Measuring landscape dynamics for park resources

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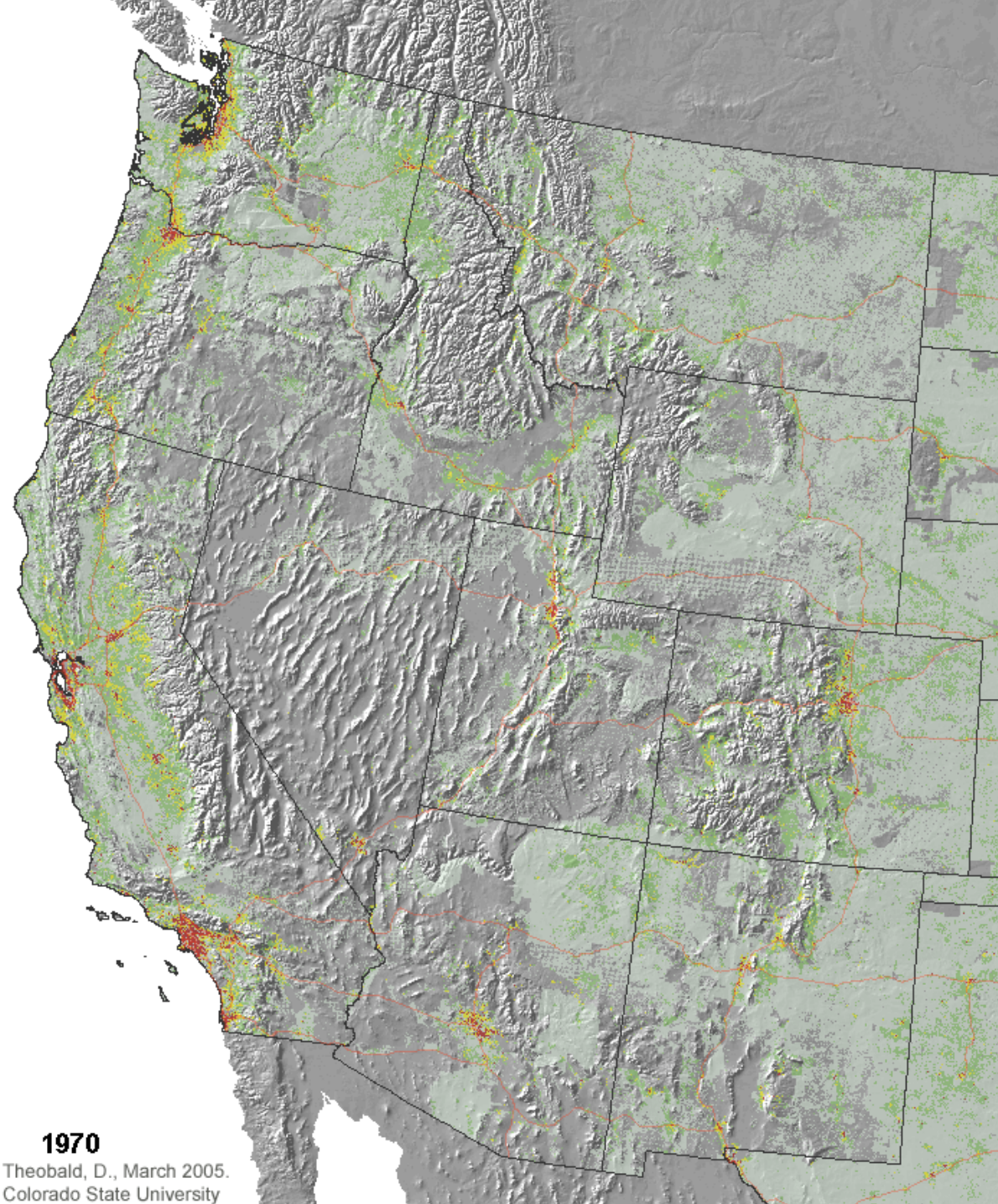
Road map

Landscape dynamics and importance to parks

Broad framework of landscape metrics

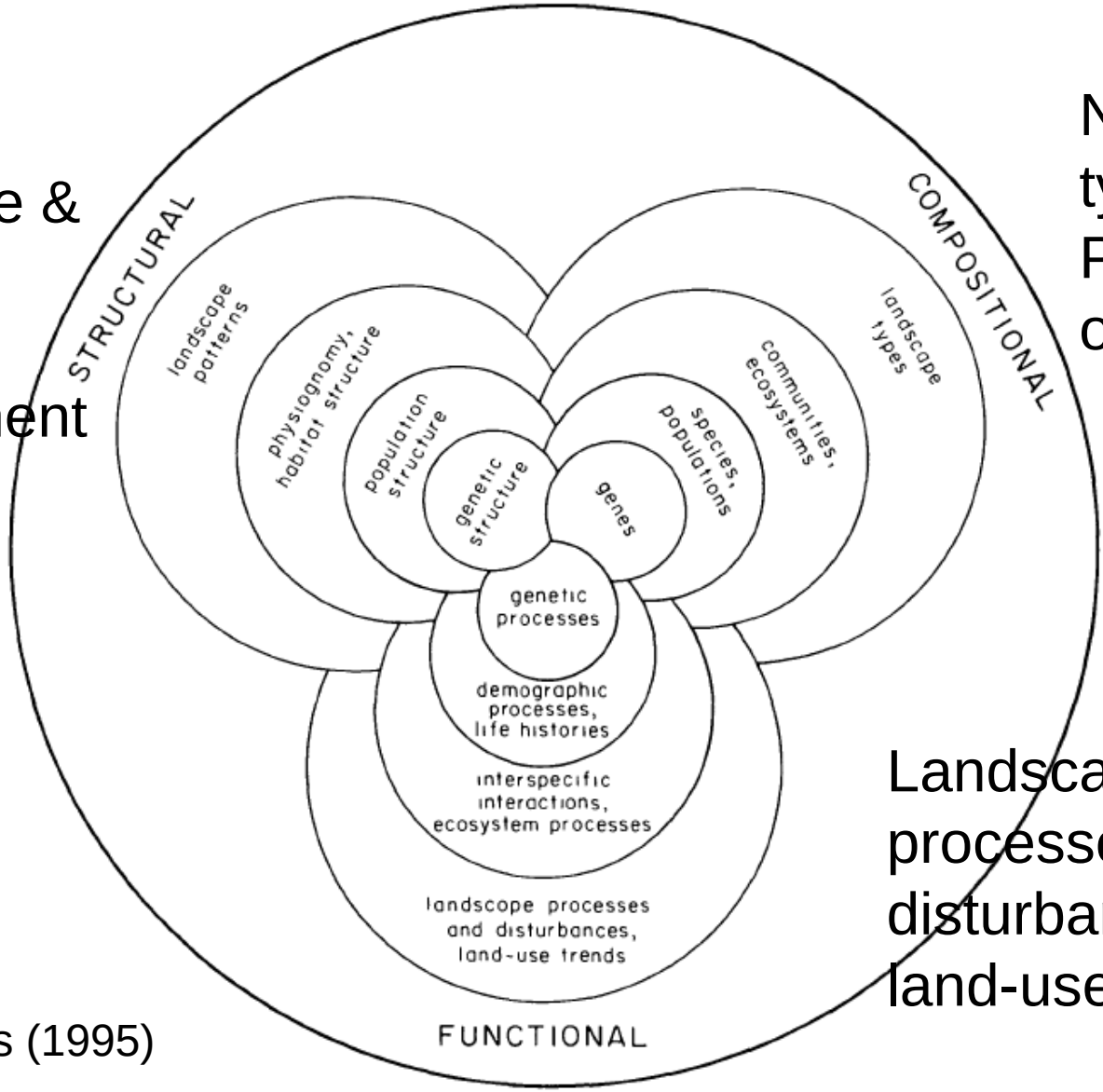
Five examples:

1. Ecoregional vs. 5 km buffer context
2. Accessibility to urban areas
3. “Natural” land cover fragmentation
4. Landscape connectivit using networks
5. Fire regime & historica land use



Conceptual framework for pattern metrics

Patch size & shape, contrast, arrangement



Number of types
Proportion of each type

Landscape processes, disturbances, land-use trends

Li and Reynolds (1995)

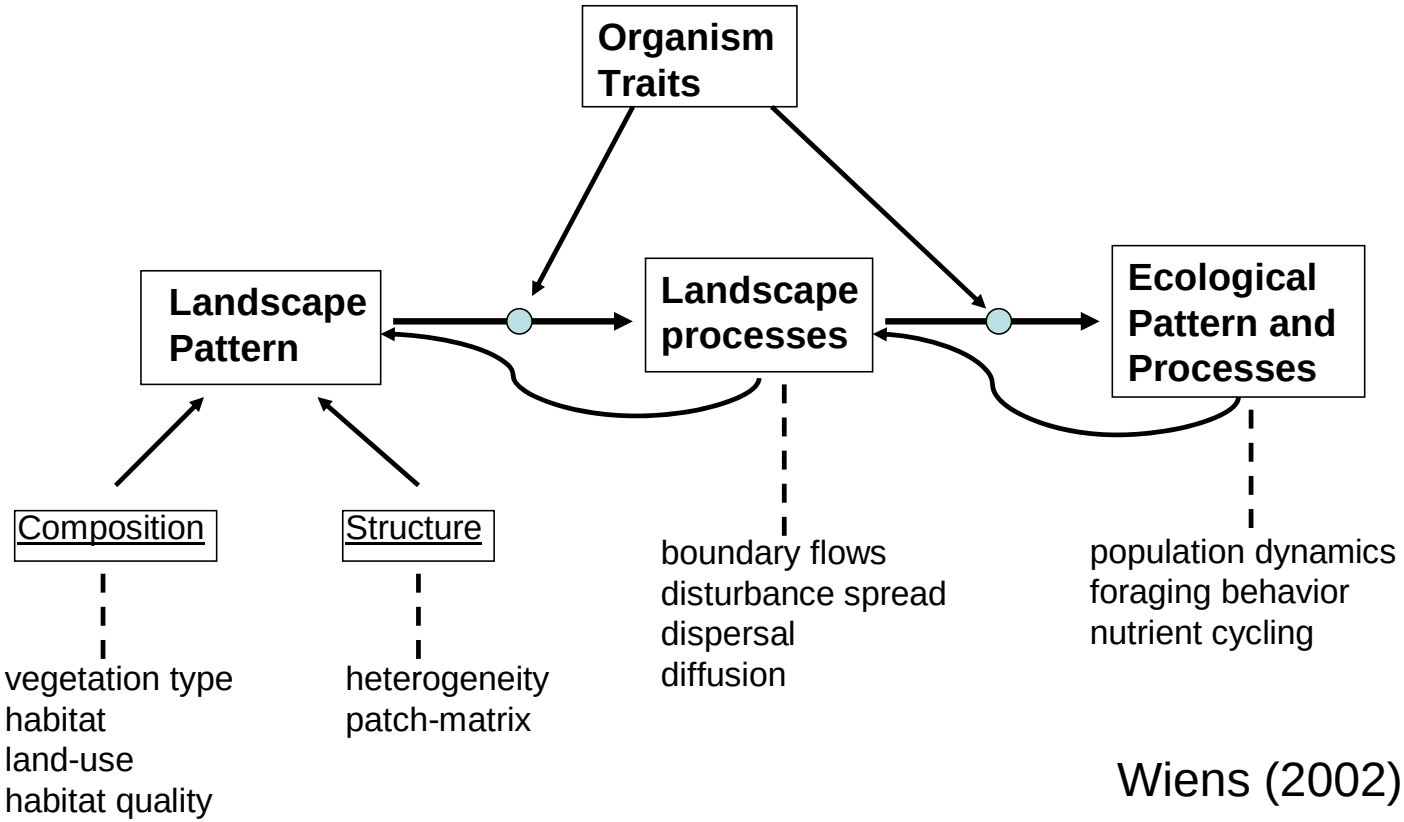
Noss (1990)

Landscape pattern metrics

To *quantitatively measure* heterogeneity of a landscape

To *compare* landscapes: a) same landscape but changes over time; b) different scenarios; c) different landscapes

To *infer* underlying agents of pattern formation, as a precursor to more strategic hypothesis testing



