USING LIDAR TO ASSESS THE ROLES OF CLIMATE AND LAND-COVER DYNAMICS AS DRIVERS OF CHANGES IN BIODIVERSITY

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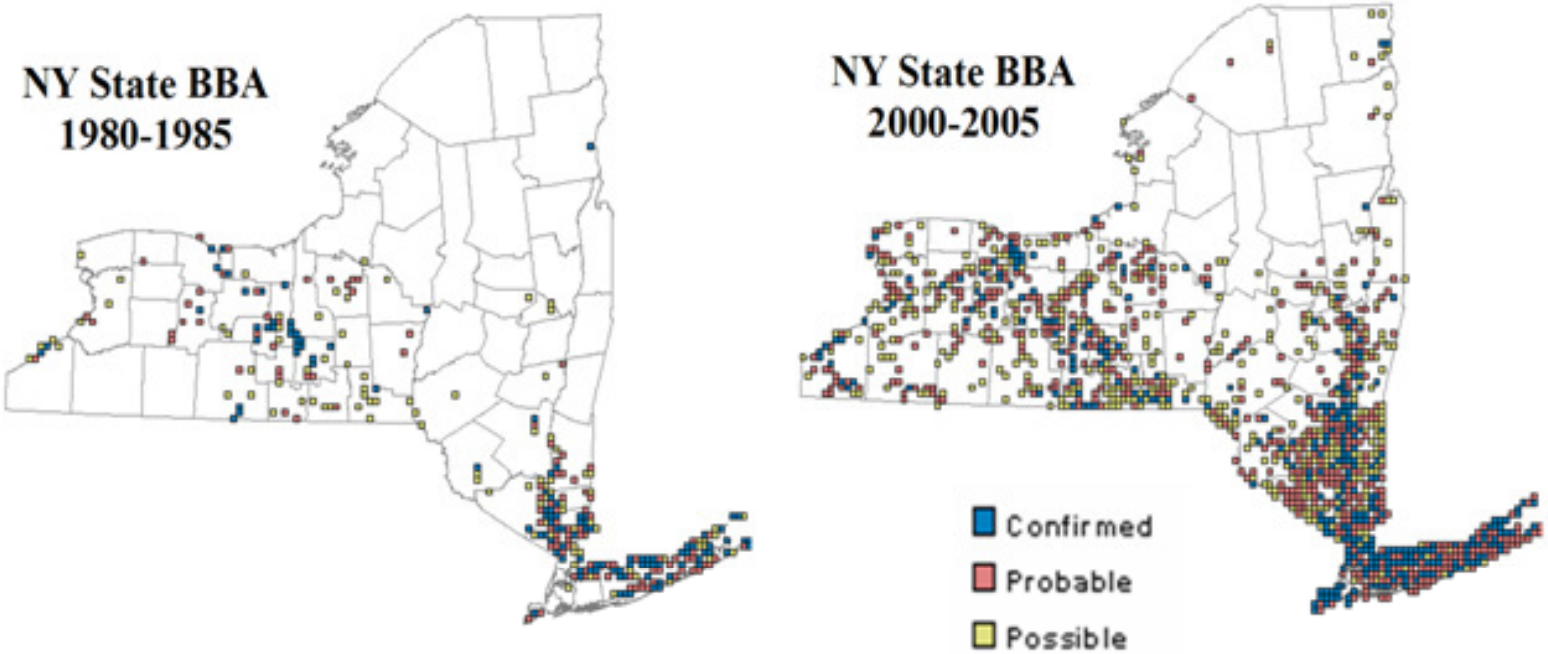
Motivation



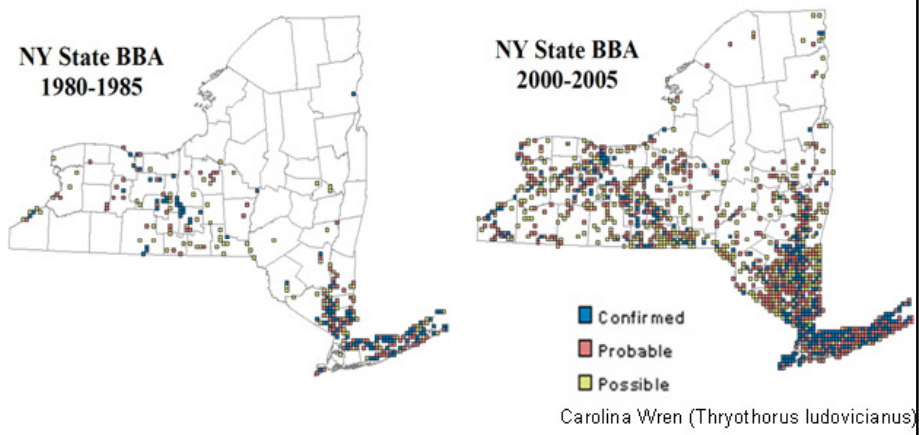
Carolina Wren (Thryothorus ludovicianus)

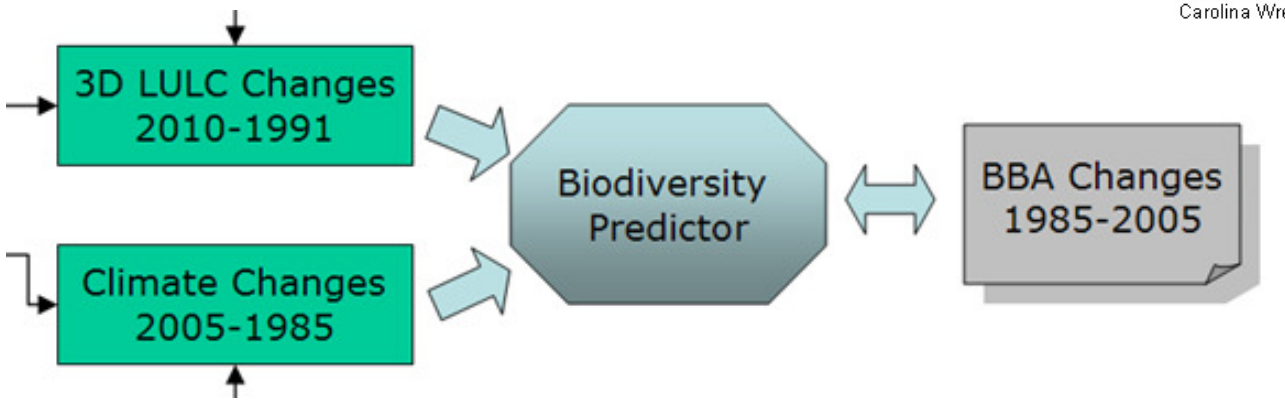
NY State Breeding Bird Atlas:

- From 129 bird species, 57.4% experienced a northward shift in the mean latitude of their distribution.
- Southern range limits of 43 northerly species have shifted northward an average of 11.4 km.

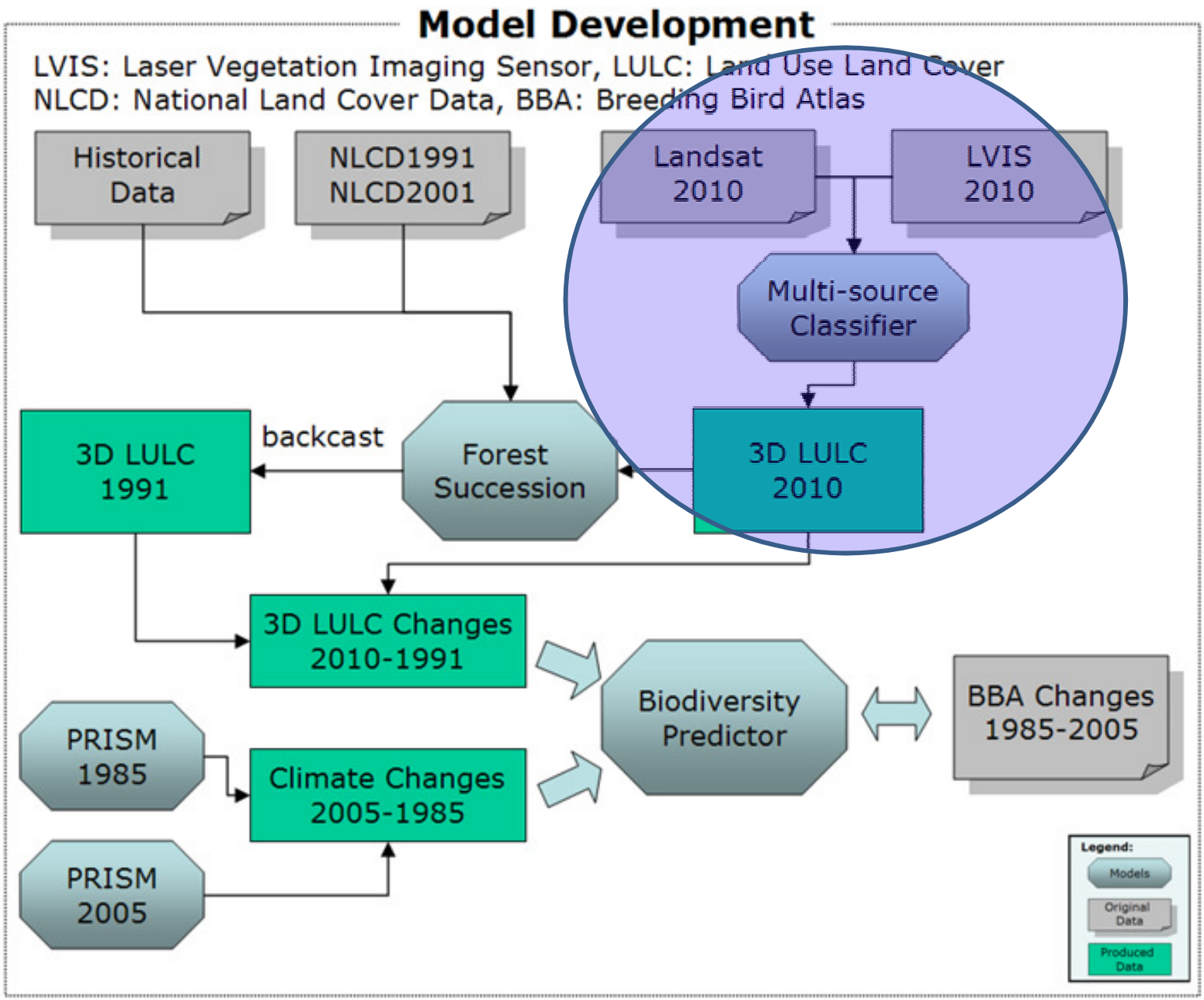
What are the drivers behind this change?

