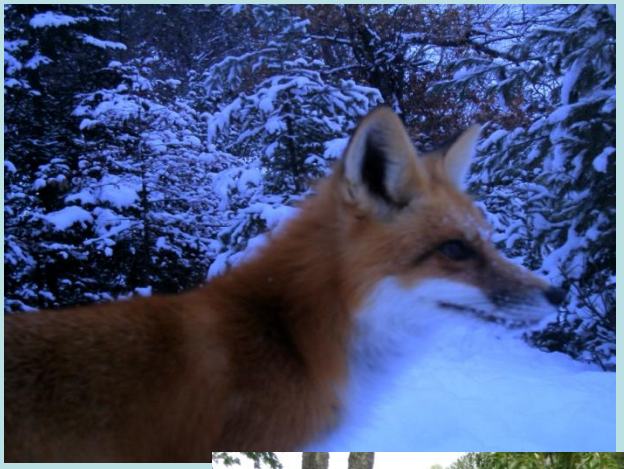
Quantifying the Ecological Benefits of Lakeshore Restoration in Northern Wisconsin

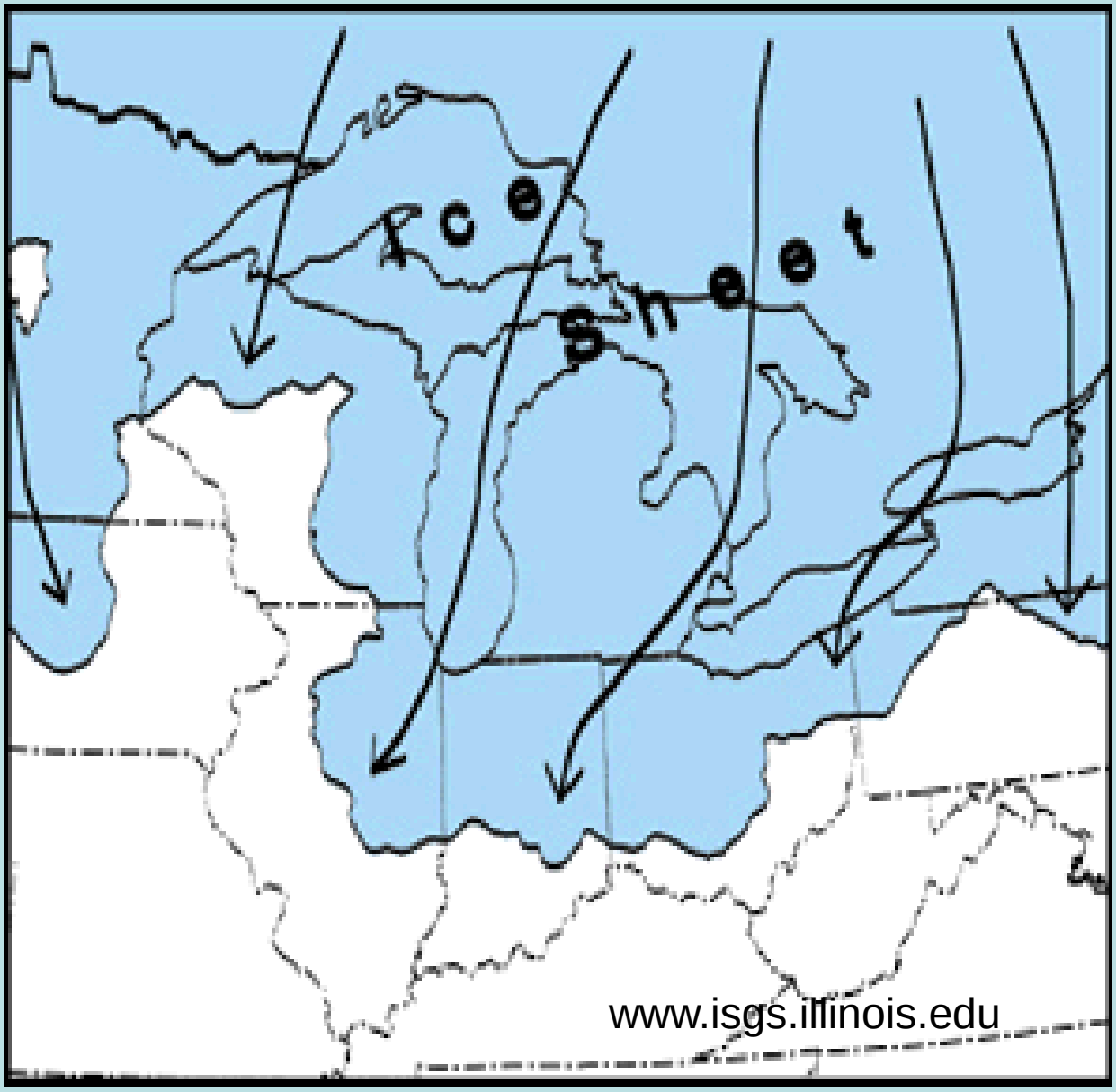
Photo by: D. Haskell

Overview

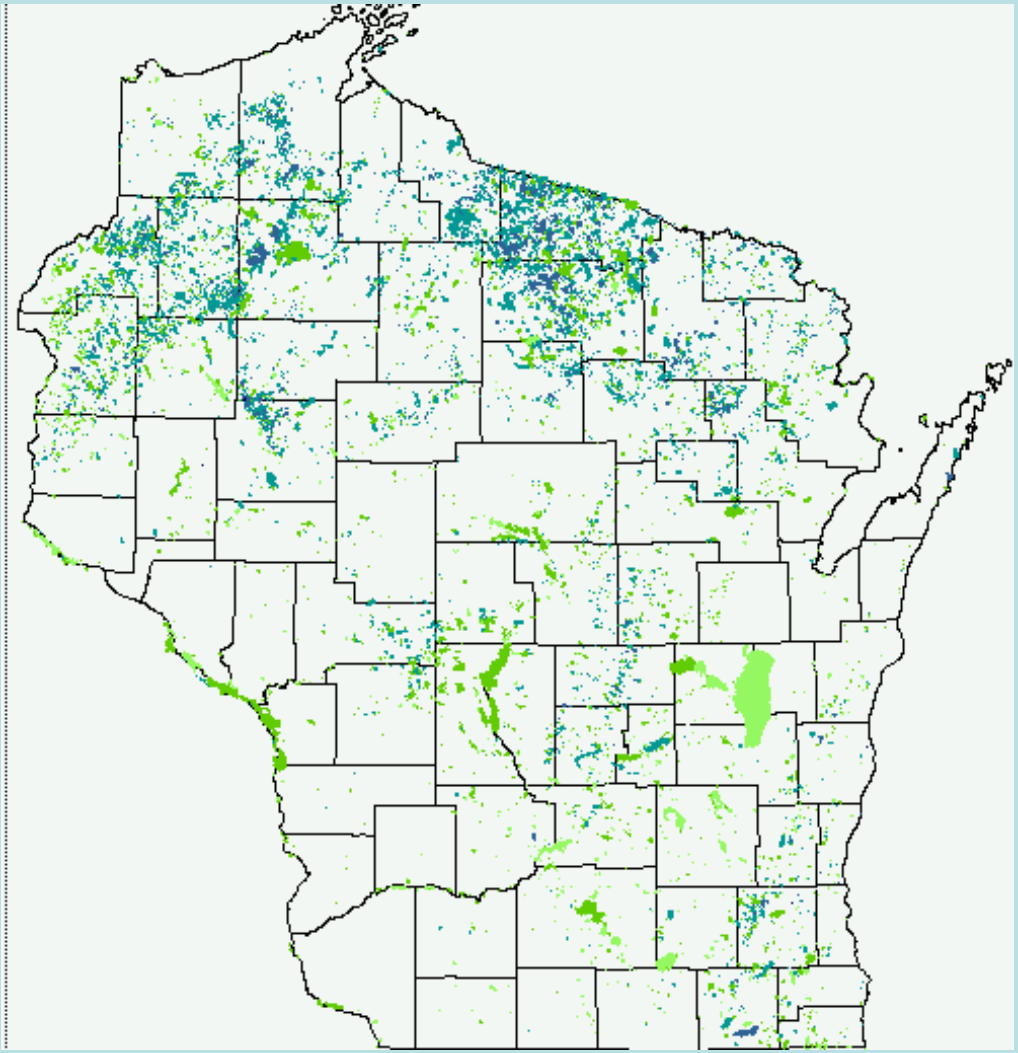
- Background Information
  - Geological & human history
  - Previous research
- Mammal Research
- Lakeshore Restoration
- Down Woody Material (DWM) Experiment
- Before & After



Photos by D. Haskell


Ice sheet
www.isgs.illinois.edu

Estimated 15,000 Lakes



Source dnr.wi.gov

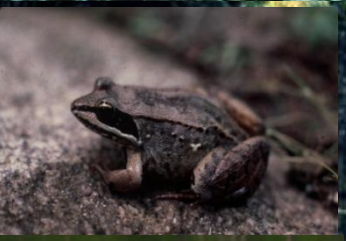
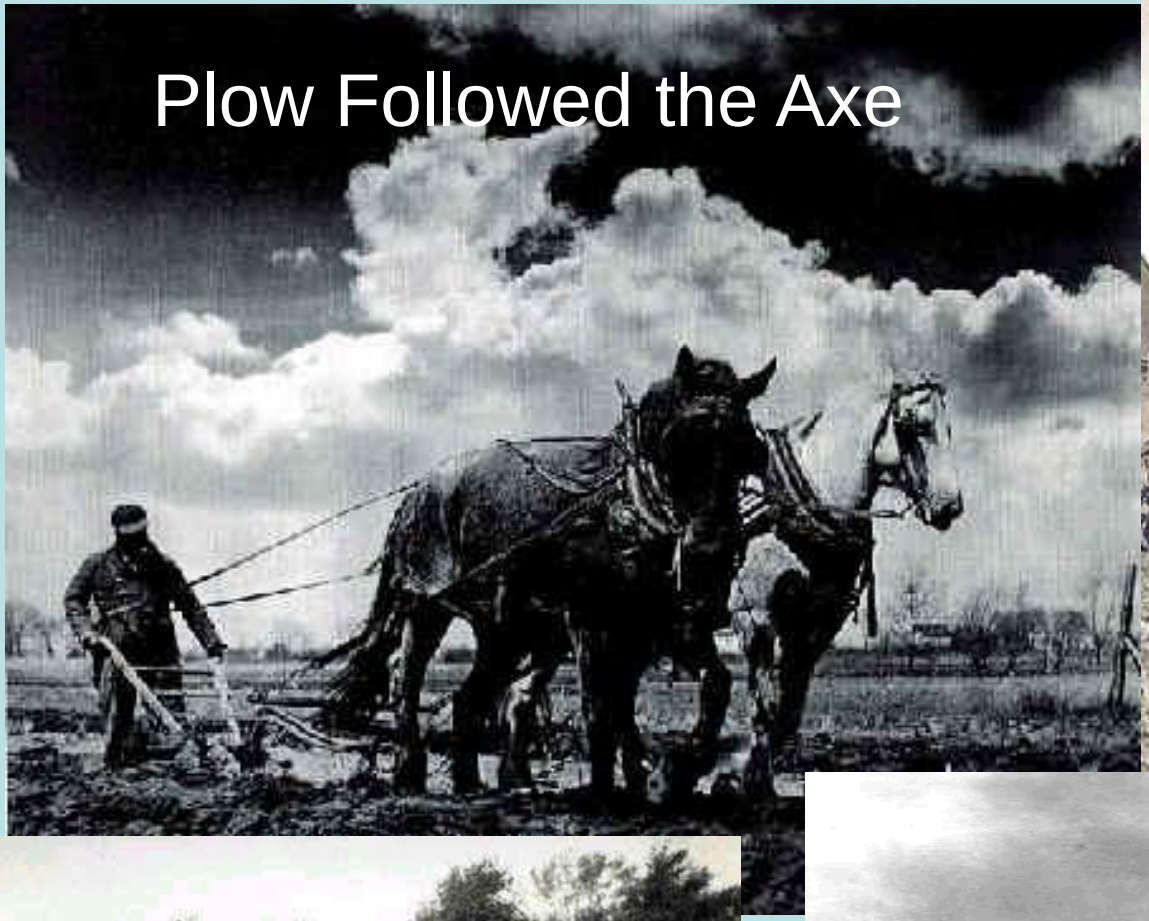


Photo Credit WDNR

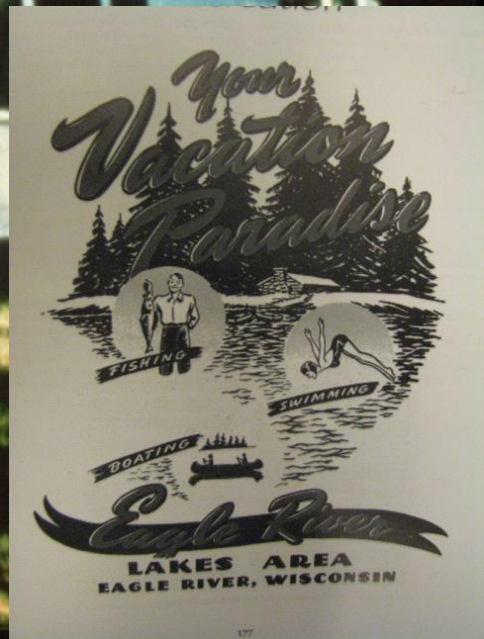

3140
www.wisconsinhistory.com

Plow Followed the Axe



www.northfieldhistoricalsociety.org

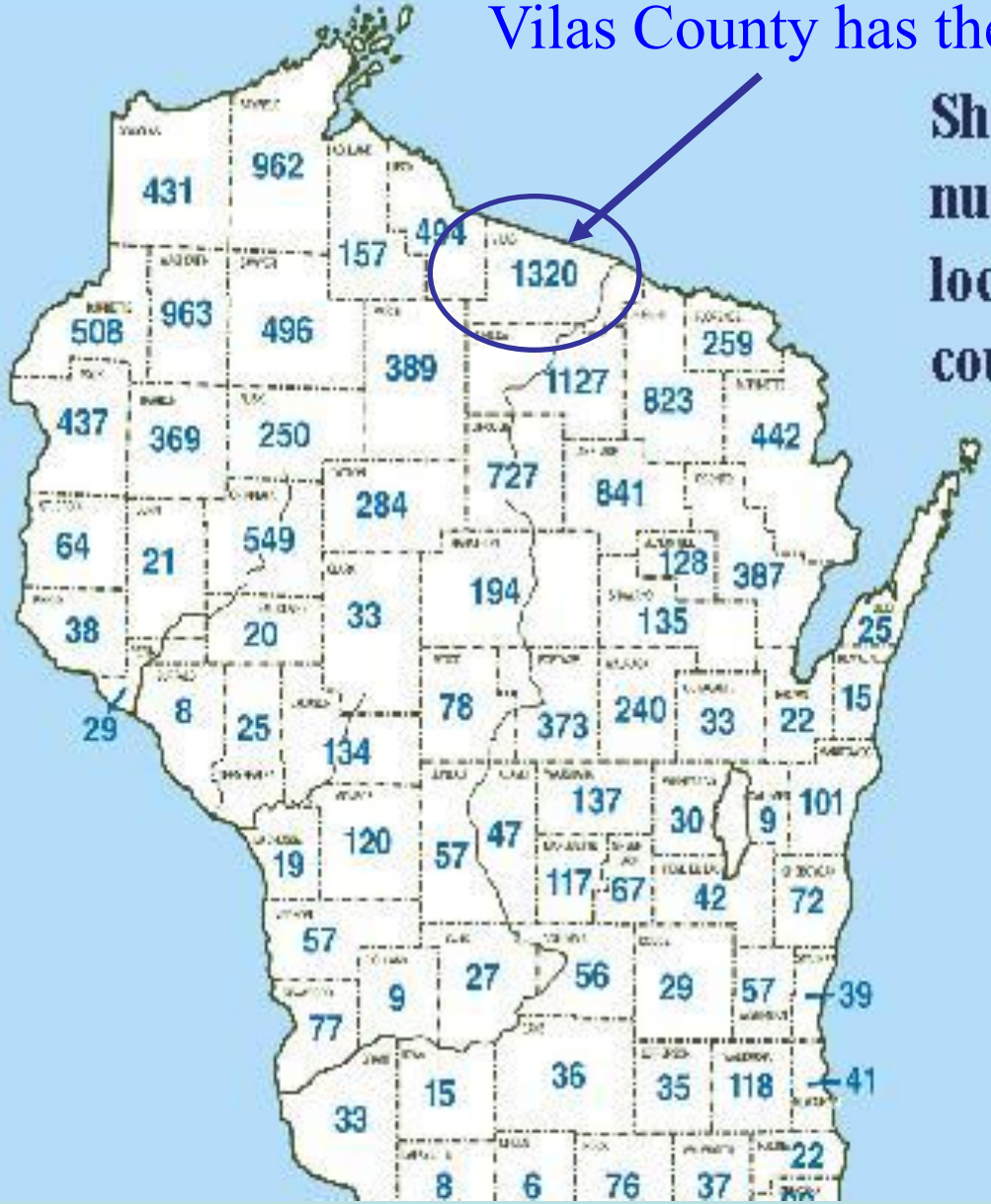
Early Housing Development & Resorts



Wisconsin lakes by county

Vilas County has the most lakes

Shown are the number of lakes located in each county.

