Deconstructing Nature and its Benefits

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ENL
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Overview

Benefits of Nature: Neighborhood Greenspace

Why is Nature Beneficial

- Attention Restoration Theory
- Experimental Studies

Deconstructing Nature

Future Directions

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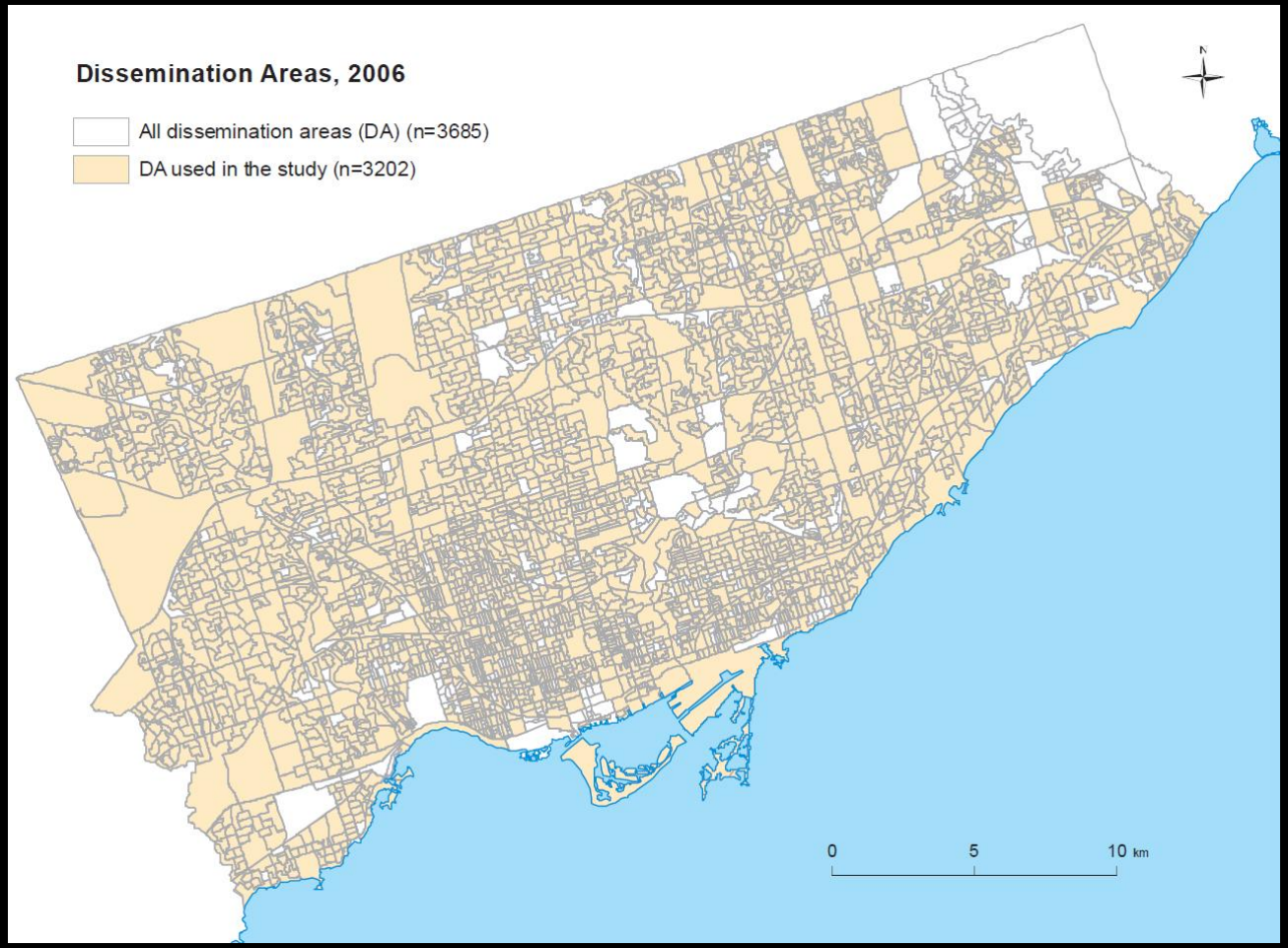
Neighborhood green-space

Neighborhood green-space and health in a large urban center

AIM: assessing the extent to which proximity to natural green spaces is associated with positive health outcomes

Kardan et al., (2015) Scientific Reports

Dissemination areas of Toronto



Kardan et al., (2015) Scientific Reports

Satellite image

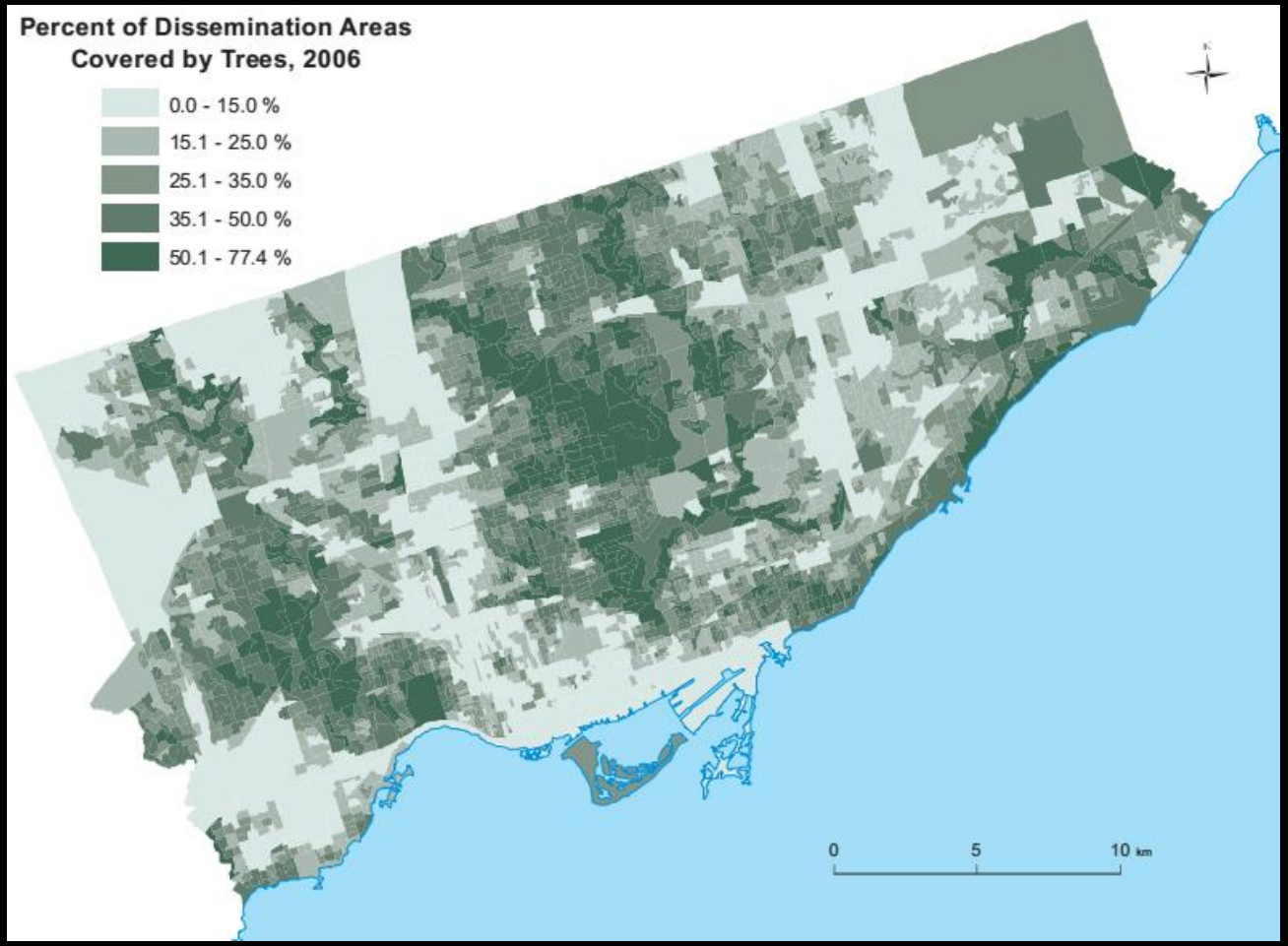
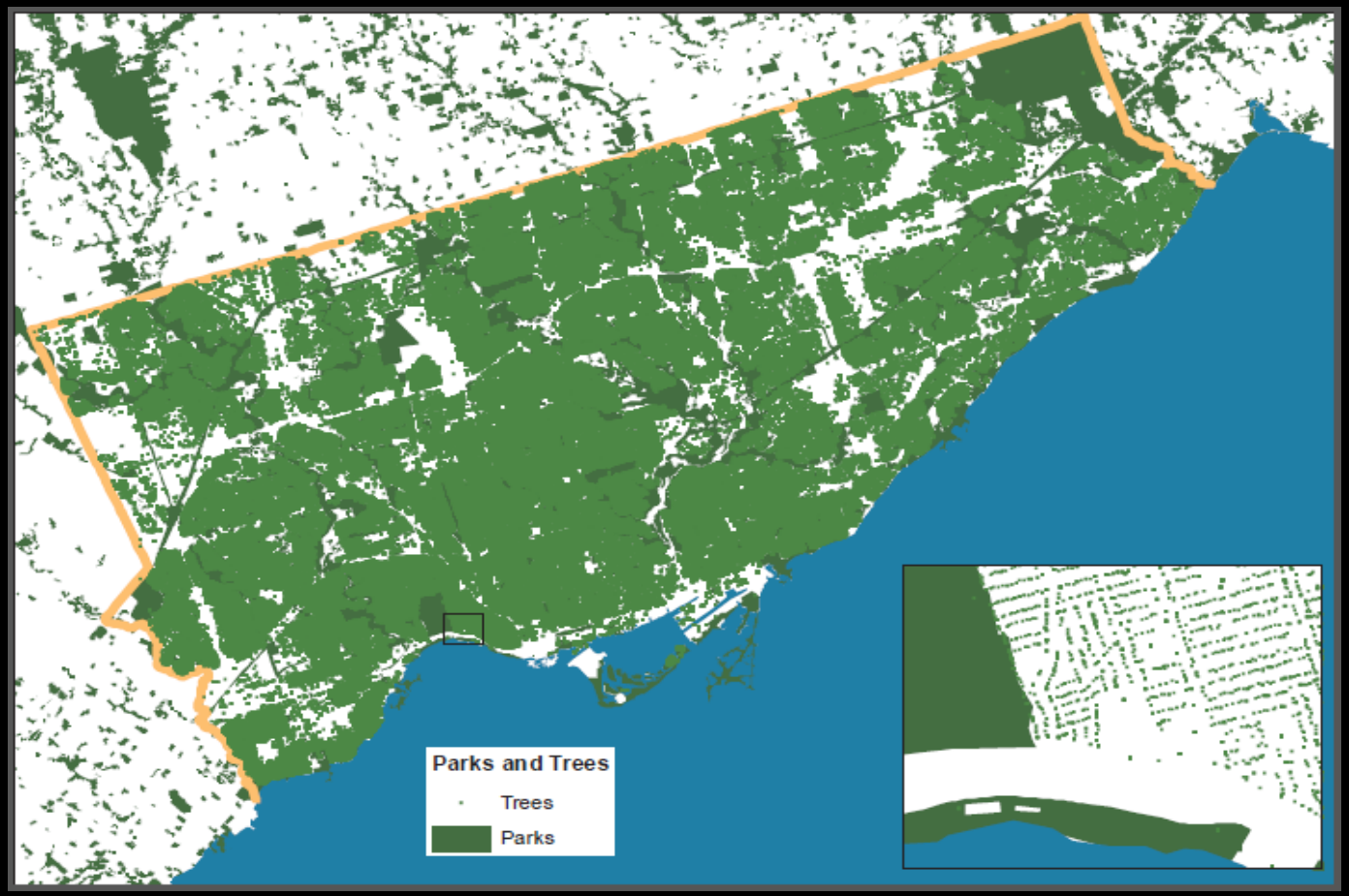


Image from Toronto GIS Polygon data Forest and Land Cover

Kardan et al., (2015) Scientific Reports

Individual trees in Toronto



Kardan et al., (2015) Scientific Reports

Regression of health perception

- A 1% increase in health perception is associated with:
  - Ten more trees on the street per block
  - $10,200 increase in both annual income & DA median income
  - 7 years younger

Kardan et al., (2015) Scientific Reports

Regression of metabolic disorders

- A 1% decrease in metabolic disorders is associated with:
  - 11 more trees on the street per block
  - $19,700 increase in both annual income & DA median income
  - 1.4 years younger

Kardan et al., (2015) Scientific Reports

Related Work: Ulrich, (1984) *Science*

Examined patient recovery time from gallbladder surgery

Patients with views of nature from hospital window vs. built wall:

-Recovered faster from the surgery (by about 1 day)

-Used less analgesics

Public Housing

Robert Taylor Homes in Chicago; have now been demolished

Public Housing (U.S.)

- Poor environments to live in
  - Crime
  - Drugs
- Effect on children
  - Academic underachievement
  - Juvenile delinquency
  - Teenage pregnancy

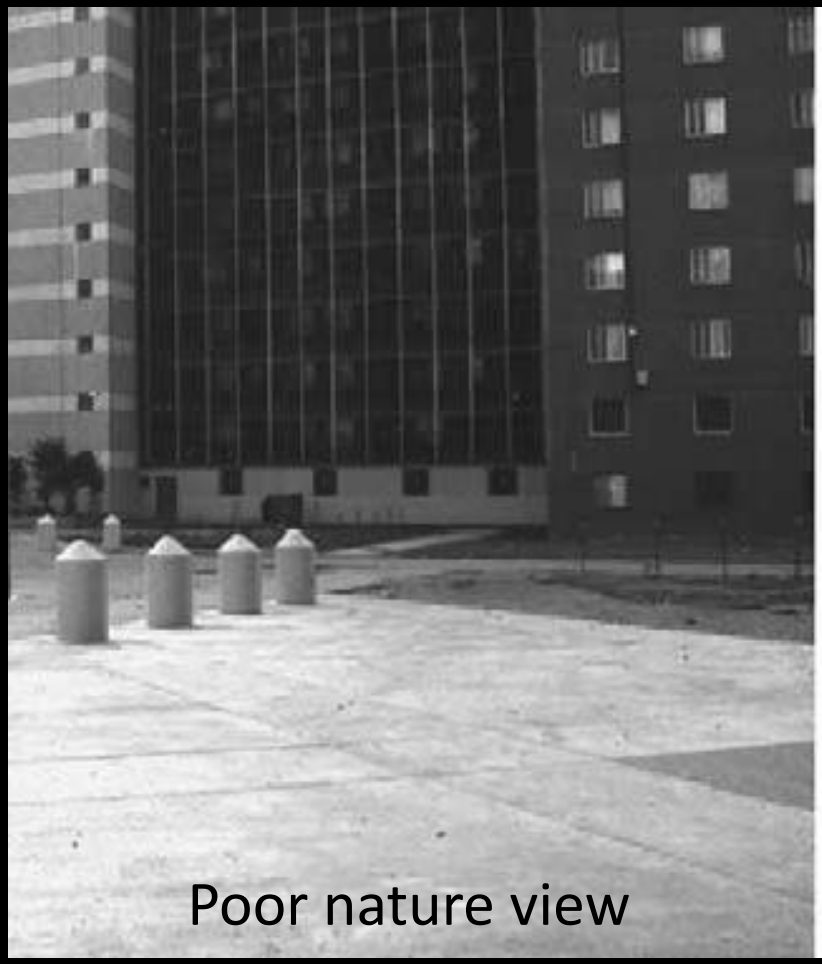
Nature and Public Housing

Taylor, Kuo and Sullivan, 2001

Studied views from windows in Robert Taylor Public Housing

169 Child-Guardian Pairs

Samples from Taylor, Kuo, and Sullivan



Poor nature view

Good nature view

The more nature from view

Memory and Attention Improvements

- Better scores on concentration and memory tests such as Backwards Digit Span

Self-Discipline Improvements

- Better impulse inhibition (e.g., Stroop)
- Better Delay of Gratification

Taylor, Kuo and Sullivan 2001

Study with Adults (Crime Reports)

Poor nature view

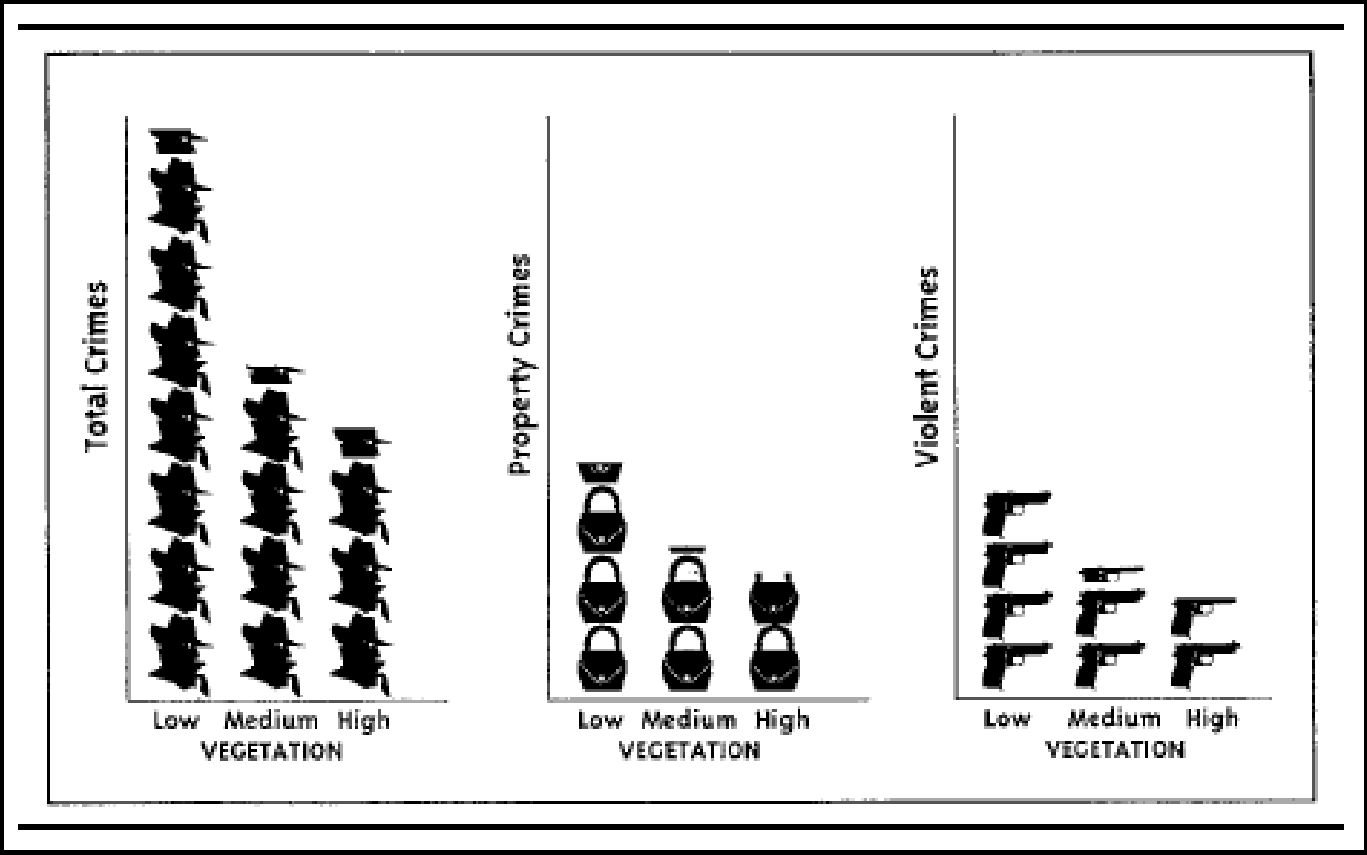
Good nature view

Ida Wells Public Housing facility

Kuo and Sullivan 2001a

Vegetation and Crime

Number of crimes reported decreased linearly with the amount of surrounding vegetation



Kuo and Sullivan, 2001a

Nature, Aggression and Attention

Studied 145 adults in Robert Taylor Homes

Poor nature view

Good nature view

Kuo and Sullivan 2001b[18]

More Nature leads to less Aggression

With more nature

- Less overall aggression
- Less range of aggressive tactics
- Less mild and severe aggression

Greater Attention in more green environment

Important: Attention Mediated Aggression Improvements

Kuo and Sullivan 2001b

Summary of Nature Restoration

Presented a very modest intervention that had a positive impact on diverse problems

Not suggesting that nature will solve all aspects of these problems

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Theories as to why interacting with nature is beneficial

Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995; Kaplan, 2001; Kaplan & Berman, 2010; Berman et al., 2008; Berman et al., 2012)

Biophilia Hypothesis (Kellert & Wilson, 1993) and Nature Connectedness (Mayer et al., 2009)

Stress-Reduction (Ulrich et al., 1991)

Attention Restoration Theory (ART)

Voluntary or **Directed Attention** (Top-Down/endogenous attention)

Directed Attention is finite and can be depleted

Involuntary Attention (Bottom-Up/exogenous attention)

Involuntary Attention is less susceptible to depletion

ART continued

Find environments rich in interesting stimuli to activate involuntary attention, while at the same time not taxing directed attention

Nature is one example of such an environment

Soft Fascination

It is theorized that the capture of involuntary attention should be soft (i.e., not all consuming)

