# Influences of Agricultural Land Use on Southern High Plains Amphibians

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# Lecture Structure

I. Amphibian Abundance, Community Composition, and Source-Sink Dynamics

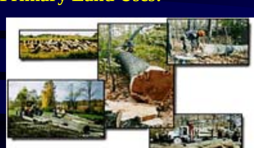
II. Postmetamorphic Body Size

III. Agricultural Landscape Structure

# Introduction

**Anthropogenic Habitat Destruction and *Landscape Disturbance***

**2 Primary Land Uses:**



>10 U.S. Studies

3 Major U.S. Studies

Conservation Biology 8:60–71,
Annual Review of Ecology and Systematics 30:113–165

# Introduction

## Agricultural Cultivation

**United States Studies:**

2 of the 3 Studies: (Con. Bio. 13:1437–1446, Can. J. Zool. 77:1288–1299)

- Positive Associations/Elevated Abundance in Cropland

1 of the 3 Studies: (Wildlife Society Bulletin 27:759–769)

- No Effect of Cultivation

**Canadian & European Studies:**

- Cultivation negatively affects abundance, richness, and fitness correlates.

Call Surveys
Breeding Season

(e.g., Ecology 77:2091–2097,
Con. Bio. 11:1000–1009,
Eco. Int. Bull 17:65–73,
J. Biogeography 25:763–772)

# Introduction

## Amphibians and the Southern High Plains

Thousands of Playa Wetlands
25,000

13 Species of Amphibians
TN: 85 spp

Landscape Cultivation

- Effect of Disturbance
- Effect of Landscape Structure

Intact Grassland

# Introduction

## Research Objectives

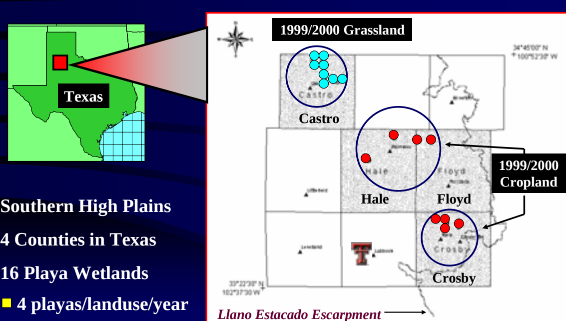
1) Influence of agricultural land use on amphibian community characteristics.
2) Influence of agricultural land use and year on postmetamorphic body size of amphibians.
3) Effect of landuse on chaotic dynamics of amphibians.
4) Effect of landuse on temporal niche partitioning of amphibians.
5) Determine if a relationship existed between agricultural landscape structure and amphibian community composition.

| 2 Landuses | 2 Years | 16 Playas |
|---|---|---|
| •Cultivation, Grassland | •1999, 2000 | •4/landuse/year |

## Objective 1

**Effect of Landuse and Year on Population Demographics of Southern High Plains Amphibians**

## Study Area and Playas




- Southern High Plains
- 4 Counties in Texas
- 16 Playa Wetlands
  - 4 playas/landuse/year

## Experimental Design

*3-Factor Nested-Factorial Design*

| | Landuse: Cropland | Landuse: Grassland |
|---|---|---|
| Year: 1999 | Playa: 1, 2, 3, 4 | Playa: 5, 6, 7, 8 |
| Year: 2000 | Playa: 9, 10, 11, 12 | Playa: 13, 14, 15, 16 |

## Methods: Terrestrial Capture

- •Partially Enclosed (25%)
  - •60-cm Drift Fence
  - •19-L Pitfall Traps

- •Checked Alternate Days
- •16 May-17 October 1999
- •19 April-18 August 2000

## Methods: Biological Processing

- •Snout-vent Length
- •Mass

- •5 individuals/ playa/species/ age class/day

*n* =2816 cropland

*n* = 2372 grassland

- •Toe-Clipped
- •Recaptures not Measured

## Response Variables

2 Categories

**General Demographics:** *Continuous*

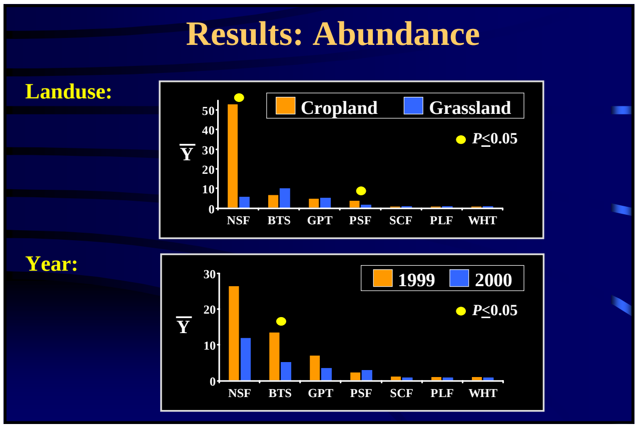
| | |
|---|---|
| Mean Daily Abundance | By Species |
| Mean Daily Species Diversity | All Species |

