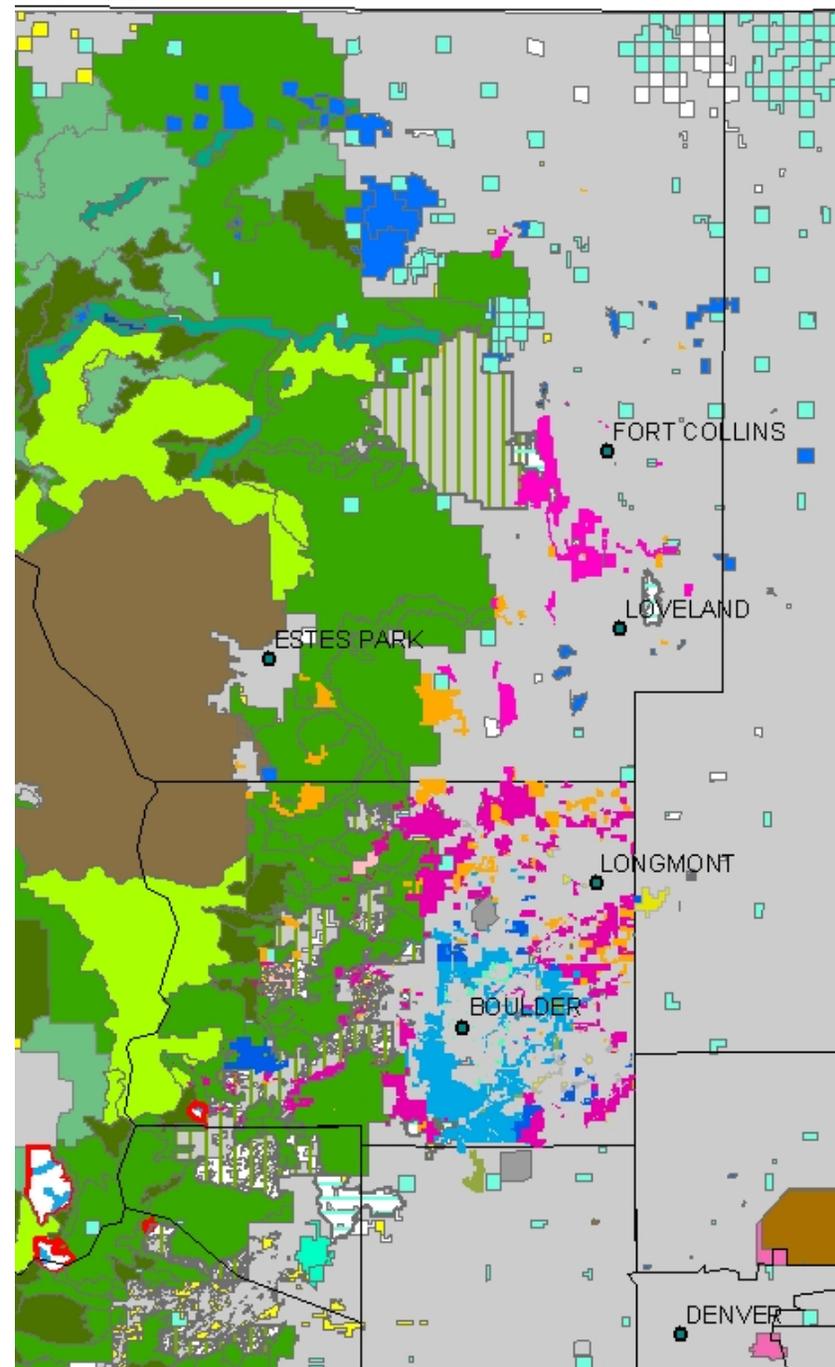
Dr. David M. Theobald, Nate Peterson, Grant Wilcox

