Synthesis of a complete land use/land cover data set for the conterminous United States emphasizing accuracy in area and distribution of agricultural activity

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Department of Geography & Environmental Studies
Northeastern Illinois University

Computation Institute
University of Chicago

M.A. Thesis Defense
July 21, 2011

Outline

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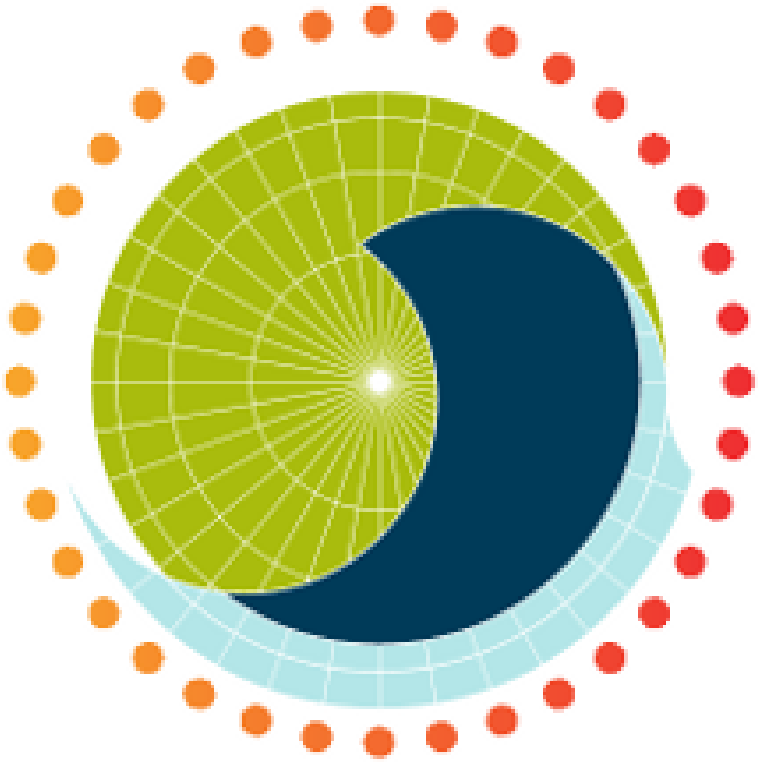

Community
Integrated
Model of
Economic
and
Resource
Trajectories for
Humankind

http://www.cimearth.org/

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Introduction

PEEL model

For forecasting. . .

Partial
Equilibrium
Economic
Land Use

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Introduction

PEEL model

For forecasting. . .

- Land use conversion to/from cropland

Partial
Equilibrium
Economic
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Introduction

PEEL model

Partial
Equilibrium
Economic
Land Use

For forecasting. . .

- Land use conversion to/from cropland
- Choice among locally viable crops for cultivation under profit maximization

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Outline

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Objectives

Data Set Synthesis

Requirements

- 5 arc-minute resolution

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Objectives

Data Set Synthesis

Requirements

- 5 arc-minute resolution
- Sub-pixel analysis

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Objectives

Data Set Synthesis

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- 5 arc-minute resolution
- Sub-pixel analysis
- Global extent (eventually)

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Objectives

Data Set Synthesis

Requirements

- 5 arc-minute resolution
- Sub-pixel analysis
- Global extent (eventually)
- Annual time series (eventually)

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Advantages

- Analysis runs like a program

Objectives

Reproducible Research

Advantages

- Analysis runs like a program
- Final output is a publication-quality PDF

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- Maps, charts, tables updated in place

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- Analysis runs like a program
- Final output is a publication-quality PDF
- Maps, charts, tables updated in place
- Source code under version control

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Advantages

- Analysis runs like a program
- Final output is a publication-quality PDF
- Maps, charts, tables updated in place
- Source code under version control
- Base data subject to review

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Software Tools

LaTeX

- LaTeX (typesetting)

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Software Tools

LaTeX

- LaTeX (typesetting)
- R (analysis)

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Software Tools

LaTeX

- LaTeX (typesetting)
- R (analysis)
- Sweave (preprocessing)

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Software Tools

LaTeX

- LaTeX (typesetting)
- R (analysis)
- Sweave (preprocessing)
- other R add-on packages (raster, ggplot2)

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Outline

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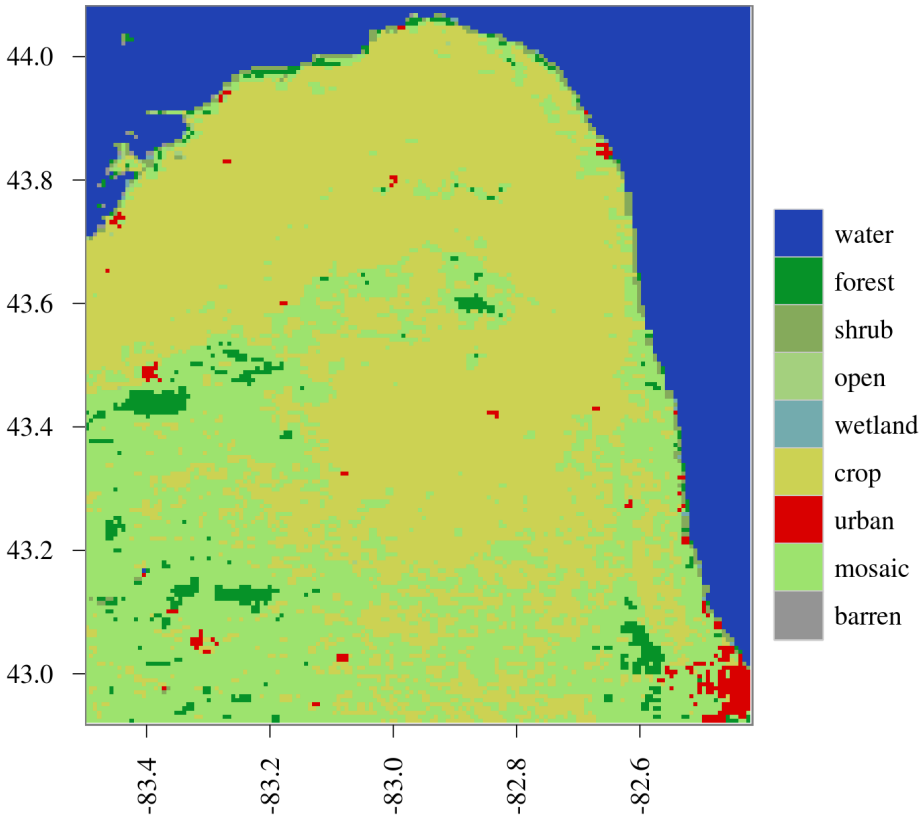
Data Sets

MODIS Land Cover Type (MLCT)



- Resolution: $\sim$500 m (15″)

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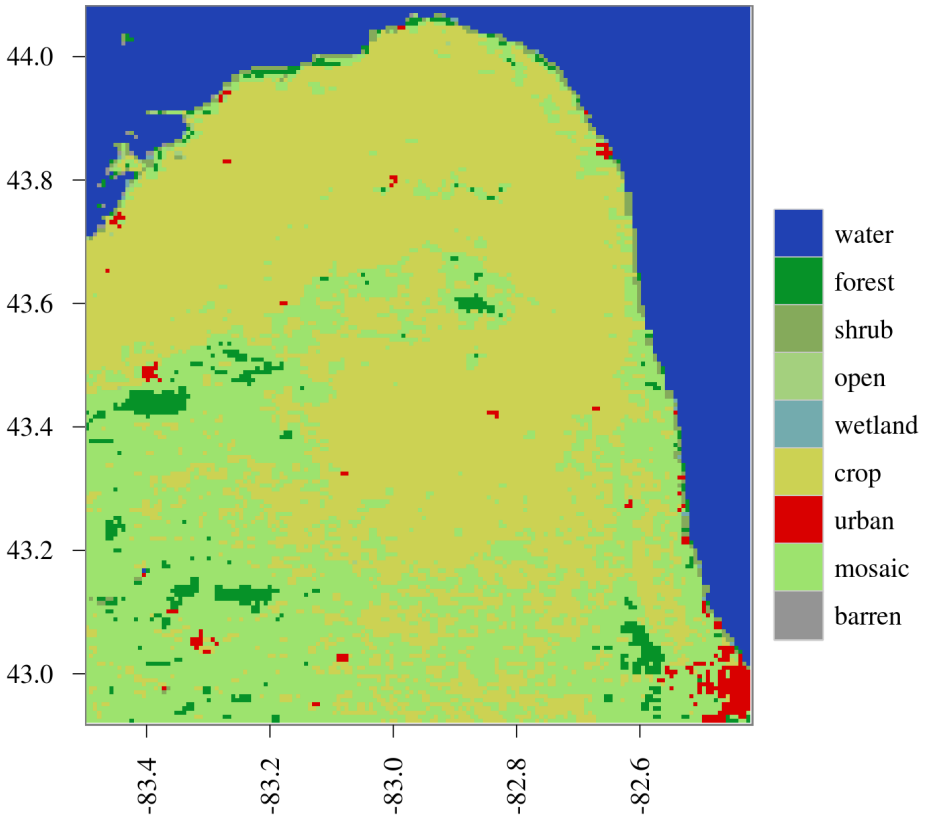

- Resolution: $\sim$500 m ($15''$)
- 17 classes simplified to 9

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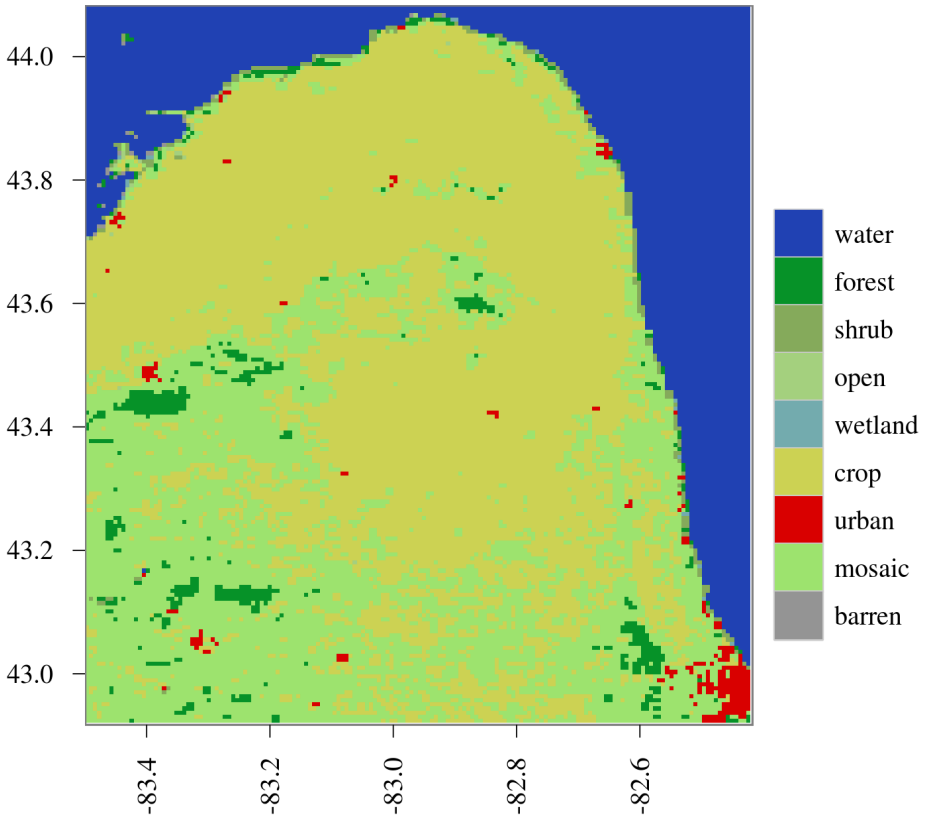
Data Sets

MODIS Land Cover Type (MLCT)



- Resolution: ∼500 m (15″)
- 17 classes simplified to 9
- Mosaic contains 40–60% crop

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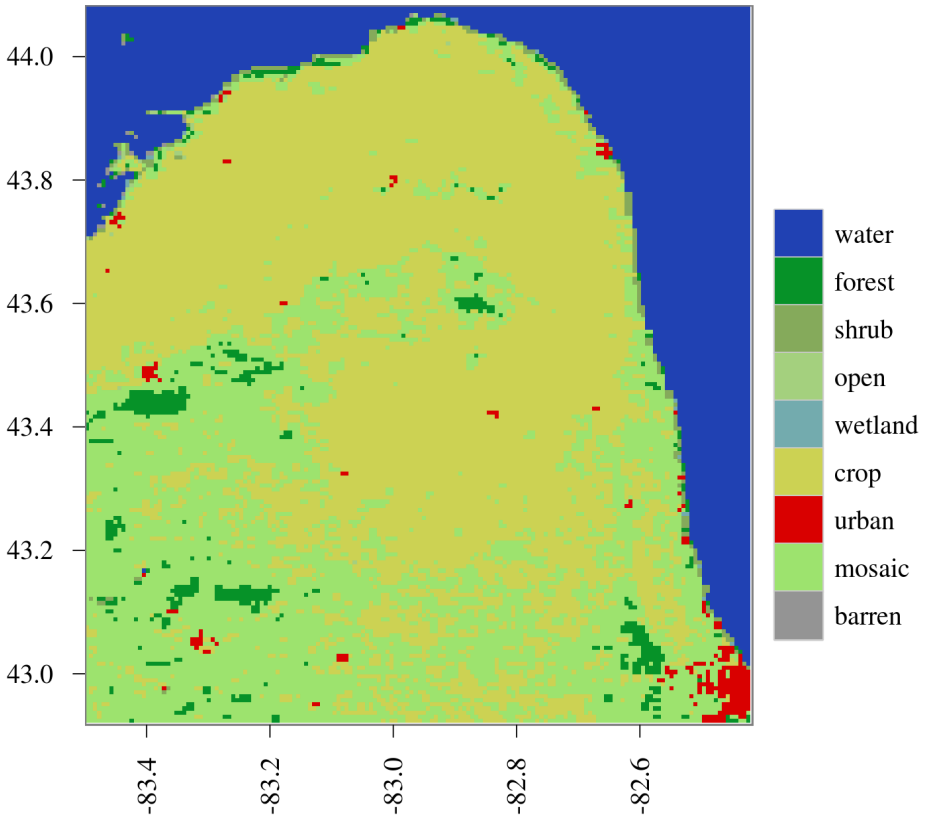
Data Sets

MODIS Land Cover Type (MLCT)



- Resolution: ∼500 m (15″)
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- Annual time series 2001–2008

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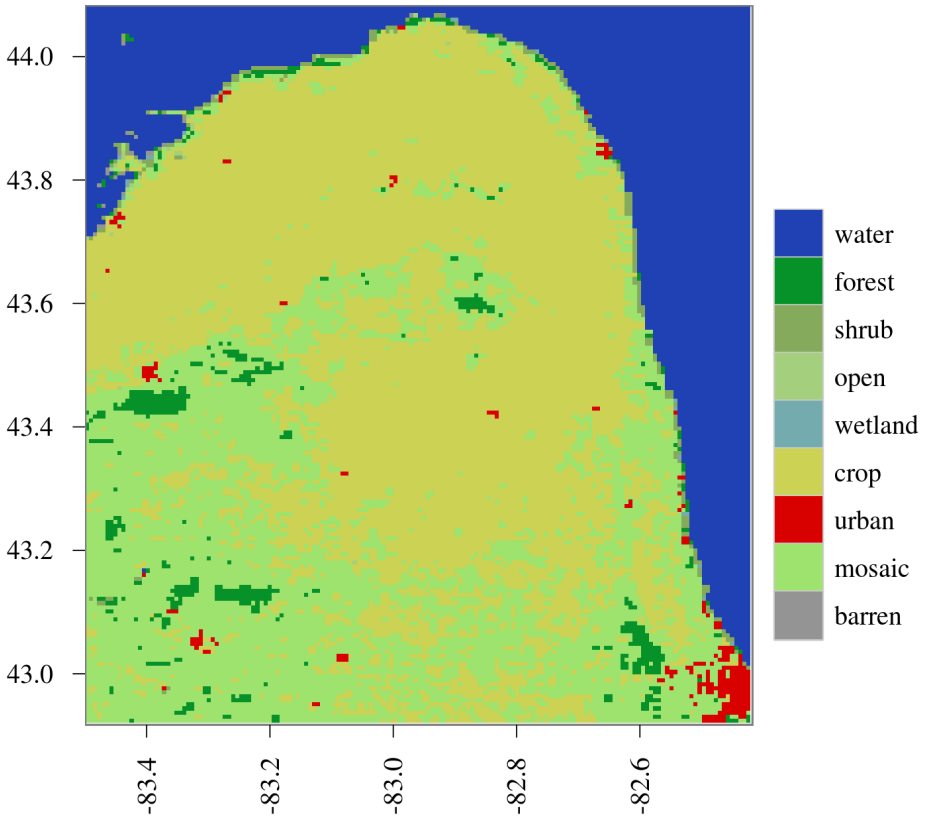
Data Sets