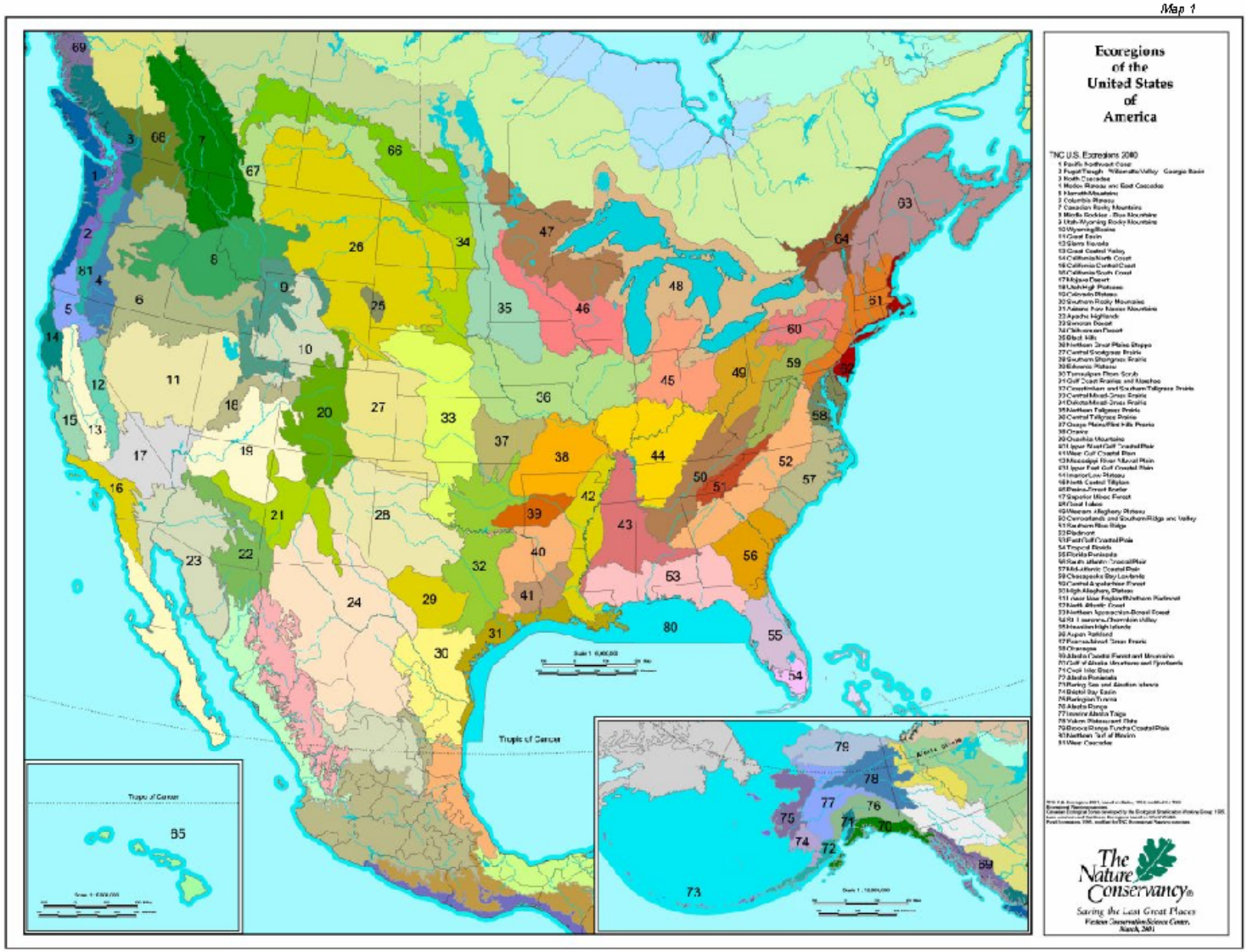
Wiens (2002)

Recommendations for using metrics

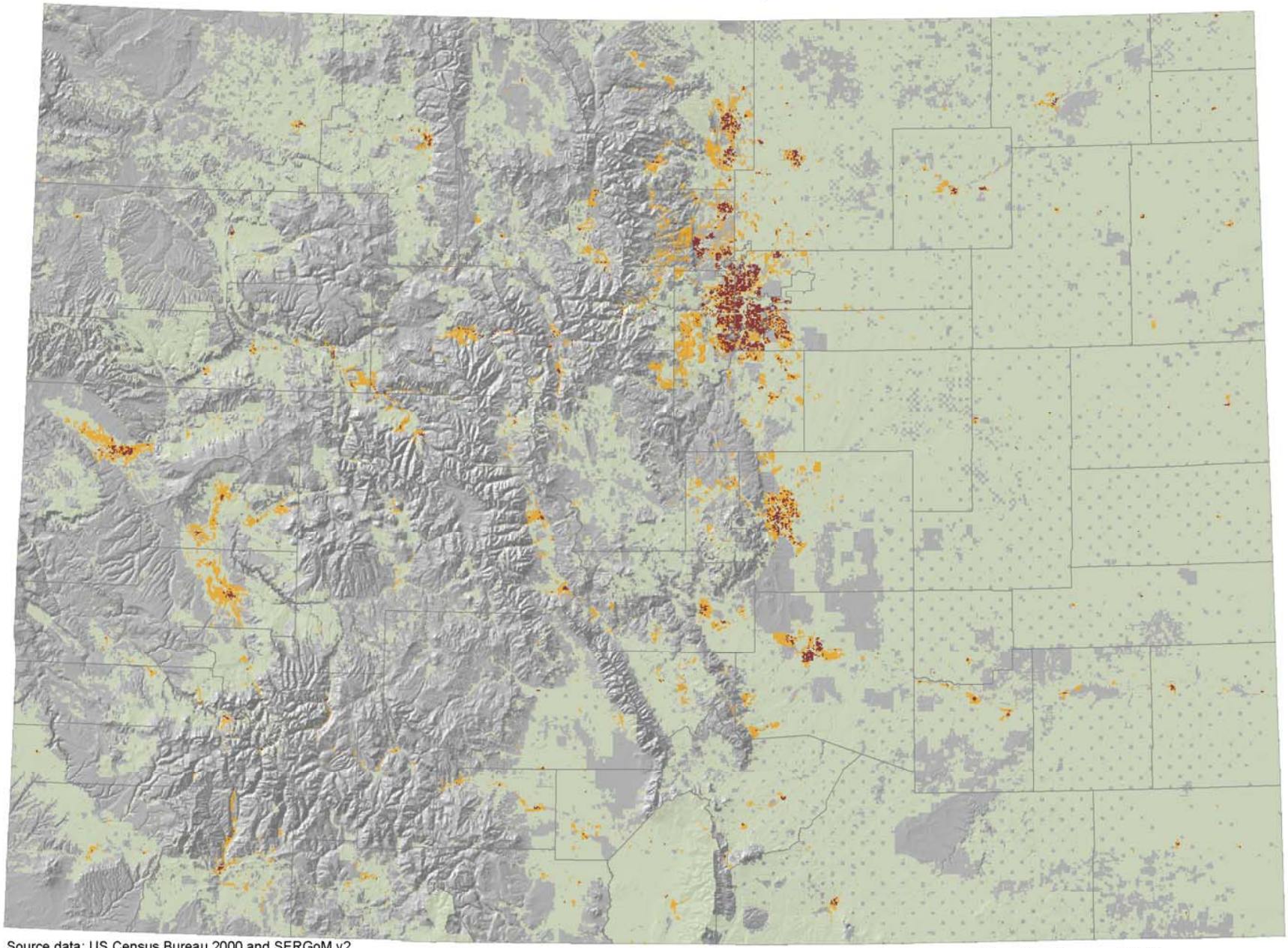
- Landscapes should be carefully described:
  - Grain & extent; data source, land cover classification; number (N) & amount (p_i) of each class type
- Metrics should be consistently evaluated:
  - Sensitive and monotonic to pattern change?
  - Do they behave well with scale (grain & extent) changes?
  - What are the confidence limits?
  - Simple and clear mathematical & analytical description (with computer code)

Gardner & Townsend (2004) NPS I&M Workshop

Example 1: Landscape dynamics & ecoregional context



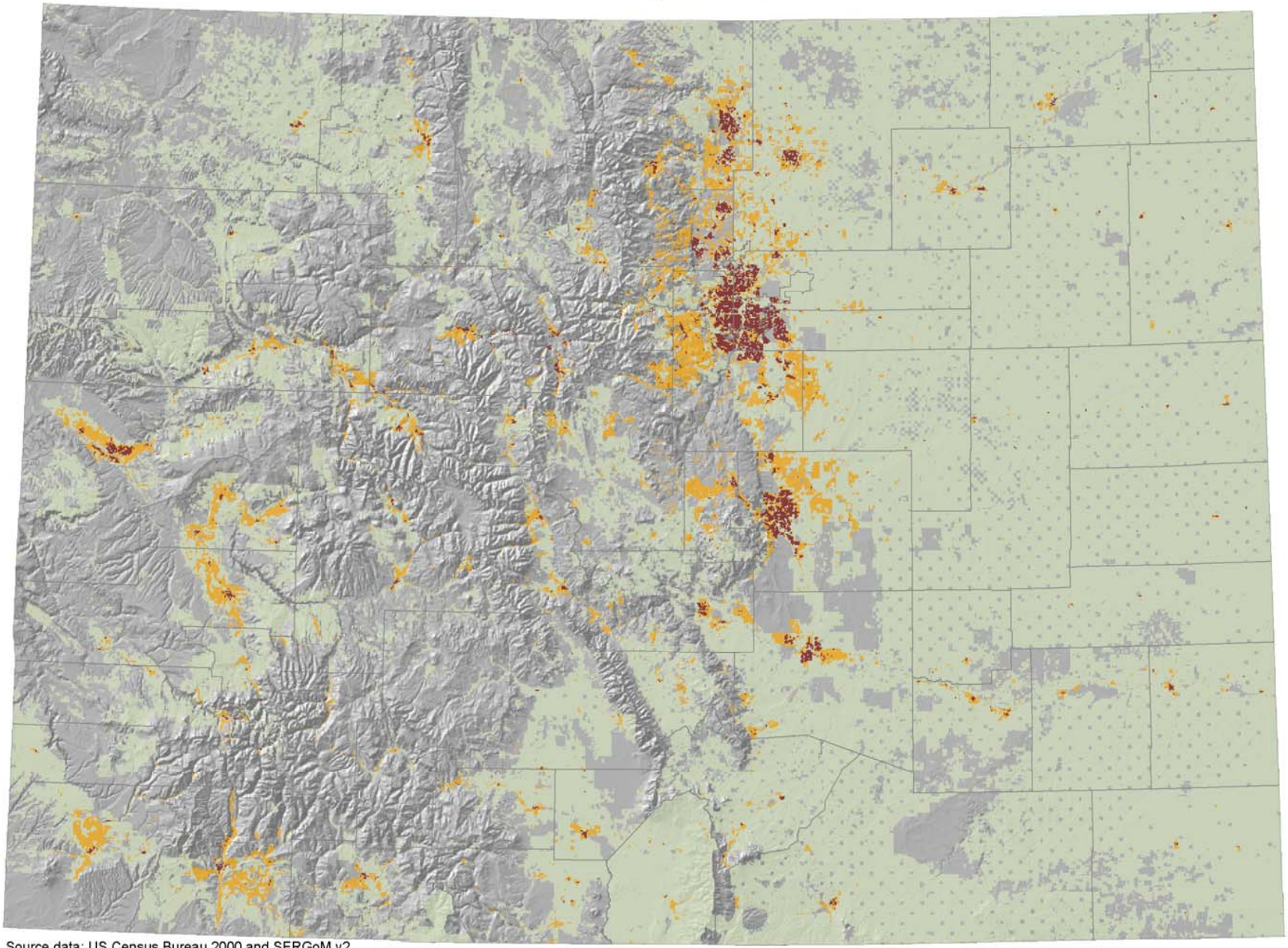
Colorado Housing Density 1970



Source data: US Census Bureau 2000 and SERGoM v2,
created by David Theobald, Natural Resource Ecology Lab
Colorado State University, 24 May 2005.