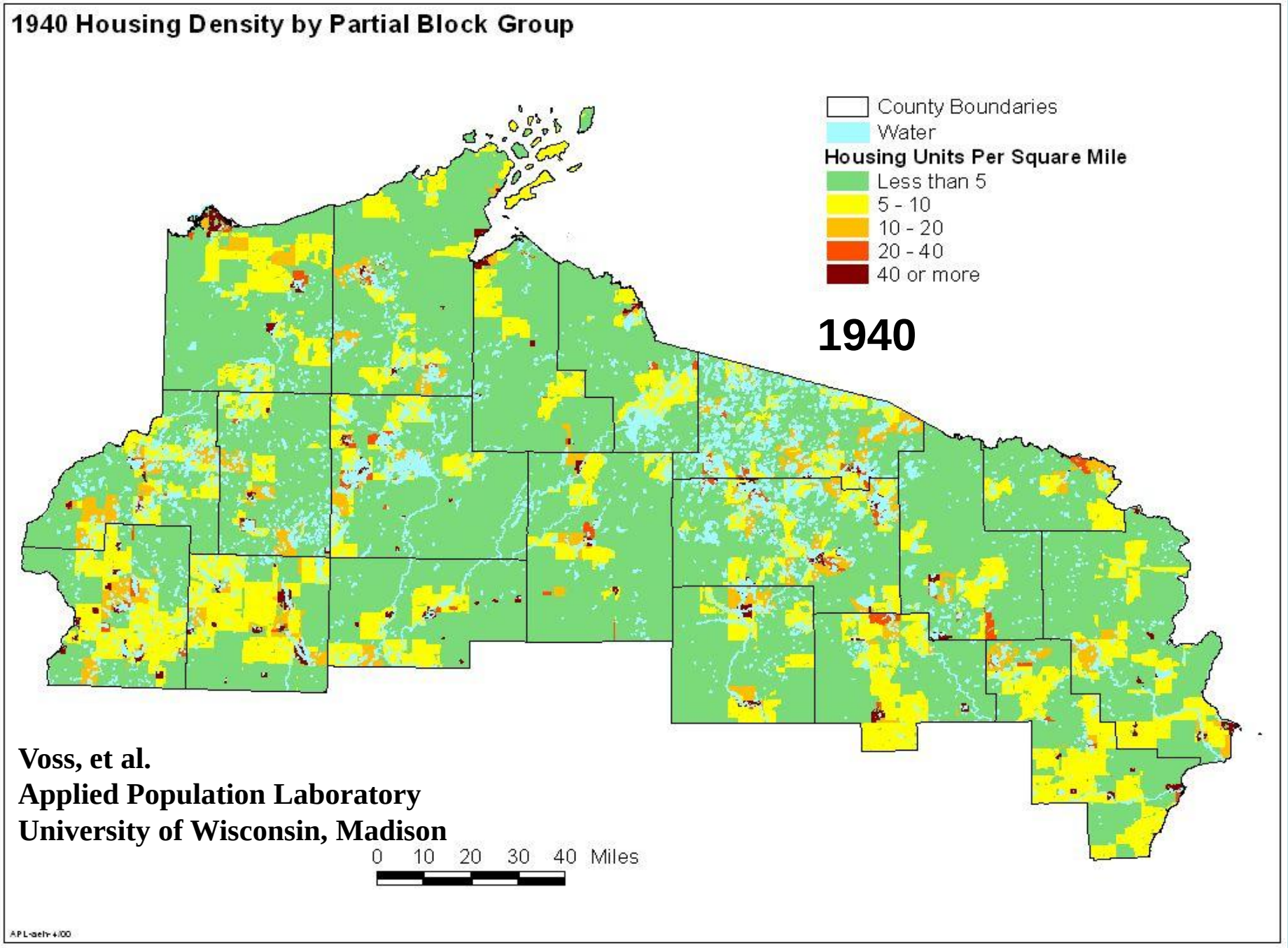


Source WDNR

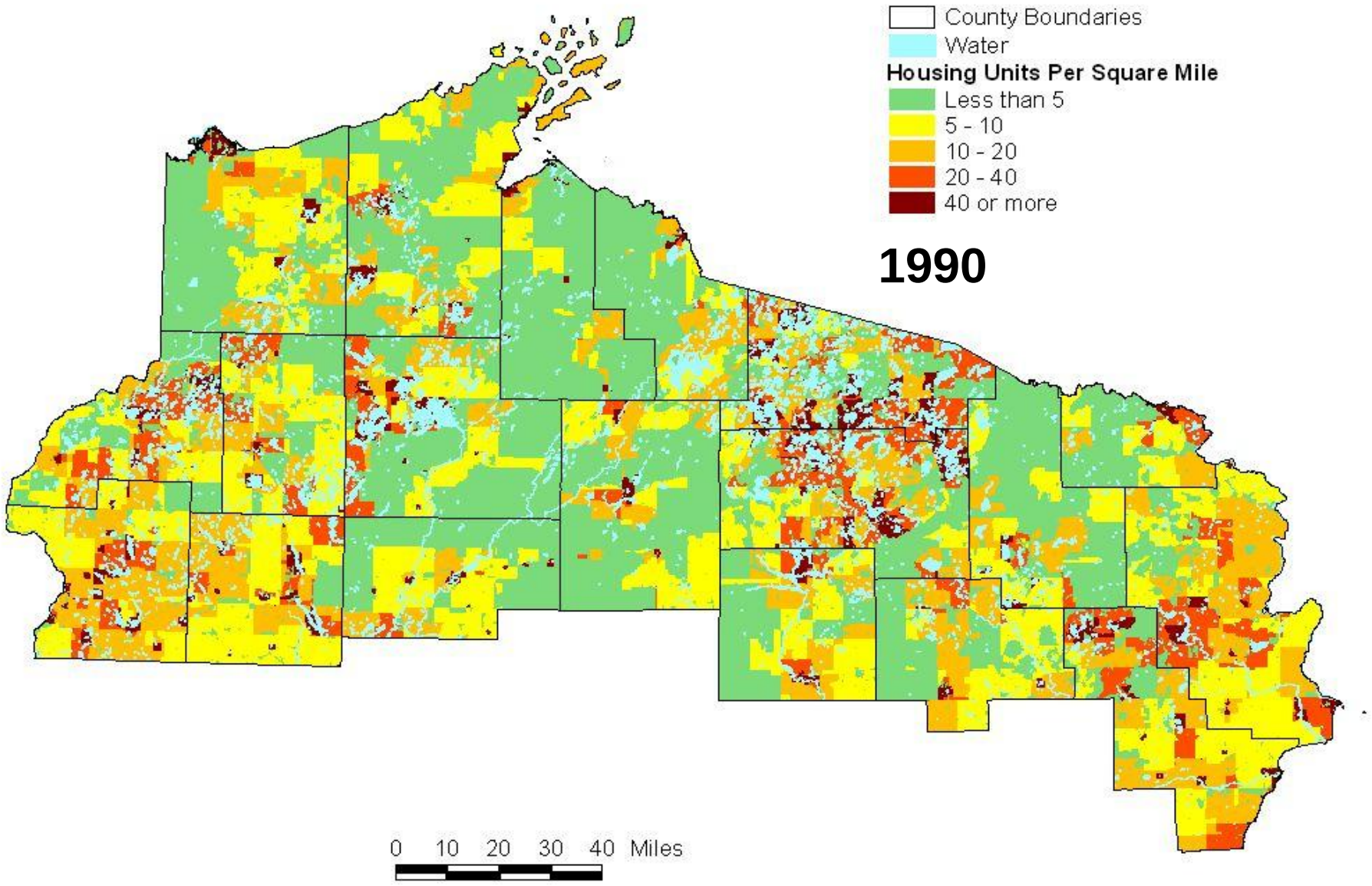
Vilas County

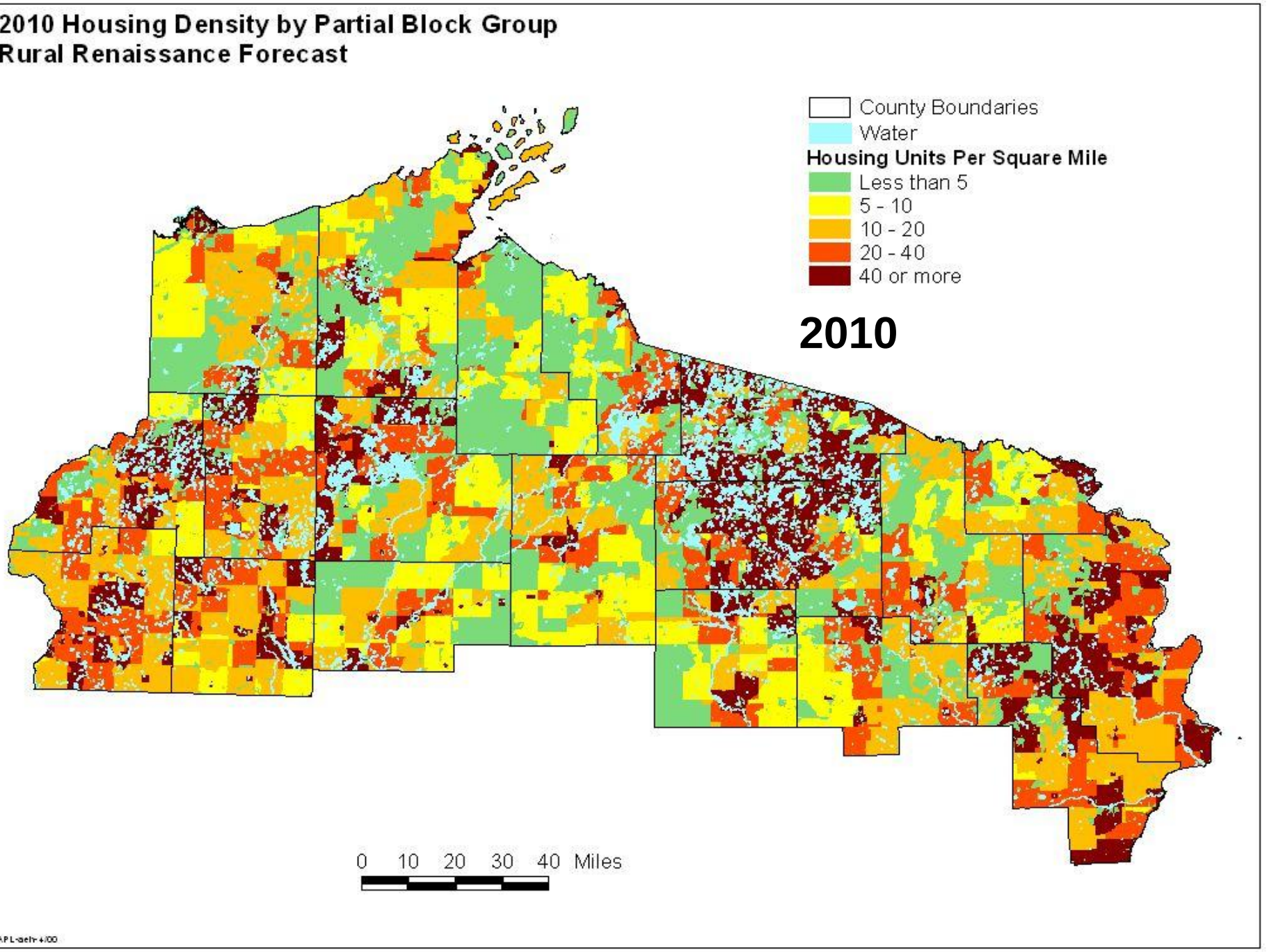
- 1018-mile^2 area
- ~ 53% area privately owned
- 1320 lakes (0.25 to > 3700 acres)
- Depths from 3 to 100 ft
- Lakes accounts for 16% area
- Surrounded by hardwood-conifer mix forest

(WDNR 1995)

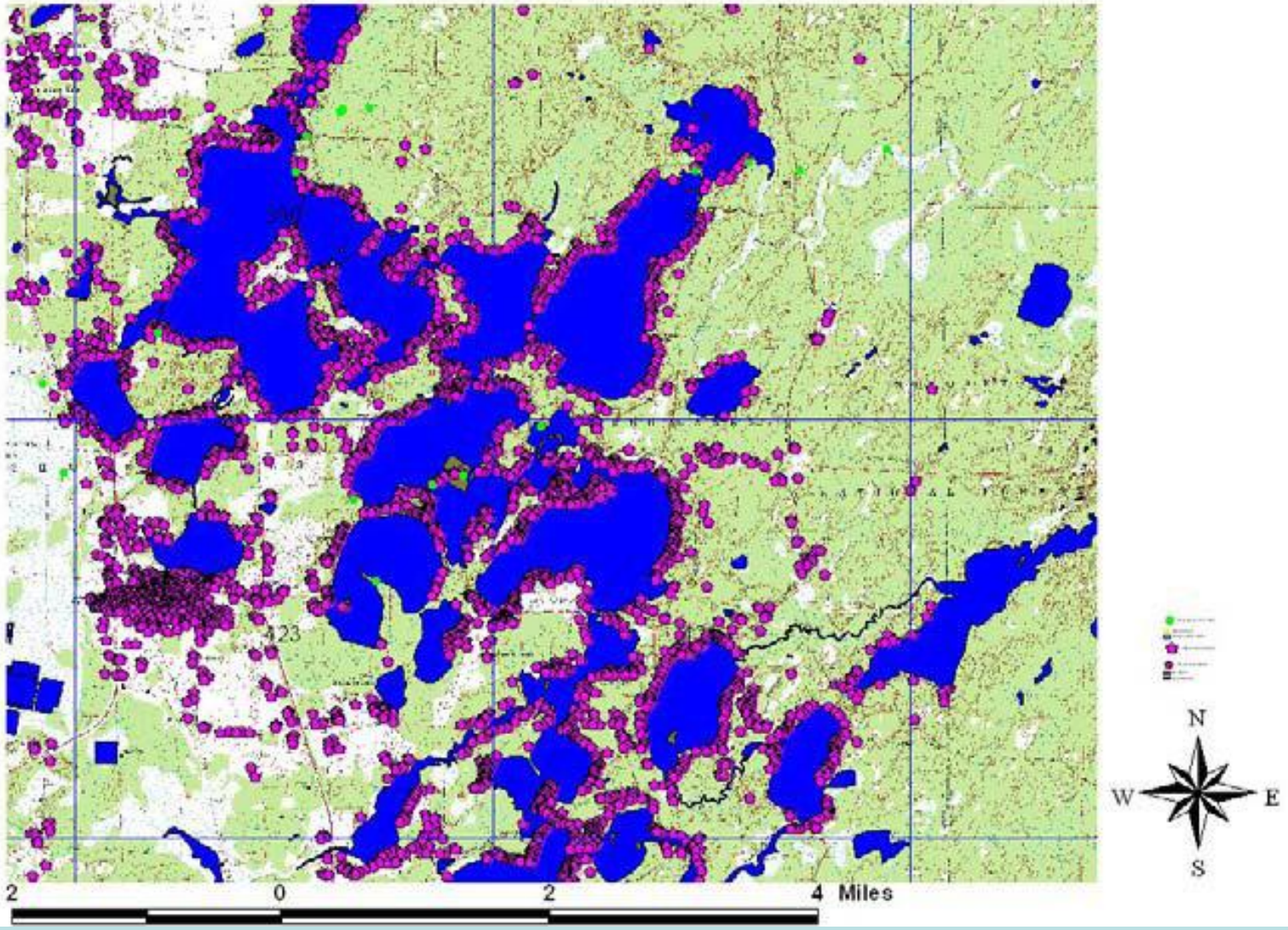

1940 Housing Density by Partial Block Group
County Boundaries
Water
Housing Units Per Square Mile
Less than 5
5 - 10
10 - 20
20 - 40
40 or more
1940
Voss, et al.
Applied Population Laboratory
University of Wisconsin, Madison
0 10 20 30 40 Miles

