US EPA ARCHIVE DOCUMENT

Ecological Indicators for Floodplain Forests of the Wisconsin River

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“Ecological investigations...have demonstrated [riparian corridors] to be key landscape features...[that] maintain biodiversity by providing an unusually diverse array of habitats and ecological services.”

- Naiman et al. 1993

Overall Project Objectives

- Identify landscape metrics that are most useful for monitoring population, community, and ecosystem processes in large-river floodplains.

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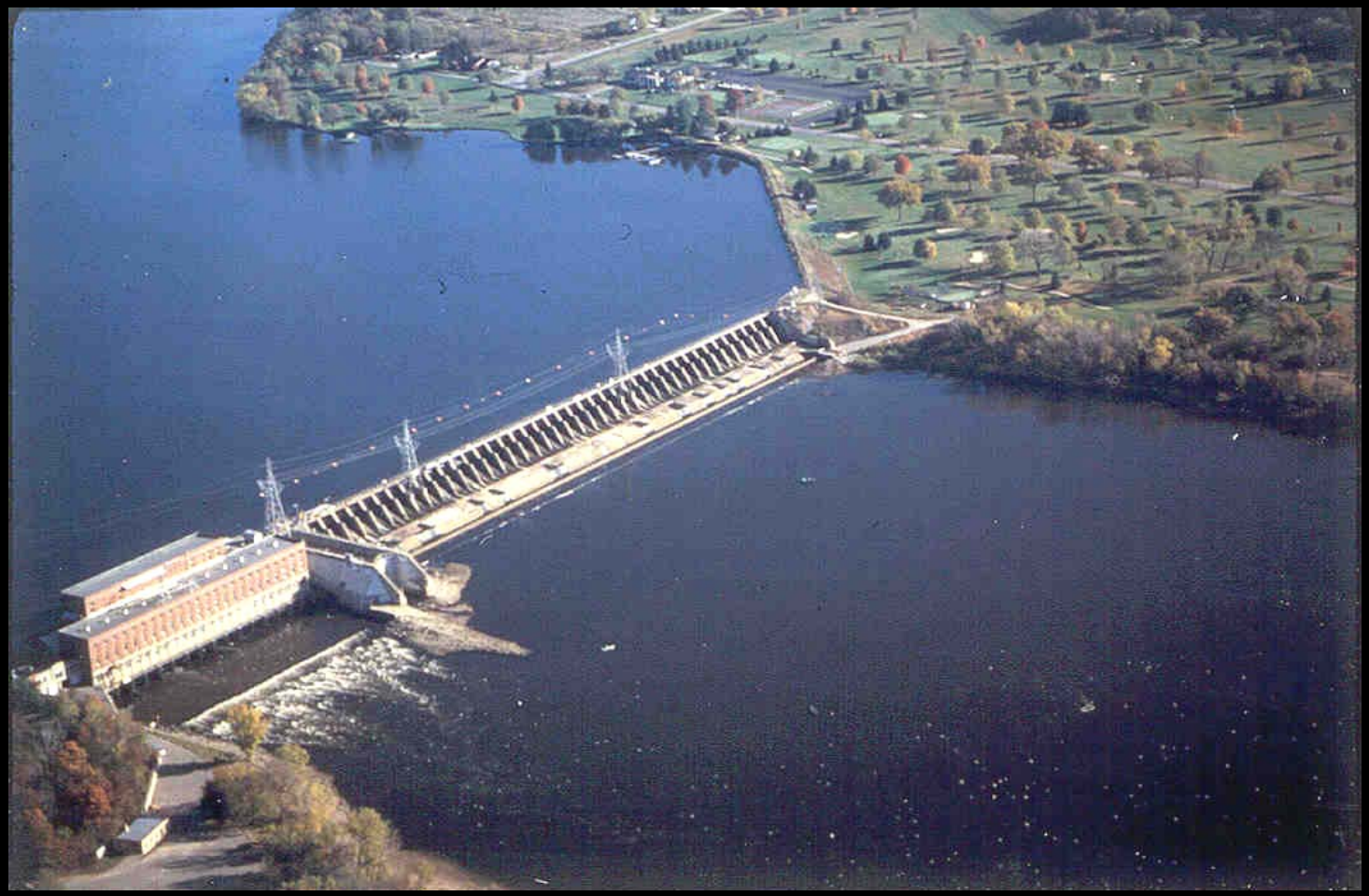
- Identify landscape metrics that are most useful for monitoring population, community, and ecosystem processes in large-river floodplains.
- Identify the constraints on extrapolating relationships between landscape metrics and ecological processes in large-river floodplains.

Motivation

- Development of indicators that use available data and correlate well with ecological function is a widely recognized research need.
- Many existing data sources can be used to quantify patterns.
- Many important environmental changes occur at spatial scale of landscapes.

