# Goat dietary selections, performance and browsing effects on a brush-invaded oak savanna in southwest Wisconsin over 3 years

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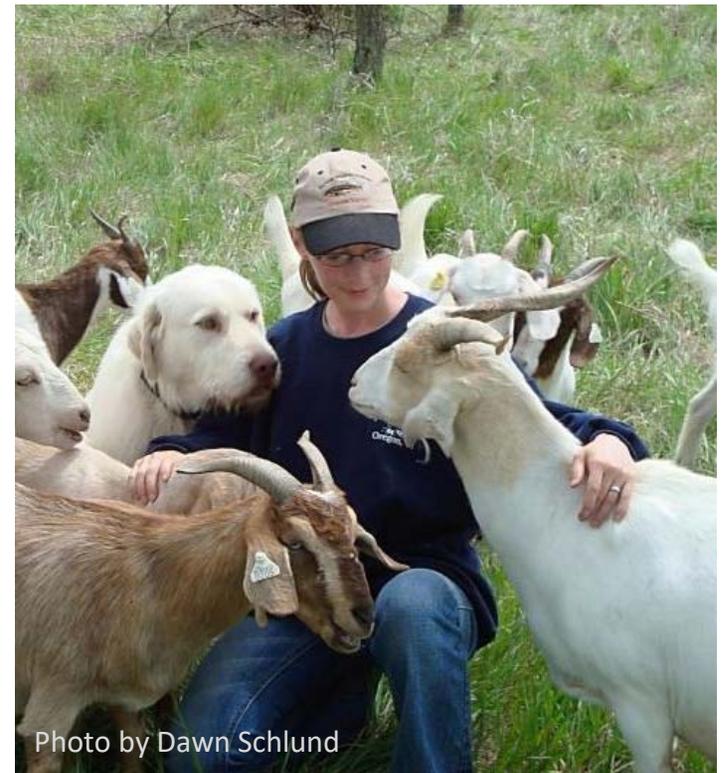Thesis Defense
Agriculture Hall, UW-Madison
Monday July 8, 2019

Photo by Dawn Schlund

Photo by Cherrie Nolden

2

# Multiflora Rose in West Virginia

- West Virginia, multiflora rose, 1986
- Goats reduced brush from 45% to 15% in one season
- Sheep required 3 seasons to do the same
  - Mowing/herbiciding improved sheep effectiveness
- Actual goat kill of brush
  - Early season defoliations
  - 5 years, killed 98%
- Management
  - Goats for brush
  - Sheep for forbs
  - Cattle for toppling

(Bryan, 1994)

Photo by Cherrie Nolden

# Suggested timing of control for select species in southern Wisconsin

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada thistle | | | | | | | | | | | | |
| Crown vetch & Bird's foot trefoil | | | | | | | | | | | | |
| Garlic mustard & Dame's rocket | | | | | | | | | | | | |
| Japanese knotweed | | | | | | | | | | | | |
| Leafy spurge | | | | | | | | | | | | |
| Phragmites | | | | | | | | | | | | |
| Plumeless & Musk thistles | | | | | | | | | | | | |
| Purple loosestrife | | | | | | | | | | | | |
| Reed canary grass | | | | | | | | | | | | |
| Spotted knapweed | | | | | | | | | | | | |
| Sweet clovers | | | | | | | | | | | | |
| Tansy | | | | | | | | | | | | |
| Teasels | | | | | | | | | | | | |
| Wild parsnip | | | | | | | | | | | | |
| Woody Shrubs | | | | | | | | | | | | |

Legend:
- Flowering (pink)
- Spray foliar Herbicide (blue)
- Burn (yellow)
- hand-pull, dig (green)
- Apply herbicide to cut stems (black)

# Brush Management Strategies

- Prescribed Fire

- Mechanical

- Chemical

- Biological


- Timing
- Intensity
- Frequency
- Duration


Kay Ledbetter


Rich Walton


DCNR, 2002


Katie Baumann

5
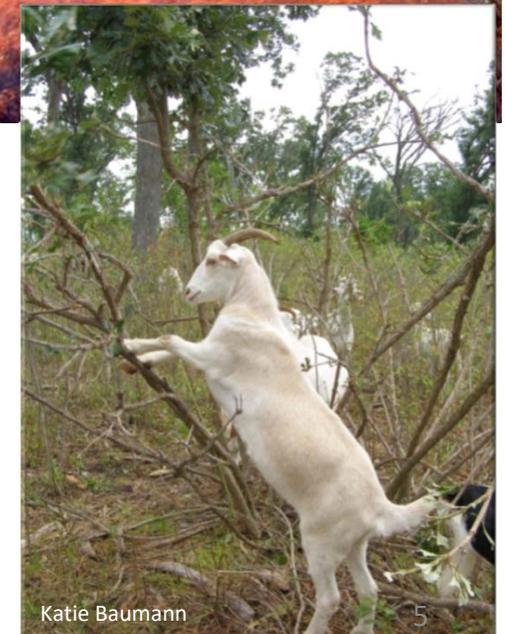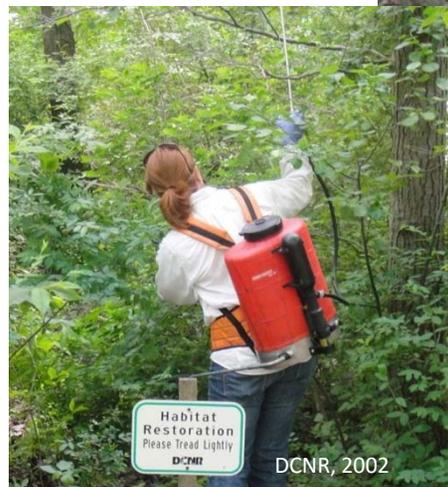
# Effectiveness at Vegetation Control

– Natural and trained animal food preferences
  - Mimic mother, herdmates
  - Species forage preferences
  - Self-medication
  - Novel food introduction

– Natural and trained behavior
  - Herding, flocking
  - Paddock move anticipation

– Human management
  - Pasture size and location
  - Animal density
  - Duration, Intensity, Frequency
  - Timing
  - Understanding the system, effects of impacts
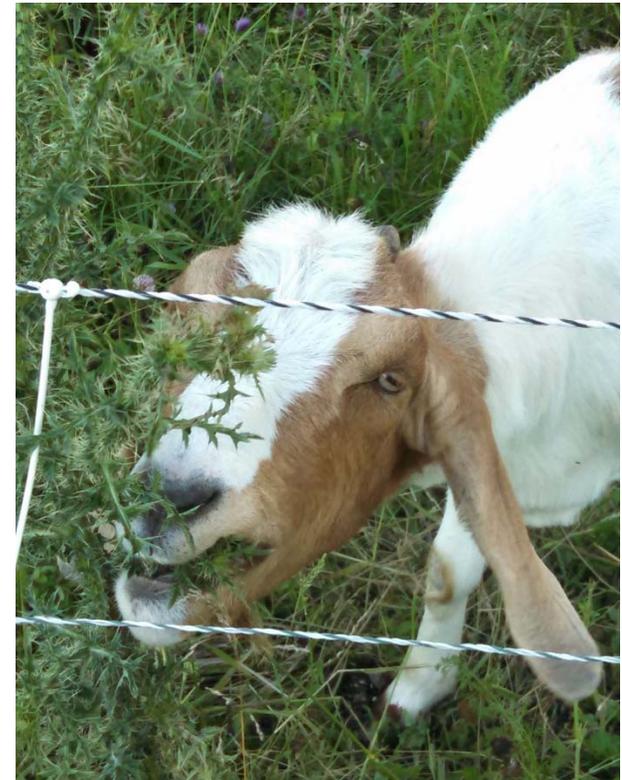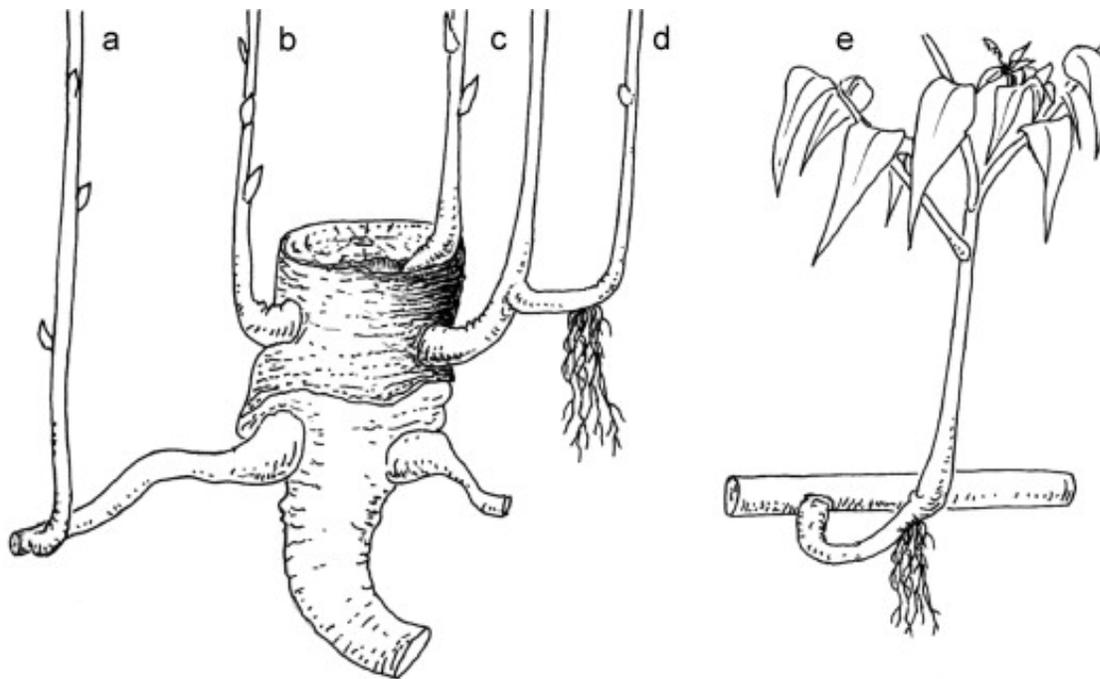  - Being observant, adaptable, flexible

Photo by Cherrie Nolden

6

# Brush Response to Disturbance

- Root bud response
- Single defoliation
- Repeated defoliation
- Apical dominance


Katie Baumann




Kowarik & Samuel, 2006

Steven Edholm

# Rotational Grazing Concepts

Applied in brush  ->  Rotational Browsing



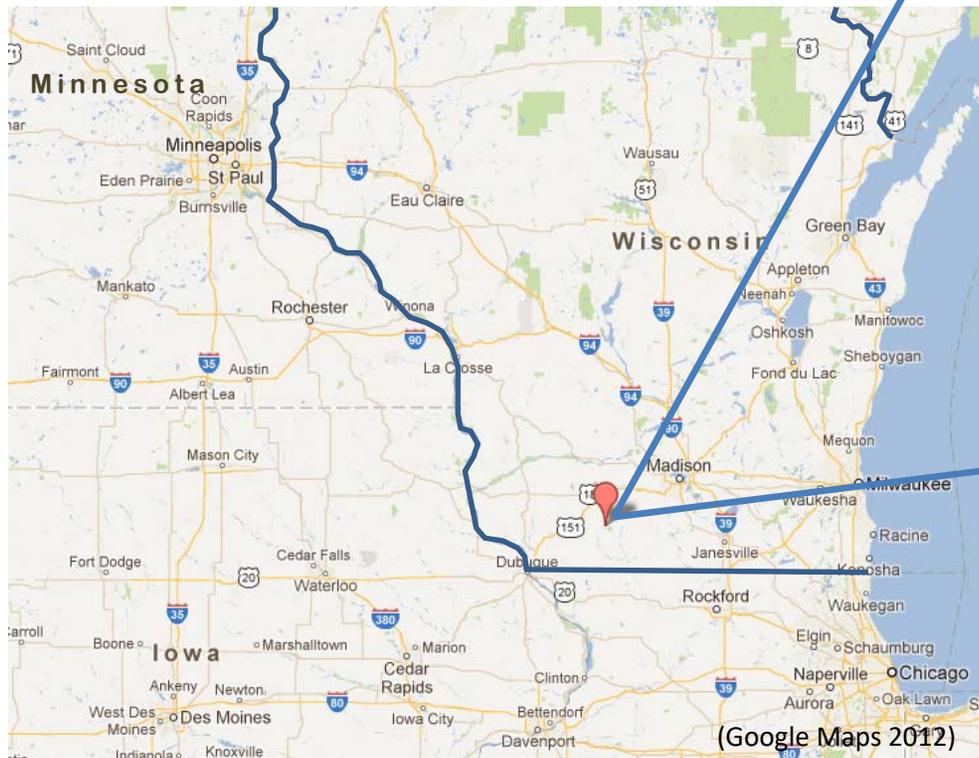164 ft

164 ft

164 ft

1.24 ac

Photo by Cherrie Nolden

# 1° Research Question:

Can rotational **browsing with goats** be both an effective **restoration tool** for reducing a dense brush midstory and meet basic standards for **goat meat production**?