1990 Housing Density by Partial Block Group



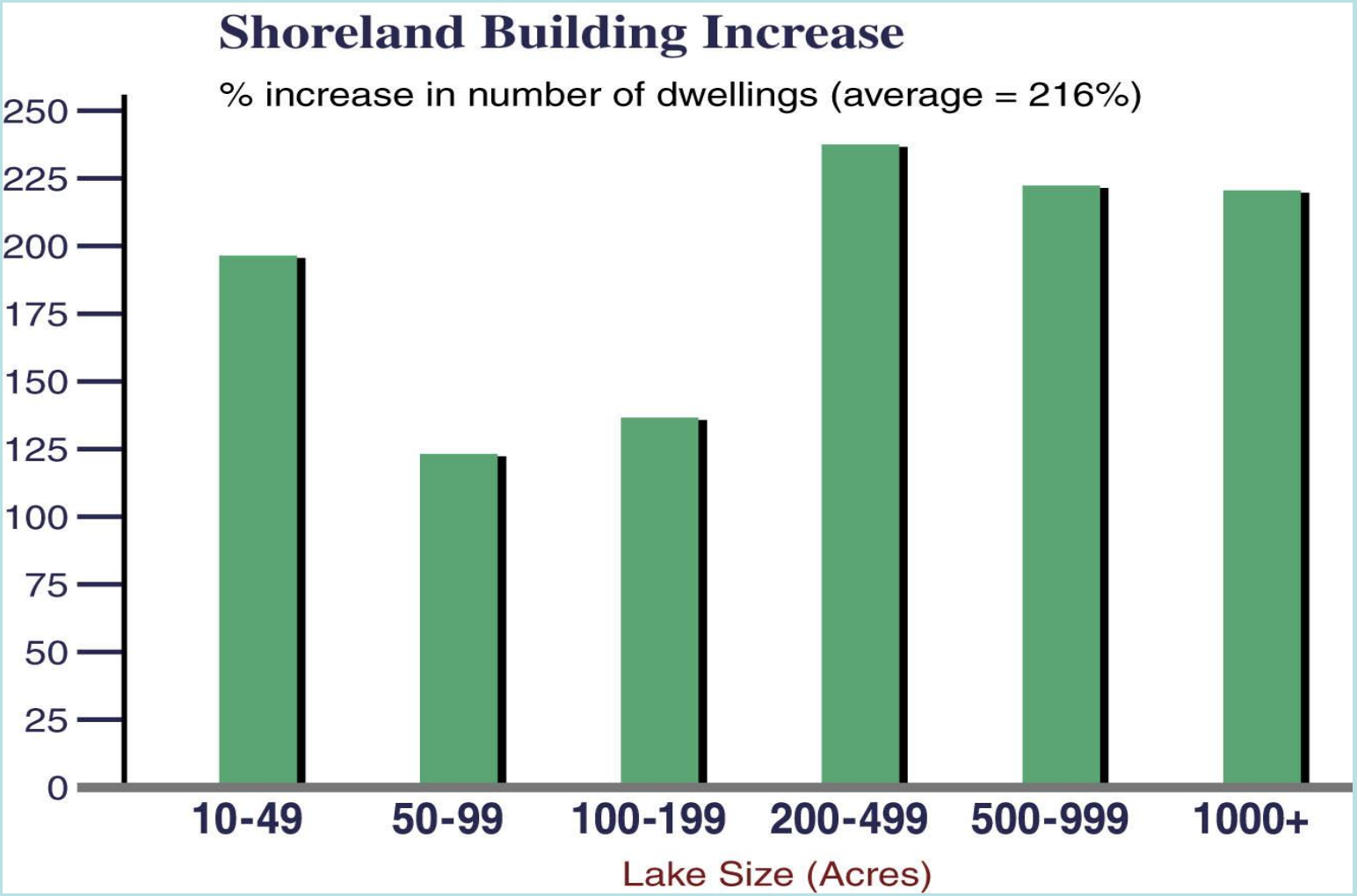

2010 Housing Density by Partial Block Group
Rural Renaissance Forecast
County Boundaries
Water
Housing Units Per Square Mile
Less than 5
5 - 10
10 - 20
20 - 40
40 or more
2010
0 10 20 30 40 Miles

HOUSING DEVELOPMENT PLOTTED



Source WDNR

Housing Development Since 1965



Source WDNR

Chapter NR 115

Wisconsin's Shoreland Management Program

- Shoreland vegetative cutting restrictions (35 ft buffer zone).
- Housing density 52/mile.
- Minimum shoreline frontage 100 ft.
- Building structures 75 ft set back from original high water mark.
- **Within the buffer zone no more than 30 ft shall be clearcut**.

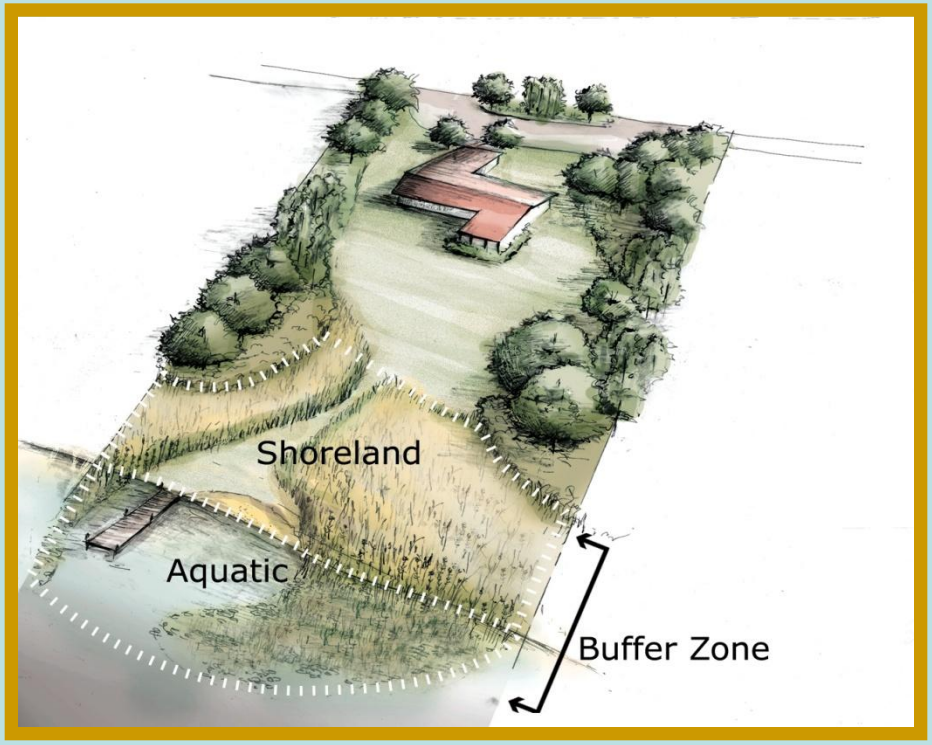


Photo by: D. Haskell

Photo by: D. Haskell

Residential Development in Vilas County

- Housing development doubled in 1990s
- Over half with lake frontage
- 61% of medium size buildings (1000- 3000 ft^2) within 100 m of lakes.

(Schnailberg *et al.* 2002)

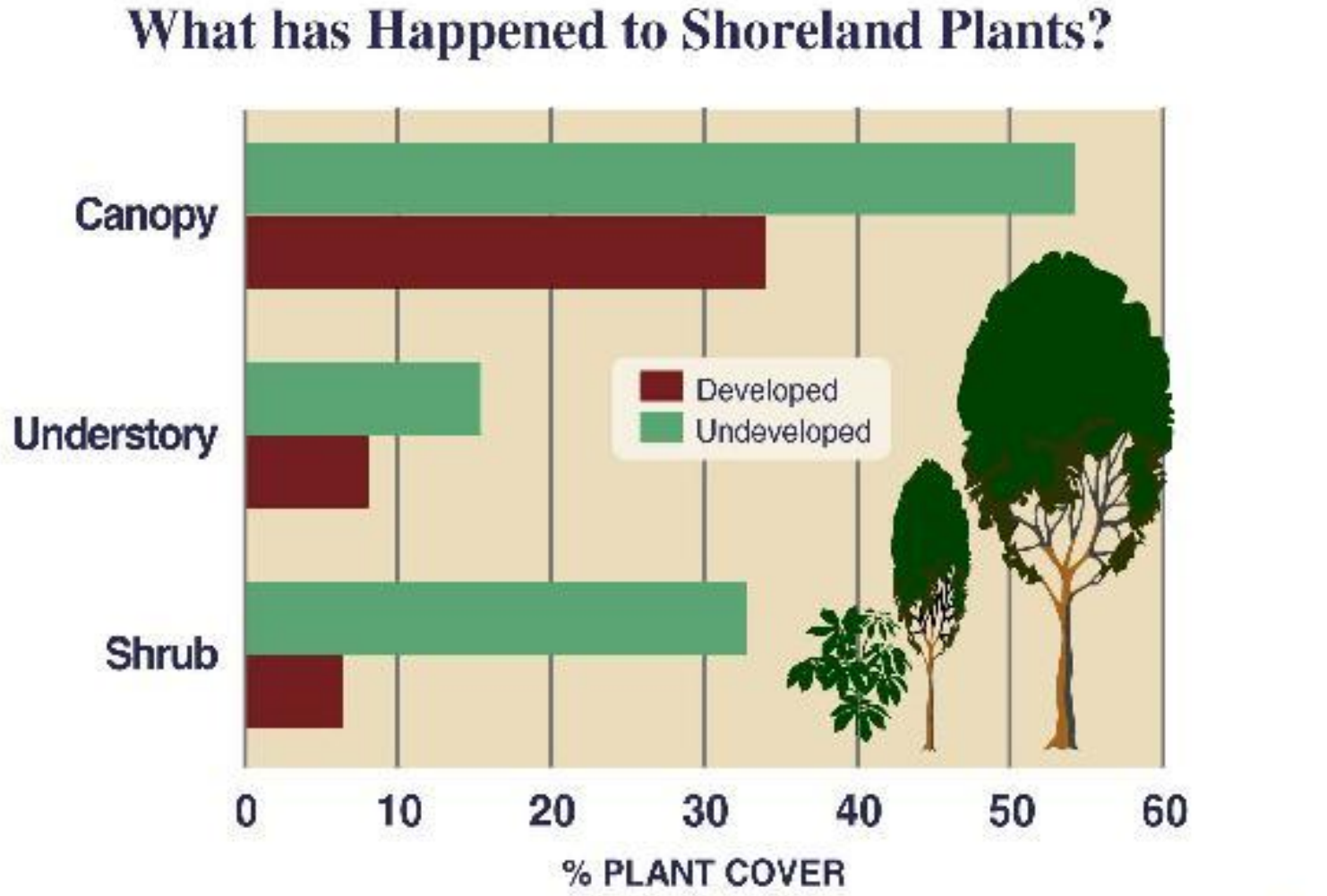
Photo by: D. Haskell

Research in the 1990s

- WDNR comparison on Low & High Development Lakes
  - Vegetation
  - Amphibian
  - Avian
  - **Mammals** ???
- UW-Trout Lake Research Station
  - Woody habitat
  - Fish population & growth

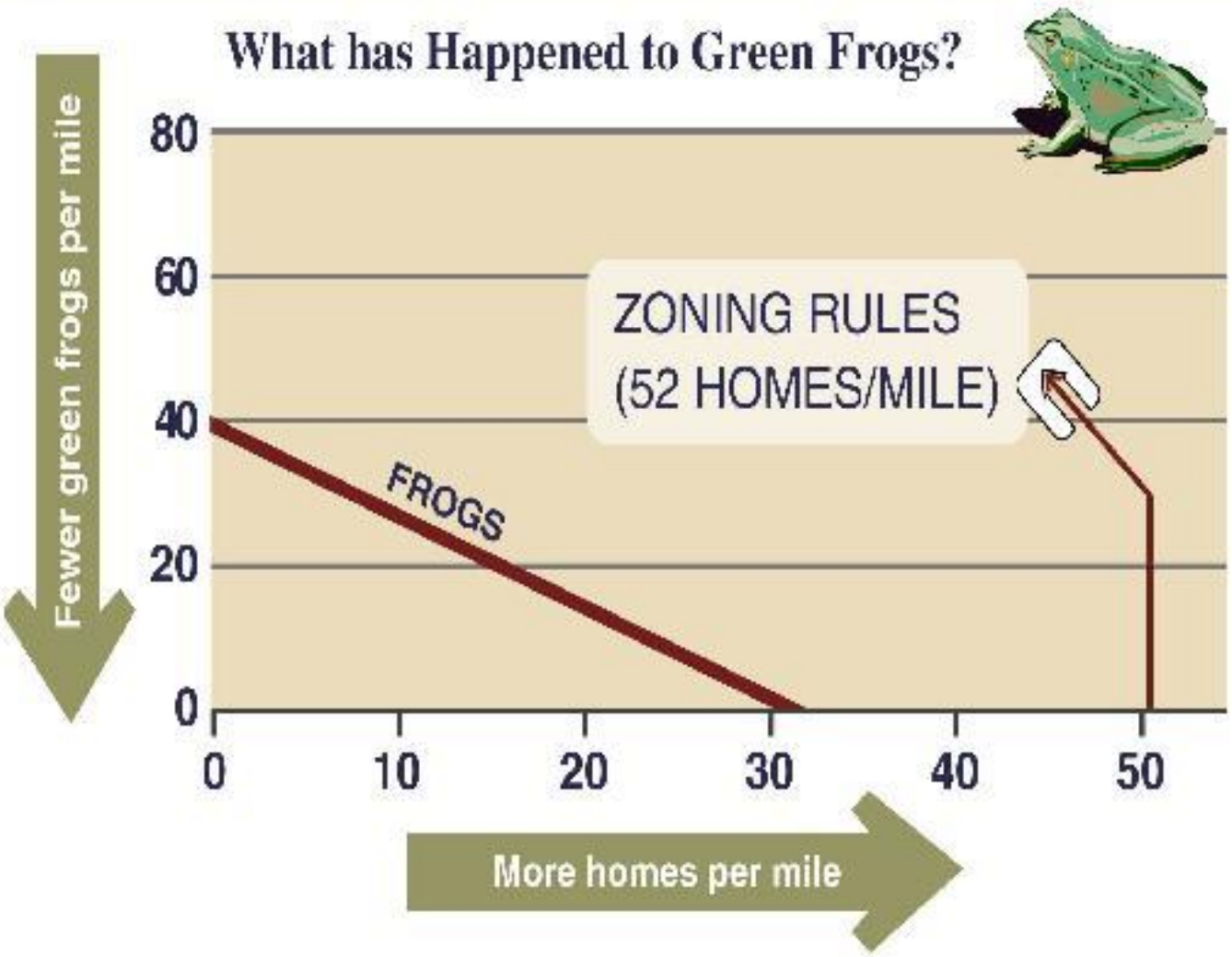
Shoreland plants trends

(Elias & Meyer 2003)