Habitat Fragmentation

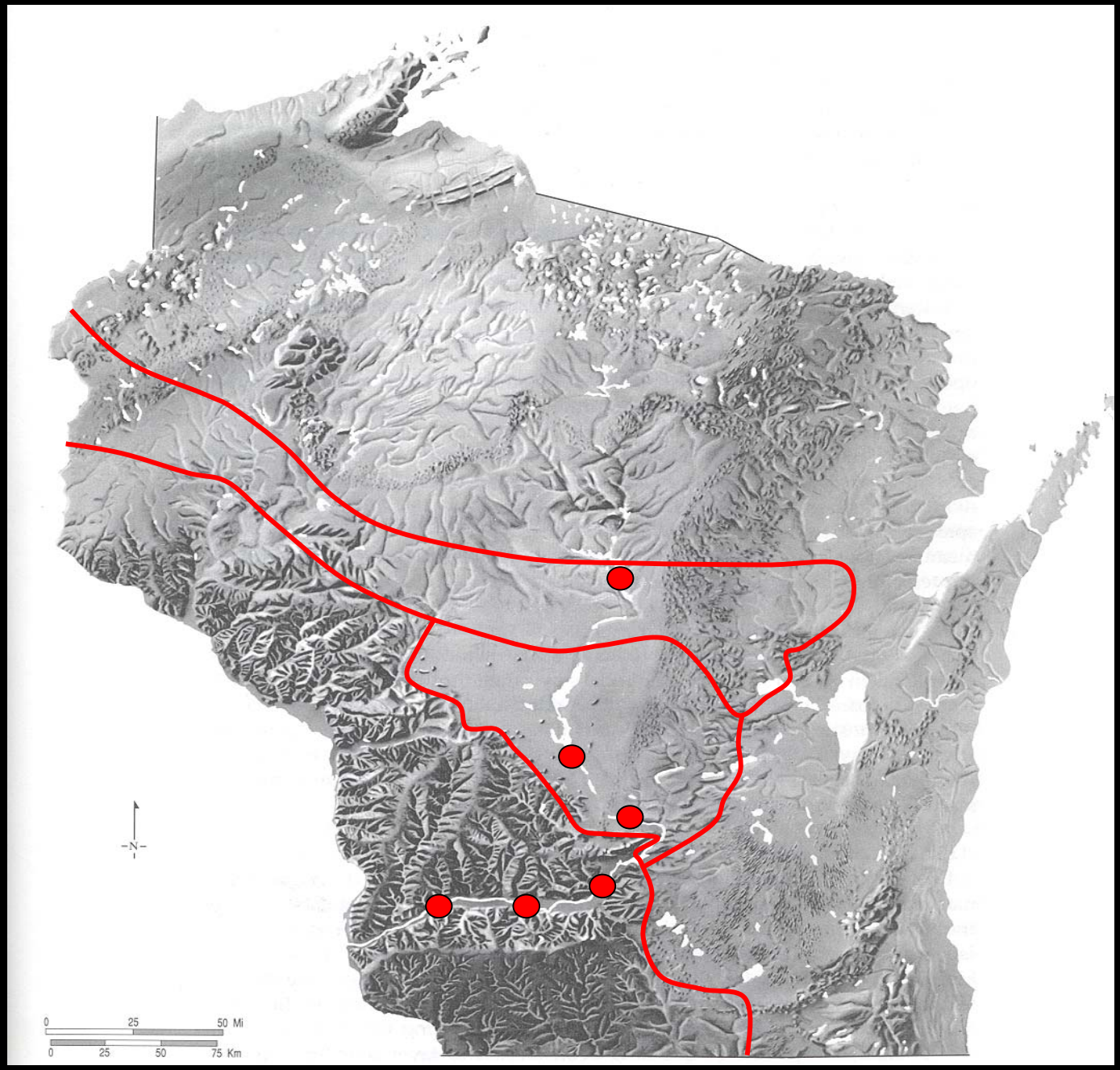
Land-use Change



Hydrologic Alteration

Approach

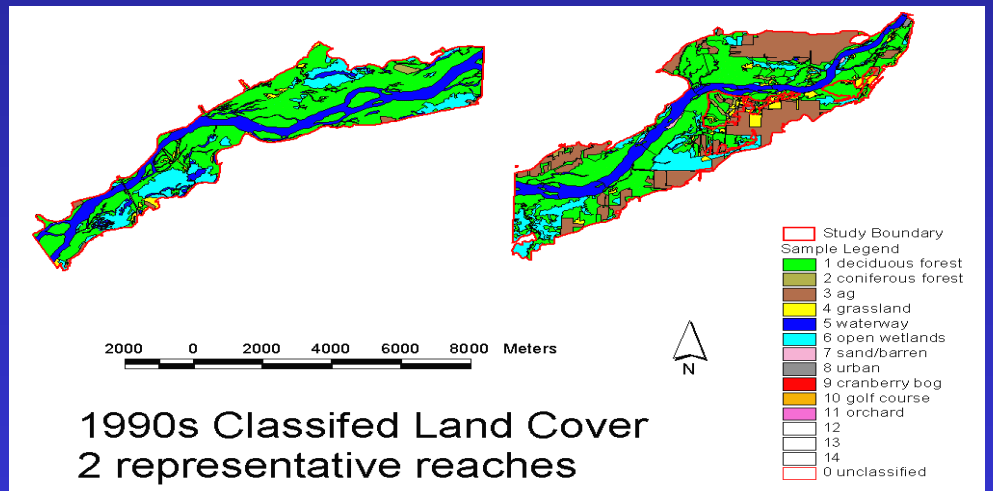
- 1999-2001
  - Conduct intensive yet broad-scale field studies in six study reaches.
  - Relate landscape metrics to ecological response variables.
- 2002
  - Test predicted relationships in three new reaches.
  - Assess constraints on extrapolation through statistical analyses and modeling.


N
0 25 50 Mi
0 25 50 75 Km

Study Reach Characteristics

Reach	Length (km)	Area (km^2)	% Forest	Dist. up (km)
Stevens Point	12	17	47	329
Necedah	20	33	53	223
Wisc. Dells	21	106	42	178
Sauk City	18	53	44	118
Spring Green	18	32	49	88
Blue River	16	27	57	40

Blue River



Wisconsin Dells

Dominant Trees

- River Birch (*Betula niger*)
- Cottonwood (*Populus deltoides*)
- Silver Maple (*Acer saccharinum*)

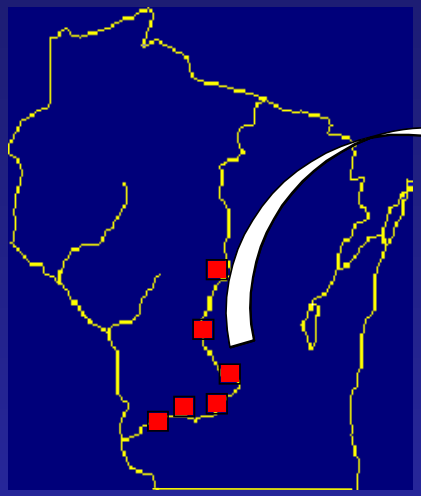
↓

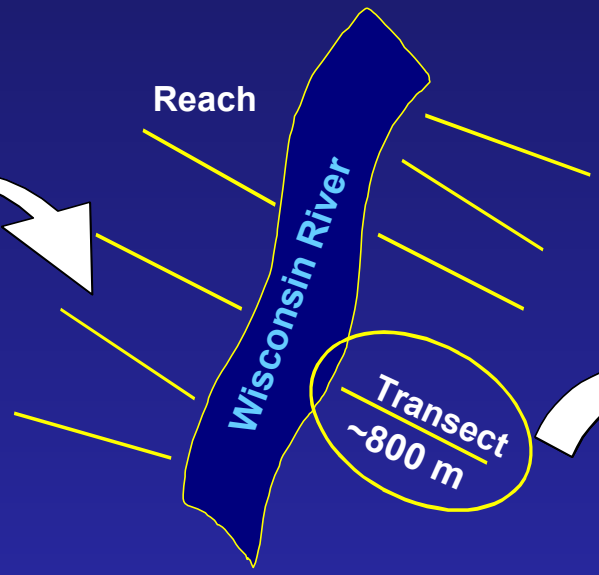
- Green Ash (*Fraxinus pennsylvanica*)
- American Elm (*Ulnus americana*)
- Swamp White Oak (*Quercus bicolor*)

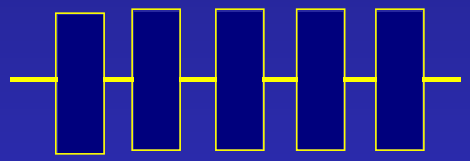
↓

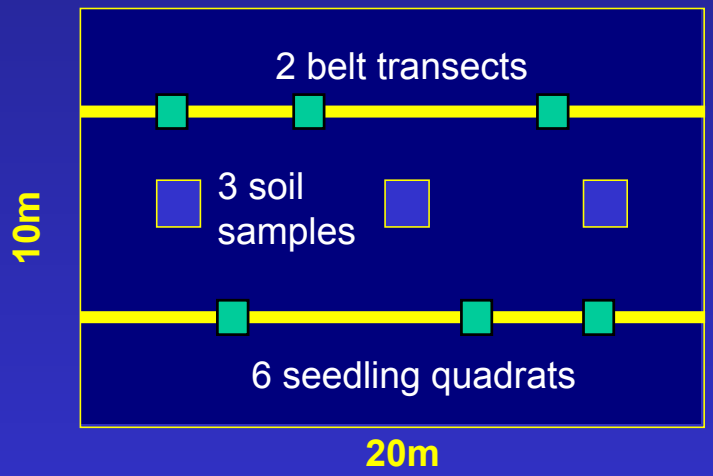
- Basswood (*Tilia americana*)
- Northern Hackberry (*Celtis occidentalis*)
- Bitternut Hickory (*Carya cordiformis*)
- Oak spp. (*Quercus* spp.)

Field Sampling









Plots separated by ≥120 m

Data Analyses

- Community structure
  - Ordination (CA and CCA)
- Occurrence of species
  - Logistic regression
- Abundance of species (when present), functional groups
  - Multiple regression

Key Tree Species

Floodplain Forest Birds

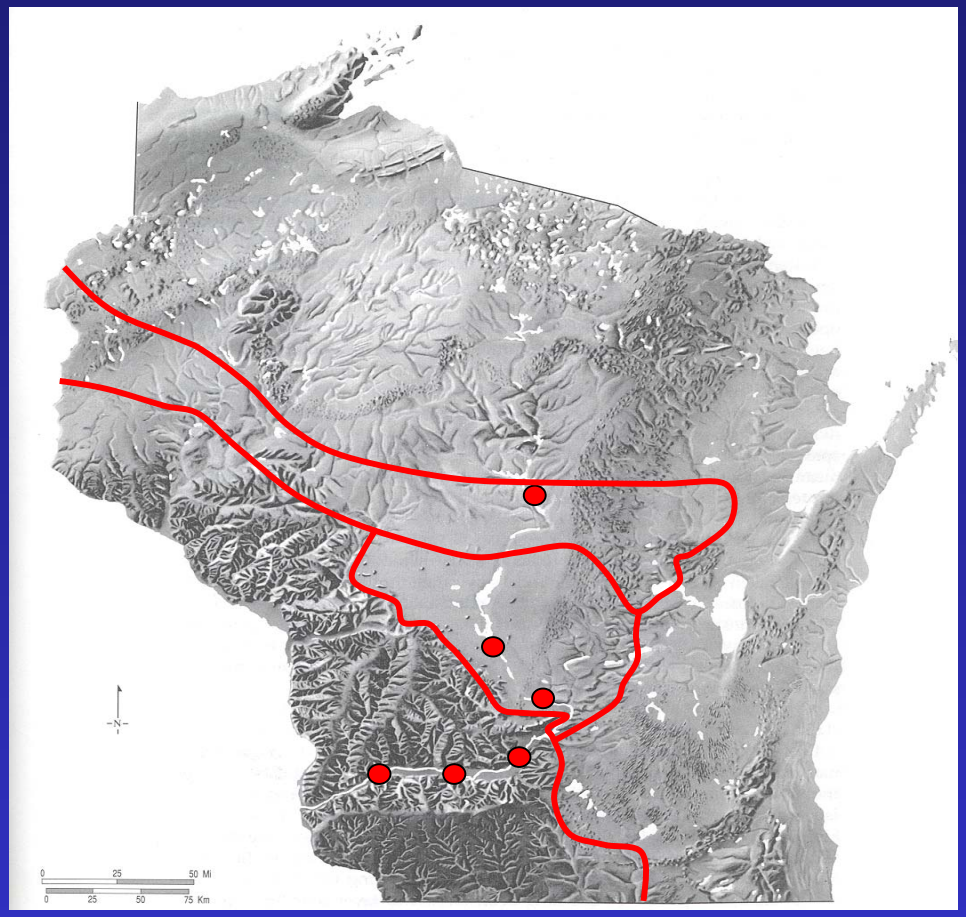
Questions – Tree Species

- How do geography, flooding, land cover and soils influence riparian forests in the Wisconsin River floodplain?

Questions – Tree Species

- How do geography, flooding, land cover and soils influence riparian forests in the Wisconsin River floodplain?
- Can “landscape indicators” explain variation in the floodplain forest, or are local field measurements (soils) needed?