Cherrie Nolden

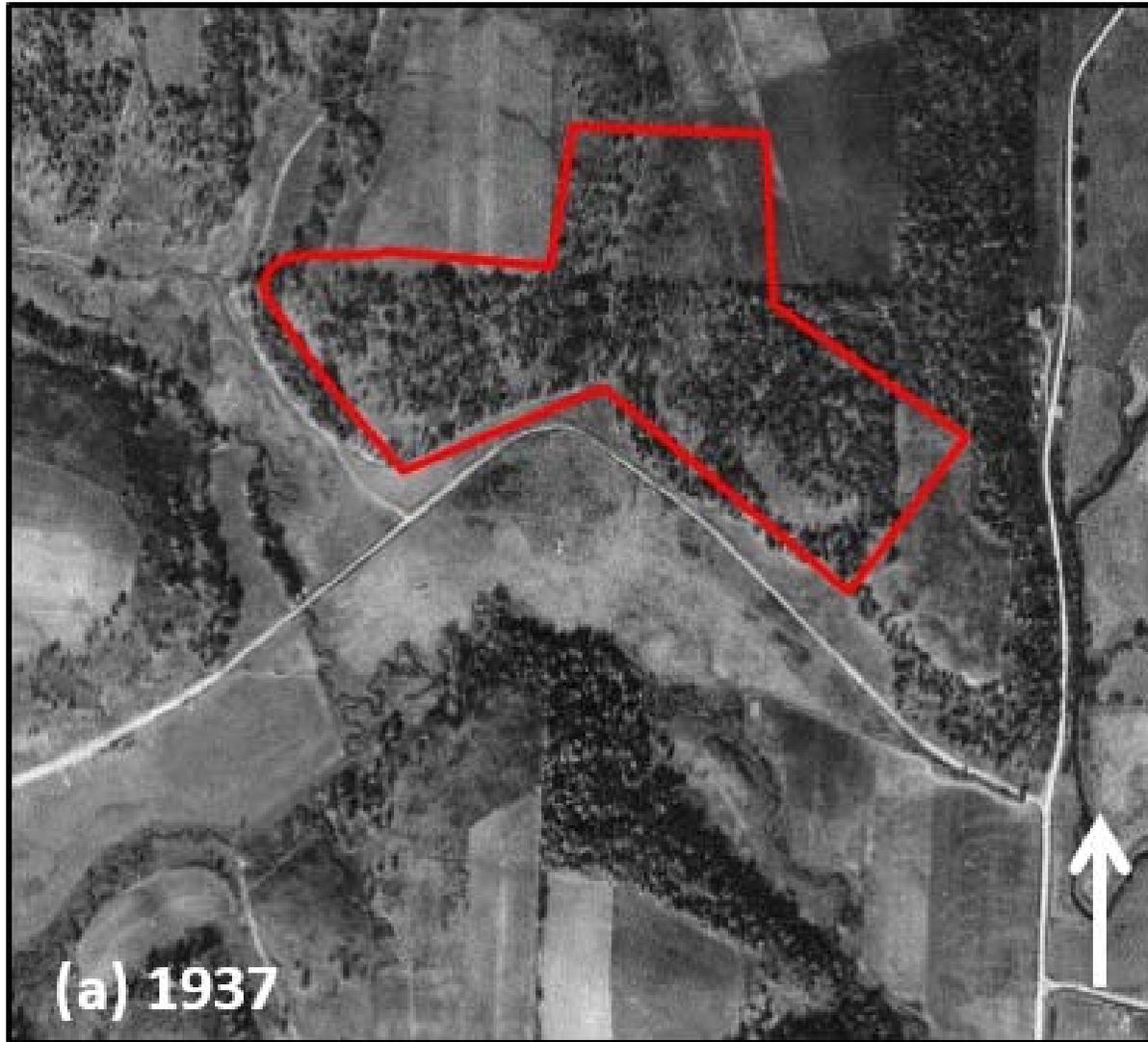# Research Site

- Yellowstone Lake Wildlife Area, WDNR
- 2008 Tree thinning
- Dense mid-story of closed shrubs



(Google Maps 2012)

# Site Layout



(a) 1937

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

# Site Layout



(b) 2005

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

# Site Layout



(c) 2008

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

# Methods: Experimental Design

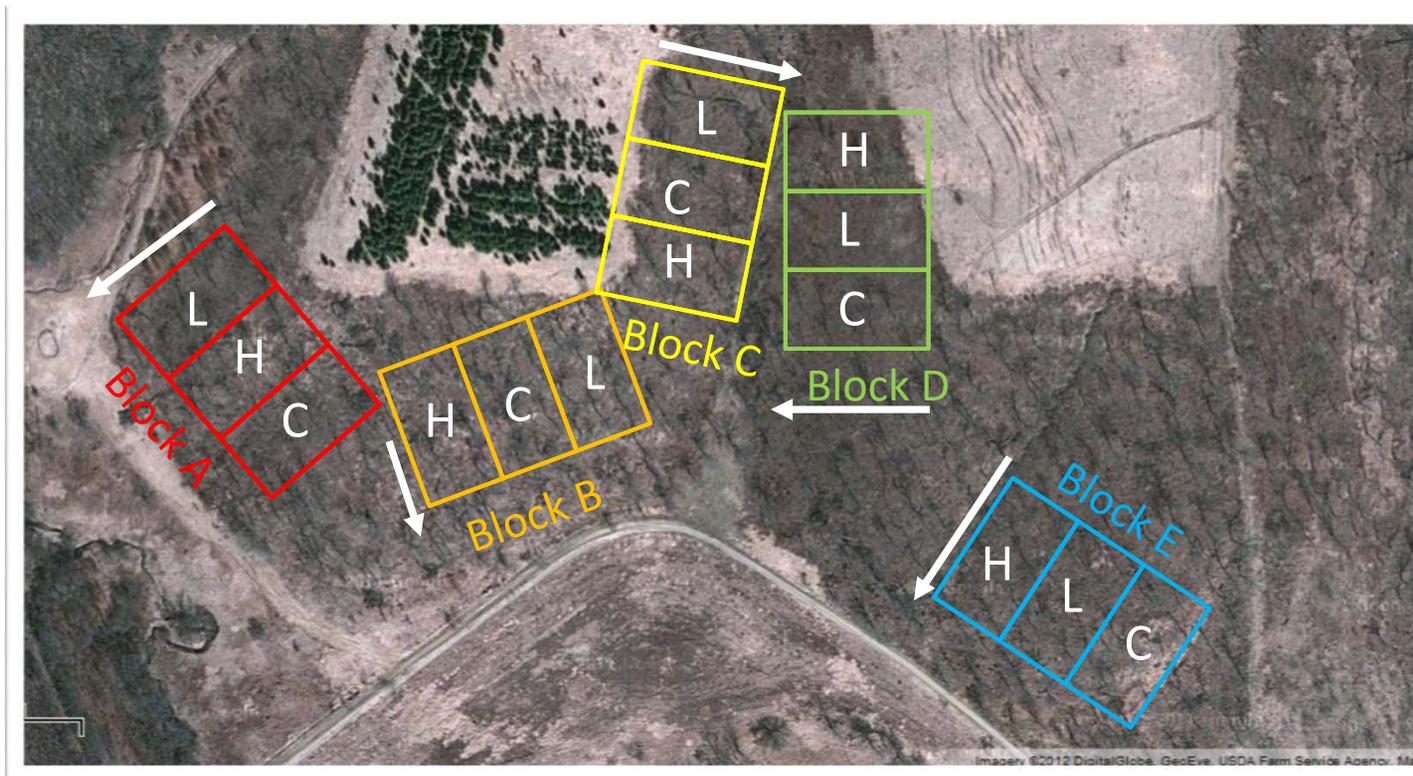- **RCB Design:**
  - 5 Blocks
  - 3 Treatments
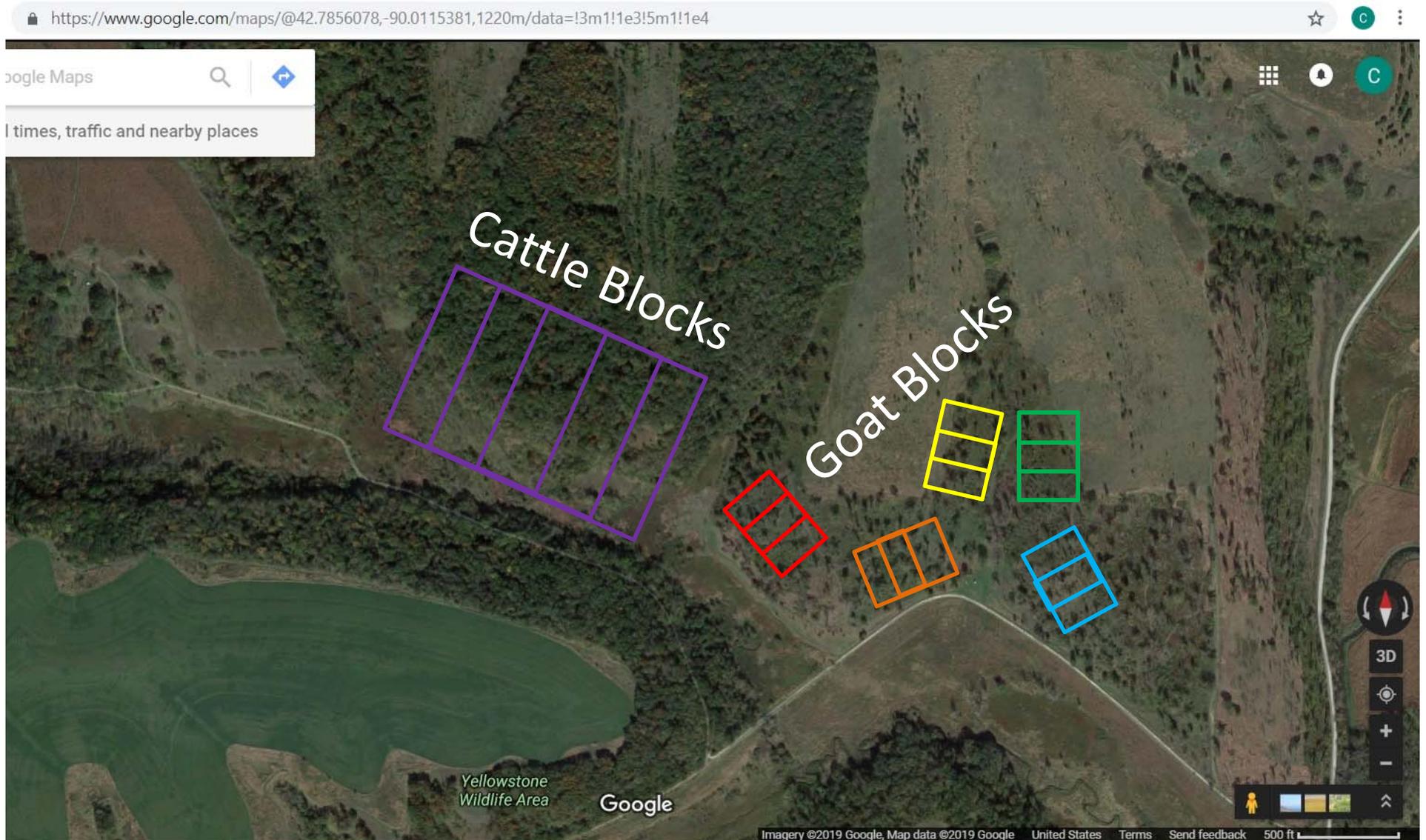  - 0.5 hectares/Trtmt

- **Treatments:**
  - Light browsing (L)
  - Heavy browsing (H)
  - Control (C)