Shoreland green frog trends

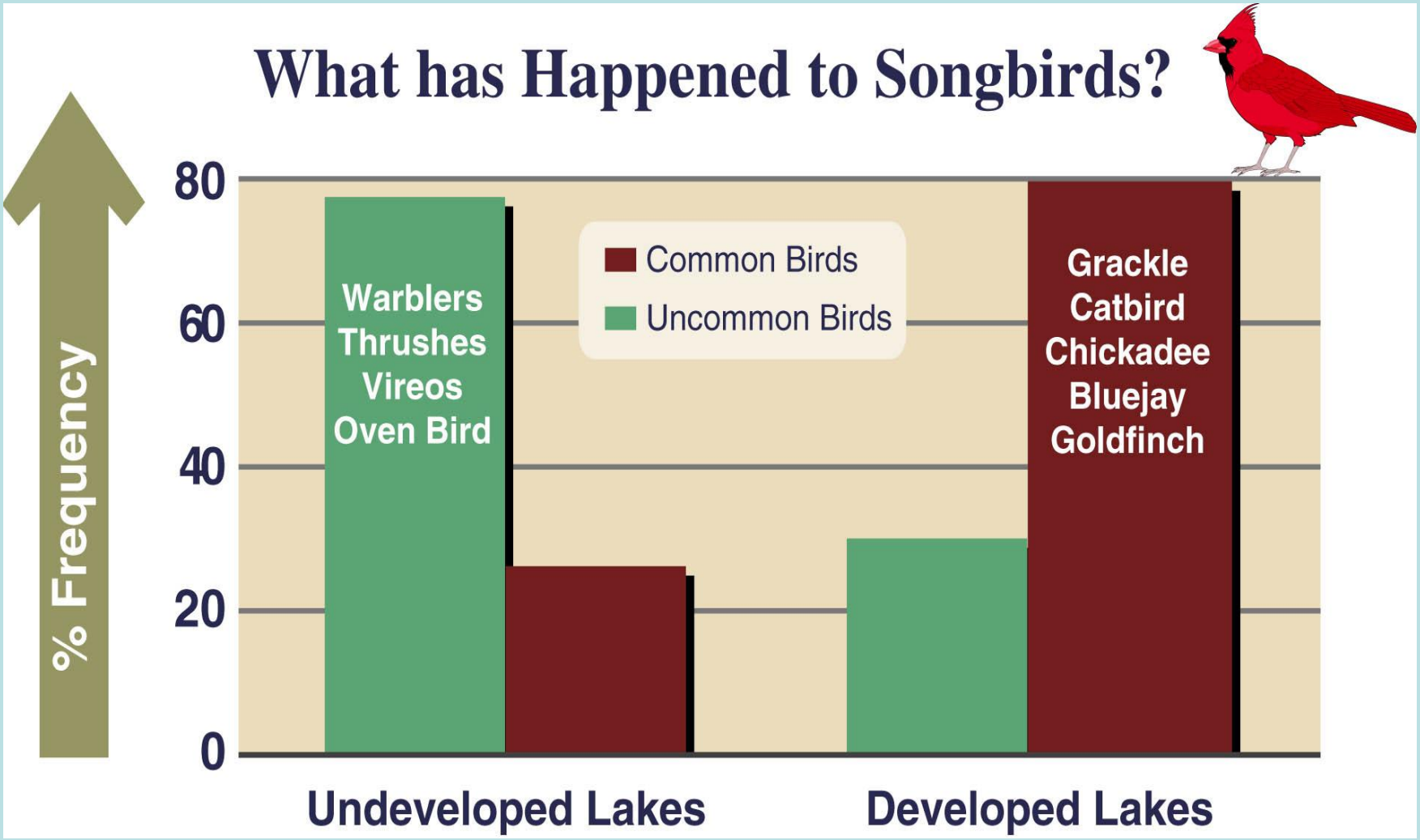
(Woodford & Meyer 2002)



Source: Wisconsin Dept. of Natural Resources

The Wisconsin Lakes Partnership

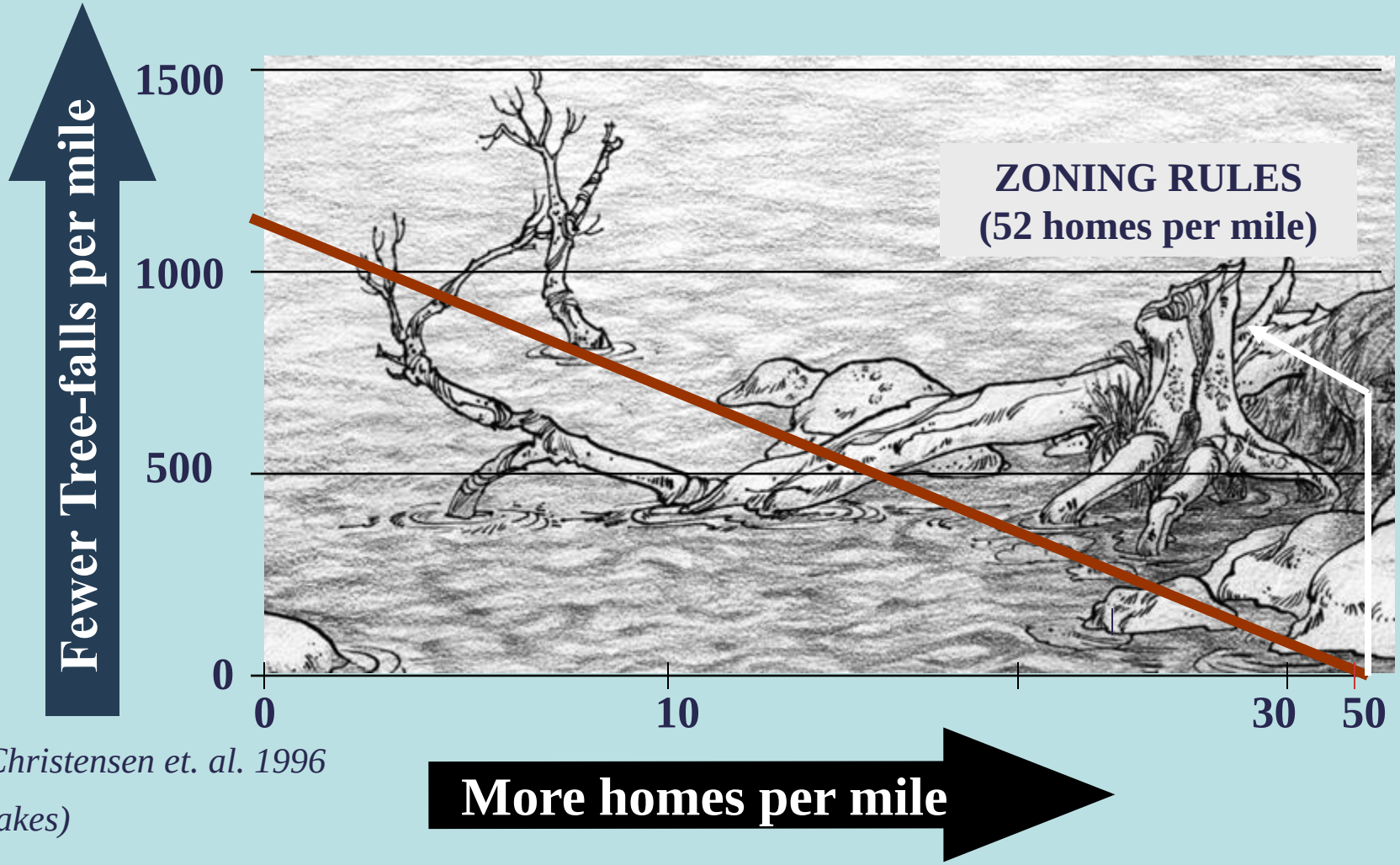
Shoreland bird trends (Lindsay *et al*. 2003)



Source: Wisconsin Dept. of Natural Resources

The Wisconsin Lakes Partnership

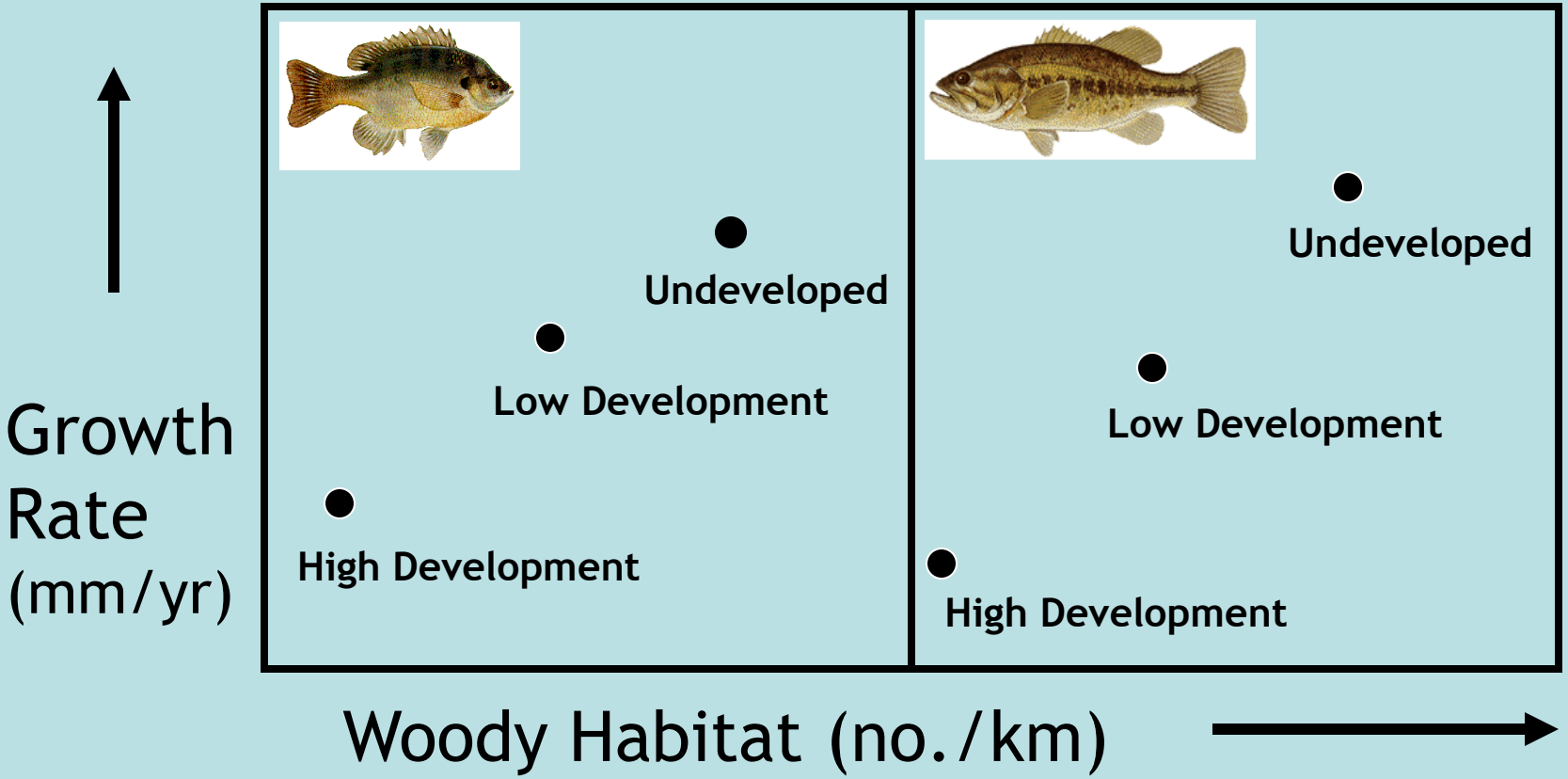
Woody Habitat in Littoral Zone



Source Christensen et. al. 1996

(16 N. Lakes)

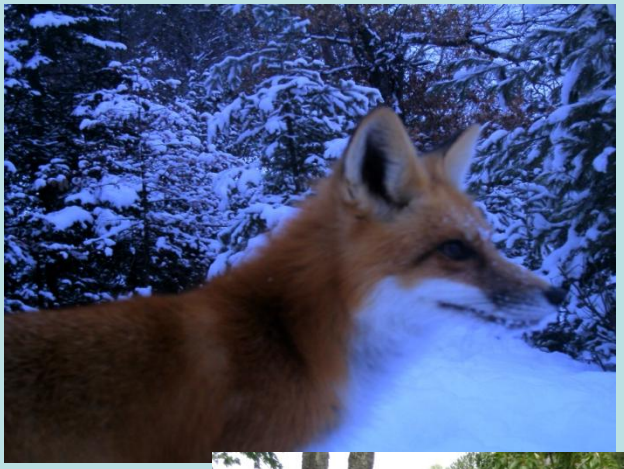
Fish grow ~3X faster in lakes with lots of woody habitat



From Schindler et al. 2000

Mammal Component

- Background Information
  - Geological & human history
  - Previous research
- **Mammal Research**
- Lakeshore Restoration
- Down Woody Material (DWM) Experiment
- Before & After



Photos by D. Haskell

Mammal Diversity of Lake Riparian Areas in Vilas County, Wisconsin

Habitat Fragmentation

- Carnivore habitat fragmentation.
- Some species are more sensitive to fragmentation.
- Meso-predator release which can lead to extirpation of ground nesting bird.

(Crooks and Soule 1999, Crooks 2002)

Photos by D. Haskell

Mid to Large Mammal Diversity

- Large carnivore presence & abundance reflect health of ecosystems
- Provides important role in structuring wildlife communities
- Affect herbivores and rodent demographics
- Preservation of carnivore species becomes important for management of ecosystems

Two Techniques Used: Snow Track Survey & Remote Cameras

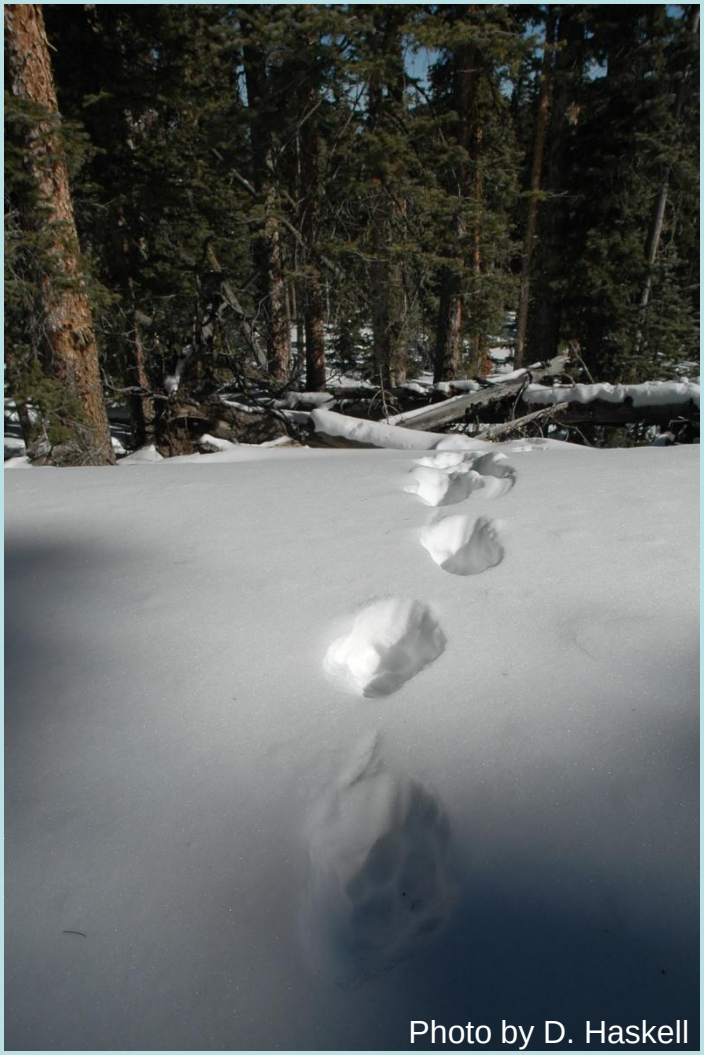
- Mammals can be elusive, nocturnal, secretive, and large HR.
- Mammals have different seasonal behavior patterns (i.e. hibernation).
- Canid species wary of human scent.
- Vegetation seasonality & body size can produce species-specific detectability.