Geographic Measures



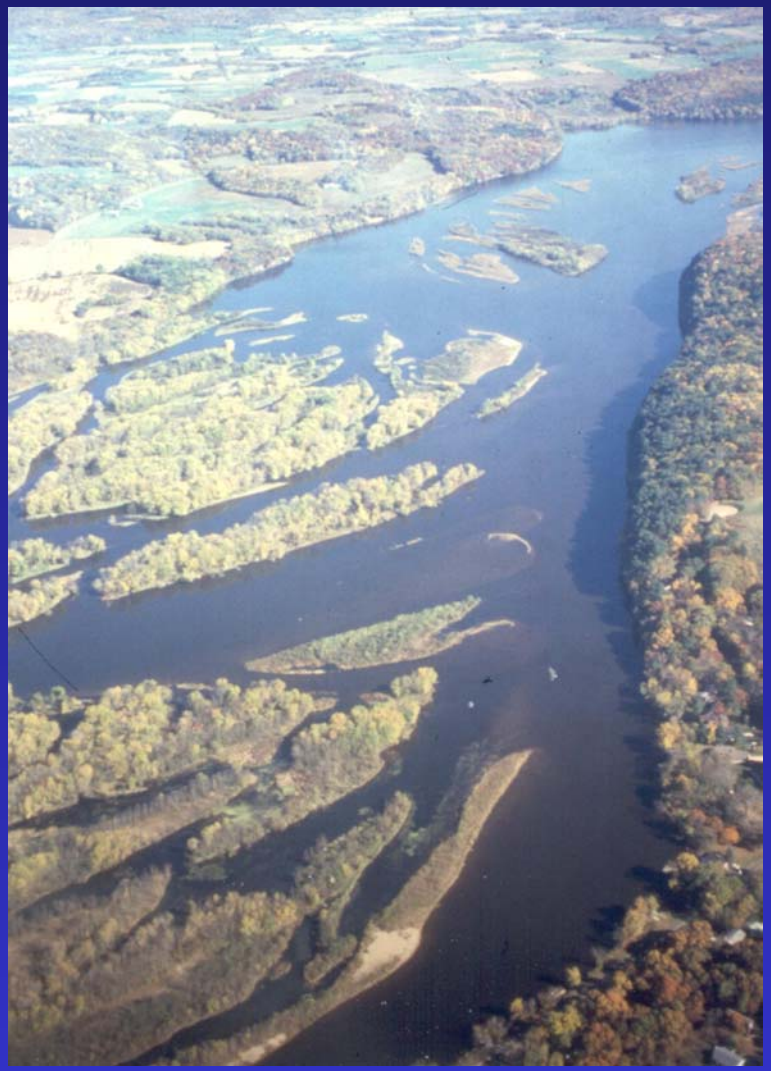
- River distance from the Mississippi River
- Northing
- Easting
- Geographic Province

Measures of Flooding Potential

- lateral distance to Wisconsin River
- relative elevation of plot
- inside/outside levee

Forest Patch Measures

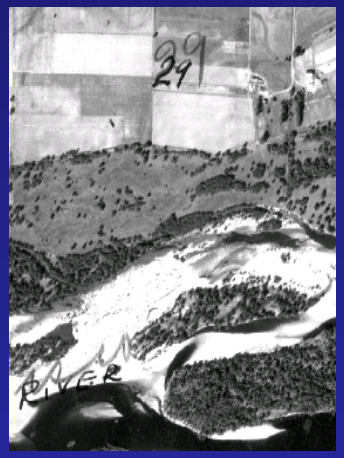
- patch area
- distance to forest edge



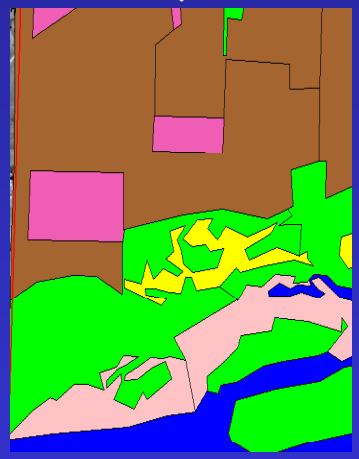
Land-cover history obtained from aerial photography

(Freeman et al. In Press)

1937

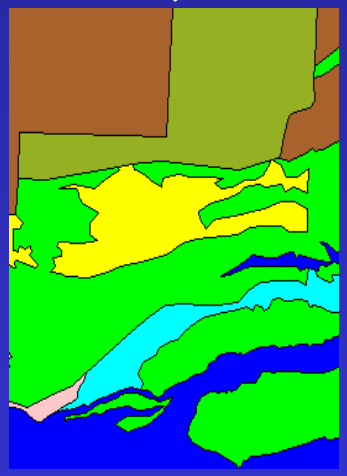


INTERPRETATION



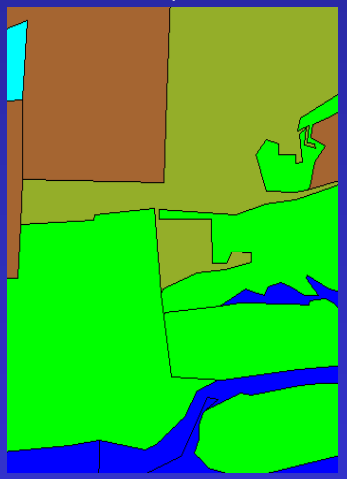
1968

INTERPRETATION



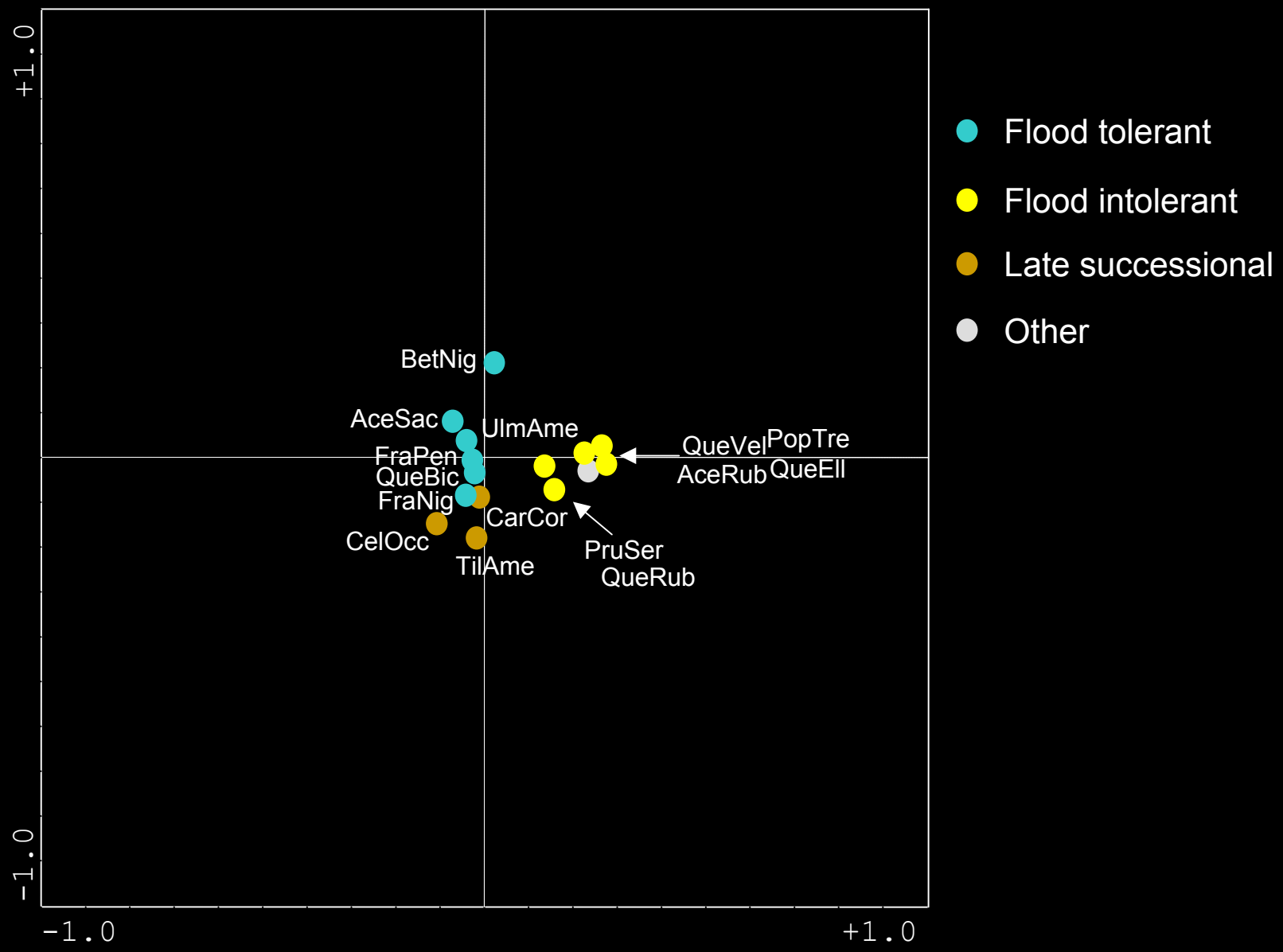
1992

INTERPRETATION



Methods

- Vegetation sampled in 405 plots (10 m x 20 m)
- All trees > 2.5 cm dbh identified to species and dbh recorded
- Composite soil sample obtained on each plot for %organic matter, texture, cations, pH