Natural environments tend to have softly fascinated stimuli

Experiment 1

N = 38

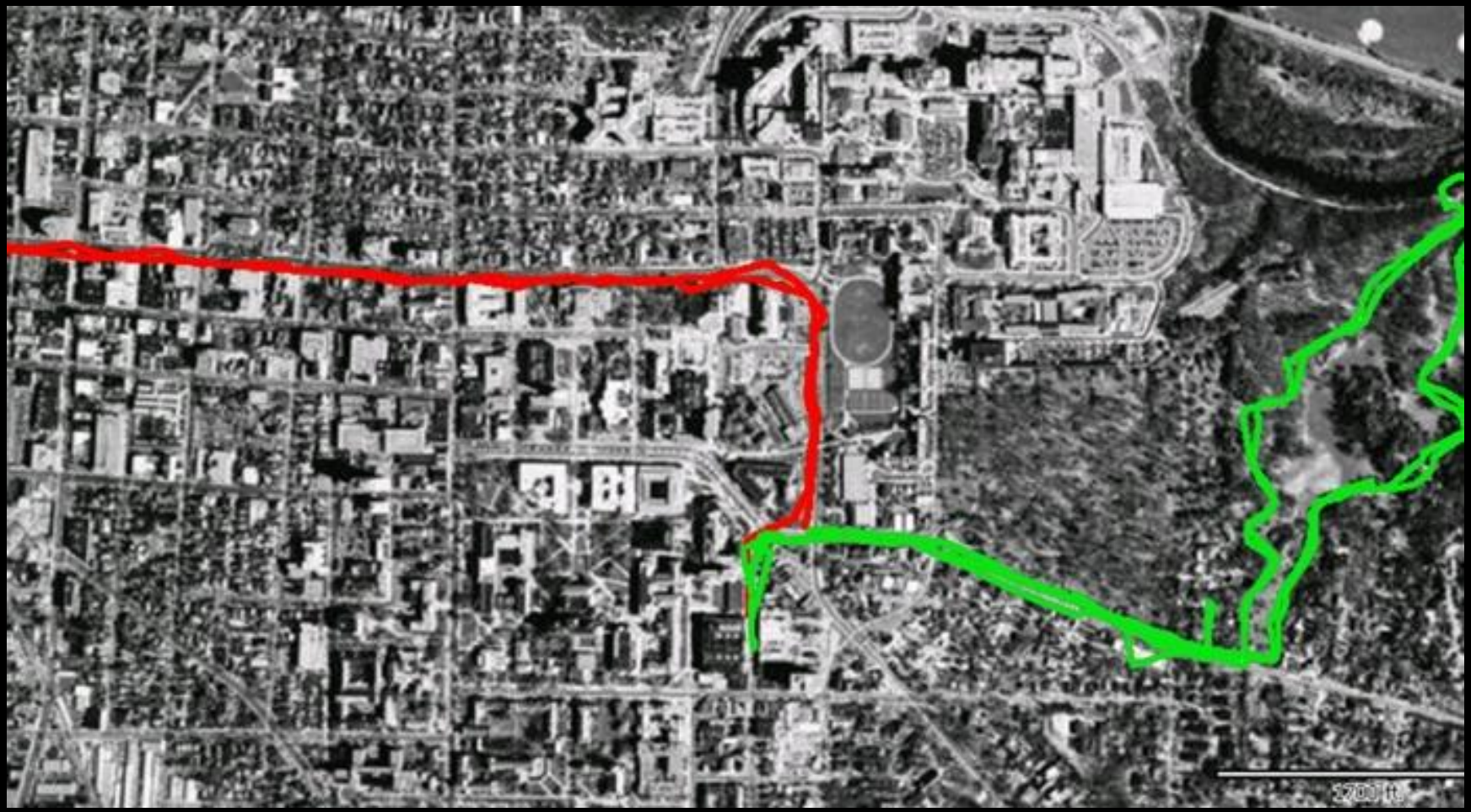
Backwards Digit Span (BDS; required directed attention)

Assessed mood changes

Fatigued participants with a challenging working-memory task

Half participants walked in nature first half in urban, came back next week and walked in other location

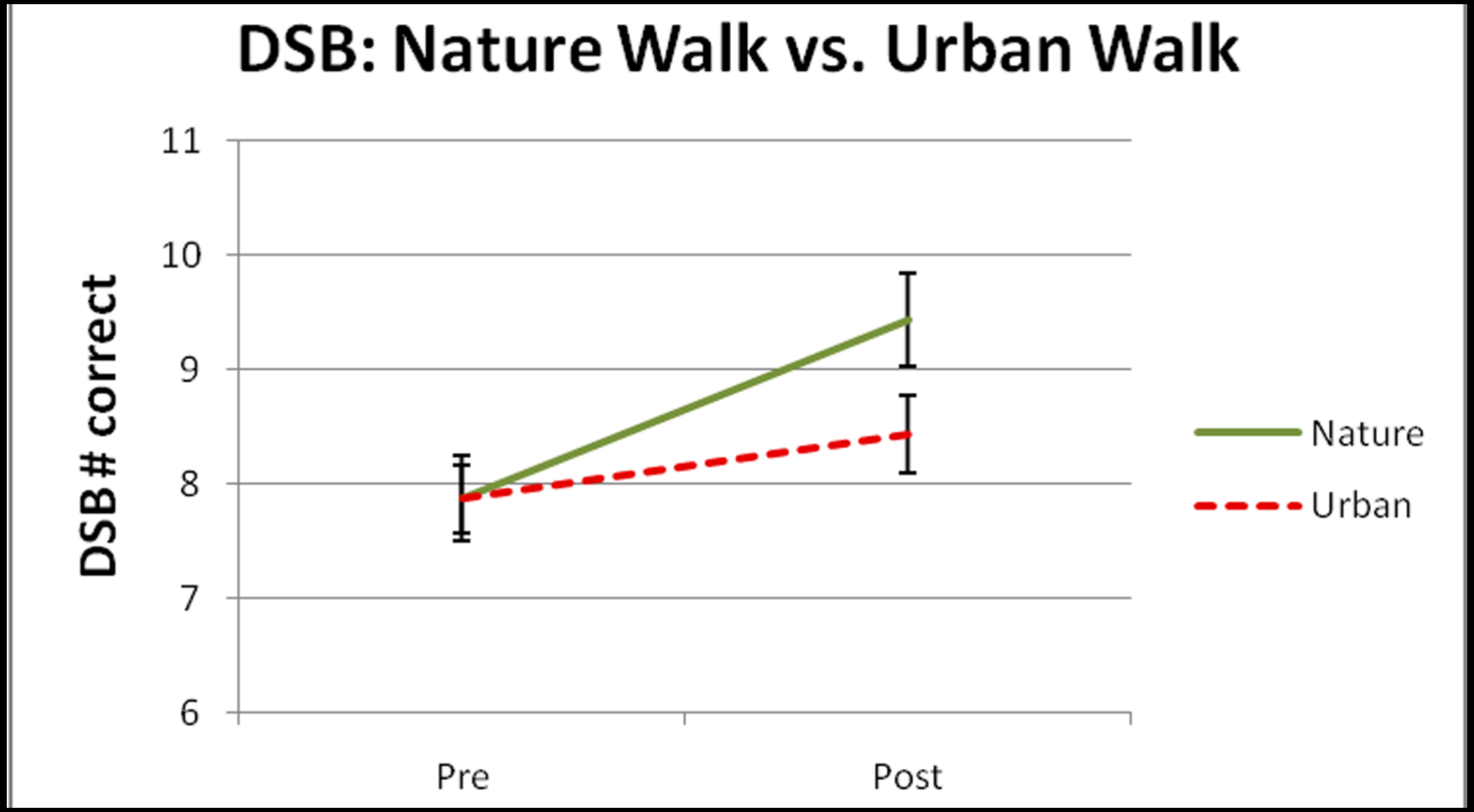
How we tested Attention Restoration Theory



Berman, Jonides and Kaplan (2008) Psychological Science

Improvements in Memory and Attention Measure

Pre-Post X Nature-Urban interaction significant, $F = 6.06$, $p < .025$



Berman, Jonides and Kaplan (2008) Psychological Science

Additional Effects of Experiment 1

No order effects*

No relationship to mood

No relationship to weather

*In a meta-analysis we are finding stronger effects in the second session

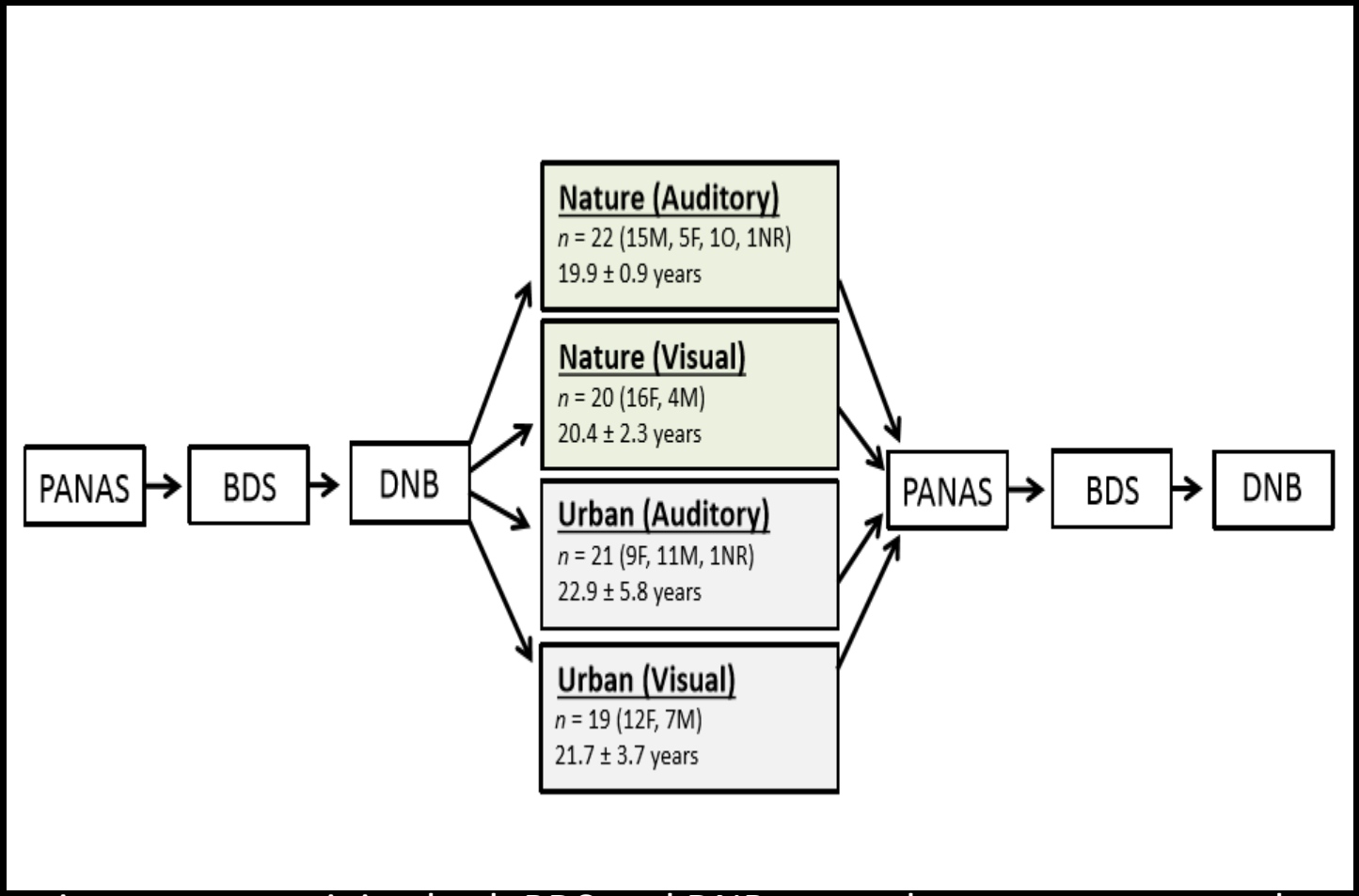
Experiment 2: Pictures

Performed a similar procedure with pictures

- viewed natural vs. urban pictures
- similar changes in BDS
- changes in executive attention portions of the Attention Network Task (ANT)

Cognitive improvement following auditory and visual exposure to nature

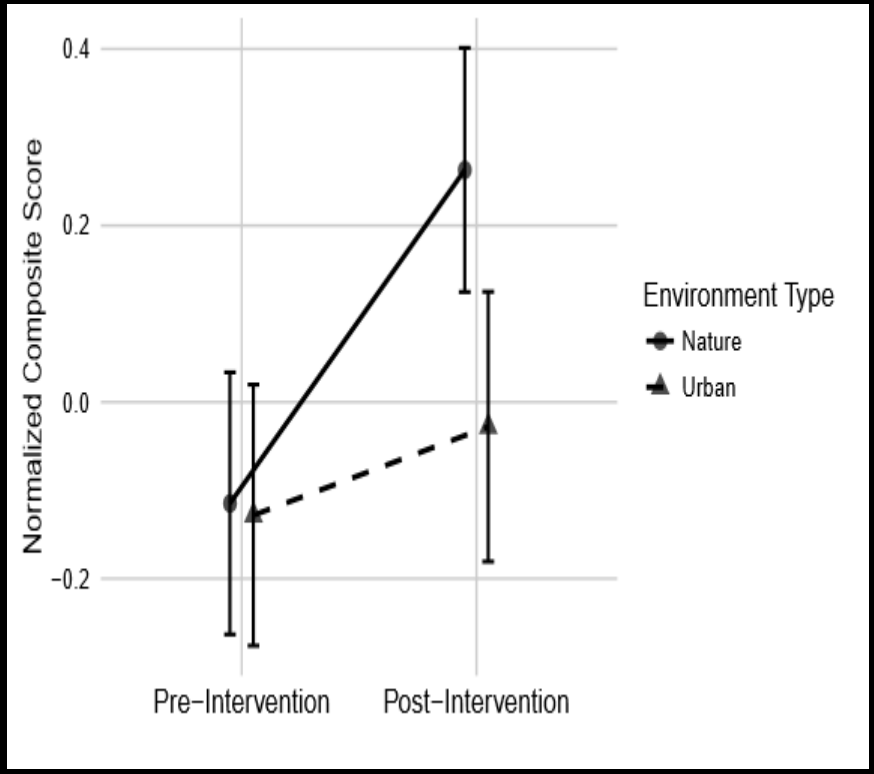
Design



* Composite score containing both BDS and DNB created to assess nature-related benefits

Van Hedger et al., in revision

Results



** Nature interventions result in significantly greater improvement compared to urban interventions*

**No modality interaction (i.e., no evidence that visual depictions of nature were more/less beneficial than auditory depictions*

Van Hedger et al., in revision

Summary of ART experiments

Brief interactions with nature led to a 20% improvement in working-memory span

Effects are not driven by mood or time of year

Similar effects were found with pictures

Similar effects for sound and visual depictions

Effects specific to directing attention

Effects more pronounced for individuals diagnosed with major depression

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Why we want to look at low-level features

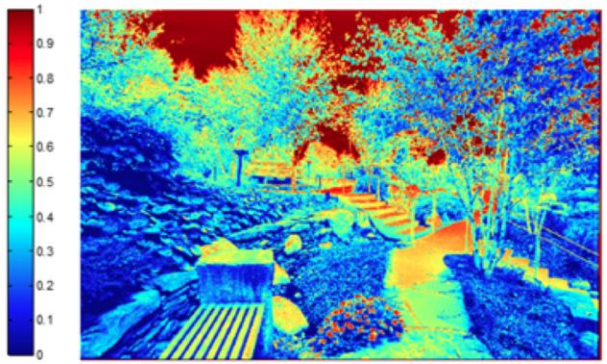
We want to develop a taxonomy of features that differentiate natural from urban scenes

It is possible that these features may impact the restorative quality of these environments

If we can define these features, then we may be able to optimally define new built environments

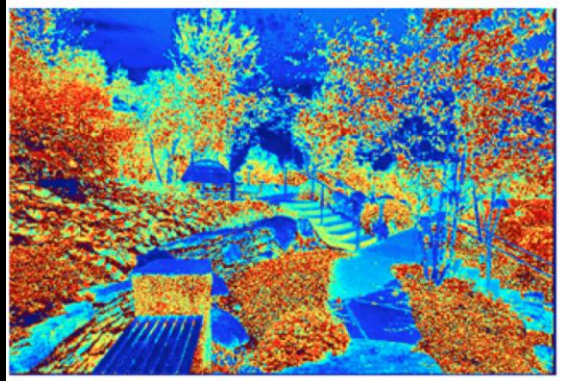
Predicting Naturalness with Low-level features
Color Features

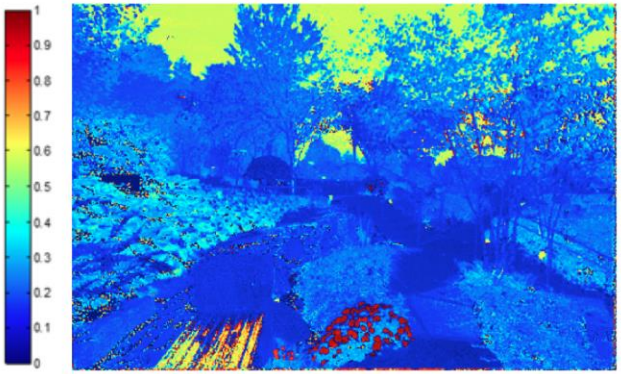
a) A sample image (b) Image's value map (c) Image's saturation map (d) Image's hue map.



Original Image

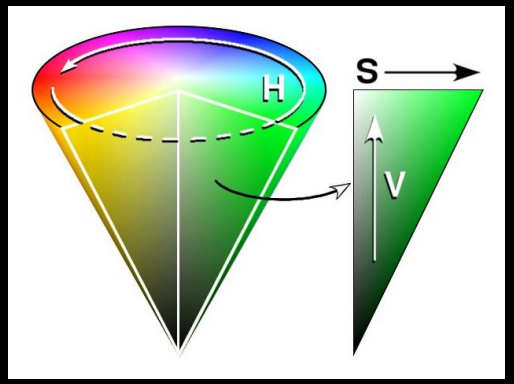
Brightness/Value





Saturation

Hue



Berman et al., (2014) PLoS ONE

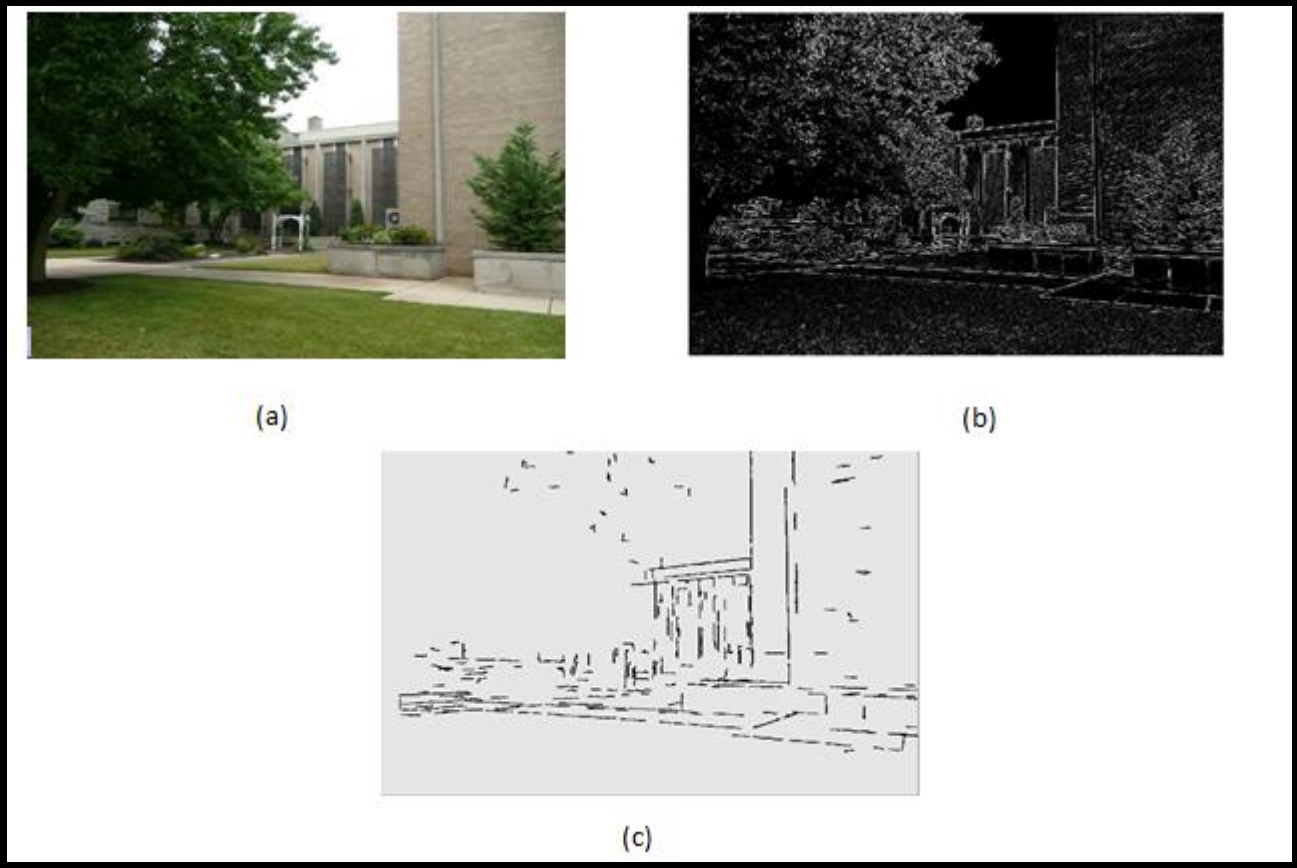
Structural Features
Grey-scale Entropy

Entropy = 7.63

Entropy = 7.10

Berman et al., (2014) PLoS ONE

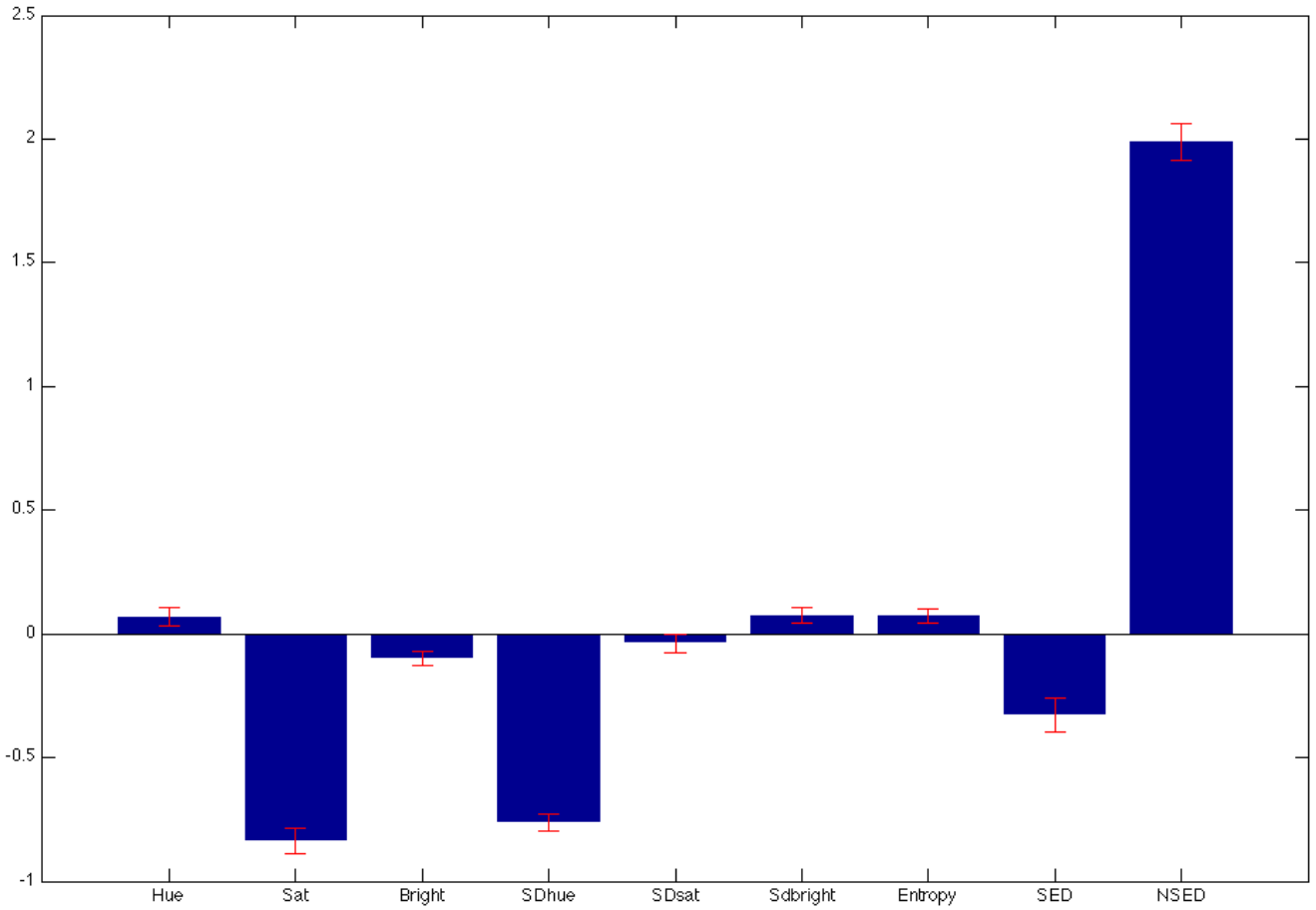
Structural Features
Straight and non-straight edges



Berman et al., (2014) PLoS ONE

Predicting Naturalness

With a machine learning algorithm, we can predict subjective naturalness with 80% accuracy



Berman et al., (2014) PLoS ONE

Predicting Preference based on low-level features

Predictor	Estimate	Std. Error	t value	CI
Bottom-up Perception of Naturalness-Color*	0.362	0.081	4.454	[0.202, 0.521]
Bottom-up Perception of Naturalness-Structure*	0.533	0.055	9.629	[0.424, 0.642]
Top-down Perception of Naturalness*	0.480	0.043	11.164	[0.396, 0.565]
Color X Structure*	0.207	0.092	2.237	[0.025, 0.389]

Adjusted R^2 = 0.47, F (4,302) = 69.36, *P<0.05

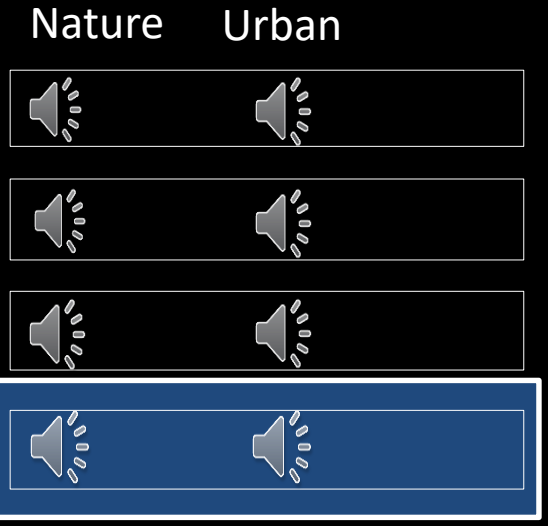
We can explain nearly 50% of the variance in preference based on these low-level features.