Approach

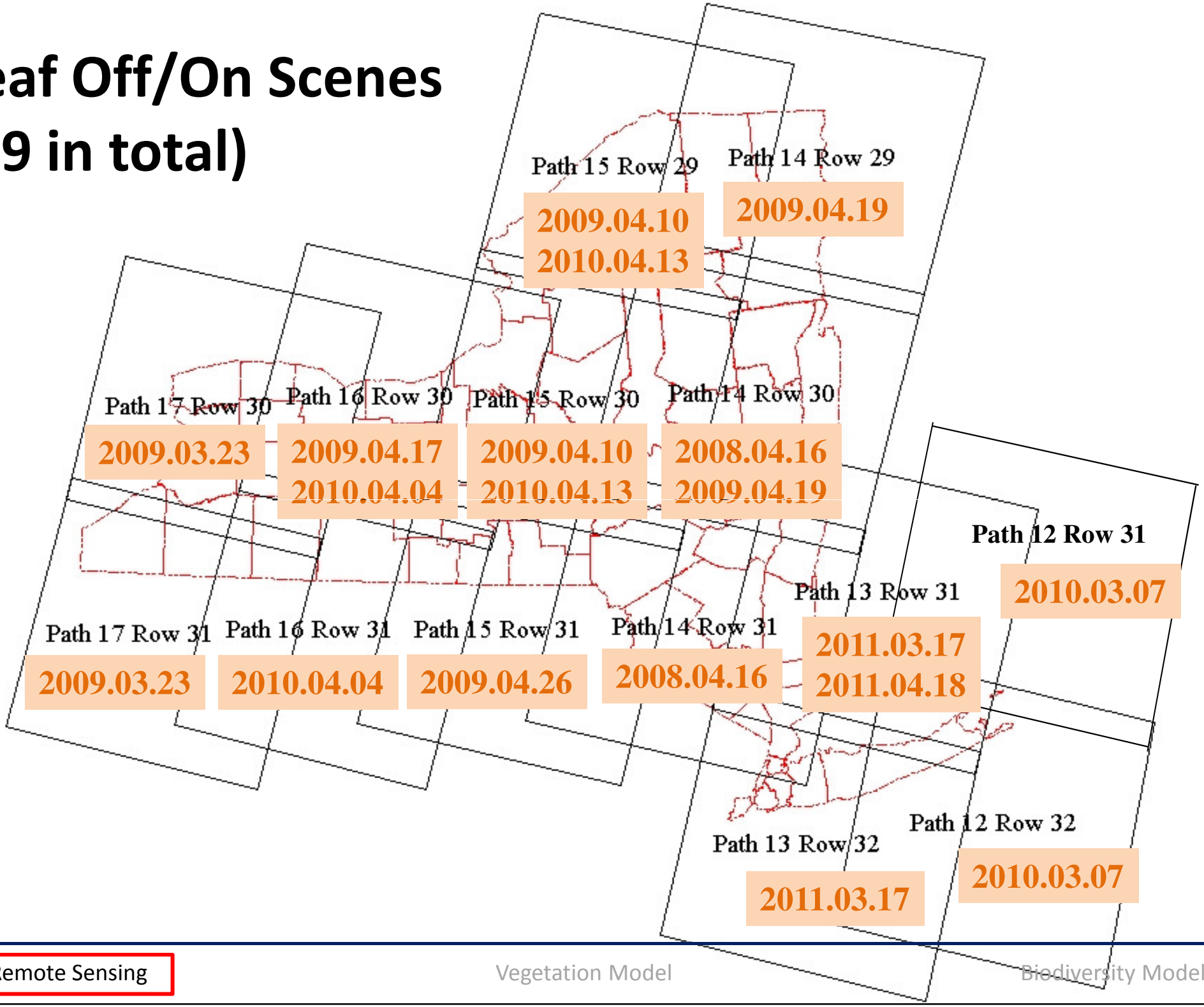

NY State BBA
1980-1985
NY State BBA
2000-2005
Confirmed
Probable
Possible
Carolina Wren (Thryothorus ludovicianus)


3D LULC Changes
2010-1991
Climate Changes
2005-1985
Biodiversity
Predictor
BBA Changes
1985-2005

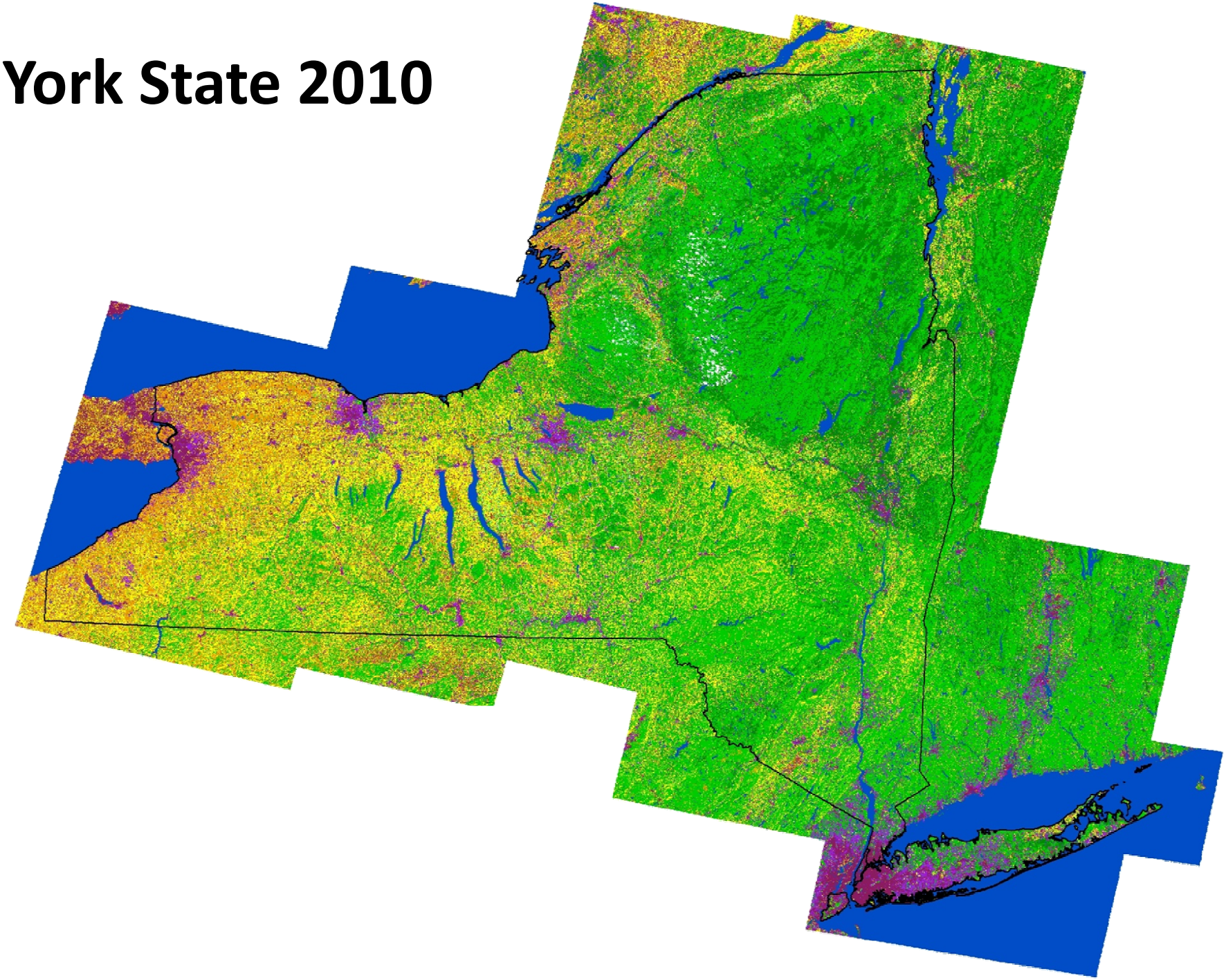
Remote Sensing



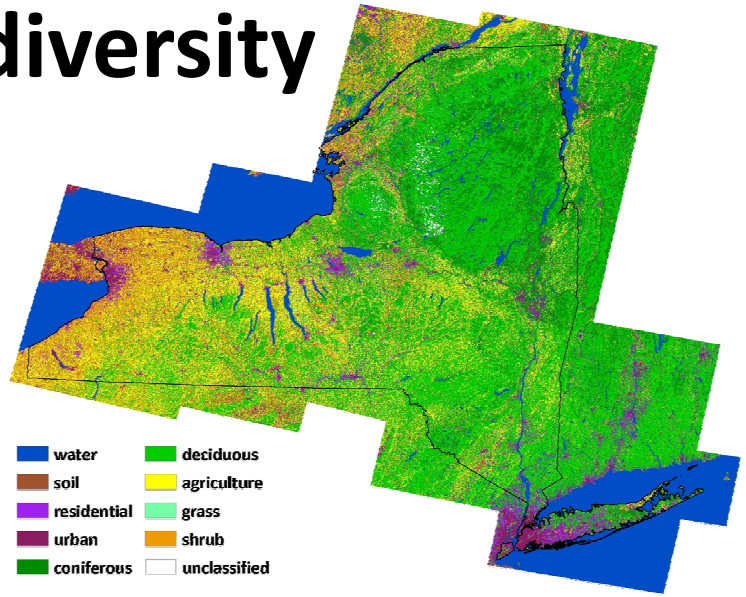
Leaf Off/On Scenes (19 in total)