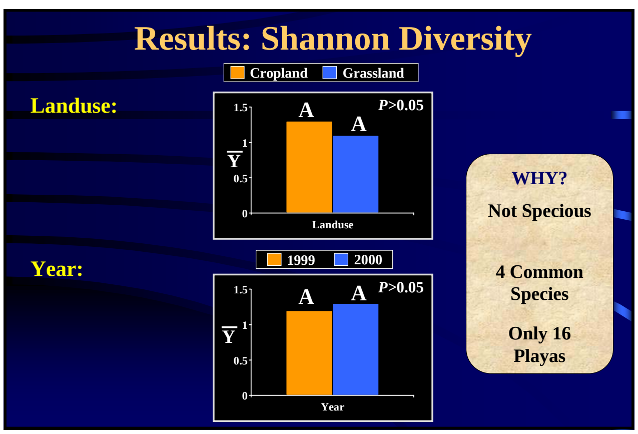
**Source-sink Dynamics:** *Categorical*

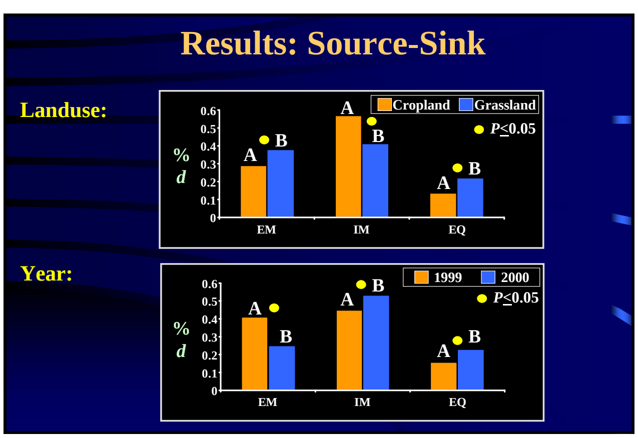
| | |
|---|---|
| Frequency of Days | All Species |

| | |
|---|---|
| •Immigration>Emigration | Sink Dynamics |
| •Emigration>Immigration | Source Dynamics |
| •Immigration=Emigration | Neutral Dynamics |

Am. Nat. 132:652–661


Results: Abundance
Landuse:
Cropland
Grassland
P≤0.05
Ȳ
50
40
30
20
10
0
NSF BTS GPT PSF SCF PLF WHT
Year:
1999
2000
P≤0.05
Ȳ
30
20
10
0
NSF BTS GPT PSF SCF PLF WHT


Results: Shannon Diversity
Cropland
Grassland
Landuse:
P>0.05
A
A
Ȳ
1.5
1
0.5
0
Landuse
Year:
1999
2000
P>0.05
A
A
Ȳ
1.5
1
0.5
0
Year
WHY?
Not Specious
4 Common Species
Only 16 Playas


Results: Source-Sink
Landuse:
Cropland
Grassland
P≤0.05
% d
0.6
0.5
0.4
0.3
0.2
0.1
0
A B A B A B
EM IM EQ
Year:
1999
2000
P≤0.05
% d
0.6
0.5
0.4
0.3
0.2
0.1
0
A B A B A B
EM IM EQ

# Discussion

## Disturbance Confined Individuals

(Knutson et al. 1999, Kolozsvary and Swihart 1999)

**Why Spadefoots?**

•Patch Viscosity

•Boundary Permeability

(Wiens 1997)

**Species-Specific Vagility**

•Landscape Complexity

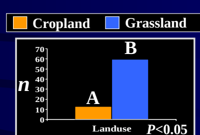
| | GR | CR |
|---|---|---|
| Fractal Dimension | 1.32 | 1.28 |
| Edge Density | 64.3 | 40.6 |

# Discussion

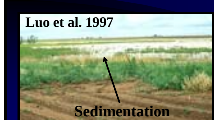
## Reduction of Intraguild Predator

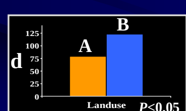
(Oecologia 128:134–141, 129:430–435)

*Anax*




*A. t. mavortium*




Spadefoots Competitively Dominant

Science 212:1284–1286
Ecology 68:1437–1452

# Discussion

## Other Explanations

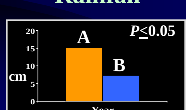
**Landuse:** •Plant Diversity and Structure

•Nutrient Influx

•Pesticides

Other Species Affected??