Kardan et al., (2015) Frontiers in Psychology

Obscuring / Removing Semantics of Nature

Sound Conditions:

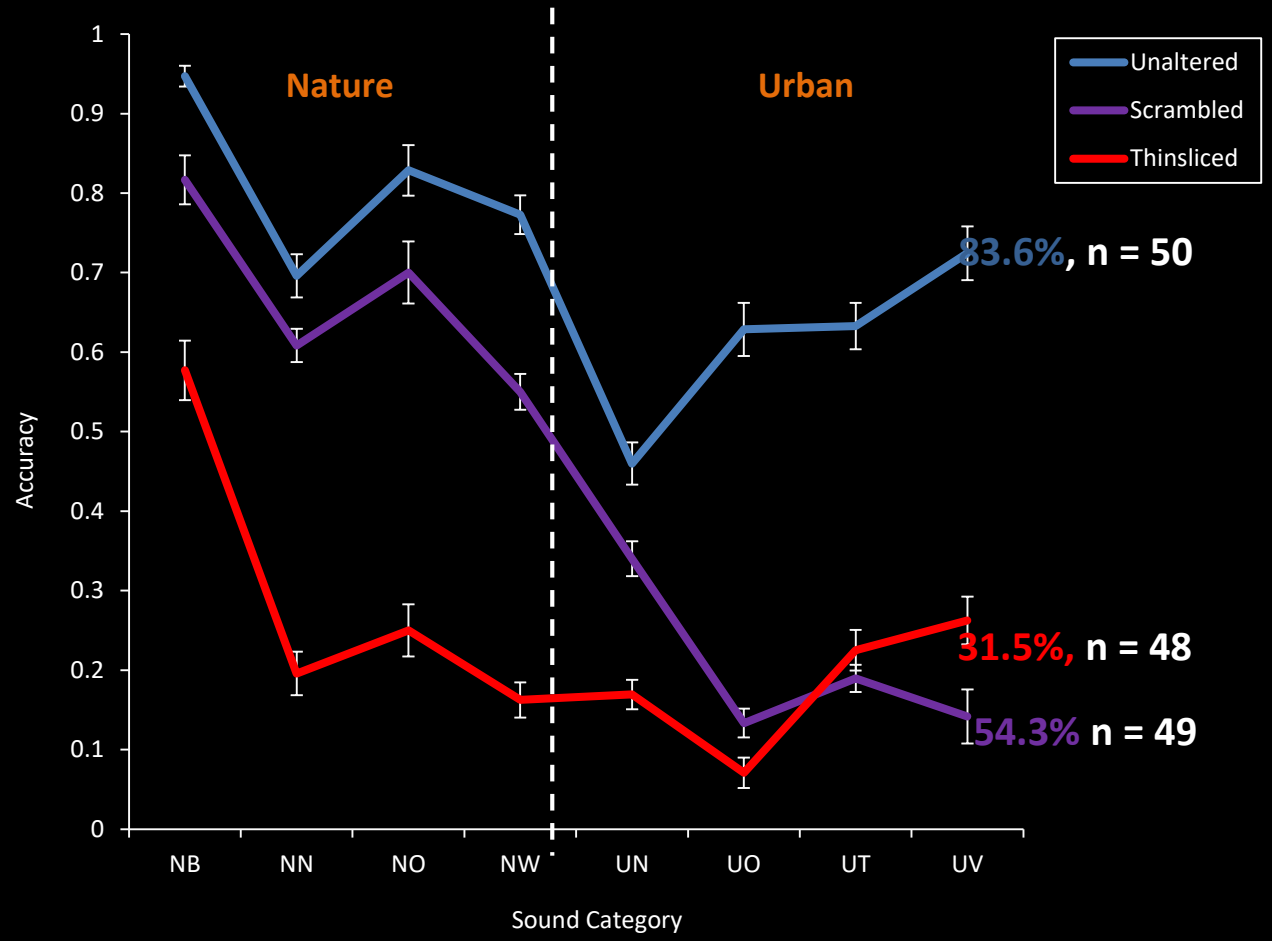
1) Unaltered
2) Time-Domain Scrambled
3) Thin-Sliced
4) **Generated***



**No objective nature or urban origins*

Results

Sound Identification

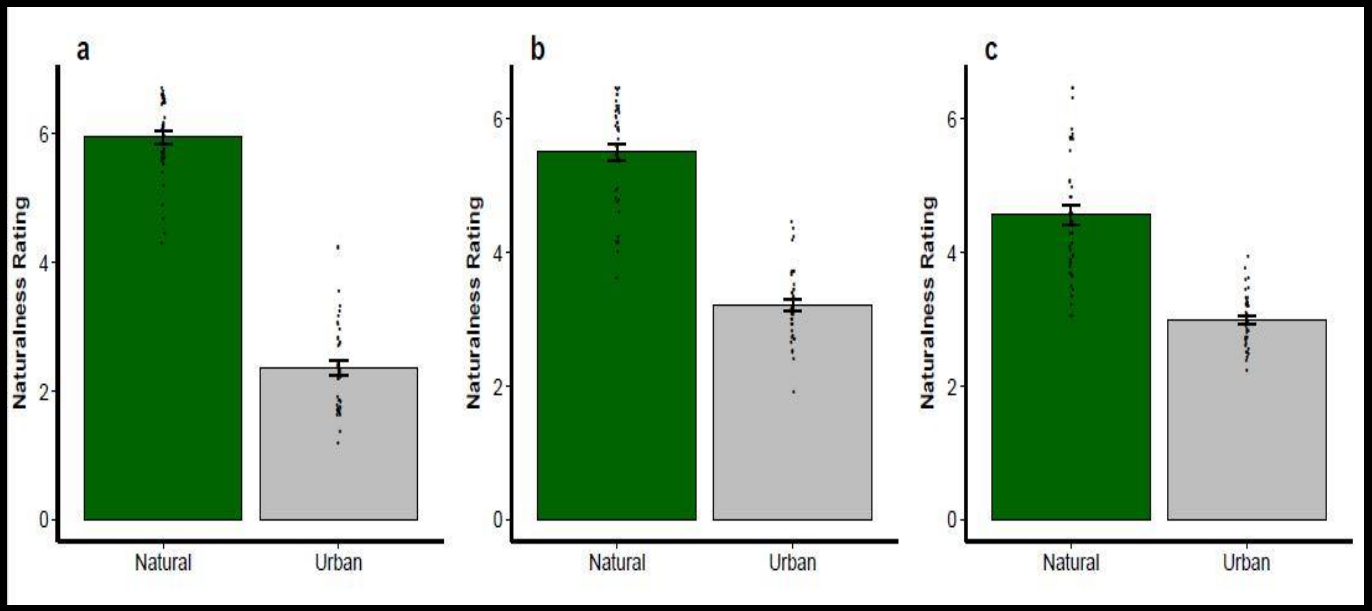


Van Hedger et al., in revision

****Scrambling and thin-slicing significantly impairs sound identifiability*

Results

Nature Ratings



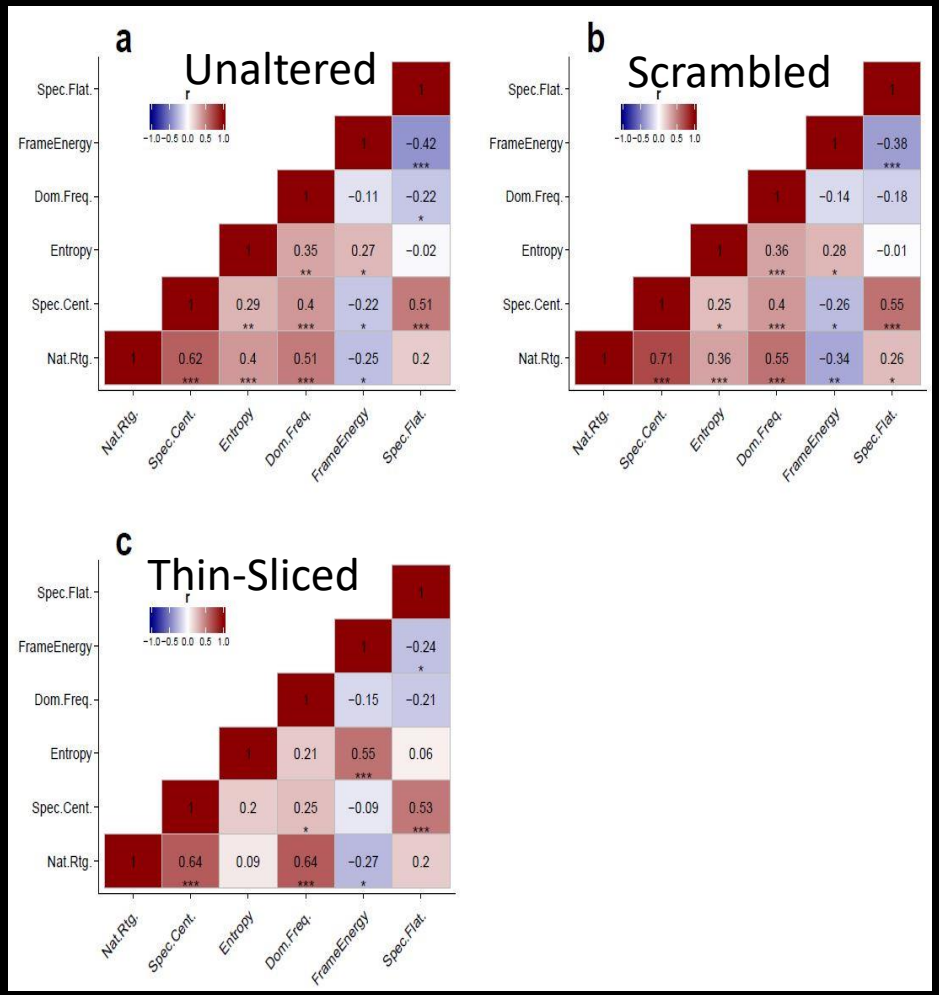
****Natural and urban soundscapes are easily differentiated*

****The difference is attenuated (but not eliminated) for scrambled and thin-sliced sounds*

Van Hedger et al., in revision

Results

Correlations of Nature Ratings and Acoustic Features

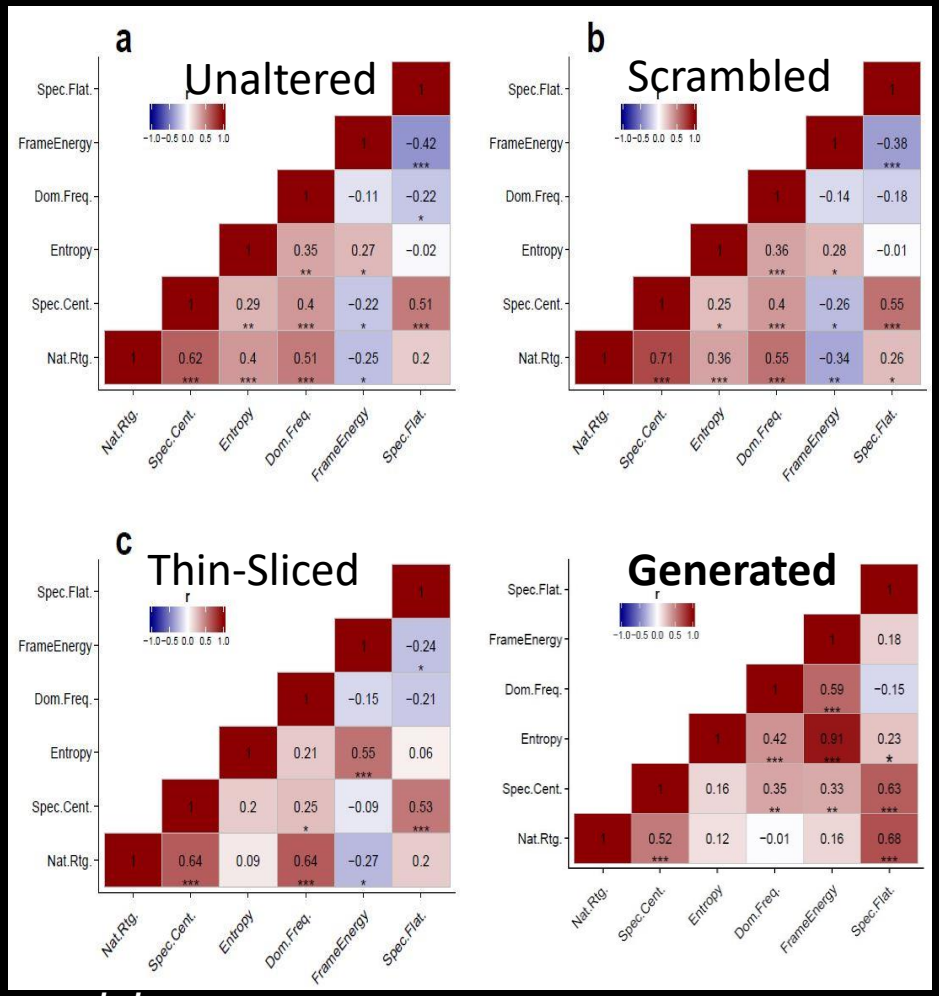


**** Spectral centroid, dominant frequency, and frame energy relate to naturalness ratings across all conditions*

Van Hedger et al., in revision

Results

Correlations of Nature Ratings and Acoustic Features



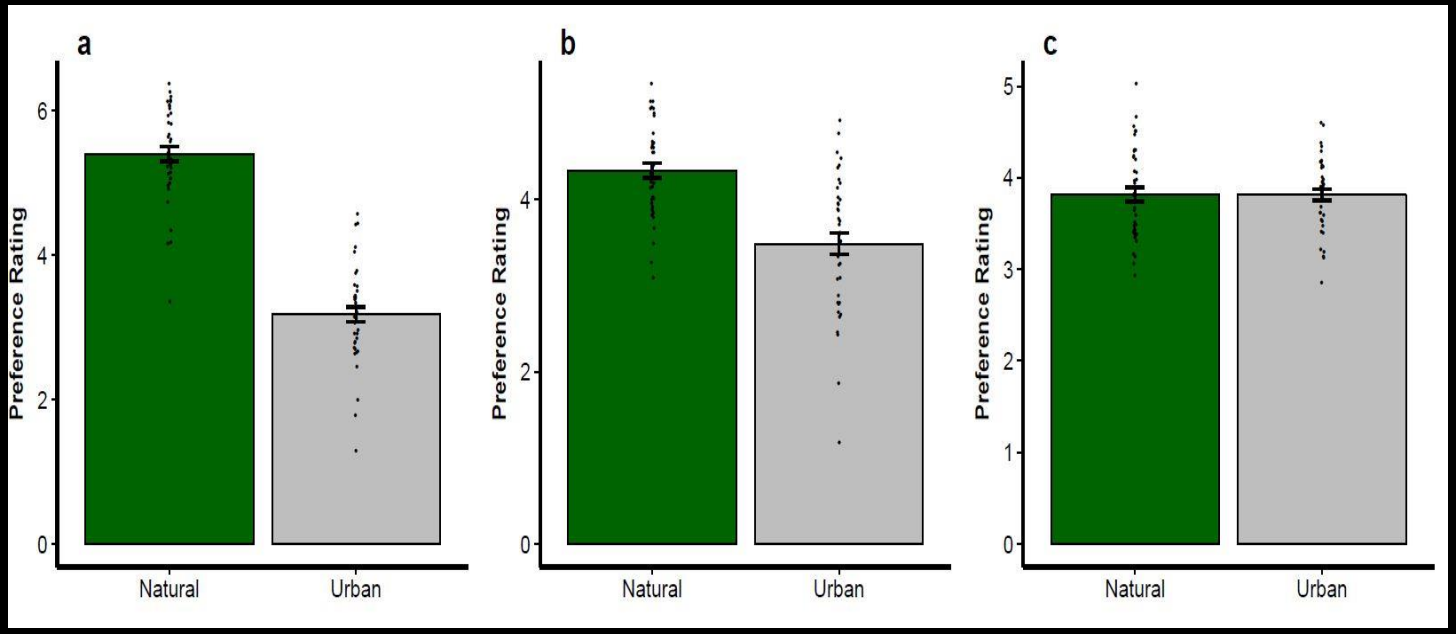
**** Spectral centroid, dominant frequency, and frame energy relate to naturalness ratings across all conditions*

****** Spectral centroid relates to nature ratings even for generated noises***

Van Hedger et al., in revision

Results

Aesthetic Ratings



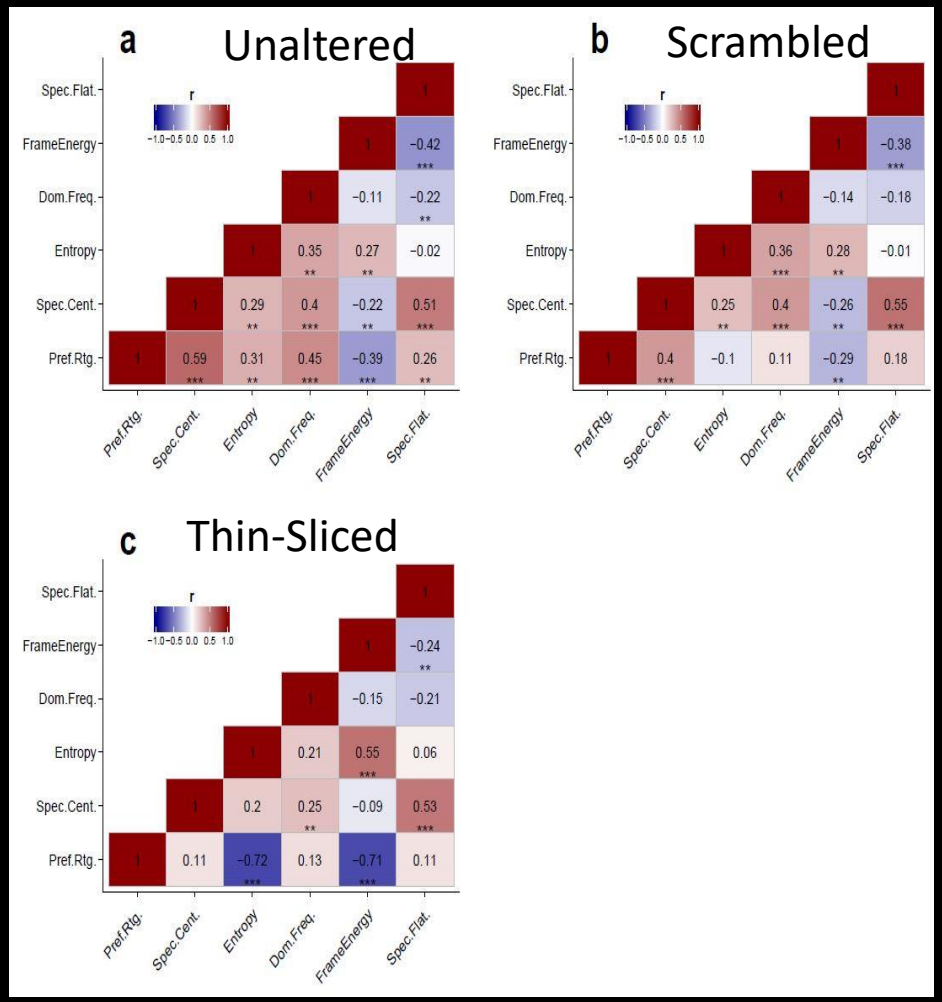
Van Hedger et al., in revision

****Natural soundscapes are preferred for unaltered and scrambled*

****Natural soundscapes are no longer preferred when presented as a thin slice (thin-slicing also resulted in the worst sound identifiability in Exp.1)*