New York State 2010



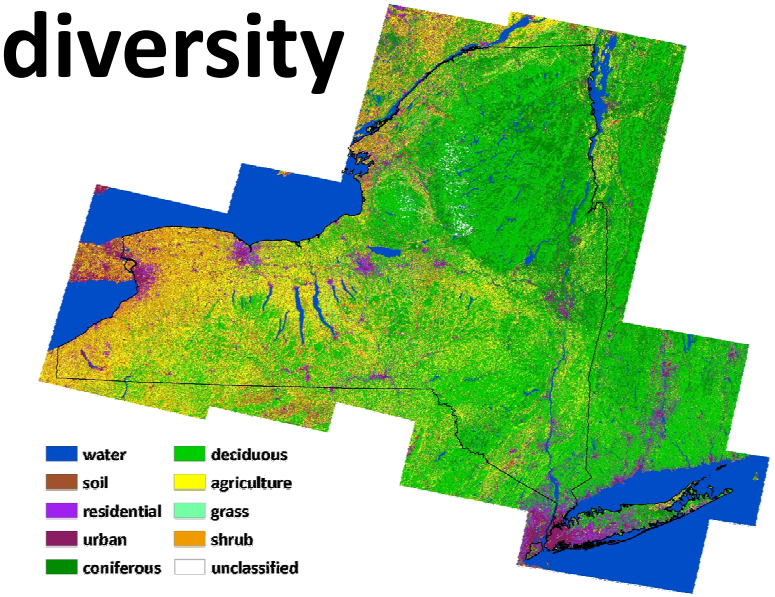
Shrubs: Important for avian biodiversity