0 10 20 40 Miles

Colorado Housing Density 2000



Source data: US Census Bureau 2000 and SERGoM v2,
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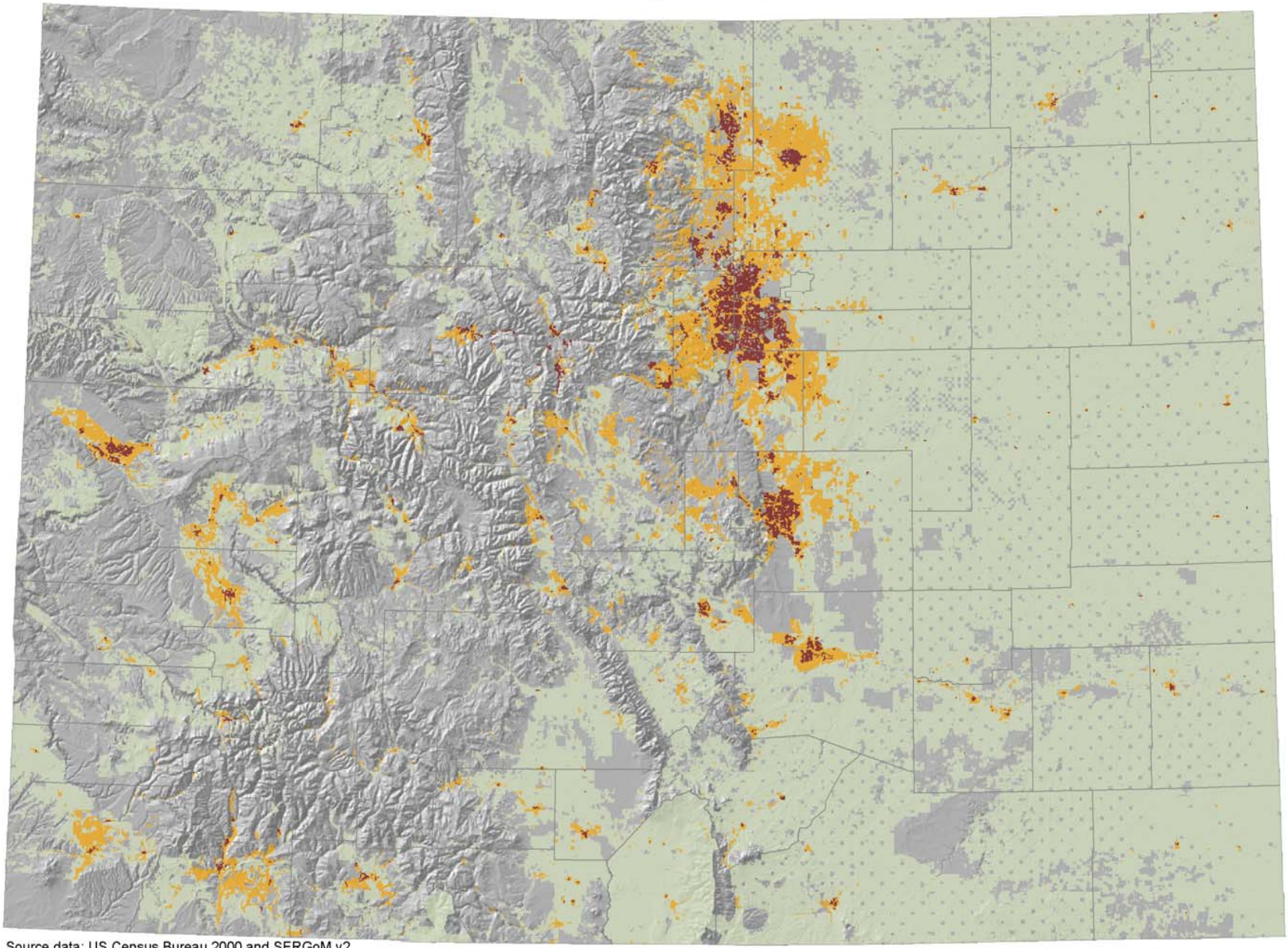
Colorado State University, 24 May 2005.

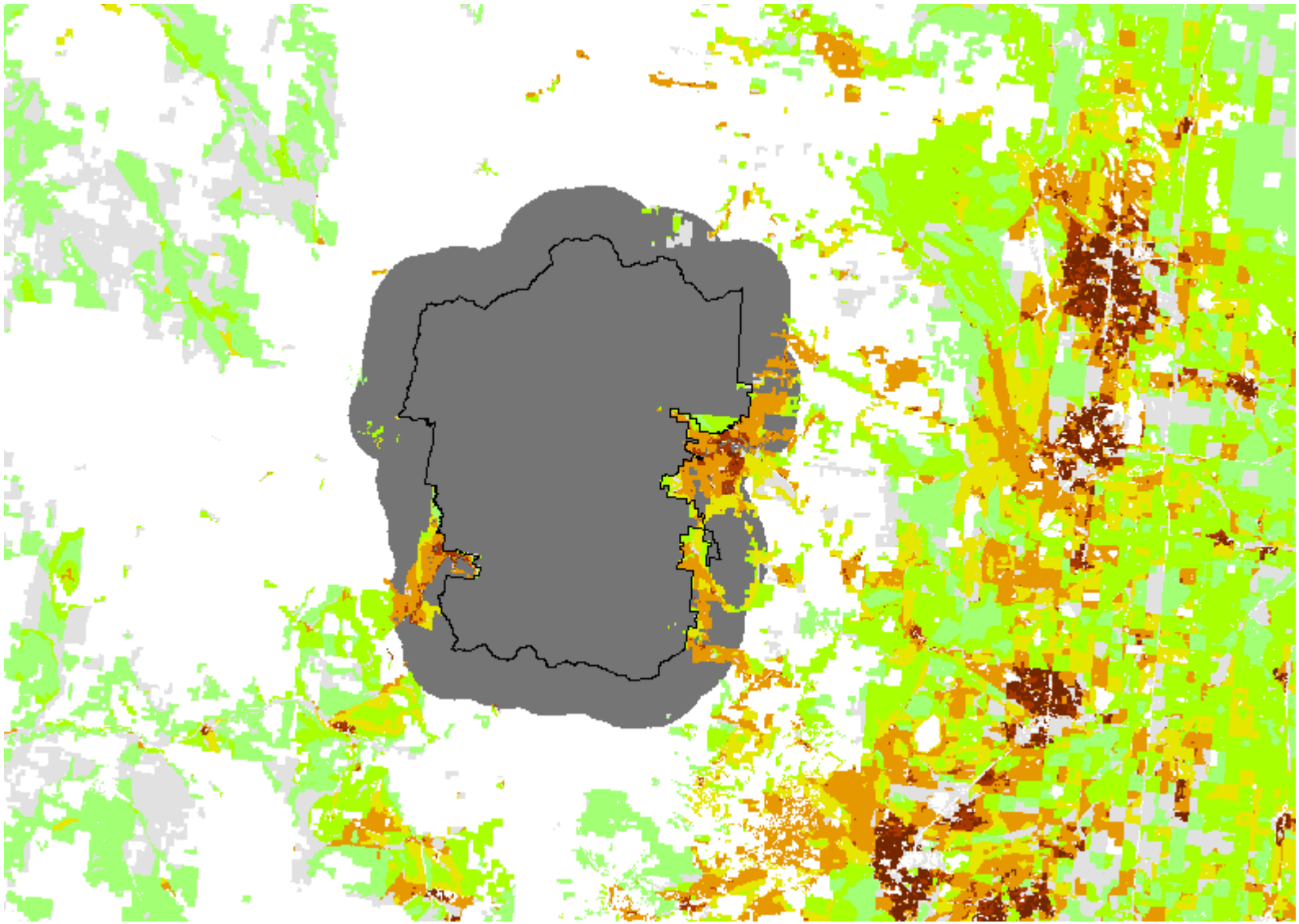
Colorado Housing Density 2030



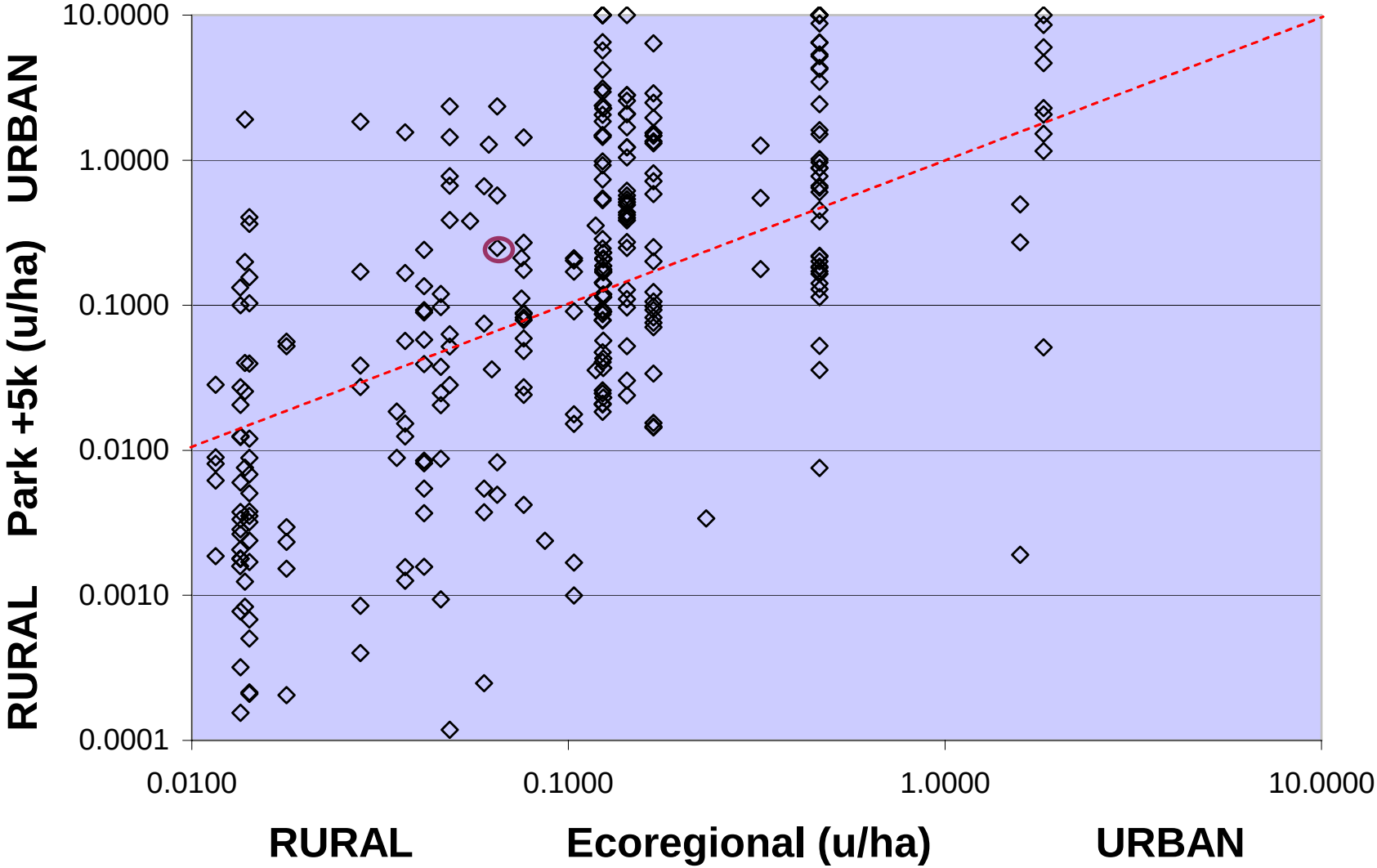
Source data: US Census Bureau 2000 and SERGoM v2,
created by David Theobald, Natural Resource Ecology Lab
Colorado State University, 24 May 2005.