MODIS Land Cover Type (MLCT)



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- Annual time series 2001–2008
- 3 layers

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Data Sets

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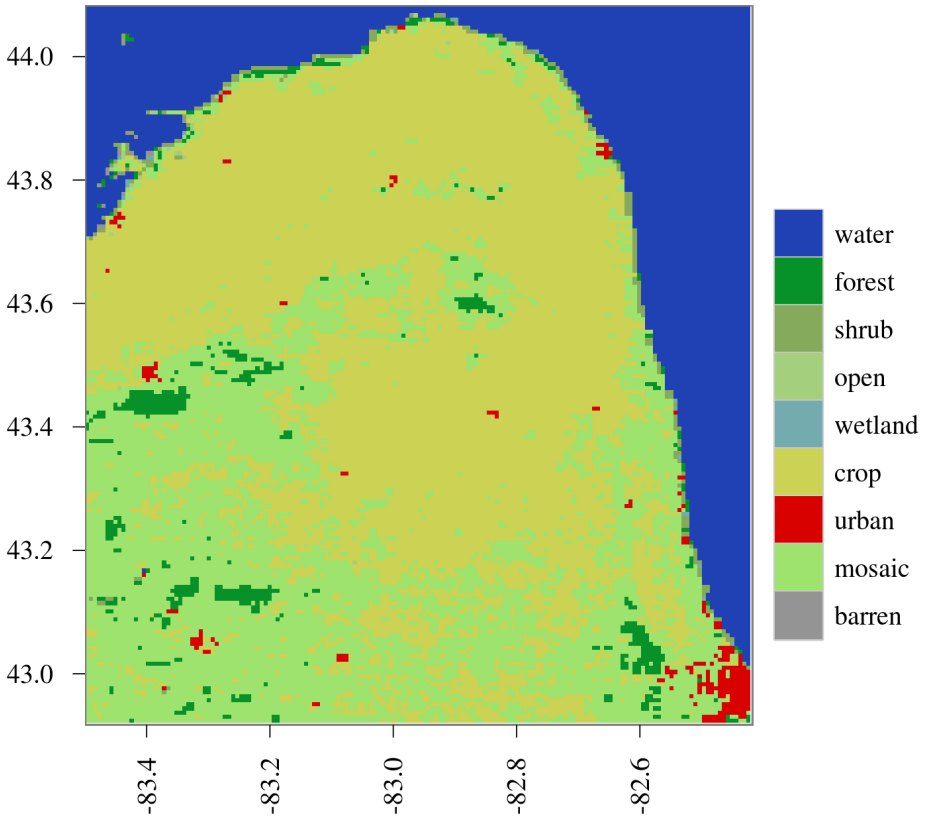

- Resolution: ∼500 m (15″)
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- 3 layers
  - Primary class

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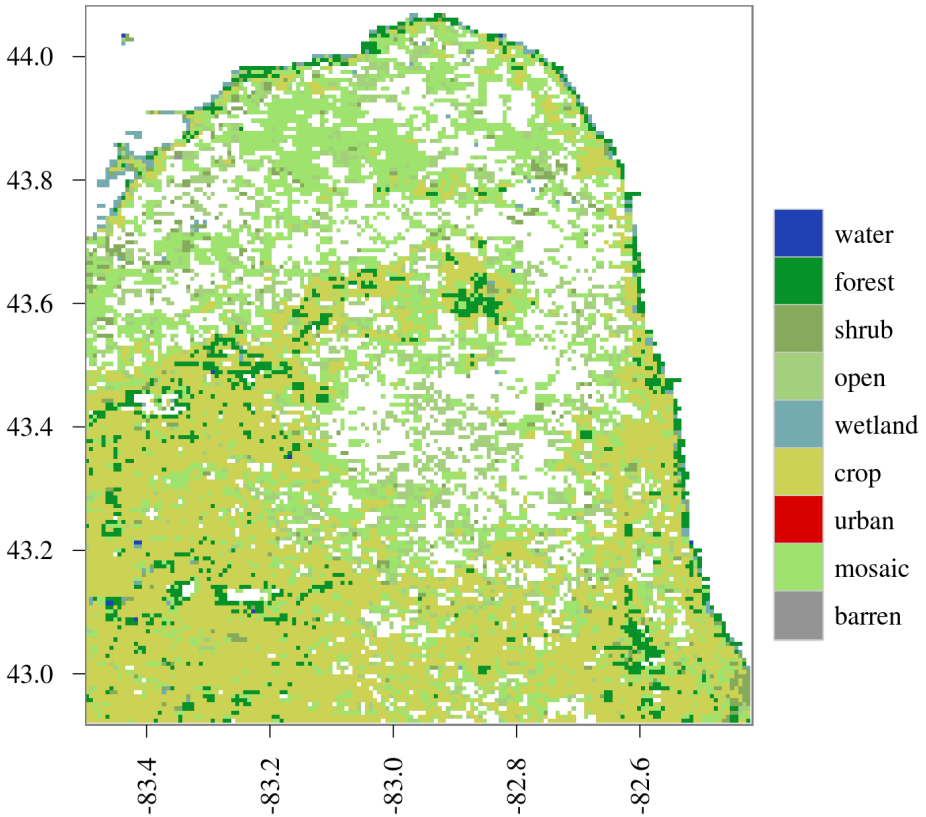
Data Sets

MODIS Land Cover Type (MLCT)



- Resolution: ∼500 m (15″)
- 17 classes simplified to 9
- Mosaic contains 40–60% crop
- Annual time series 2001–2008
- 3 layers
  - Primary class
  - Secondary class

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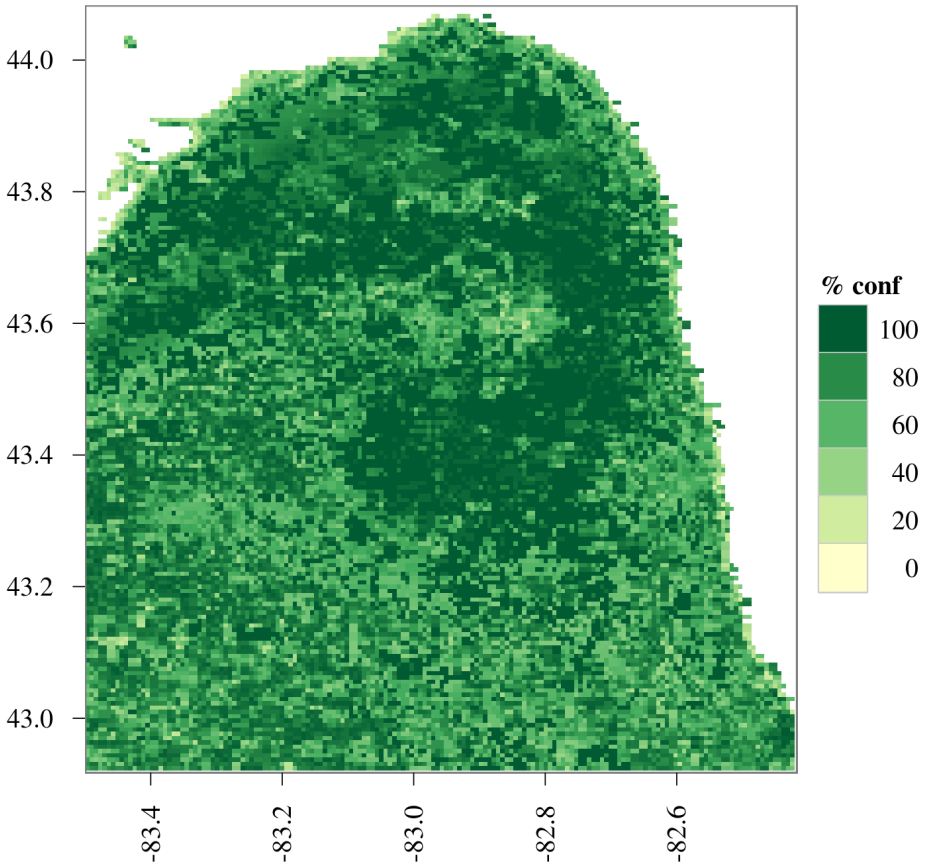
Data Sets

MODIS Land Cover Type (MLCT)



- Resolution: ∼500 m (15″)
- 17 classes simplified to 9
- Mosaic contains 40–60% crop
- Annual time series 2001–2008
- 3 layers
  - Primary class
  - Secondary class
  - Confidence level

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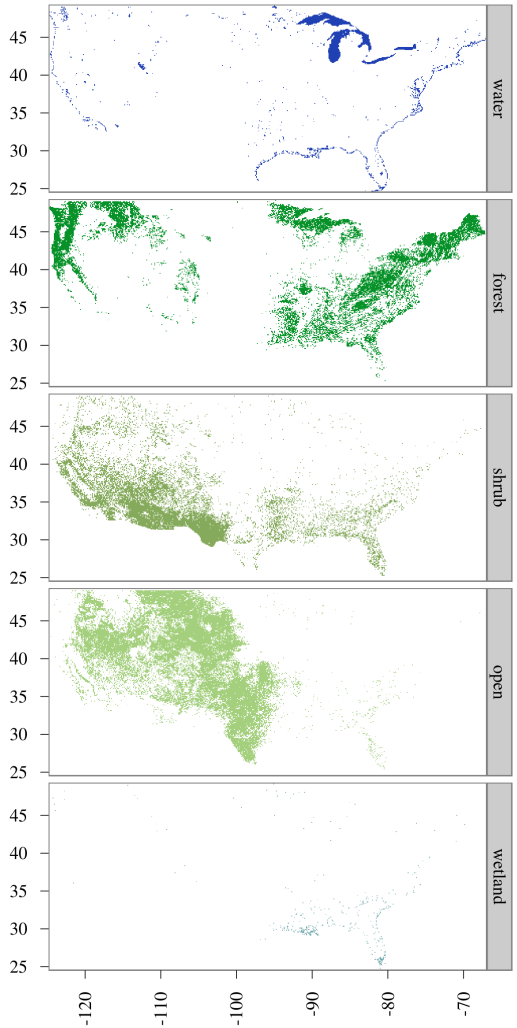
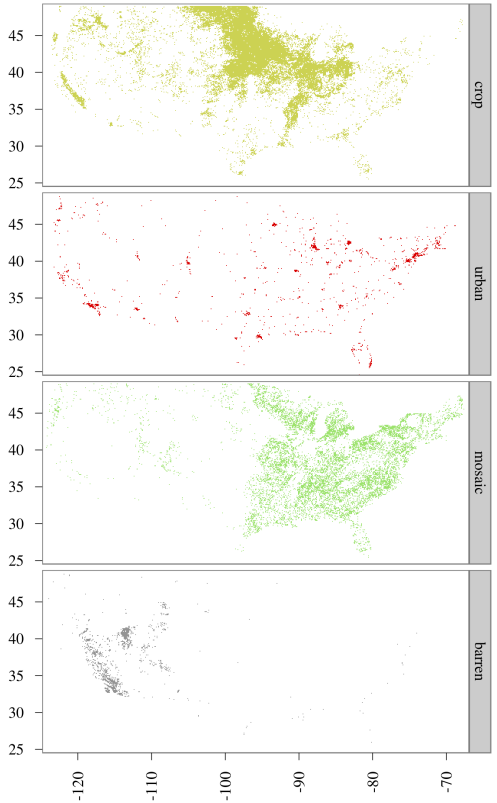
Data Sets

MLCT Primary Class Facet Maps





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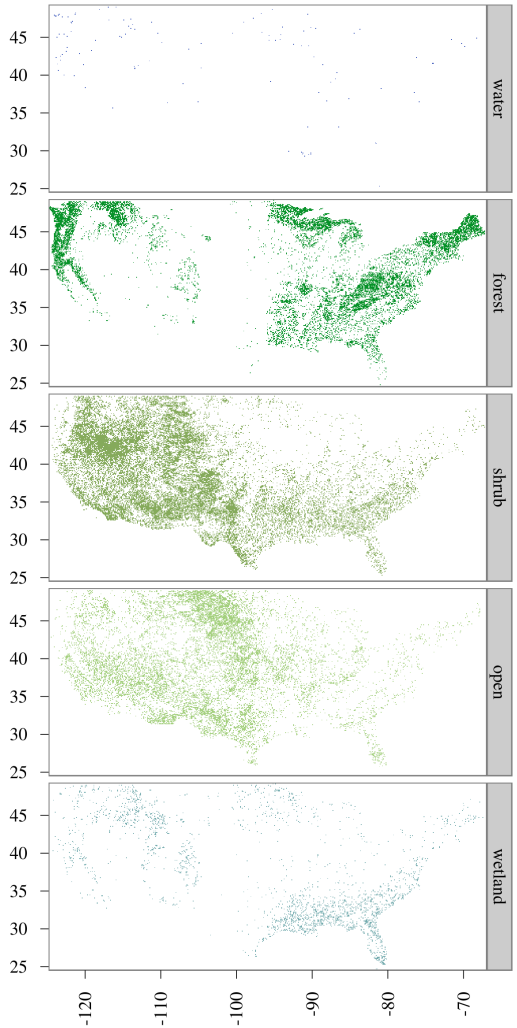
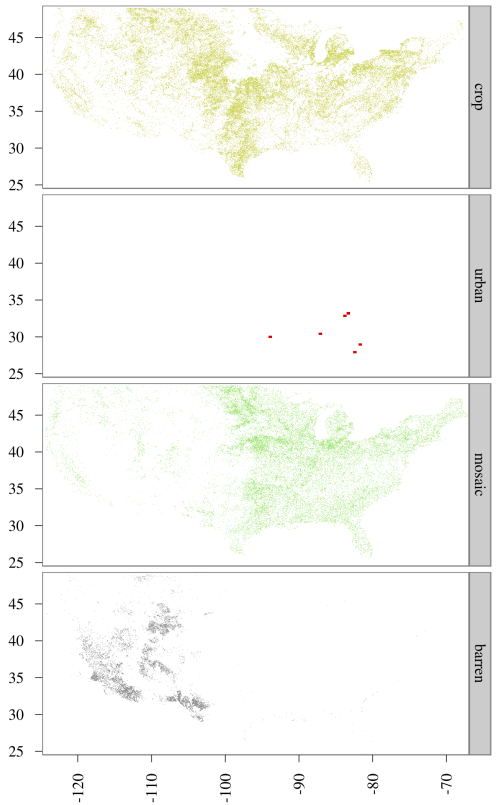
Data Sets

MLCT Secondary Class Facet Maps





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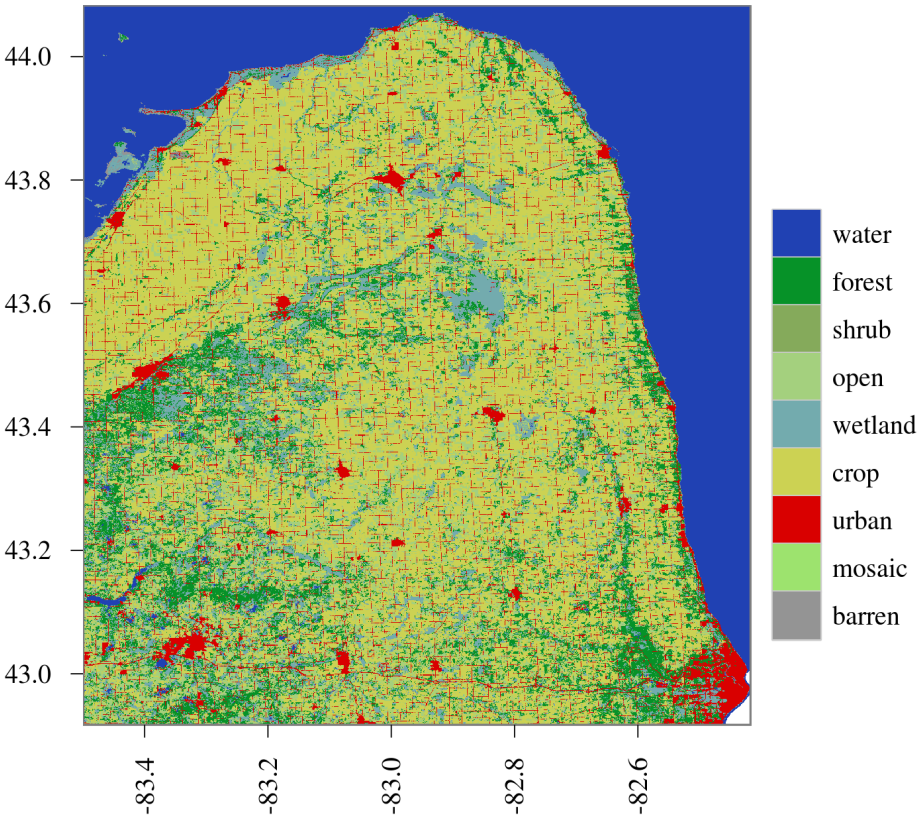
Data Sets