Results

Correlations of Aesthetic Ratings and Acoustic Features



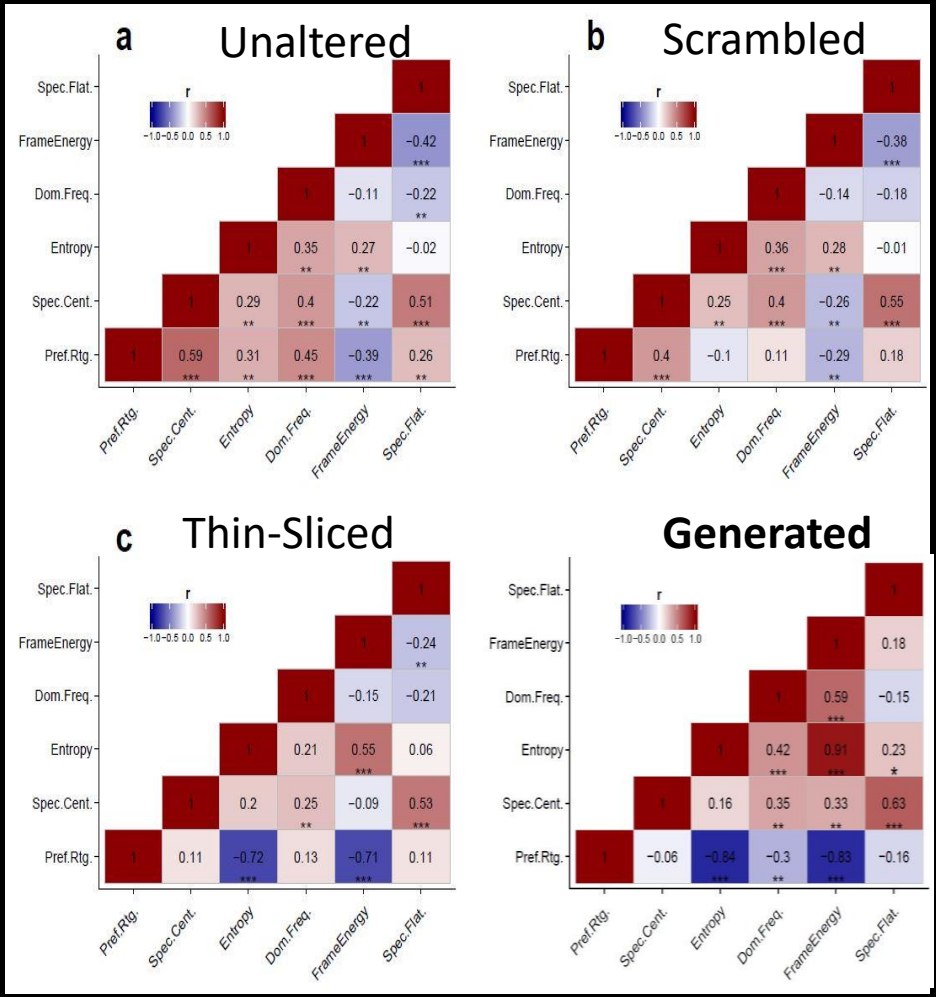
**** Spectral centroid not correlated with aesthetic ratings in thin-sliced group*

**** Spectral entropy and frame energy are strongly negatively correlated with aesthetic ratings for thin-sliced*

Van Hedger et al., in revision

Results

Correlations of Aesthetic Ratings and Acoustic Features



Van Hedger et al., in revision

**** Spectral centroid not correlated with aesthetic ratings in thin-sliced group*

**** Spectral entropy and frame energy are strongly negatively correlated with aesthetic ratings for thin-sliced*

****** This relationship persists for generated noises***

Summary

We believe we have a solid taxonomy of low-level visual features that distinguish the environments (both in visual and auditory domain)

Now we can manipulate those features to examine changes in memory and attention

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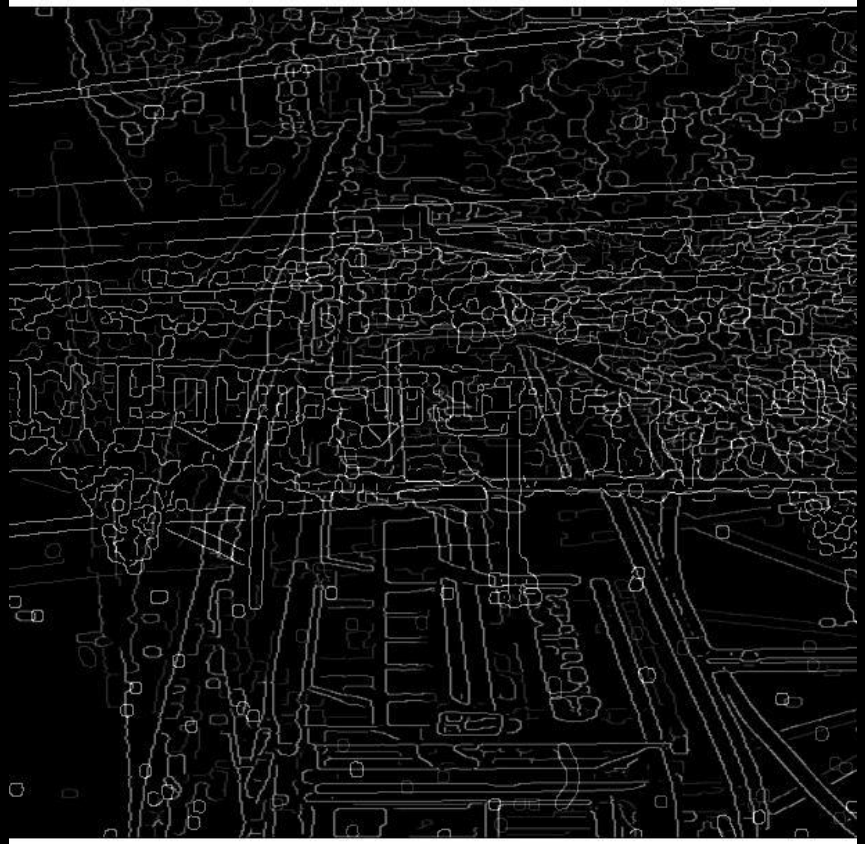
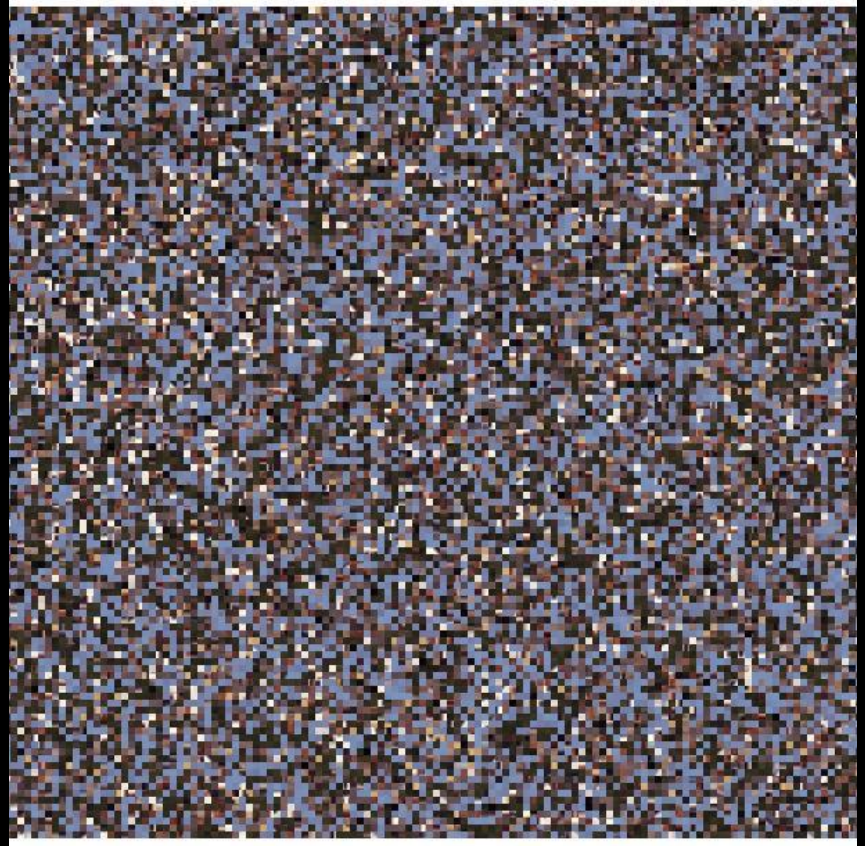
Manipulating Features



Manipulating Features



Conceptual features

River

Street

Utilizing Eye-Tracking: Visual features at fixations

Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

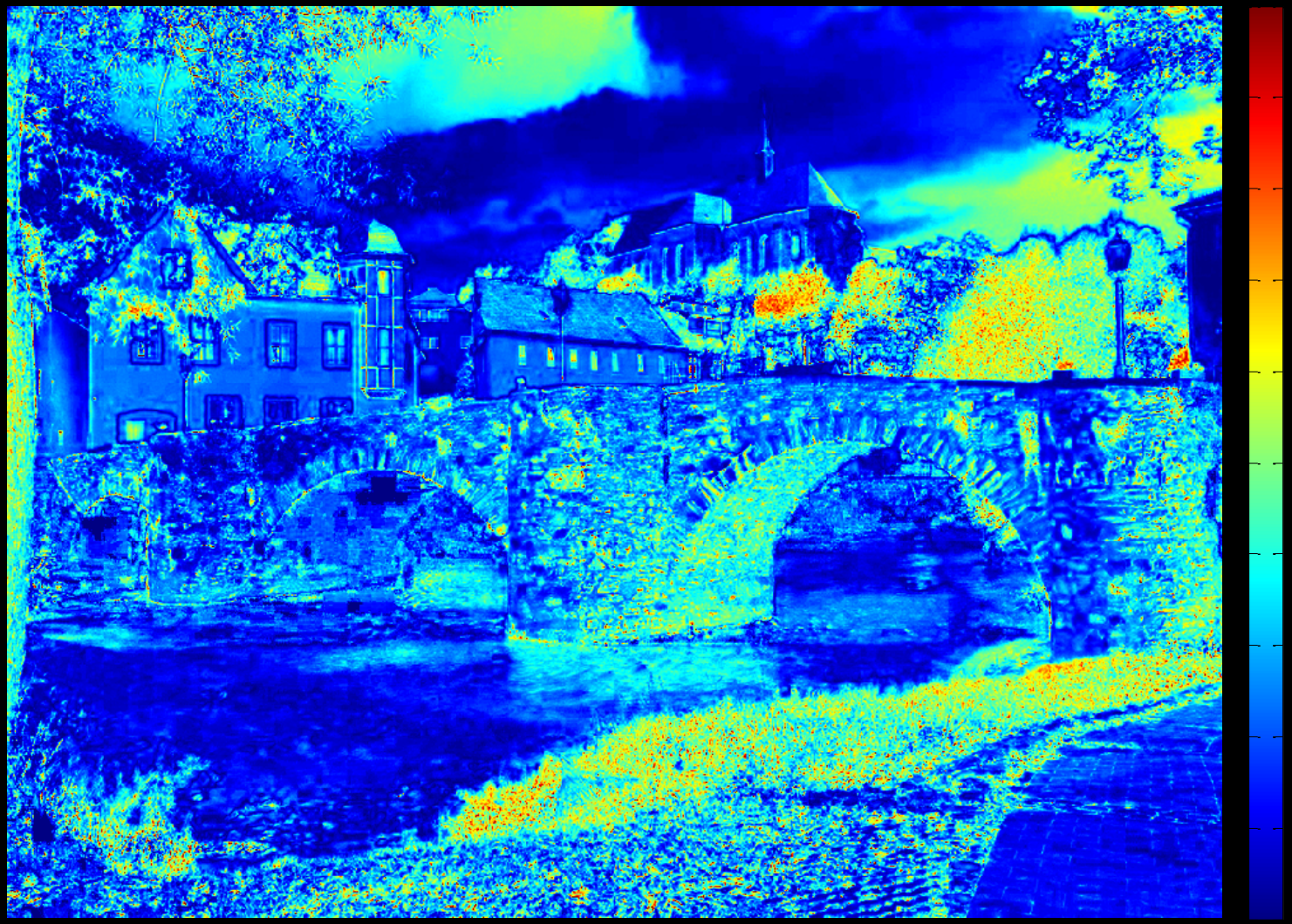
Visual features at fixations (Edges)

Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

Visual features at fixations (Edges)

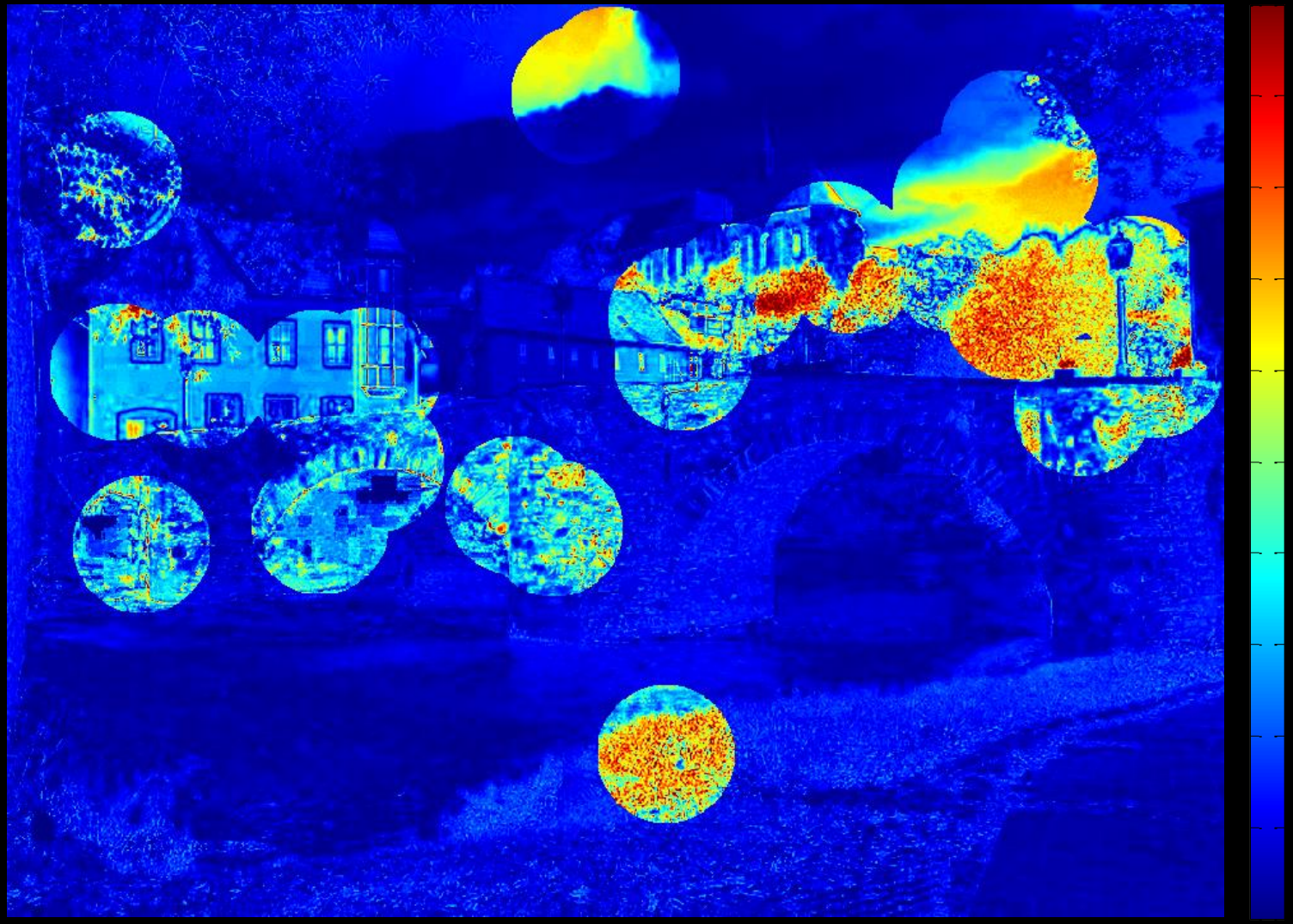
Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

Visual features at fixations (Saturation)



Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

Visual features at fixations (Saturation)



Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

Mental State Prediction

With these visual features we can predict with 80%+ accuracy the task that participants are doing.

Might there be a characteristic eye-movement pattern when viewing nature scenes that may be more restful than when viewing urban scenes

Kardan et al., (2015) Journal of Experimental Psychology: Human Perception and Performance

Conclusion

Interacting with nature can have significant benefits to health and well-being

Brief interactions with nature can produce significant benefits in memory and attention

As Daniel Burnham said: “Make no little plans.”

Future work in our lab is focused on the elements of nature that lead to these benefits to impact future design

Acknowledgments

- John Jonides
- Steve Kaplan
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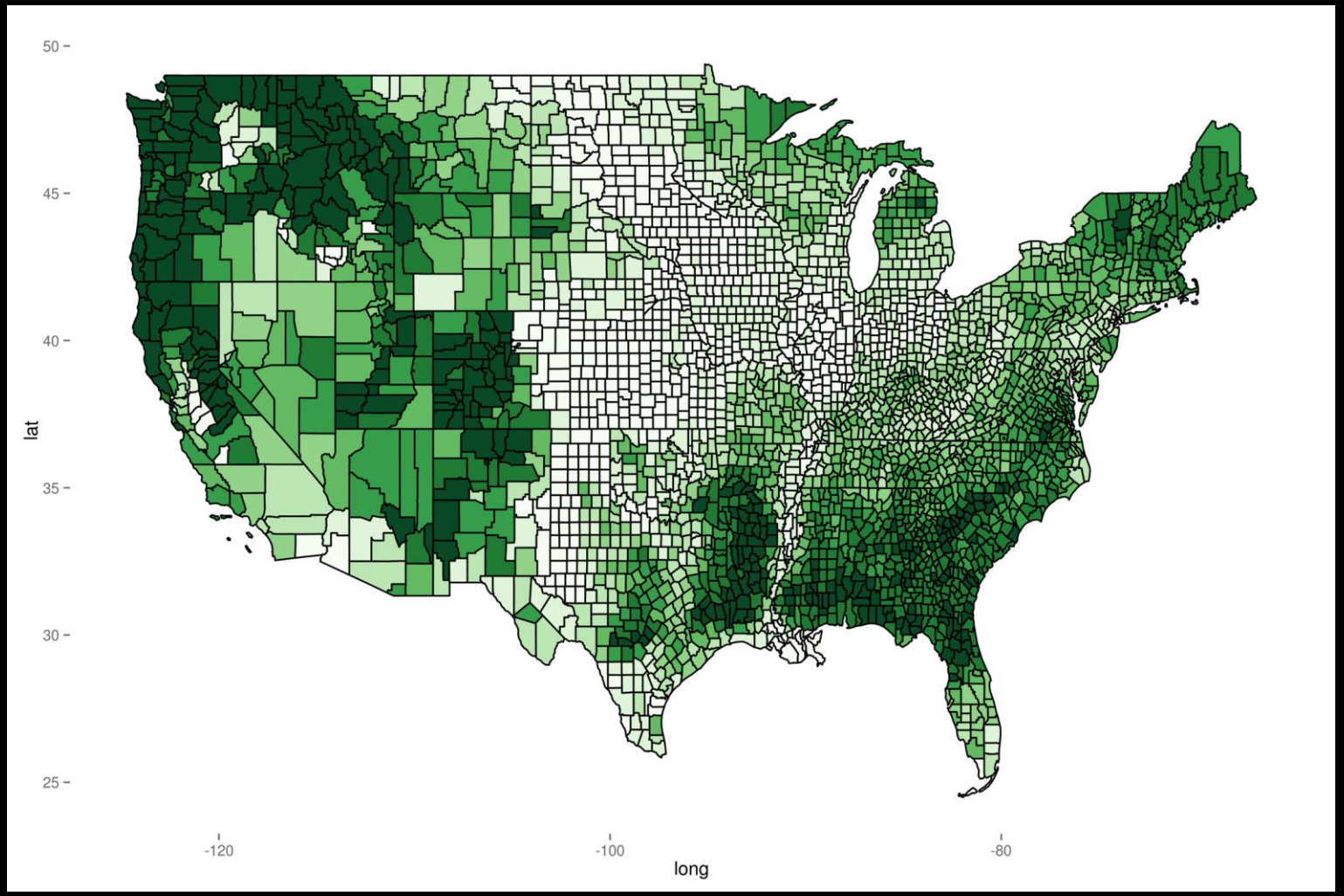
- Tomas Paus
- John Henderson
- The David Suzuki Foundation
- The TKF Foundation
- National Science Foundation
- National Institute of Mental Health