- **Goats:**
  - 6.4 AUE
  - Mix-breed
  - Meat type



15

# Highlander & Goat Research Sites

# Methods: Vegetation Sampling

- Nested Quadrats

- Coverboard



1m$^2$ Herb

5m$^2$ Brush

2.5m
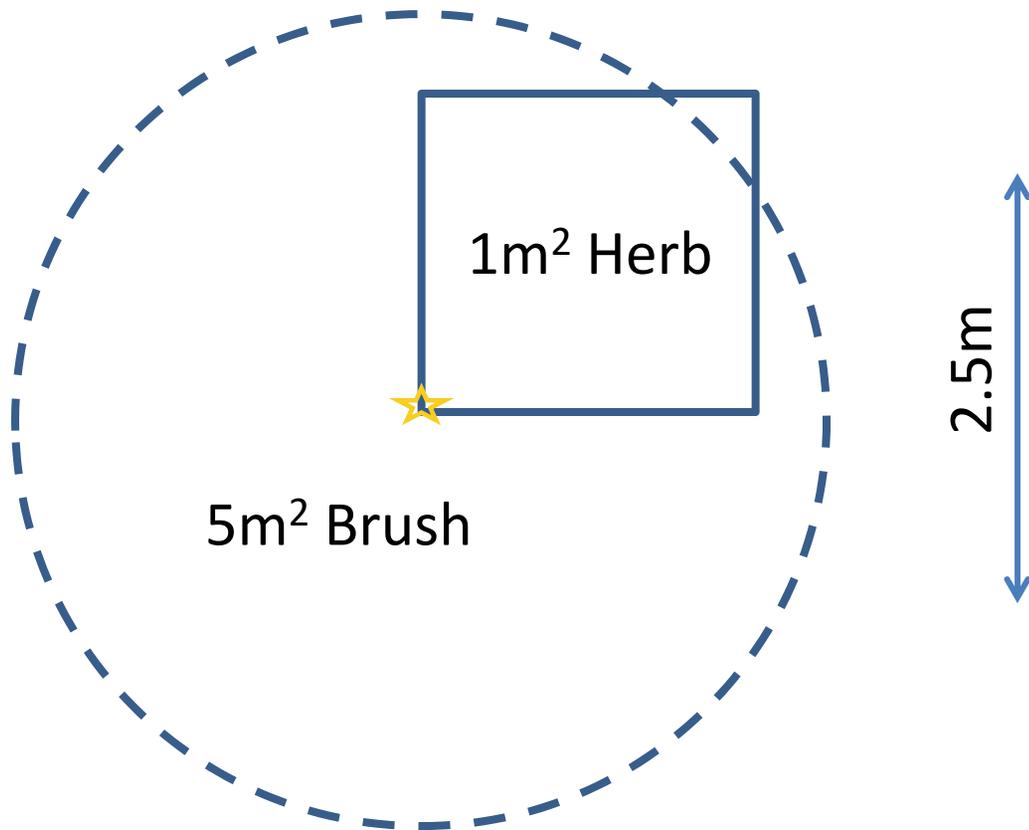
18 per treatment

# Methods: Variables Examined

**BRUSH**
- Richness
- Density
- Cover
- Height
- Stem Density

**HERBACEOUS**
- Richness
- Cover

**BIOPHYSICAL**
- Light penetration
- Soil compaction
- Litter depth

**GOATS**
- Weight
- Parasitism
- Dietary Selection
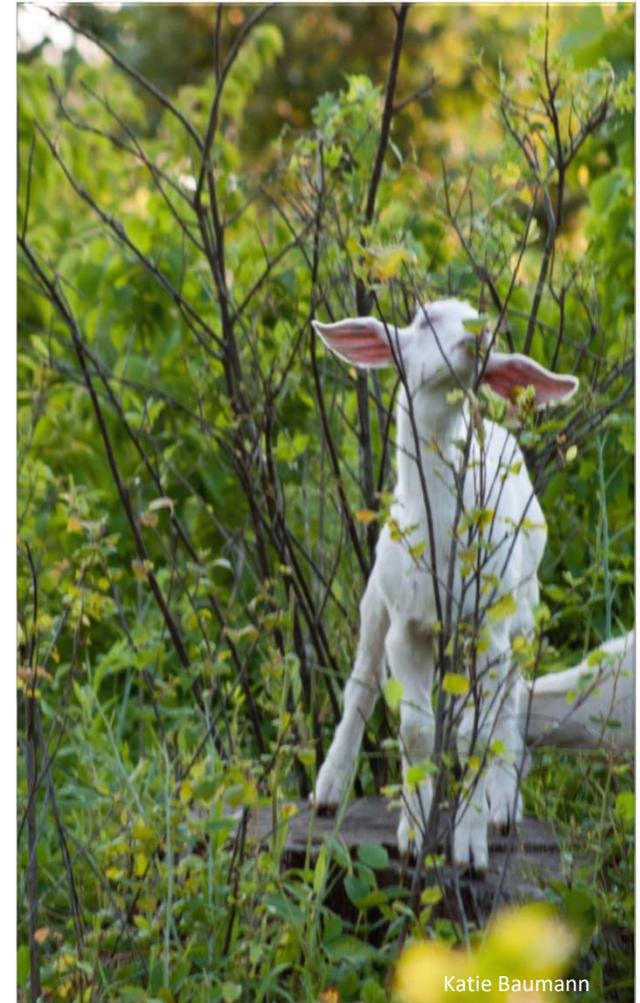
Katie Baumann

# Methods: Hypotheses

**BRUSH**

Richness
Density
Cover
Height
Stem Density

$H_0$: means equal btwn controls, treatments

**HERBACEOUS**

Richness
Cover

$H_a$: means unequal btwn controls, treatments

**BIOPHYSICAL**

Light penetration
Soil compaction
Litter depth

**GOATS**

Weight
Parasitism
Dietary Selection

$H_0$: no change, $H_a$: before$\neq$after

$H_a$: % eaten=cover

$H_a$: % eaten=by herd

# Methods: Data Analysis

**BRUSH**
- Richness
- Density
- Cover
- Height
- Stem Density

**HERBACEOUS**
- Richness
- Cover

**BIOPHYSICAL**
- Light penetration
- Soil compaction
- Litter depth

**GOATS**
- Weight
- Parasitism
- Dietary Selection

SAS

PROC MIXED,

ANOVA,

P ≤ 0.05

Ranked for normality

pdmix800 for letters

Kulcyznski's Similarity Index,

P ≤ 0.05

# Goat Diet Selections and Performance

- ## Goat follows
  - ### Forage type selections
    - 6 d/rotation
    - 6 goats, 15 sec for 5 min
    - 4 times/d

- ## 3 private herds
  - ### Pre & post browsing
    - Weights for ADG
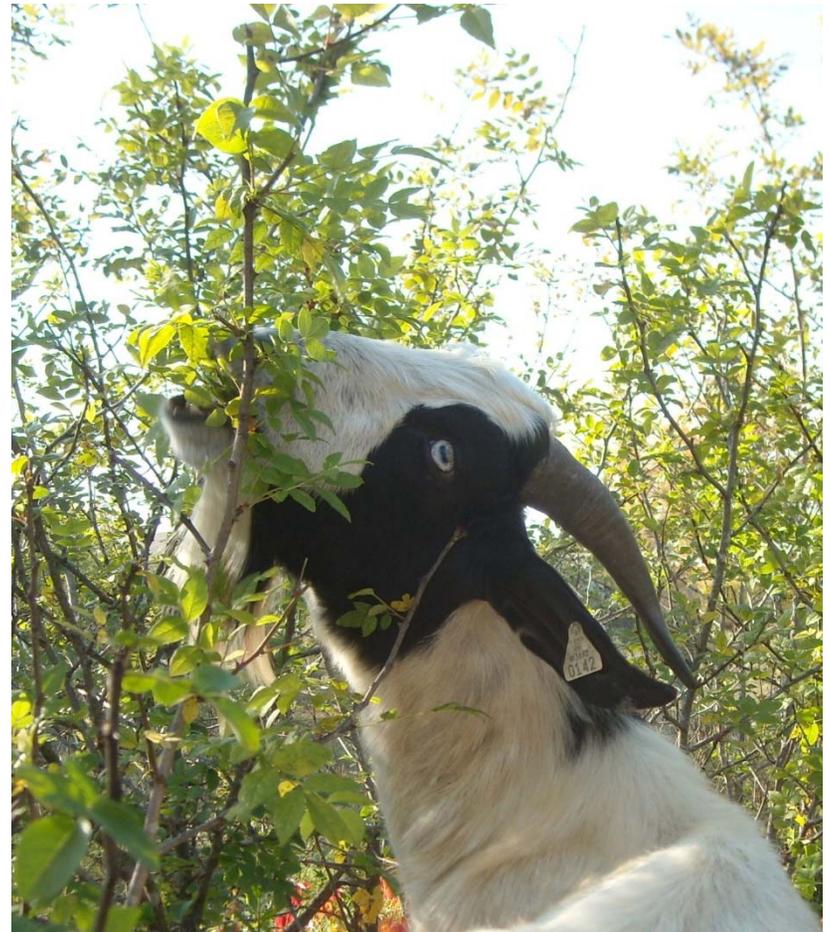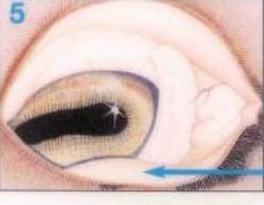    - Body Condition Scores
    - FAMACHA Scores



Photo: Cherrie Nolden

# Kulcyznski's Similarity Index

- Diet composition informs selection discrimination relative to plant composition

- KSI = $[(2c_i)/(a_i+b_i)]$ * 100
- Where
  - $a_i$ = % basal cover of component i,
  - $b_i$ = % of component i detected in goat diet
  - $c_i$ = the lesser of $a_i$ or $b_i$

- KSI values
  - ≥ 80% indicated little or no discrimination (i.e., selection patterns were similar to plant availability)
  - Between 21% and 79% indicated moderate discrimination
  - ≤ 20% indicated either strong preference for or avoidance of individual plant species
  - Preference and avoidance were distinguished from one another by comparing the proportion of goat diets composed of component i with basal cover of component i in paddocks

Oosting, 1956; Ferreira et al., 2009; Sowers et al., 2019

# FAMACHA



**FAMACHA© ANAEMIA GUIDE**

| | | |
|---|---|---|
| 1 | OPTIMAL – (NO DOSE) | ✓ |
| 2 | ACCEPTABLE – (NO DOSE) | ✓ |
| 3 | BORDERLINE – DOSE? | ? |
| 4 | DANGEROUS – DOSE! | ! |
| 5 | FATAL – DOSE!!! | ☠ |

DEVELOPED AND SUPPORTED BY:

**INSTRUCTIONS FOR USE**
**Examination**
- Examine sheep in good, natural light
- Open the eyelid as shown in the sketch
- Push the upper eyelid down with the upper thumb, while the lower thumb gently pulls the lower lid downward
- Look especially at the colour inside the lower eyelid
- Open the eyelid for a short time only, or else the mucous membrane may become redder
- Compare the colours seen to those on the reverse side of this card
- Score the sheep 1 to 5 and proceed as explained in the pamphlet
- If in doubt, score the sheep at the lower (paler) category
- Examine weekly and no less than every 2 to 3 weeks
- Contact your veterinarian if you have any questions

Look inside bottom eyelid
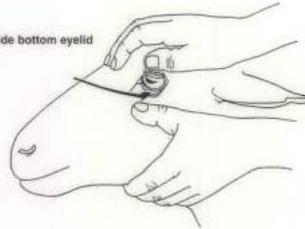
**Precautions**
- Only properly trained persons should use this card
- Read the full information pamphlet before using the guide and follow instructions carefully
- This guide is intended for sheep only
- If used for goats, all those in category 3 should also be treated
- This card is an aid in the control of wireworm only
- Paleness or reddening of the eyes may have other causes
- Maintain standard worm control measures
- The colours of this card will fade with time, especially if exposed to the sun
- Replace the card after 12 months use
- As the system is used in conditions outside their control, no organisation involved in its development or distribution accepts liabilty for losses or problems associated with its use

**COPYRIGHT**
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*Haemonchus contortus* – **barber pole worm**

Images courtesy of Dr. David Thomas, UW-Madison, Sheep Production and Management 430, Spring Semester 2013

# Ecological Changes



**Control**

**Lightly Browsed**

**Heavily Browsed**

Photos by Katie Baumann

24

Brush Cover by Height-Coverboards
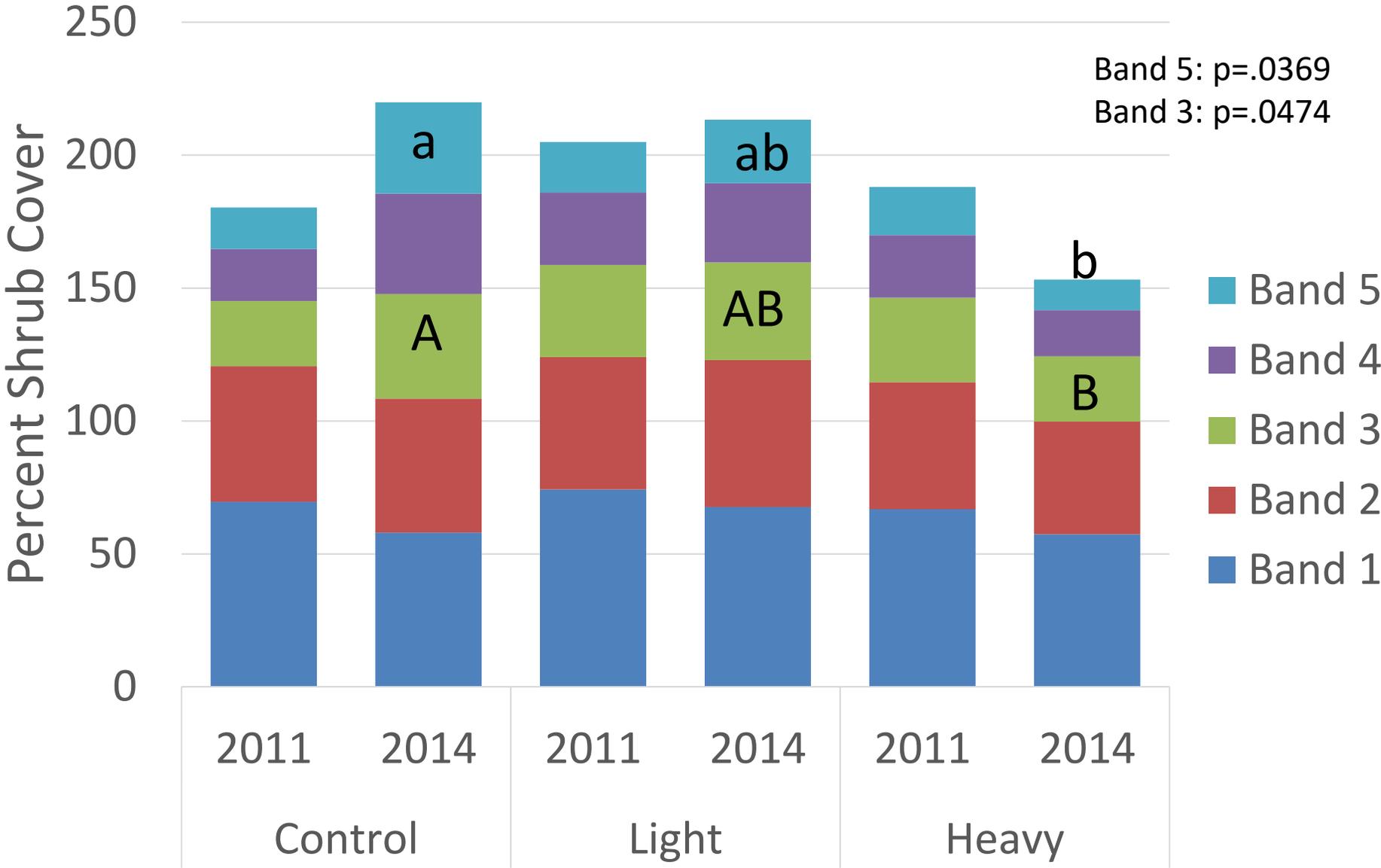
Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