0 10 20 40 Miles

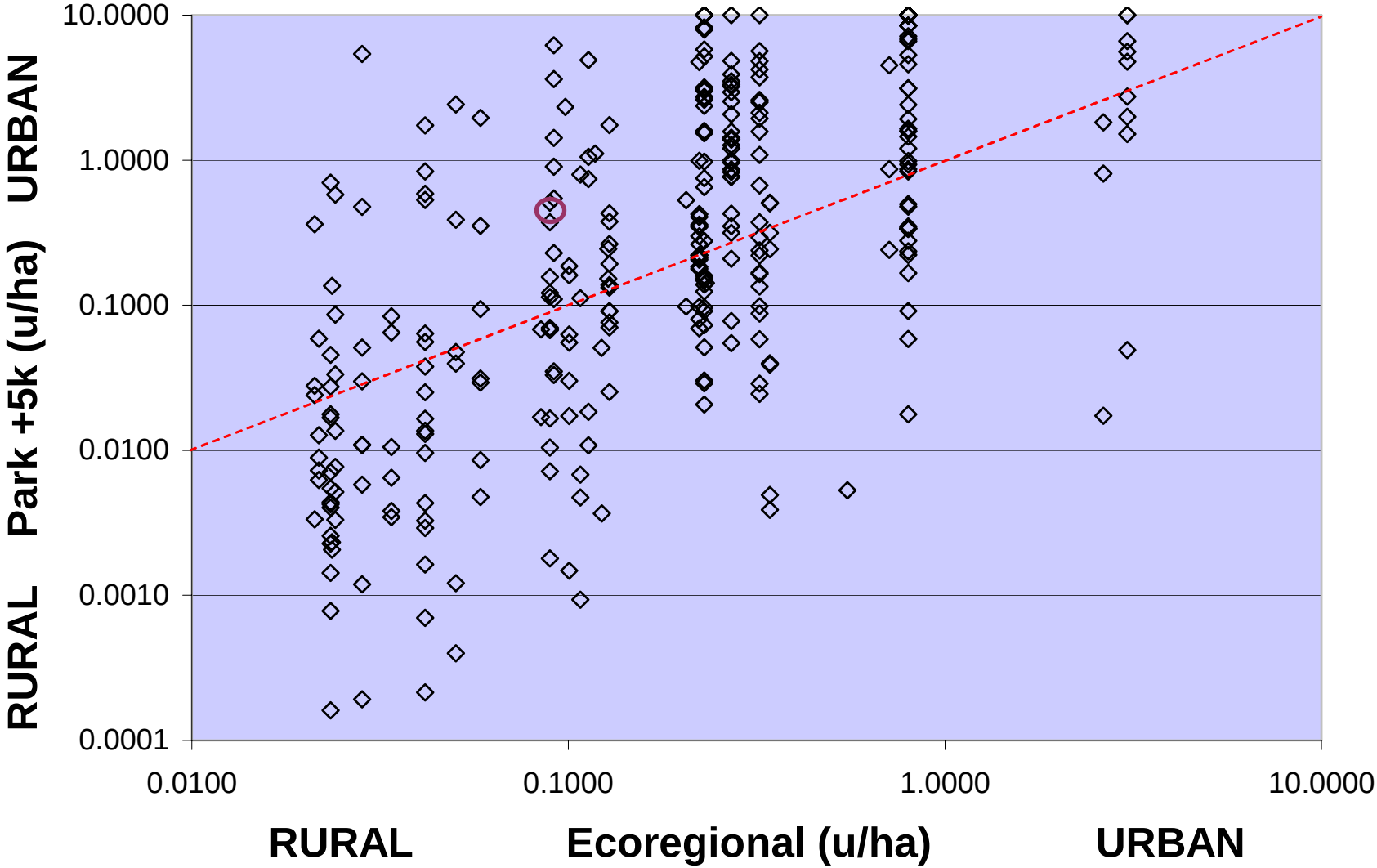
Compared to adjacent areas (5 km)



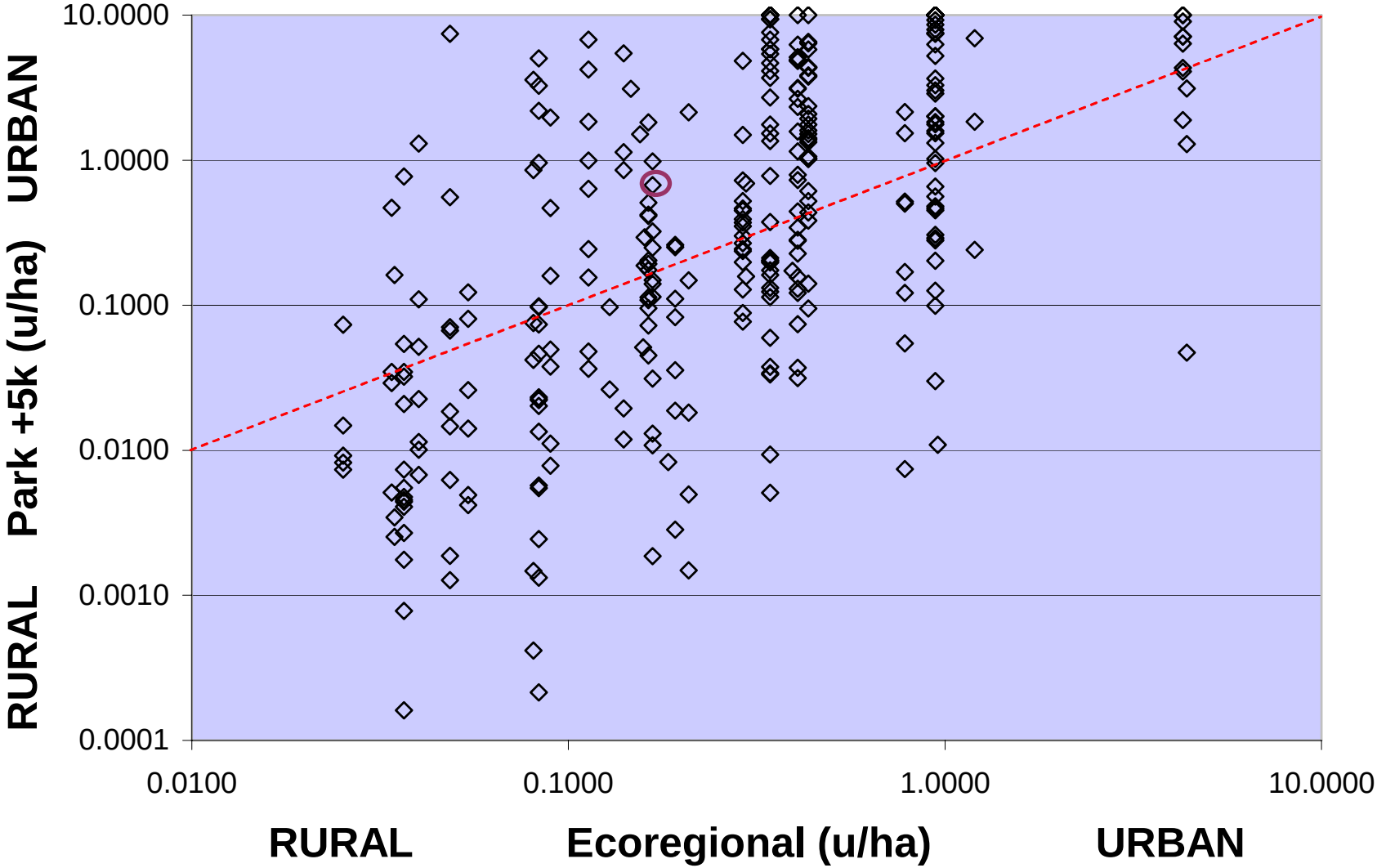
Landscape context 1970



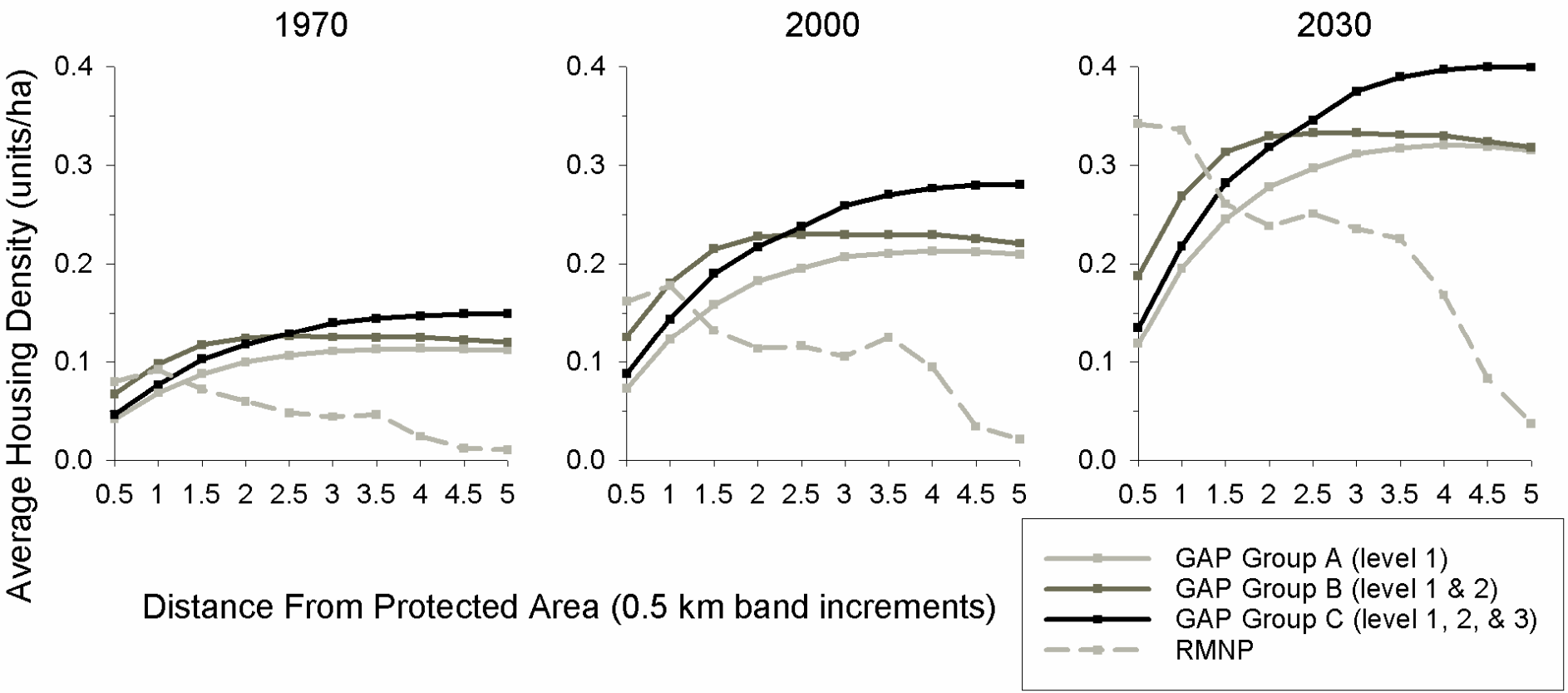
Landscape context 2000



Landscape context 2030



Growth on the edge



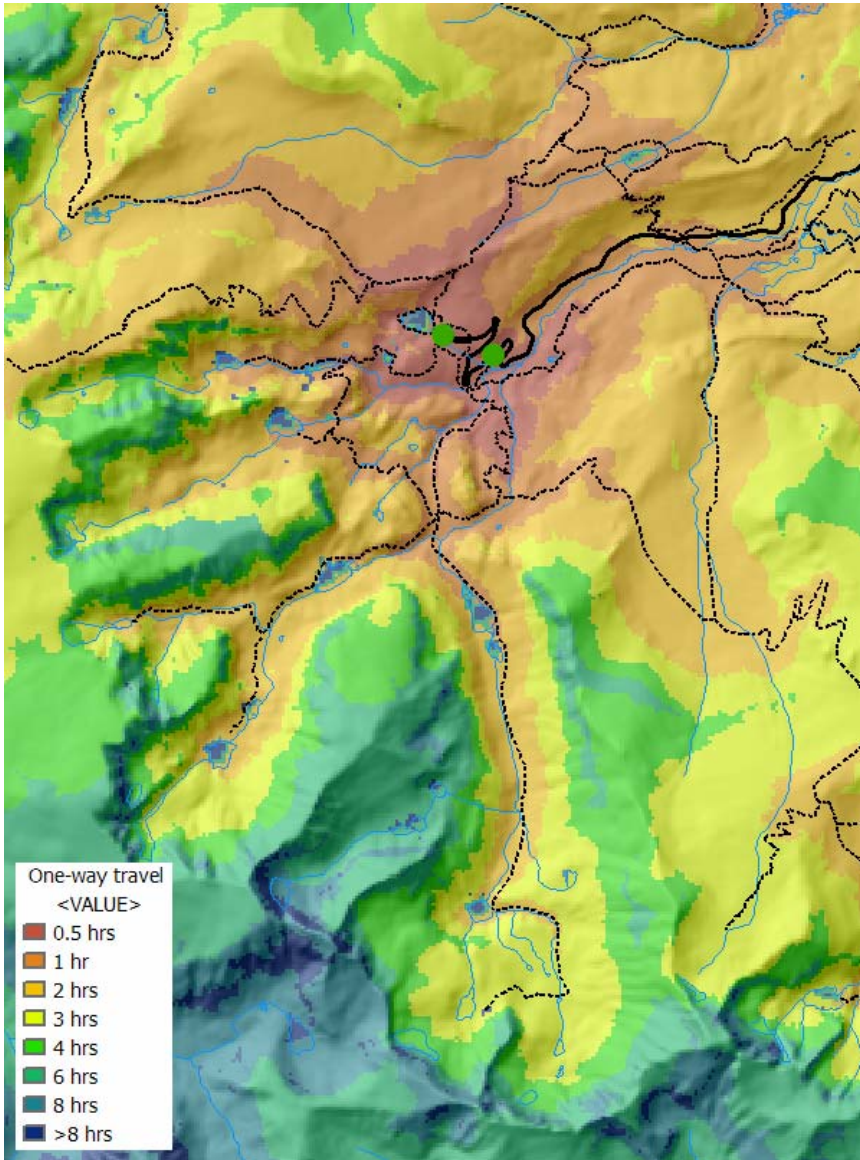
Wade and Theobald (*in prep*.)