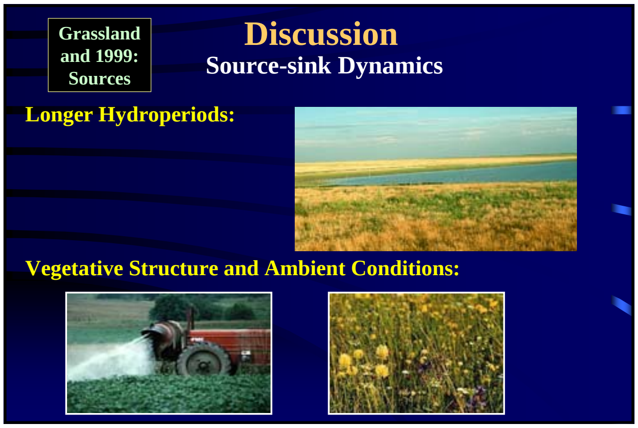
**Year:** Rainfall

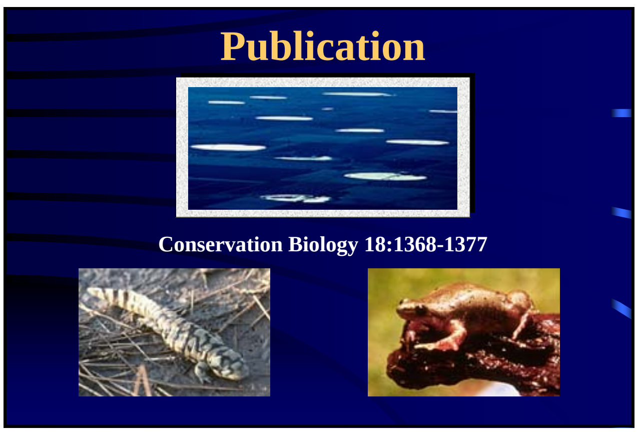


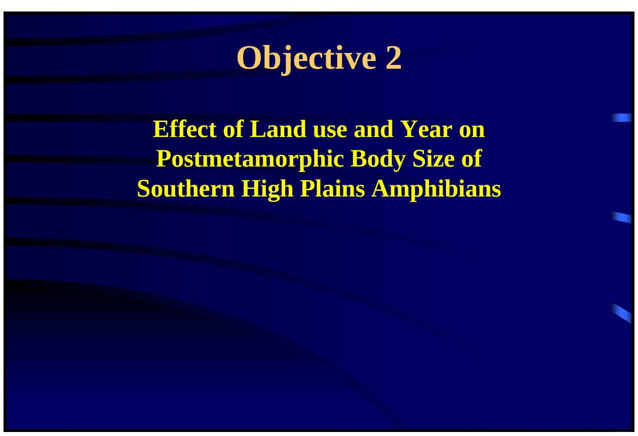

•Survival

•Breeding Success

•Food Abundance


Grassland and 1999: Sources
Discussion
Source-sink Dynamics
Longer Hydroperiods:
Vegetative Structure and Ambient Conditions:


Publication
Conservation Biology 18:1368-1377


Objective 2
Effect of Land use and Year on
Postmetamorphic Body Size of
Southern High Plains Amphibians

## Body Size Hypotheses

**Wilbur and Collins (1973):**
Science 182:1305-1314

**Body size at metamorphosis will be a consequence of the larval environment and confer fitness to postmetamorphic adults.**

**Earl Werner (1986):**
American Naturalist
128:319-341

**Postmetamorphic body size is a consequence of size-specific mortality and growth rates in both the larval and terrestrial environments.**

**"Catch-up" Growth**

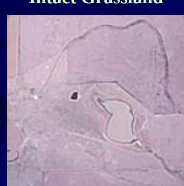
## Effect of Landuse on Body Size?

**Few studies have explored the possible influences of agricultural land use on postmetamorphic body size of amphibians.**

**SHP Landuses:**

**Agricultural Cultivation**

**Intact Grassland**



**Potential Effects**

- **Hydroperiod**
- **Density**
- **Chemicals**

## Research Objective

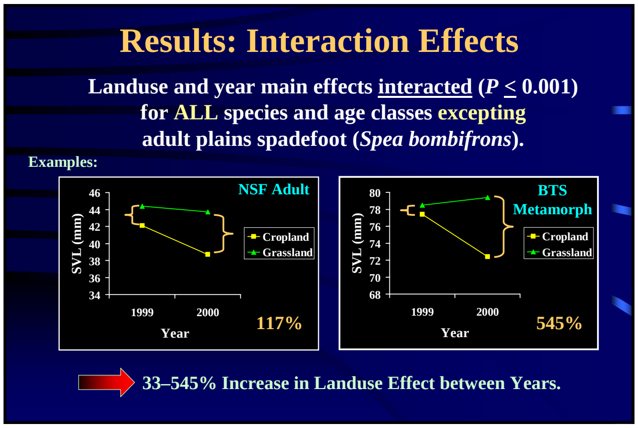
**Compare postmetamorphic body size between individuals captured in cultivated and grassland (control) landscapes during 2 years (1999 and 2000).**