+1.0
-1.0
-1.0
+1.0
BetNig
AceSac
UlmAme
FraPen
QueBic
FraNig
CelOcc
TilAme
CarCor
QueVel
PopTre
AceRub
QueEll
PruSer
QueRub
Flood tolerant
Flood intolerant
Late successional
Other

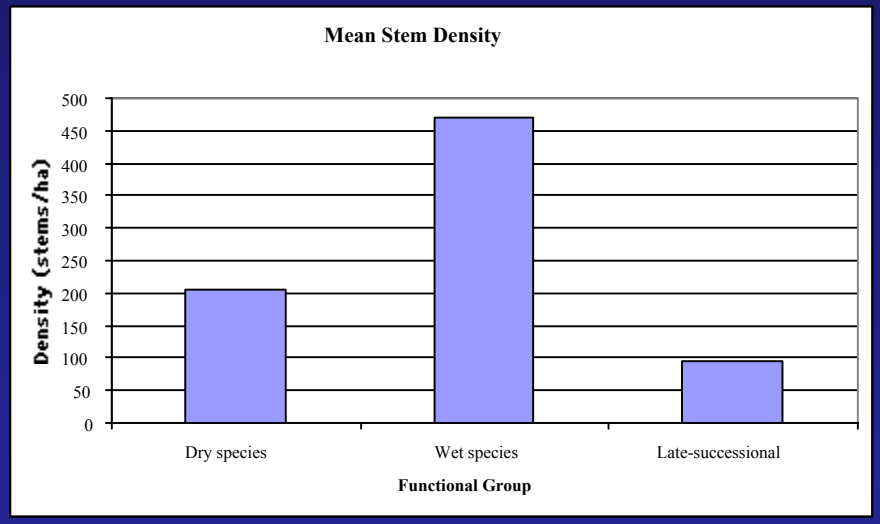
Functional Groups

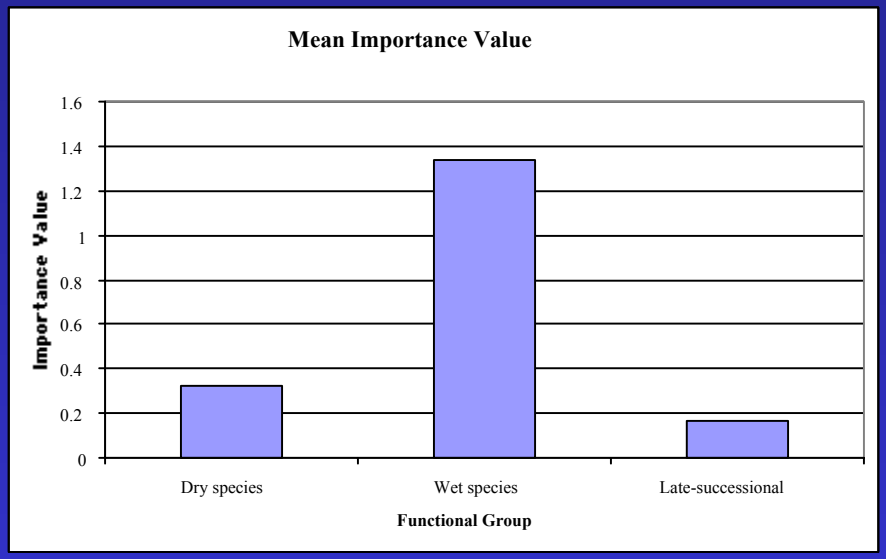
Group	Species
Flood tolerant (wet)	*Acer saccharinum, Betula nigra, Fraxinus nigra, Fraxinus pennsylvanica, Populus deltoides, Quercus bicolor, Salix nigra, Ulmus americana*
Flood intolerant (dry)	*Quercus ellipsoidalis, Quercus velutina, Quercus rubra, Prunus serotina, Populus tremuloides*
Late successional	*Carya cordiformis, Carpinus caroliniana, Tilia americana*

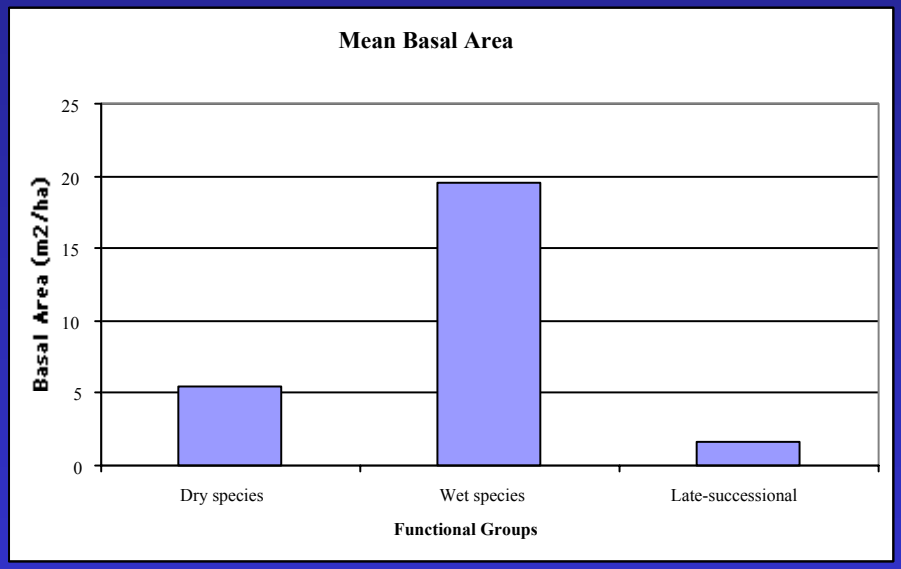
Mean abundance measures for functional groups (n=405)

Flood-tolerant species were dominant

Subsequent analyses reported for Importance value

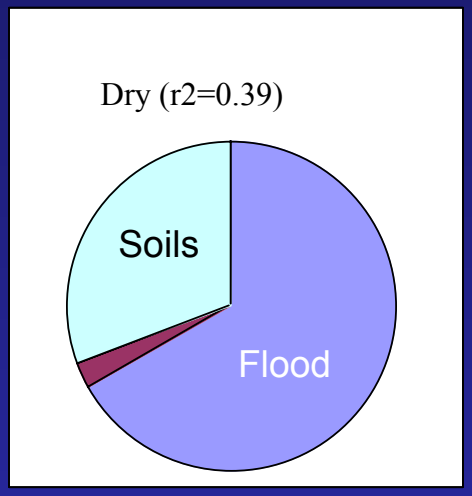


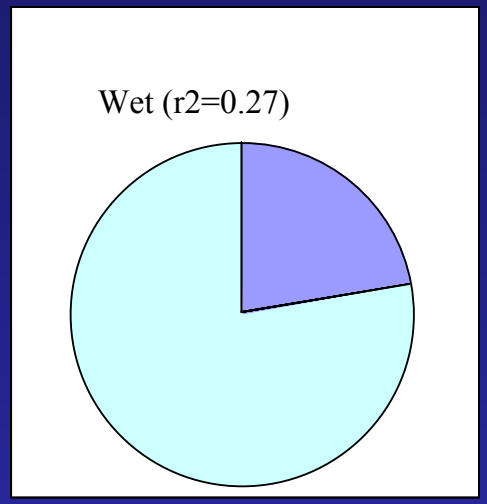


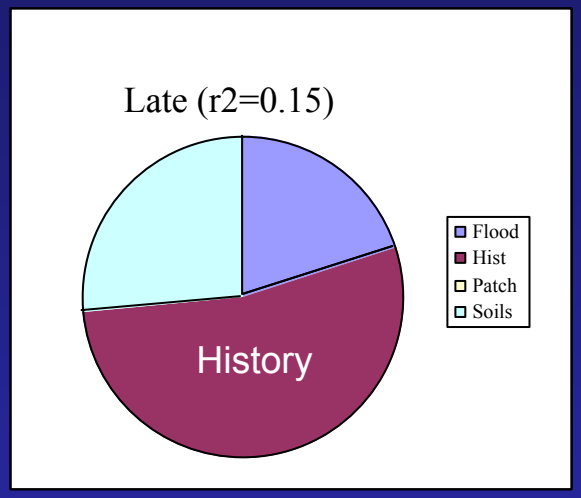


Multiple Regression on Importance Values
(relative contribution to explained variance)