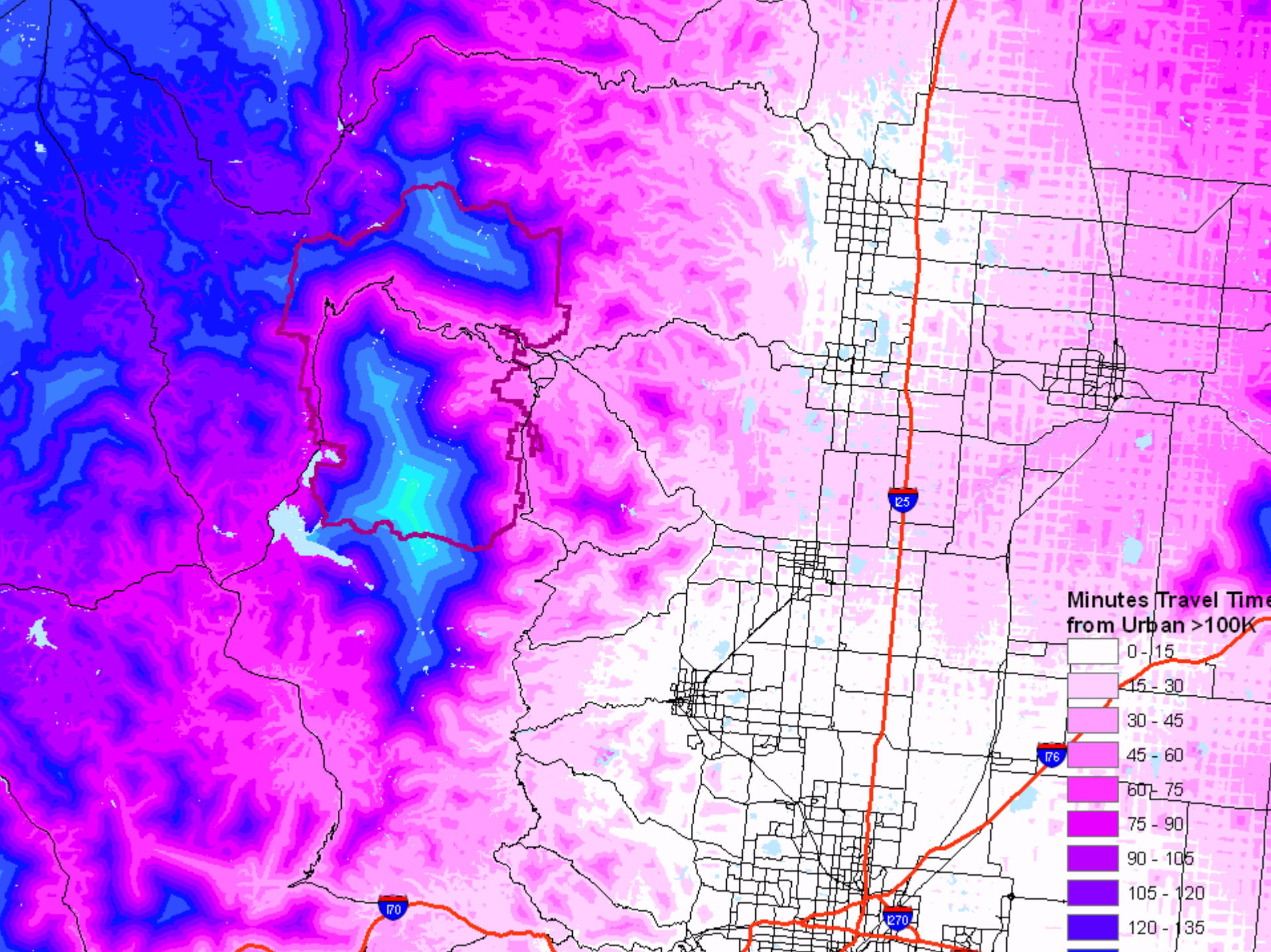
Landscape dynamics

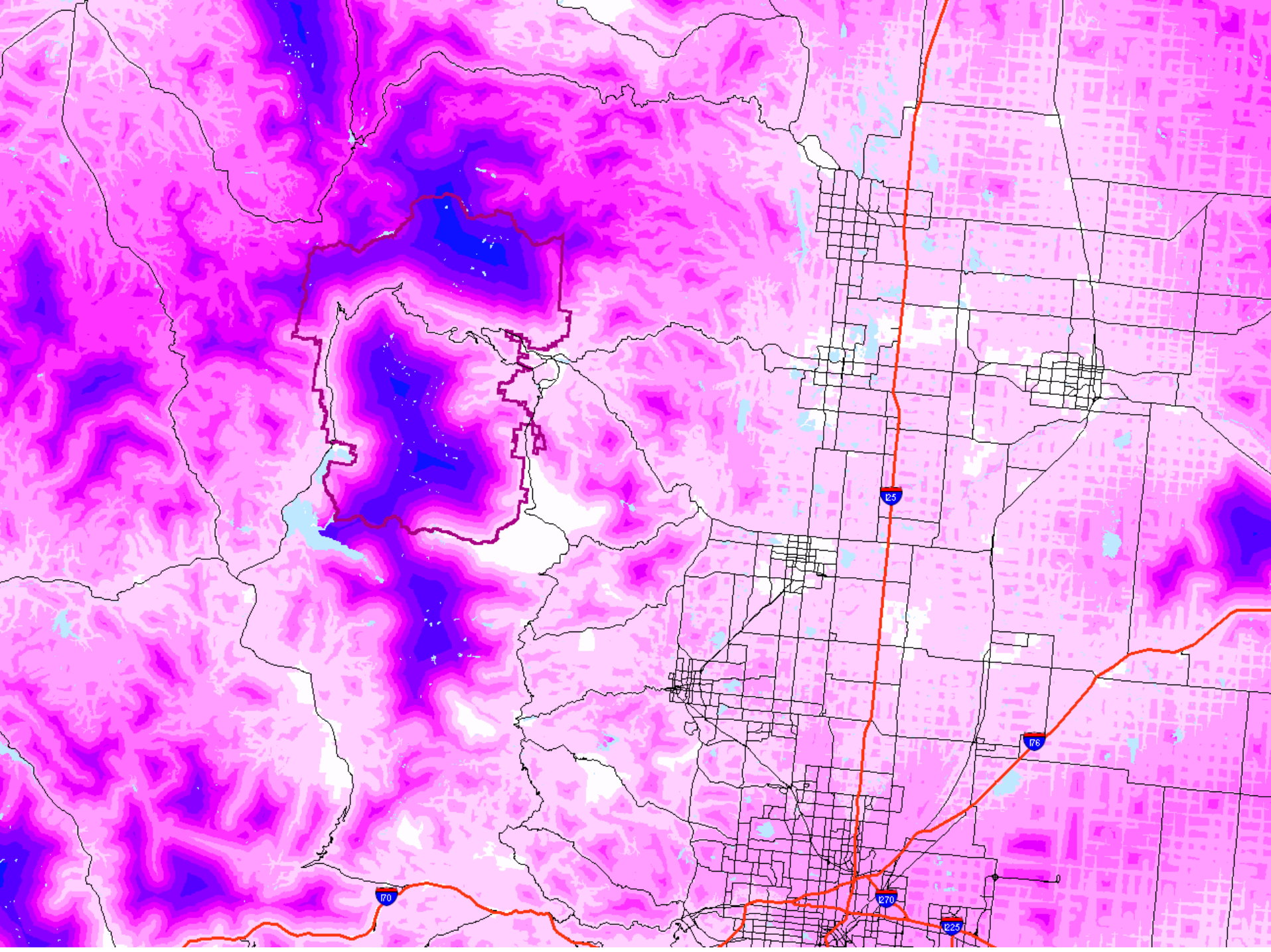
- Place parks within an ecologically meaningful context
  - Ecoregions, watersheds, minimum dynamic area, etc.
- Housing density data gets at land use (not cover) not typically identified in NLCD
  - Urban typically at least 1 per 1 ha
- Housing density could be used as a basic layer on which to define “gradient” of possible changes (Jones’ point Day 1)
- Analytical units can vary with specific objective
  - water, air, terrestrial processes; human accessibility

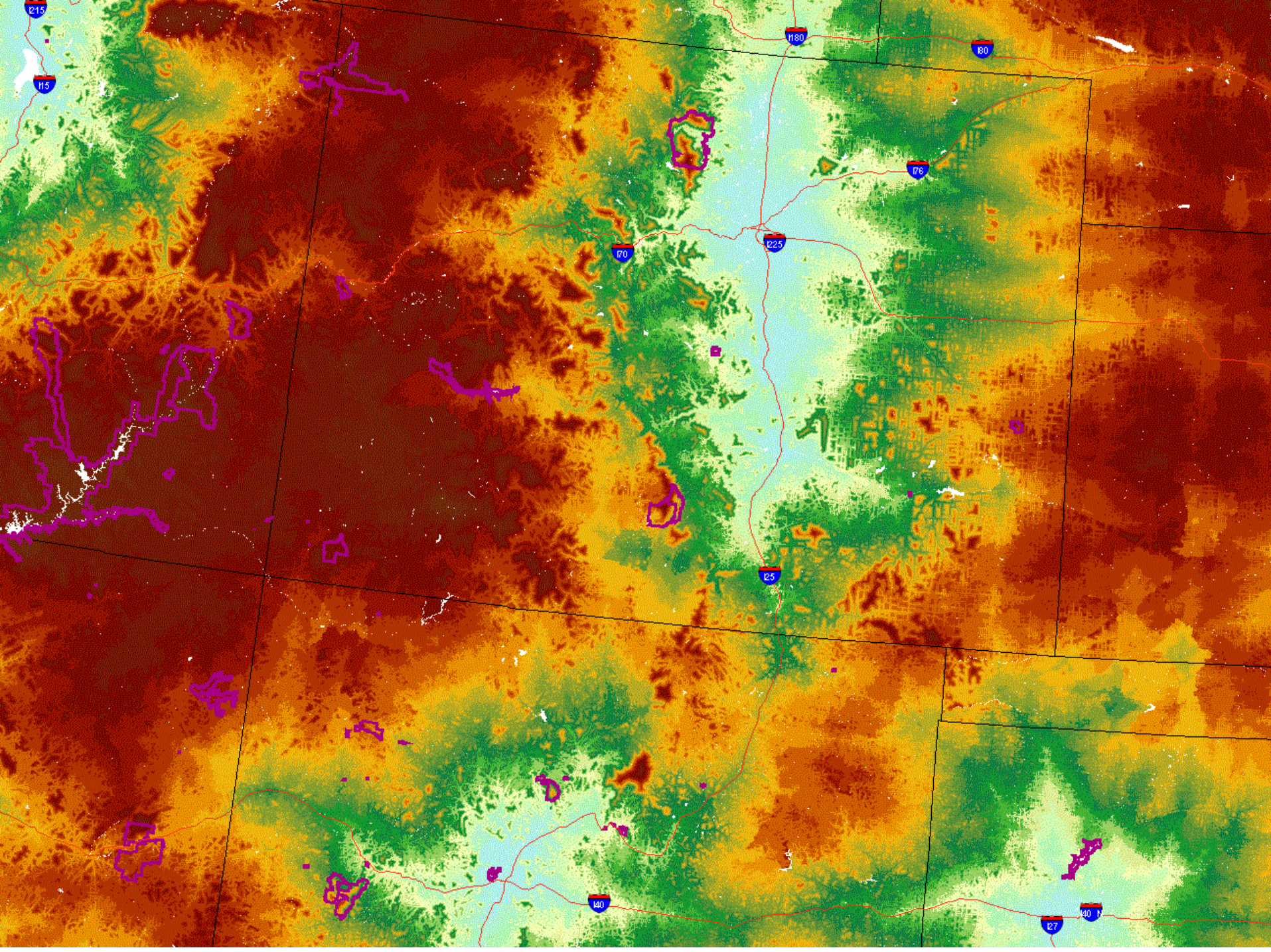
Example 2. Accessibility to (& w/in) parks

- Accessibility defined as travel time from urban areas (places) along road infrastructure
- Distinguished population above & below 100,000
- Minutes travel time weighted (by population) average