Natural Resource Ecology Lab

Colorado State University

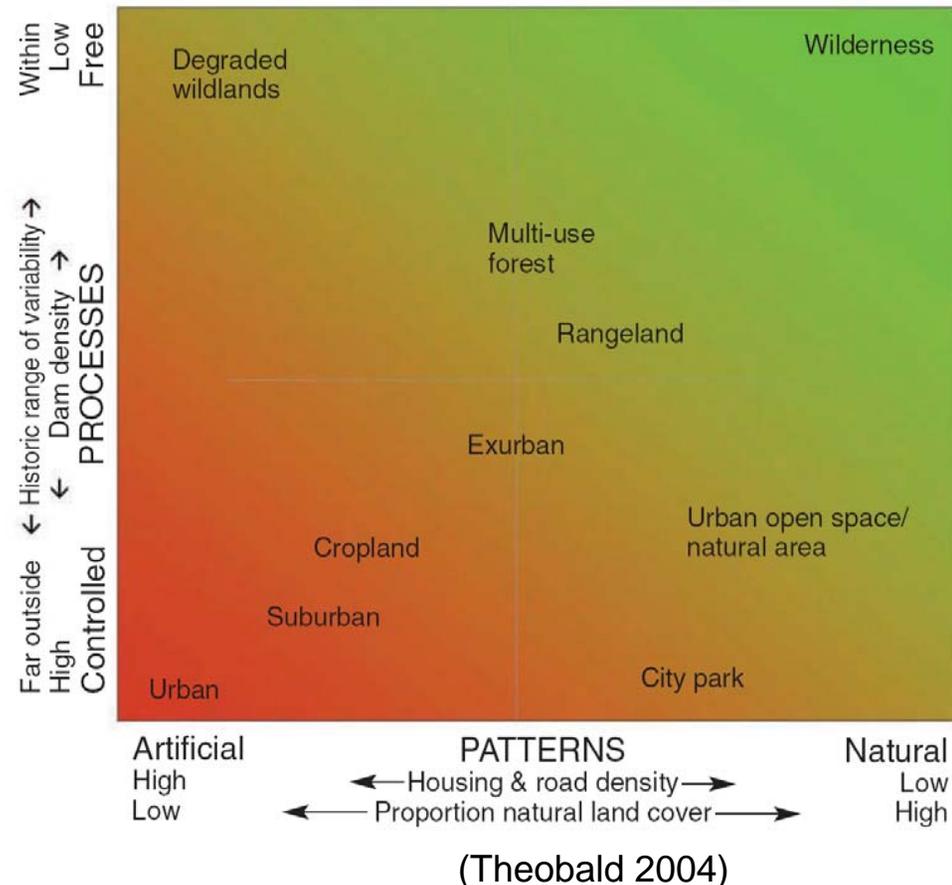


# Land stewardship maps? Public & private lands?

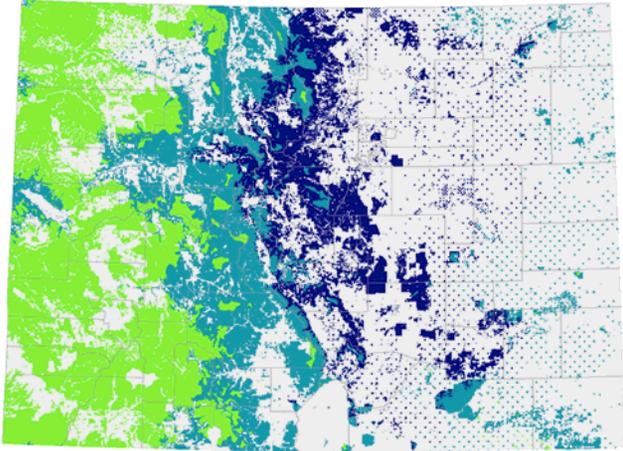


# Human modification framework

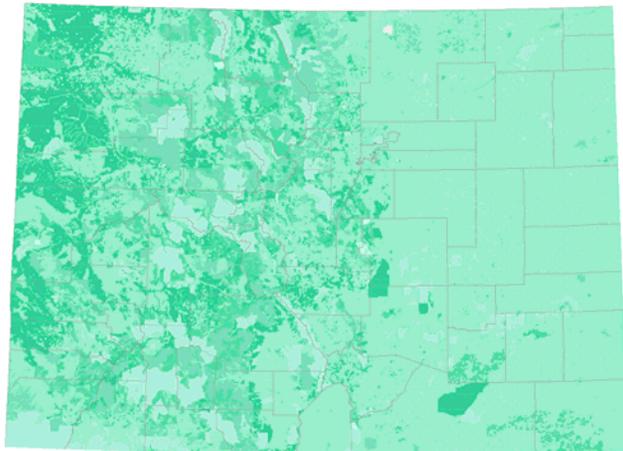
- Three factors (or human use types) to characterize land use based on human activities. Principally, humans:
  - concentrate or intensify resources by reconfiguring and construct buildings and other infrastructure (urban/built-up)
  - harness or remove natural resources (production/extraction)
  - visit but do not extract significant resources (recreation/tourism/work)