(Hoffman 1996, O'Connell *et al. 2006)*

Snow track surveys

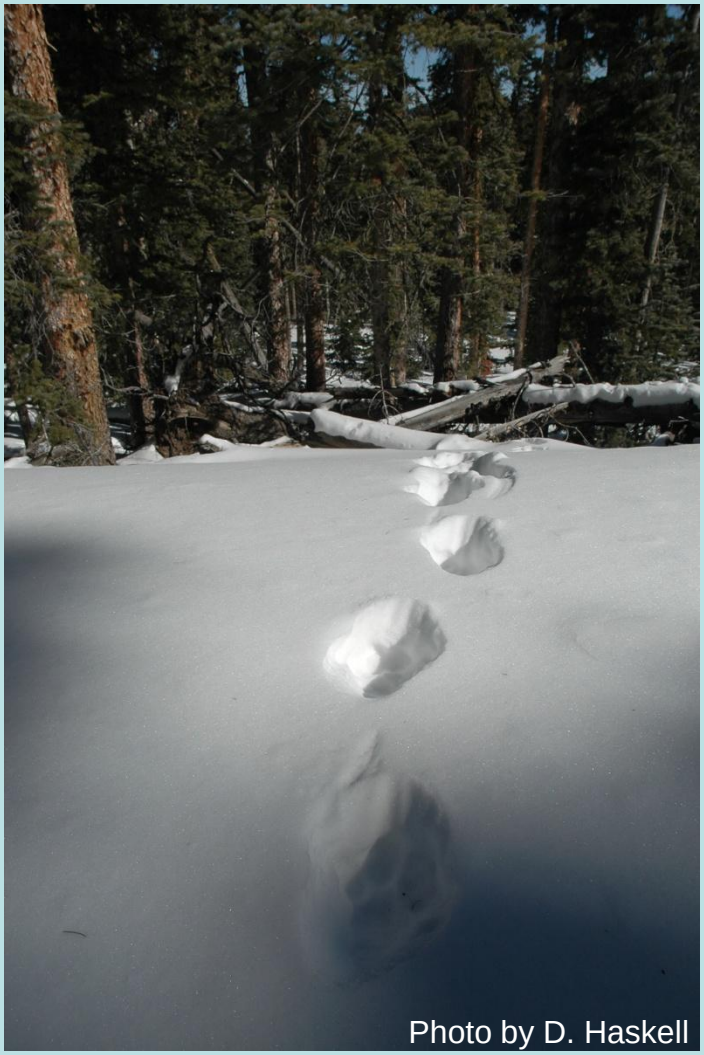
- Reliable technique
- Mammals can be identified by tracks
- Determine demographics
- Reveals a continuous record of movement
- Does not disrupt behavior
- Less costly than other techniques

(Halfpenny 1985)



Snow Track Methods

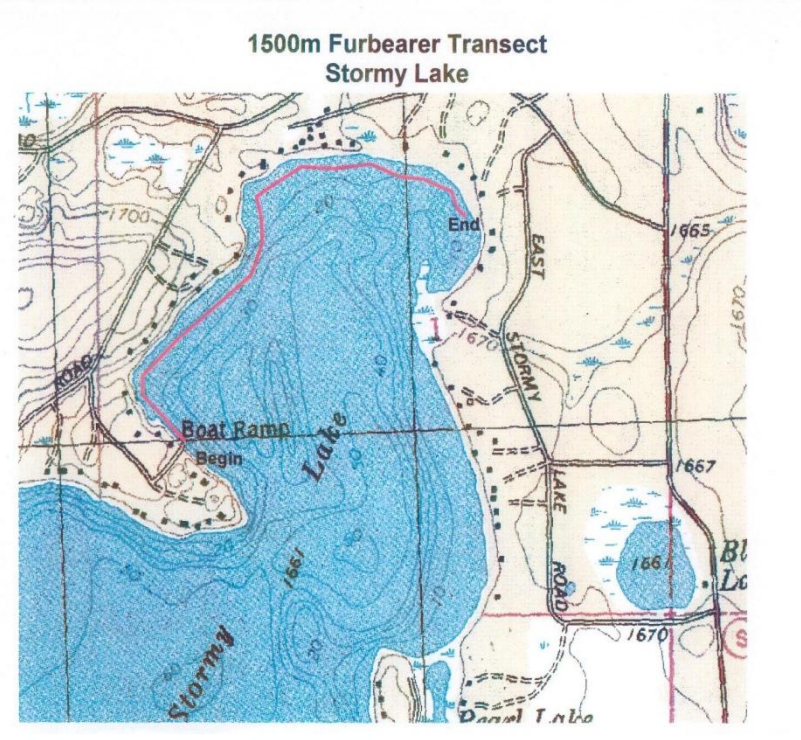
- Ten pairs of lakes surveyed in 2008
- 1500 m transects parallel with shore
- Conducted from January-March
- All fresh furbearer tracks tallied
- Non-carnivore species recorded



Snow Track Survey Transects

High-Development

N = 10
Housing density ≥10/km
Mean house density ~ 21/km



Low-Development

N = 10
Housing density < 10/km
Mean house density ~ 2/km

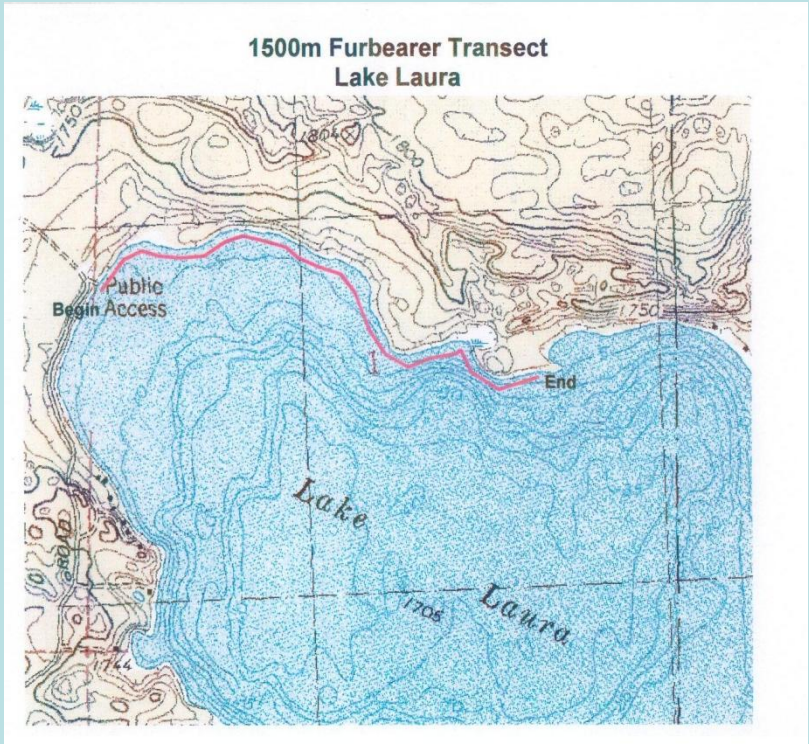


Photo by D. Haskell


Photo by D. Haskell

Photo by D. Haskell

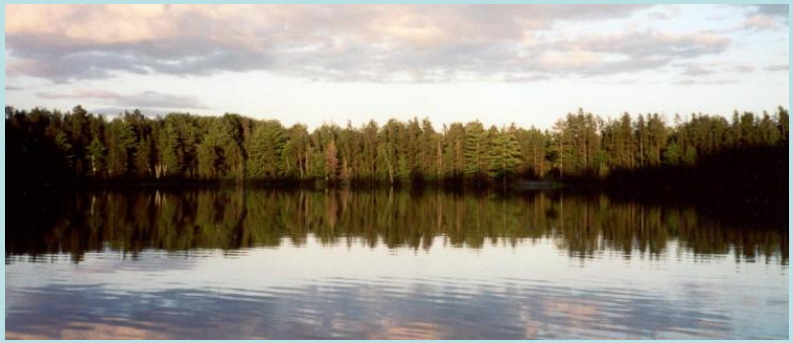
Remote Camera Methods

High-Development:

- *n* = 2
- Mean house density ~ 16/km
- Cameras *n* = 6
- Sites randomly picked
- Sites at ≥ 1 km apart

Low-Development:

- *n* = 2
- Mean house density ~ 1/km
- Cameras *n* = 6
- Sites randomly picked
- Sites at ≥ 1 km apart



Remote Camera

- Relatively less labor
- Relatively lower intrusiveness
- Low inherent bias
- Data on multiple species
- Can identify individuals
- Detect both predators & prey
- Valuable for public outreach

(Kays and Slauson 2008)

Camera Placement

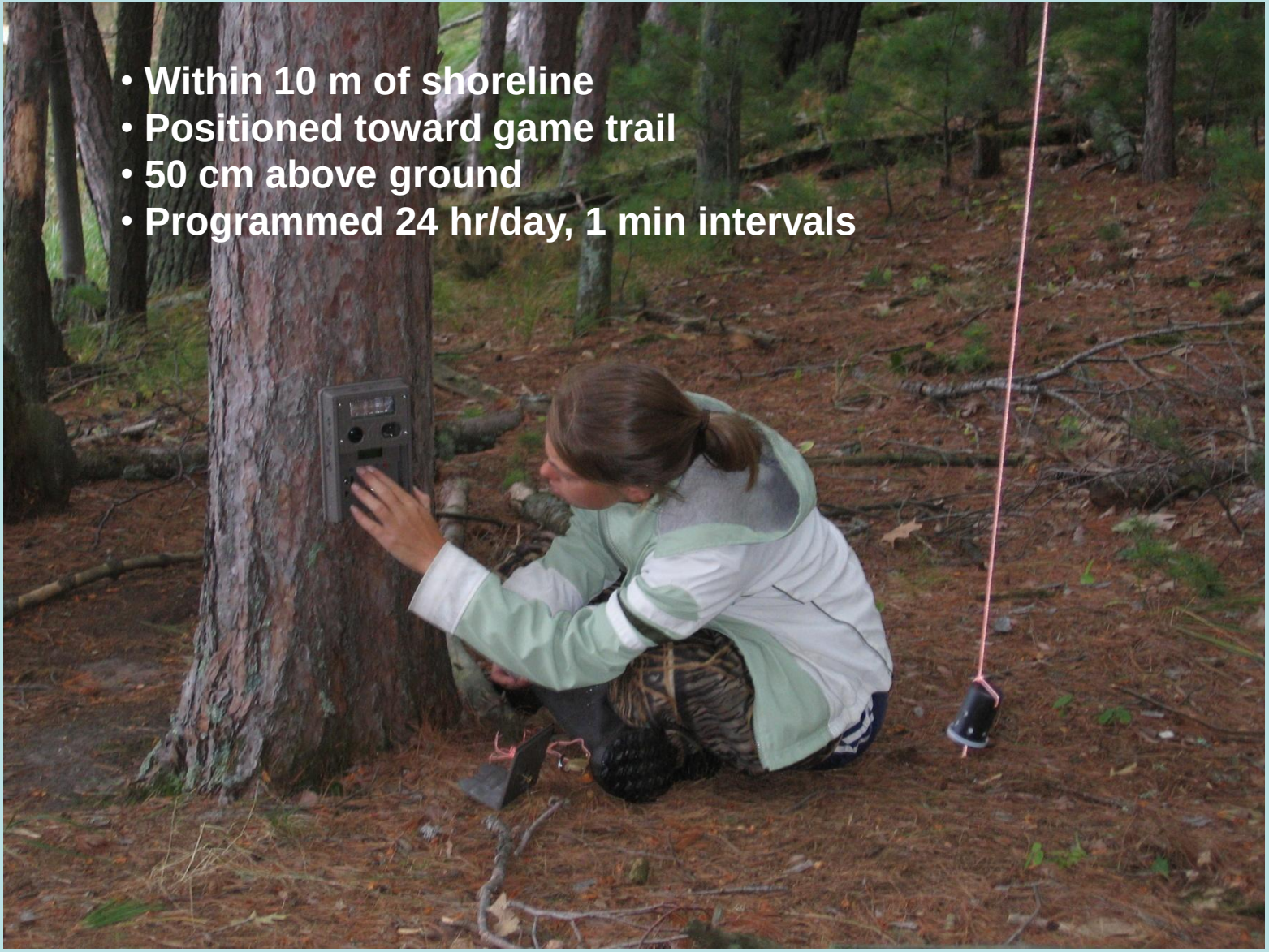


Photo by M. Woodford


9/22/08 7:24 PM WDbR
Cuddeback


10/07/07 12:58 PM WDNR
Cuddeback


6/18/08 5:01 AM WDNR
Cuddeback


7/14/07 2:58 PM WDNR
Cuddeback

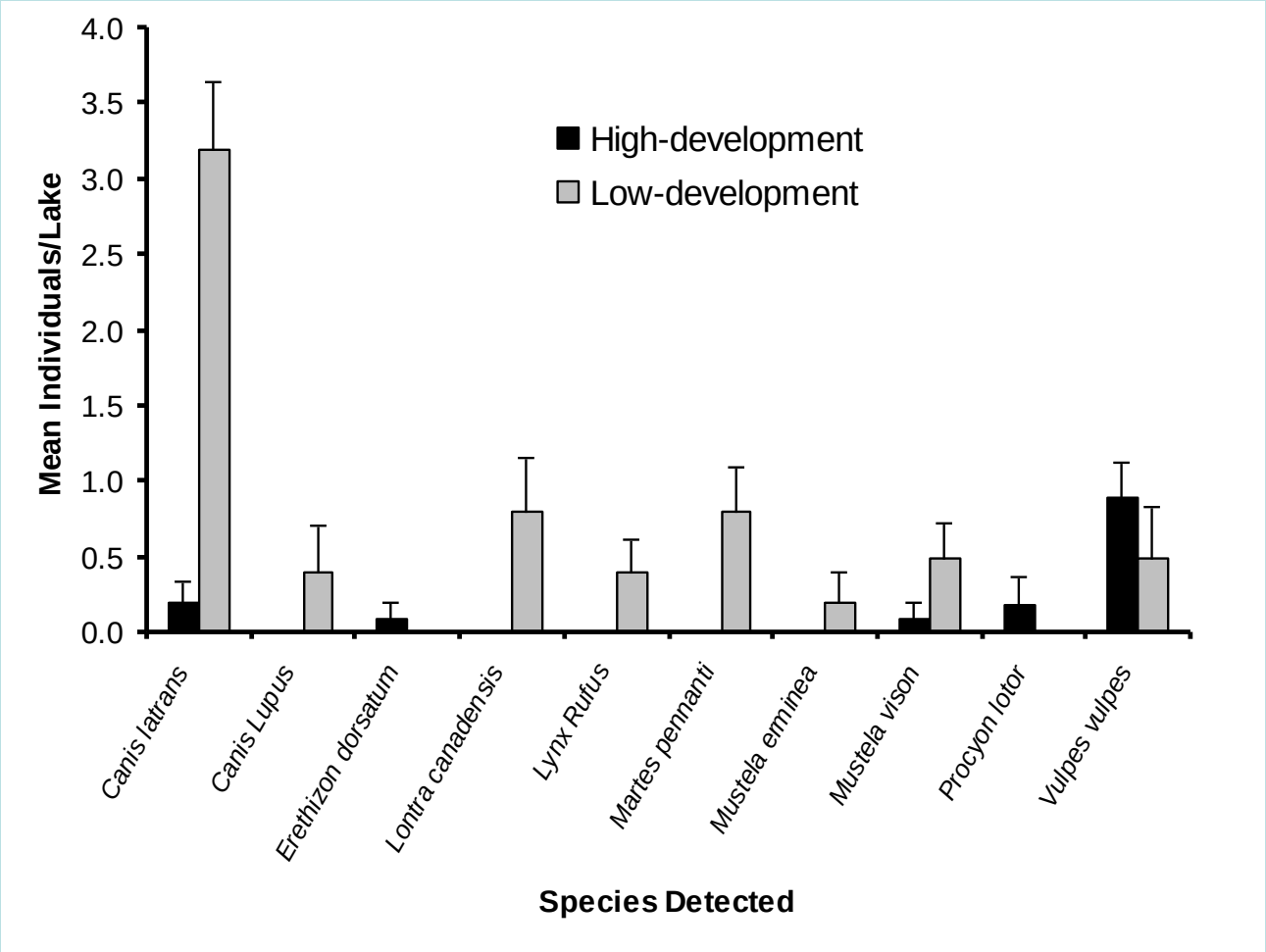

7/17/07 2:25 AM WDNR
Cuddeback.