National Land Cover Database (NLCD)



- Resolution: $\sim$30 m (1.25″)

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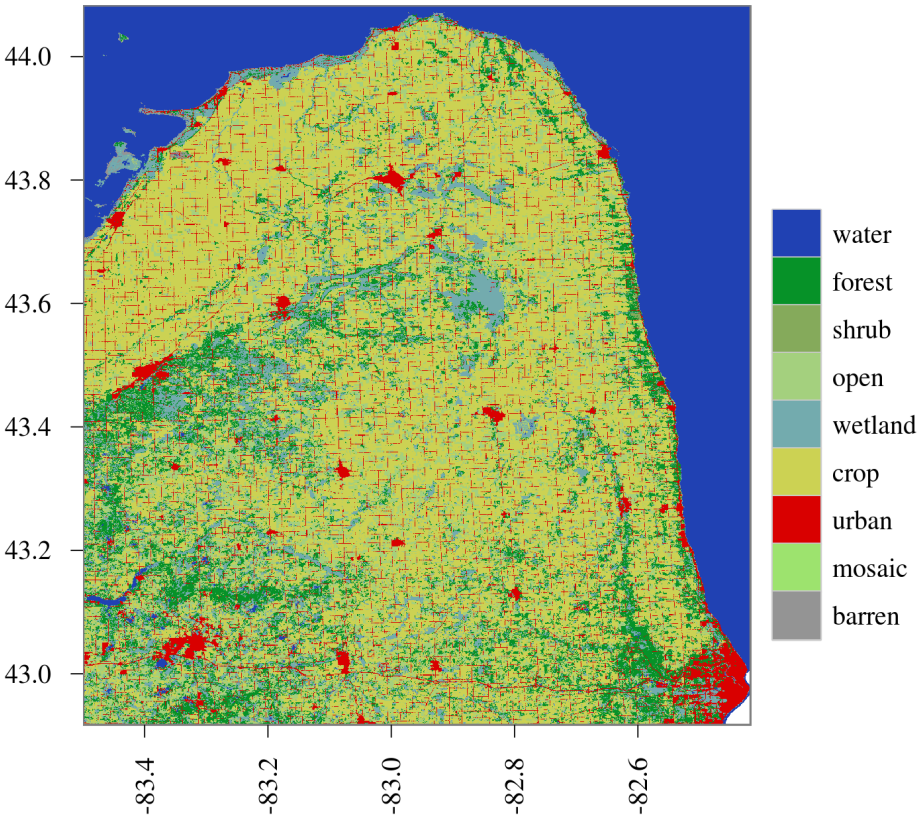
Data Sets

National Land Cover Database (NLCD)



- Resolution: ∼30 m (1.25″)
- Single thematic layer

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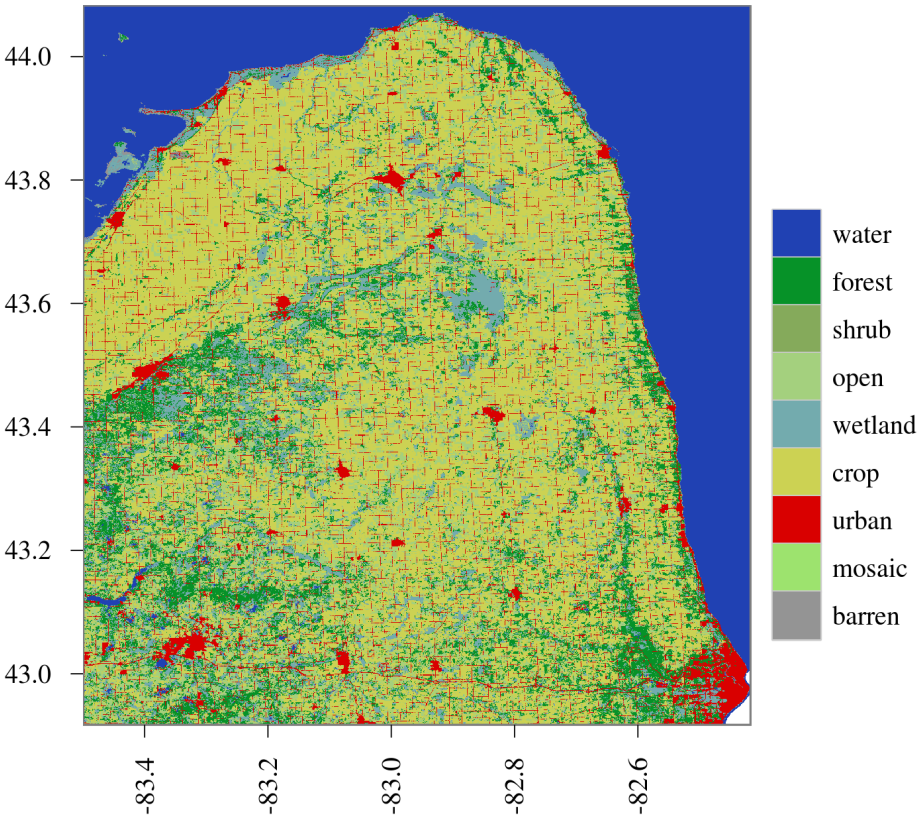
Data Sets

National Land Cover Database (NLCD)



- Resolution: ∼30 m (1.25″)
- Single thematic layer
- 29 classes simplified to 8

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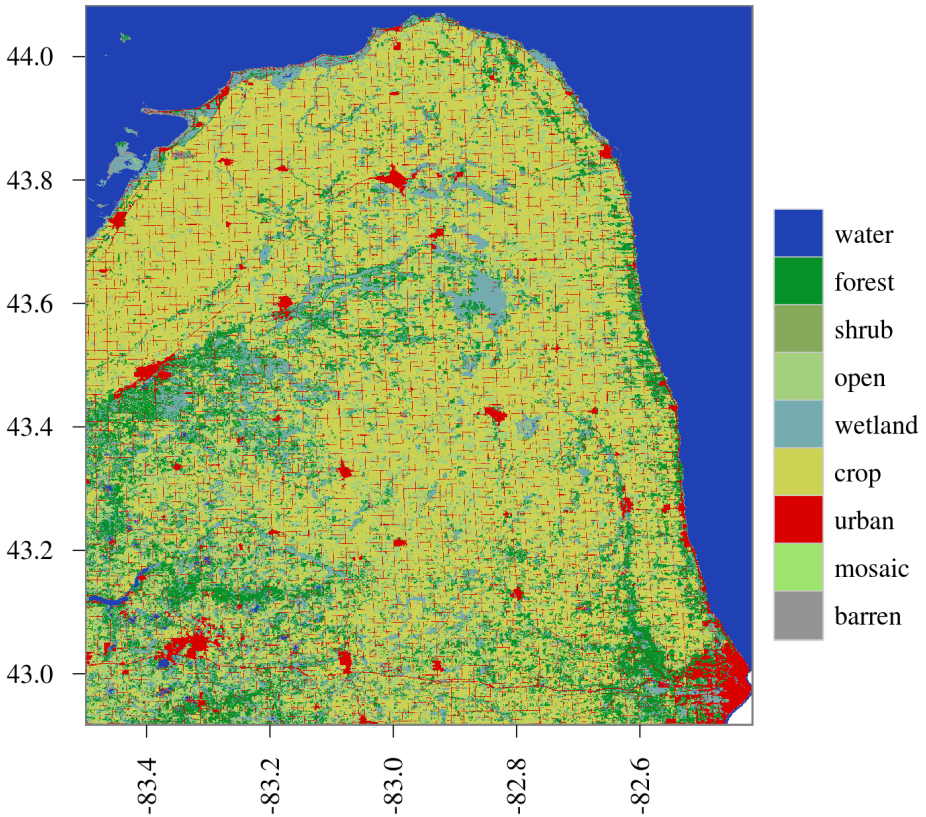
Data Sets

National Land Cover Database (NLCD)



- Resolution: ∼30 m (1.25″)
- Single thematic layer
- 29 classes simplified to 8
- No mosaic class

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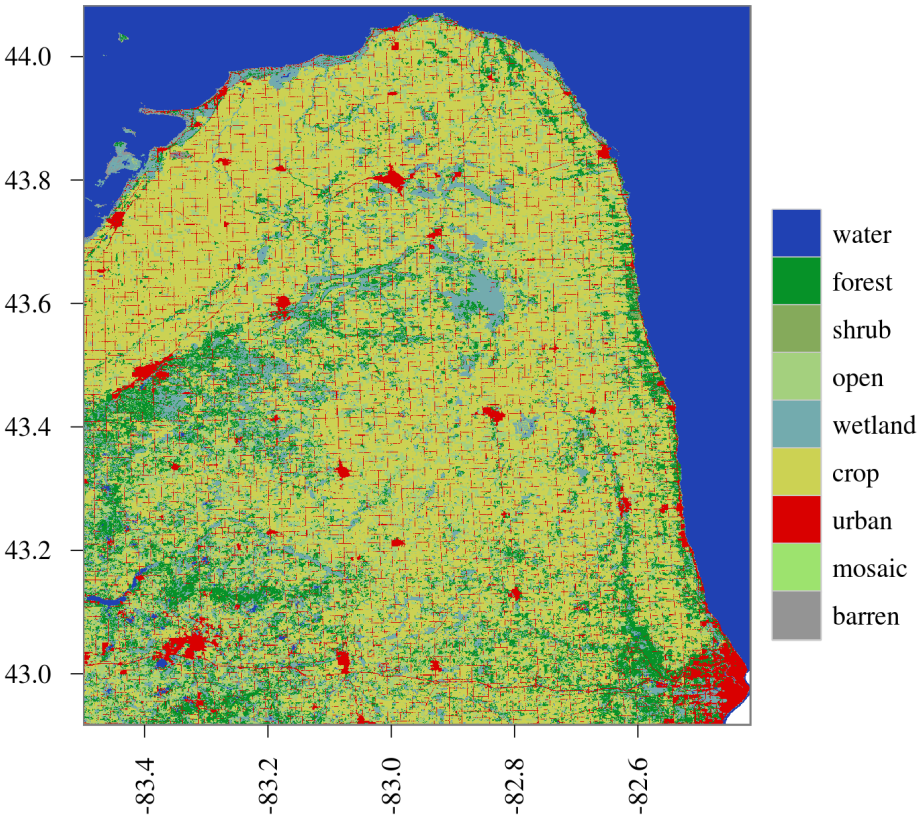
Data Sets

National Land Cover Database (NLCD)



- Resolution: ∼30 m (1.25″)
- Single thematic layer
- 29 classes simplified to 8
- No mosaic class
- 2001 only, USA & PR only

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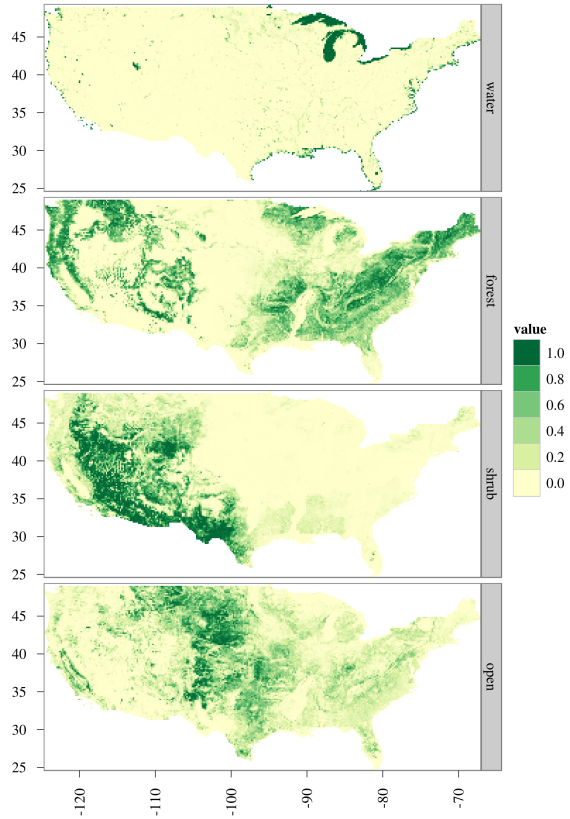
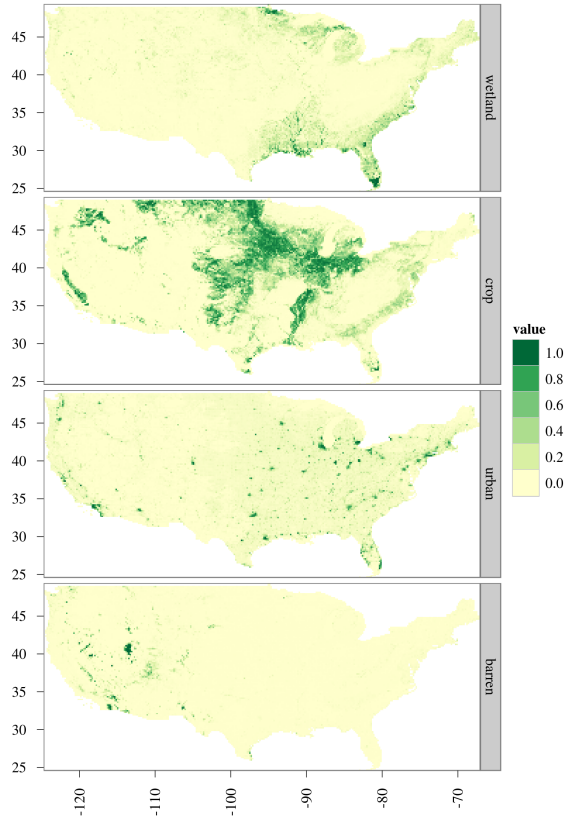
Data Sets