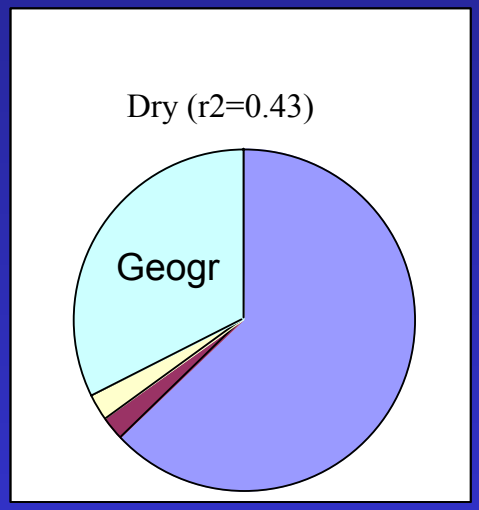
With soils

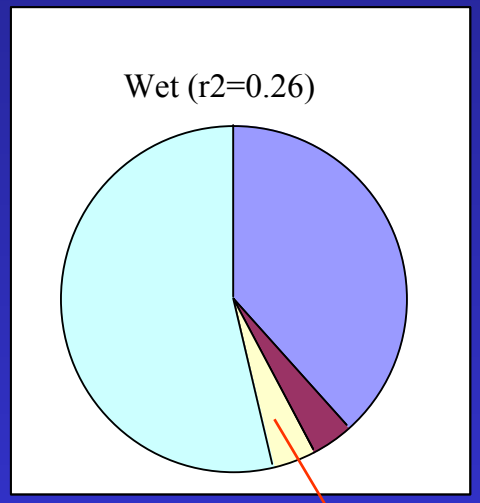




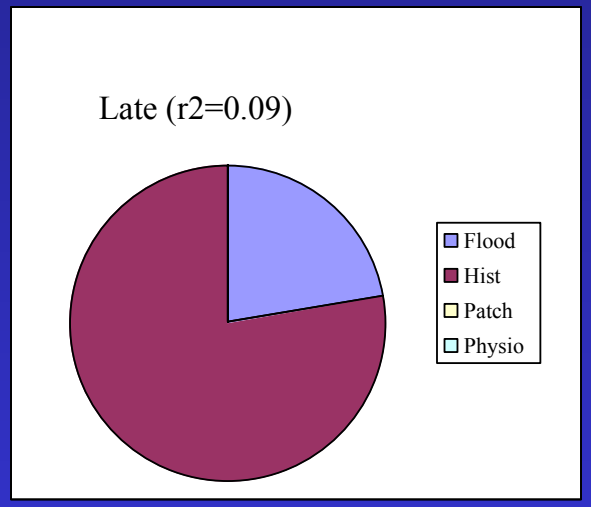


Without soils





Patch



Functional Groups–Summary

- Flooding influence dominated by levee effect
- Land-cover history significant
- Dry species explained mostly by levee
  - Also soils or geographic province
- Wet species explained mostly by soil or geographic province
  - Also levee effect
- Late species explained by land-cover history

  Also levee effect

- Comparable models with and without soils
  - Landscape indicators generally worked well.

Focal Species
(occurred on at least 10% of plots)

Species	Abbrev.	Common Name
Acer saccharinum	AceSac	Silver maple
Betula nigra	BetNig	River birch
Carya cordiformis	CarCor	Yellowbud hickory
Fraxinus pennsylvanica	FraPen	Green ash
Quercus bicolor	QueBic	Swamp white oak
Quercus velutina	QueVel	Black oak
Ulmus americana	UlmAme	American elm

Models - Species Presence

Without soils

Species	Geogr	Flooding	History	Patch	Concordance
AceSac	X	X		X	65%
BetNig	X	X	X		69%
FraPen		X	X		66%
QueBic	X		X		70%
UlmAme	X				65%
QueVel	X	X	X	X	75%
CarCor		X	X		69%

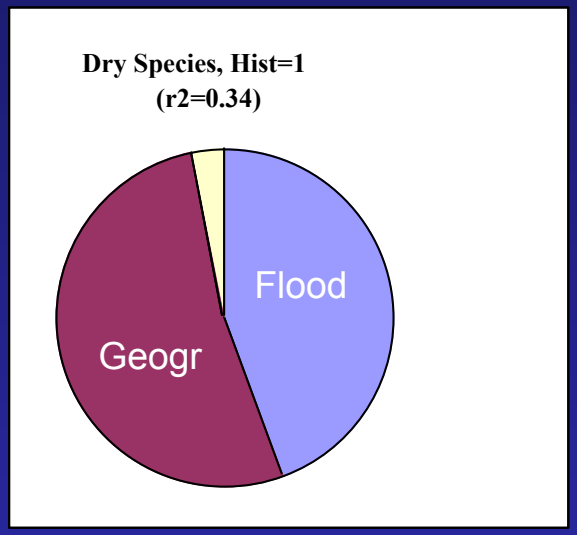
With soils

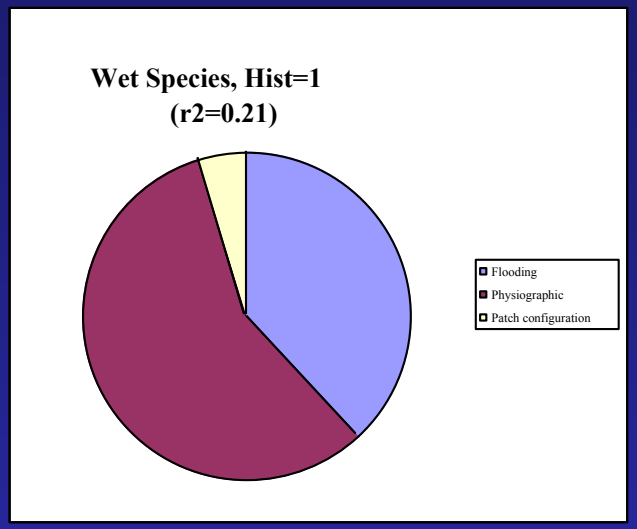
Species	Geogr	Flooding	Hist	Patch	*Soils*	Concordance (% change)
AceSac					X	70% (+5)
BetNig					X	61% (-8)
FraPen		X	X			60% (-2)
QueBic		X	X			60% (+2)
UlmAme	X				X	66% (+1)
QueVel	X	X	X	X	X	85% (+10)
CarCor			X		X	68% (+2)

Variation in Importance Value with Land-use History

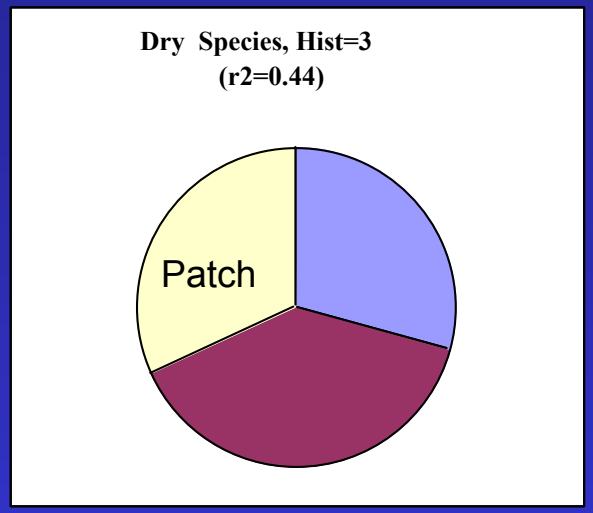
Will patch configuration matter more in disturbed forest?