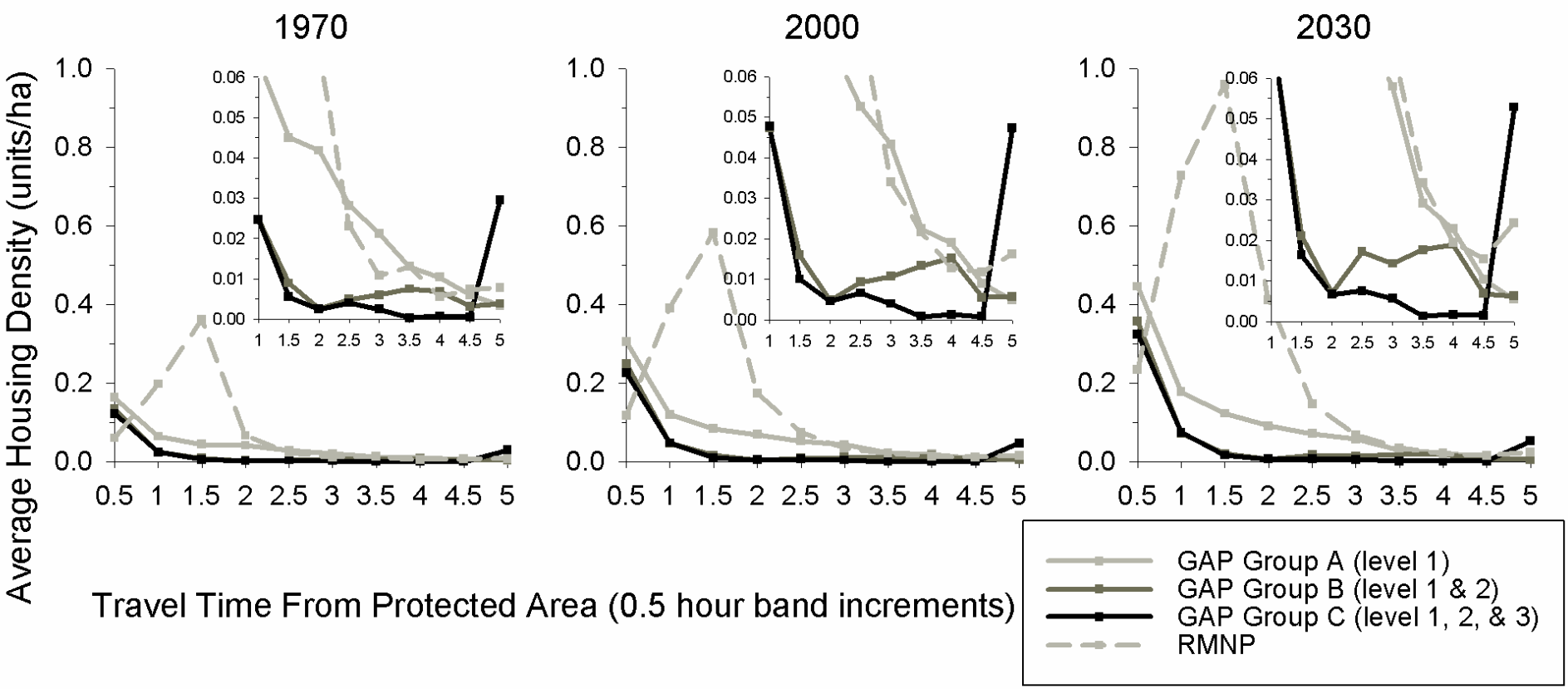



Minutes Travel Time
from Urban >100K
0 - 15
15 - 30
30 - 45
45 - 60
60 - 75
75 - 90
90 - 105
105 - 120
120 - 135
I25
I76
I70
I270


I25
I76
I70
I270
I225


I215
I15
I180
I80
I76
I70
I225
I25
I40
I27
I40

Growth on the edge

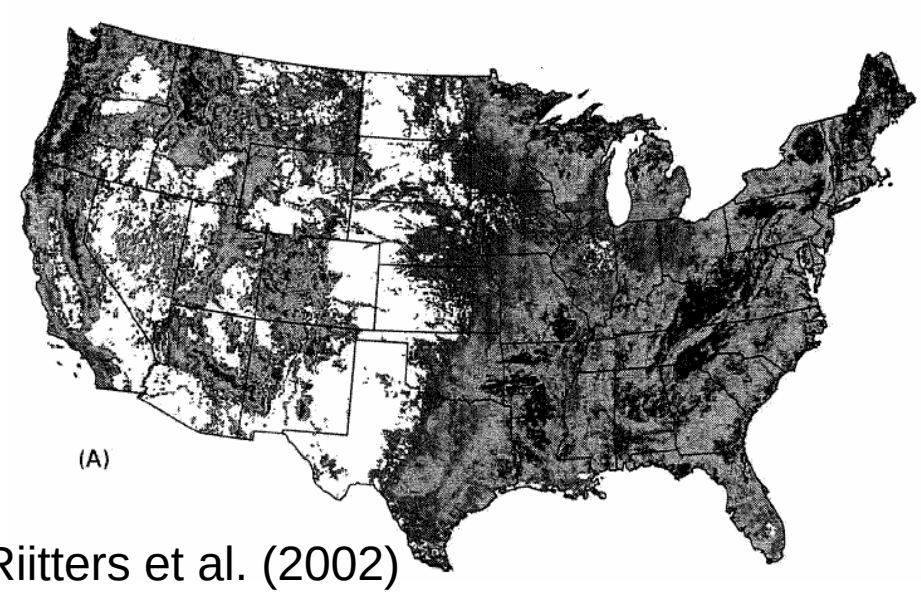


Wade and Theobald (*in prep*.)

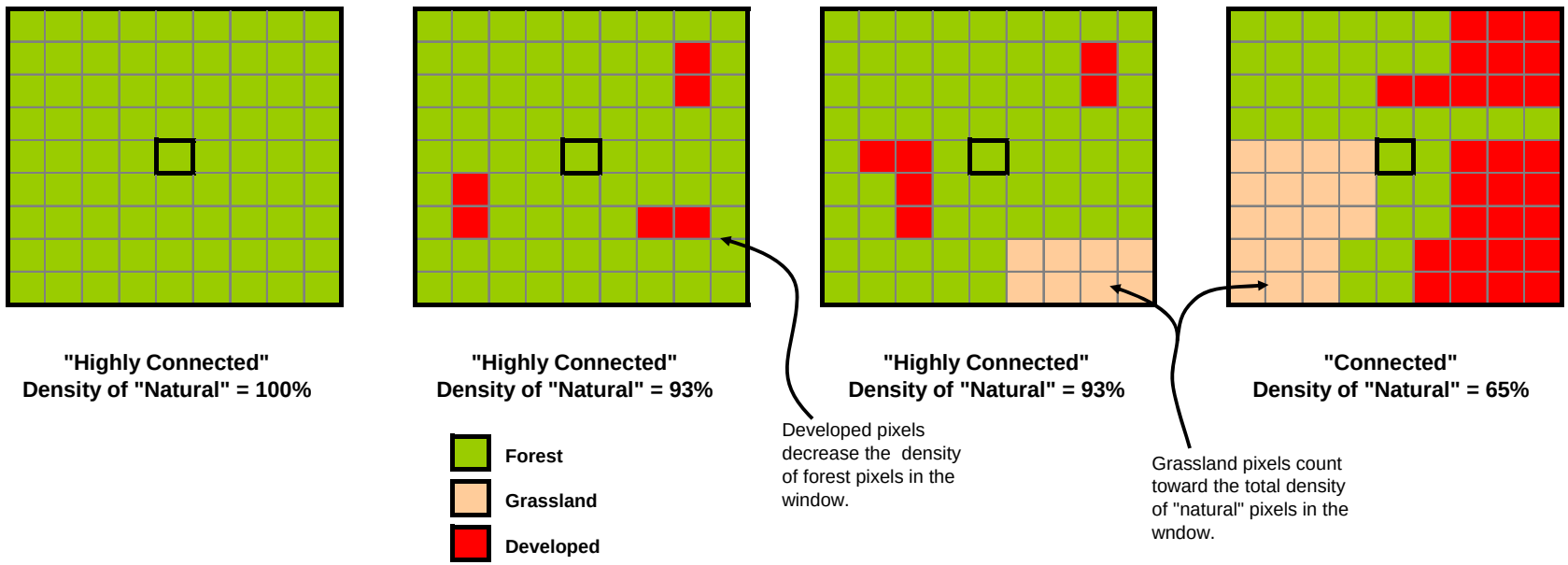
Example 3. Fragmentation

Proportion of forest in moving window (P_f)

Core forest (e.g., Heinz Center's draft report)



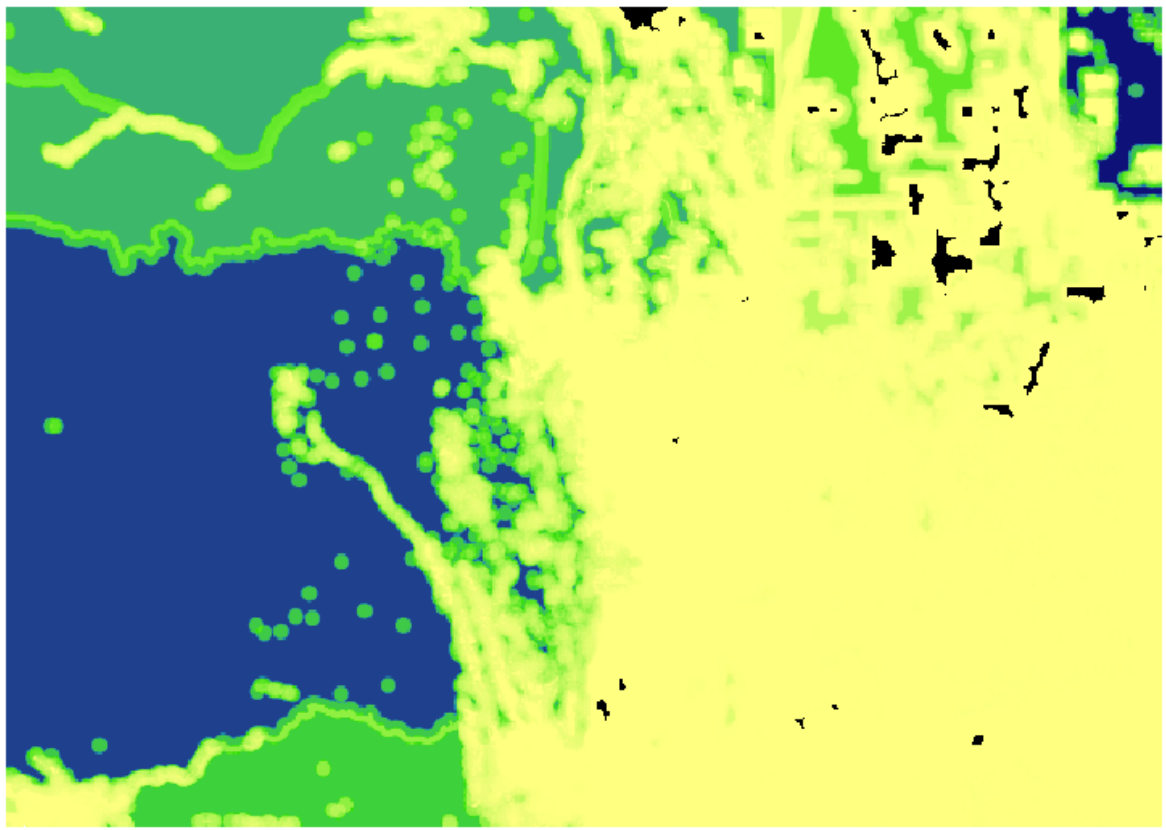
Riitters et al. (2002)