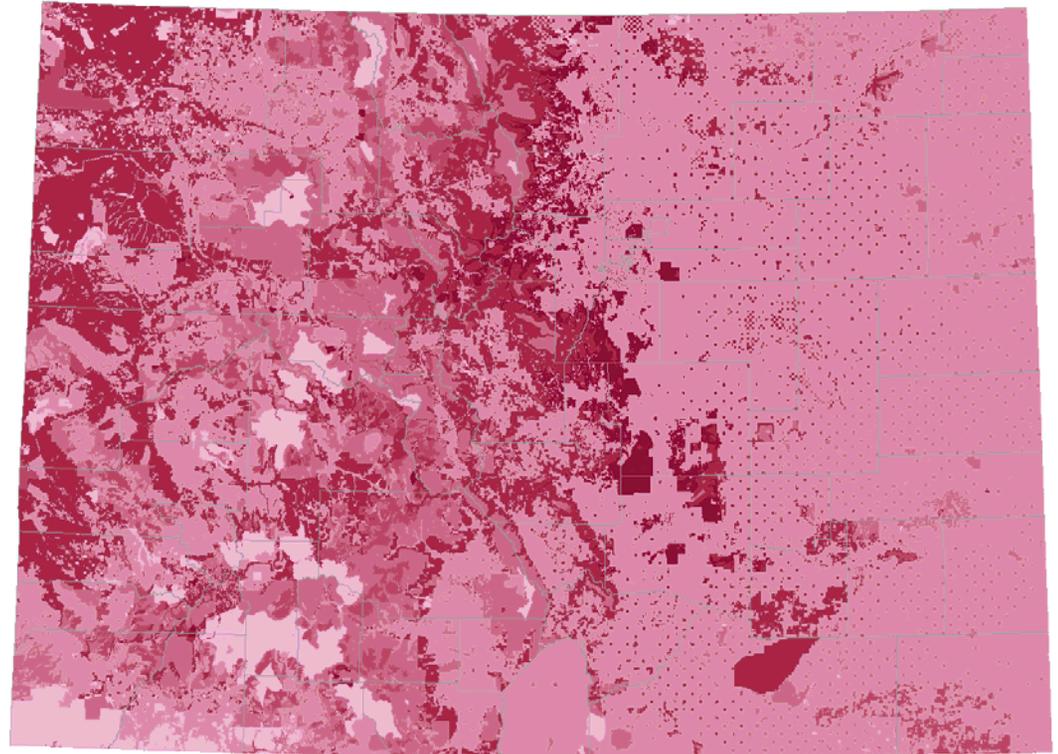
# Recreation/tourism



Accessibility



Managed Uses



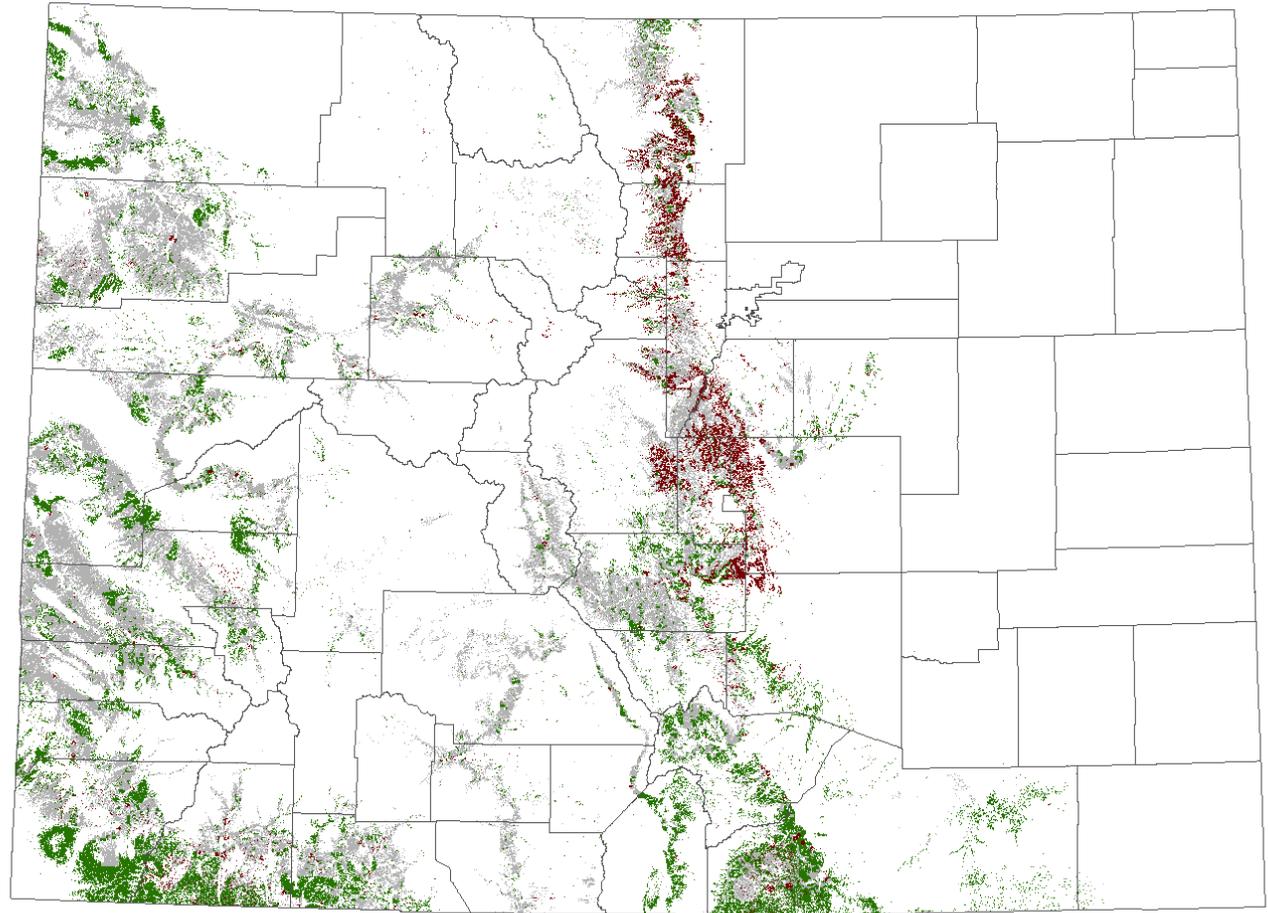
Composite

# Results – HMF composite



# Results (forest zones)

<i>Ecological systems</i> <sup>[1]</sup>	<i>Mean HMF (SD)</i>
Upper montane (spruce-fir)	0.329 (0.159)
Mid-montane (Douglas fir, Lodgepole pine)	0.428 (0.192)
Lower montane (Ponderosa pine, Pinyon-Juniper)	0.405 (0.203)
Aspen	0.313 (0.135)



Statewide: 0.392 (SD=0.231)

# Conclusions

- Continued pressure on forest conversion and change in land use – values are shifting along with demographics
- Progress in using GIS-based methods to help inform rural land use planning
- Technical challenges, but basic data on private land use changes needed
- Model world continuous vs. discrete (binary)