NLCD Aggregated Cover Fractions





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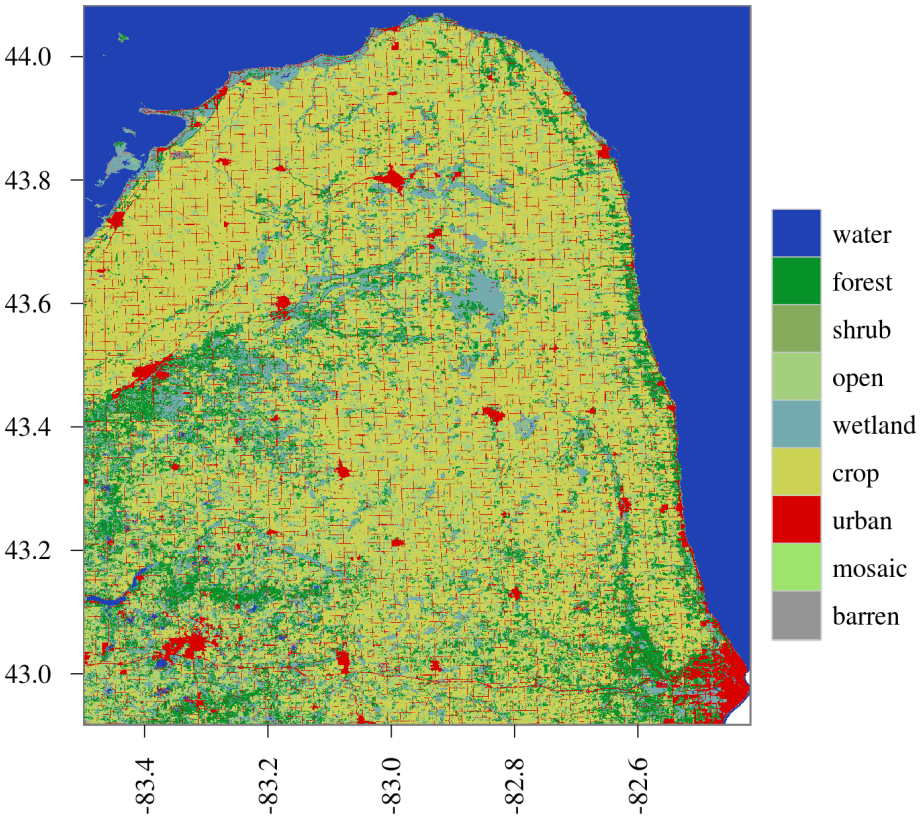
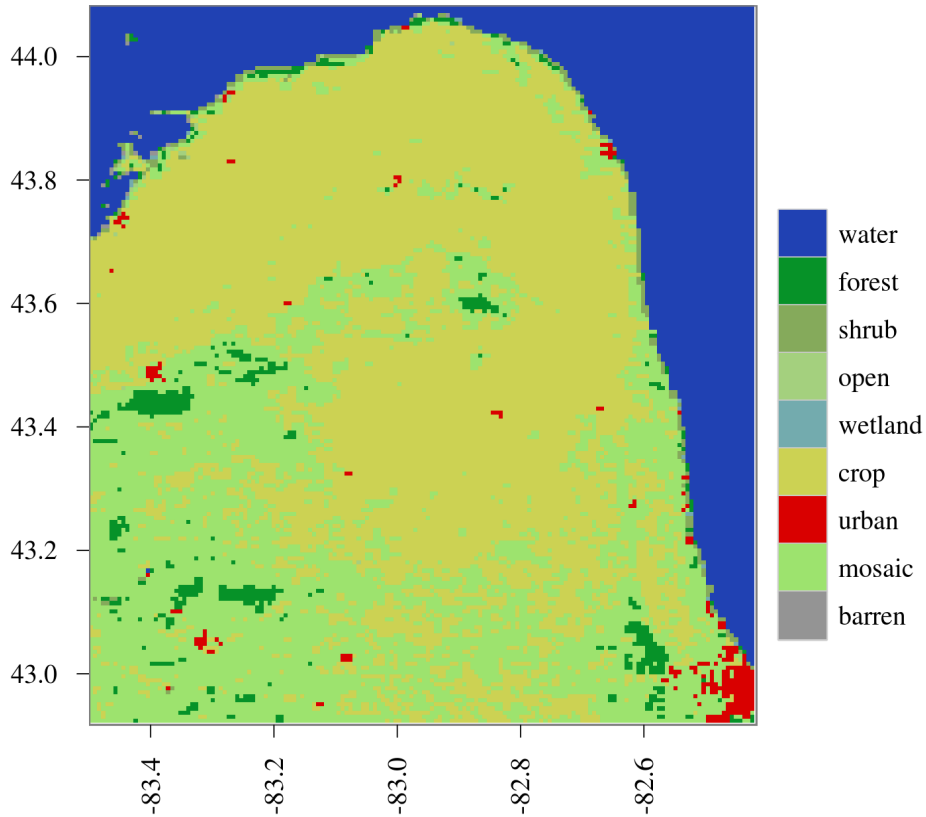
Data Sets

Comparison of MLCT Primary and NLCD





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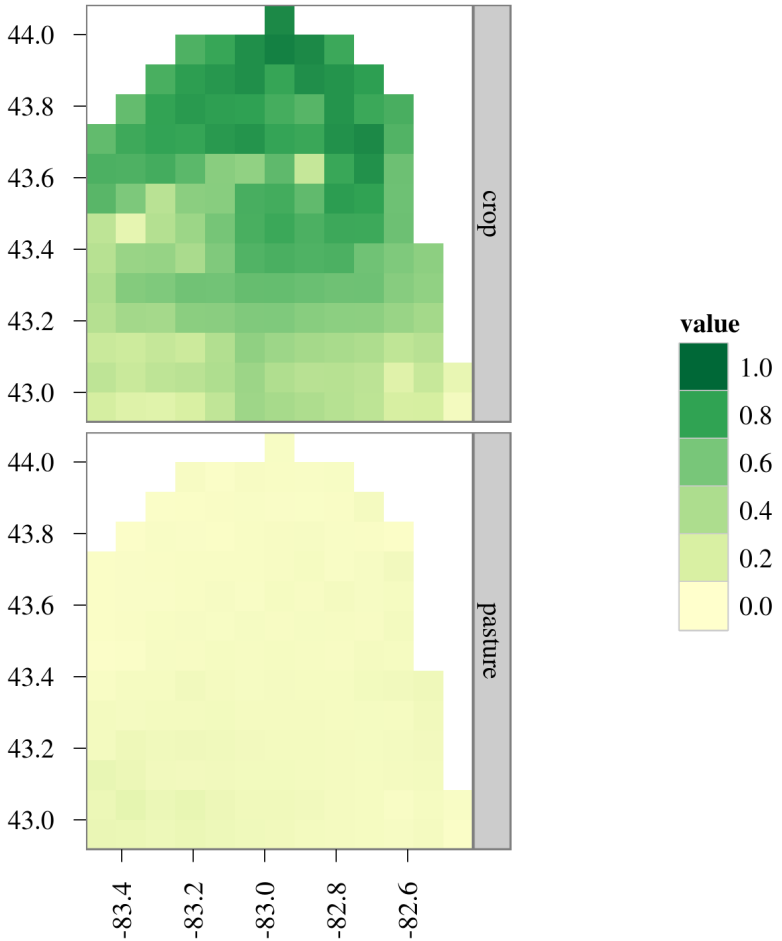
Data Sets

Agland2000 (Ramankutty, et al.; 2008)



- Advantages

Data Sets

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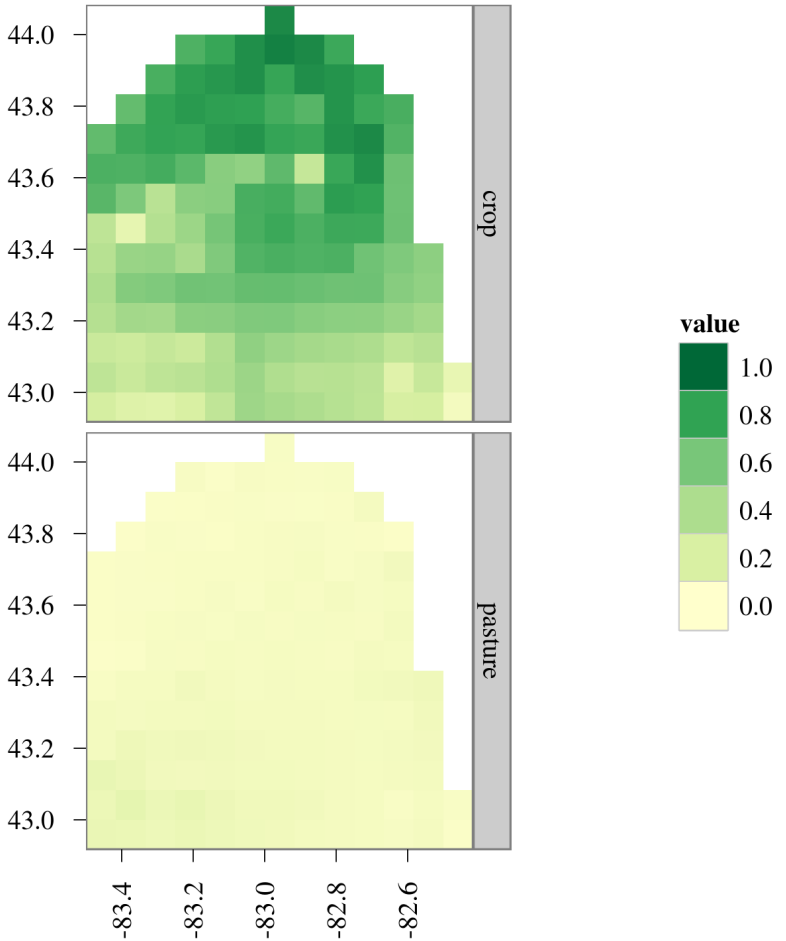

- Advantages
  - Census-based

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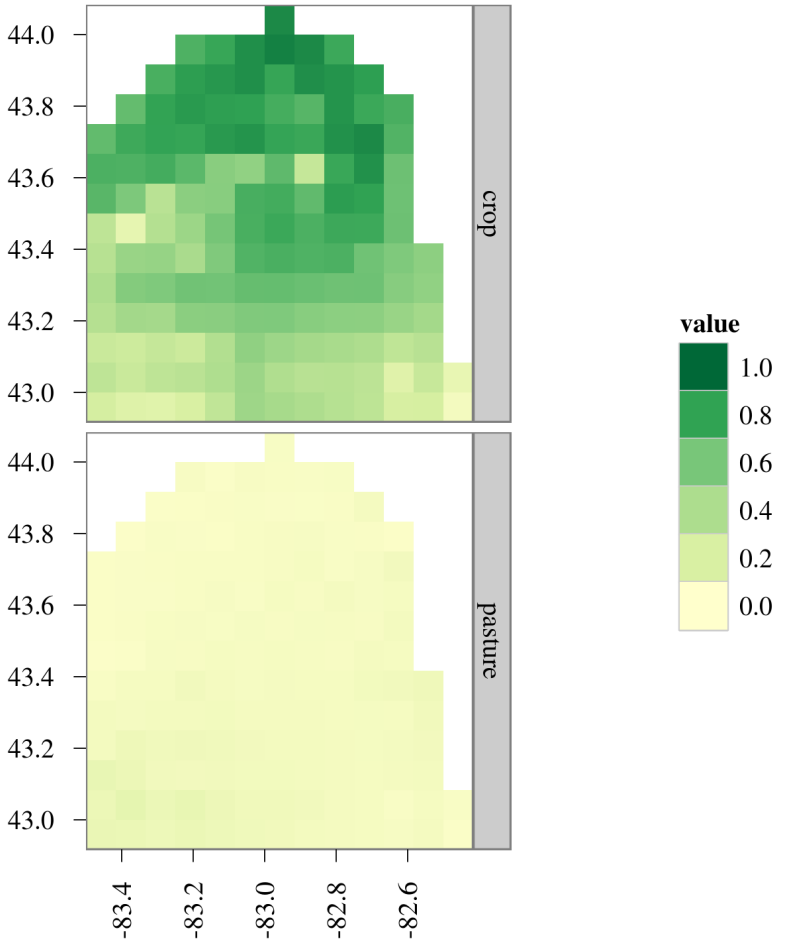

- Advantages
  - Census-based
  - 5′ resolution

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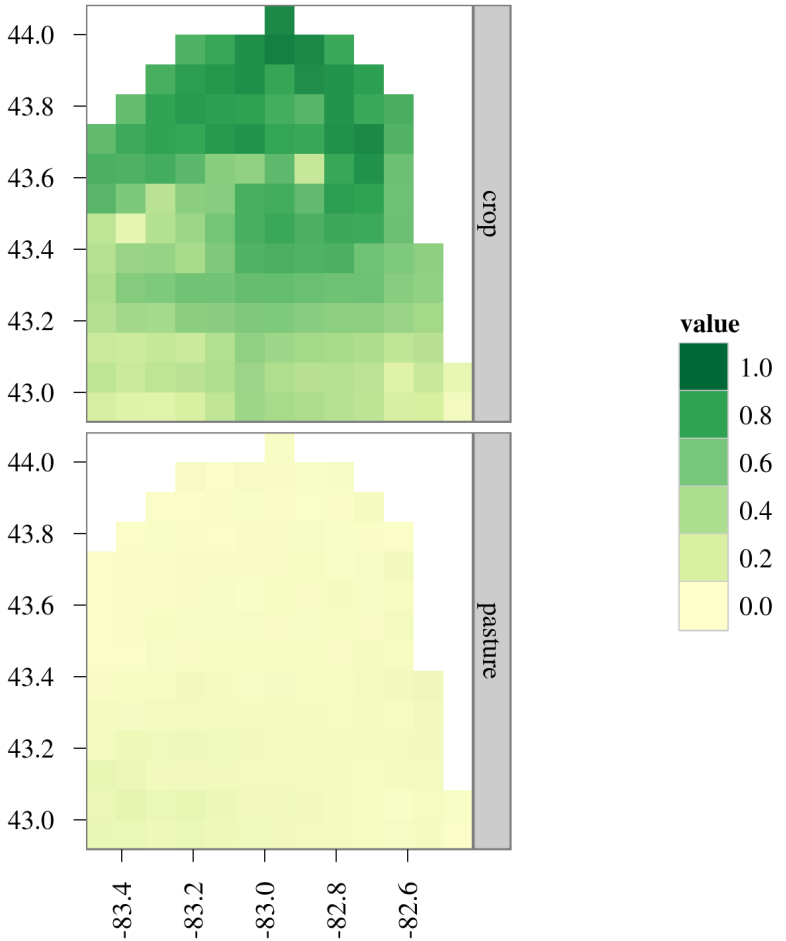

- Advantages
  - Census-based
  - 5′ resolution
  - Global extent

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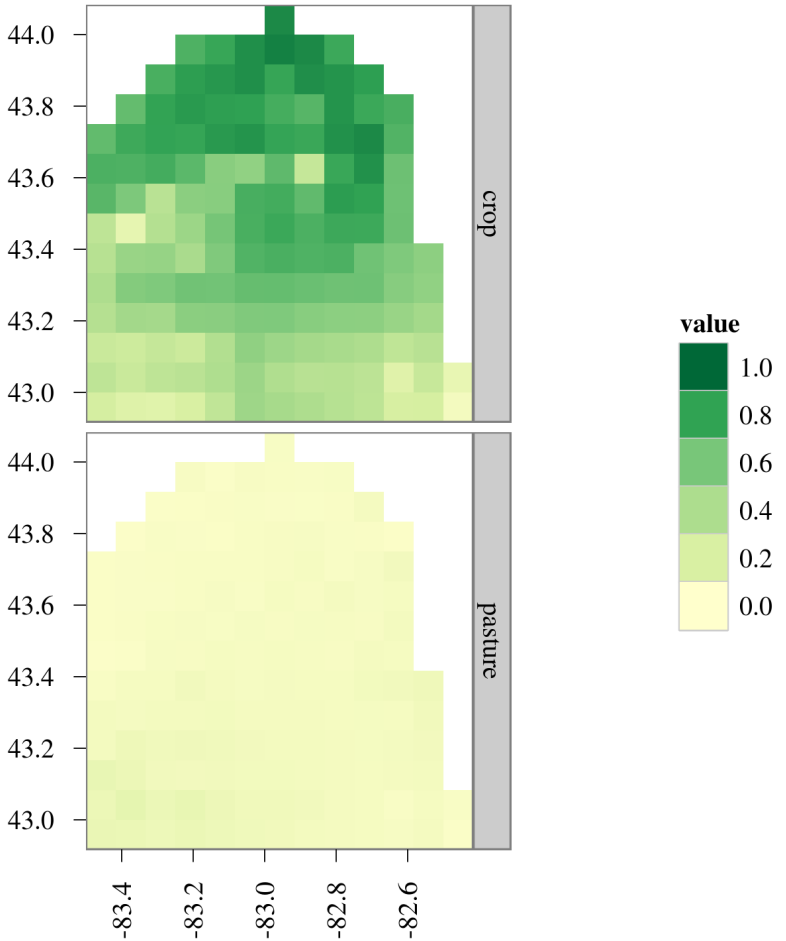

- Advantages
  - Census-based
  - 5′ resolution
  - Global extent
- Challenges

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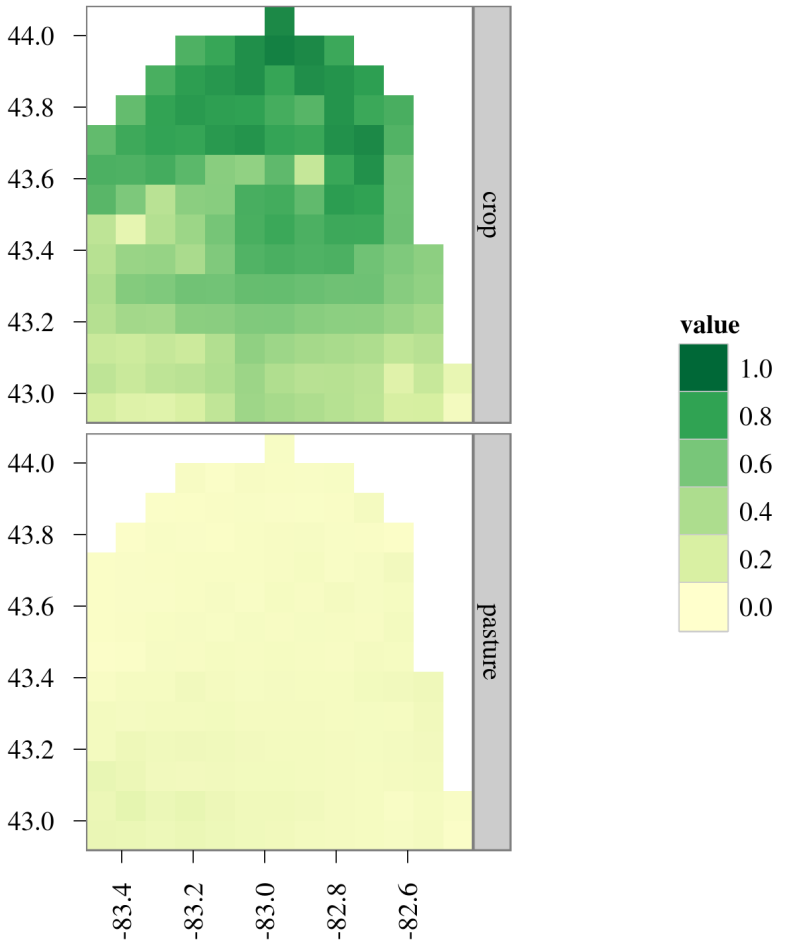