NLCD 2006 accuracy <30%

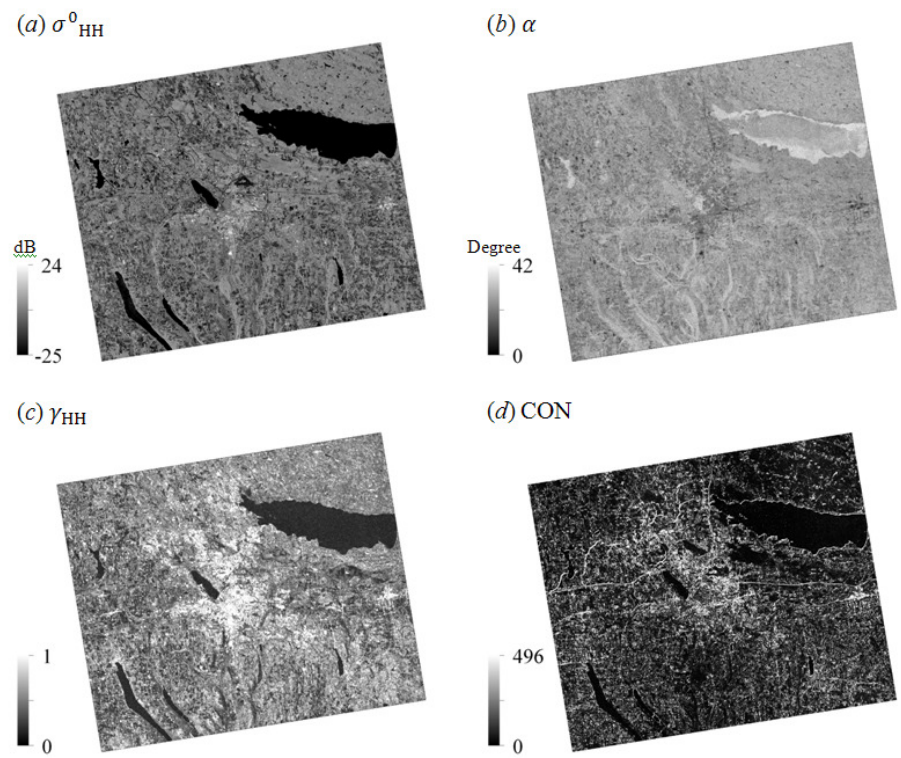
Multi-temporal Landsat: ~49%

Shrubs: Important for avian biodiversity



NLCD 2006 accuracy <30%
Multi-temporal Landsat: ~49%

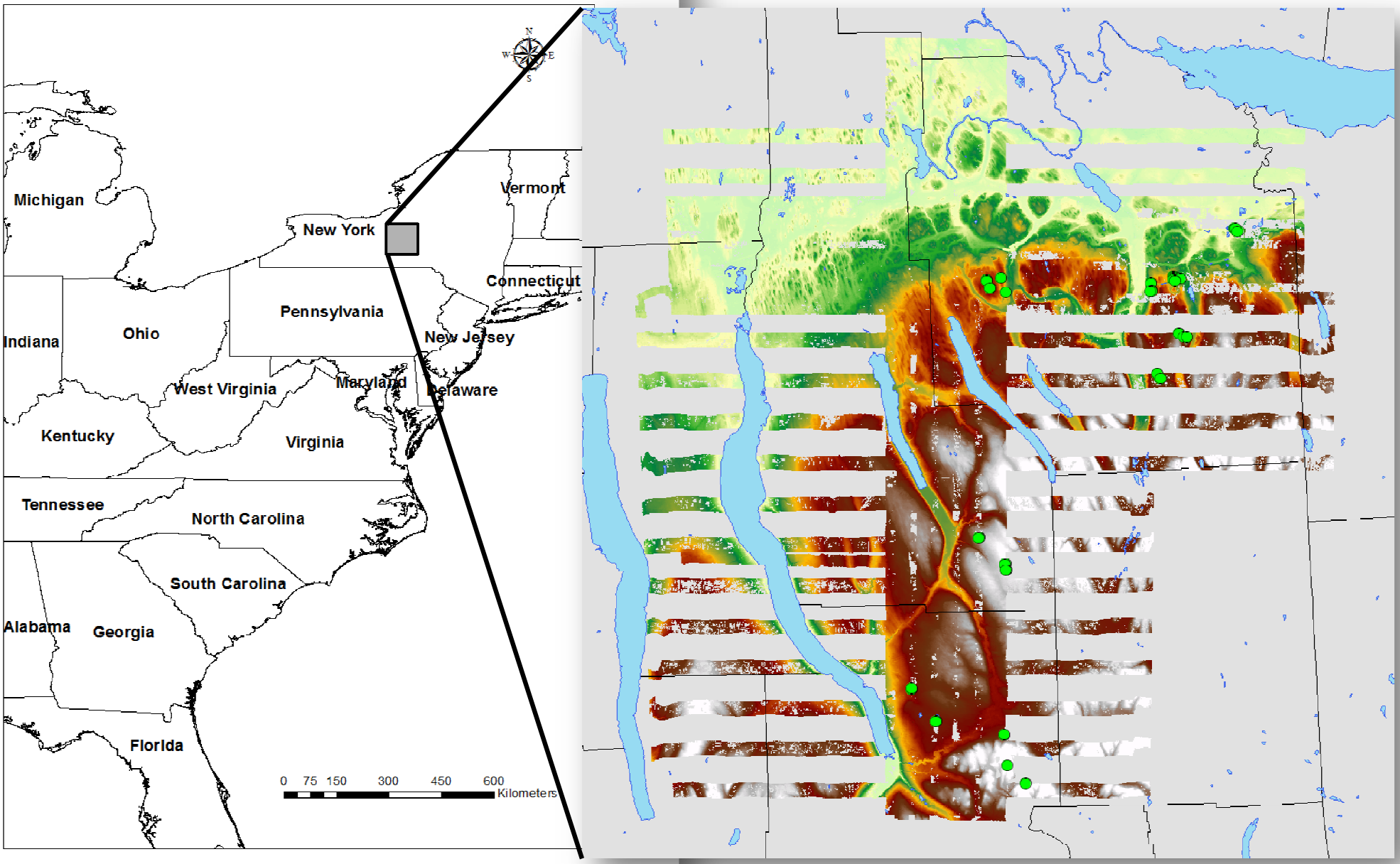
Landsat + PALSAR: ~53%*

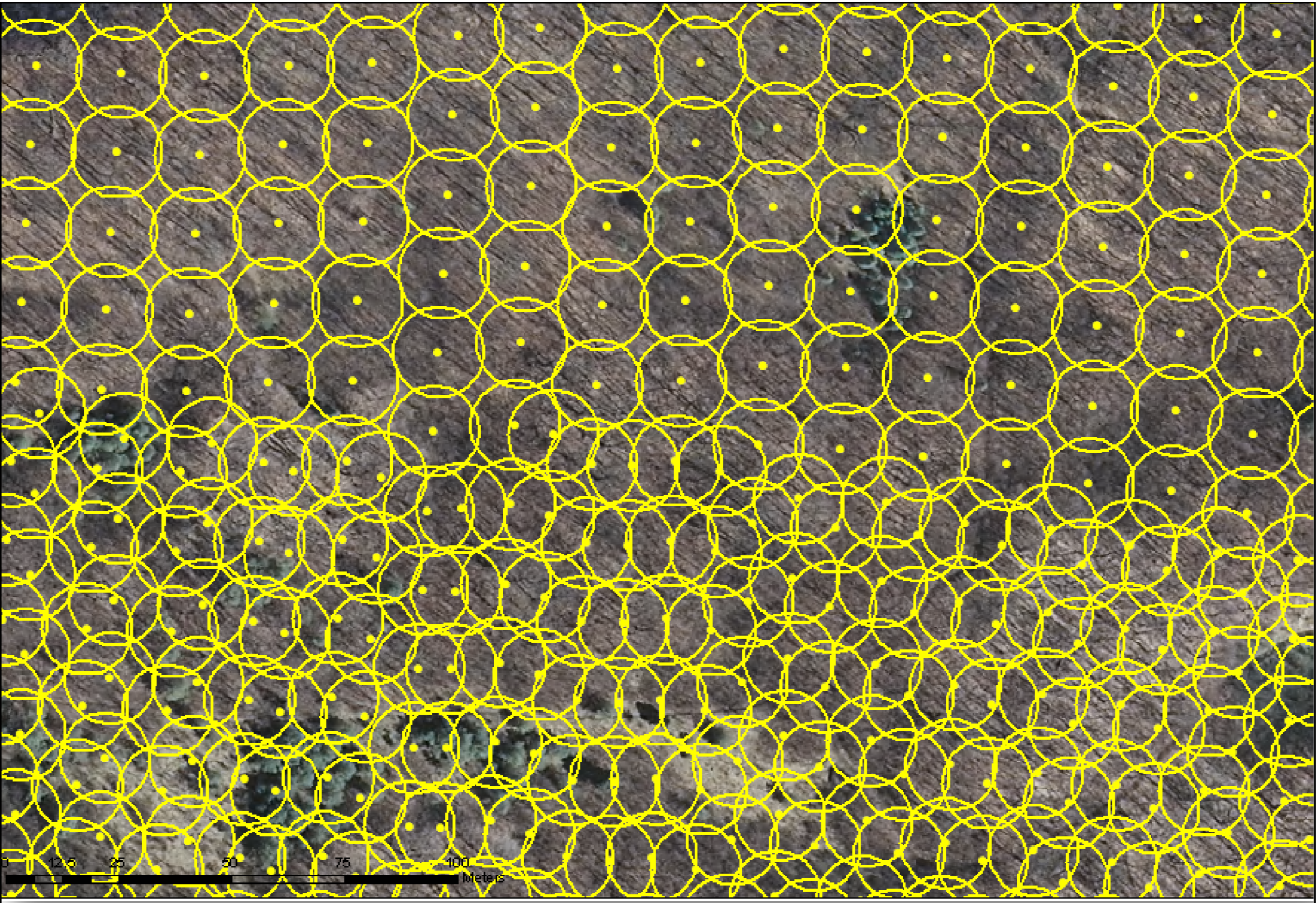


Shrubs: Important for avian biodiversity

LiDAR LVIS: Large-footprint waveform sensor

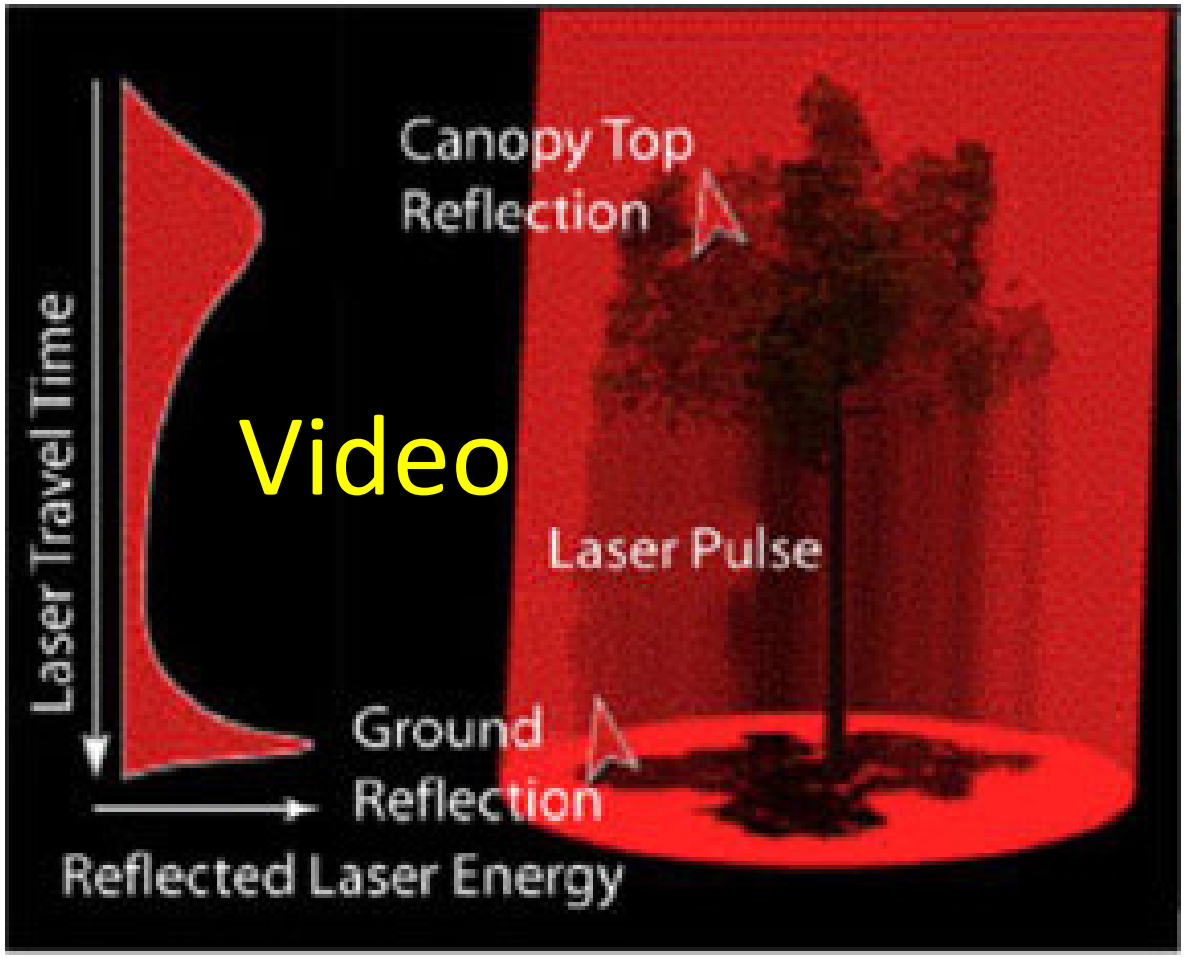
LIDAR

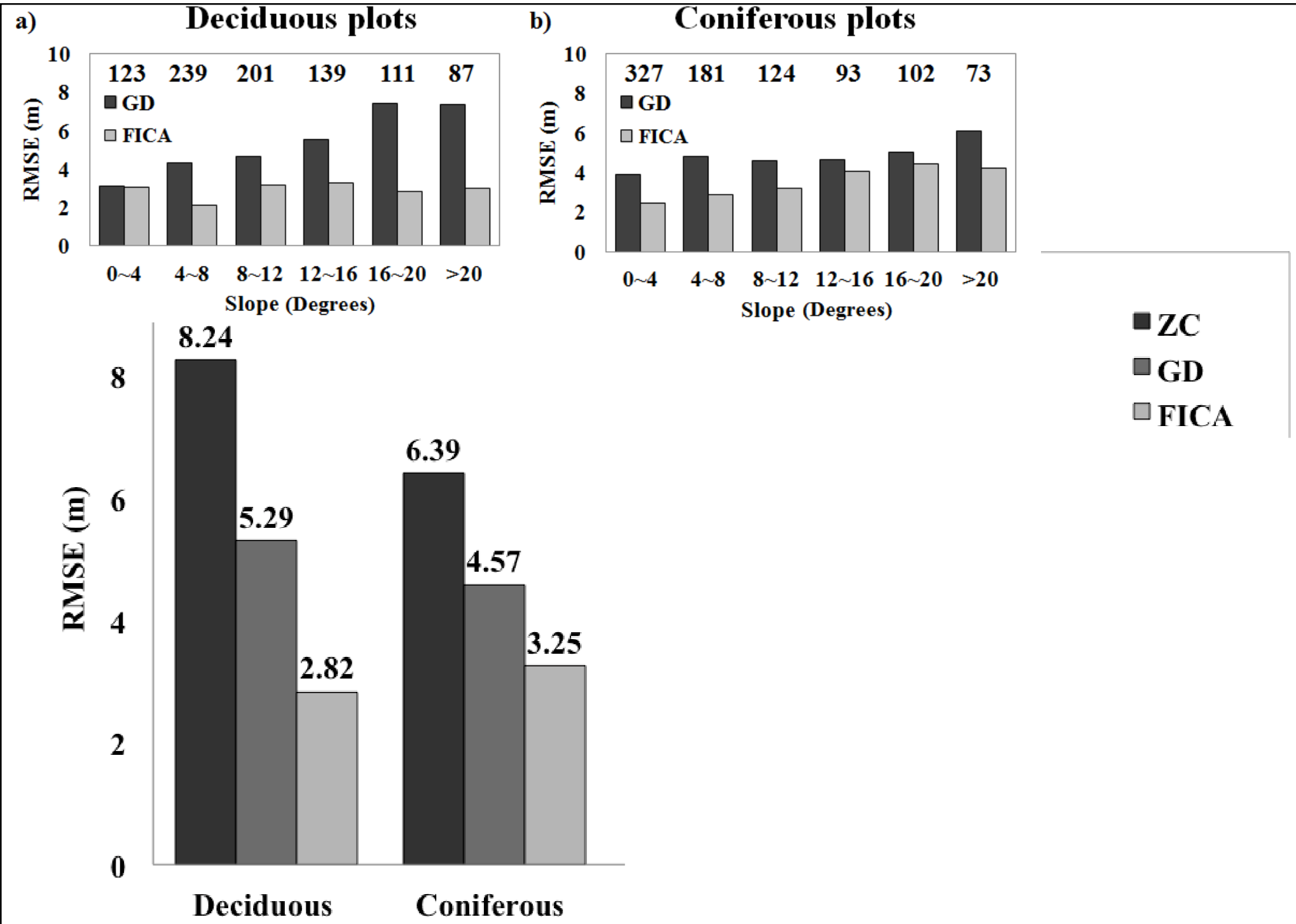

Michigan
New York
Vermont
Connecticut
Pennsylvania
Indiana
Ohio
New Jersey
West Virginia
Maryland
Delaware
Kentucky
Virginia
Tennessee
North Carolina
South Carolina
Alabama
Georgia
Florida
0 75 150 300 450 600
Kilometers