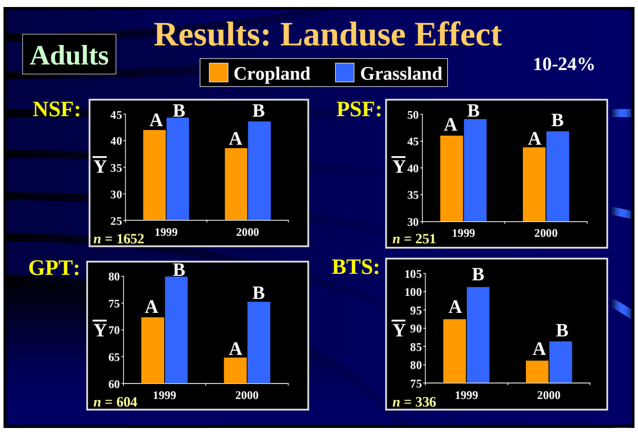
**4 Species**

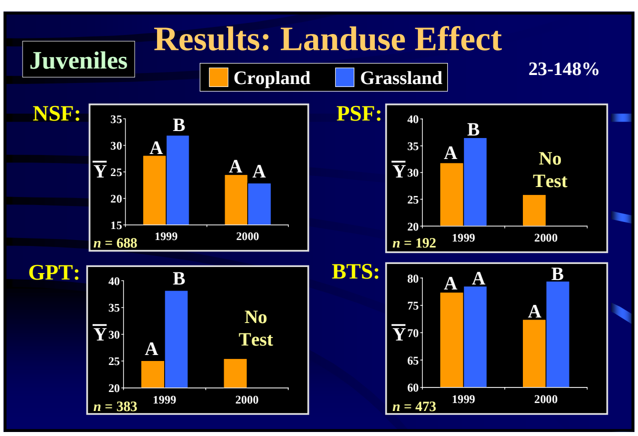
- *Spea multiplicata* (New Mexico spadefoot)
- *Spea bombifrons* (plains spadefoot)
- *Bufo cognatus* (Great Plains toad)
- *Ambystoma tigrinum mavortium* (barred tiger salamander)

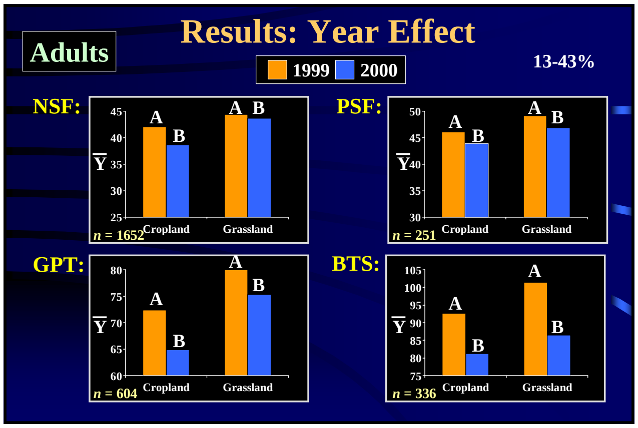
**3 Age Classes**

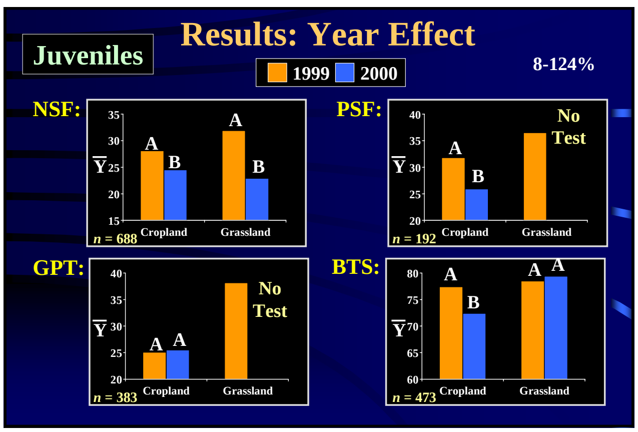
- Metamorph*
- Subadult
- Adult*


Results: Interaction Effects
Landuse and year main effects interacted (P ≤ 0.001)
for ALL species and age classes excepting
adult plains spadefoot (Spea bombifrons).
Examples:
NSF Adult
SVL (mm)
Cropland
Grassland
1999
2000
Year
117%
BTS
Metamorph
SVL (mm)
Cropland
Grassland
1999
2000
Year
545%
33–545% Increase in Landuse Effect between Years.


Results: Landuse Effect
Adults
Cropland
Grassland
10-24%
NSF:
n = 1652
PSF:
n = 251
GPT:
n = 604
BTS:
n = 336
1999
2000


Results: Landuse Effect
Juveniles
Cropland
Grassland
23-148%
NSF:
n = 688
PSF:
No Test
n = 192
GPT:
No Test
n = 383
BTS:
n = 473
1999
2000