Extras

Larger GIS dataset from different years
Preliminary Analysis



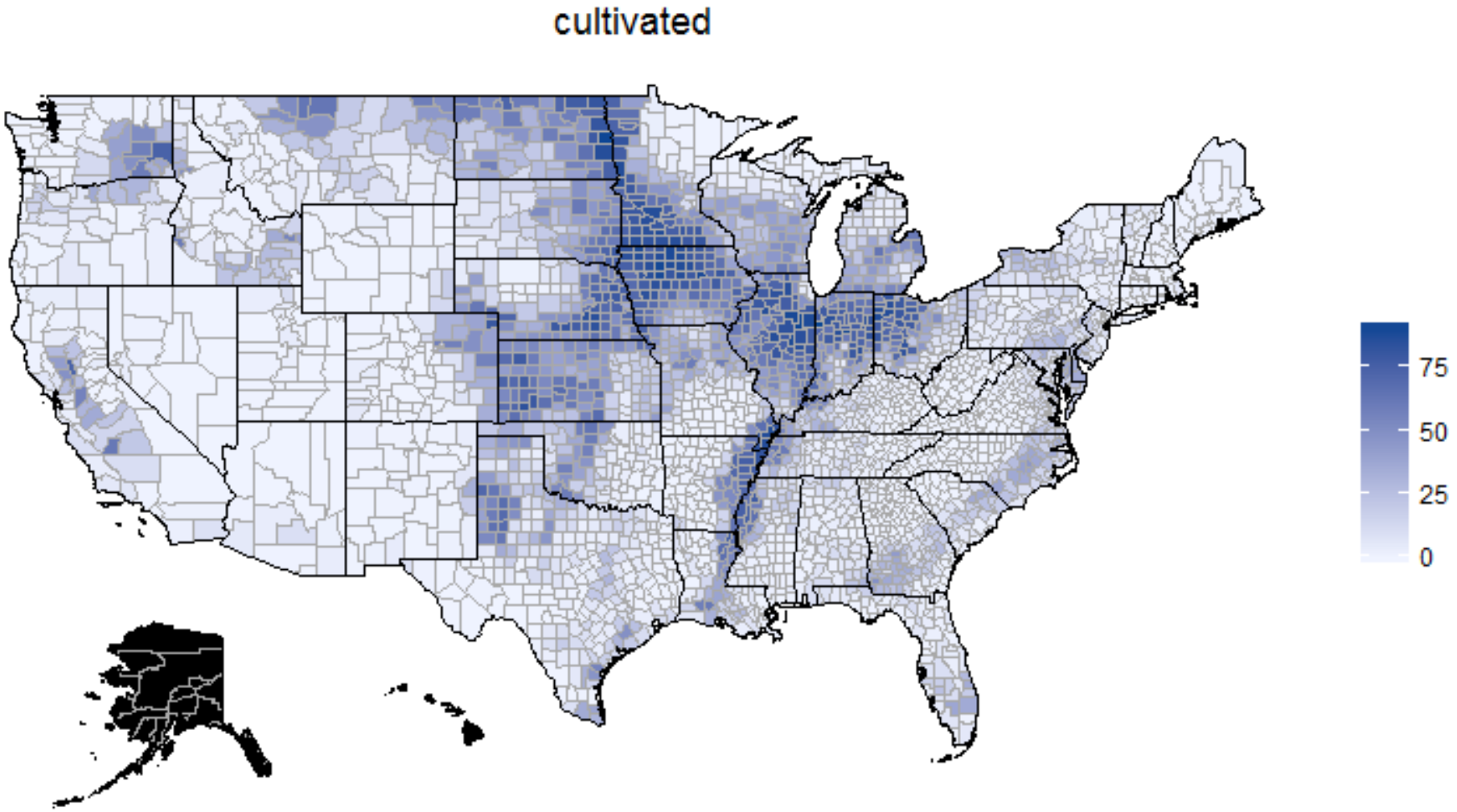
MarketScan

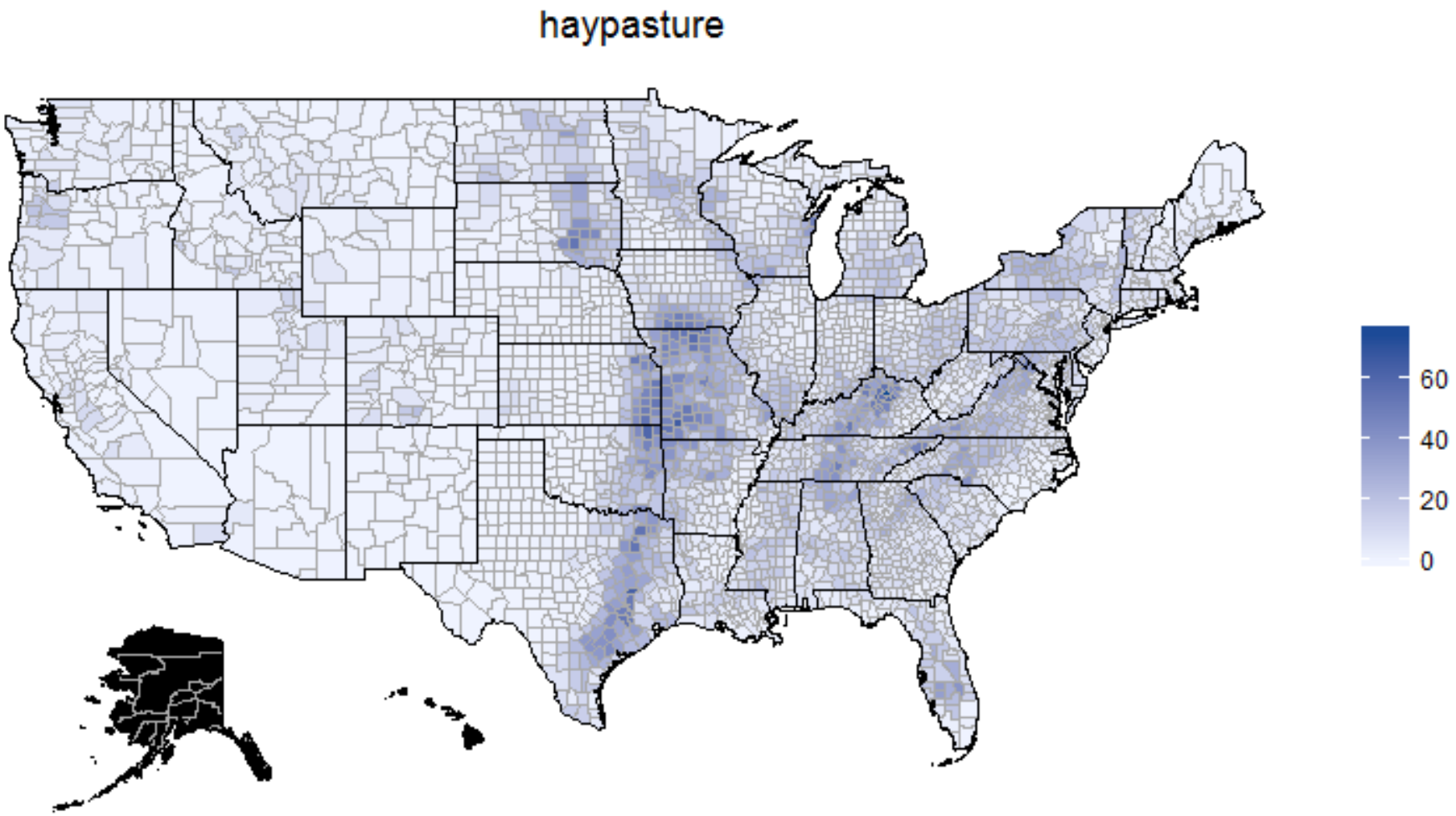
- A database of health insurance claims covering both Medicare and commercial claims
  - Database is skewed towards wealthier population as the Medicare claims are those that are supplemental to private insurance
- Localized to the county level for years 2003-2010
- 19.6 million people enrolled in 2003, 48.7 million enrolled in 2010 (not including AK, HI, or DC)
- Linear regression models shown for 2003 are using 2003 MarketScan data, 2000 Census data, and 2001 National Land Cover Data
- Models for 2010 are using 2010 MarketScan data, 2010 Census data, and 2011 National Land Cover Data (won't show these data today)

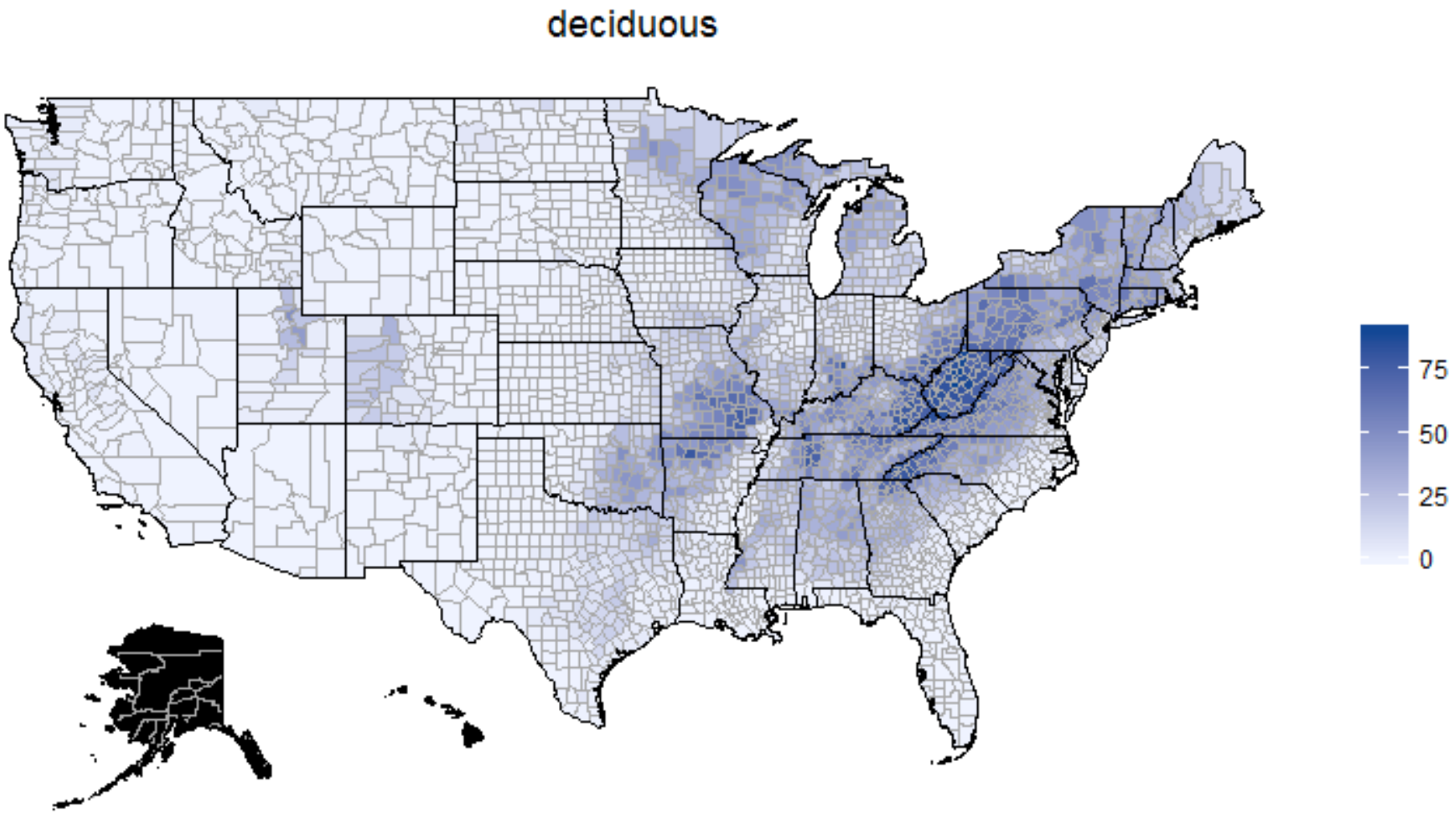
Demographics

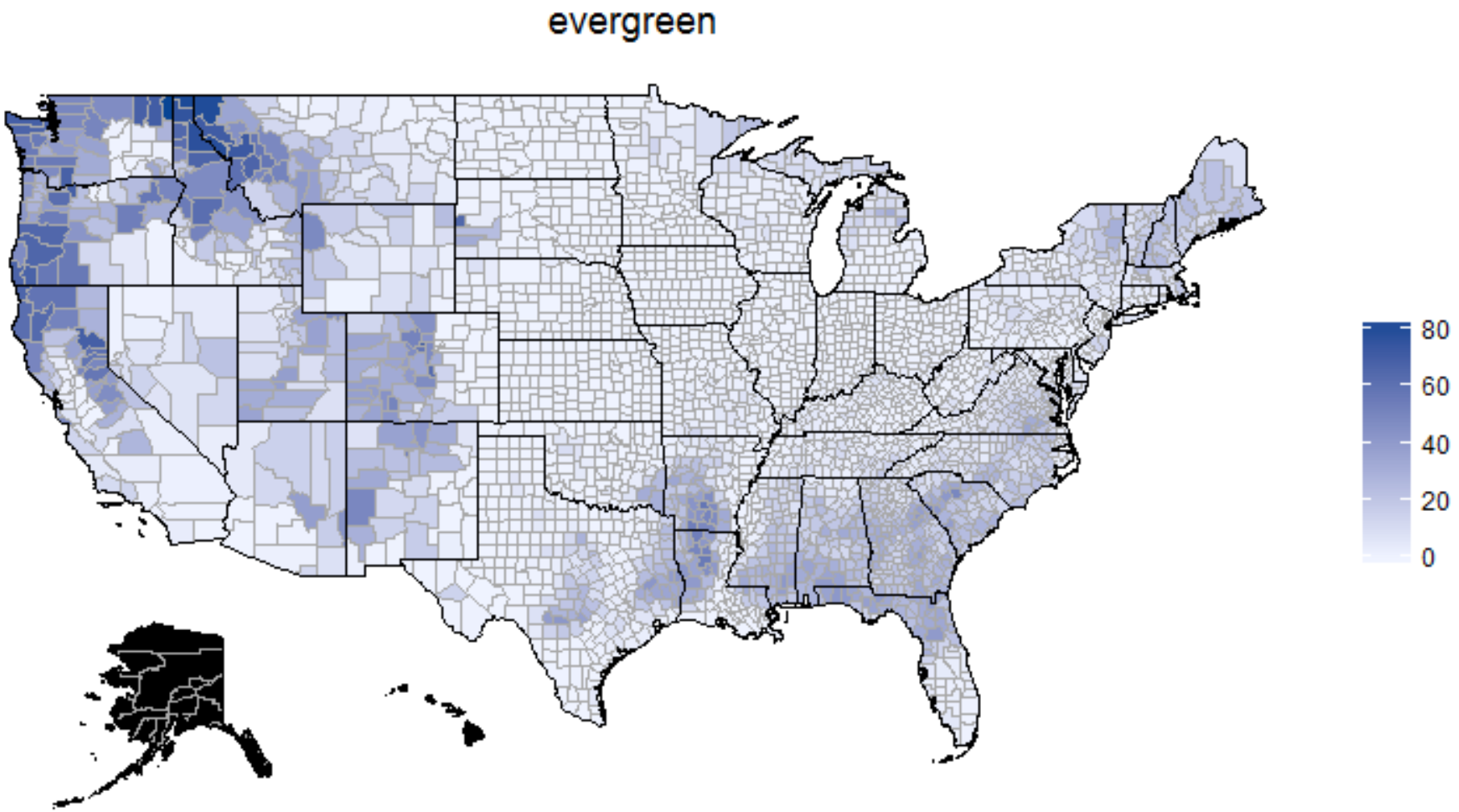
- Median Household Income
- Percent Black
- Percent Hispanic
- Education Index
- Percent Households Income over $100K
- Population Density
- Percent Enrolled (in MarketScan)
- Average Age (of MarketScan population)
- Only included counties with over 100 people enrolled
  - 2841 counties

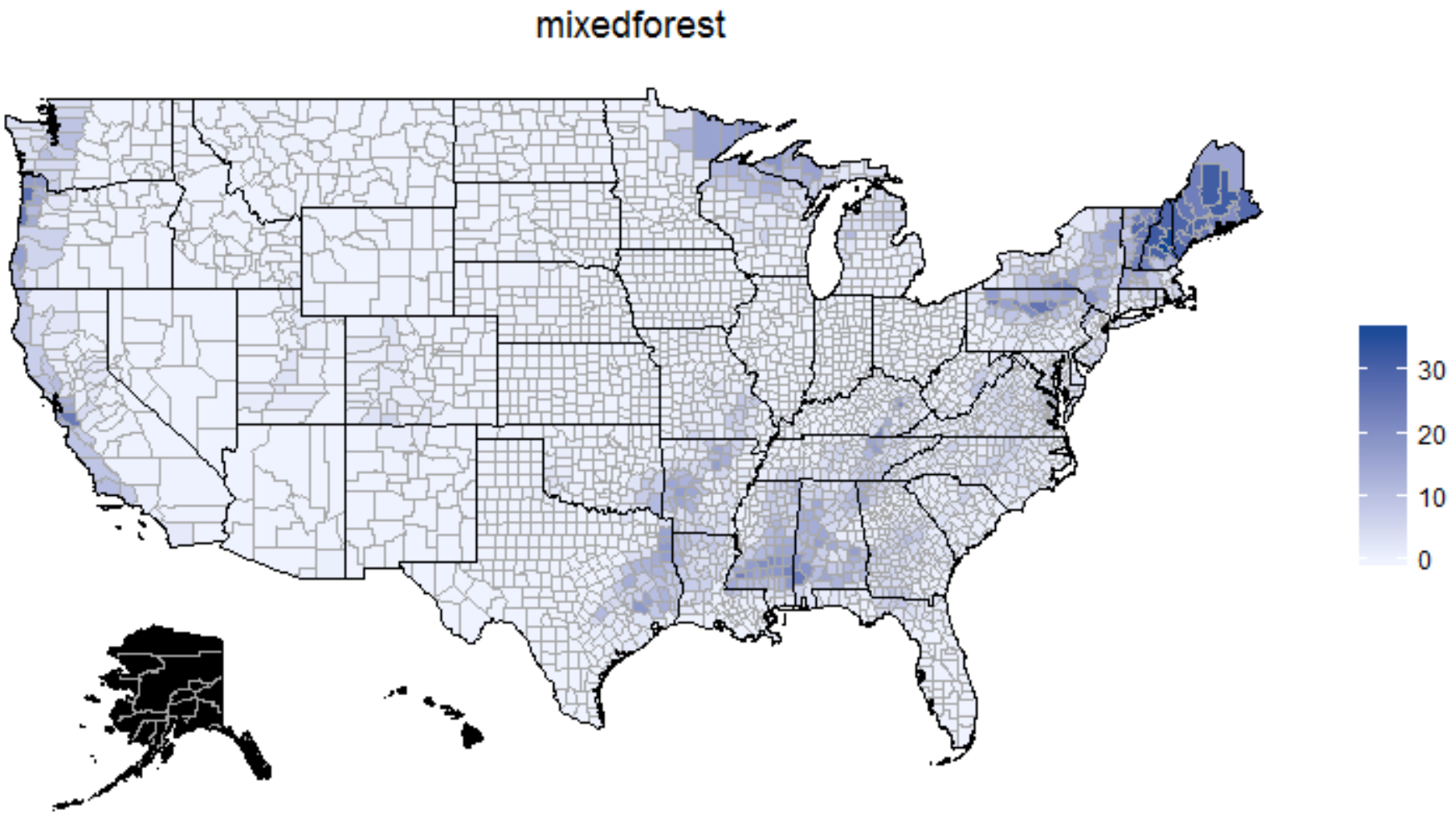
Class\ Value	Classification Description
Water	
11	**Open Water** - areas of open water, generally with less than 25% cover of vegetation or soil.
12	**Perennial Ice/Snow** - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	
21	**Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	**Developed, Medium Intensity** – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	**Developed High Intensity** -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	
31	**Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	
41	**Deciduous Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	**Evergreen Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	**Mixed Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrubland	
51	**Dwarf Scrub** - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	**Shrub/Scrub** - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	
71	**Grassland/Herbaceous** - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72	**Sedge/Herbaceous** - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73	**Lichens** - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	**Moss** - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	
81	**Pasture/Hay** – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	**Cultivated Crops** – areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	
90	**Woody Wetlands** - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	**Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