Brush Cover (%) Overall

2011: p=.7417
2014: p=.0265

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

Brush Height (m)

2011: p=.6682
2014: p=.0184

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

# Leaf Litter Depth (cm)

2011: p=.5652
2012: p=.0559
2014: p=.7538



Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI
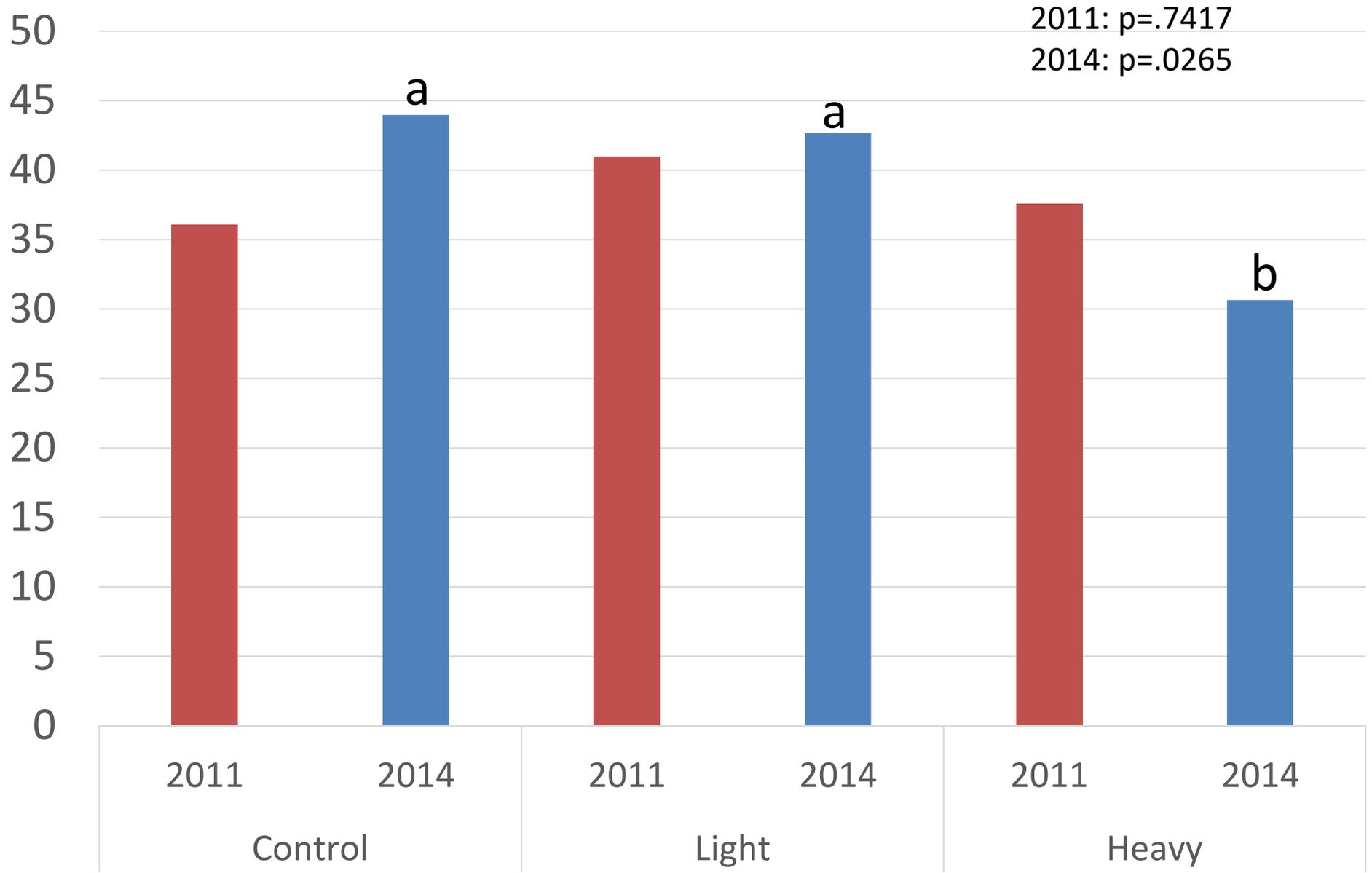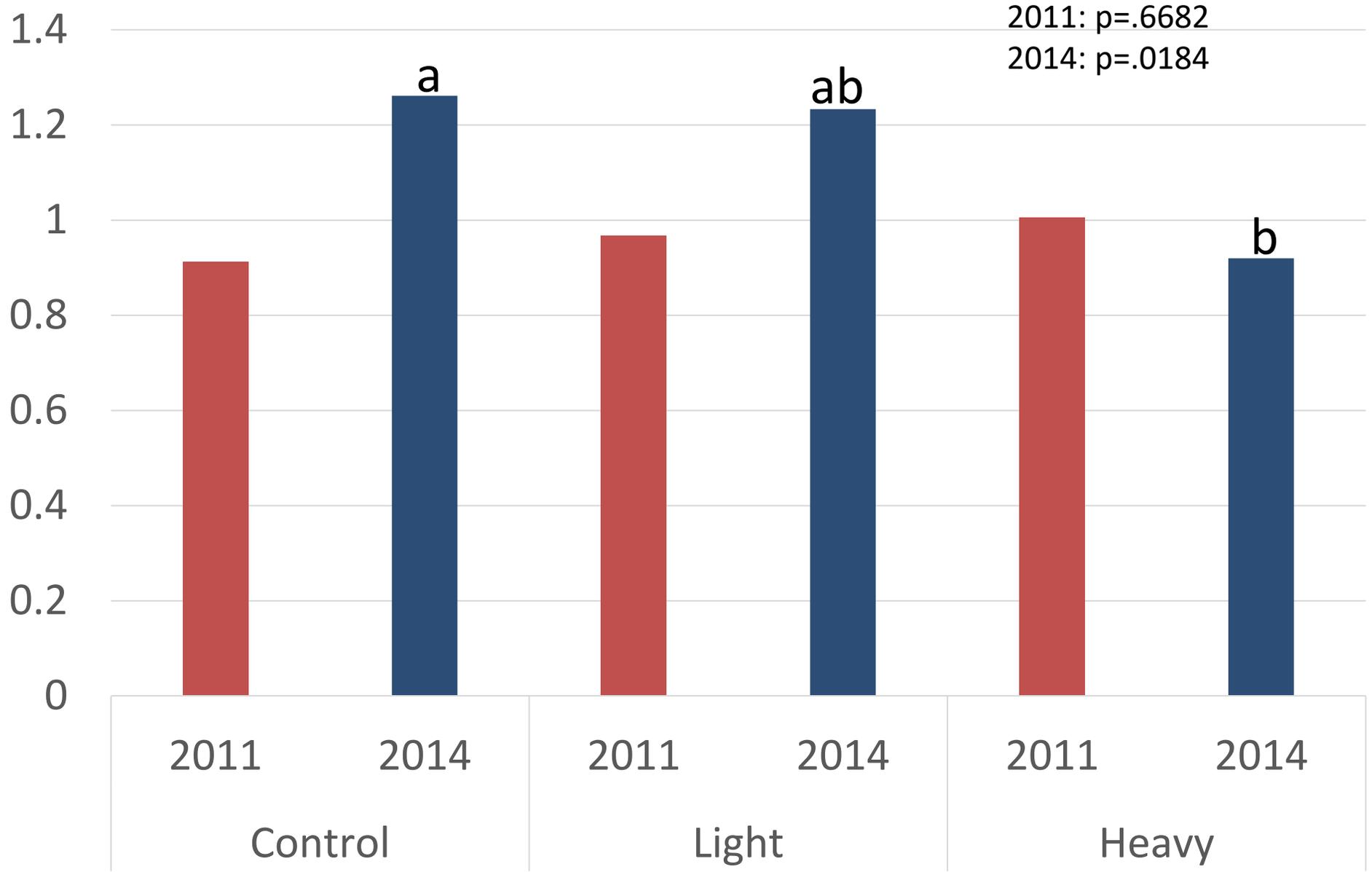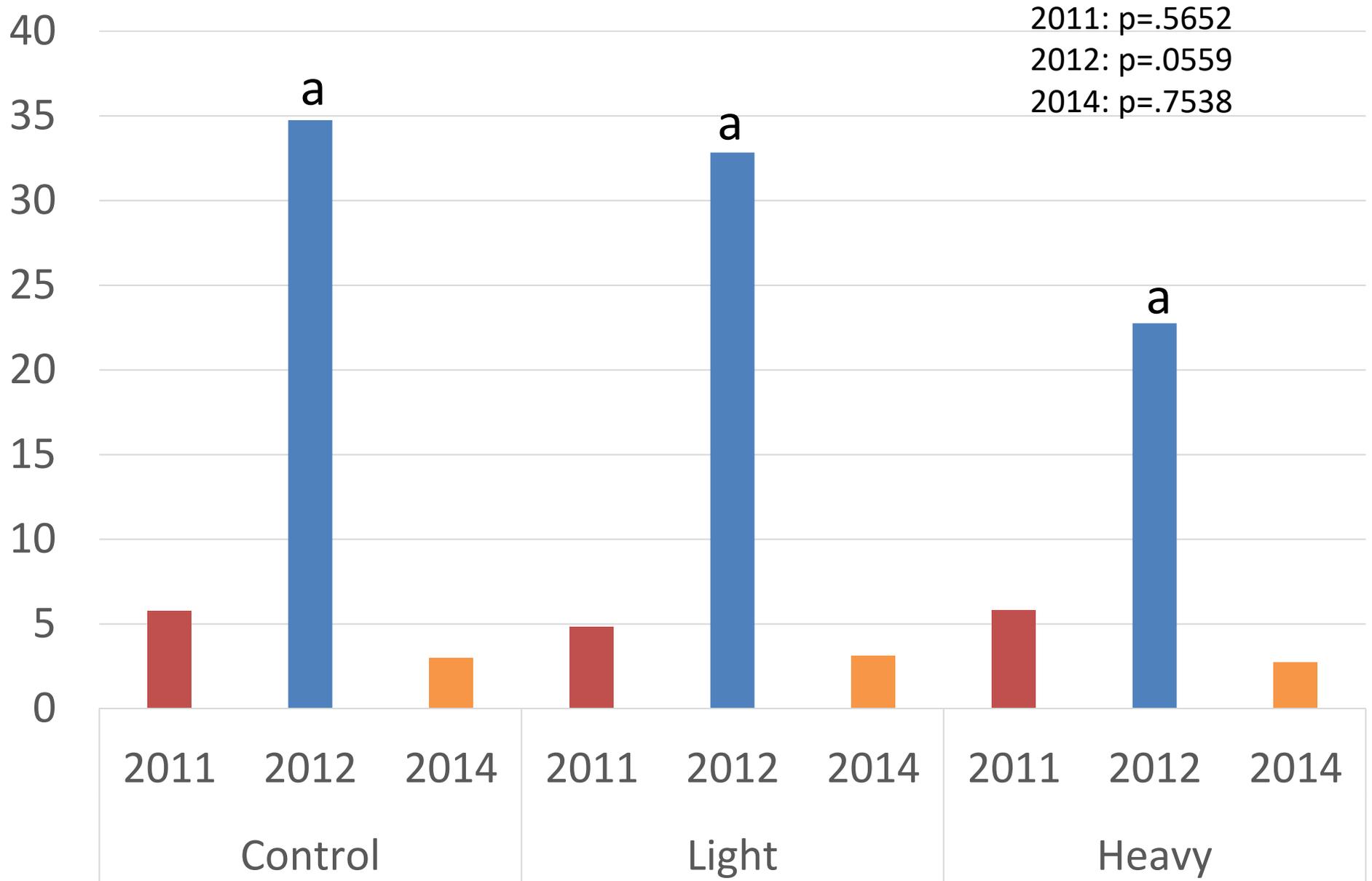
Soil Penetration Depth (inches) - Compaction