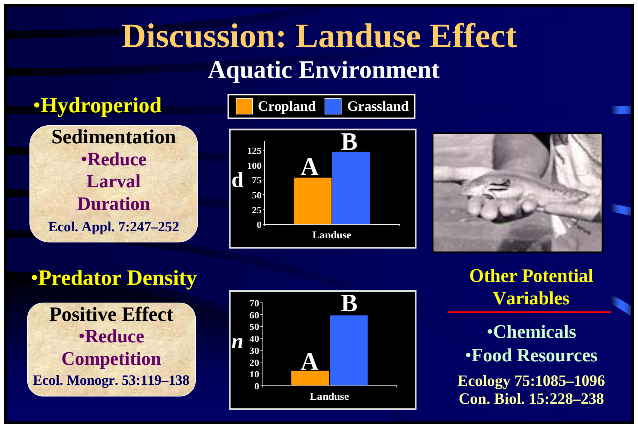

## Summary of Results

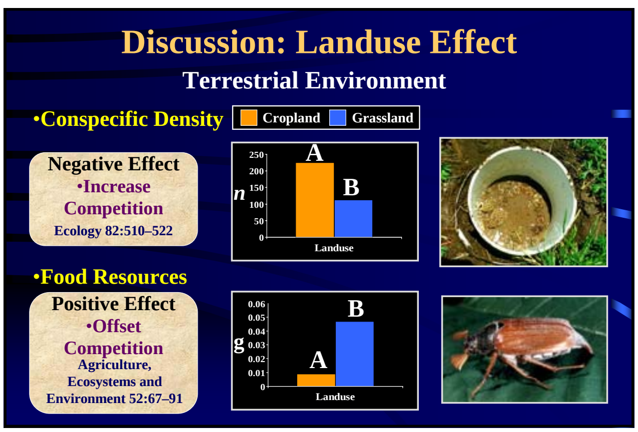
**Landuse Effect:** 10-148%

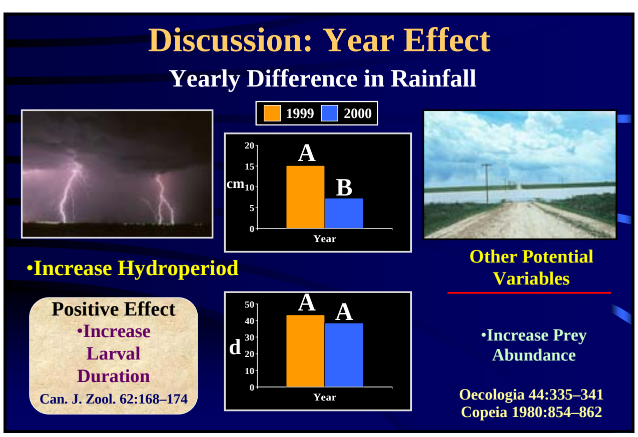
Postmetamorphic body size of individuals captured in grassland landscapes was <u>greater</u> than those captured in cropland landscapes generally for all age classes and species.

**Year Effect:** 8-124%

Postmetamorphic body size was <u>greater</u> in 1999 than in 2000 for most age classes and species.


Discussion: Landuse Effect
Aquatic Environment
•Hydroperiod
Cropland
Grassland
Sedimentation
•Reduce
Larval
Duration
Ecol. Appl. 7:247–252
d
Landuse
A
B
•Predator Density
Positive Effect
•Reduce
Competition
Ecol. Monogr. 53:119–138
n
Landuse
A
B
Other Potential
Variables
•Chemicals
•Food Resources
Ecology 75:1085–1096
Con. Biol. 15:228–238


Discussion: Landuse Effect
Terrestrial Environment
•Conspecific Density
Cropland
Grassland
Negative Effect
•Increase
Competition
Ecology 82:510–522
n
Landuse
A
B
•Food Resources
Positive Effect
•Offset
Competition
Agriculture,
Ecosystems and
Environment 52:67–91
g
Landuse
A
B


Discussion: Year Effect
Yearly Difference in Rainfall
1999
2000
cm
Year
A
B
•Increase Hydroperiod
Positive Effect
•Increase
Larval
Duration
Can. J. Zool. 62:168–174
d
Year
A
A
Other Potential
Variables
•Increase Prey
Abundance
Oecologia 44:335–341
Copeia 1980:854–862

## Conservation Implications

### Advantages of Body Size in Amphibians

| | |
|---|---|
| •Age at 1st Reproduction | •Foraging Efficiency |
| •Mating Success | •P[Predator Escape] |
| •Fecundity | •P[Surviving Dehydration] |

→ P[Survival and Reproduction] = Fitness

Large > Small

→ P[Population Persistence]

Ecology 69:184–192, 71:1599–1608, 75:1383–1396

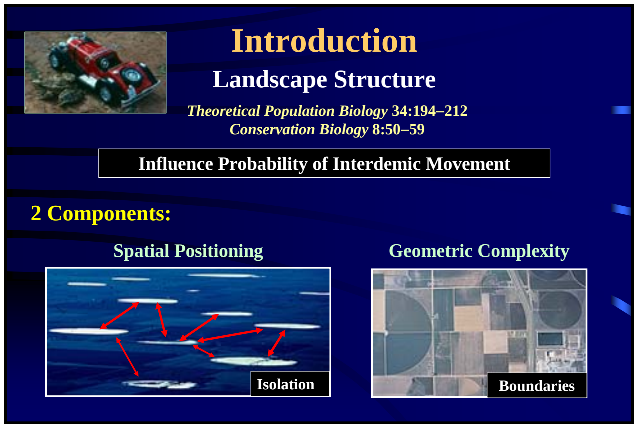
★ Cropland Playas P[Extinction] → Drier Years