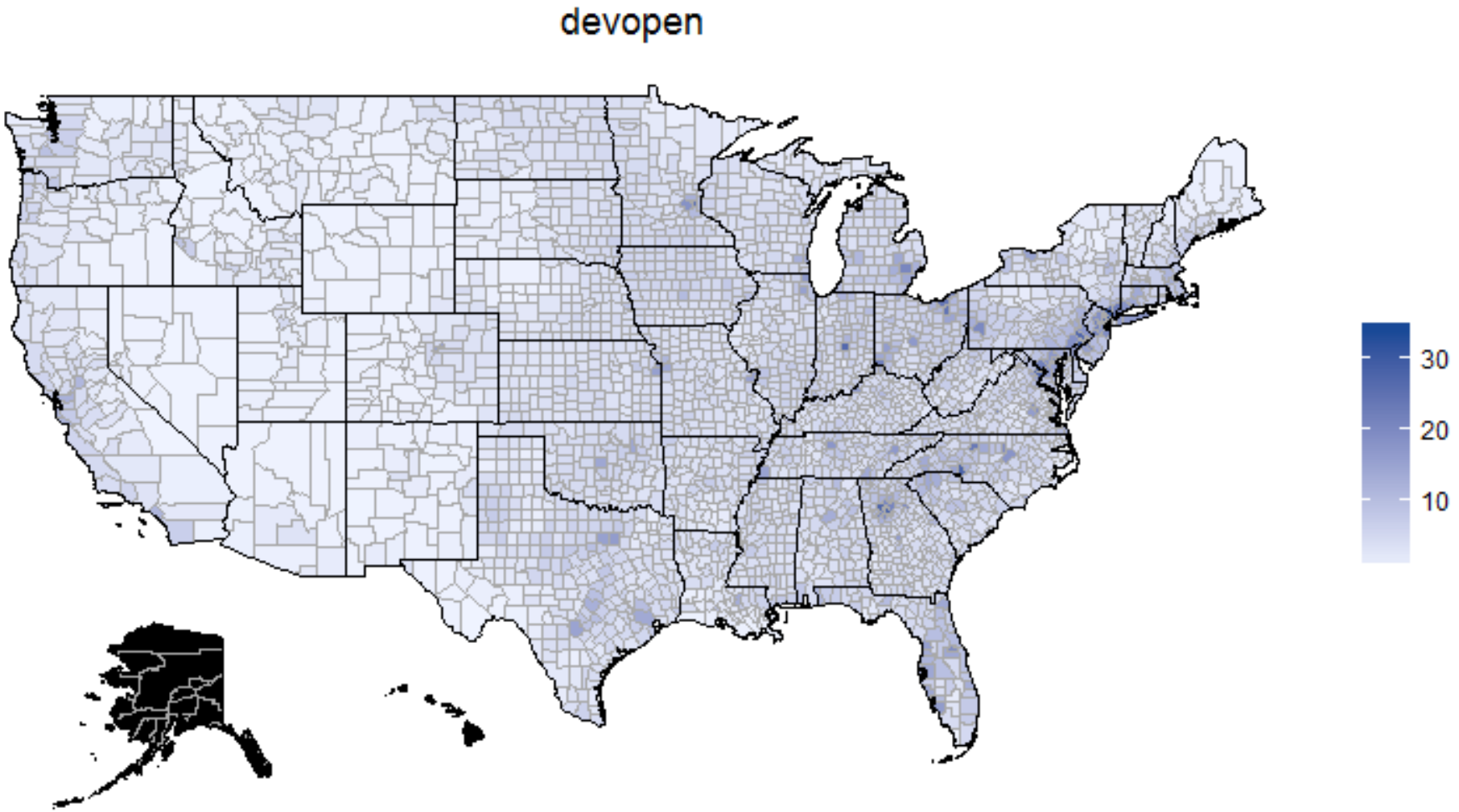

cultivated
75
50
25
0

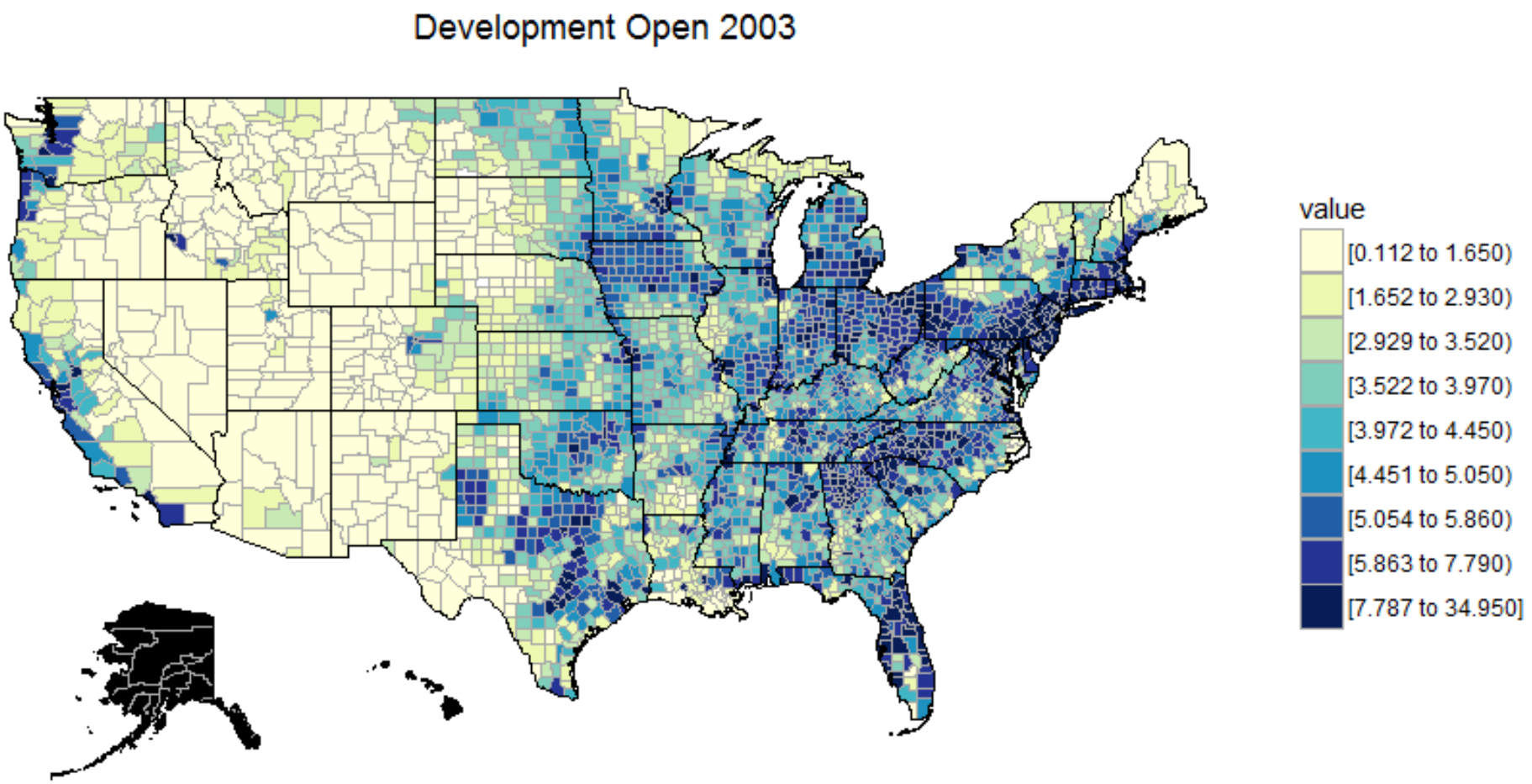

haypasture
60
40
20
0

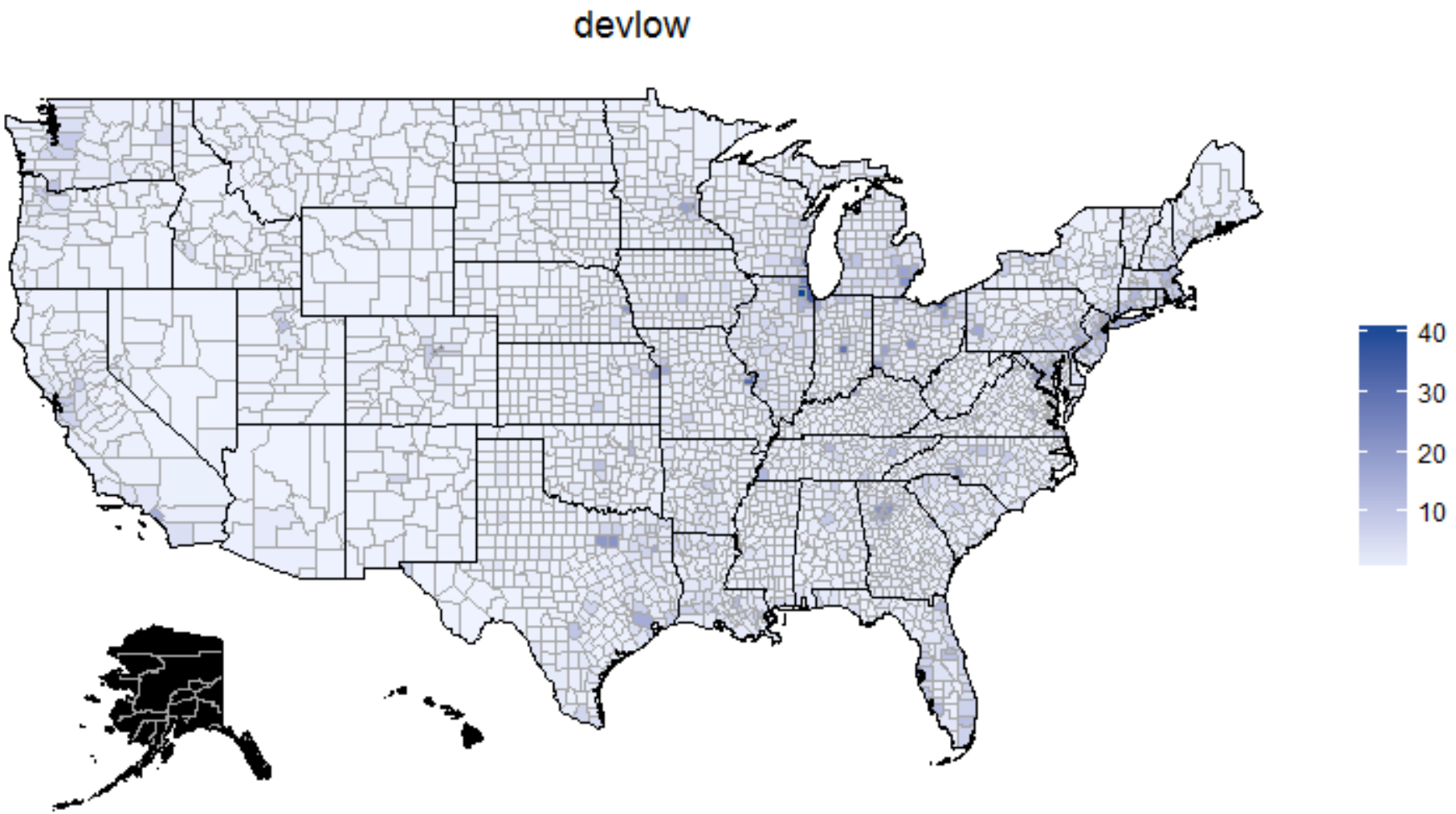

deciduous
75
50
25
0

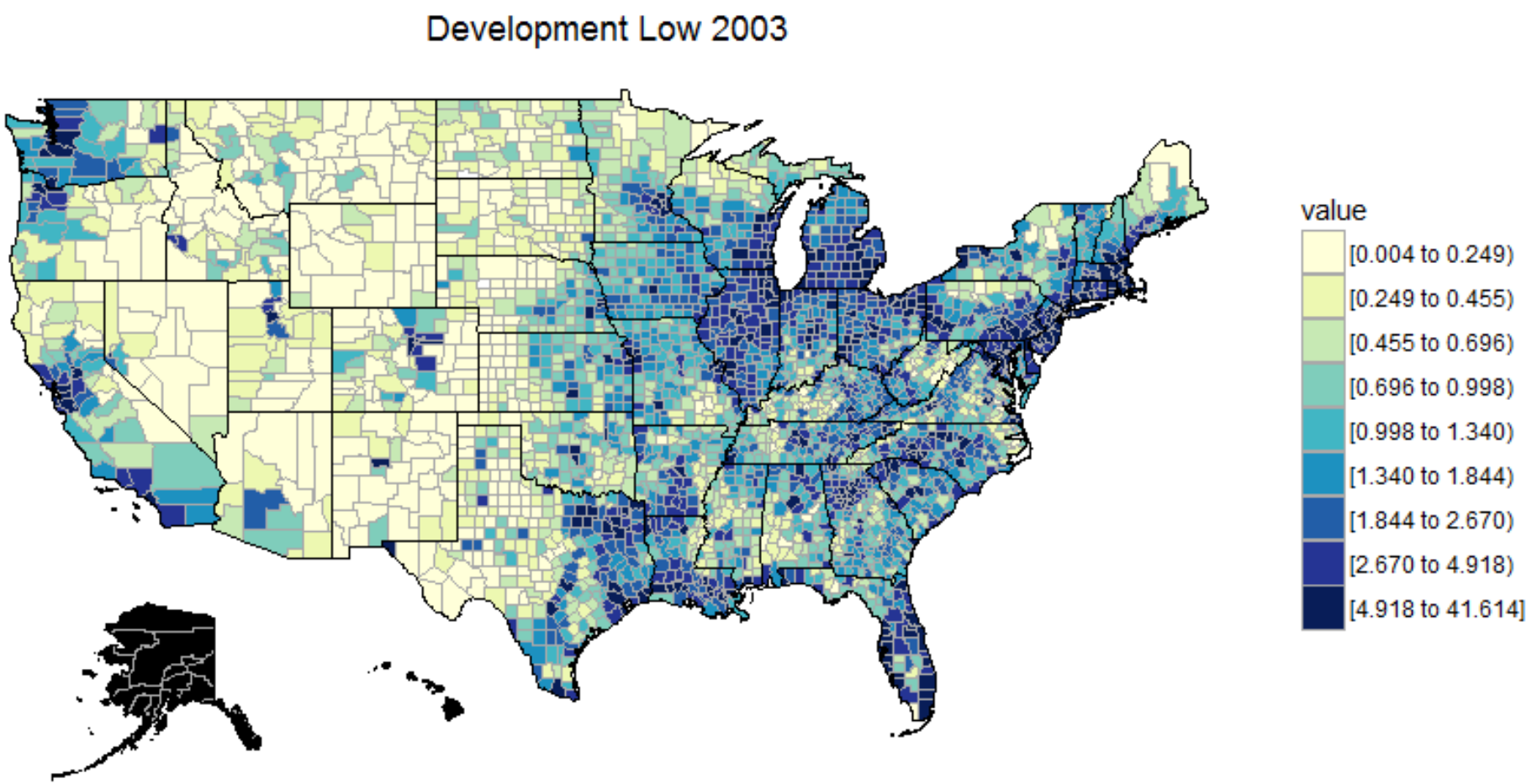

evergreen
80
60
40
20
0

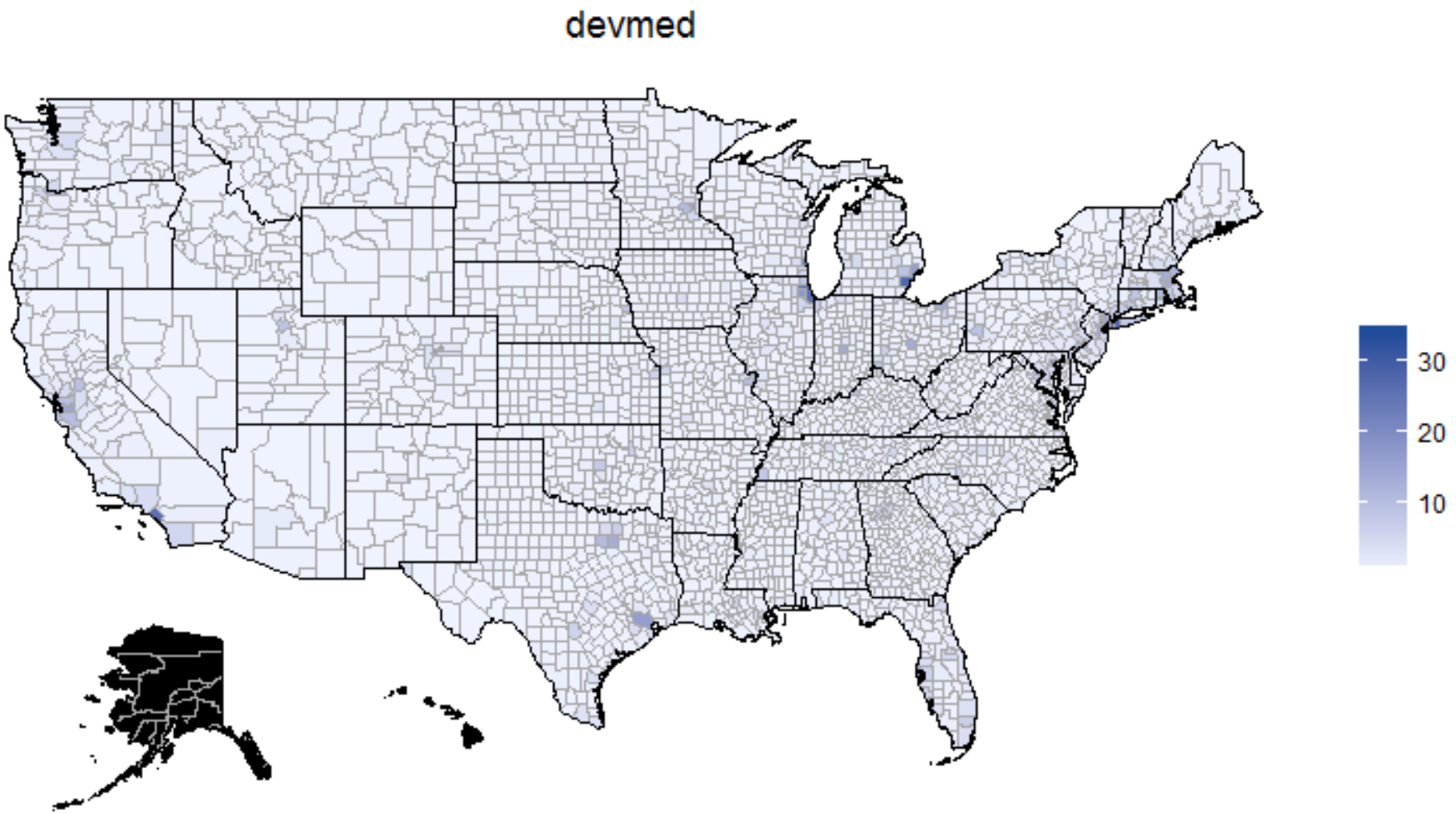

mixedforest
30
20
10
0

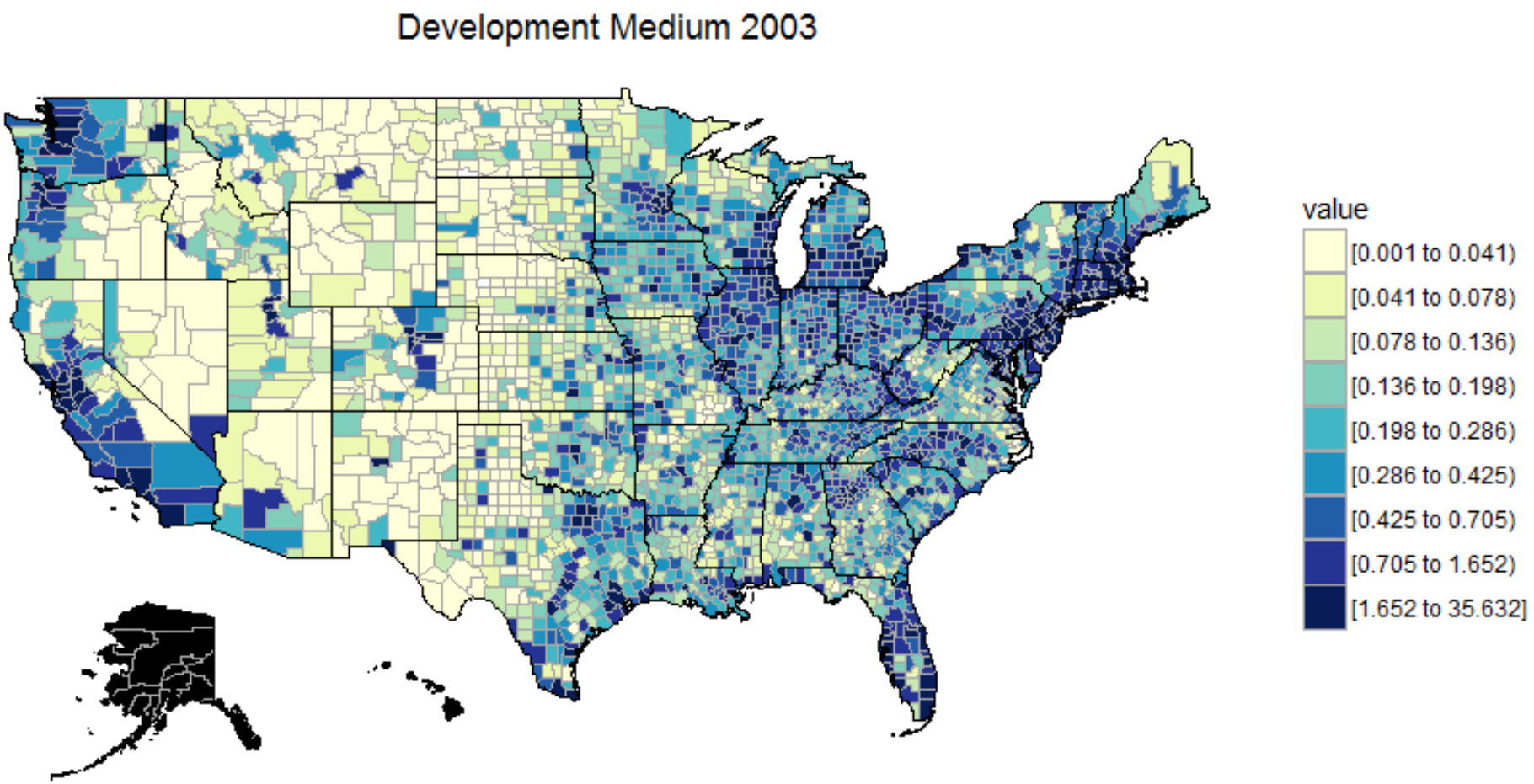

devopen
30
20
10

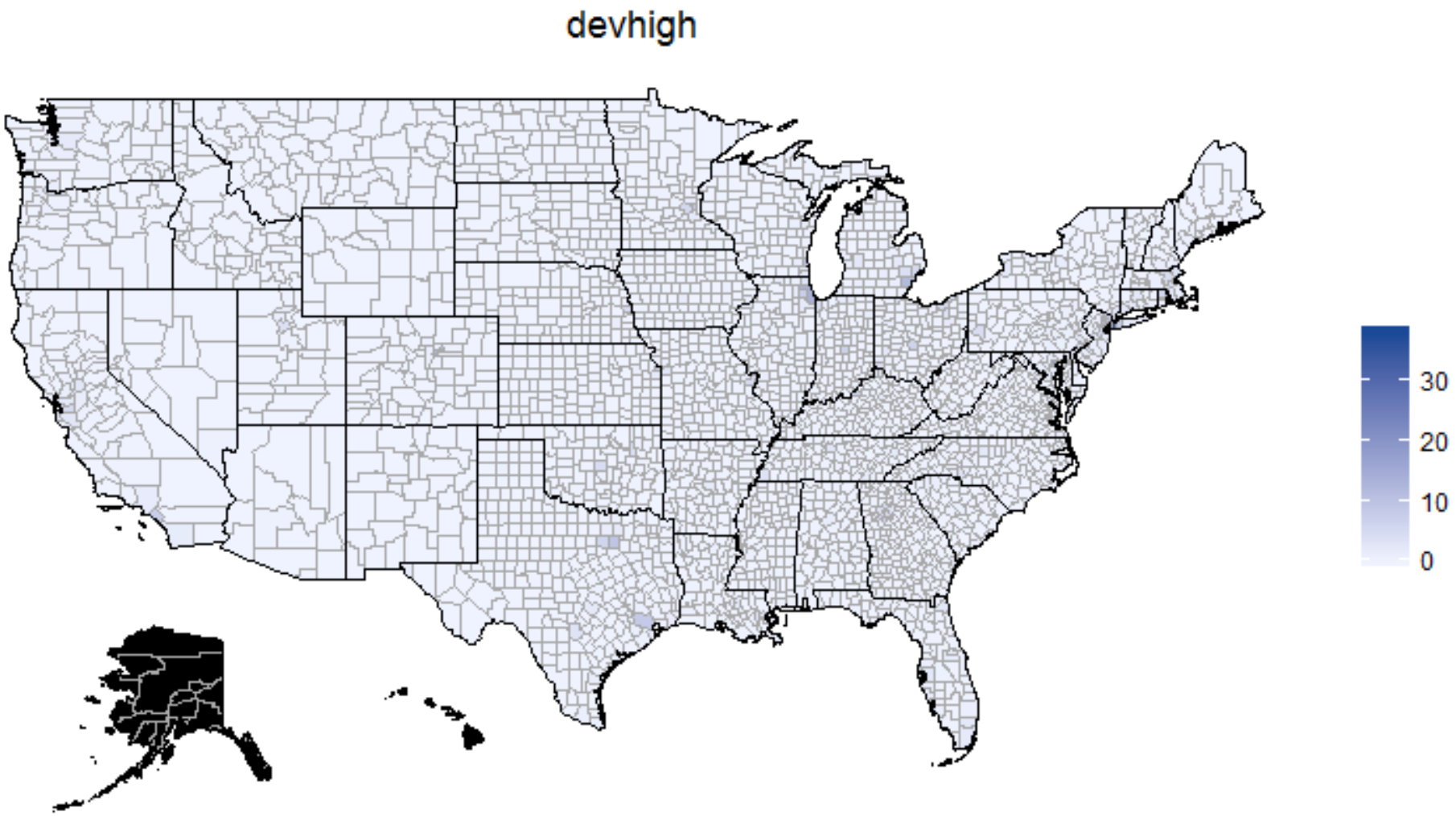

Development Open 2003
value
[0.112 to 1.650)
[1.652 to 2.930)
[2.929 to 3.520)
[3.522 to 3.970)
[3.972 to 4.450)
[4.451 to 5.050)
[5.054 to 5.860)
[5.863 to 7.790)
[7.787 to 34.950]


devlow
40
30
20
10

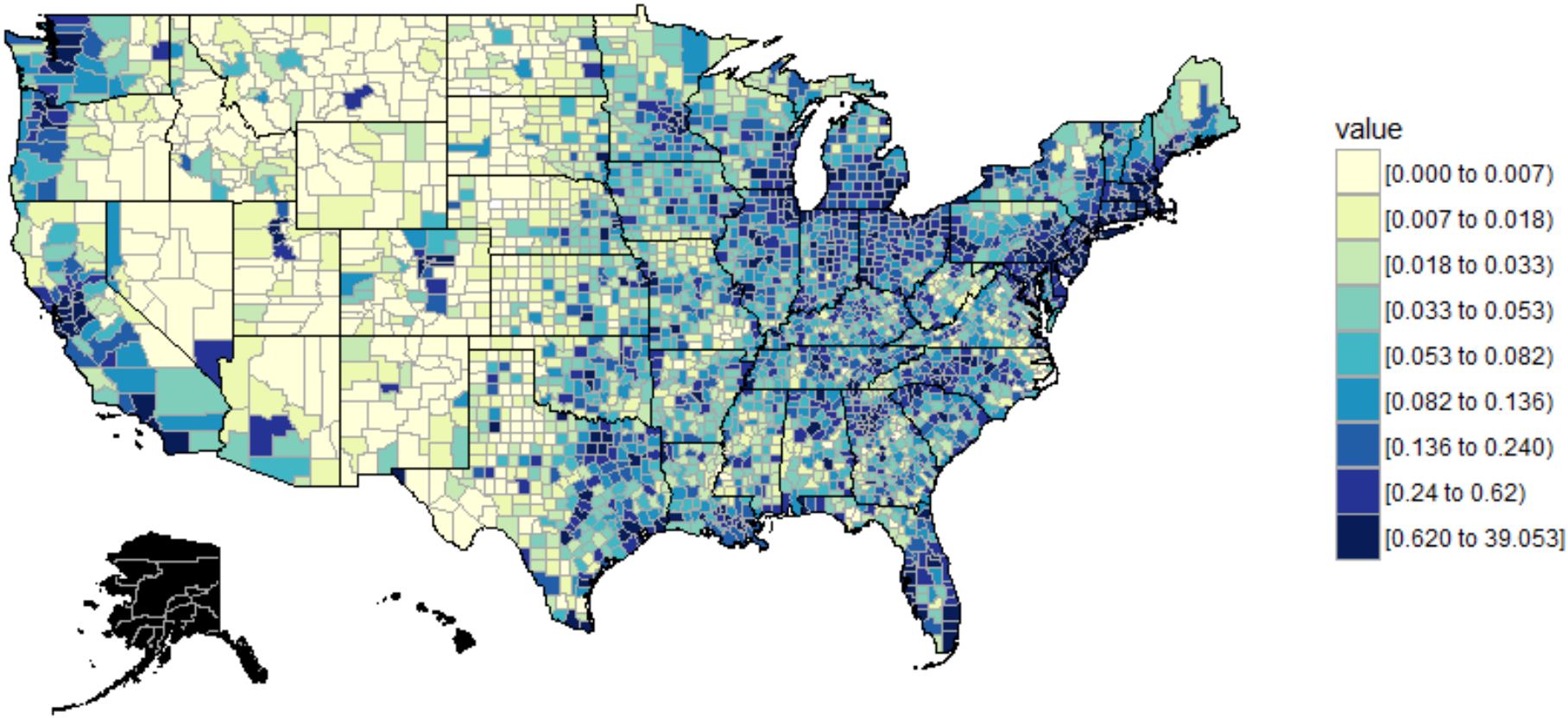

Development Low 2003
value
[0.004 to 0.249)
[0.249 to 0.455)
[0.455 to 0.696)
[0.696 to 0.998)
[0.998 to 1.340)
[1.340 to 1.844)
[1.844 to 2.670)
[2.670 to 4.918)
[4.918 to 41.614]