2012: p=.6854
2014: p=.7644

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

29
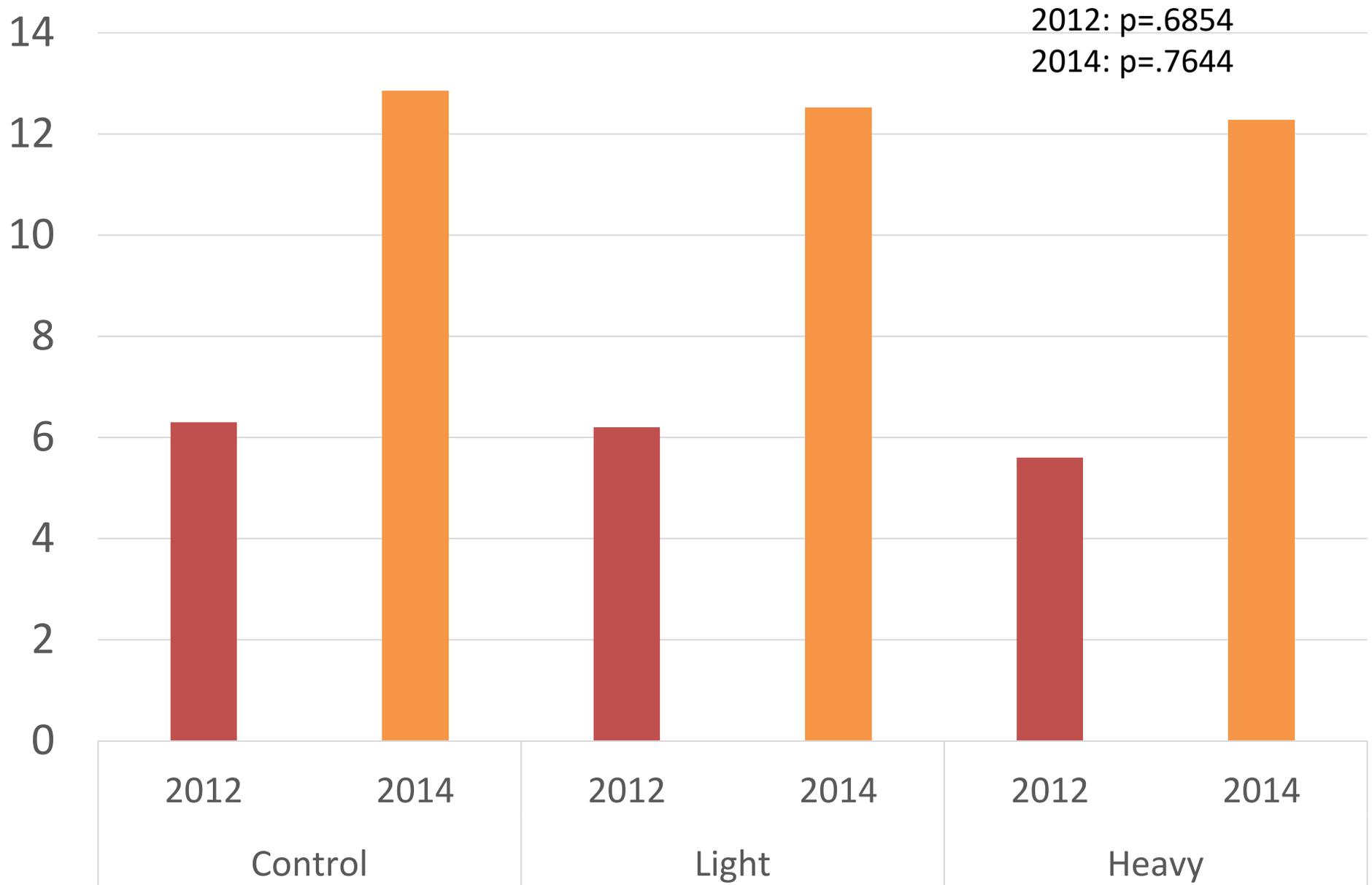
# Herbaceous % Cover by Treatment
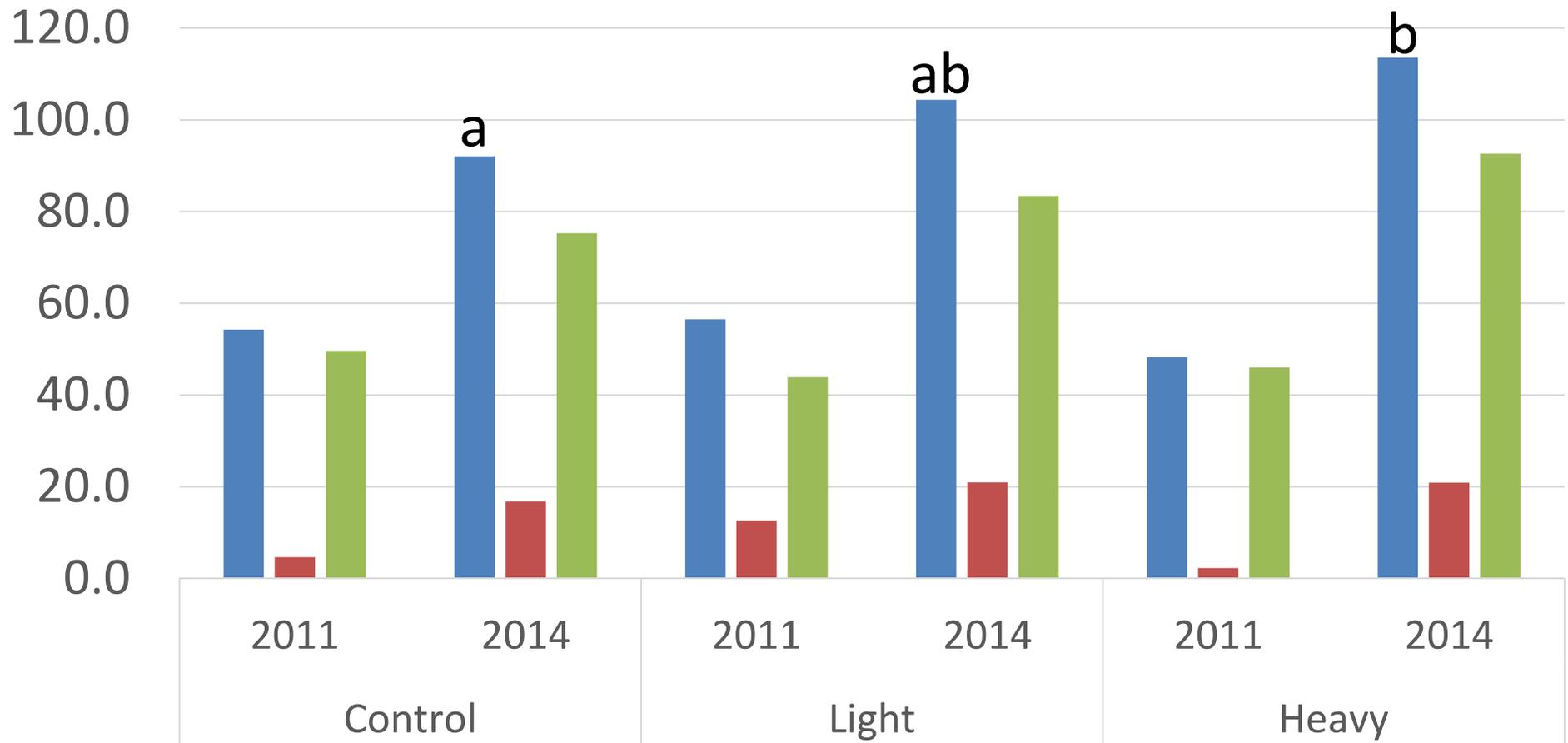


Legend:
- Herbaceous Cover (%)
- Graminoid Cover (%)
- Forb Cover (%)

Control
- 2011: p=.8675
- 2014: p=.0436

Light
- 2011: p=.1453
- 2014: p=.7440

Heavy
- 2011: p=.6195
- 2014: p=.1118

# Richness by Treatment (species/m$^2$)
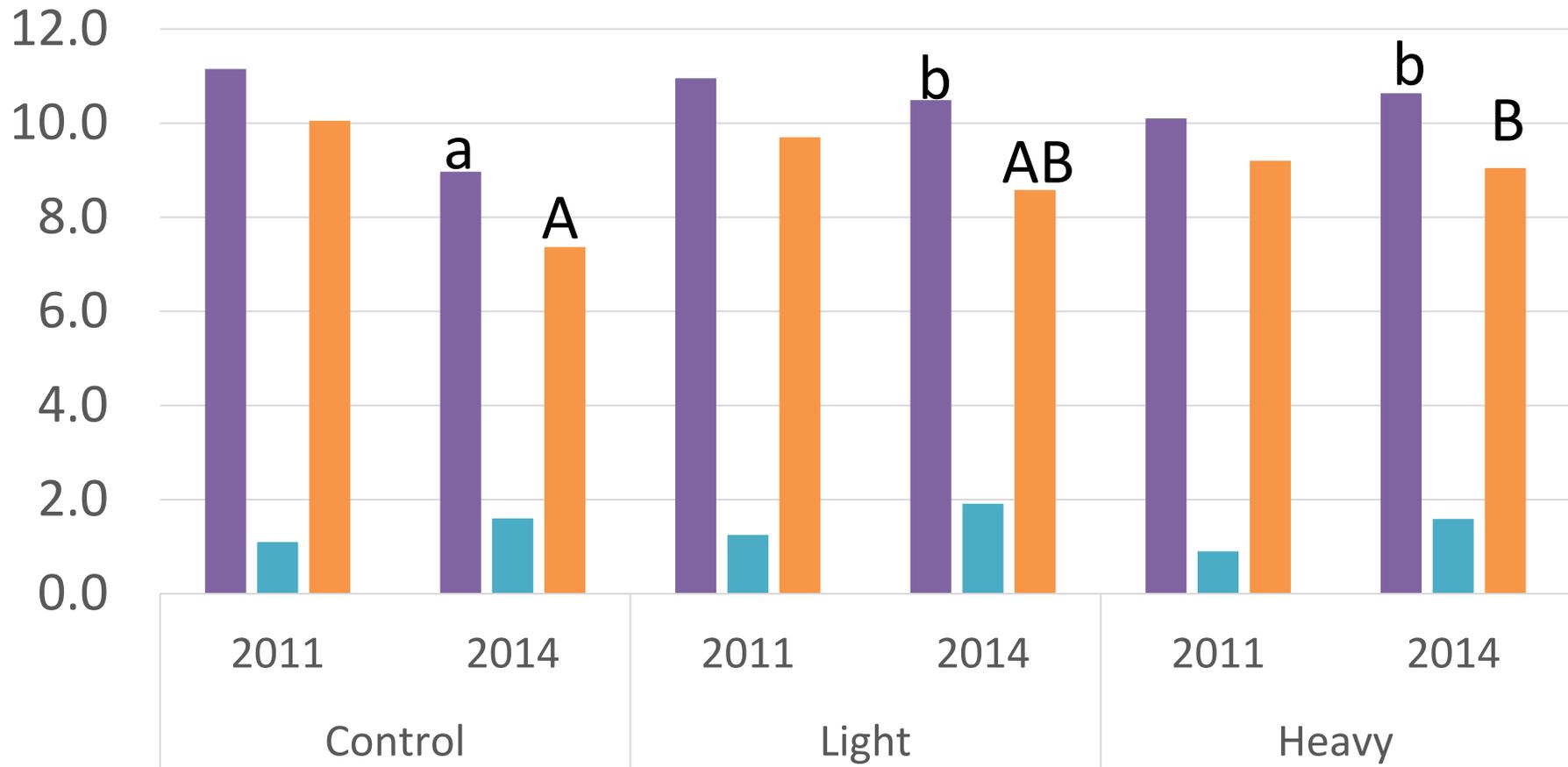


Legend: Herbaceous Species Count, Graminoid Species Count, Forb Species Count

2011: p=.6765
2014: p=.0096

2011: p=.1588
2014: p=.4184

2011: p=.5044
2014: p=.0180

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI

# Average Richness per Quadrat (species/m$^2$)



2014: p=.0076

Legend:
- Sun Gram
- Sun Forb
- Invas Gram
- Invas Forb

X-axis: 2011, 2012, 2014 (Control); 2011, 2012, 2014 (Light); 2011, 2012, 2014 (Heavy)

Y-axis: 0, 0.5, 1, 1.5, 2, 2.5, 3

Labels: a (Control 2014), ab (Light 2014), b (Heavy 2014)