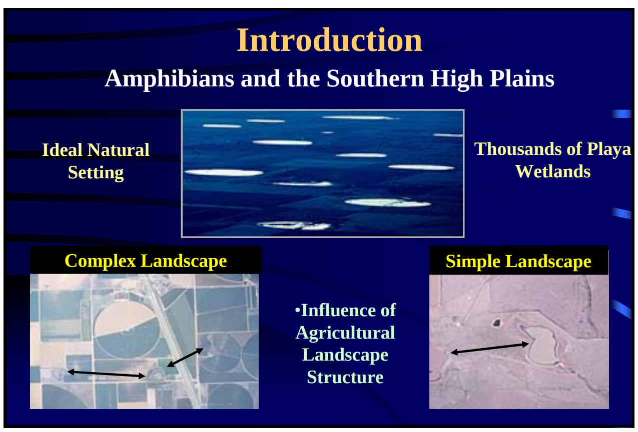
## Publication

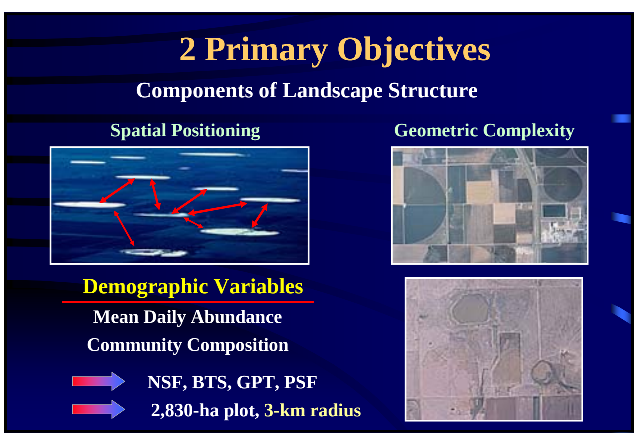
Journal of Wildlife Management 69(2):515-524

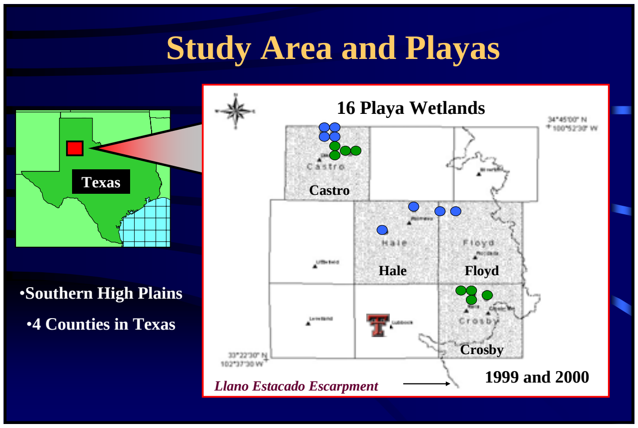
## Objective 5

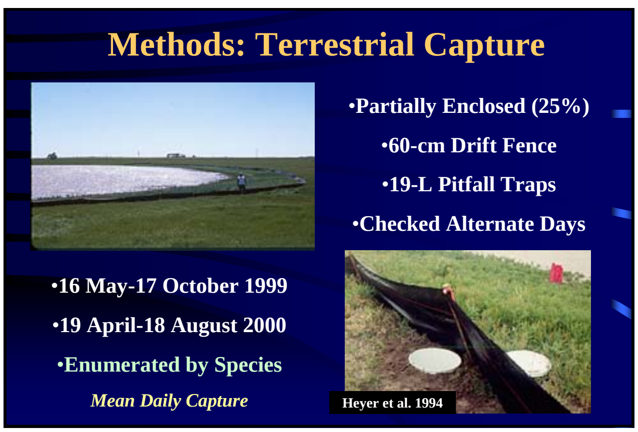
**Influence of Landscape Structure on Community Composition and Relative Abundance of Amphibians**

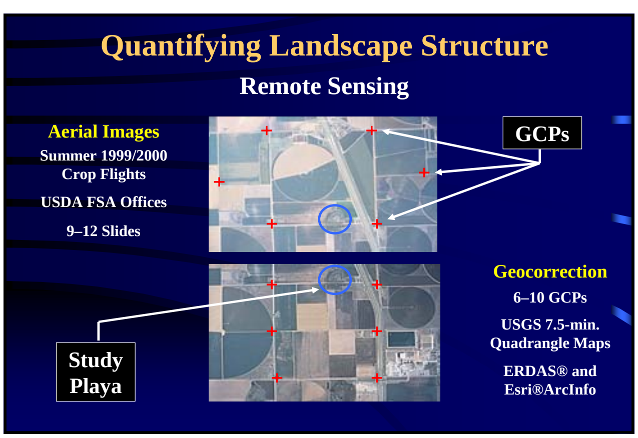

Introduction
Landscape Structure
Theoretical Population Biology 34:194–212
Conservation Biology 8:50–59
Influence Probability of Interdemic Movement
2 Components:
Spatial Positioning
Geometric Complexity
Isolation
Boundaries