- Advantages
  - Census-based
  - 5′ resolution
  - Global extent
- Challenges
  - Different land mask

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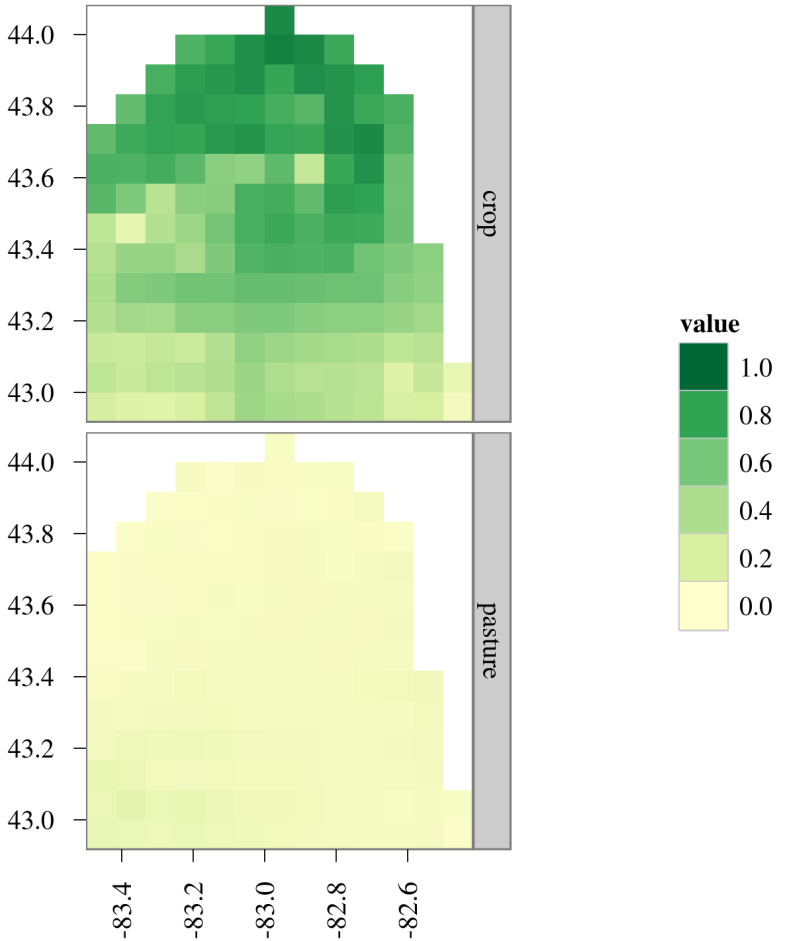

- Advantages
  - Census-based
  - 5′ resolution
  - Global extent
- Challenges
  - Different land mask
  - Be aware of circularity w/MLCT!

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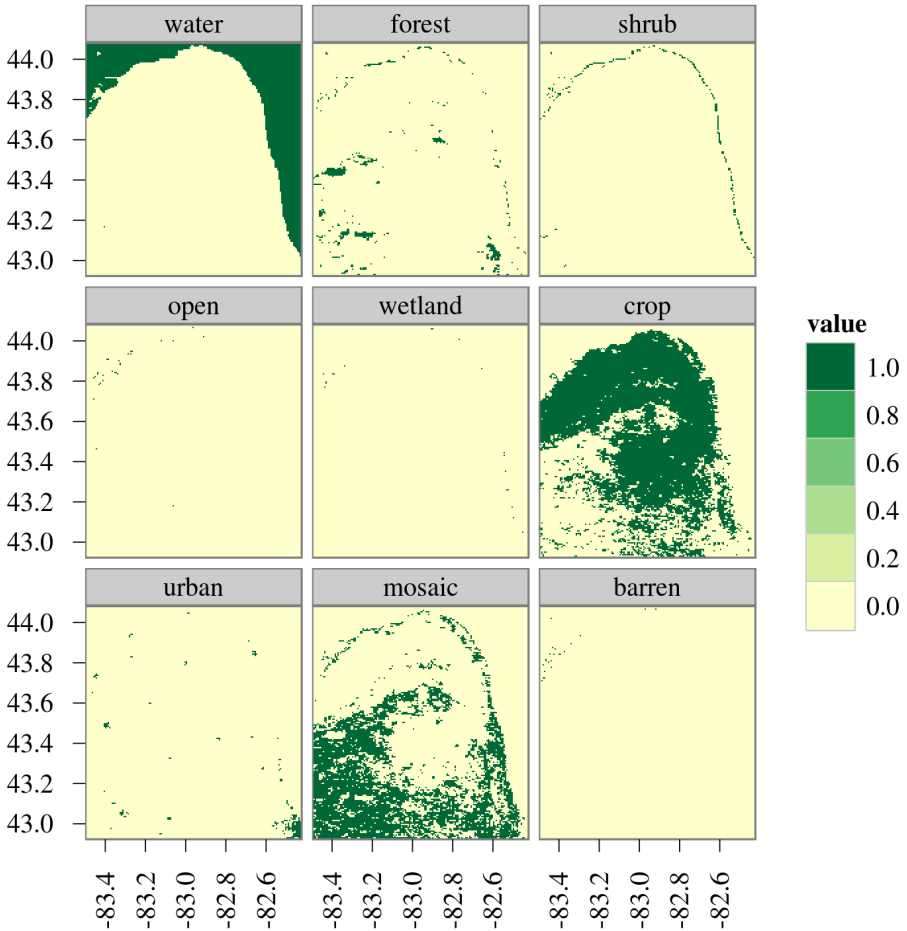
Methodology

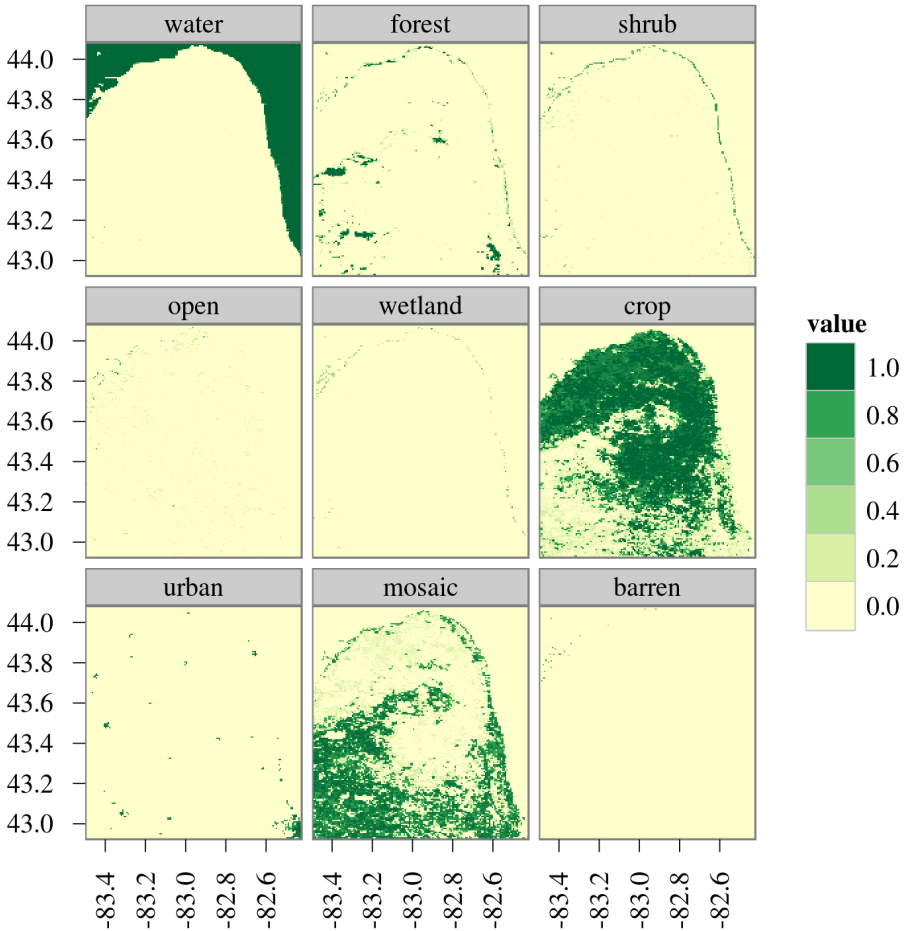
Sub-pixel Areas and Aggregation



Sub-pixel fractions at original resolution for $A_{min} = 1$

Methodology

Sub-pixel Areas and Aggregation



Sub-pixel fractions at original resolution for $A_{min} = 0.5$

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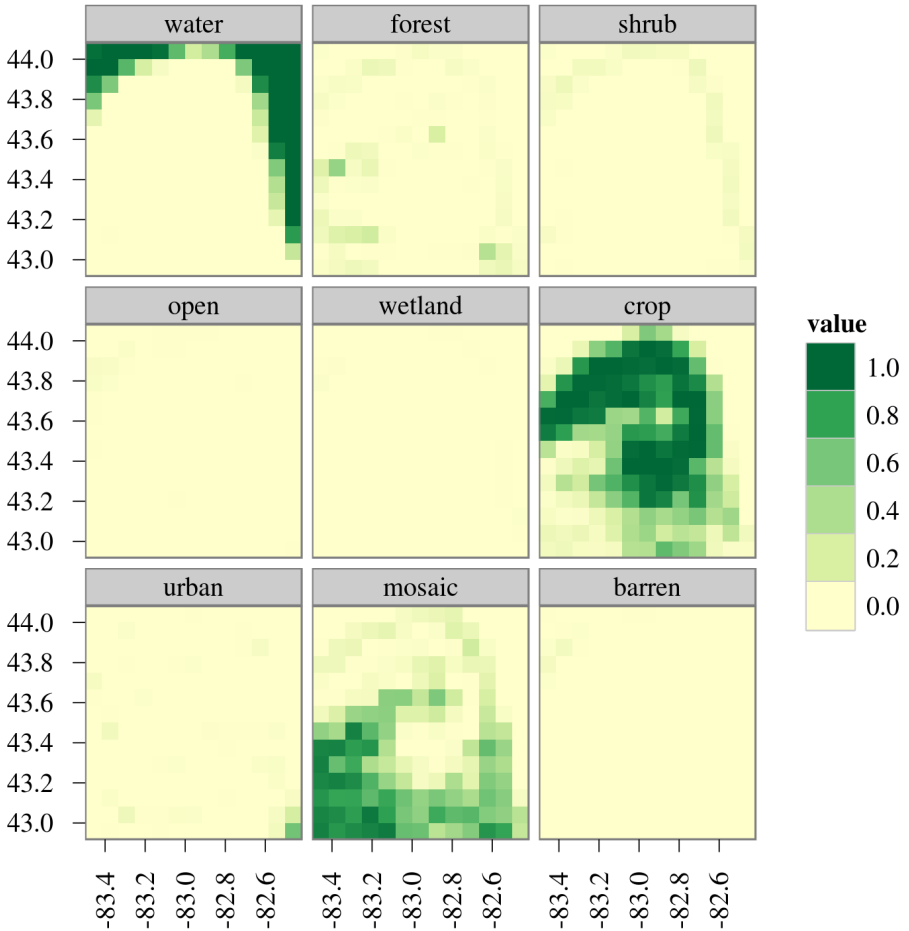
Methodology

Sub-pixel Areas and Aggregation



Aggregated sub-pixel fractions for $A_{min} = 1$

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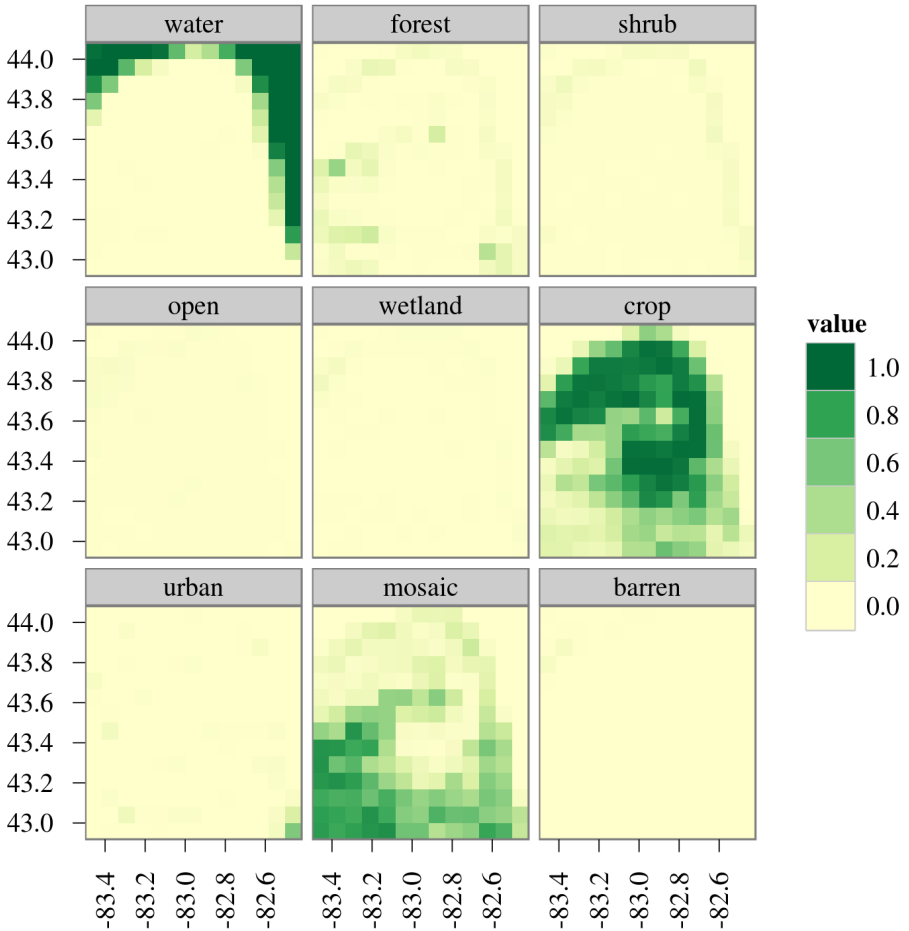
Methodology

Sub-pixel Areas and Aggregation



Aggregated sub-pixel fractions for $A_{min} = 0.5$

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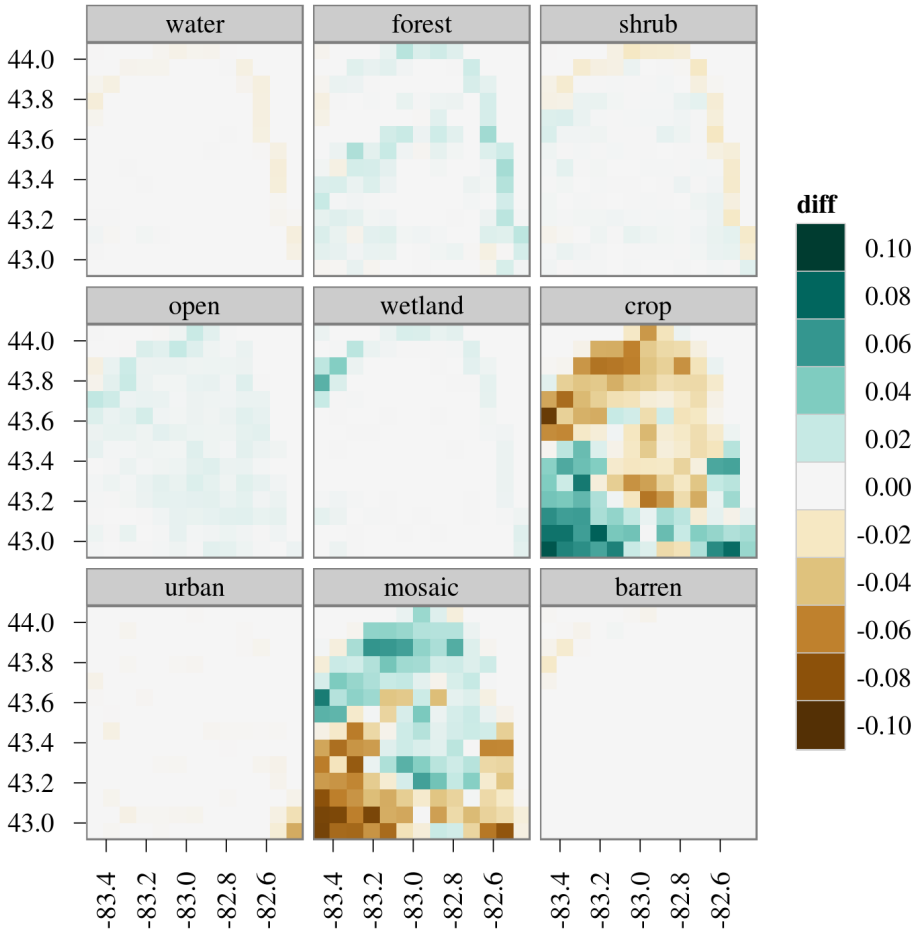
Methodology