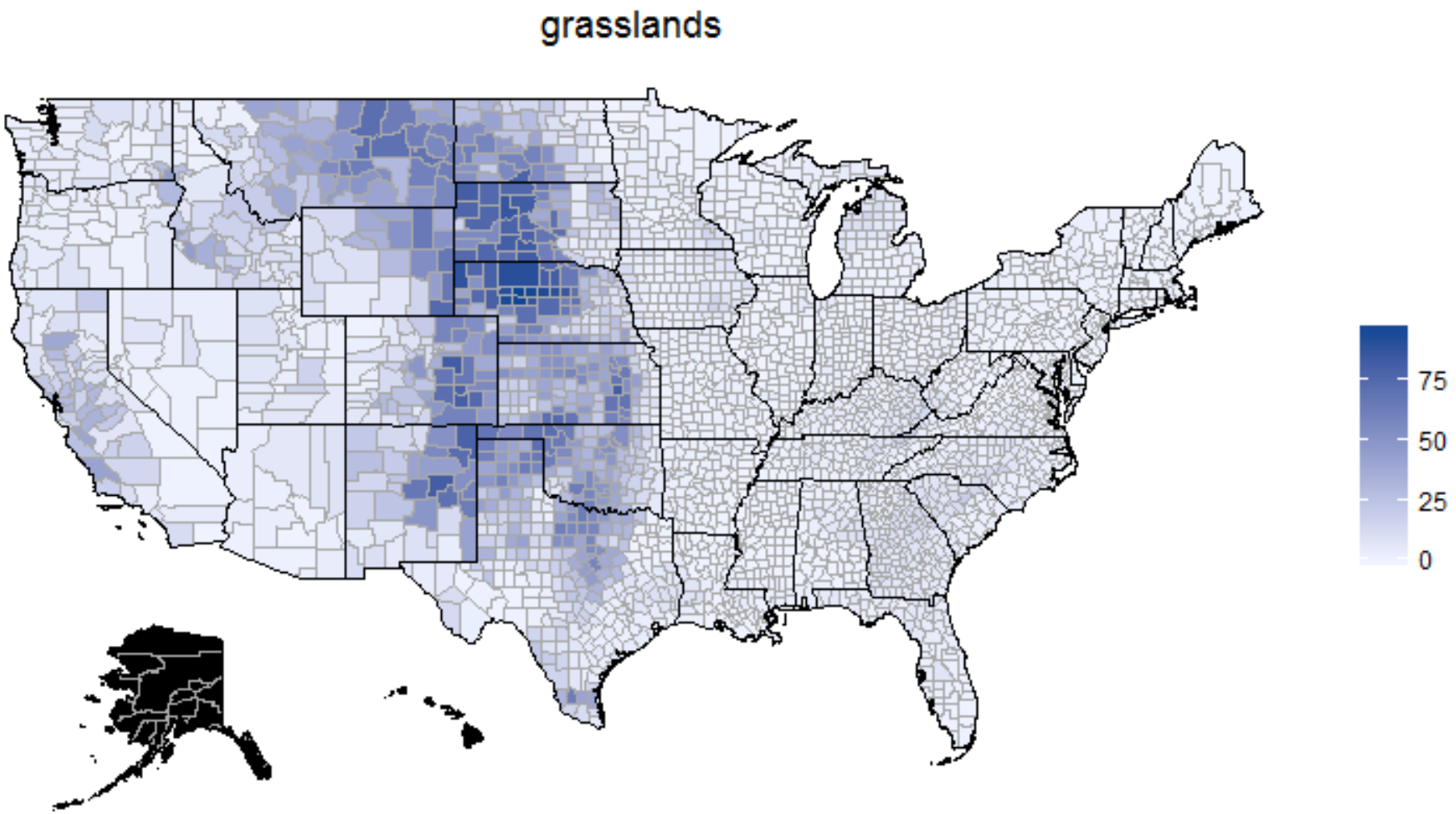

devmed
30
20
10

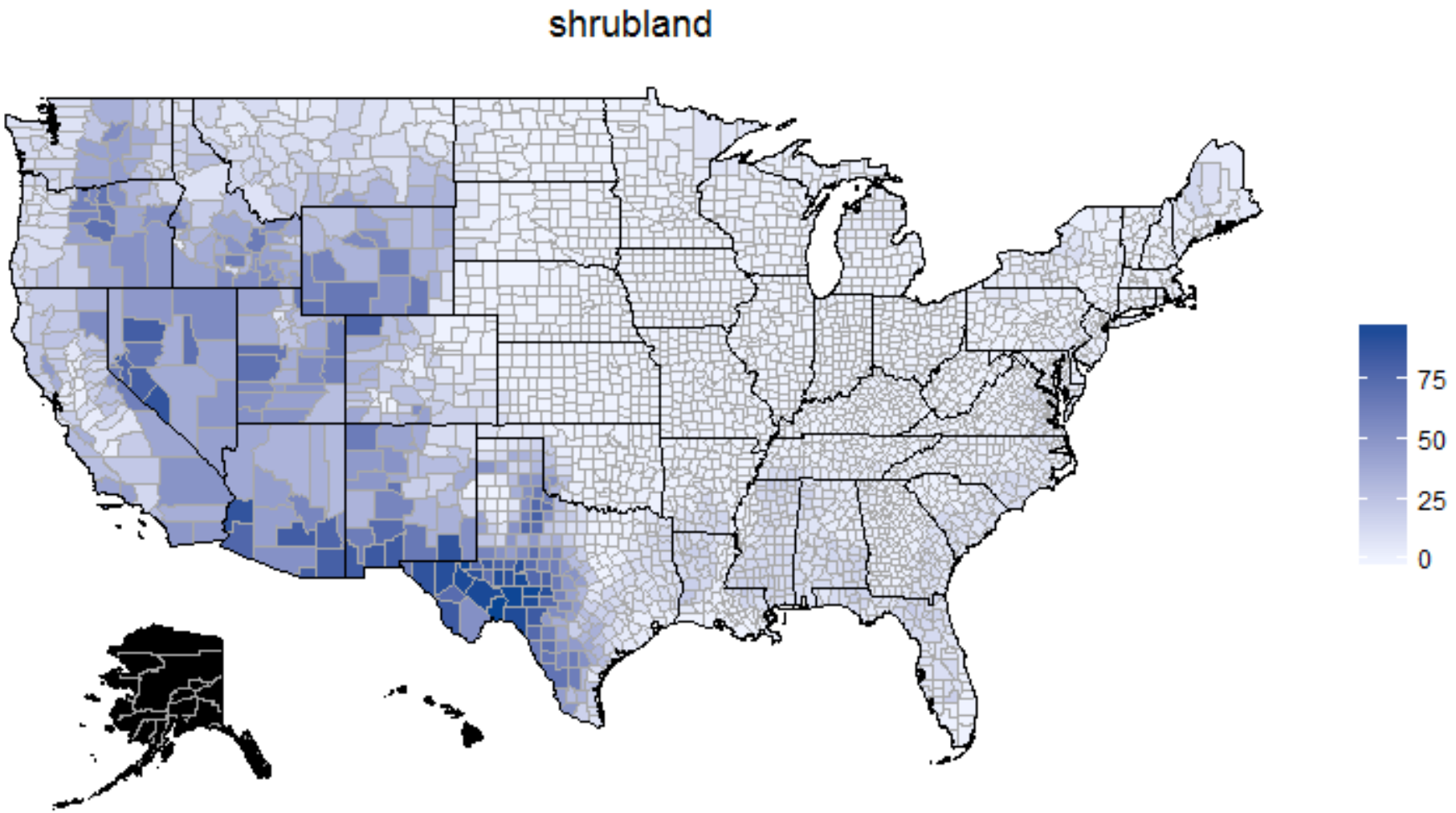

Development Medium 2003
value
[0.001 to 0.041)
[0.041 to 0.078)
[0.078 to 0.136)
[0.136 to 0.198)
[0.198 to 0.286)
[0.286 to 0.425)
[0.425 to 0.705)
[0.705 to 1.652)
[1.652 to 35.632]