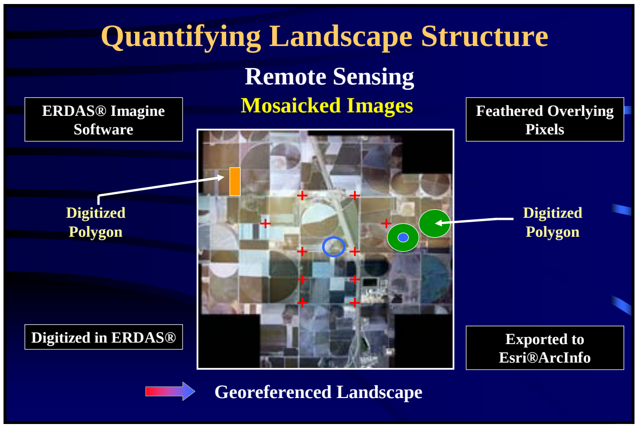

Introduction
Amphibians and the Southern High Plains
Ideal Natural Setting
Thousands of Playa Wetlands
Complex Landscape
Simple Landscape
•Influence of Agricultural Landscape Structure

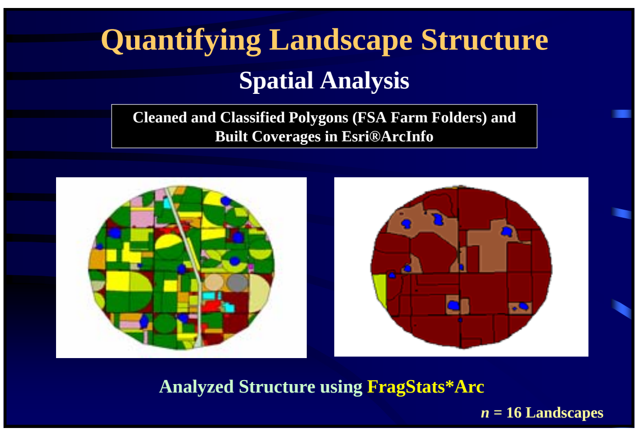

2 Primary Objectives
Components of Landscape Structure
Spatial Positioning
Geometric Complexity
Demographic Variables
Mean Daily Abundance
Community Composition
NSF, BTS, GPT, PSF
2,830-ha plot, 3-km radius


Study Area and Playas
16 Playa Wetlands
Texas
Castro
Hale
Floyd
Crosby
•Southern High Plains
•4 Counties in Texas
Llano Estacado Escarpment
1999 and 2000


Methods: Terrestrial Capture
•Partially Enclosed (25%)
•60-cm Drift Fence
•19-L Pitfall Traps
•Checked Alternate Days
•16 May-17 October 1999
•19 April-18 August 2000
•Enumerated by Species
Mean Daily Capture
Heyer et al. 1994


Quantifying Landscape Structure
Remote Sensing
Aerial Images
Summer 1999/2000
Crop Flights
USDA FSA Offices
9–12 Slides
GCPs
Geocorrection
6–10 GCPs
USGS 7.5-min.
Quadrangle Maps
ERDAS® and
Esri®ArcInfo
Study
Playa




## Quantifying Landscape Structure

### Spatial Analysis

**FragStats*Arc → 13 Spatial Metrics**

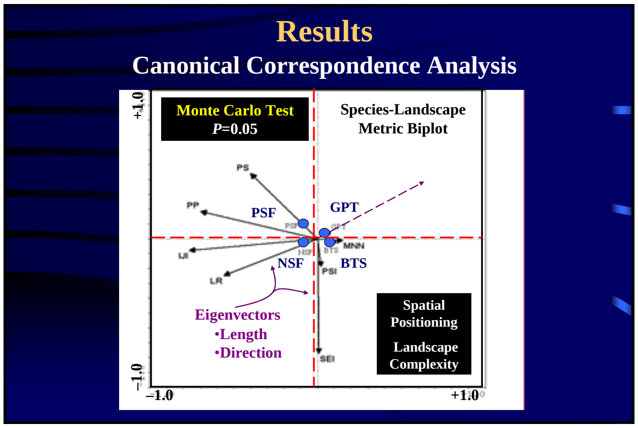
**Playa Positioning**

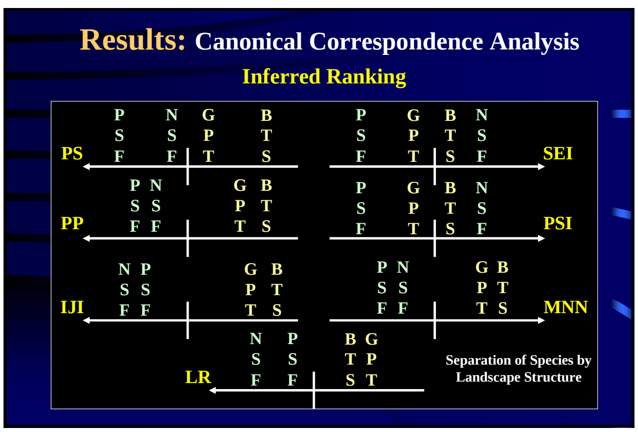
- Shape Index (PSI)
- Playa Size (PS)
- MNN Study Playa (PNN)
- MNN All Playas (MNN)
- Percent & Number of Playas (PP, NP)
- Interspersion/Juxtaposition Index (IJI)