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI
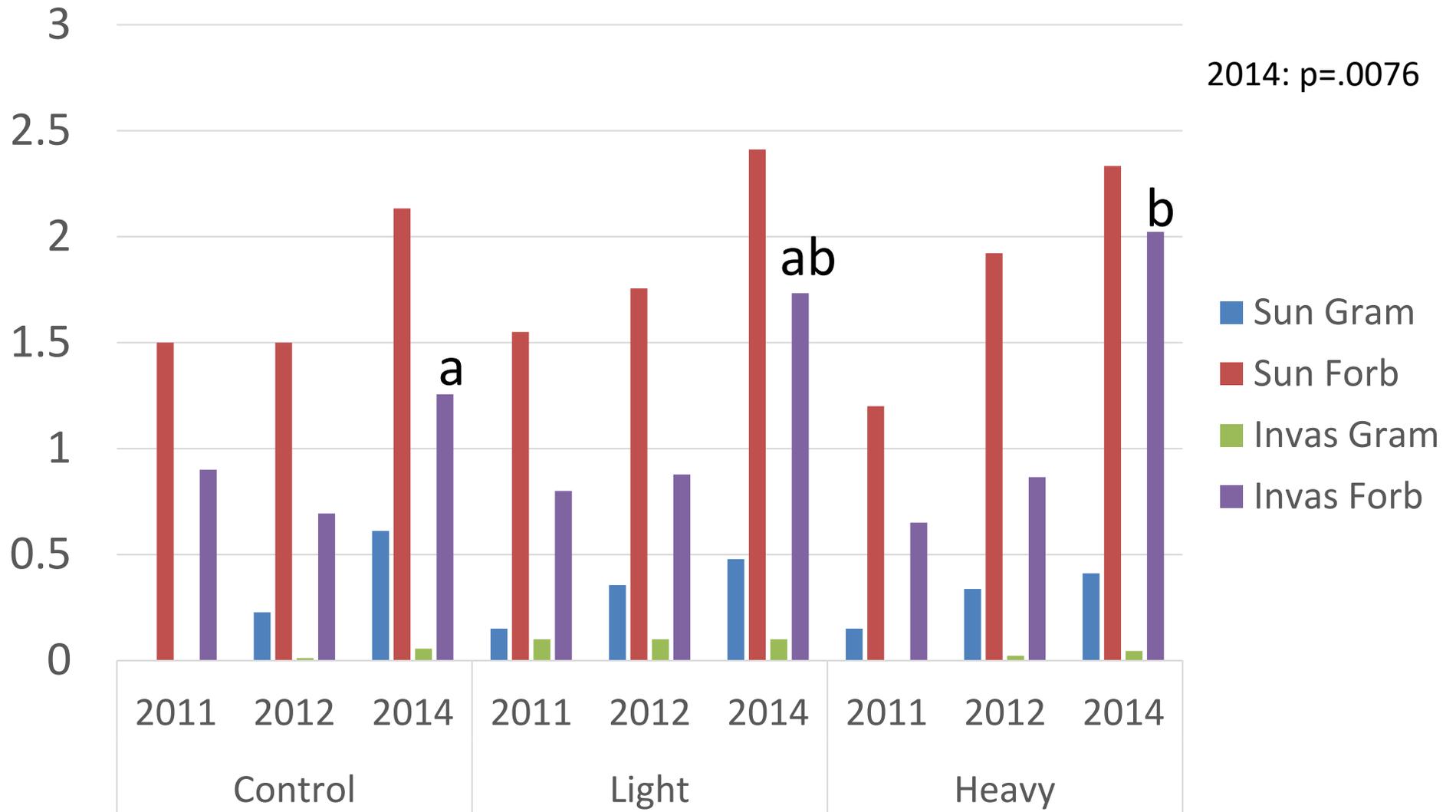
Average Species % Cover per Quadrat

2014: p=.0313

Legend: Sun Gram, Sun Forb, Invas Gram, Invas Forb

Control — 2011, 2012, 2014 (a)
Light — 2011, 2012, 2014 (ab)
Heavy — 2011, 2012, 2014 (b)

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI
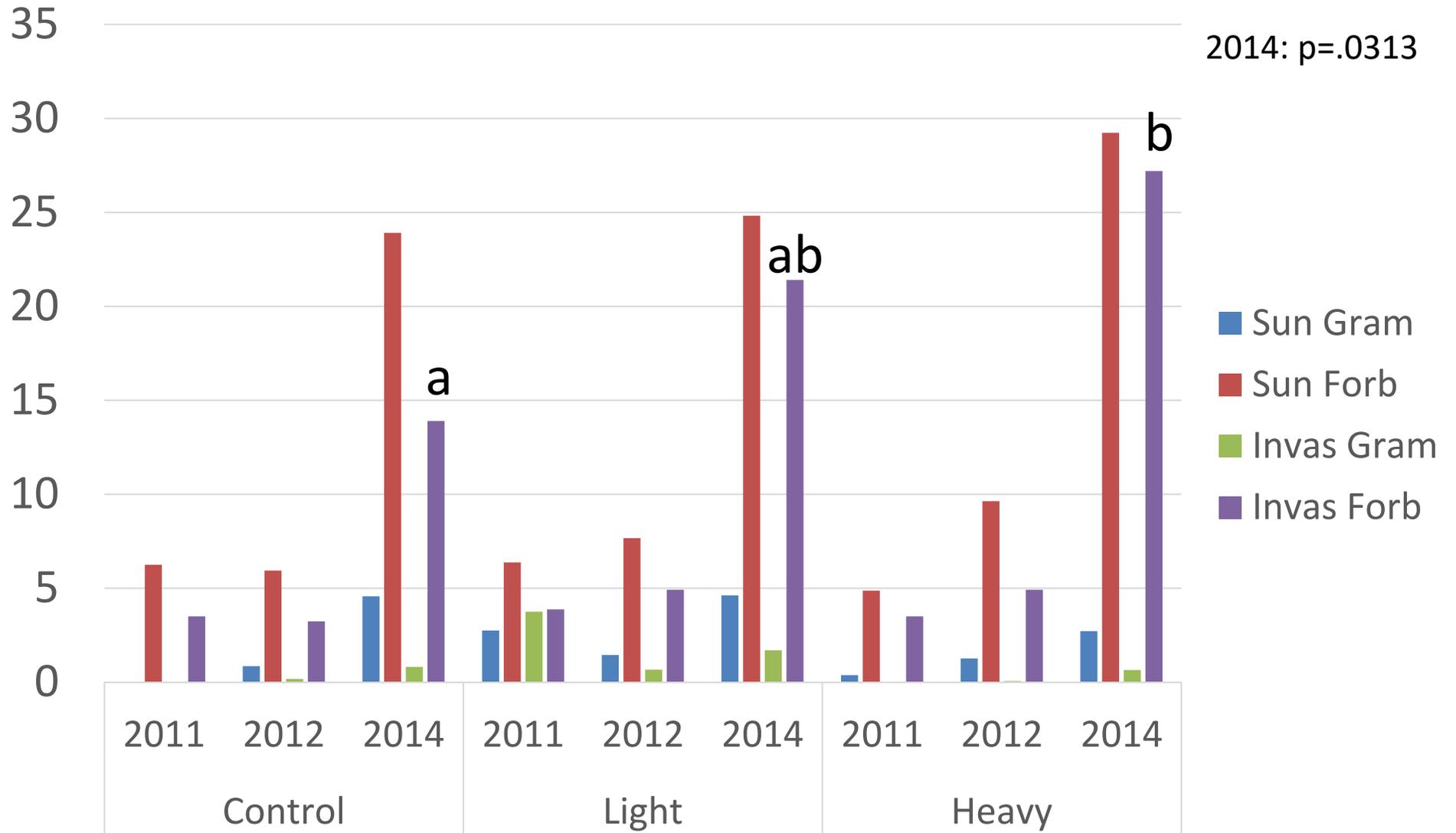
# Availability vs. Goat Selections in WI



**2011-2014 Ave Forage Availability**
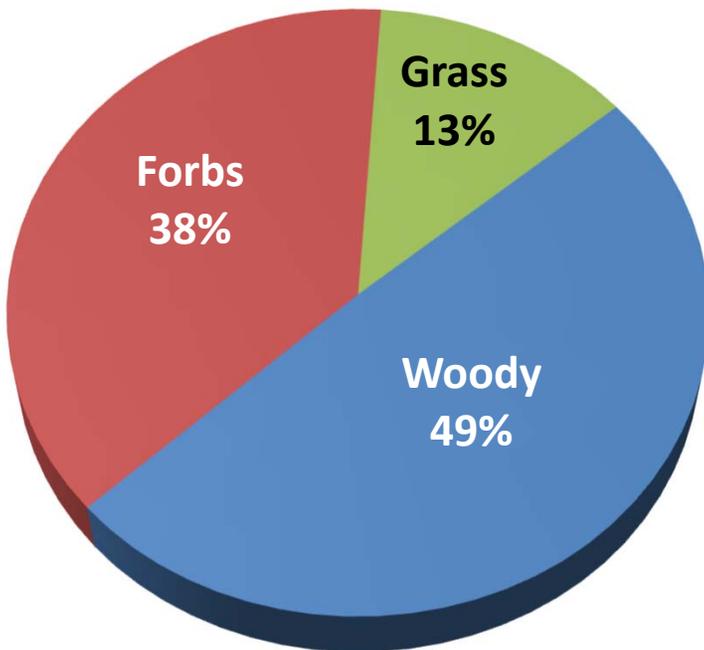
**2011-2013 Ave Goat Forage Selections**

Grass 13%

Forbs 38%

Woody 49%

Grass 3%

Forbs 12%

Woody 85%

Nolden et al., unpublished data, Yellowstone Lake Wildlife Area, WDNR, Blanchardville, WI
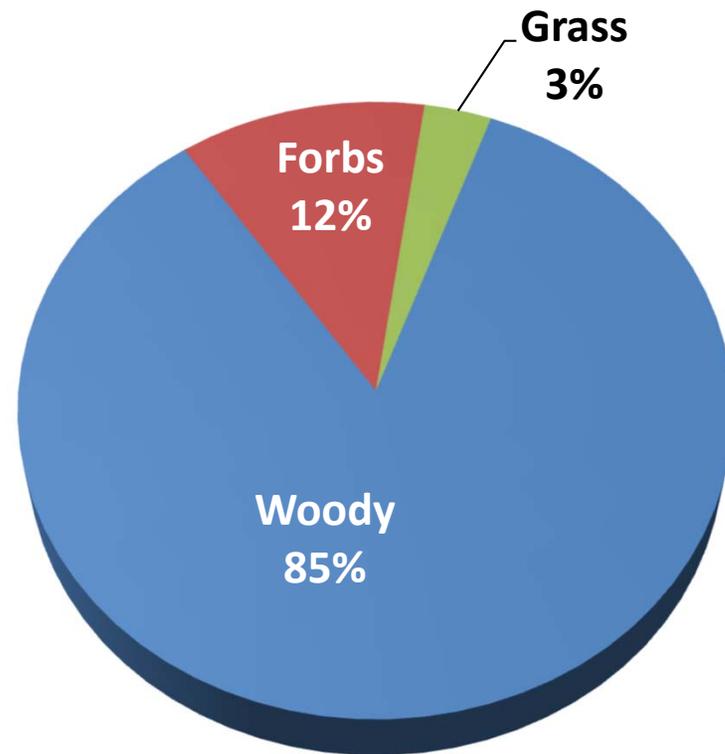
# Forage Selections in WI Oak Savanna



**Scottish Highland Cattle**

Woody Spp 36%

Grasses 29%

Forbs 35%
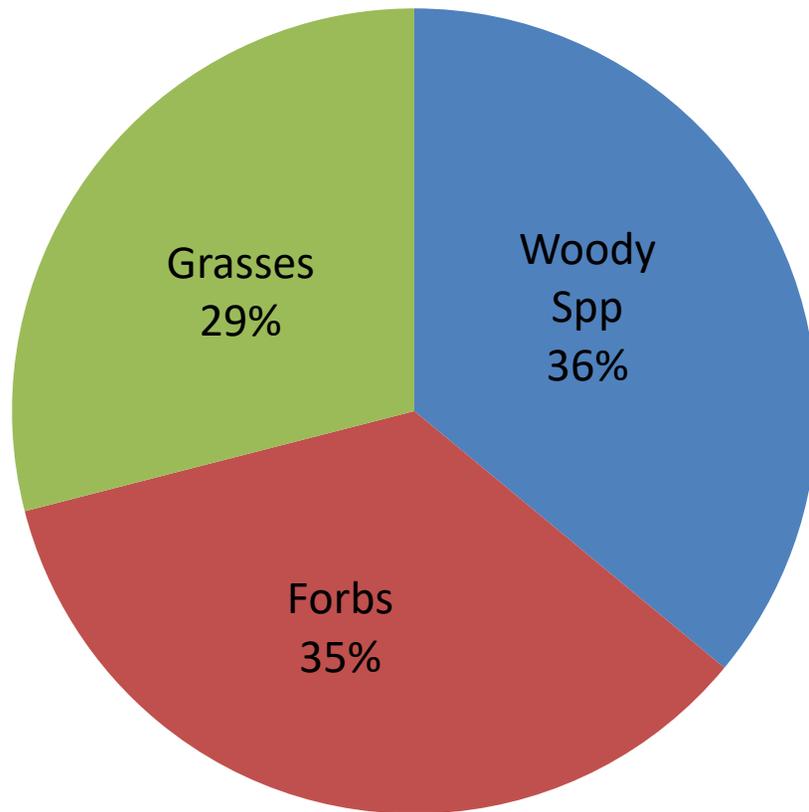
(Harrington and Kathol, 2009)