9/27/08 1:27 AM WDNR
Cuddeback.


8/04/07 3:34 AM WDNR
Cuddeback


7/25/09 11:04 AM WDNR
Cuddeback

Snow Track Survey Results



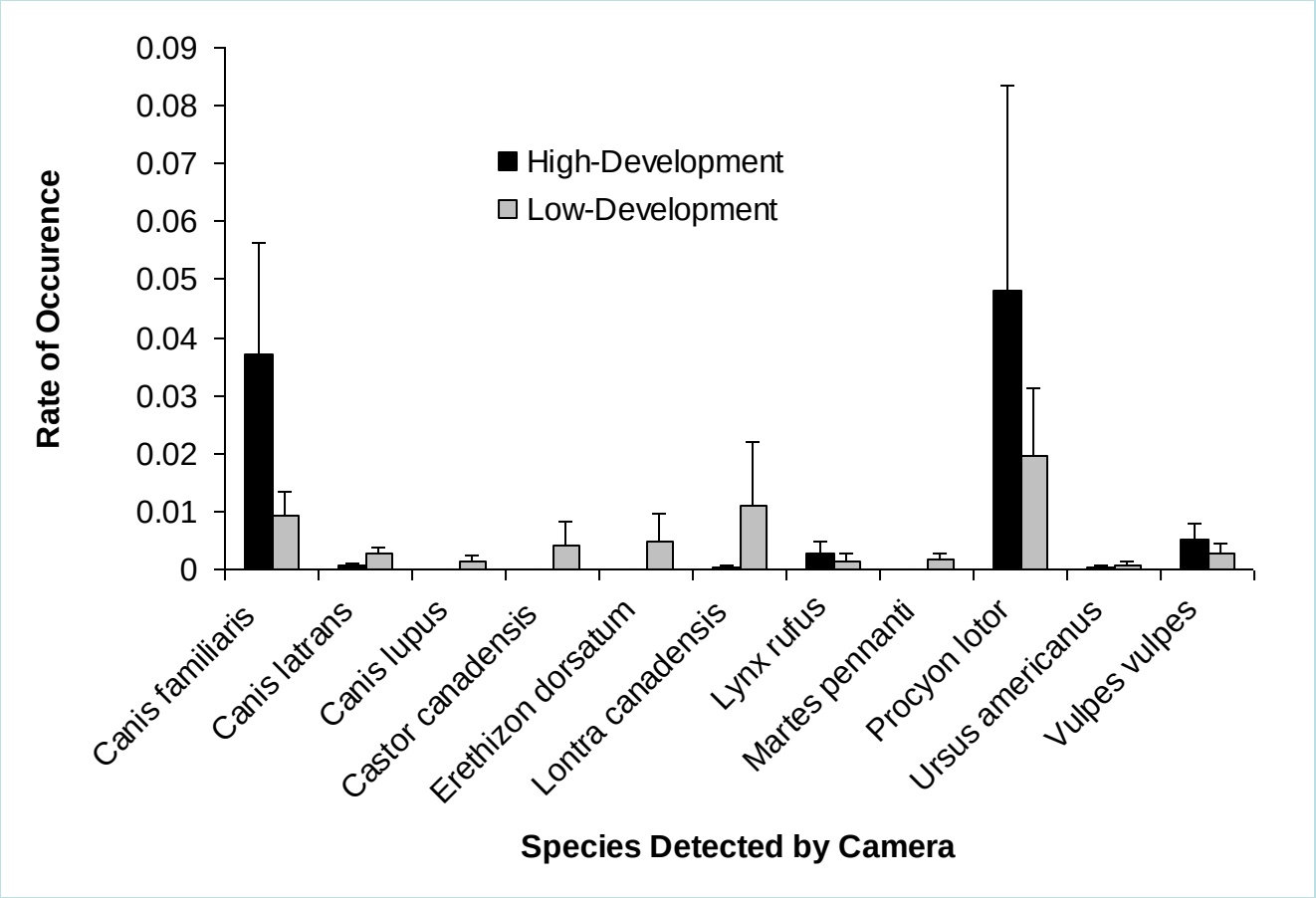
Other Mammals

- **Cottontail Rabbit *(Sylvilagus floridanus)***
  - Associated HD
  - ***P* = < 0.001**
- **Snowshoe Hare *(Lepus americanus)***
  - Associated LD
  - ***P* = 0.017**
- **Deer *(Odocoileus virginianus)***
  - Associated HD
  - ***P* = < 0.001**

Photos by D. Haskell

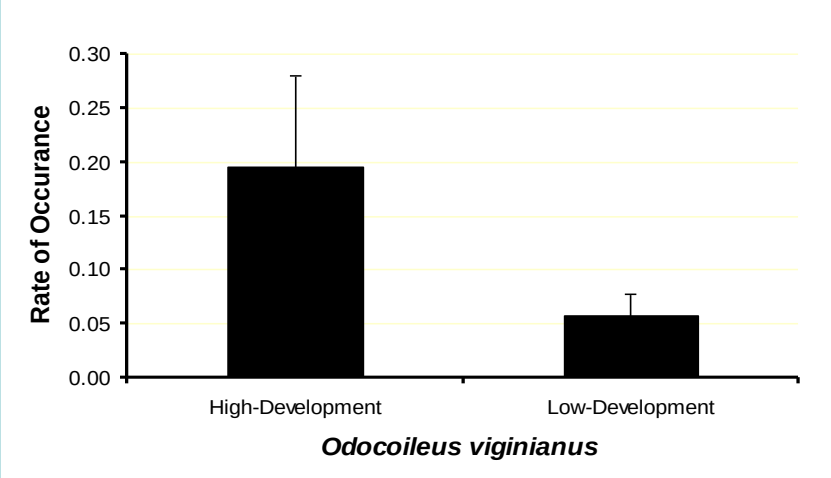
Remote Camera Results

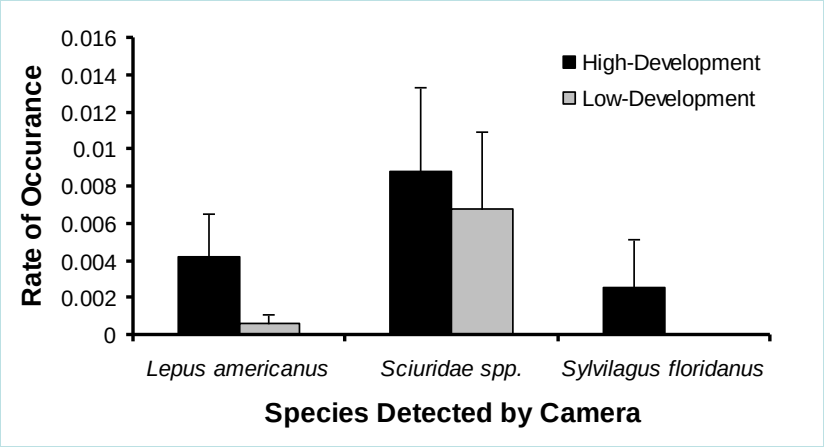
- June 2007-August 2008 (excluding Jan & Feb 2008) 2850 camera nights/lake type.
- Calculated rate of occurrence (number of events/camera nights) for each species.
- I define event when a species was detected within a 24 hr period.



Remote Camera Results

- 2850 Camera nights/lake type
- White-tailed deer 3x higher on HD
- Hare occurrence higher on HD
- Cottontail no occurrence on LD





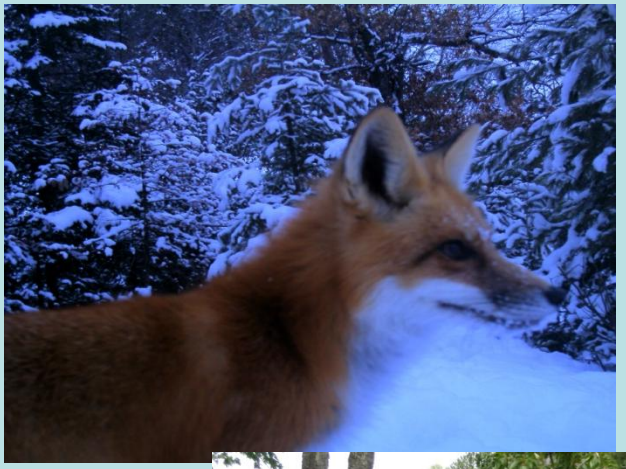
Discussion

- Mammal diversity & richness higher on LD.
- Coyote & Bobcats may be sensitive to HD.
- Red fox & raccoon associated to HD.

Photos by D. Haskell

Restoration

- Background Information
  - Geological & human history
  - Previous research
- Mammal Research
- **Lakeshore Restoration**
- Down Woody Material (DWM) Experiment
- Before & After



Photos by D. Haskell

RESEARCH QUESTION: Can lakeshore restoration mitigate the environmental impacts of development?

Photo by Dan Haskell

Objectives

- Objective 1 - Assess whether lakeshore vegetative community and habitat structure can be restored (Long Term Inventory and Monitoring).
- Objective 2 – Evaluate wildlife population response to lakeshore restoration efforts (Long term Inventory and Monitoring).
- Objective 3 - Maximize the success of restoration projects by experimentally testing restoration techniques (Short Term Experimentation).

BACIP Optimal Study Design

Before–After-Control-Impact-Paired Design

(Green 1979, Morrison 2002)

- This design is commonly used for impact assessment (effects of restoration).
- Sub-samples taken at all sites before and after treatment (restoration).
- Sites are sampled simultaneously over time.

BACIP for Lakeshore Restoration

- **SAMPLE UNITS:**

3 paired lakes - 1 high development, 1 low development. Similar size, water chemistry, shoreline characteristics.

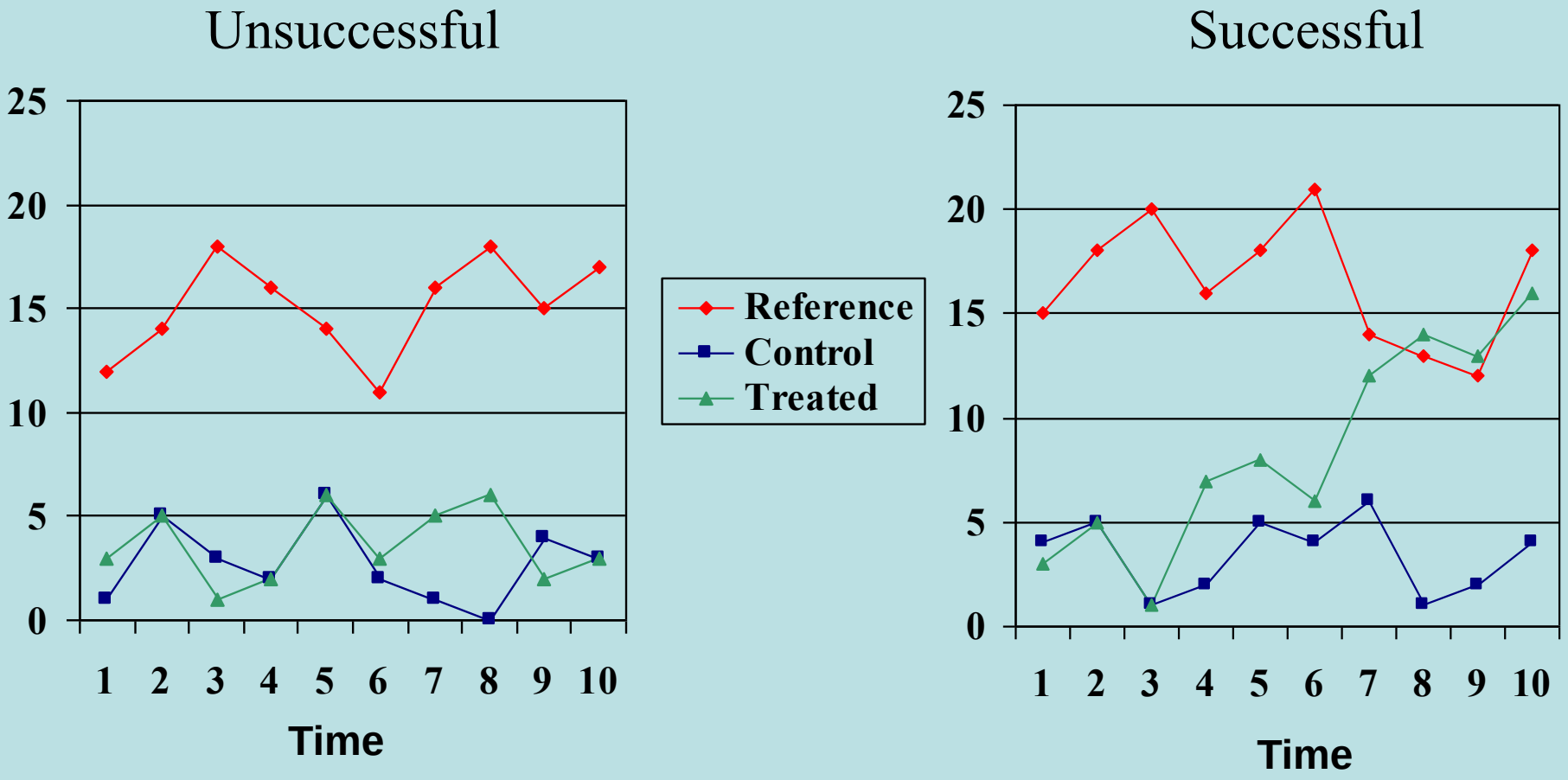
- **QUADRATS AND TRANSECTS:**

Reference (low-developed), control (developed, no restoration), and impact (developed, with restoration) quadrats and transects.

- **MEASUREMENTS:**

Pre-restoration (baseline) and post-restoration measures for $\geq$ 10 years.

Hypothesis: Over time, measurements at the impact sites (restored) will be significantly different from that at the control sites, and will approach the measurements made at the reference (low-development) sites.



Three Paired Lakes Sampled in 2007 - 2009

High-Development:

- Found
- Moon
- Lost

Low-Development:

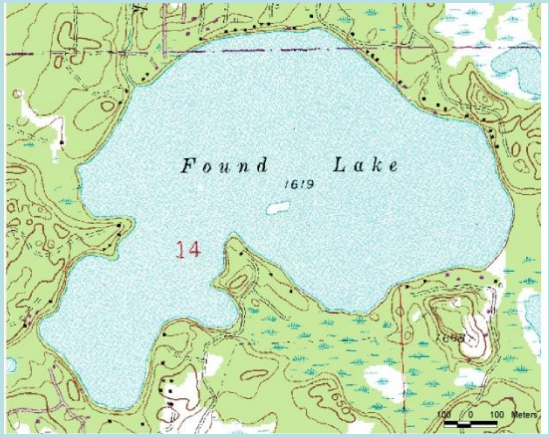
- Escanaba
- Jag
- White Sand

Lakes were paired by:

- Surface size
- Water Chemistry
- Lake Type (drainage, seepage, spring)
- Substrate

Found Lake

- 326 acre drainage lake.
- Housing density: 16.7 houses/km.
- Home to several fishing resorts in the past that evolved into individual parcels.
- 1999 suffered from a thunderstorm with high winds, toppling hundreds of mature trees along the north-northeast shoreline.



