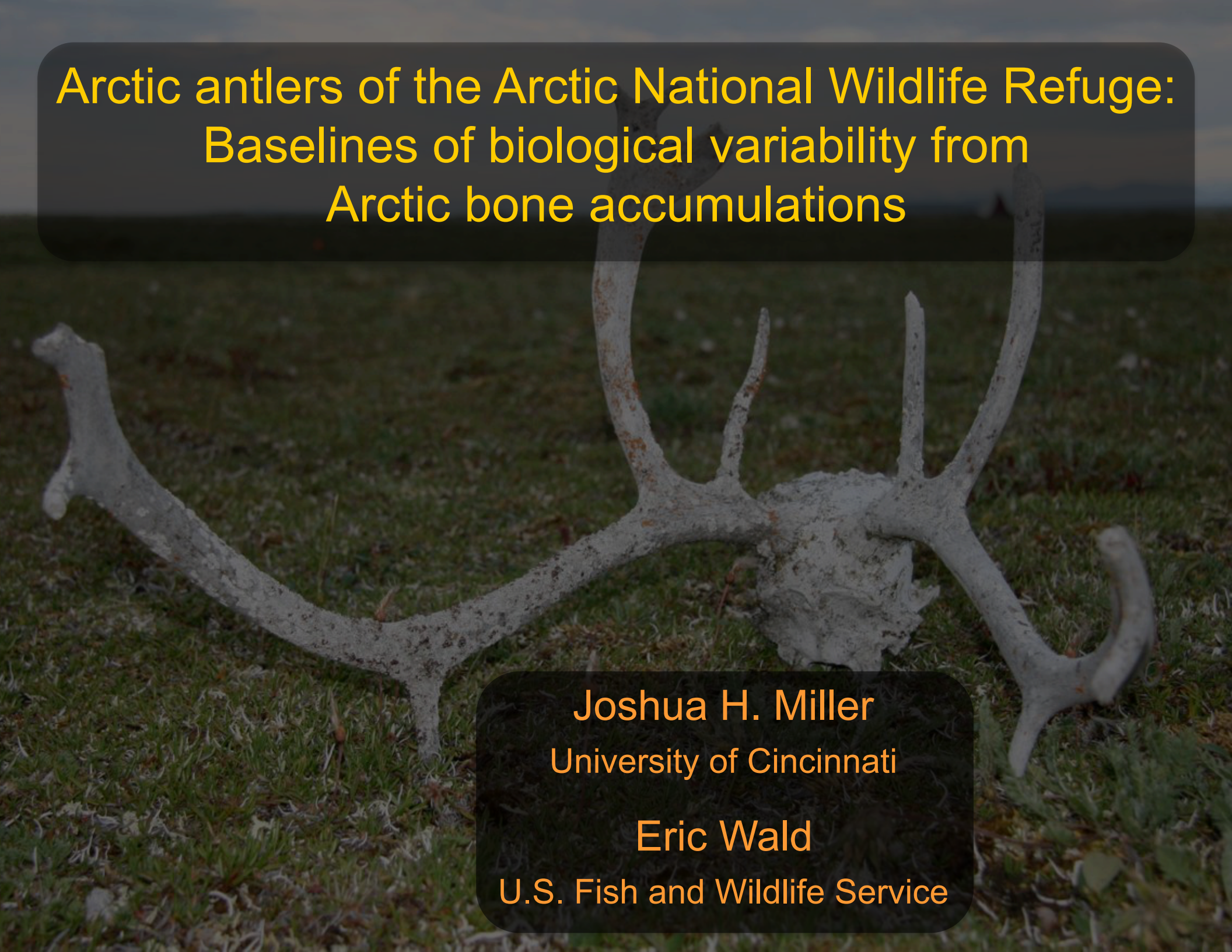
Arctic antlers of the Arctic National Wildlife Refuge: Baselines of biological variability from Arctic bone accumulations



Joshua H. Miller
University of Cincinnati

Eric Wald
U.S. Fish and Wildlife Service

Acknowledgments

Discussions & Logistical Support

Pat Druckenmiller
Dave Payer

Funding

Field assistants (USFWS)

Meagan Boldenow
Wendy Elsner
Janet Jorgenson

Historical Contexts & Ecological Baselines

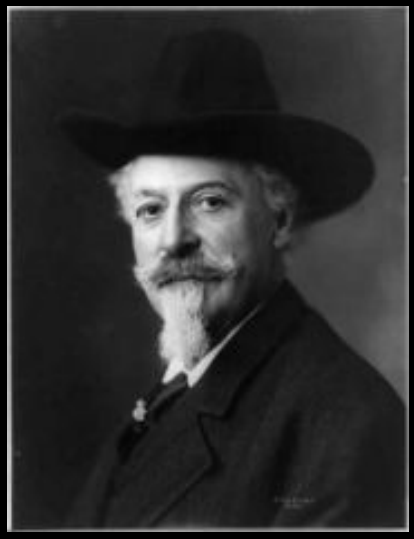
Historical contexts/Baselines essential for understanding current populations