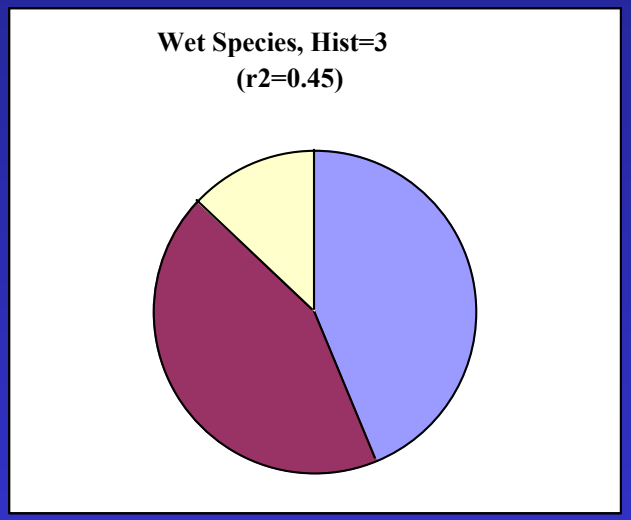
Forested before 1930s





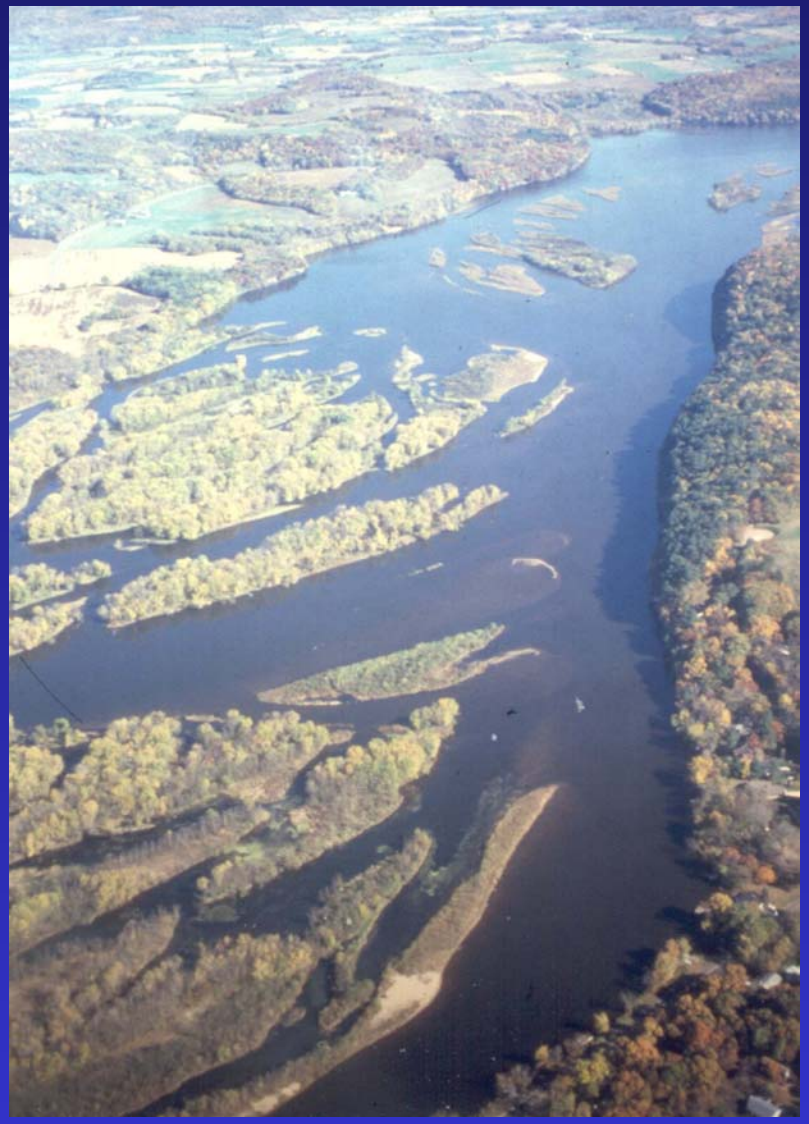
Forested since 1960s





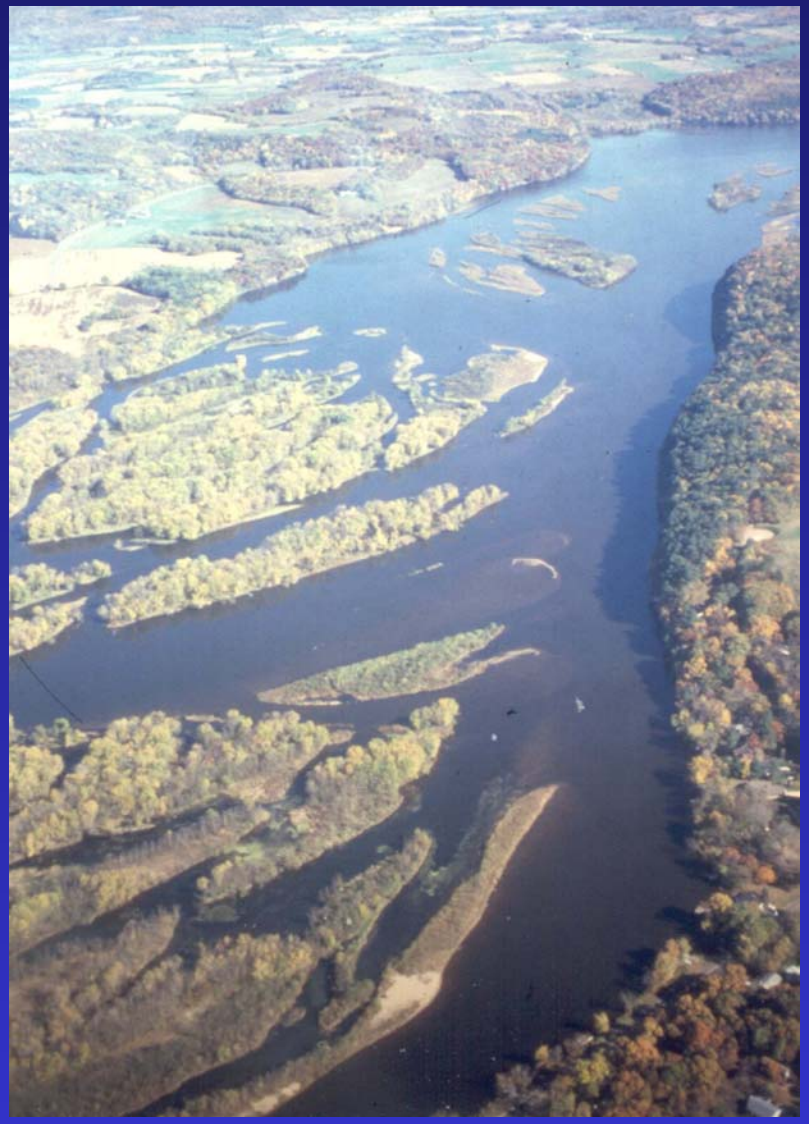
Conclusions

- Abiotic template is important for floodplain trees, especially for flood-tolerant species



Conclusions

- Abiotic template is important for floodplain trees, especially for flood-tolerant species
- Effects of human-induced changes must be considered to explain variation in the floodplain forest
  - Historic land cover
  - Modification of flow



Key Tree Species

Floodplain Forest Birds

Coal Creek, Colorado

Baraboo River, Wisconsin

Questions – Floodplain Birds

- To what extent do broad-scale measures account for variation in habitat occupancy by forest birds in a large-river floodplain?

Questions – Floodplain Birds

- To what extent do broad-scale measures account for variation in habitat occupancy by forest birds in a large-river floodplain?
- How much additional variation can be explained by local habitat measures?

Community

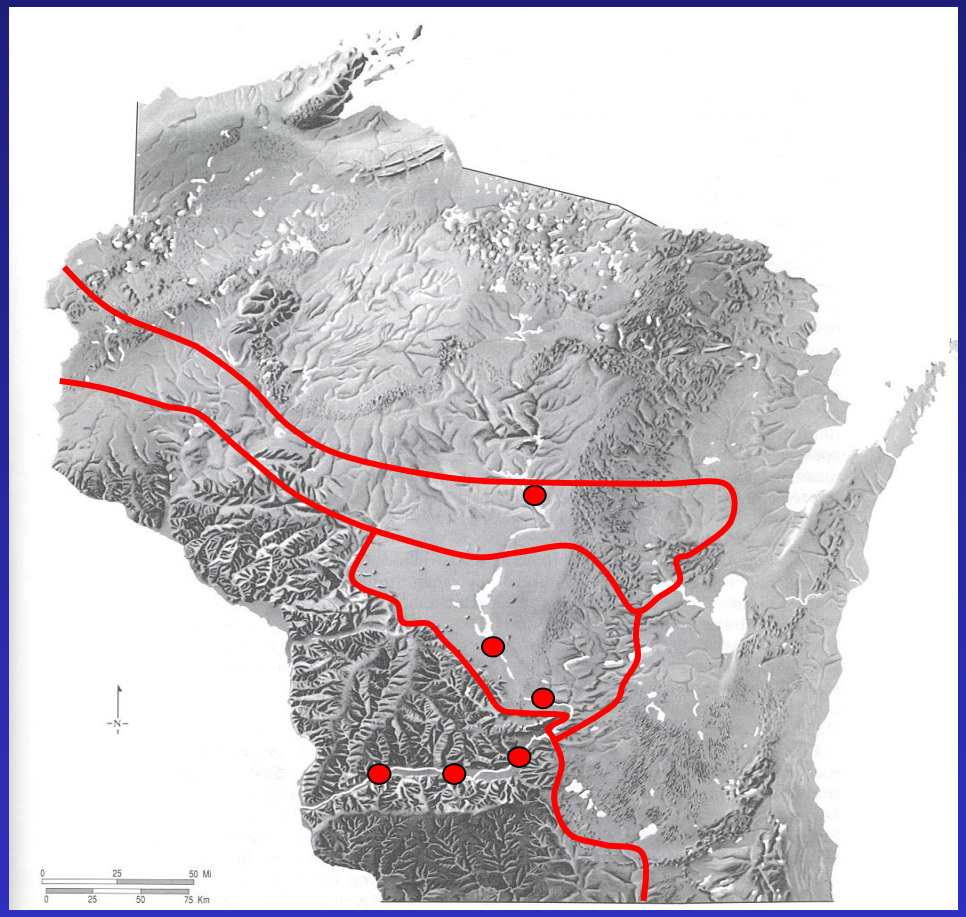
Generality

Guilds

Detail

Individual Species

Geographic Measures



- River distance from the Mississippi River
- Northing
- Easting
- Geographic Province

Landscape Measures

- patch area
- distance to patch edge
- distance to river
- floodplain forest width