0
12.5
25
50
75
100
Meters

Remote Sensing

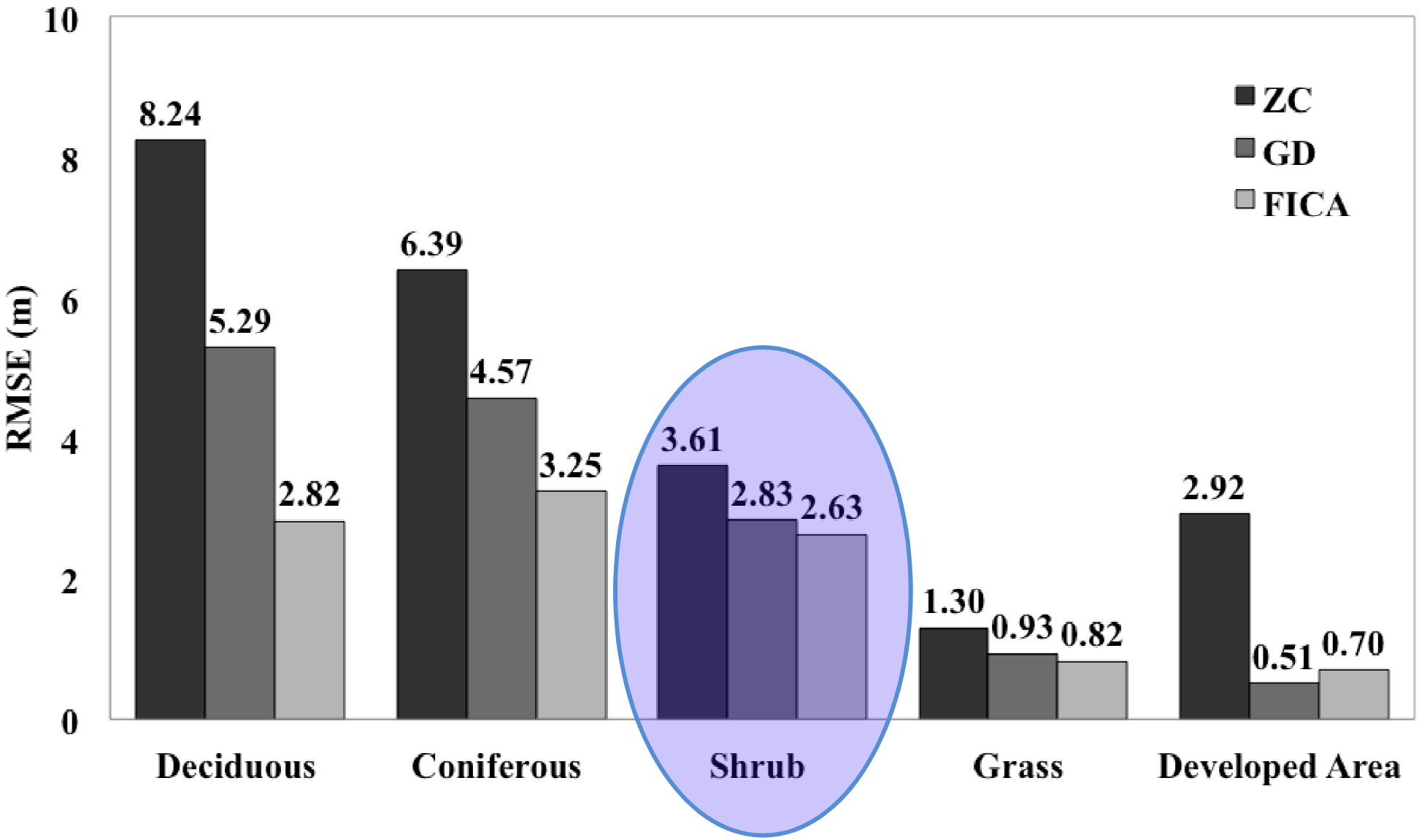
Ground detection using LiDAR LVIS




a)
Deciduous plots
123 239 201 139 111 87
GD
FICA
RMSE (m)
0 2 4 6 8 10
0~4 4~8 8~12 12~16 16~20 >20
Slope (Degrees)
b)
Coniferous plots
327 181 124 93 102 73
GD
FICA
RMSE (m)
0 2 4 6 8 10
0~4 4~8 8~12 12~16 16~20 >20
Slope (Degrees)
ZC
GD
FICA
RMSE (m)
0 2 4 6 8
8.24
5.29
2.82
6.39
4.57
3.25
Deciduous
Coniferous

Remote Sensing

Ground detection using LiDAR LVIS



Remote Sensing

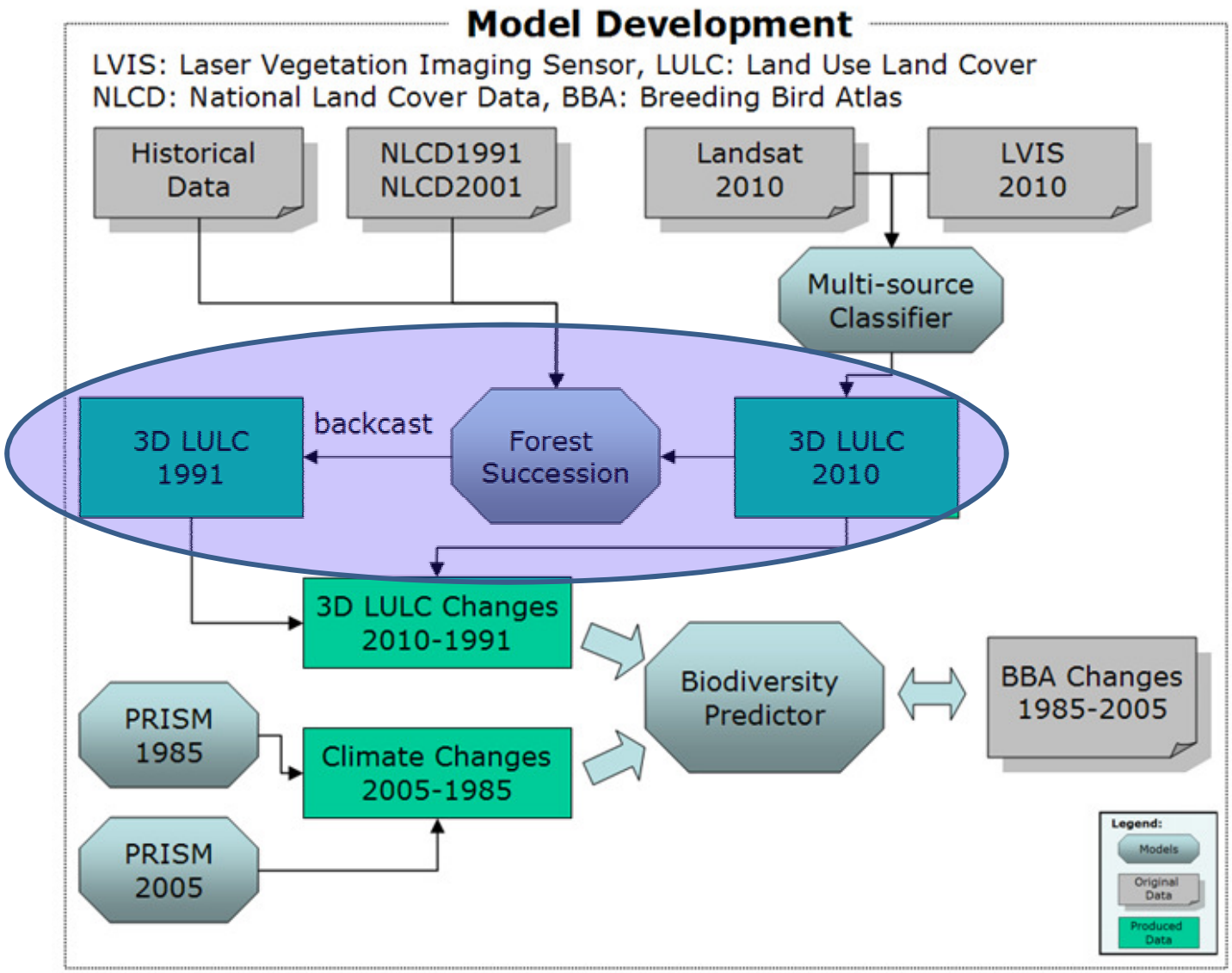
Ground detection using LiDAR LVIS + Landsat fusion specifically for shrubs

	PCF	GD
Bias	0.5	2.84
MAE(m)	1.41	2.84
RMSE(m)	**1.92**	**3.36**

PCF (Partial Curve Fitting) = Our method

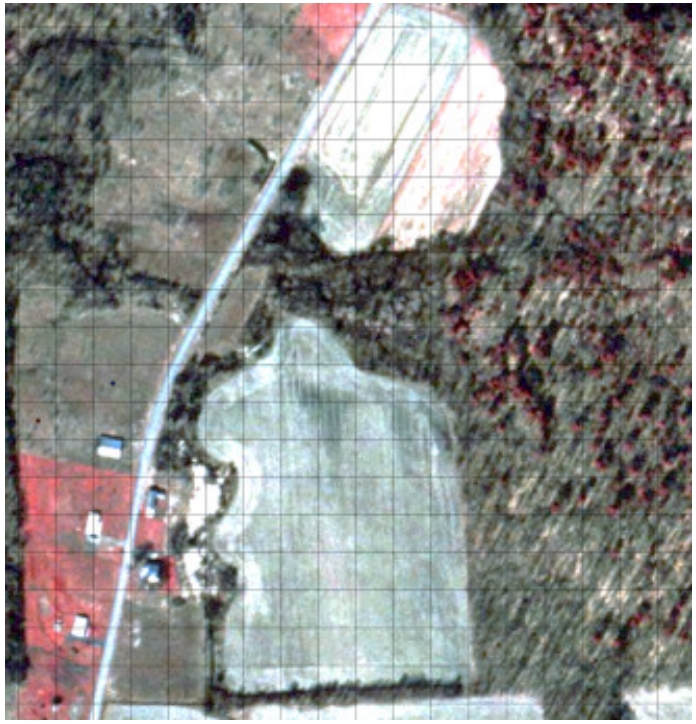
GD (Gaussian Decomposition) = Existing benchmark method

Forest Succession Model

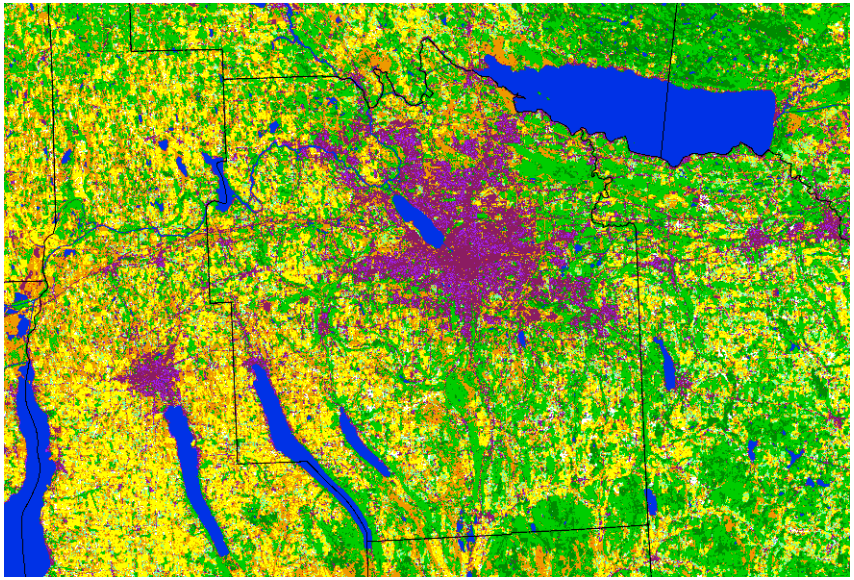


Methods

- State-based Markov transition model of land cover change
- ~2600 points classified