Historical Contexts & Ecological Baselines

Historical contexts/Baselines essential for understanding current populations

Historical Contexts & Ecological Baselines

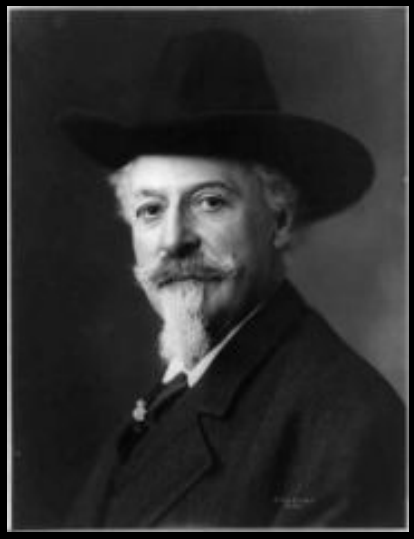
Historical contexts/Baselines essential for understanding current populations



"Buffalo" Bill Cody

Historical Contexts & Ecological Baselines

Historical contexts/Baselines essential for understanding current populations



"Buffalo" Bill Cody

Pile of Bison Skulls – c.1870's

— ? →

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

High-quality ecological data
In bone & shell accumulations

- Richness
- Community structure
- Changes over time

(Kidwell 2007, Western & Behrensmeyer 2009, Terry 2010a, 2010b, Dietl & Flessa 2011 Miller 20011, Behrensmeyer & Miller 2012)

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

High-quality ecological data
In bone & shell accumulations

- Richness
- Community structure
- Changes over time

  (Kidwell 2007, Western & Behrensmeyer 2009, Terry 2010a, 2010b, Dietl & Flessa 2011 Miller 20011, Behrensmeyer & Miller 2012)

- Landscape use

  (Miller 2012)

- Functional ecology (community-level)

  (Miller et al. 2014)

Historical Contexts & Ecological Baselines

Is it possible to go into the field today and collect historical data on current populations?

High-quality ecological data
In bone & shell accumulations

- Richness
- Community structure
- Changes over time

  (Kidwell 2007, Western & Behrensmeyer 2009, Terry 2010a, 2010b, Dietl & Flessa 2011 Miller 20011, Behrensmeyer & Miller 2012)

- Landscape use

  (Miller 2012)

- Functional ecology (community-level)

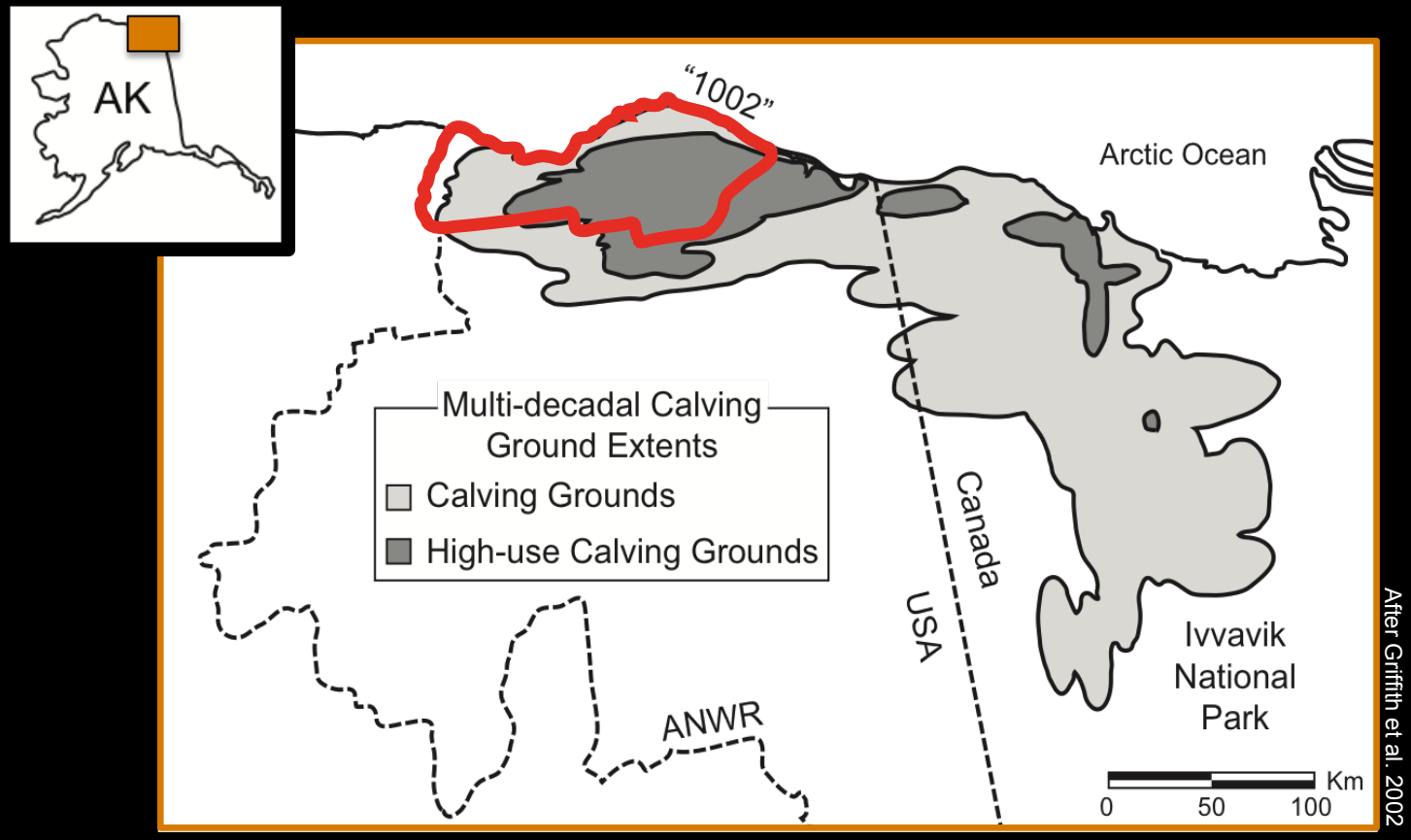
  (Miller et al. 2014)