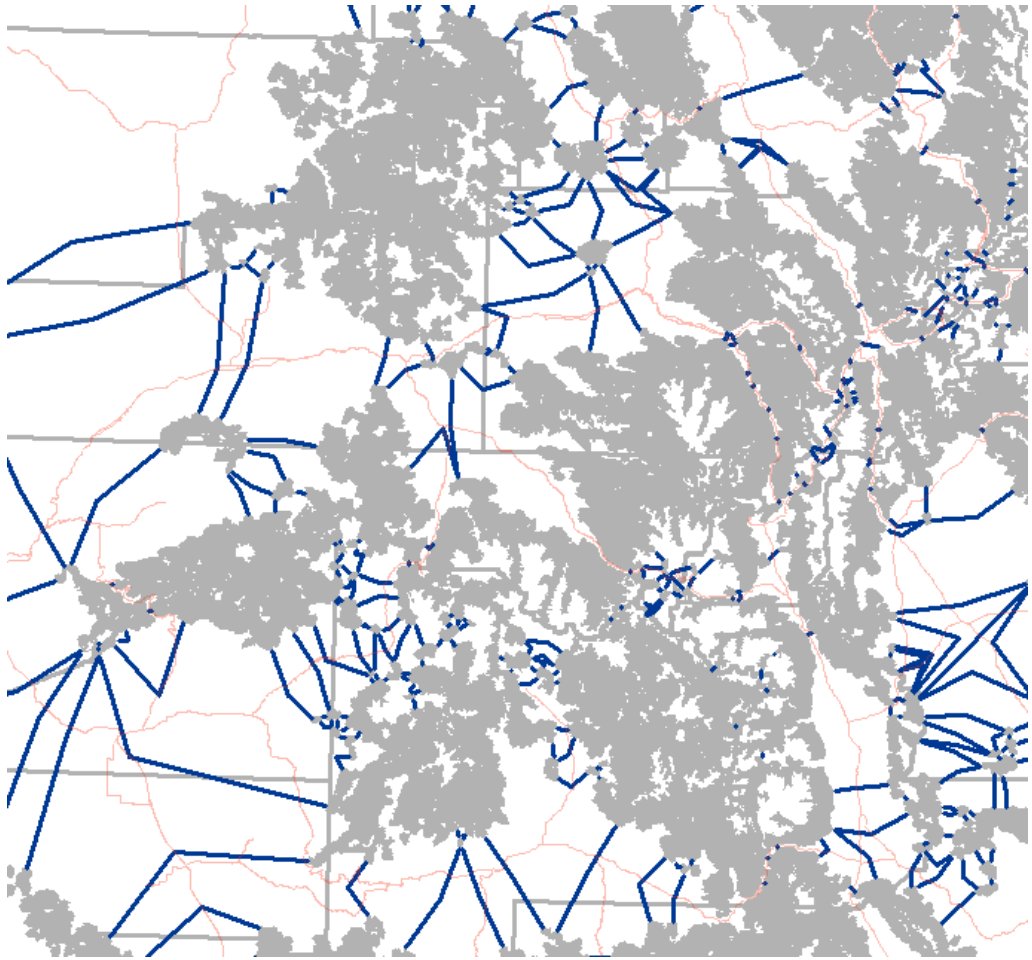
Natural cover fragmentation

Patch adjusted proportion index (PAPI), moving window

$$PAPI = P_n \times (A^{0.5} / \#\ patches)$$



Example 4. Landscape connectivity using network metrics



Patch importance: T_i

$$S_i = \sum_{j=1}^{n} P_j \exp^{-c_{ij}} A_j$$

Hanski's Incidence Function measure

$$T_i = \sum_{j=1}^{n} A' A_j w_{ij}$$

$A' = \log(1 + A_i/A_k)$

patch size to immediate k neighbors

A_i = area of patch i

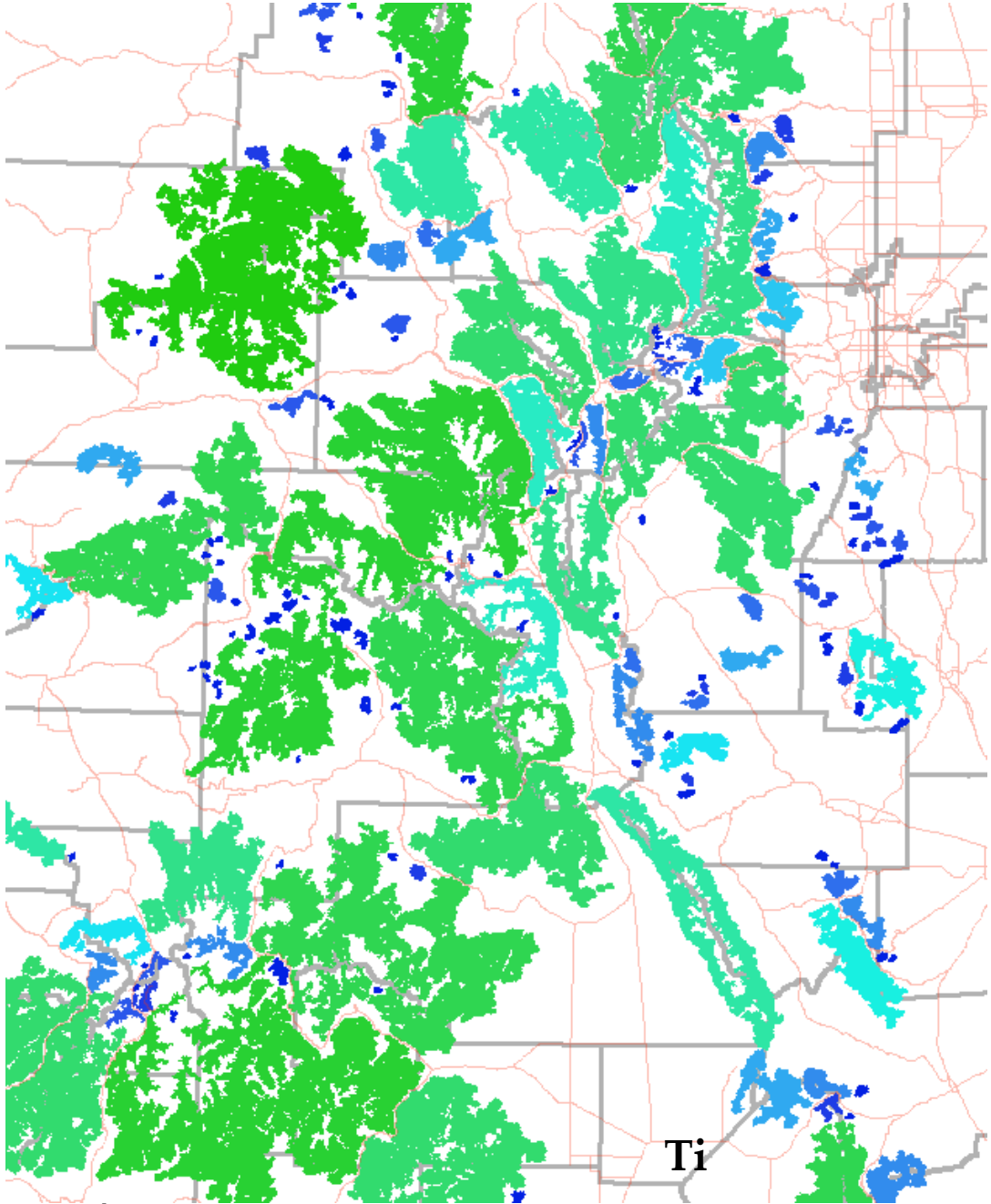
A_j = area of patch j

A_k = sum of area of neighboring patches k

$w_{ij} = 1/\sum c_{ij}$

$c_{ij} = d^{1.75}$, d is Q_n cost-distance from patch i to j

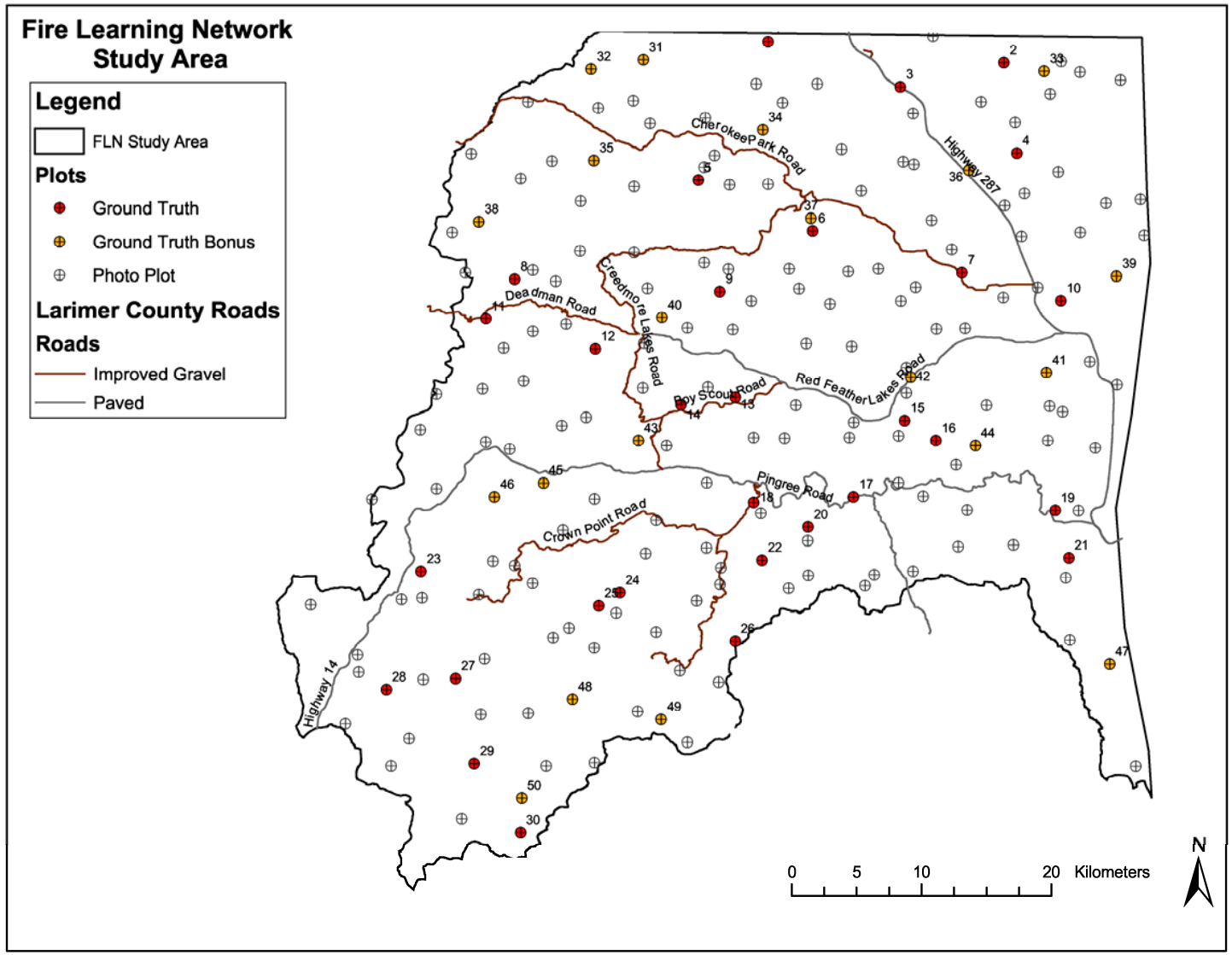
Patch importance (lynx)



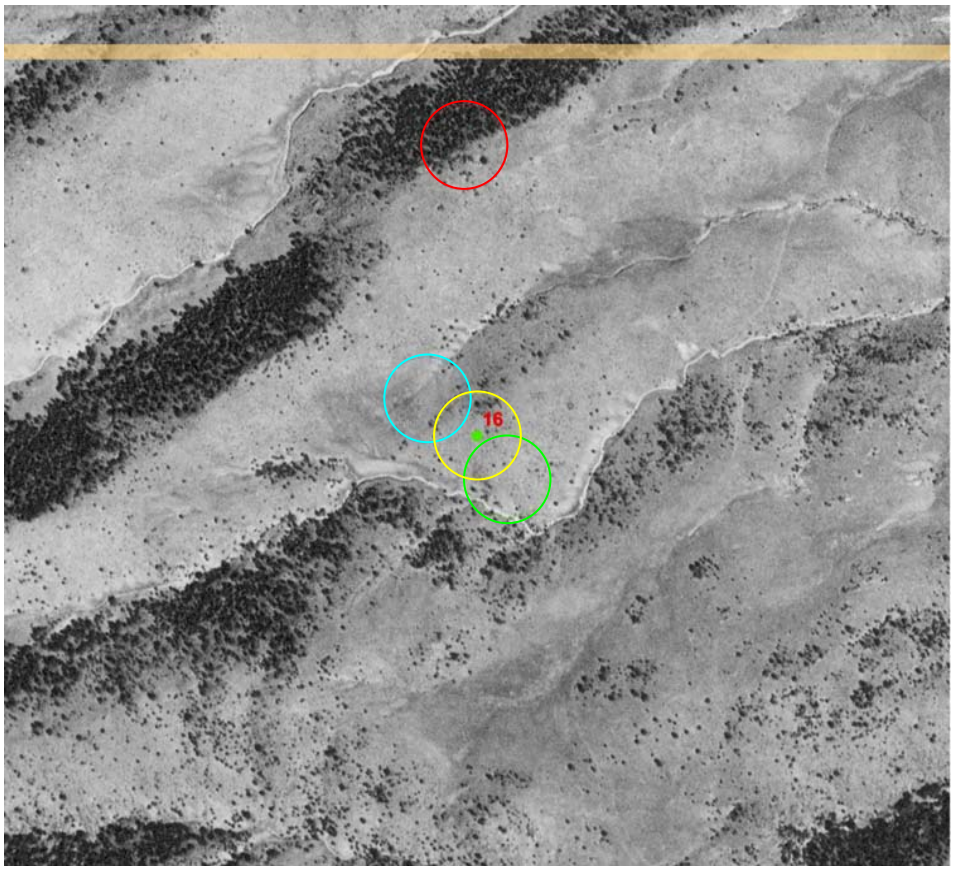
- Network-based
- Go beyond adjacent neighborhood limitations