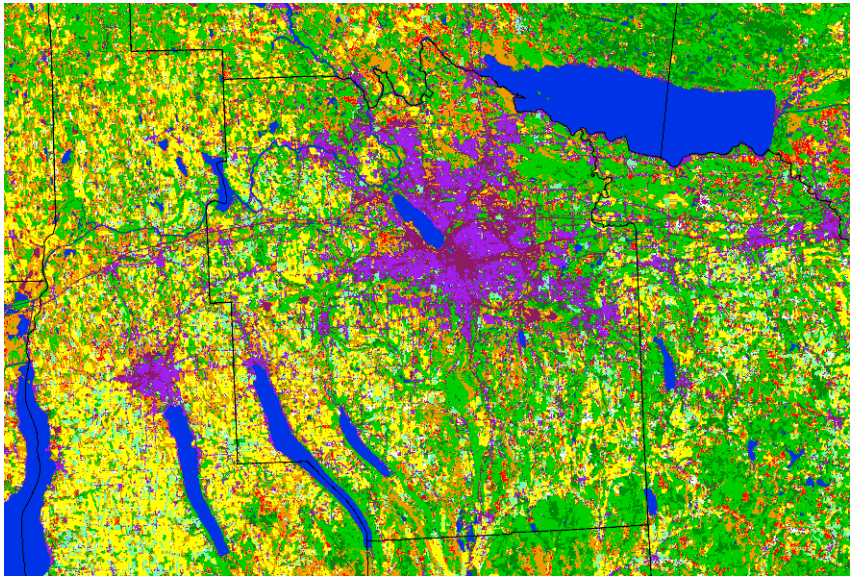


Forest Succession Results



1985

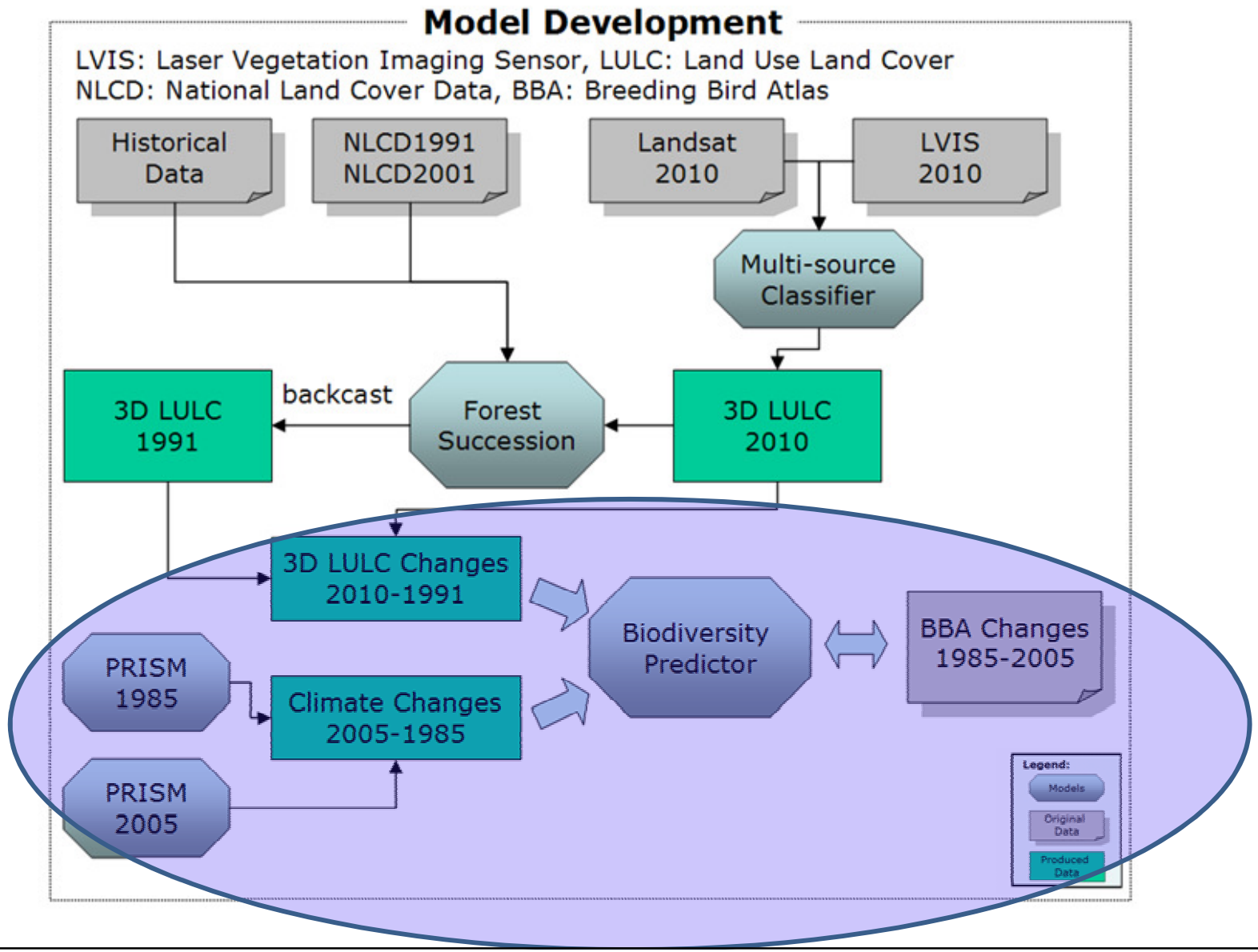
- 01Water
- 03Residential
- 04Urban
- 05Coniferous
- 06Deciduous
- 09Shrub
- 10Cloud
- 12Grass
- 13Old-field
- 14Agriculture



2005

Biodiversity Model

Community turnover



METHODS

Response:

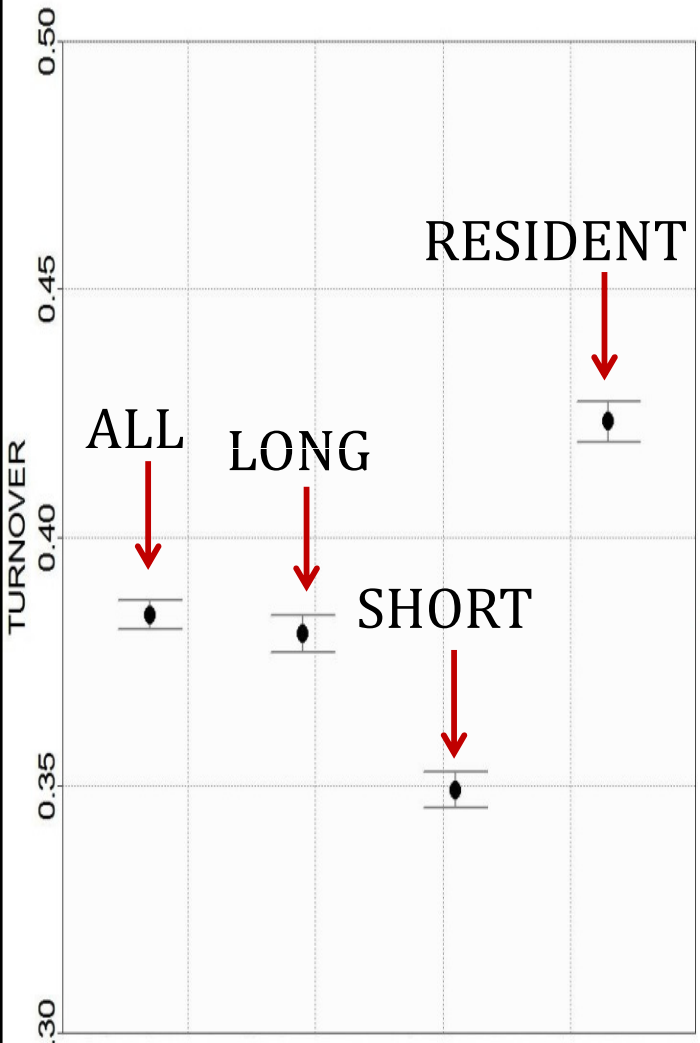
- Temporal Turnover (BBA 1980s-2000s): TURN = (E+C)/(E+C+P)
- Extinction (BBA 1980s-2000s): EXT = E/(E+P)
- Colonization (BBA 1980s-2000s): COL = C/(E+C+P)

Covariates:

- Temporal (1980-2005) trends in climatic covariates: Maximum Temp (TMAX, °C/25 years), Minimum Temp (TMIN, °C/25 years), Precipitation (PRECIP, mm/25 years).
- Landscape fragmentation: Edge density (ED, m/ha), Percent Developed Land (DEVEL, %)
- Change in Survey Effort (EFF)