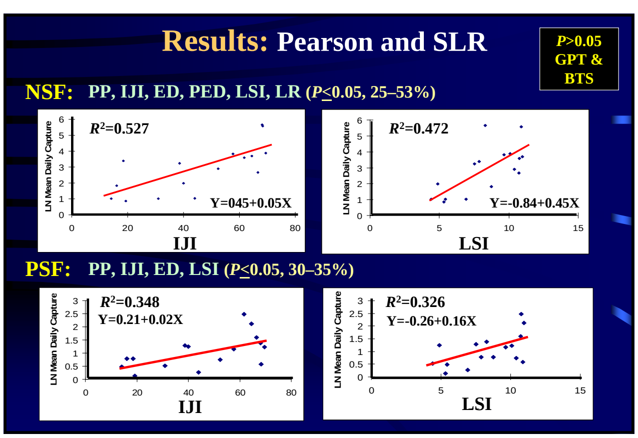
**Geometric Complexity**

- Playa Edge Density (PED)
- Edge Density (ED, m/ha)
- Landscape Shape Index (LSI)
- Landuse Richness (LU)
- Shannon Evenness (SEI)
- Shannon Diversity (SDI)

McGarigal and Marks 1995


Results
Canonical Correspondence Analysis
Monte Carlo Test
P=0.05
Species-Landscape
Metric Biplot
+1.0
–1.0
PS
PP
PSF
GPT
IJI
LR
NSF
BTS
MNN
PSI
SEI
Eigenvectors
•Length
•Direction
Spatial
Positioning
Landscape
Complexity
–1.0
+1.0


Results: Canonical Correspondence Analysis
Inferred Ranking
PS
PSF NSF GPT BTS
PSF GPT BTS NSF
SEI
PP
PSF NSF GPT BTS
PSF GPT BTS NSF
PSI
IJI
NSF PSF GPT BTS
PSF NSF GPT BTS
MNN
LR
NSF PSF BTS GPT
Separation of Species by
Landscape Structure


Results: Pearson and SLR
P>0.05
GPT &
BTS
NSF: PP, IJI, ED, PED, LSI, LR (P≤0.05, 25–53%)
R²=0.527
Y=045+0.05X
LN Mean Daily Capture
IJI
R²=0.472
Y=-0.84+0.45X
LSI
PSF: PP, IJI, ED, LSI (P≤0.05, 30–35%)
R²=0.348
Y=0.21+0.02X
IJI
R²=0.326
Y=-0.26+0.16X
LSI

## Summary of Results

### Canonical Correspondence Analysis:

Landscape structure influenced the composition of the amphibian assemblage at playa wetlands.

GPT and BTS were negatively associated with spadefoots (NSF, PSF).

### Pearson and SLR:

Spadefoots were positively associated with metrics representing optimal spatial positioning of playas and geometric complexity of the landscape.

GPT and BTS abundance was not influenced univariately by landscape structure.

## Discussion

### Spadefoots Influenced by Structure

(With and Crist 1995, Wiens et al. 1997, McIntyre 2000)

**Small Body Size**

'+' Correlated w/ Vagility

•Patch Viscosity

•Boundary Permeability

**Geometrically Complex Landscapes**

Unable to Penetrate

Increased Nestedness/Abundance

(Can. J. Zool. 77:1288–1299)

**Optimally Juxtaposed Wetlands**

P[Dispersal] ↑

Metapopulation Theory

(Am. Nat. 148:226–236)

## Discussion

### GPT and BTS '–' Associated with Spadefoots

(Ecol. Monogr. 53:119–138, Copeia 1999:515–520, Wildl. Soc Bull. 27:759–769)

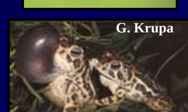
**Differential Competitive Ability**

•Competitively Dominant Larvae

•Postmetamorphic Diet Overlap

D. Pfennig

**Differential Microhabitat Use**



G. Krupa

## Conservation Implications

**Agricultural Landscape Structure can Influence Species Composition and Abundance of Amphibians**

- •Isolated Wetlands — P[extinction]
- •Geometrically Complex Landscapes — Confinement?
- → Species Dependent

More Research:
- •Species-Specific Vagility
- •Dispersal Occurrences

**Ecologists should consider landscape structure when planning conservation endeavors for amphibians.**

## Publication

Landscape Ecology 19:719-729

## Conservation Implications of Southern High Plains Research

**Recommend Retention and Restoration of Grasslands Surrounding Playa Wetlands**

Why?
- •Abundance & Community Structure Altered
- •Source Dynamics in Grassland Playas
- •Disturbance Affects Natural Dynamics and Chaos
  - Chaos can decrease probability of metapopulation extinction.
- → •Body Size is '–' Affected by Disturbance

**Landscape structure may be as or more important than landuse.**

## Funding

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**Student Research Grants:**

- Society of Wetland Scientists
- Ducks Unlimited, Inc.

**Home Depot Provided Buckets for Pitfall Traps**