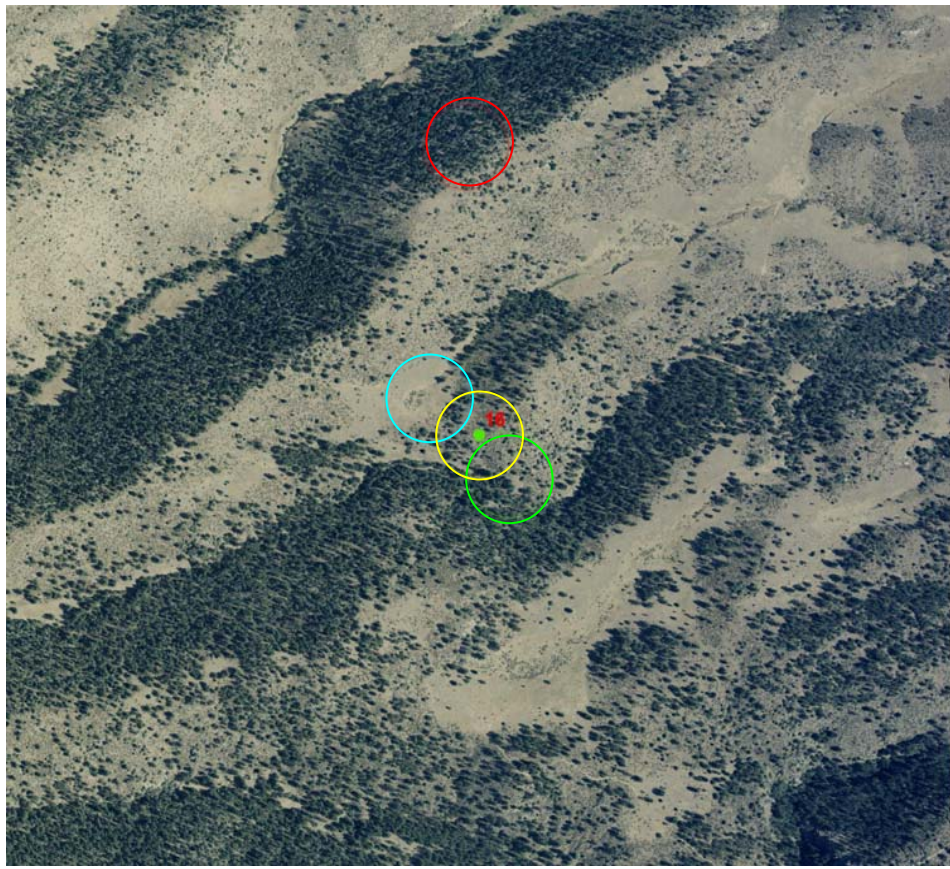
Theobald 2006 – Connectivity conservation

Example 5. Fire regime in ponderosa pine ecosystem



Paired historical, current aerial photos





1938: Center OPEN; A PDFY; B: OPEN; C: OPEN

2000: Center PPWY; A PPFY; B: OPEN; C: PPFY

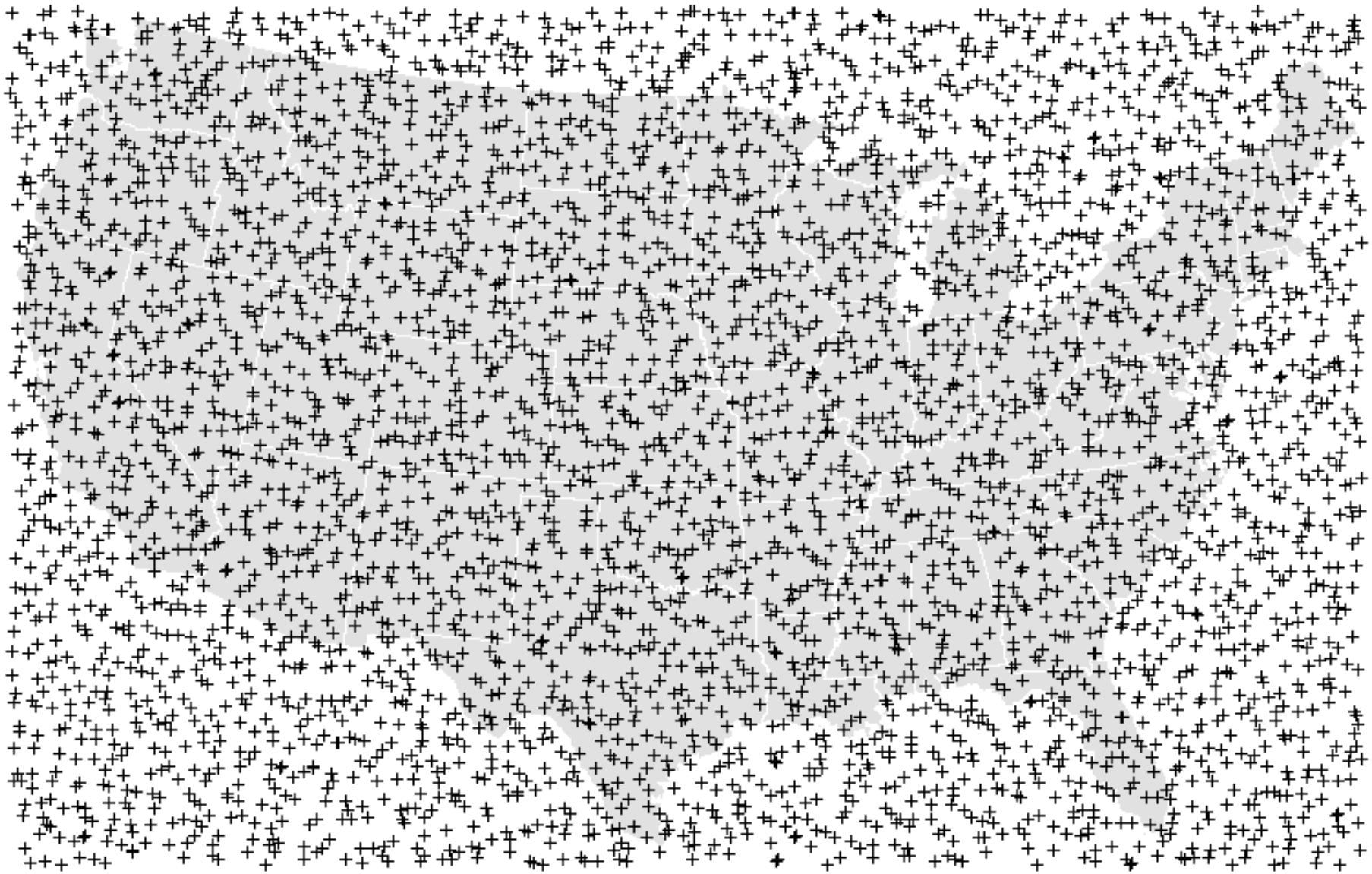
Land use data needed for interpretation!

Land cover type (% canopy)	***Historical (%)***	***Current (%)***	***Desired Future… ….?***
Open (<10%)	50.0	42.2	
PP Woodland (10-30%)	14.9	13.7	
PP Forest (>30%)	12.2	16.4	
Mixed Woodland (10-30%)	1.4	7.9	
Mixed Forest (>30%)	14.2	16.4	
Lodgepole Pine Woodland (10-30%)	0.0	0.6	
Lodgepole Pine Forest (>30%)	4.1	2.7	

Summary

- 1. Housing density important measure of landscape dynamics
- 2. Human accessibility important way to provide context for analyzing changes inside & outside of parks
- 3. Fragmentation indices tied to proportion, adjusted by patch size
- 4. Broad-scale landscape (ecosystem) connectivity relies on configuration metrics (network-based)
- 5. Land use history important (subtle modifications that are difficult to examine through cover alone)

Need for a national, well-distributed, sample design that can facilitate multi-scale (1 km, 30 m, 1 m field), disparate efforts

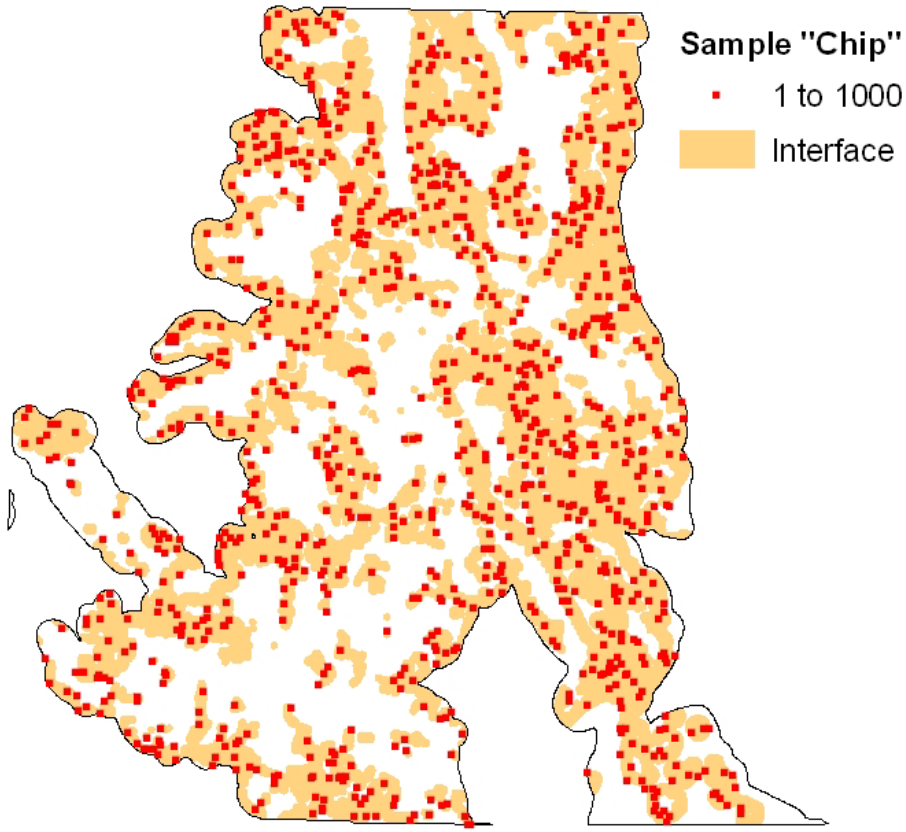


Theobald et al. (*in press*)

Sampling Design

Spatially Balanced
Random Grid

Sample 1 km “Chips”



Guidelines for using landscape metrics

1. Determine appropriate scale
   - from point data compute variogram, etc.
   - based on assumption of organism/process scale
2. Identify the appropriate “ecological” neighborhood
   - Based on organism/process scaling
3. Formulate a theoretical relationship between candidate metrics and process under study *a priori* to determine ecological relevant metrics
4. Conduct sensitivity analysis: how robust are results?
   - Examine how sensitive results are to variety of scales
   - Be sure to parameterize to establish boundaries when relationship falls

NLCD (1992) “Natural” cover

Class	***Natural (binary)***	***Natural (gradient)***	***NLCD Class***	***Natural (binary)***	***Natural (gradient)***
11 Snow	1	1.0	51 Shrublands	1	1.0
12 Lakes/res	0	0.5	61 Orchards	0	0.5
31 Res (ld)	0	0.2	71 Grasslands	1	1.0
22 Res (hd)	0	0.1	81 Pasture	0	0.6
23 Comm/ind	0	0.0	82 Row crops	0	0.3
31 Barren	1	0.8	83 Non-row crops	0	0.3
32 Quarries	0	0.4	84 Other ag	0	0.3
33 man made	0	0.4	85 Ag – rec	0	0.4
41 Forest dec	1	1.0	91 Wetlands (f)	1	1.0
42 Forest con	1	1.0	92 Wetlands (h)	1	1.0
43 Forest mixed	1	1.0			