1999 Storm


Photo by: D. Kloepfer

Removal of DWM

Results from Strom Event & Human Activity

- Open canopy layer and understory vegetation die off
- Erosion proceeded to occur
- Residents failed at veg. re-establishment
- Enrolled in restoration project

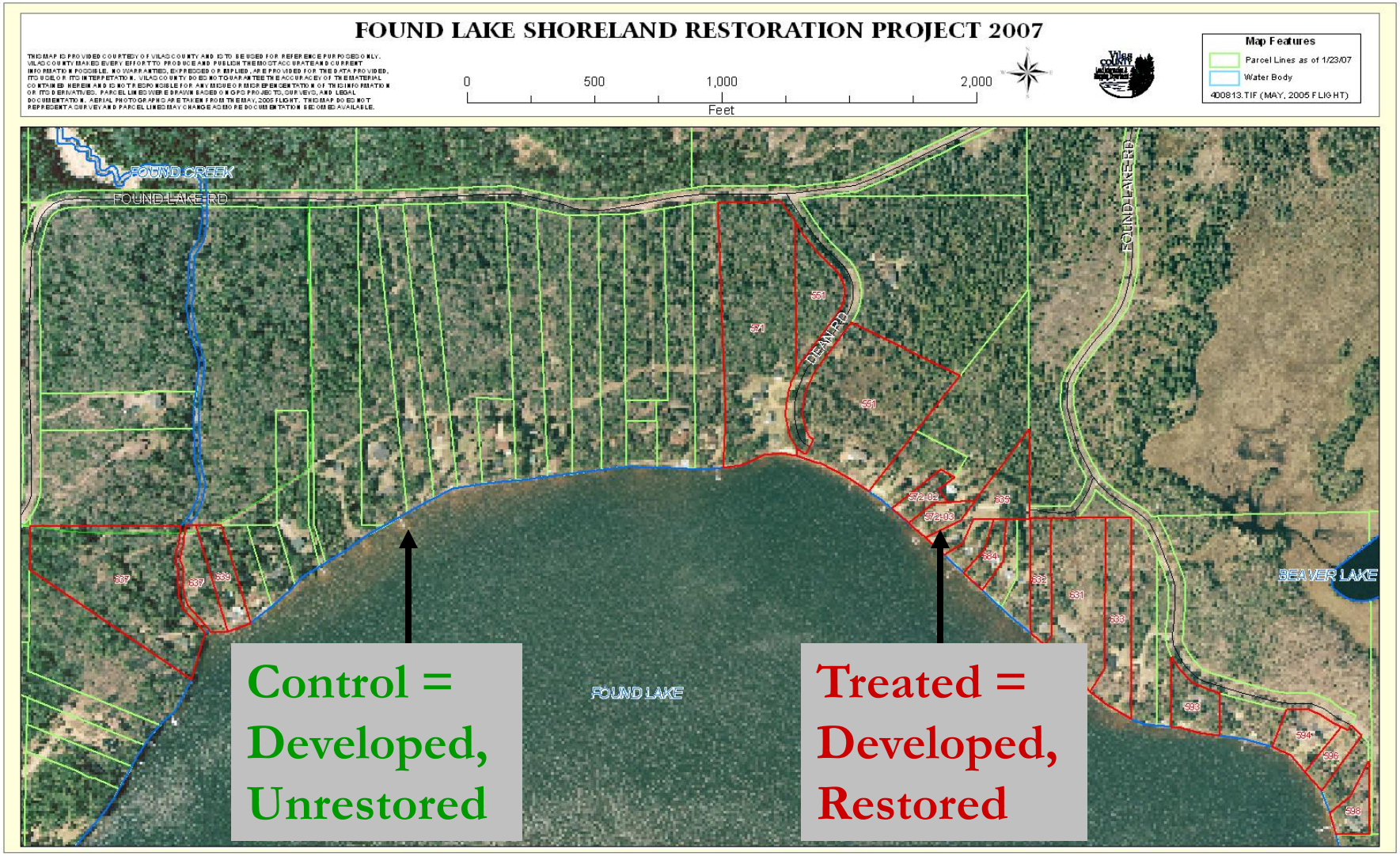
Photos by Dan Haskell

Photo by Dan Haskell

VCLWD Lakeshore Restoration Program

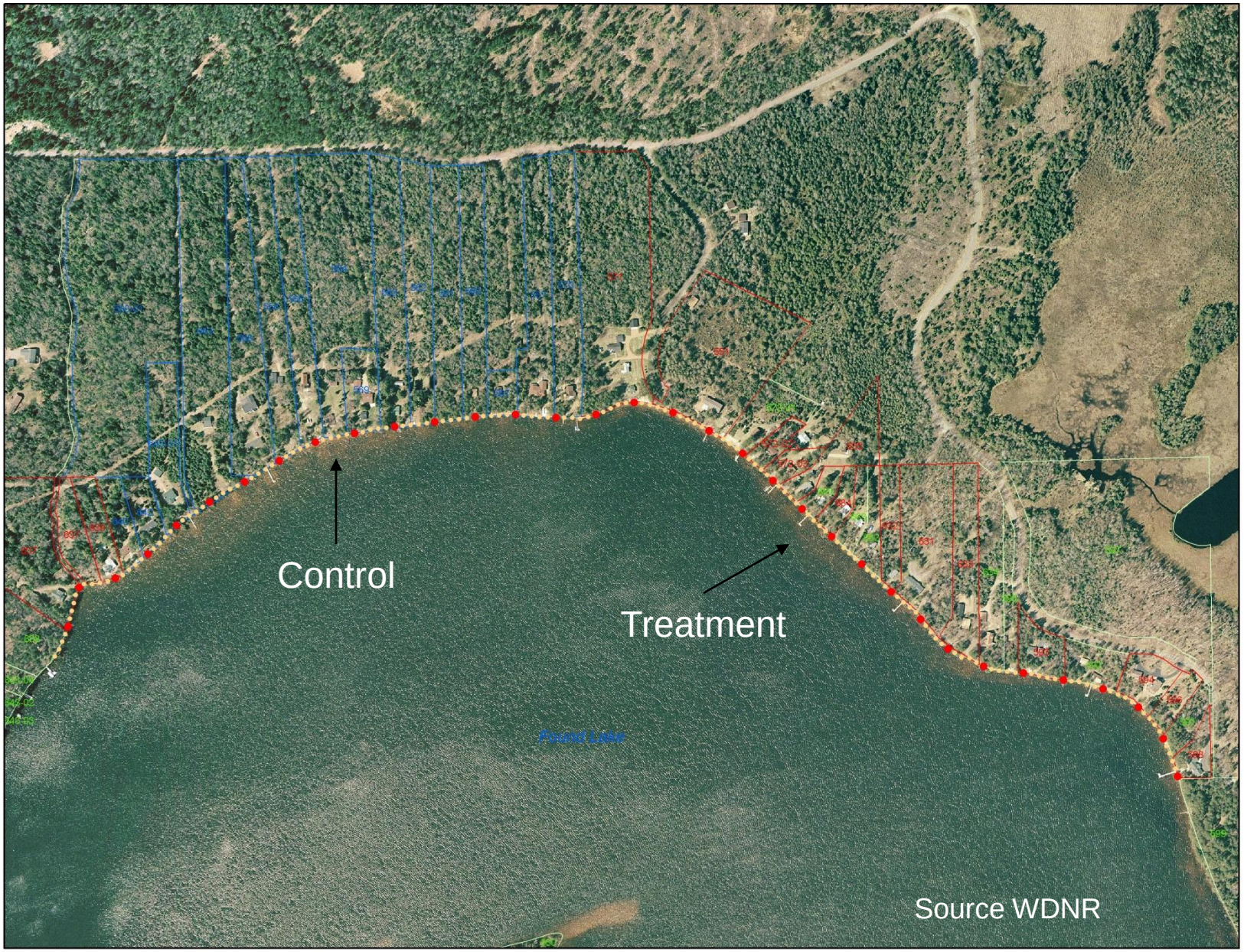
- Requires property owners to plant native species within buffer zone.
- Address erosion issues (bioengineer techniques).
- Sign a ten-year contract.
- Funded by DATCP (70%).
- On going since 2000; $30-$60k/year.
- Success of restoration???

Restoration Completed at Found Lake 2007 & 2008 in Partnership with VCLWCD, WDNR, WDATCP, MTU

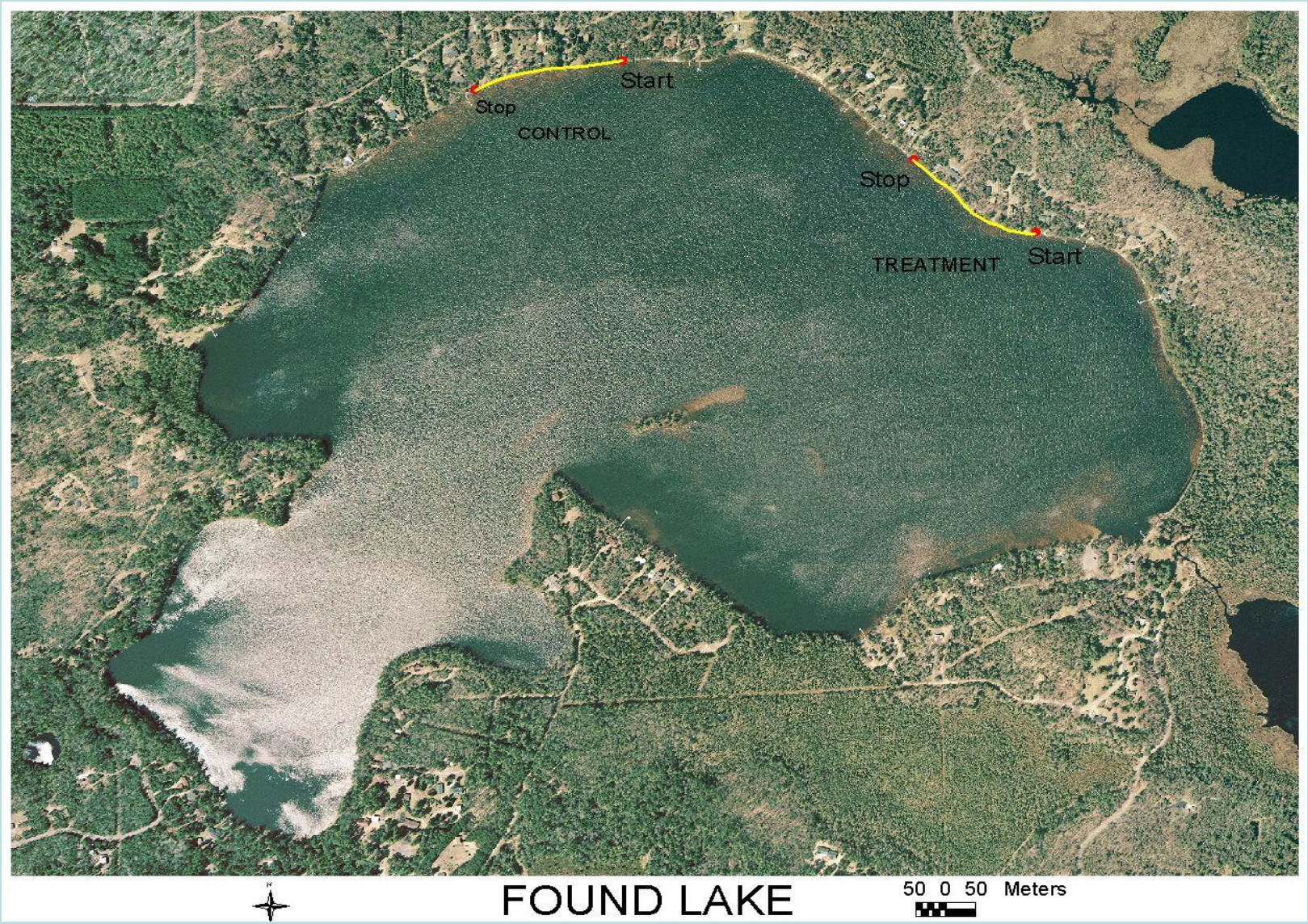


Source WDNR

Vegetation Quadrats (10-m^2)



Bird, Amphibian, Small Mammal Transects



Source WDNR

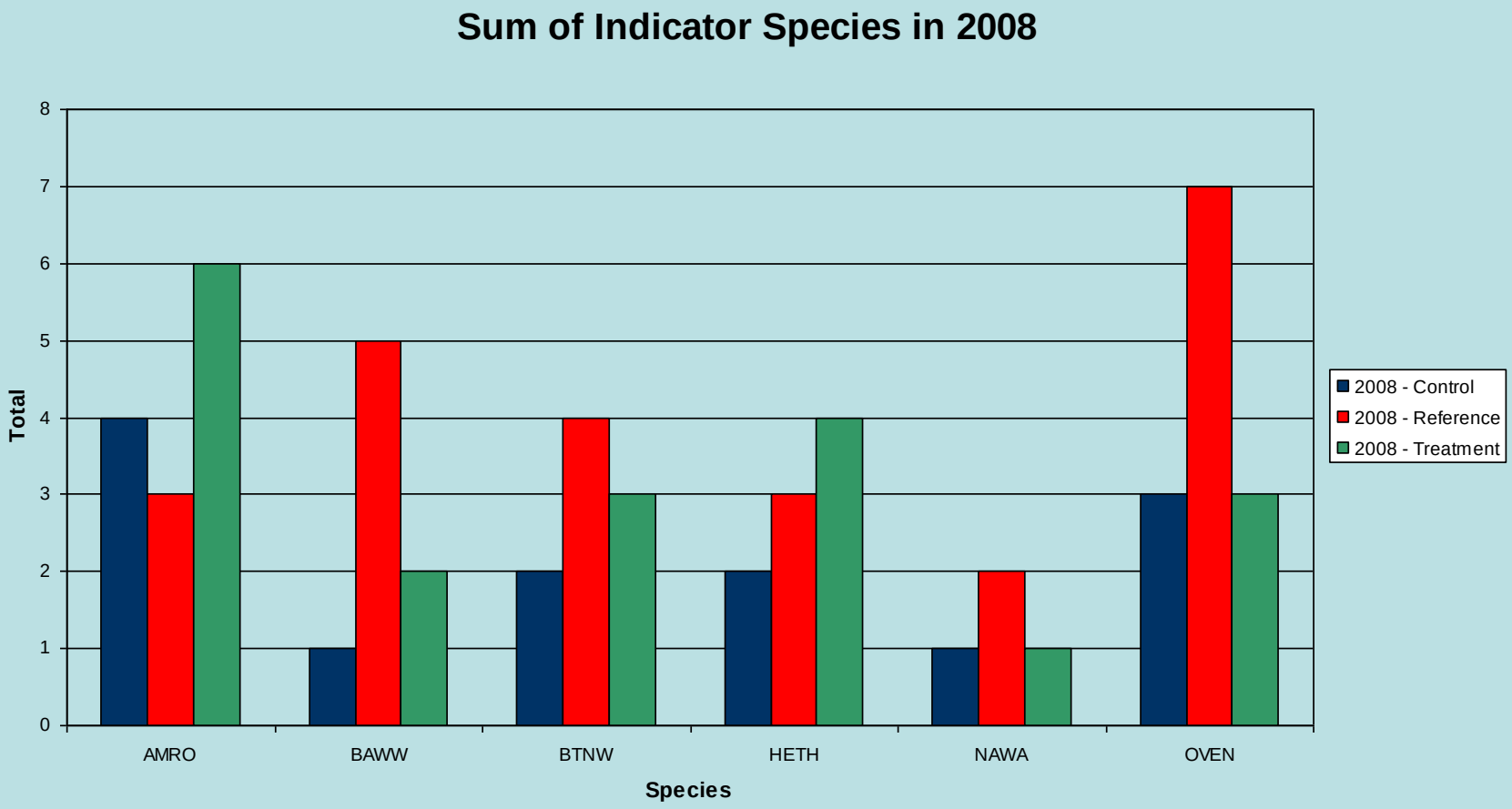
Paired Reference: Escanaba Lake

Small Mammal Trapping

Avian Surveys

- Tallied all species seen or heard
- 23 indicator species
  - Ground & shrub nesting
  - Canopy nesting
  - Cavity nesting

2008 Avian Results



Results From Restoration Efforts

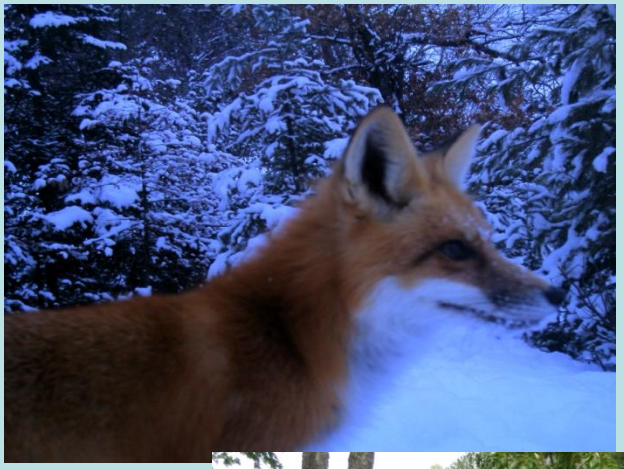
- 12 private properties on Found Lake
- 72,333 ft^2
- 12,324 ground cover plants (100 spp.)
- 1,941 shrubs (30 spp.)
- 220 trees (20 spp.)
- 4001 ft of fence (deer enclosure)

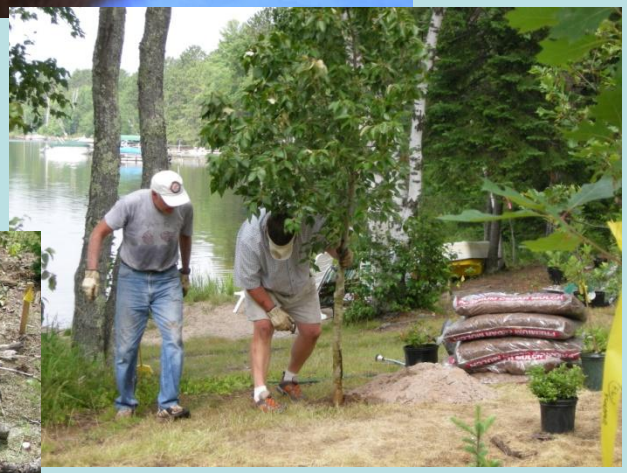
Photo by Dan Haskell

Landowners & Agency Personnel

DWM Experiment

- Background Information
  - Geological & human history
  - Previous research
- Mammal Research
- Lakeshore Restoration
- **Down Woody Material Experiment**
- **Before & After**





Photos by D. Haskell

Benefits of Down Woody Material (DWM)

- DWM important component to ecosystems.
- Influence soil and sediment flow.
- Energy flow & nutrient cycling.
- Provides nursery sites for plants.
- Provides organic matter to soil.
- Creates microclimates.
- Influences interactions between terrestrial & aquatic systems.
- Critical habitat for variety of wildlife.
- Fungi use as nutrient source.