Sub-pixel Areas and Aggregation



Difference of aggregated sub-pixel fractions, positive when $f(A_{min} = 0.5)$ is greater

Methodology

Mosaic Decomposition

- Mosaic land is 50% crop land

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- Remainder is blend of forest, open, and shrub (by definition)

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- That blend is proportional to their presence elsewhere in the same $5''$ grid cell (our assumption)

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Methodology

Mosaic Decomposition

- Mosaic land is 50% crop land
- Remainder is blend of forest, open, and shrub (by definition)
- That blend is proportional to their presence elsewhere in the same 5″ grid cell (our assumption)
- If none of those classes are represented we assume an equal blend of all three

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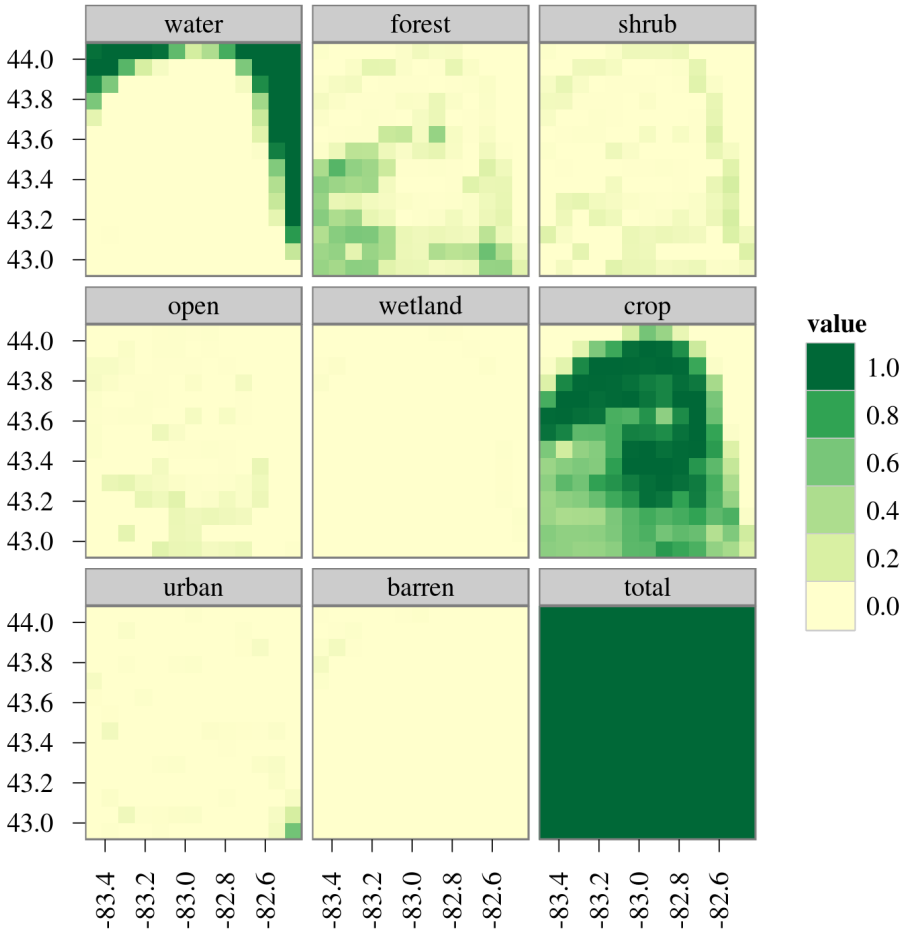
Methodology

Mosaic Decomposition



Aggregated cover fractions after mosaic decomposition, $A_{min} = 1.0$

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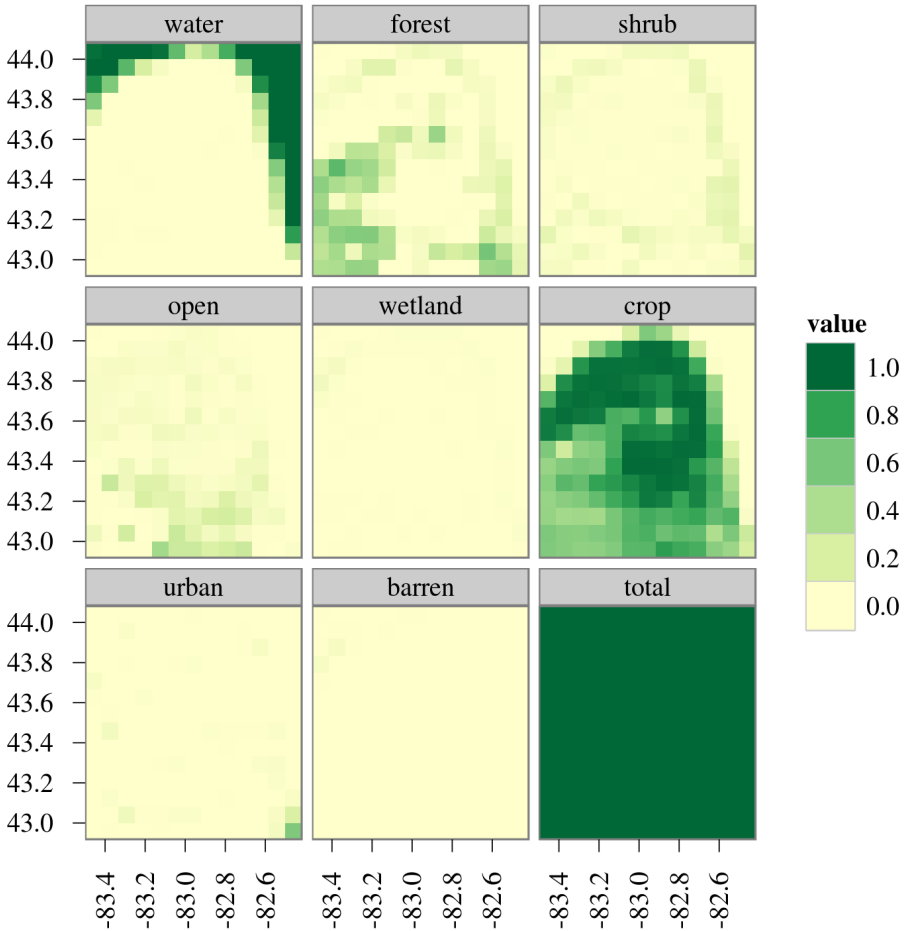
Methodology

Mosaic Decomposition



Aggregated cover fractions after mosaic decomposition, $A_{min} = 0.5$

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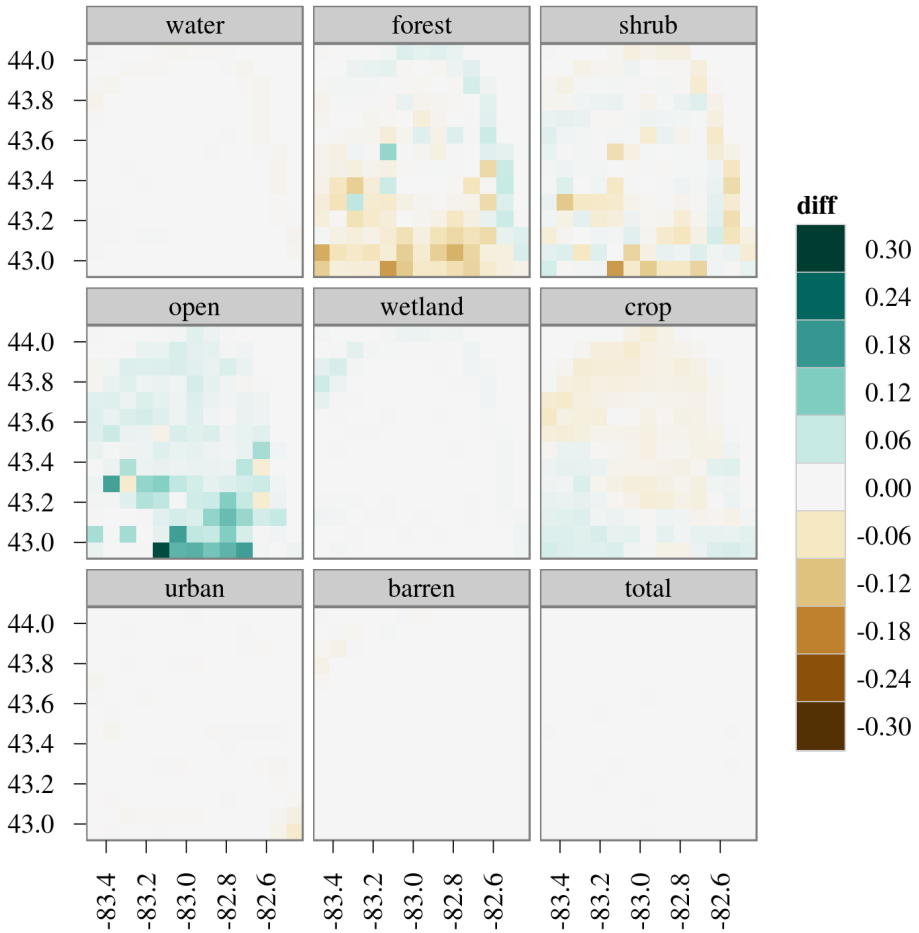
Methodology

Mosaic Decomposition



Differences of sub-pixel fractions after mosaic decomposition,

positive when $f(A_{min} = 0.5)$ is greater

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Outline

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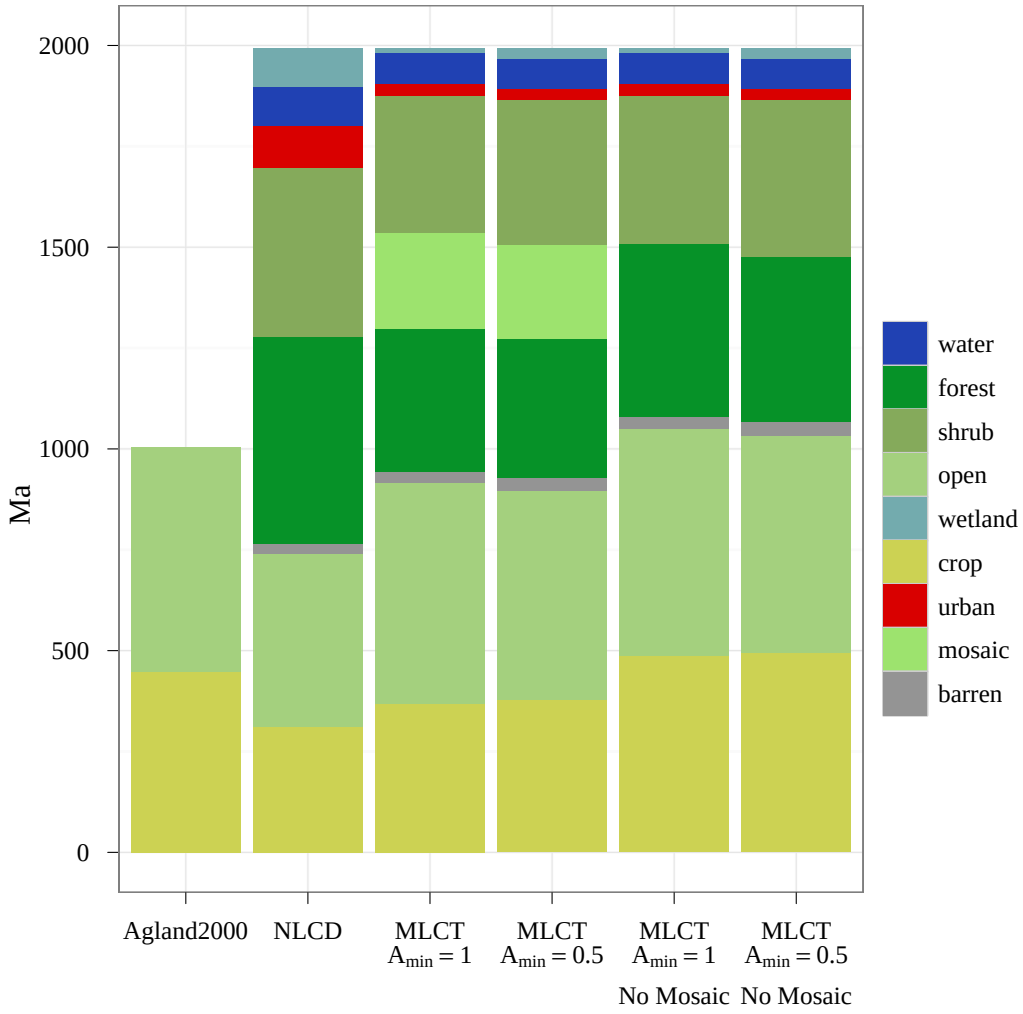
Analysis

Total Areas



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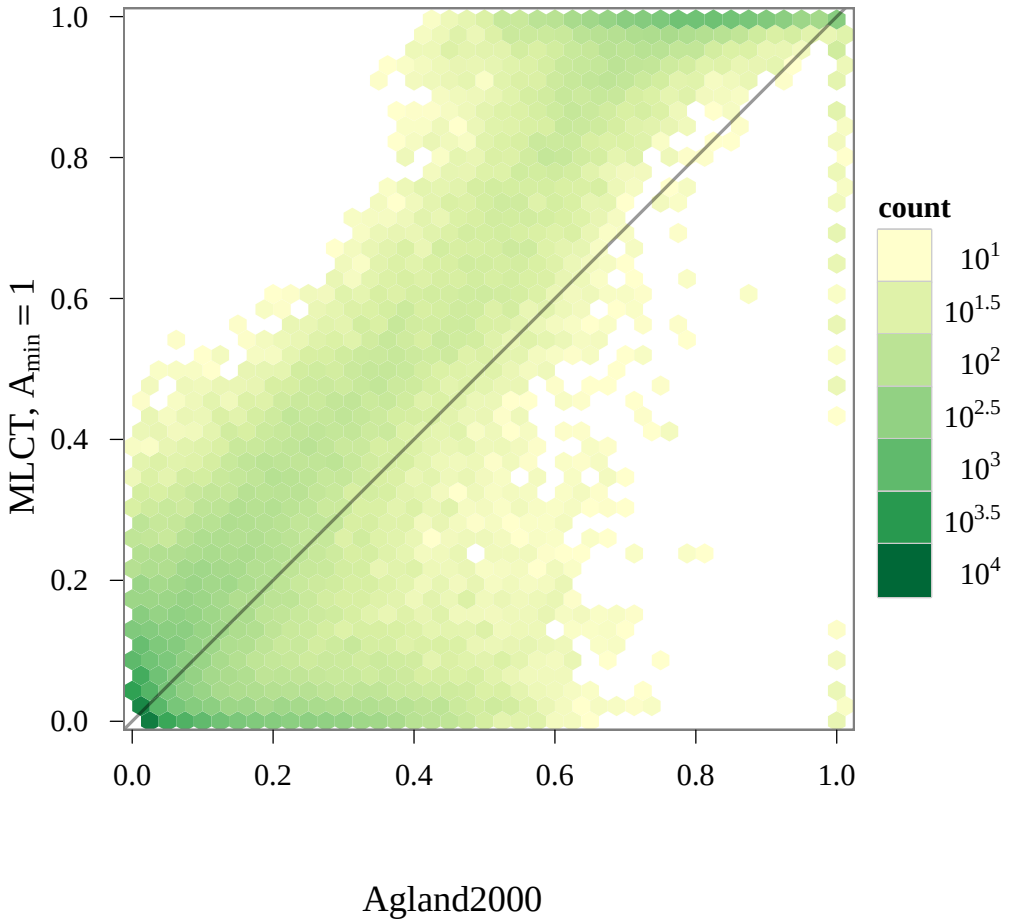
Analysis