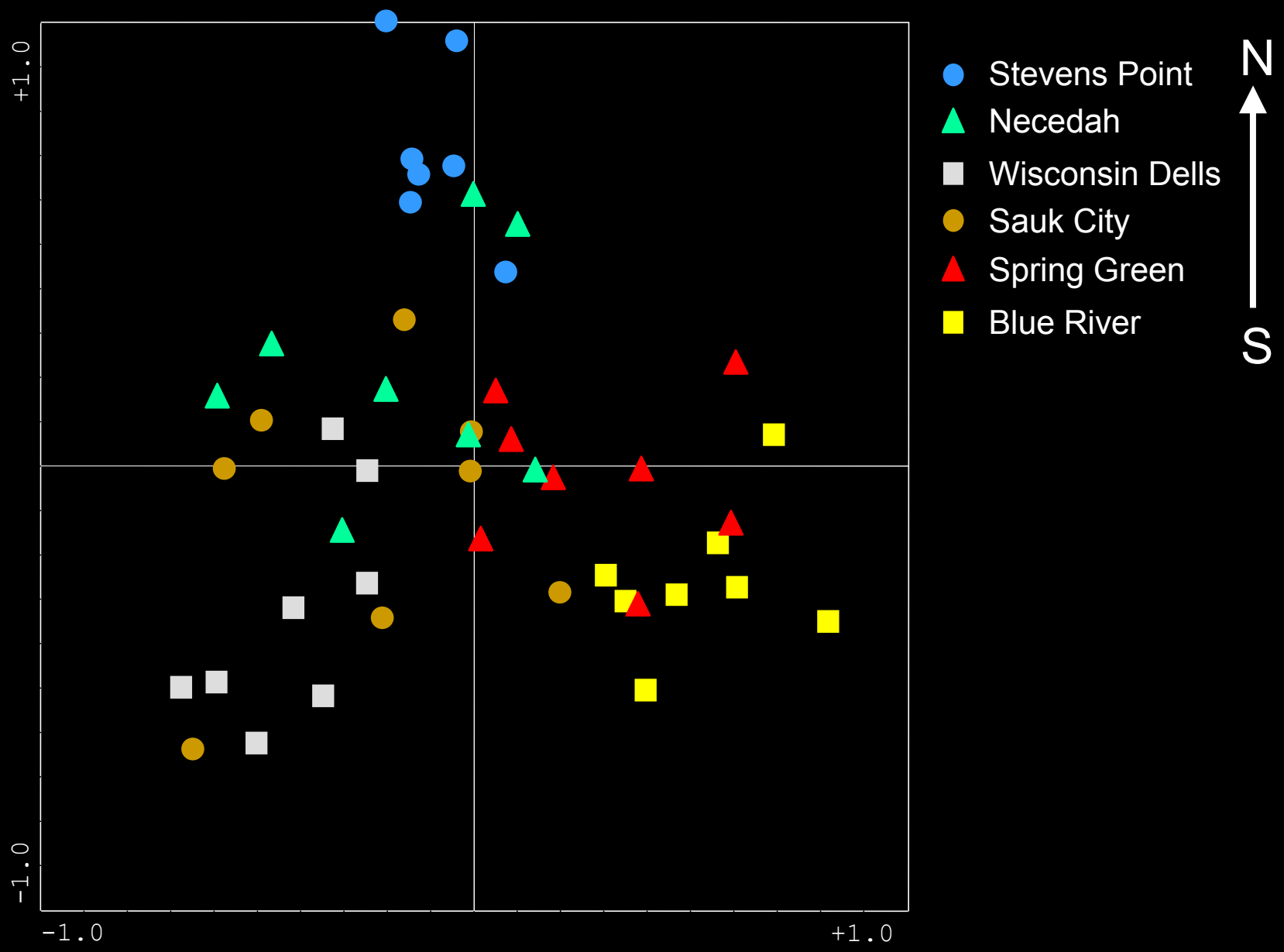
- forested area surrounding a transect within:
  - 100 m
  - 500 m
  - 1500 m
  - 3000 m

Local Habitat Measures

- canopy cover (3 layers)
- shrub cover
- herbaceous ground cover
- dominant tree species
- flood tolerance of dominant trees
- invasive shrubs
- number of lg. trees (>30cm dbh)
- number of standing dead trees
- canopy breaks
- land cover in 1930s and 1960s

Bird Surveys

- point counts
- 6 reaches
- 8 transects per reach
- 5 points per transect
- points ≥120 m apart
- all birds seen and heard
- multiple observers
- 1999-2000
- 2x during the breeding season


+1.0
-1.0
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+1.0
Stevens Point
Necedah
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N
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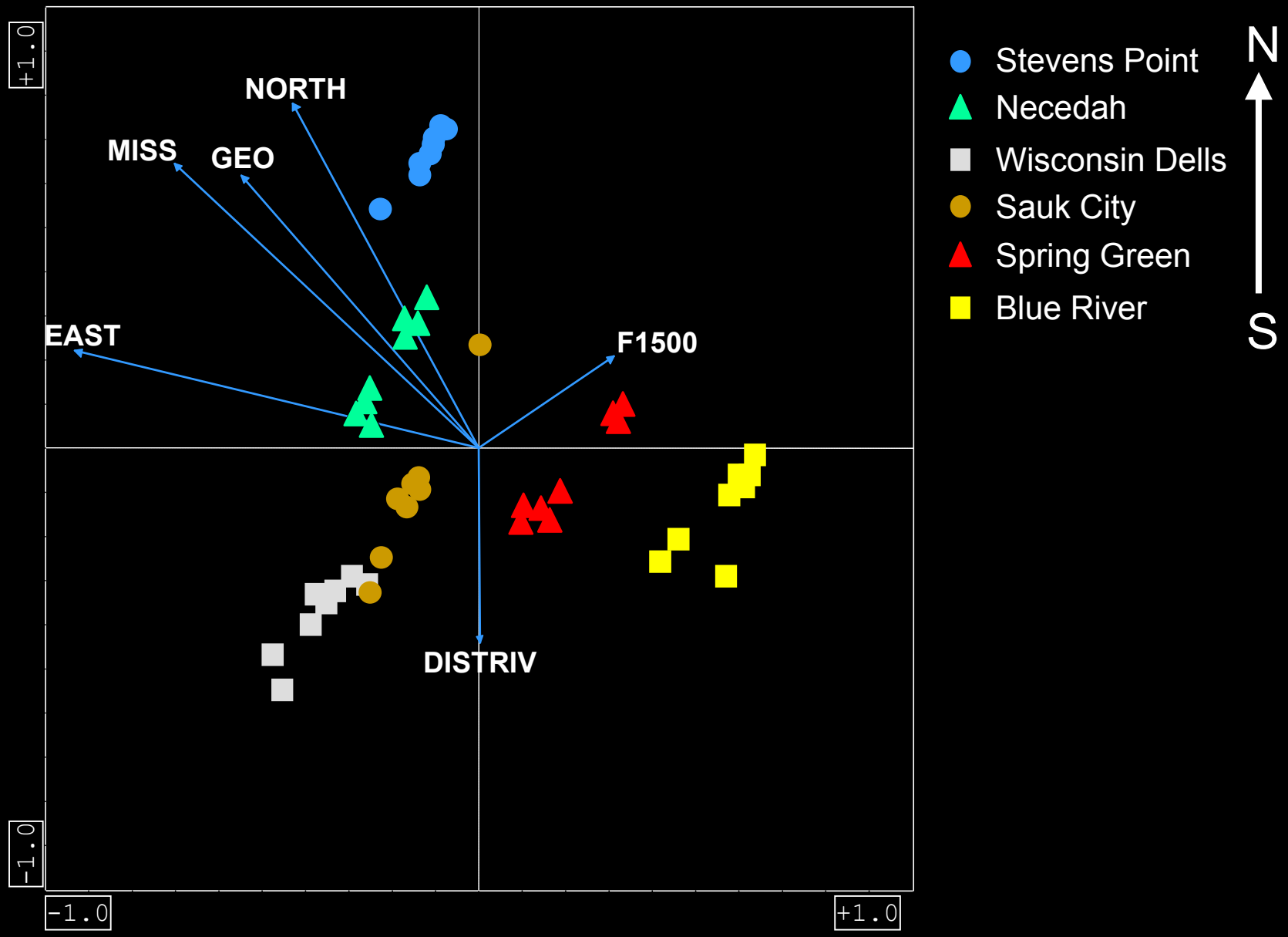
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NORTH
MISS
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F1500
DISTRIV
Stevens Point
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Sauk City
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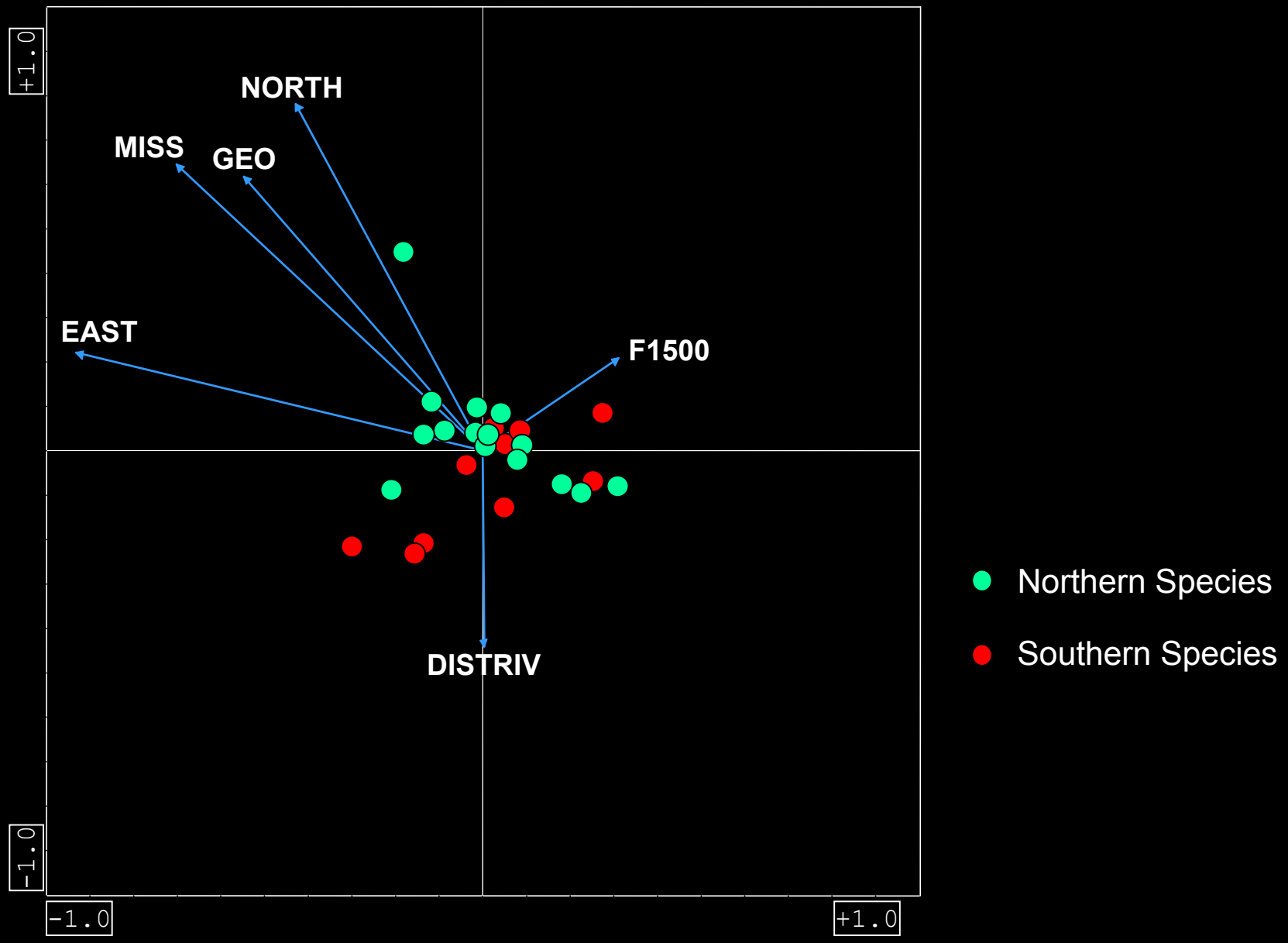
S