**Meat Goats**

Grasses 3%

Forbs 12%

Woody Spp 85%
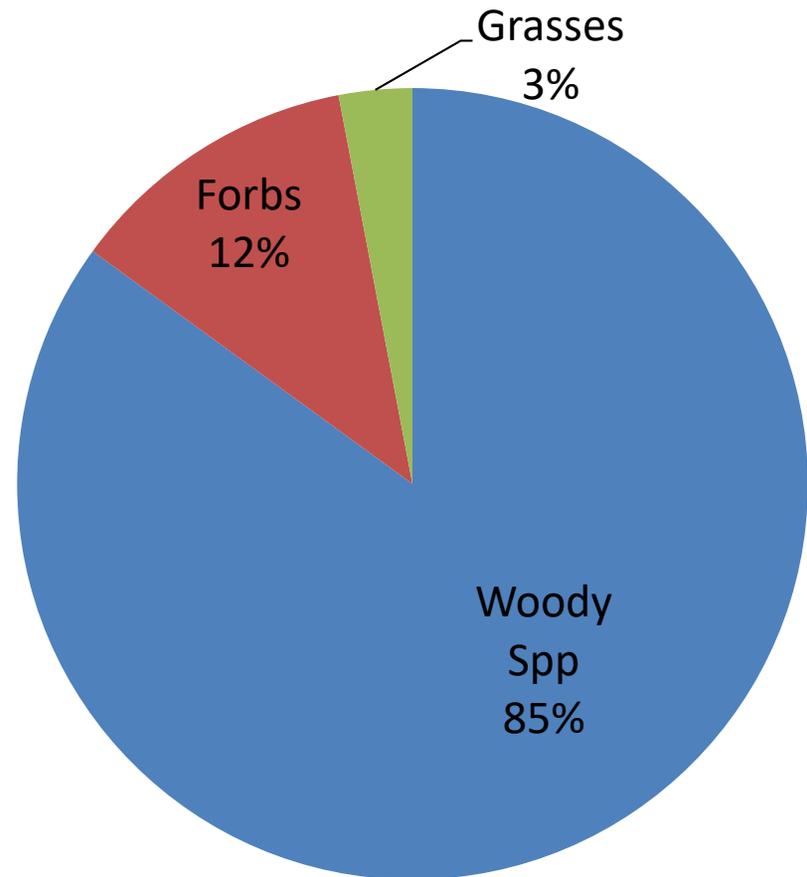
(Nolden et al., unpublished data, 2019)

Dietary Selections

Cattle
- Browse (7)
- Forbs (12)
- Grass (81)

Sheep
- Browse (22)
- Forbs (17)
- Grass (61)

Goats
- Browse (43)
- Grass (45)
- Forbs (12)
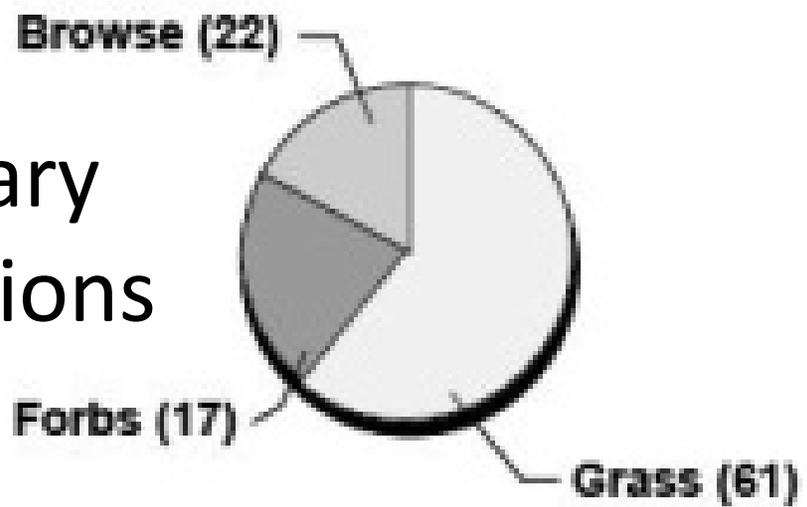
Horses
- Forbs (6)
- Browse (4)
- Grass (90)
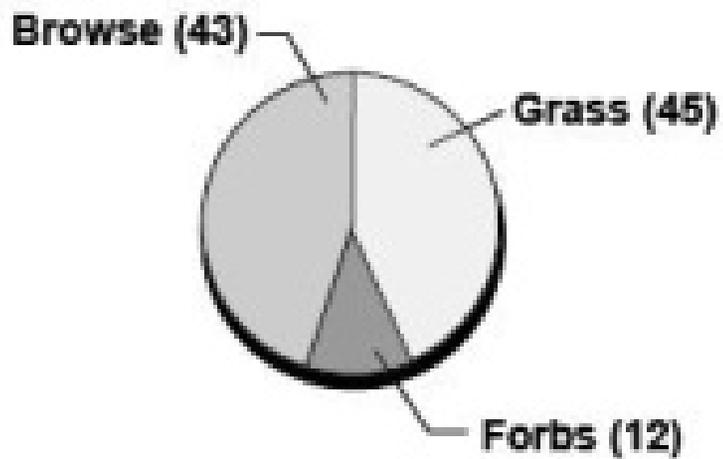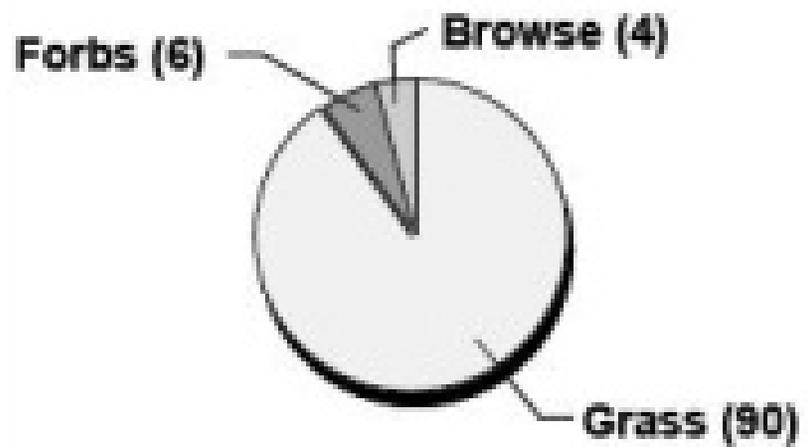
# Kulcyznski's Similarity Index

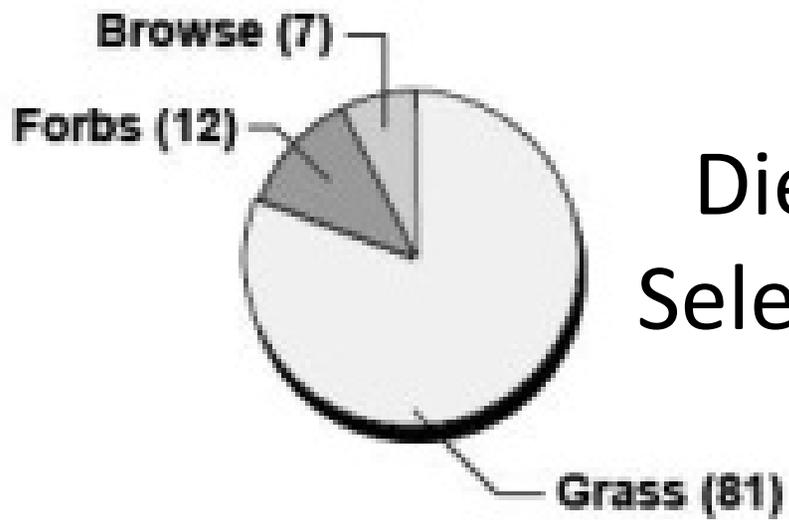| Item | Botanical composition, % [1] | | | P value[2] |
|---|---|---|---|---|
| | 2011 | 2012 | 2013 | |
| **Dietary botanical selection, % of diet** | | | | |
| Woody | 88.9 (± 2.2) a | 81.2 (± 2.2) b | 83.8 (± 2.0) b | <.0001 |
| Forb | 8.2 (± 1.9) b | 14.5 (± 1.9) a | 13.5 (± 1.8) a | <.0001 |
| Graminoid | 2.9 (± 0.9) a | 4.3 (± 1.0) a | 2.8 (± 0.9) a | 0.0355 |
| **Botanical Availability, % cover** | | | | |
| Woody | 39.2 (± 4.8) c | 58.3 (± 4.8) a | 45.0 (± 4.8) b | <.0001 |
| Forb | 7.1 (± 2.1) c | 11.2 (± 2.1) b | 49.2 (± 2.1) a | <.0001 |
| Graminoid | 2.1 (± 1.1) c | 5.8 (± 1.1) b | 13.7 (± 1.1) a | <.0001 |
| **KSI, % similarity [3]** | | | | |
| Woody | 56.4 (± 3.9) c¥ | 74.6 (± 3.9) a¥ | 68.5 (± 3.9) b¥ | <.0001 |
| Forb | 16.5 (± 2.5) b* | 33.2 (± 2.6) a¥ | 34.5 (± 2.3) a# | <.0001 |
| Graminoid | 1.1 (± 1.8) b* | 10.1 (± 1.9) a∞ | 14.1 (± 1.7) a∞ | <.0001 |

[1] Mixed model means and (±SE) associated with comparison of year main-effects means.

[2] Mixed model ranked P value associated with year F-test.

[3] Kulcyznski's Similarity Index (KSI):

* Strong preference (i.e. KSI ≤ 20, selection frequency > availability)

∞ Strong avoidance (i.e. KSI ≤ 20, availability > selection frequency)

¥ Moderate preference (i.e. KSI btwn 21% and 79%, selection frequency > availability)

# Moderate avoidance (i.e. KSI btwn 21% and 79%, availability > selection frequency)

# ADG (g) by Year and Goat Class, 95% CI

- 45-181 g/d is excellent kid growth (Kerr Center, 2012)
- 64 g/d OK Buck Test (Kerr Center, 2012)
- 59 g/d MD Buck Test (W. Maryland University, 2011-2012)
- 91 g/d BAAP 2012 (Nolden, unpublished data)

Mean ADG in grams per day

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 2012 | 2013 | 2011 | 2012 | 2013 | 2011 | 2012 | 2013 | 2013 | 2011 |
| N=40 | 34 | 40 | 25 | 20 | 21 | 12 | 28 | 13 | 35 | 9 |
| Kid | | | Nursing Doe | | | Open Doe | | | Yearling | Wether |
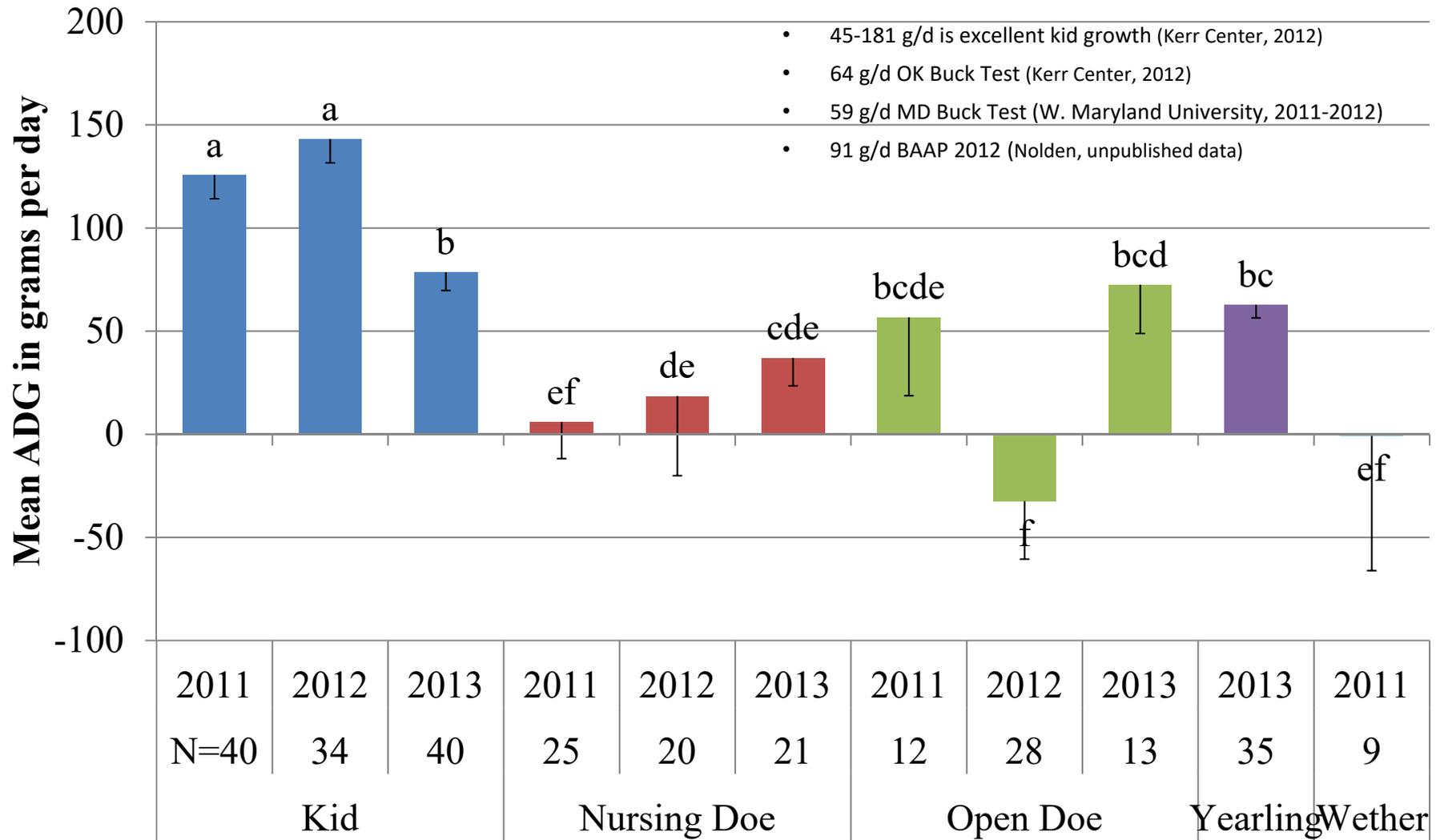
**Goat Class and Year with Count of Goats per Category**