MLCT Crop vs. Agland2000, $A_{min} = 1.0$

RMSE = 0.180



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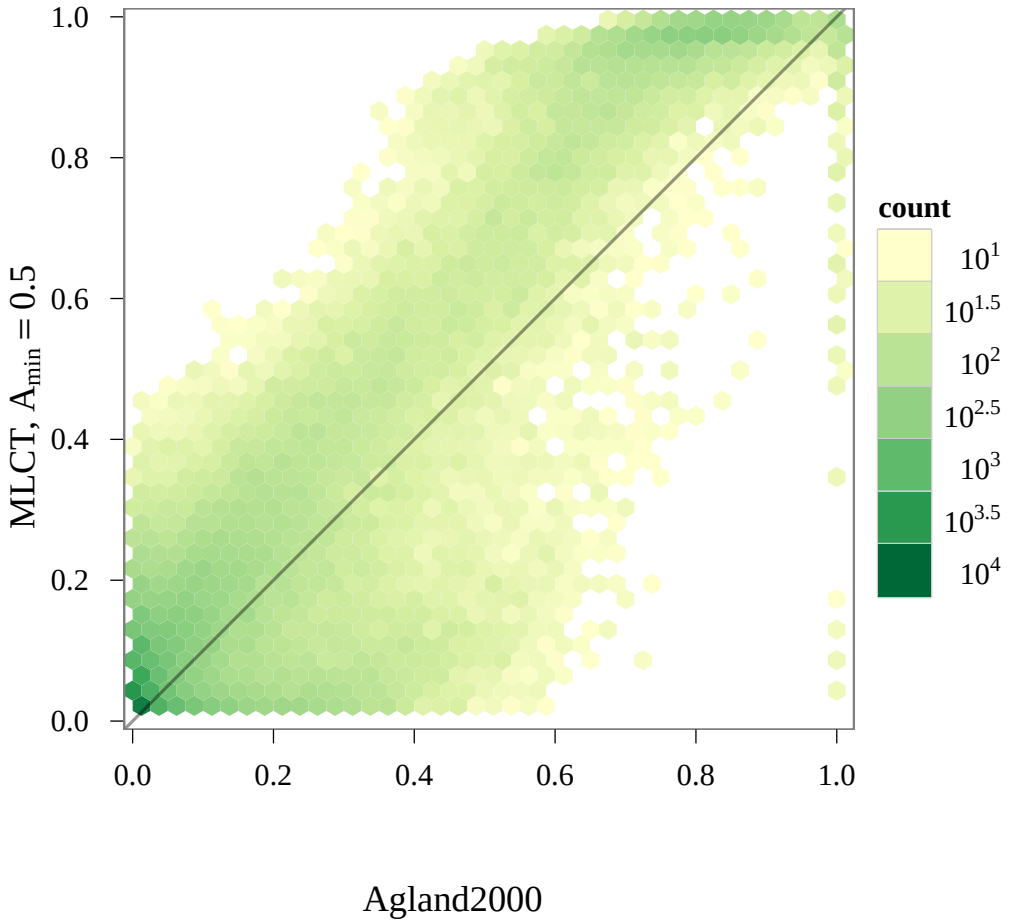
Analysis

MLCT Crop vs. Agland2000, $A_{min} = 0.5$

RMSE = 0.165



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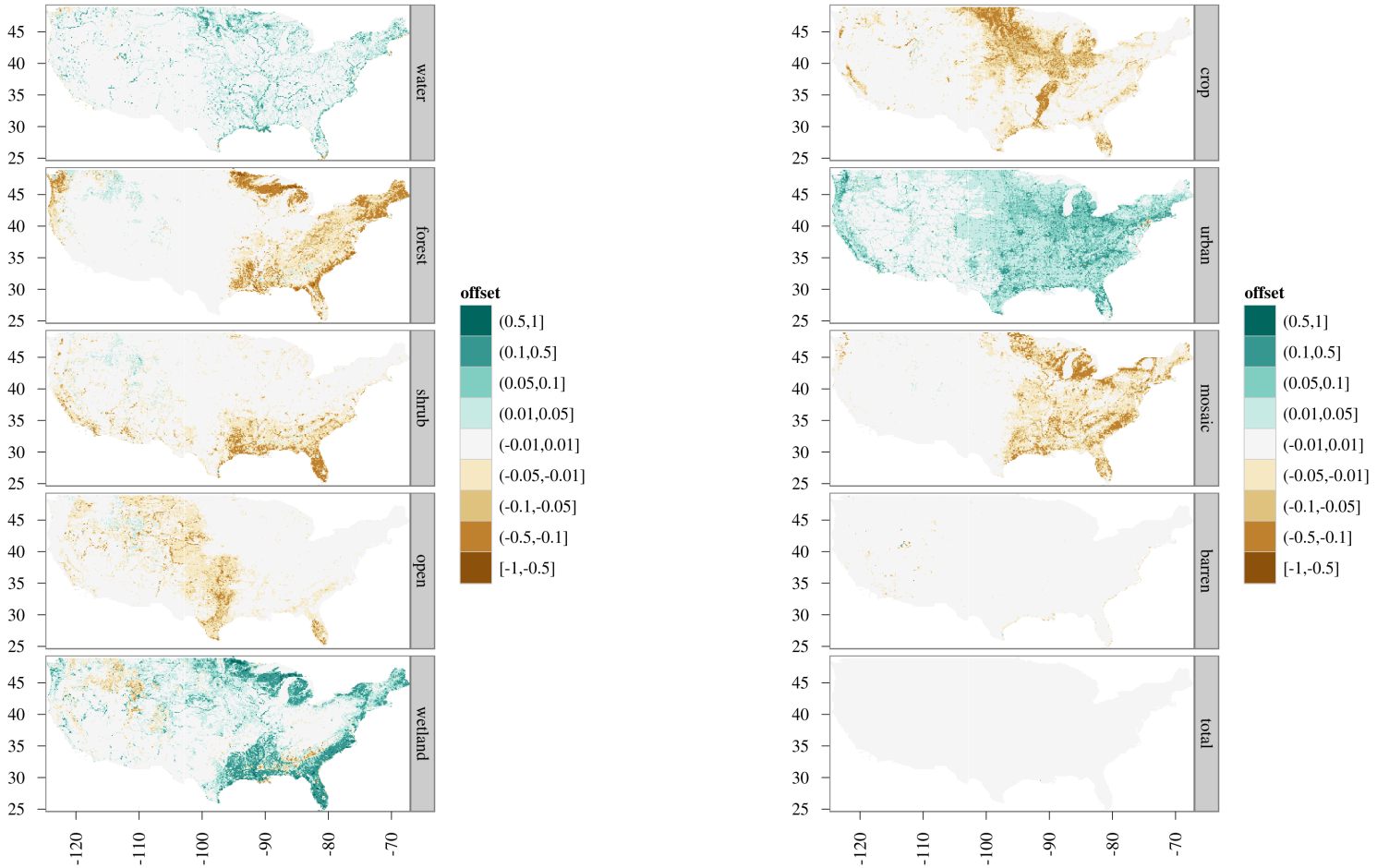
Analysis

NLCD Offsets



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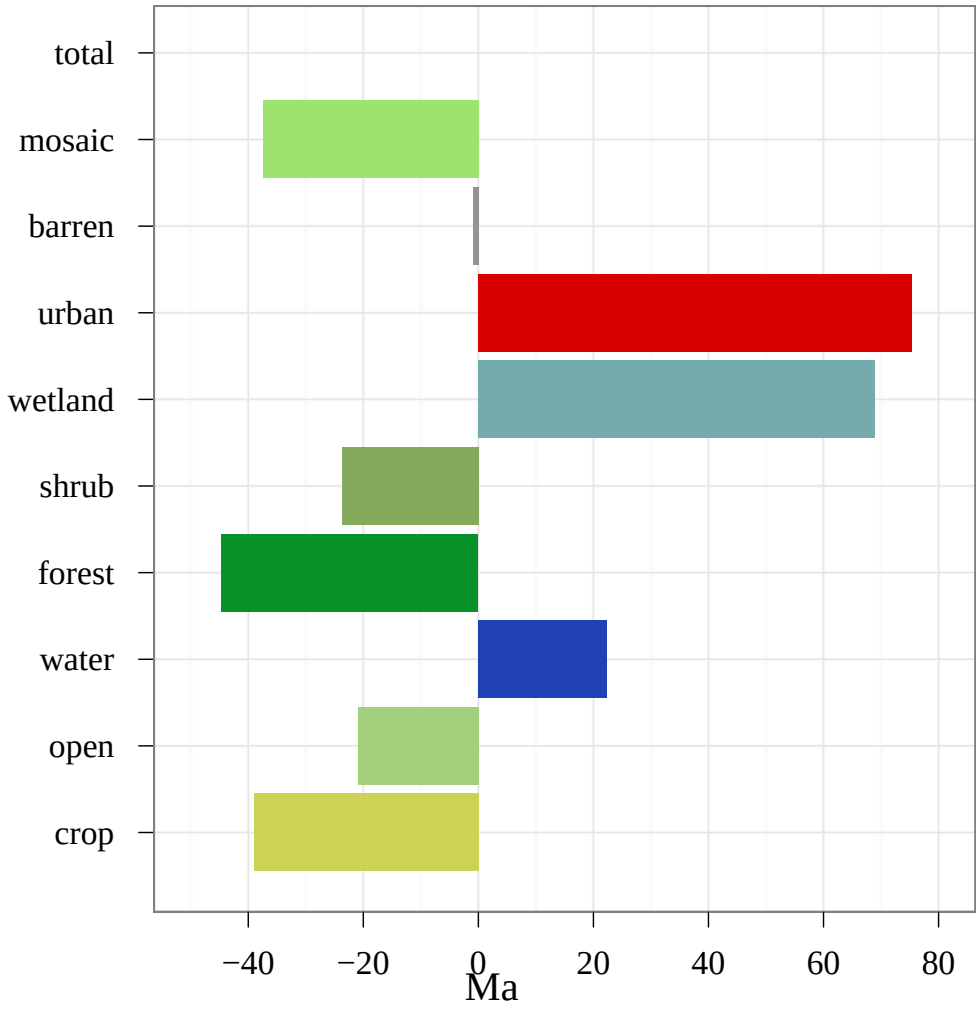
Analysis

NLCD Offsets



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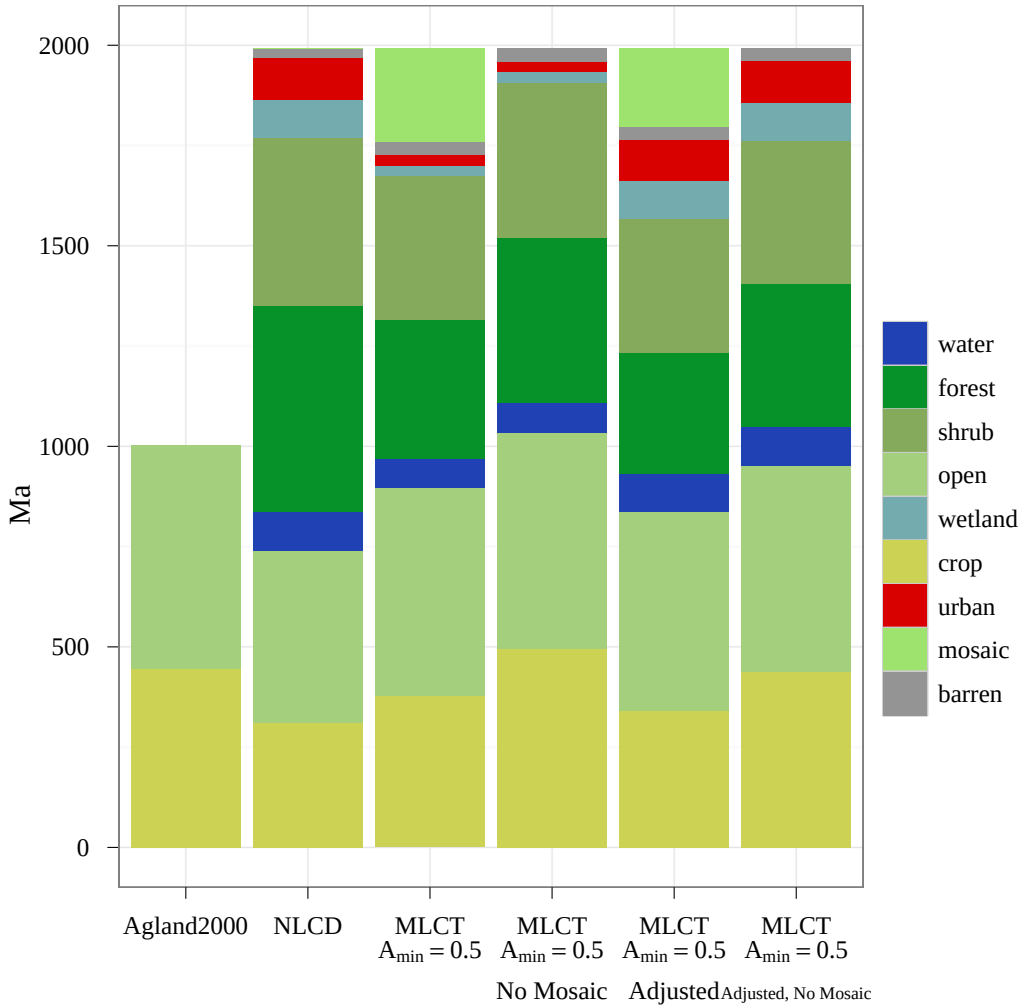
Analysis

Total Areas, Adjusted



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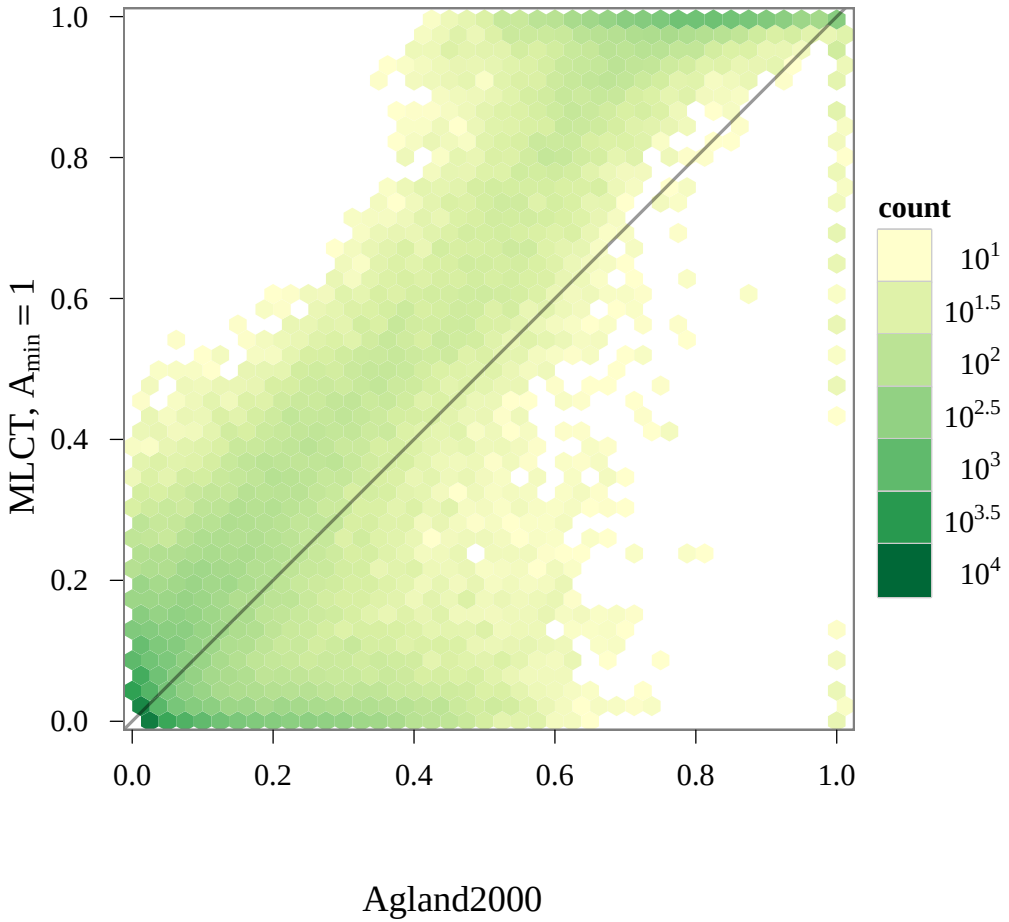
Analysis