+1.0
-1.0
-1.0
+1.0
NORTH
MISS
GEO
EAST
F1500
DISTRIV
Northern Species
Southern Species

Forest Interior Species
(n=9)

Forest Interior/Edge Species
(n=23)

Forest Edge Species
(n=20)

Interior

spp	Variables (partial R^2)			model R^2
rich	-MISS (0.07)	F100 (0.05)	-	0.13
abun	-	-	-	-

Interior/Edge

spp				model R^2
rich	-MISS (0.14)	-F1500 (0.09)	F100 (0.08)	0.31
abun	-MISS (0.11)	F100 (0.10)	-F1500 (0.04)	0.25

Edge

spp				model R^2
rich	-MISS (0.21)	-F500 (0.14)	-DISTEDGE (0.04)	0.39
abun	-MISS (0.26)	-F500 (0.12)	-DISTEDGE (0.04)	0.43

Neotropical Migrant Species
(n=26)

Short-Distance Migrant Species
(n=18)

Resident Species
(n=8)

Neotropical Migrant spp	Variables (partial R^2)			model R^2
rich	-	-	-	-
abun	-	-	-	-

Short Distance Migrant spp				model R^2
rich	-MISS (0.48)	-F500 (0.11)	-	0.59
abun	-MISS (0.43)	-F500 (0.06)	-	0.49

Resident spp				model R^2
rich	-MISS (0.32)	–DISTRIV (0.09)	-	0.41
abun	-MISS (0.18)	-	-	0.18

Woodpecker Species
(n=7)

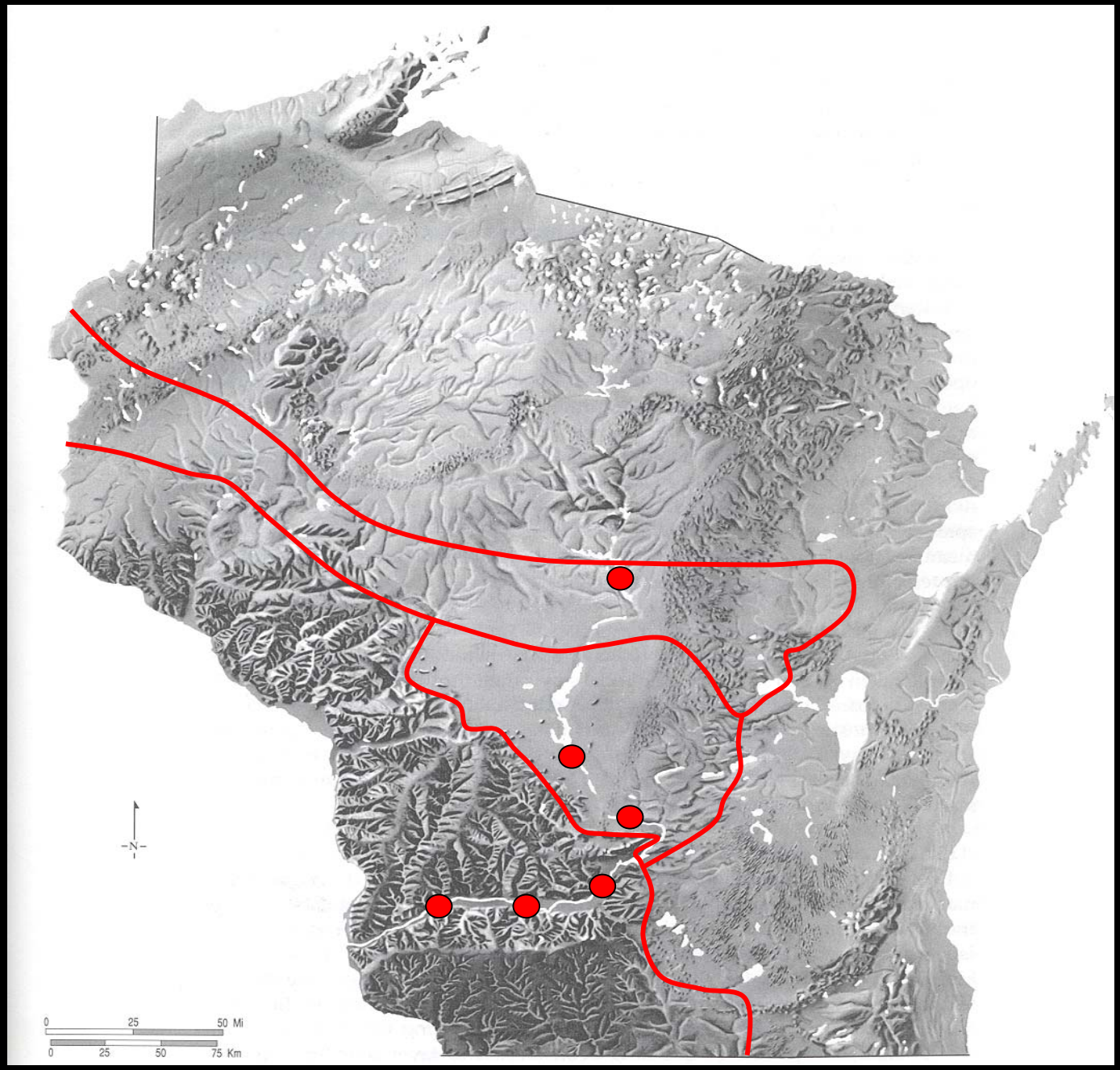
Woodpecker spp	Variables (partial R^2)			model R^2
rich	-MISS (0.42)	-DISTRIV (0.12)	-F1500 (0.04)	0.58
abun	-MISS (0.45)	-DISTRIV (0.08)	AREA (0.02)	0.55

spp	Local model R^2	Landscape model R^2
rich	0.35	0.13
abun	0.34	-

Interior/Edge spp	Local model R^2	Landscape model R^2
rich	0.37	0.31
abun	0.47	0.25

Conclusions

- Broad-scale measures explained a substantial portion of the variation in habitat use by some avian species in these floodplain forests.


N
0 25 50 Mi
0 25 50 75 Km

Conclusions

- Broad-scale measures explained a substantial portion of the variation in habitat use by some avian species in these floodplain forests.

- For species commonly thought to be sensitive to habitat fragmentation, measures that have typically been used to quantify this process explained little of the variation in habitat use of floodplain forests along the Wisconsin River.

Habitat Edge

Wisconsin River