(Harmon *et al.* 1986)

Testing the Addition of DWM to Restoration Sites

- **Objective:** Compare 3 different coverages of DWM, minimize soil temp & moisture variation, estimate 1st year of plant survival & growth.

- **Hypothesis:** Soil temp & moisture vary less on DWM plots, plant survival and growth will be greatest on DWM plots.

Photo by Dan Haskell

Plants in Test Plots

- **Three Shrubs: *(n = 90)***
  - One Snowberry (*Symphoricarpos albus)*
  - Two Sweet Fern (*Comptonia* peregrine)
- **25 herbs & grass: (*n =750)***
  - Little-blue stem (*Schizachyrium scoparium*)
  - Barren's strawberry (*Waldstenia fragaroides*),
  - Pearly everlasting (*Anaphalis margaritacea*)
  - Bergamot (*Monarda fistulosa*)
  - Big-leaf aster (*Aster marcophyllus*)

Photo by Dan Haskell

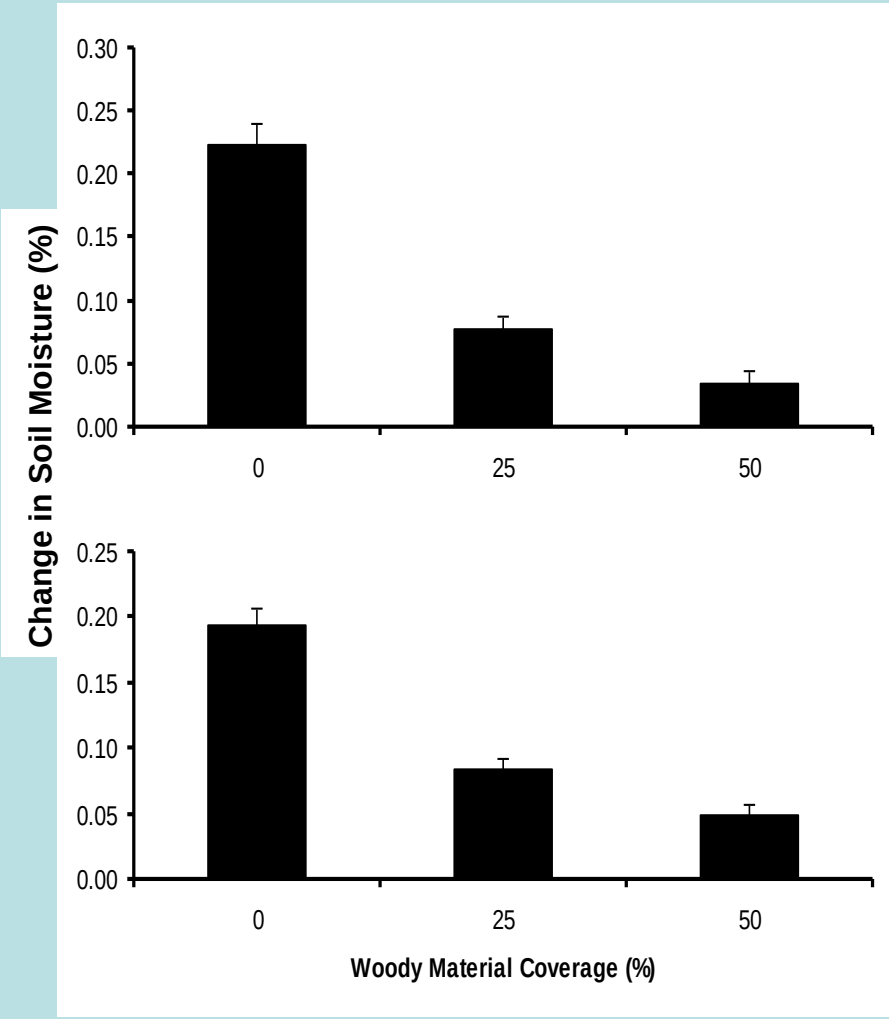
Woody Material Test Plots

Photos by Dan Haskell

2008 Soil Moisture Results

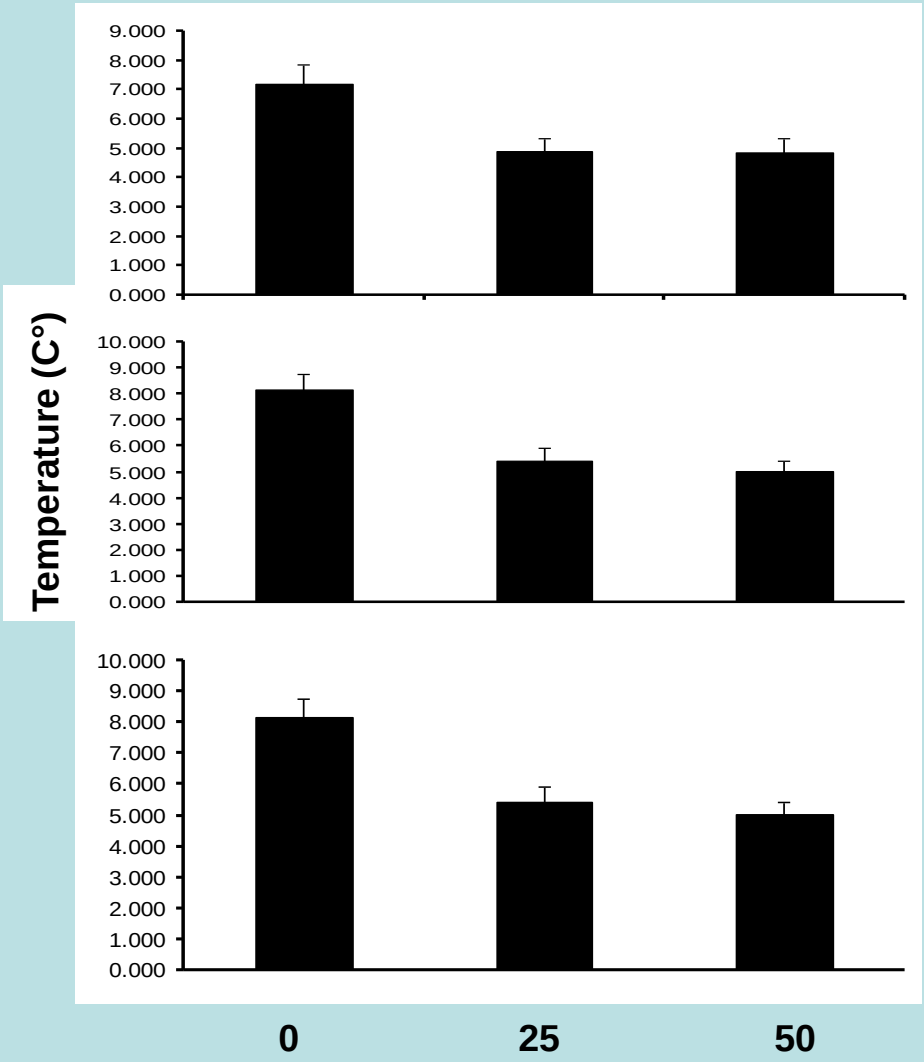
- **July:** *n* = 25/treatment
- 0% DWM plots had higher % change in moisture.
- (P = **<0.001**)

- **August:** *n* = 34/treatment
- 0% DWM plots had higher % change in moisture.
- (P = **<0.001**)



Difference Between High & Low Soil Temp

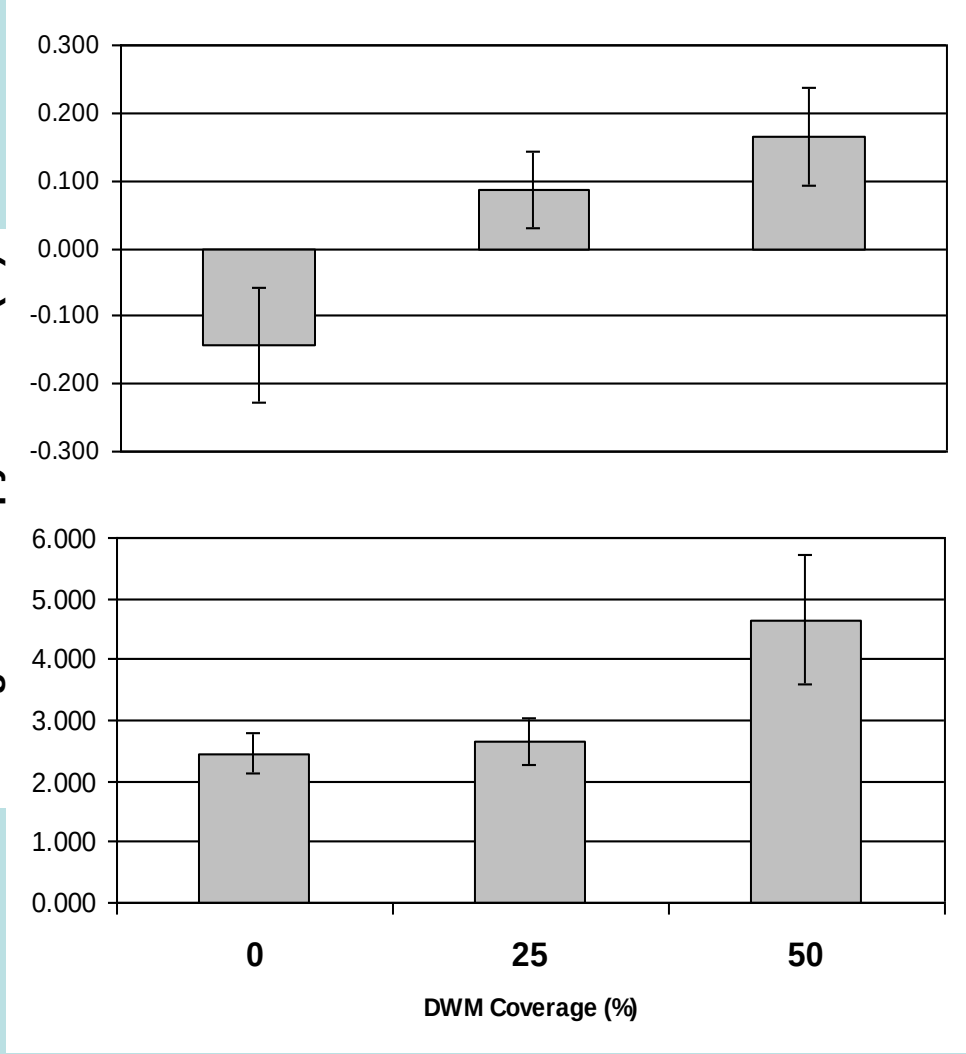
- **June:** 0% DWM plots had a greater difference in temp. (*P* = **0.005**)
- **July:** 0% DWM plots had a greater difference in temp. (*P* = **<0.001**)
- **August:** 0% DWM plots had a greater difference in temp. (*P* = **<0.001**)



Shrub Change in Canopy Volume (%)

- **Snowberry:** negative growth in 0% DWM (*P* = **0.015**)

- **Sweet Fern:** no significant difference (*P* = 0.264)

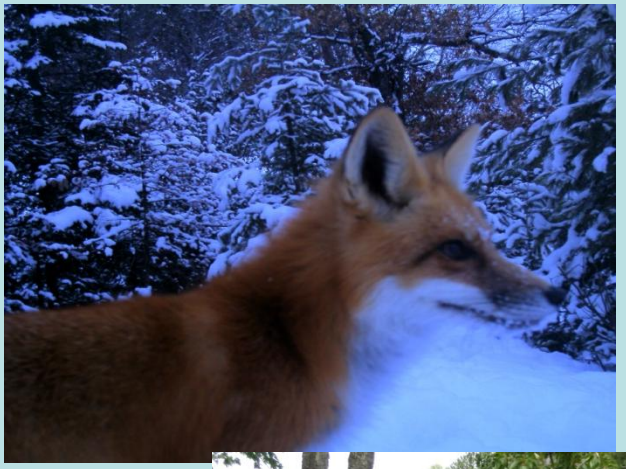


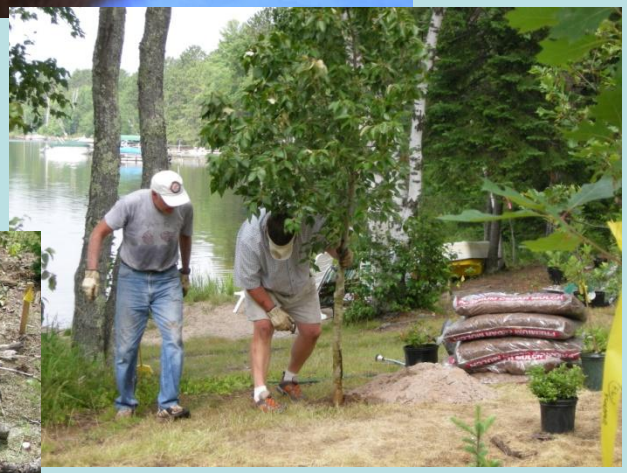
Discussion of DWM

- DWM lessened daily variation in soil temp and moisture.
- DWM improved growth of plants
- Evidence showing prevents erosion

Before & After

- Background Information
  - Geological & human history
  - Previous research
- Mammal Research
- Lakeshore Restoration
- Down Woody Material experiment
- **Before & After**





Photos by D. Haskell


Before Restoration

After Restoration


Before Restoration


After Restoration

Asphalt Driveway Before


Asphalt Driveway After
Photo by D. Haskell


Erosion Before
Photo by D. Haskell

Erosion After

Photo by D. Haskell

Rain Garden Before

Rain Garden After

Photo by D. Haskell

Before Enviro-lok Bags

Photo by D. Haskell

After Enviro-lok Bags

Photo by D. Haskell


Before Biolog
Severe Toe Erosion
Photo by D. Haskell

After Biolog

Photo by D. Haskell

Conclusion

- Restoration increases plant diversity.
- The addition of DWM influenced plants.
- Bridges gap between property owners and agency personnel.
- Provides aesthetic value.
- Future: more restoration, post-restoration data collection, long-term plant survival, deer impacts.

Lessoned Learned

- Good communication between agency personnel and landowners
- Proper irrigation for the first couple of years is critical for success
- Herbivory abatement is critical for success
- Soil samples can provide necessary information

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Questions