MLCT Crop vs. Agland2000, $A_{min} = 1.0$

RMSE = 0.180



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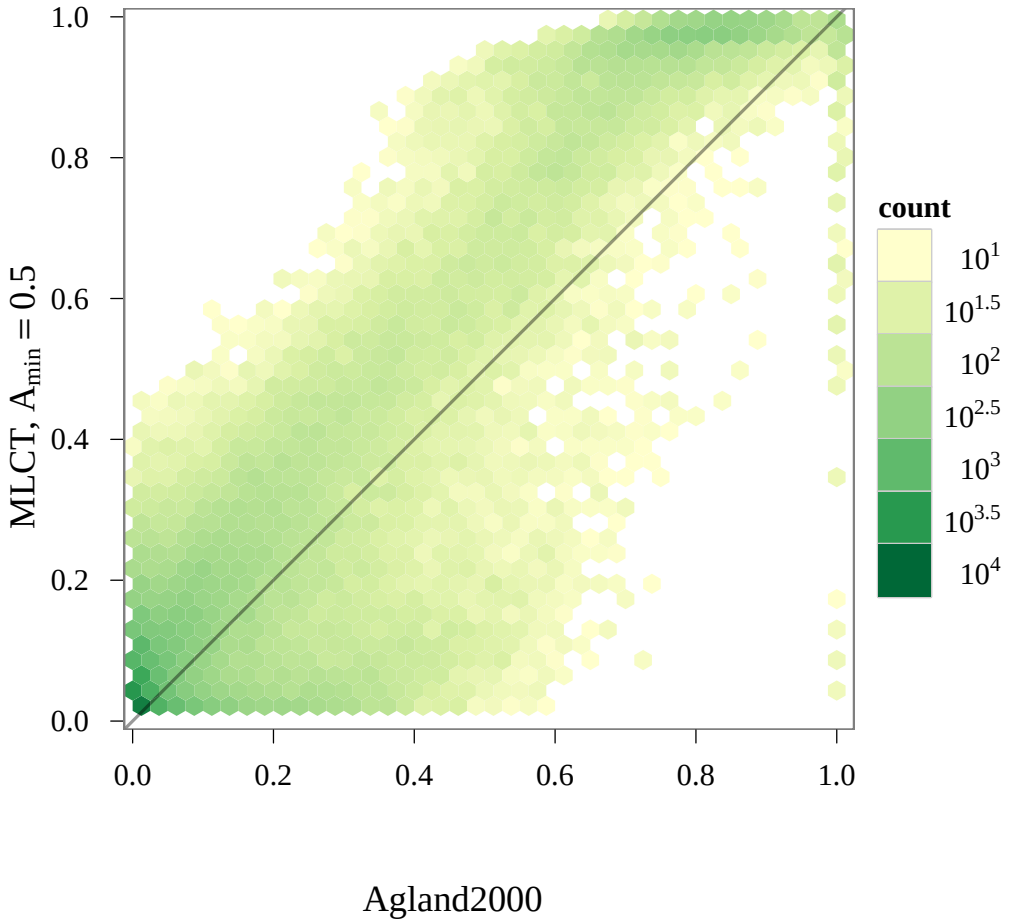
Analysis

MLCT Crop vs. Agland2000, $A_{min} = 0.5$

RMSE = 0.165



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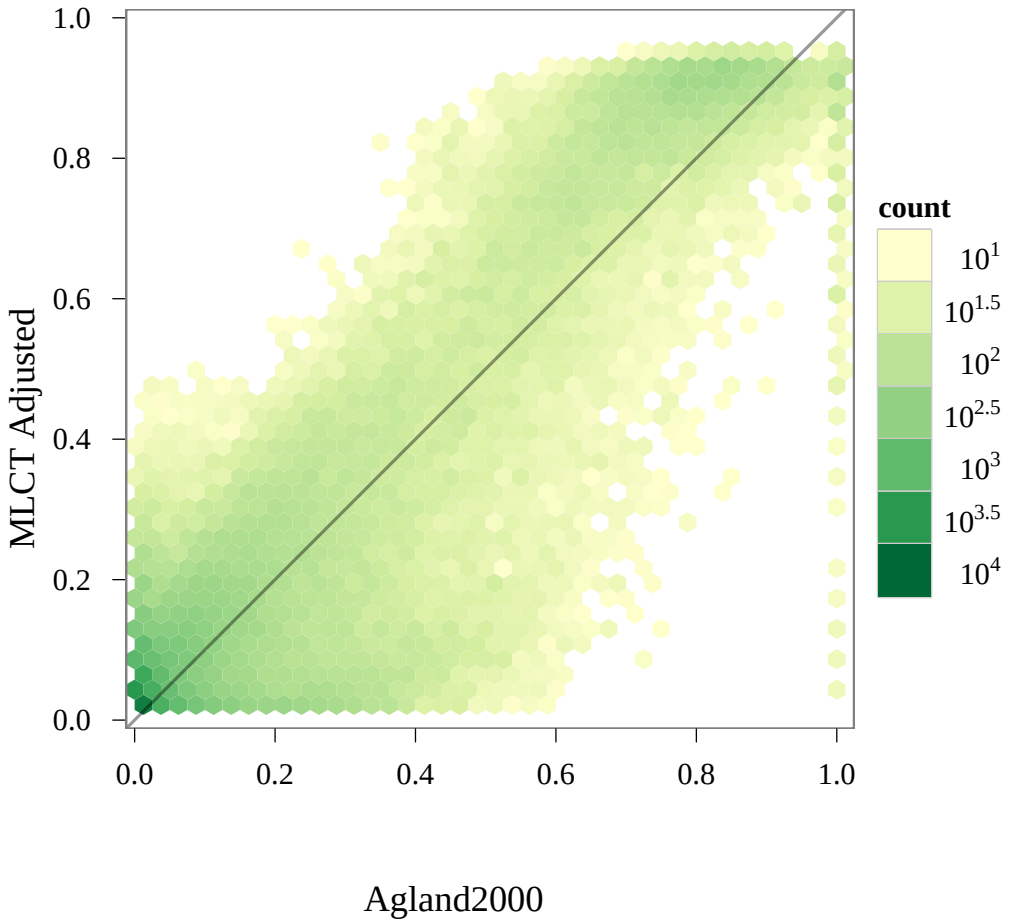
Analysis

MLCT Crop vs. Agland2000, $A_{min} = 0.5$ plus NLCD offsets

RMSE = 0.151



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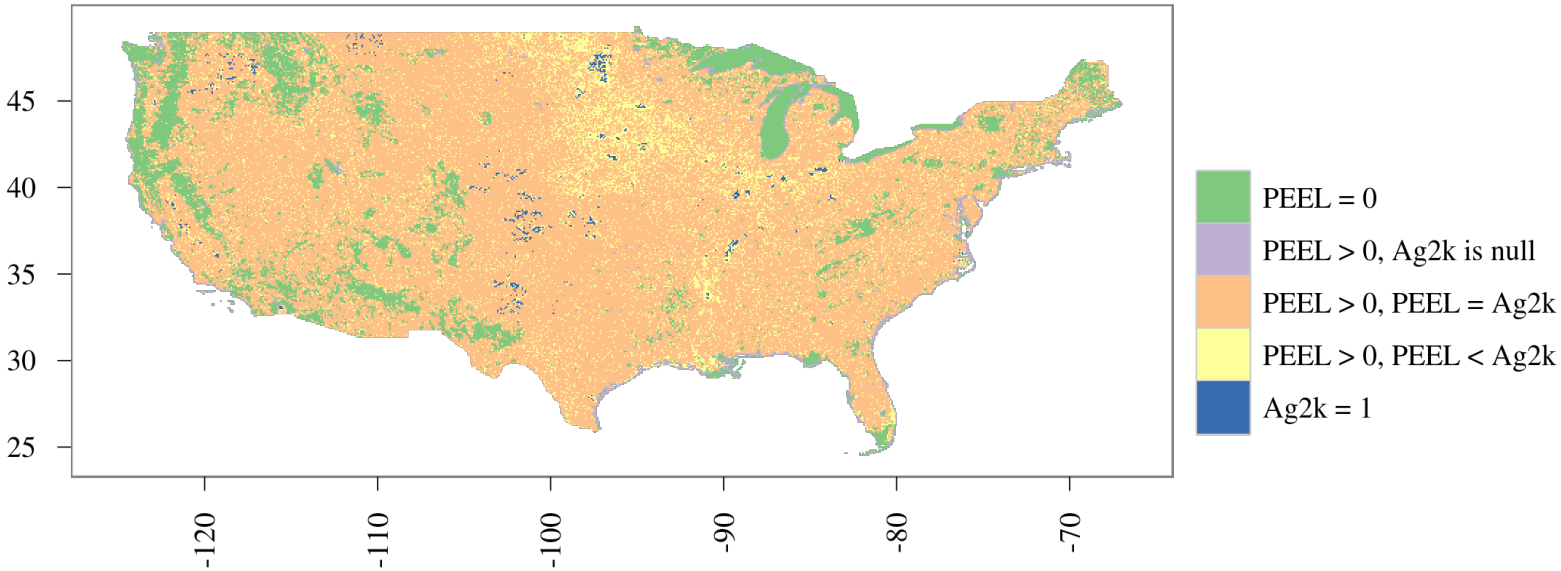
Analysis

Conflicts between NLCD offsets and Agland2000



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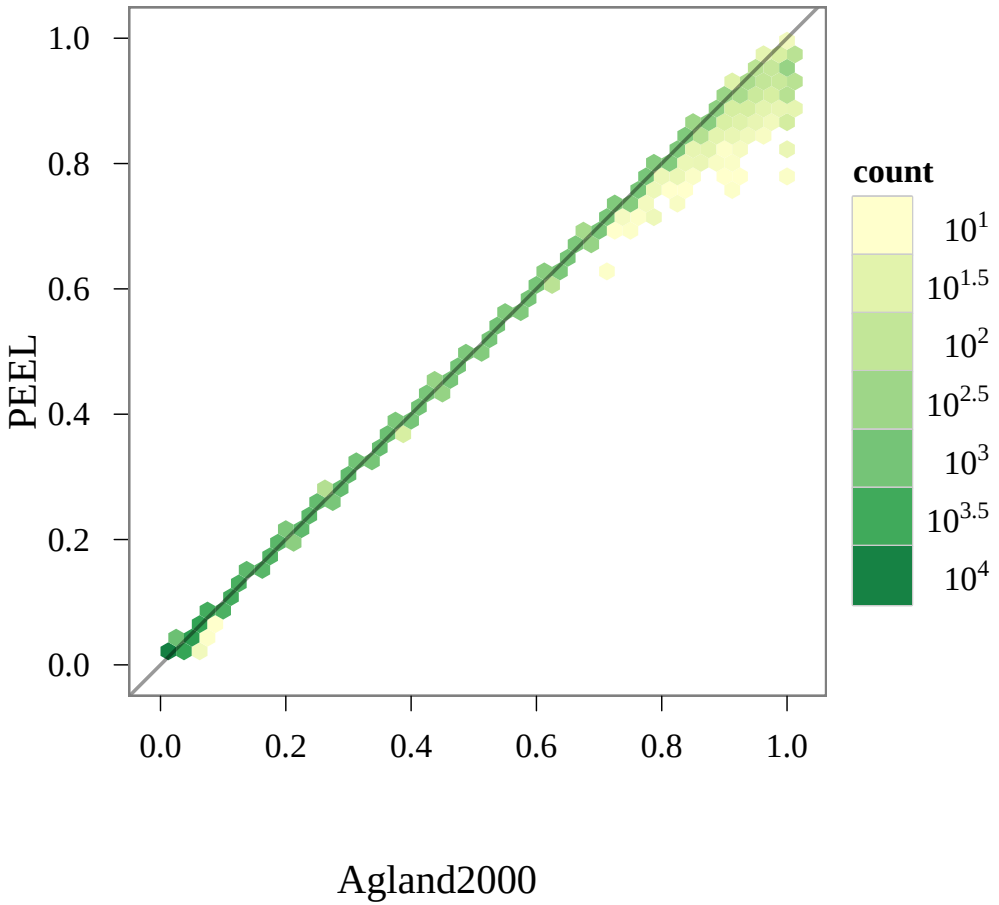
Analysis

PEEL vs. Agland2000

$$\text{RMSE} = 0.017$$



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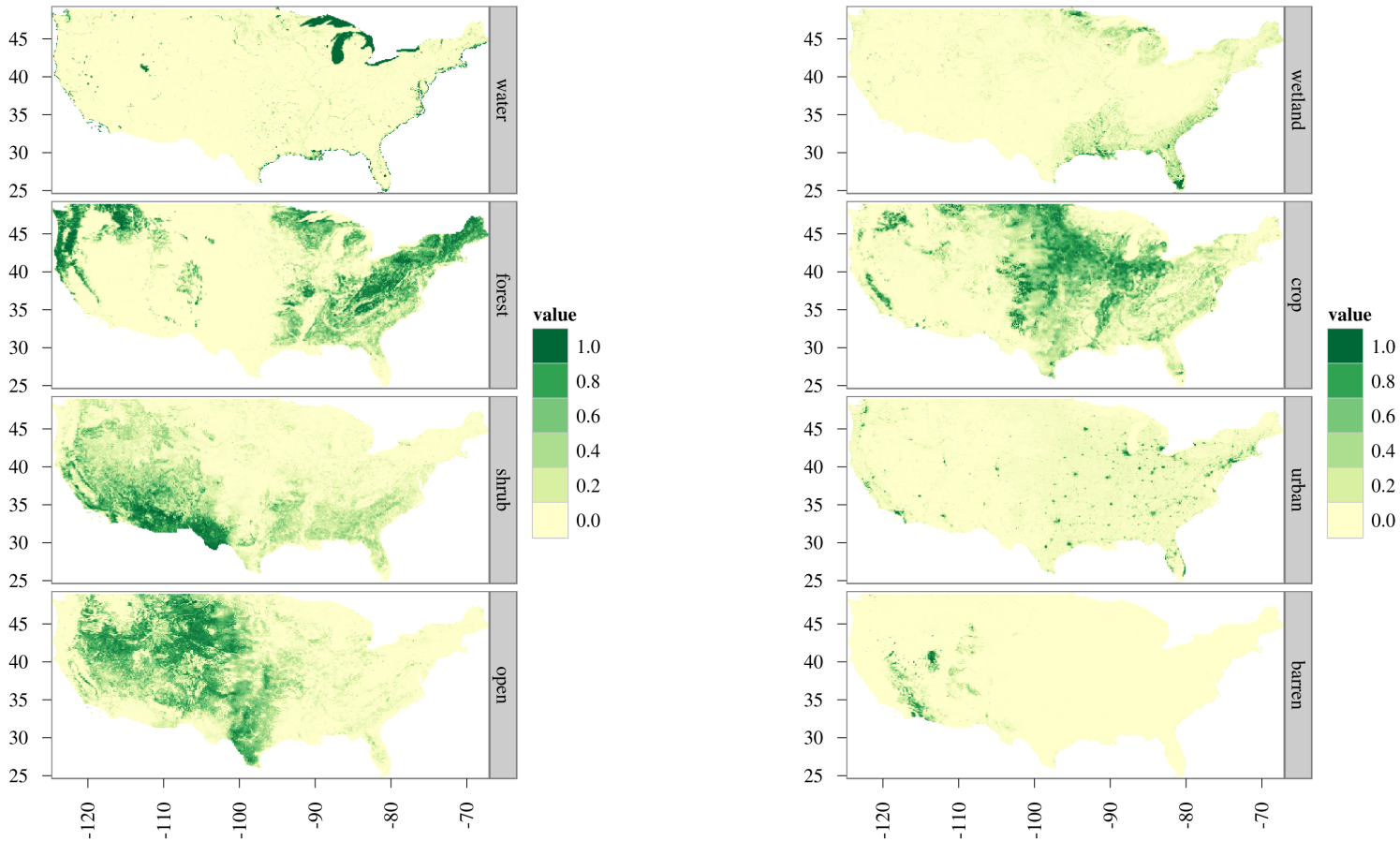
Analysis

Final PEEL maps



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Conclusion

- A rational framework for constructing a hybrid data set

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Conclusion

- A rational framework for constructing a hybrid data set
- A basis for adding a time dimension by using the ensuing MLCT maps

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Conclusion

- A rational framework for constructing a hybrid data set
- A basis for adding a time dimension by using the ensuing MLCT maps
- A basis for extending the study area globally

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Conclusion

- A rational framework for constructing a hybrid data set
- A basis for adding a time dimension by using the ensuing MLCT maps
- A basis for extending the study area globally
- A repeatable mechanism for incorporating adjustments or evaluating alternatives

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Conclusion

- A rational framework for constructing a hybrid data set
- A basis for adding a time dimension by using the ensuing MLCT maps
- A basis for extending the study area globally
- A repeatable mechanism for incorporating adjustments or evaluating alternatives
- A nicely formatted paper ready for publication somewhere!

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