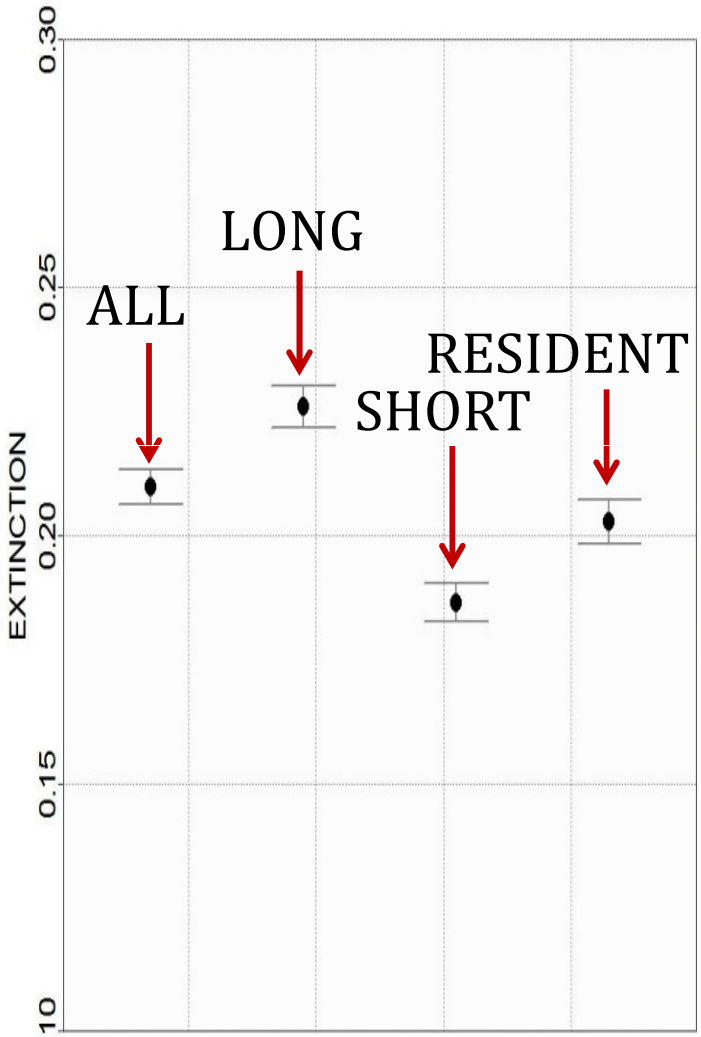
CHANGE IN AVIAN ASSEMBLAGE

TEMPORAL TURNOVER



97.5 percentile
50 percentile (mean)
2.5 percentile

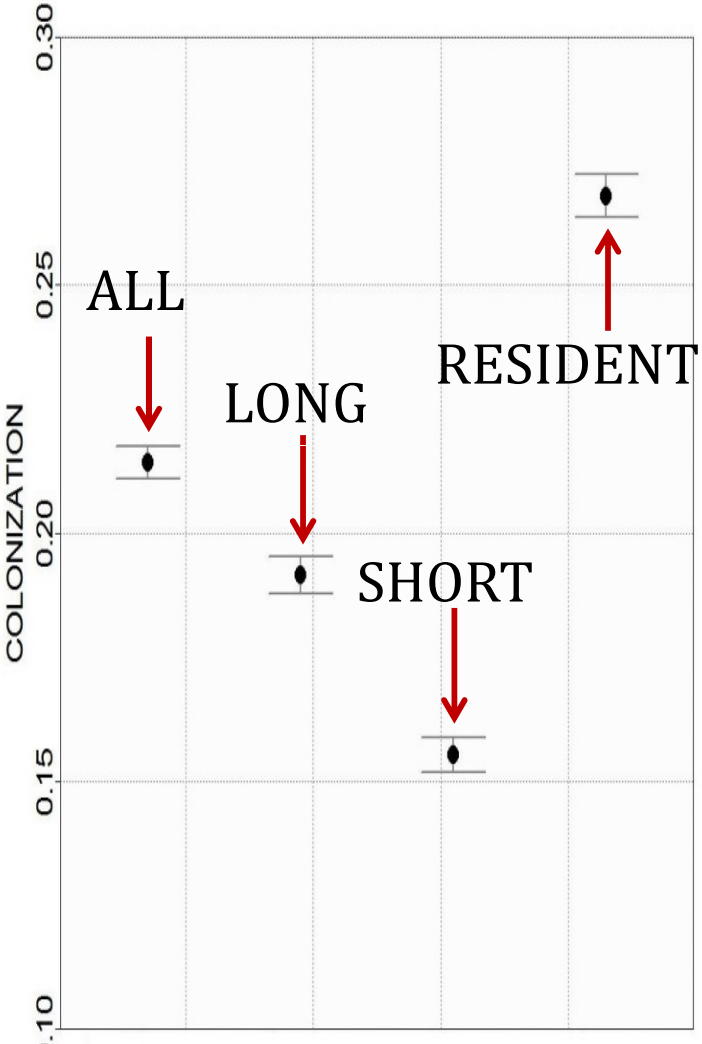
EXTINCTION



ALL SPECIES: N = 256

LONG-DISTANCE: N = 110

COLONIZATION

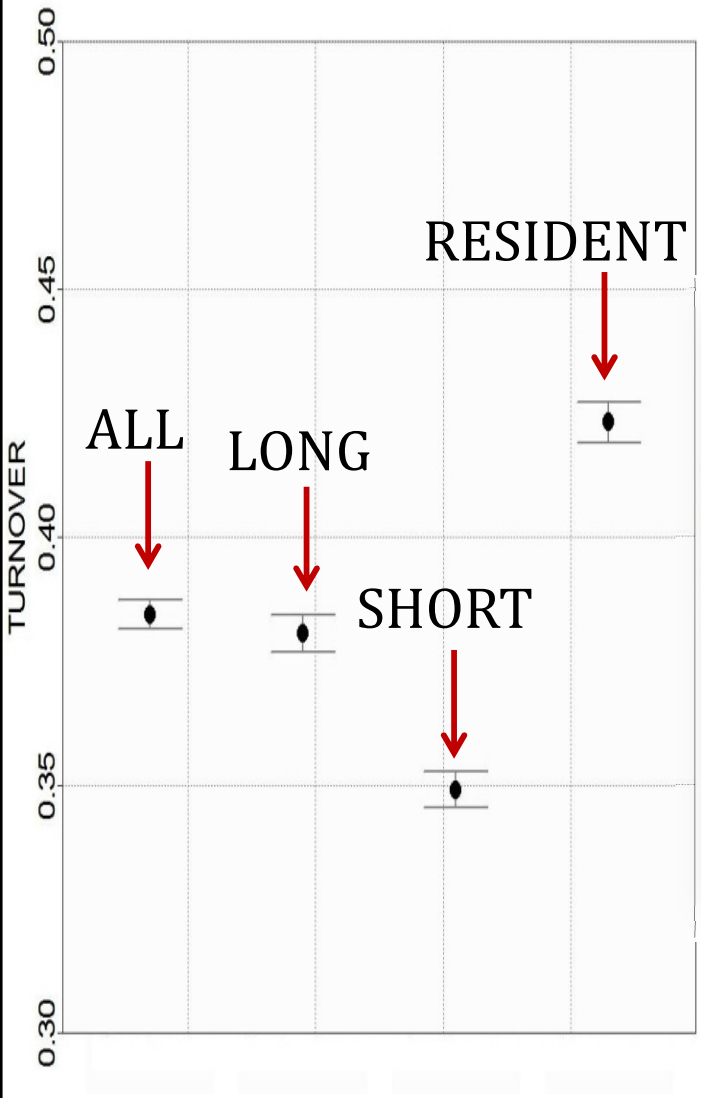


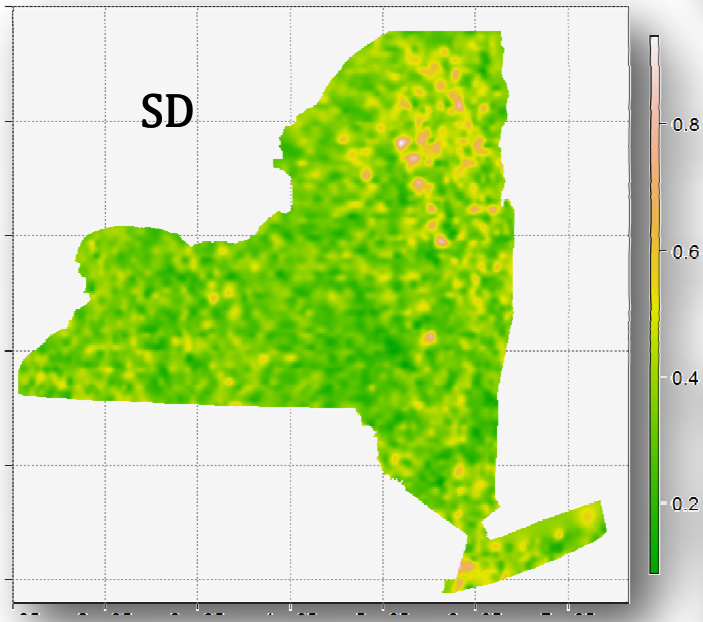
SHORT-DISTANCE: N = 67

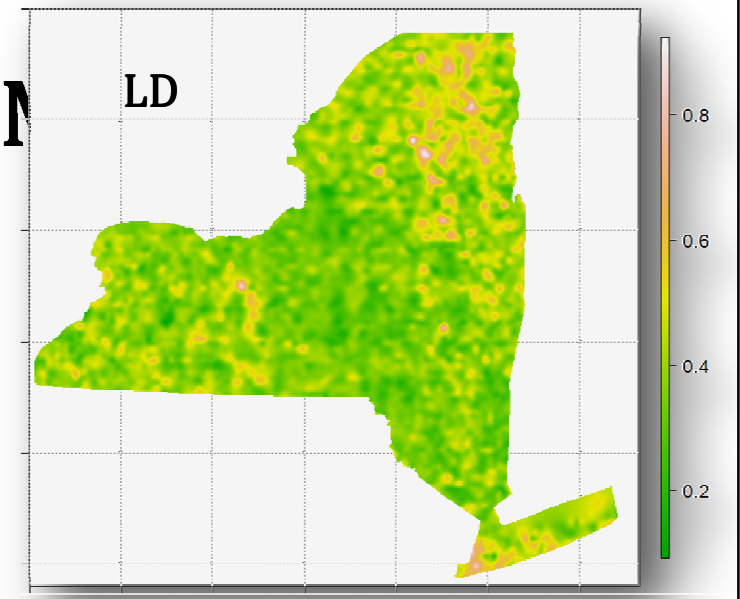
RESIDENT: N = 79

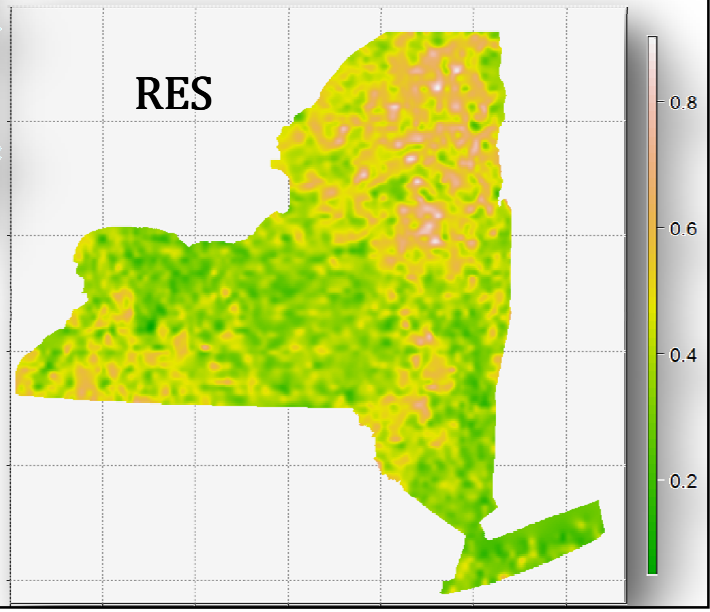
CHANGE IN AVIAN ASSEM

TEMPORAL TURNOVER









METHODS

Statistical models:

Binomial distribution

Space-varying intercept models in spBayes package (accounting for spatial autocorrelation)

Competing models:

Dependent variables: TURN, EXT, COL

Model 1: TMAX, TMIN, PRECIP, EFF

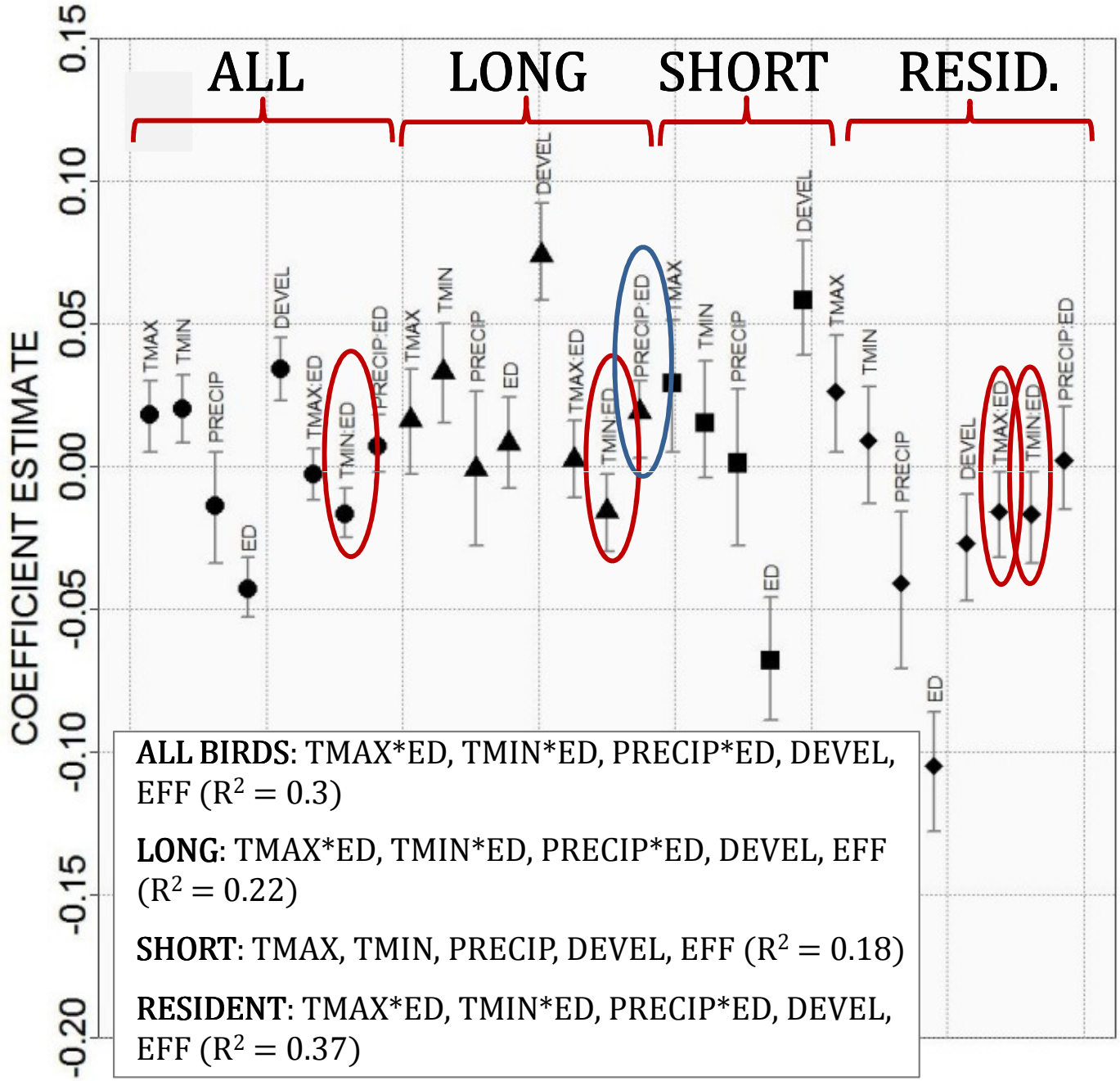
Model 2: TMAX, TMIN, PRECIP, ED, EFF

Model 3: TMAX*ED, TMIN*ED, PRECIP*ED, EFF

Model 4: TMAX, TMIN, PRECIP, ED, DEVEL, EFF

Model 5: TMAX*ED, TMIN*ED, PRECIP*ED, DEVEL, EFF

RESULTS



ALL BIRDS: TMAX*ED, TMIN*ED, PRECIP*ED, DEVEL, EFF ($R^2 = 0.3$)

LONG: TMAX*ED, TMIN*ED, PRECIP*ED, DEVEL, EFF ($R^2 = 0.22$)

SHORT: TMAX, TMIN, PRECIP, DEVEL, EFF ($R^2 = 0.18$)

RESIDENT: TMAX*ED, TMIN*ED, PRECIP*ED, DEVEL, EFF ($R^2 = 0.37$)

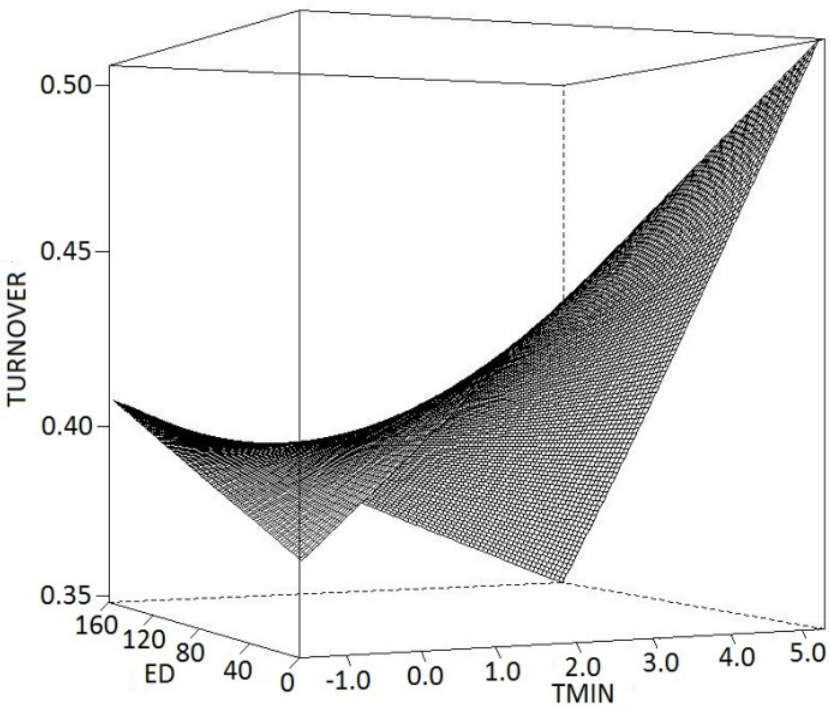
Best models (DIC) for **Temporal Turnover**

Climate-land cover **interactions** are important

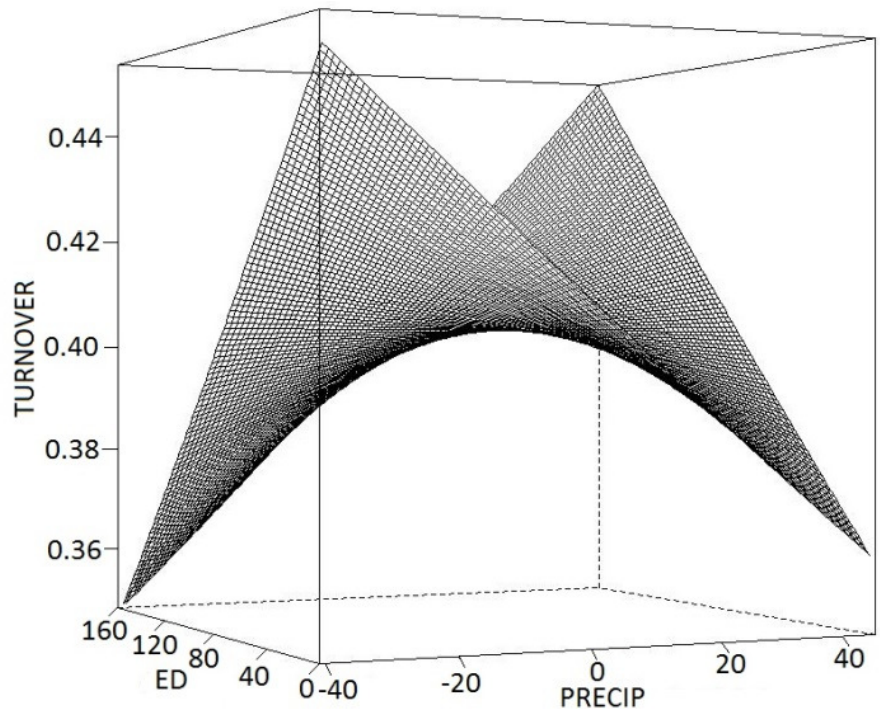
No clear differences between different migratory groupings for any of the community change metrics

RESULTS

What do these significant interactions mean? How do climate and land cover interact to shape changes in community structure?



Stronger associations between community change and **TEMP** in regions with unfragmented habitats.



Negative associations between community change and **PRECIP** in regions with unfragmented habitats, but positive in fragmented regions.

BIG PICTURE

Significant improvements in LiDAR data processing.

RADAR integration still in progress.

Interactions between avian community and climate dynamics may be different based on fragmentation level.

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