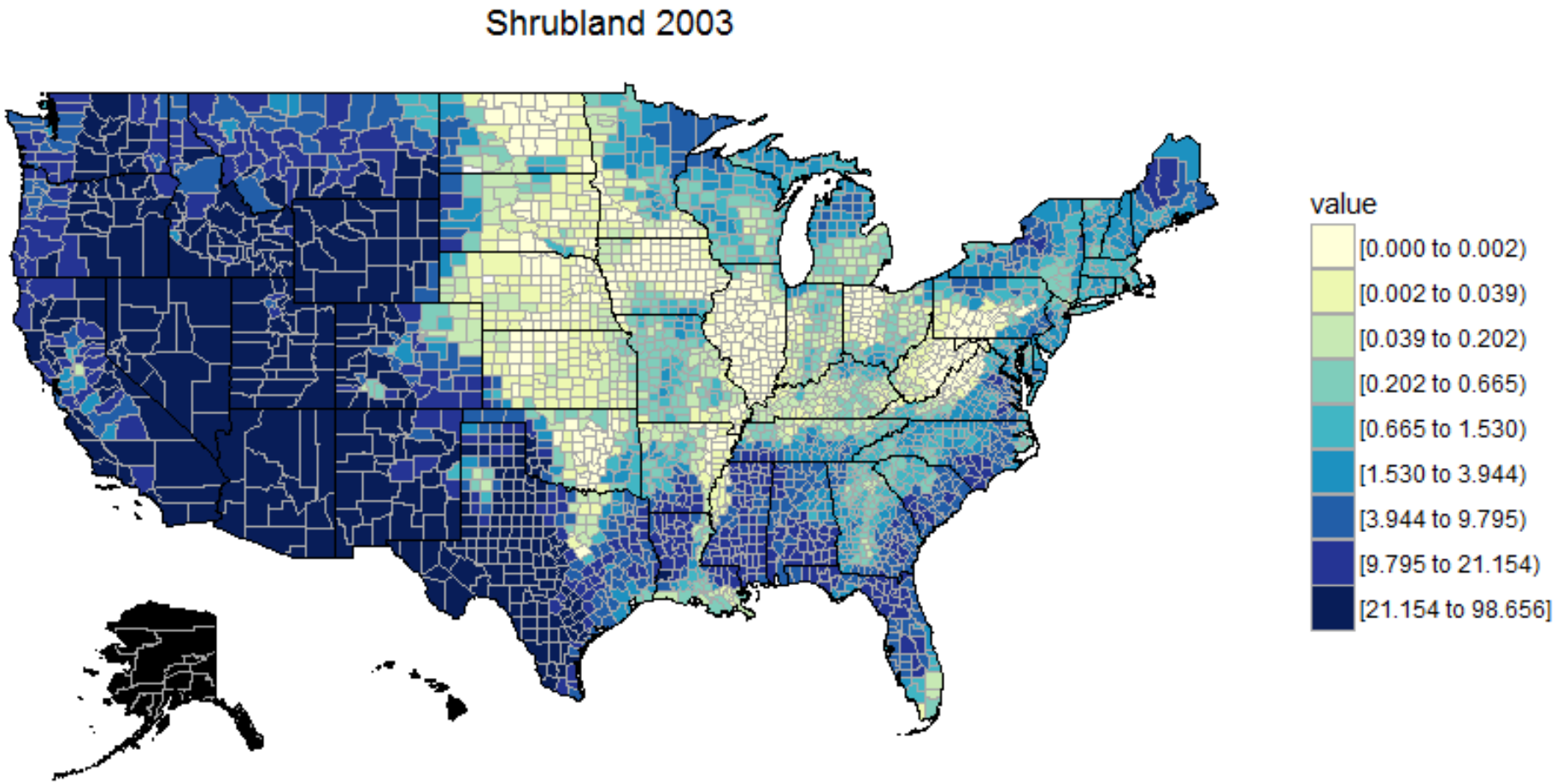

devhigh
30
20
10
0

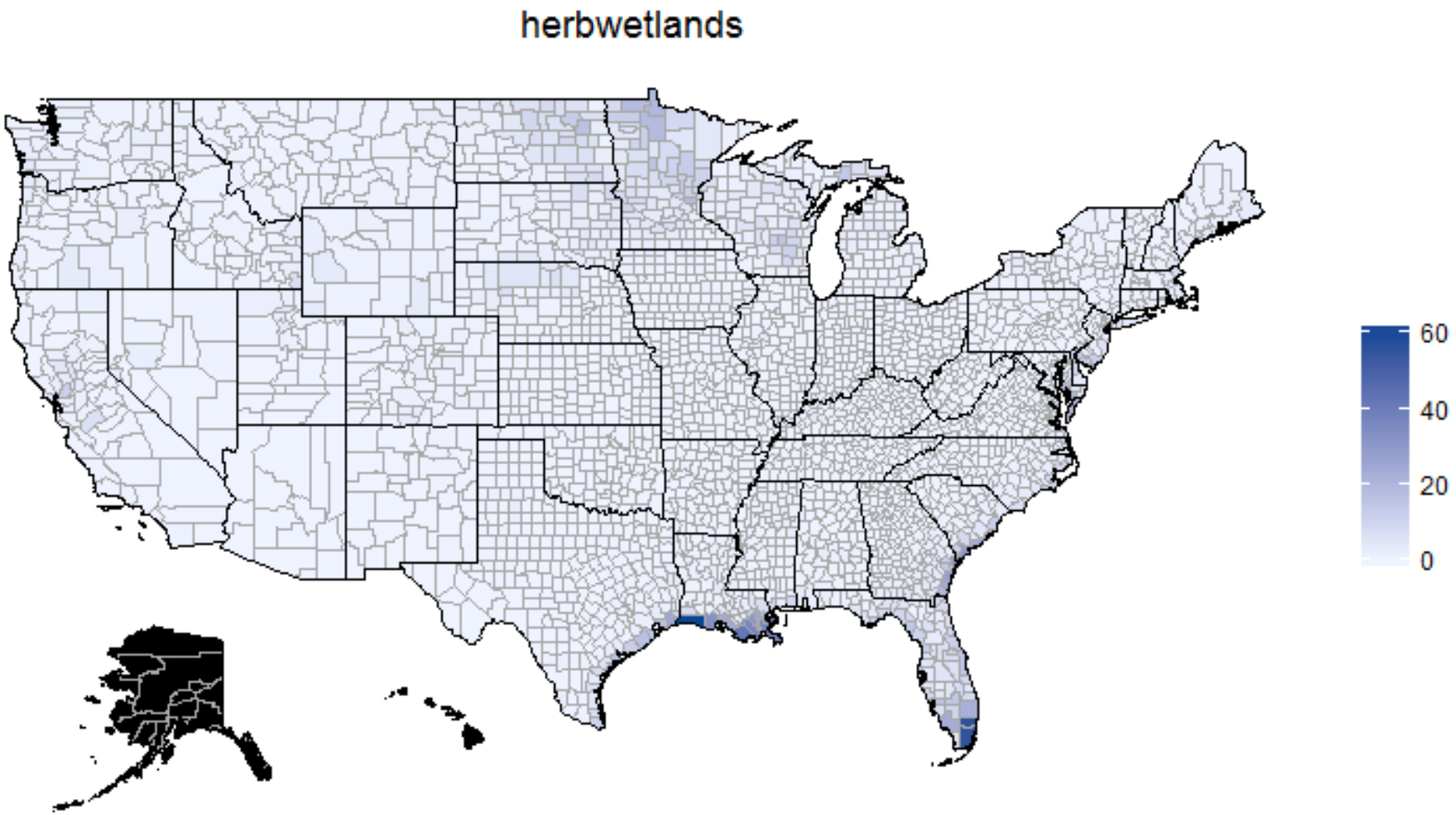
Development High 2003



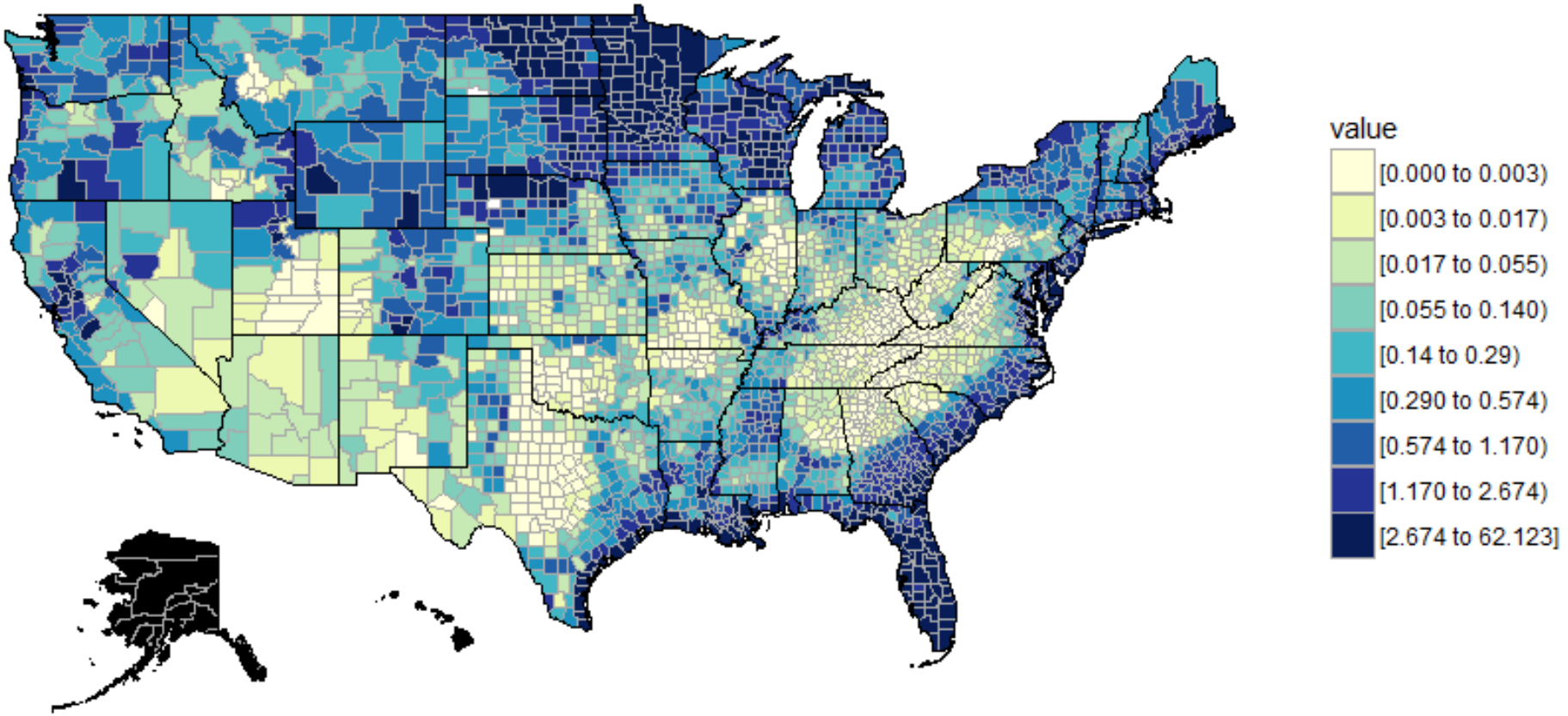

grasslands
75
50
25
0

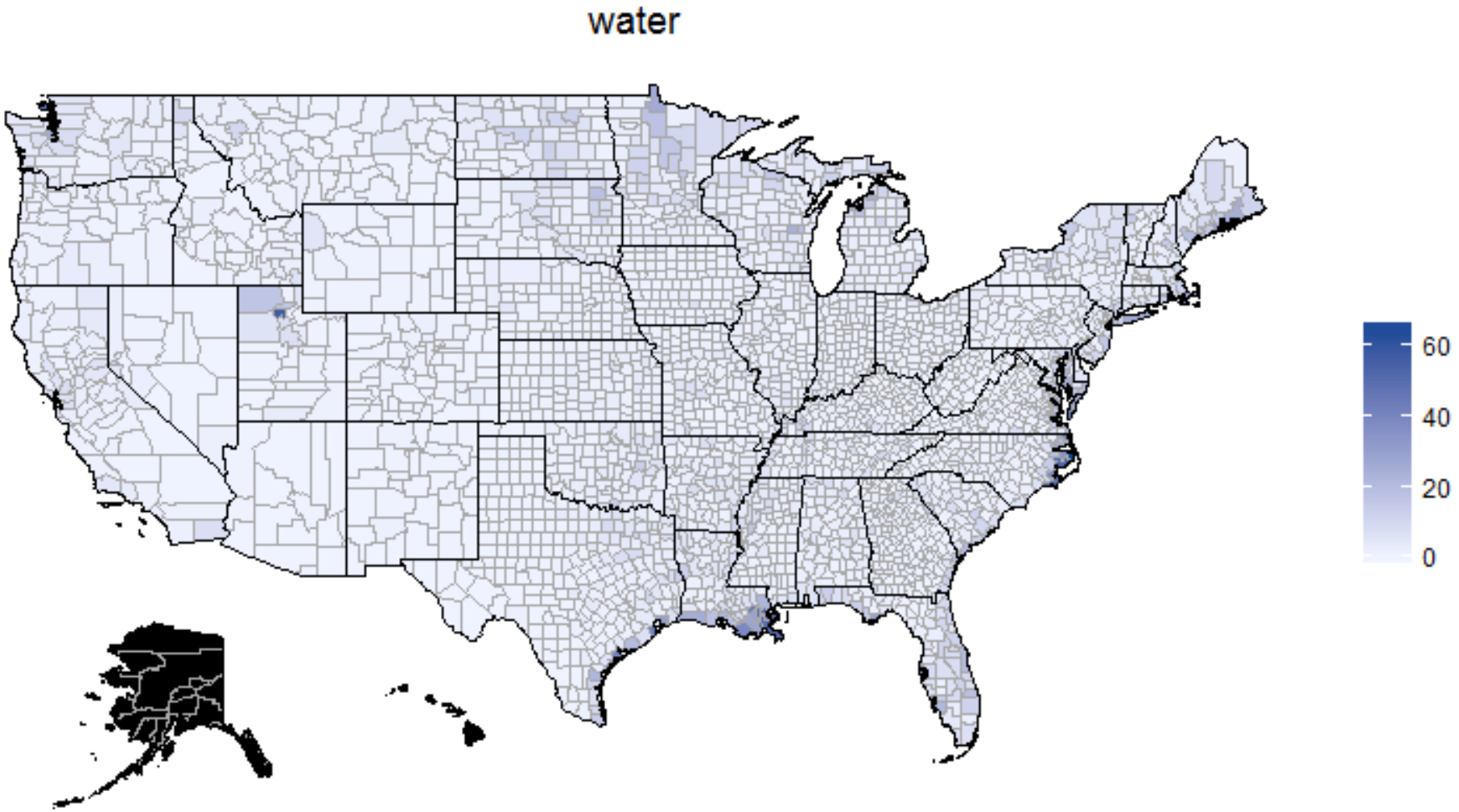

shrubland
75
50
25
0

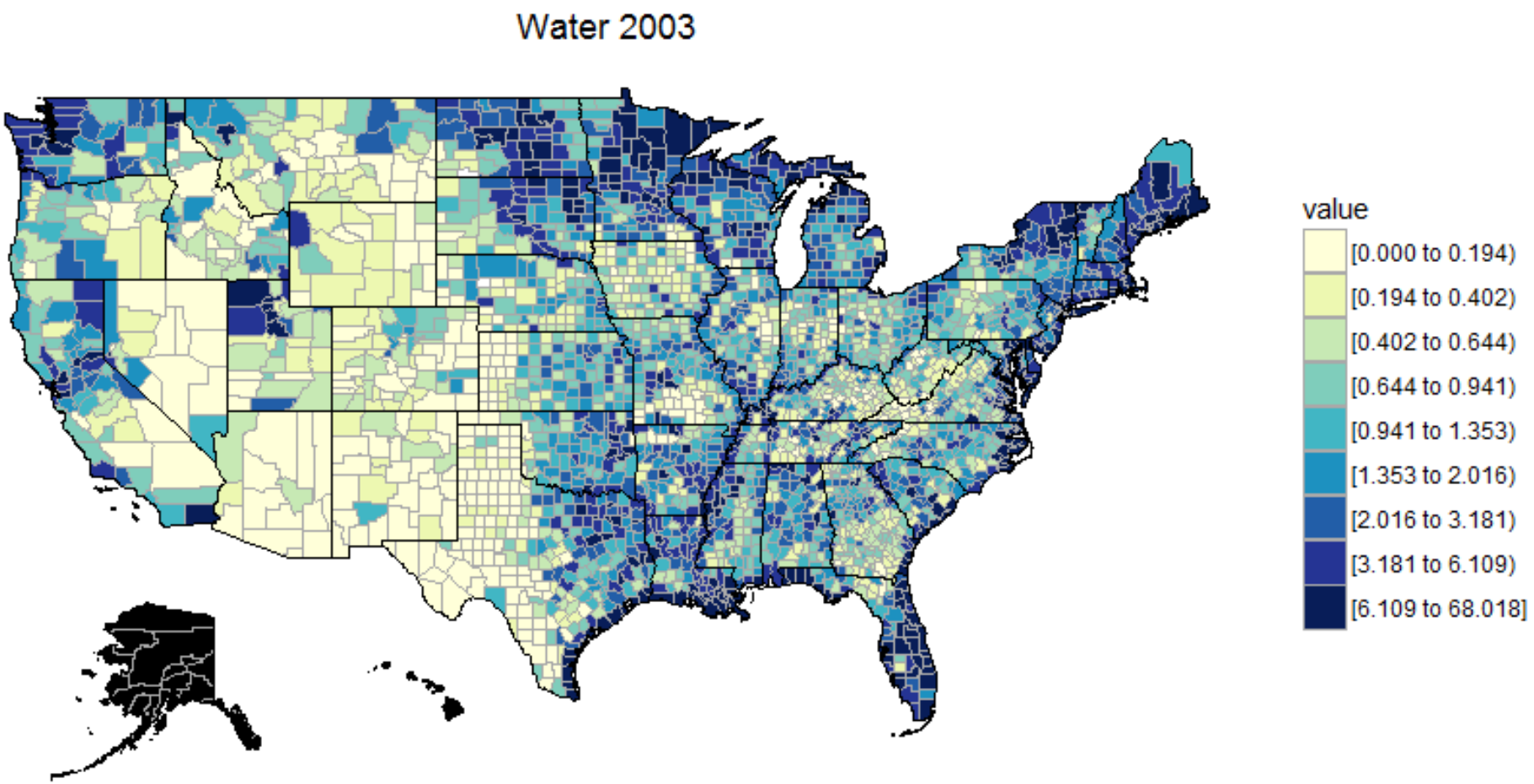

Shrubland 2003
value
[0.000 to 0.002)
[0.002 to 0.039)
[0.039 to 0.202)
[0.202 to 0.665)
[0.665 to 1.530)
[1.530 to 3.944)
[3.944 to 9.795)
[9.795 to 21.154)
[21.154 to 98.656]

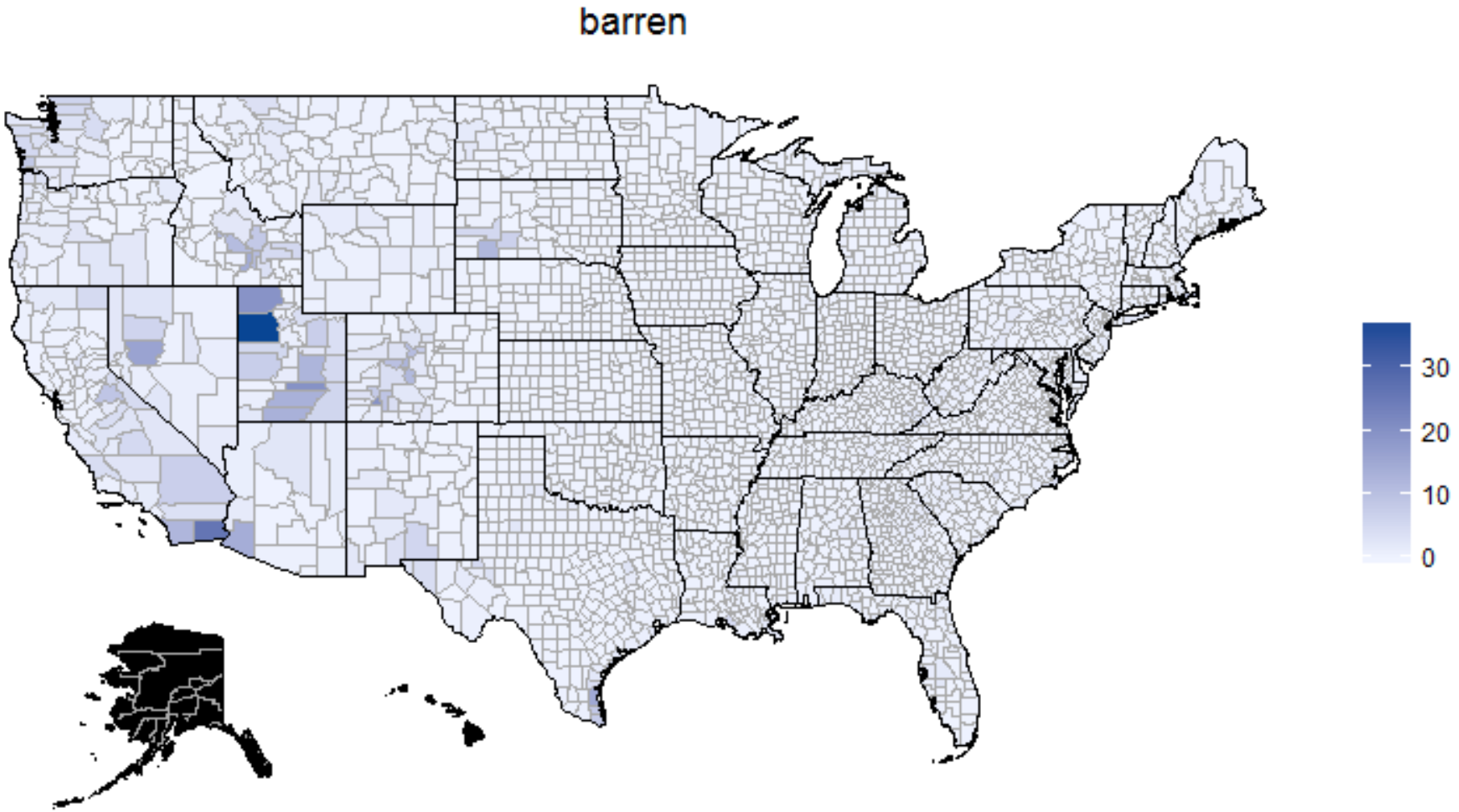

herbwetlands
60
40
20
0

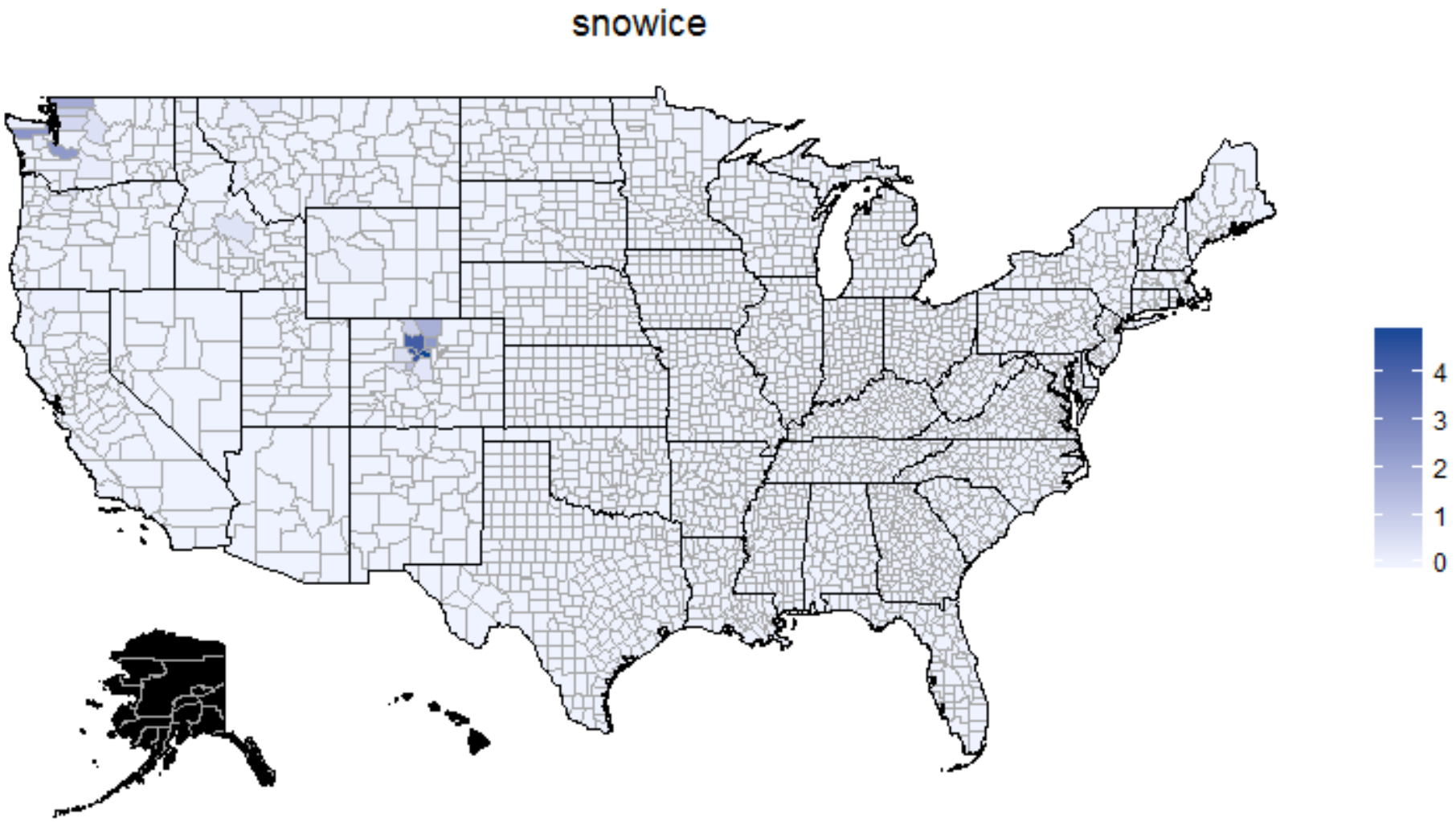
Herbaceous Wetlands 2003




water
60
40
20
0


Water 2003
value
[0.000 to 0.194)
[0.194 to 0.402)
[0.402 to 0.644)
[0.644 to 0.941)
[0.941 to 1.353)
[1.353 to 2.016)
[2.016 to 3.181)
[3.181 to 6.109)
[6.109 to 68.018]


barren
30
20
10
0


snowice
4
3
2
1
0

Experimental Design

19 participants with major depression as determined with the SCID

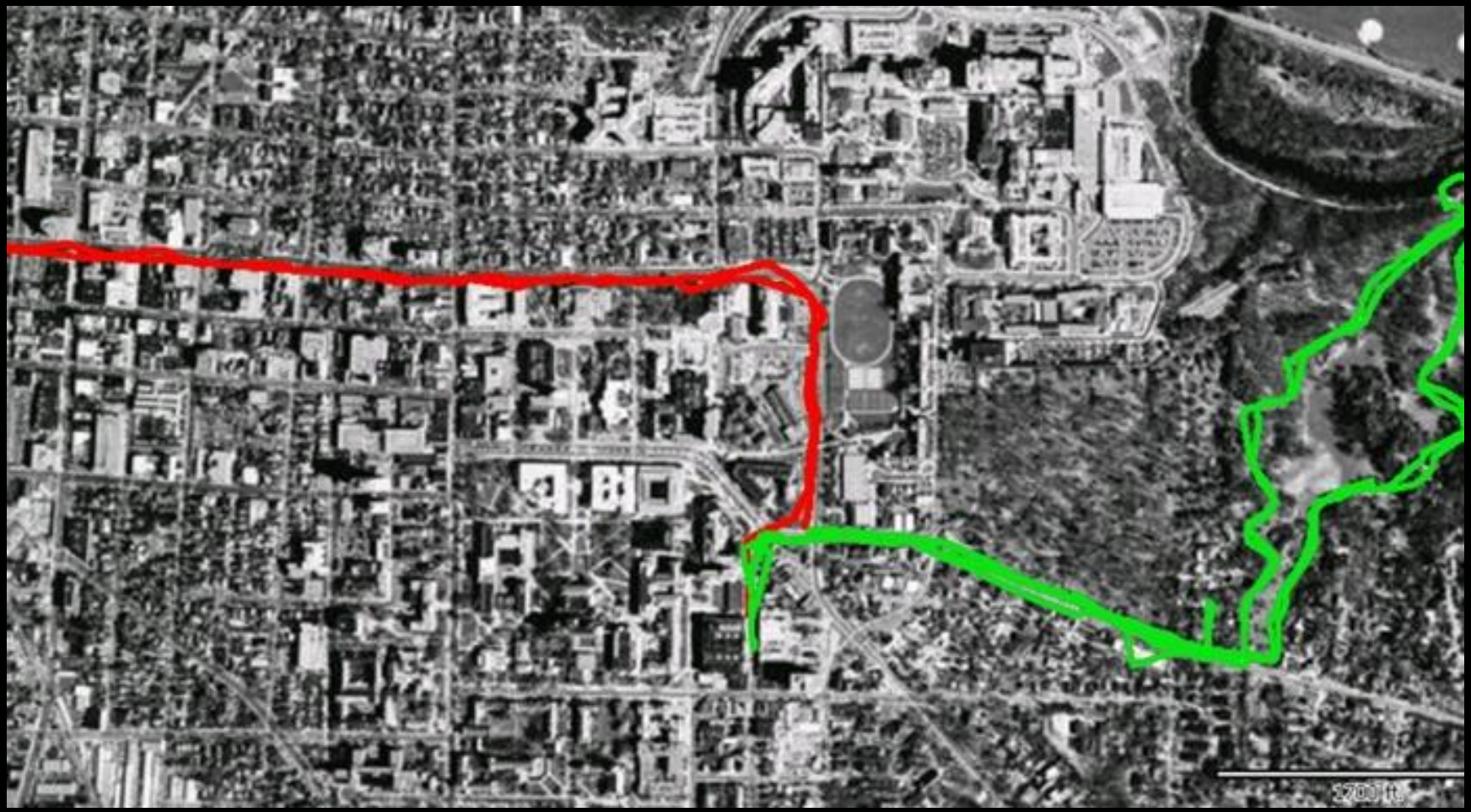
Participants were administered mood and memory measures (Backwards Digit Span; BDS)

Before walking in nature or urban environment participants recalled a negative autobiographical memory

Upon return participants repeated the mood and memory measures

A week later participants returned to the lab and repeated the procedure, but walked in the other environment

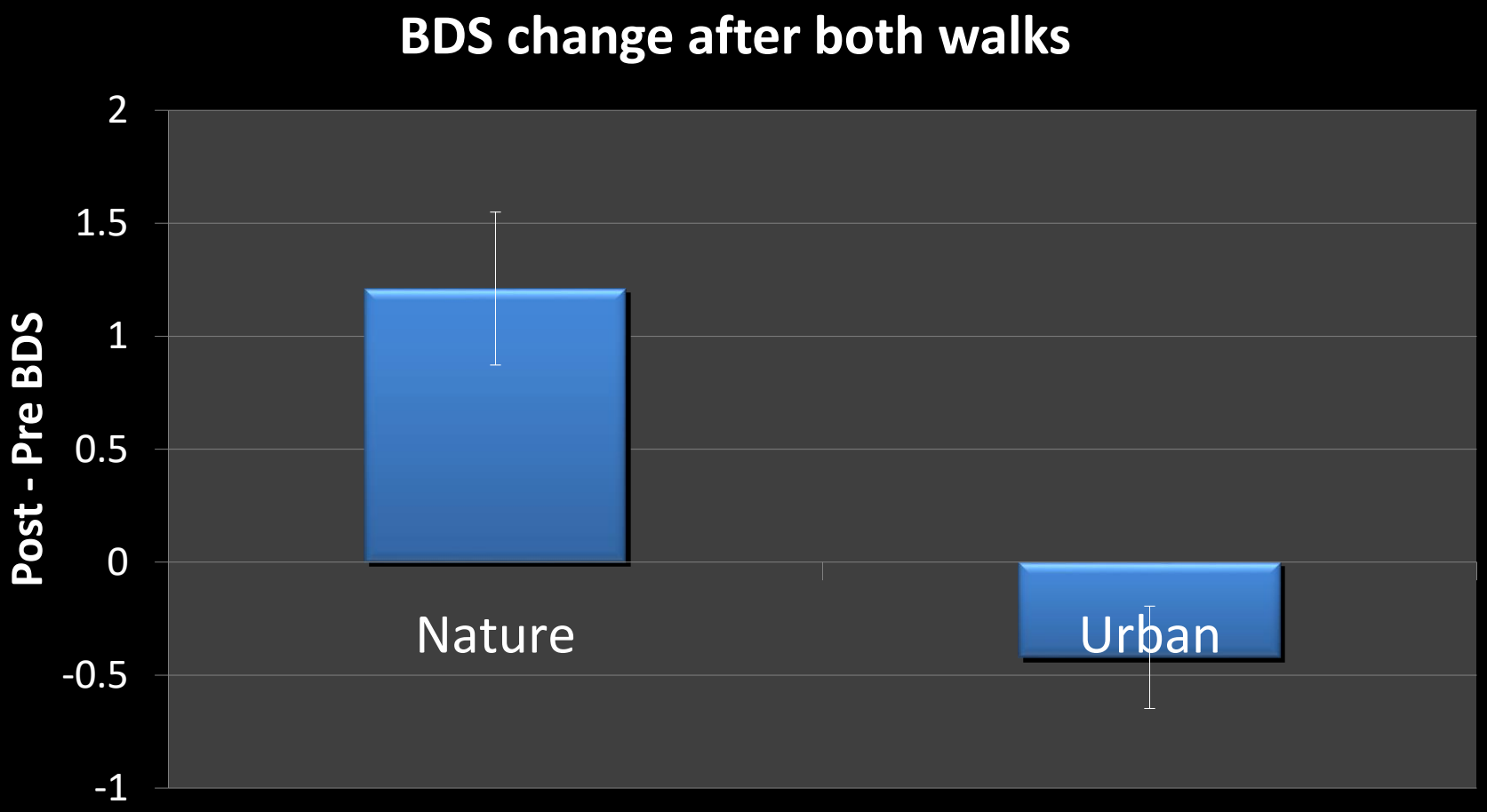
Nature and MDD



Berman, Jonides and Kaplan (2008) Psychological Science
Berman et al., (2012) Journal of Affective Disorders

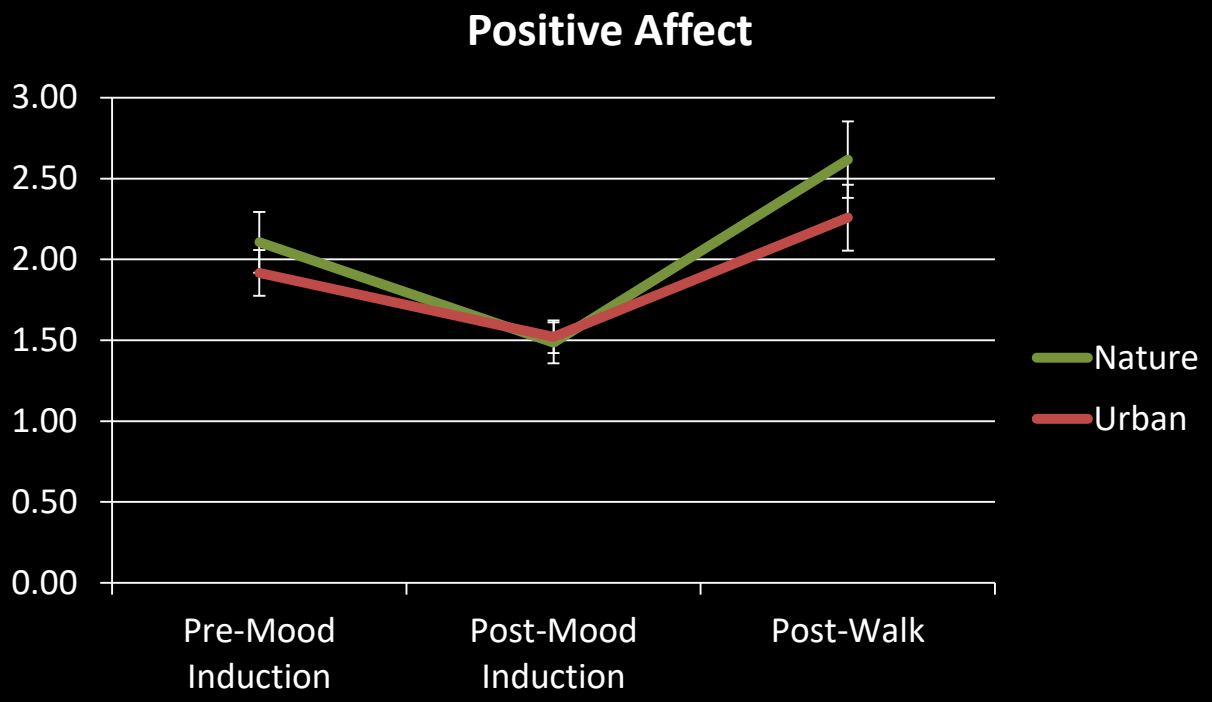
BDS Results

Pre-Post X Nature-Urban interaction significant, F = 20.5, p < .001



Berman et al., (2012) Journal of Affective Disorders

Mood Results



-Significant interaction
$F = 6.62$ $p < .05$

-Driven by post-walk
$t = 2.30$, $p < .05$

-No Pre-walk differences
$t = .393$, n.s.

We find no correlation between changes in mood and memory performance which replicates *Berman et al, 2008 Psych Science*

Berman et al., (2012) Journal of Affective Disorders

Summary of Nature and Depression

Effect sizes were 5 times larger for participants diagnosed with major depression

Again, mood improved, but did not correlate with memory effects