38

# Body Condition Score

**Goat BCS (1-5 [5]) by class at start and end, and change by year**

| Class | Year | Start[1] Mean | SE | Letter[3] | End[1] Mean | SE | Letter[3] | Change[2] Mean | SE | Letter[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| Kid | 2011 [4] | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 2012 | 3.1 | 0.08 | AB | 3.1 | 0.10 | AB | 0.03 | 0.116 | BCD |
| | 2013 | 2.8 | 0.07 | BC | 2.9 | 0.09 | BC | 0.05 | 0.107 | BC |
| Nursing Doe | 2011 [4] | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 2012 | 3.2 | 0.10 | C | 2.6 | 0.13 | C | -0.55 | 0.151 | D |
| | 2013 | 1.9 | 0.10 | BC | 2.7 | 0.13 | BC | 0.86 | 0.148 | A |
| Open Doe | 2011 [4] | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 2012 | 3.1 | 0.08 | A | 3.5 | 0.11 | A | 0.39 | 0.128 | AB |
| | 2013 | 2.1 | 0.12 | BC | 2.8 | 0.16 | BC | 0.69 | 0.188 | AB |
| Yearling | 2011 [4] | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 2012 | 4.0 | 0.45 | ABC | 2.0 | 0.58 | ABC | -2.00 | 0.677 | CD |
| | 2013 | 2.4 | 0.07 | BC | 2.9 | 0.10 | BC | 0.50 | 0.113 | AB |

[1] Starting and ending BCS (1-5) taken by the goat provider annually

[2] BCS (Body Condition Score) change calculated on an animal unit basis over the days browsed

[3] Different letters indicate significant difference within effect (Start, End or Change) at P ≤ 0.05

[4] BCS data were not collected in 2011

[5] BCS range of 1-5 is scored as: 1=emaciated, 3=ideal, 5=obese

[6] Mixed model ANOVA results for analyses of Start, End and Change

# FAMACHA Score

**Goat FAMACHA score (1-5 [4]) at start and end, and change by year**

| Class | Year | Start[1] Mean | SE | Letter[3] | End[1] Mean | SE | Letter[3] | Change[2] Mean | SE | Letter[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 1.9 | 0.11 | C | 1.9 | 0.11 | C | 0.08 | 0.141 | AB |
| Kid | 2012 | 2.2 | 0.12 | C | 2.6 | 0.12 | B | 0.41 | 0.153 | A |
| | 2013 | 2.9 | 0.11 | AB | 2.5 | 0.11 | B | -0.40 | 0.141 | B |
| | 2011 | 2.3 | 0.14 | BC | 2.1 | 0.14 | BC | -0.20 | 0.179 | AB |
| Nursing Doe | 2012 | 2.0 | 0.16 | C | 2.3 | 0.15 | BC | 0.30 | 0.200 | AB |
| | 2013 | 3.4 | 0.15 | A | 3.8 | 0.15 | A | 0.38 | 0.195 | AB |
| | 2011 | 2.1 | 0.20 | C | 2.1 | 0.20 | BC | 0.00 | 0.258 | AB |
| Open Doe | 2012 | 2.4 | 0.12 | BC | 2.3 | 0.13 | BC | -0.14 | 0.169 | AB |
| | 2013 | 3.1 | 0.19 | AB | 3.4 | 0.19 | A | 0.31 | 0.248 | AB |
| | 2011 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Yearling | 2012 | 3.0 | 0.69 | ABC | 3.0 | 0.68 | ABC | 0.00 | 0.894 | AB |
| | 2013 | 3.1 | 0.12 | A | 3.4 | 0.11 | A | 0.31 | 0.149 | A |
| | 2011 | 2.2 | 0.23 | BC | 2.0 | 0.23 | BC | -0.22 | 0.298 | AB |
| Wether | 2012 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 2013 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

[1] Starting and ending FAMACHA score (1-5) taken by the goat provider annually

[2] FAMACHA score change calculated on an animal unit basis over the days browsed

[3] Different letters indicate significant difference within effect (Start, End or Change) at $P \leq 0.05$

[4] FAMACHA score of 1=excellent, 3=moderately anemic, 5=deathly anemic

[5] Mixed model ANOVA results for analyses of Start, End and Change

# YLWA Summary

- Good impact in 4 days on heavily browsed sites
- No soil compaction
- Significant reduction in brush density and height
- Increase in invasive forbs
- 85% selection of woody species forage
  - Differences between herds in selections
- Goats healthy
  - Unchanged body condition score
  - Unchanged FAMACHA score
- Goats gained weight
  - .17-.31 lb/d for kids

# Study Limitations

- Conservative approach in design
- Site browsed for only 3 years
  – 5-8 years needed to kill some brush species (Hart, 2006)
- "Heavily" browsed was 90% defoliation
  – 100% defoliation depletes carbohydrate root reserves faster
  – Contract Browsers will remove 100% of brush within 7 feet of the ground; impacts of actual practice would be more informative
- Compaction was difficult to measure – bedrock
- Split plot study design – animal behavior
- Goat performance – added years of parasites

Environmental Risks

43

# Sales

**FENNIMORE LIVESTOCK EXCHANGE, INC.**
14034 US HWY 61 N · FENNIMORE, WI 53809
TELEPHONE (608) 822-3255

111247

2494 Allen Phile or Cherrie Nolden

12/15/2017    Page    1

| Slip# | Tag# | Hd | Bs | Description | Purchaser | Avg | Weight | Price | Amount |
|-------|------|----|----|-------------|-----------|-----|--------|-------|--------|
| 6684 | 1031 | 20 | 0 | X-Bred Kid | 4-2 | 57 | 1145 | 260.00w | 2977.00 |
| 6684 | 1031 | 1 | 0 | D-Kid | 1600- | 35 | 35 | 250.00w | 87.50 |
| 6684 | 1031 | 2 | 0 | D-Kid | 1600- | 48 | 95 | 240.00w | 228.00 |
| 6684 | 1031 | 1 | 0 | D-Kid | 553- | 35 | 35 | 162.50w | 56.87 |
| 6684 | 1031 | 2 | 0 | D-Kid | 1600- | 48 | 95 | 215.00w | 204.25 |
| 6684 | 1031 | 6 | 0 | D-Kid | 115-1 | 80 | 480 | 140.00w | 672.00 |

| **Head** | **32** | **0** | | **Total Wt** | **1885** | | | **GROSS** | **4225.62** |

INSURANCE  GOATS          4.23
SCOM                    128.00
                        132.23

| Descr | Hd | AvgWt | Avg$CWT | Avg$HD |
|-------|----|-------|---------|--------|
| X-Bred Kid | 20 | 57 | 260.00 | 148.85 |
| D-Kid | 12 | 62 | 168.73 | 104.05 |

Gross      4,225.62
Charges      132.23
Net Due    $4,093.39

| | |
|---|---|
| 180 | day grazing season (May-October) |
| 8 | lb kids at birth in May |
| 57 | lb kids at Christmas Sales |
| 240 | days old at Christmas Sales |
| 49 | Lbs needed to gain |
| 0.204 | Lbs per day ADG target |

| | |
|---|---|
| $150 | Income per kid sold |
| 4 | goats per wooded acre |
| 0.67 | 2 of 3 are kids to be sold, 1 is the dam |
| 2.67 | Sale goats produced per acre |
| $400 | dollars per wooded acre per year income |

# WI Contract Browsing Fees

- April 15 to November 1
- Hourly rate $25-60
- Delivery charge $100-200/trip
- Head/Day charge $2-3.00

- Contractor provides:
  - Fences/Energizer/Battery
  - Goats
  - Water tank
  - Mineral feeder & mineral
  - Labor

- Example
  - 15 ac woodland
  - 1 week (7 d)
  - 200 goats ($2.00)
  - 8 deliveries ($150)
  - Labor for 5 ac paddocks  (3 moves)
    - 5 hr setup, 3 hr move x 2 ($35)

$3,895 charged/wk

$506.35 income/goat

# Why Browse Goats?

- Advantages:
  - Free high-quality forage
  - 0.17-0.31 lb ADG w/o grain
  - Improved/NC BCS
  - NC FAMACHA
  - Potential for Fee Browsing
  - Parasite-free land
  - Organic land
  - Easy kidding
  - Natural goat habitat
  - Self-medication
  - Improve the environment
  - Help neighbors manage their land
  - No cropland conflict
  - Precedent
  - Economical, Profitable!

- Disadvantages:
  - Labor
  - Need portable system
  - Distance from farm
  - Discovery time
  - Potential for liability
  - Potential for vandalism
  - Potential for predation
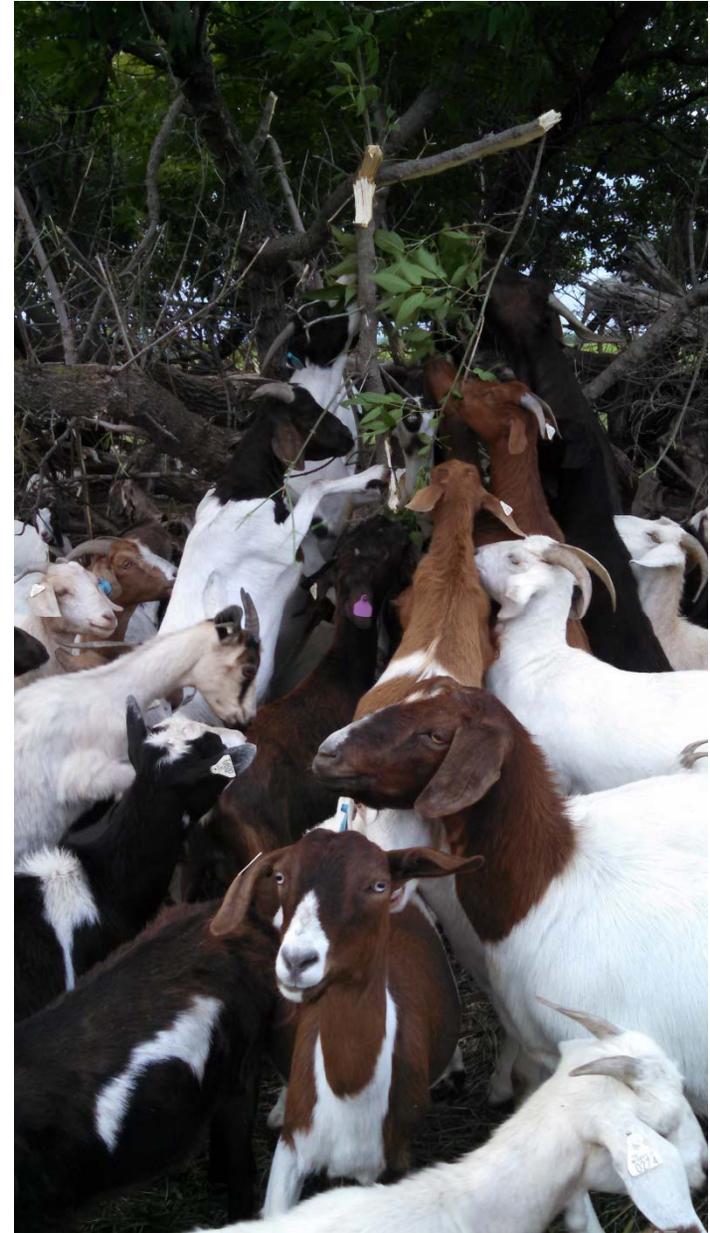


Photo by Cherrie Nolden

# Funding

# Questions?

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608-477-1981

Photo by Ken Brunson

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