Bone data are **long-lasting**

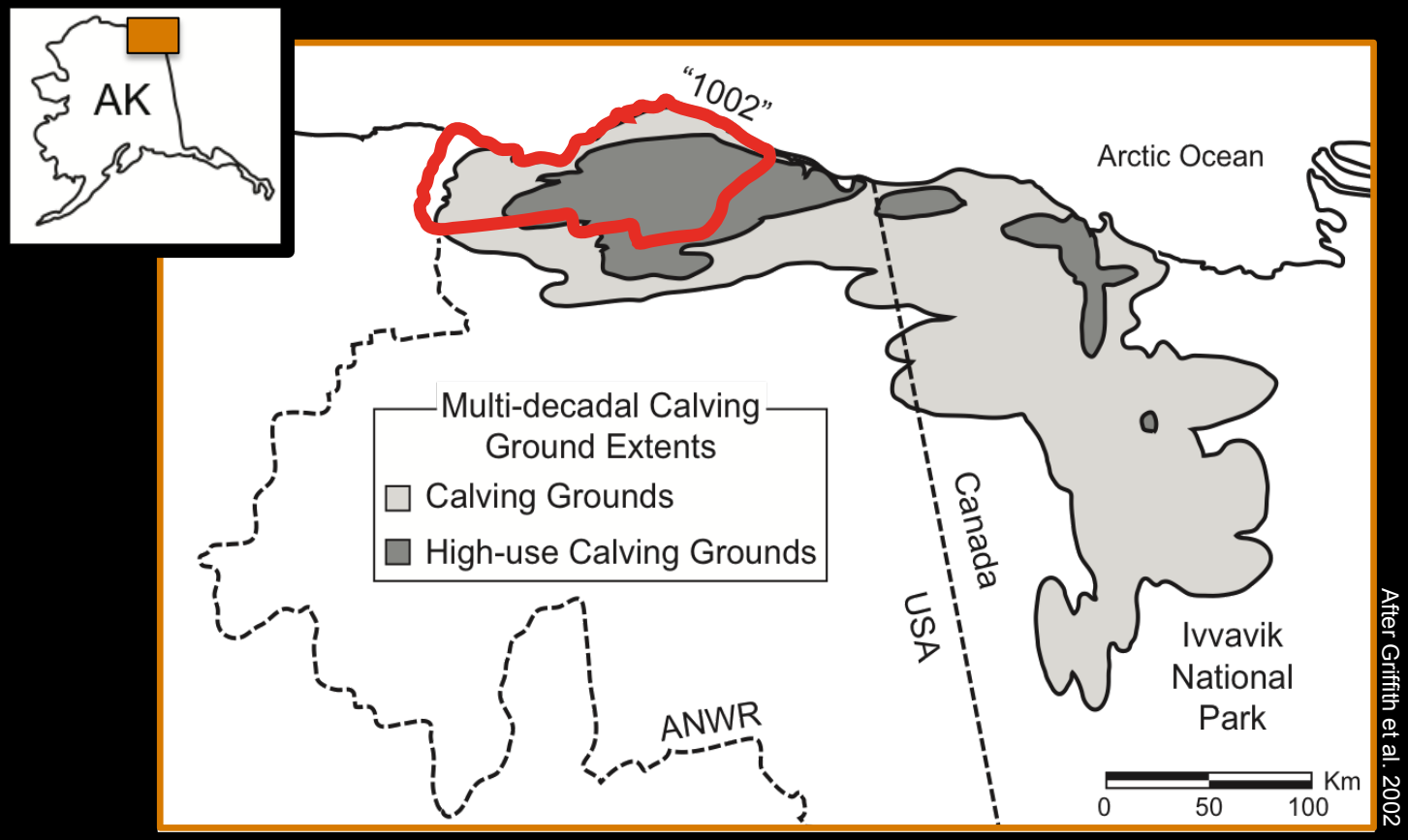
- Survive decades to millennia on landscapes

  (Behresmeyer 1978; Meldgaard 1986; Sutcliff & Blake 2000; Miller 2011)

Arctic National Wildlife Refuge (ANWR)



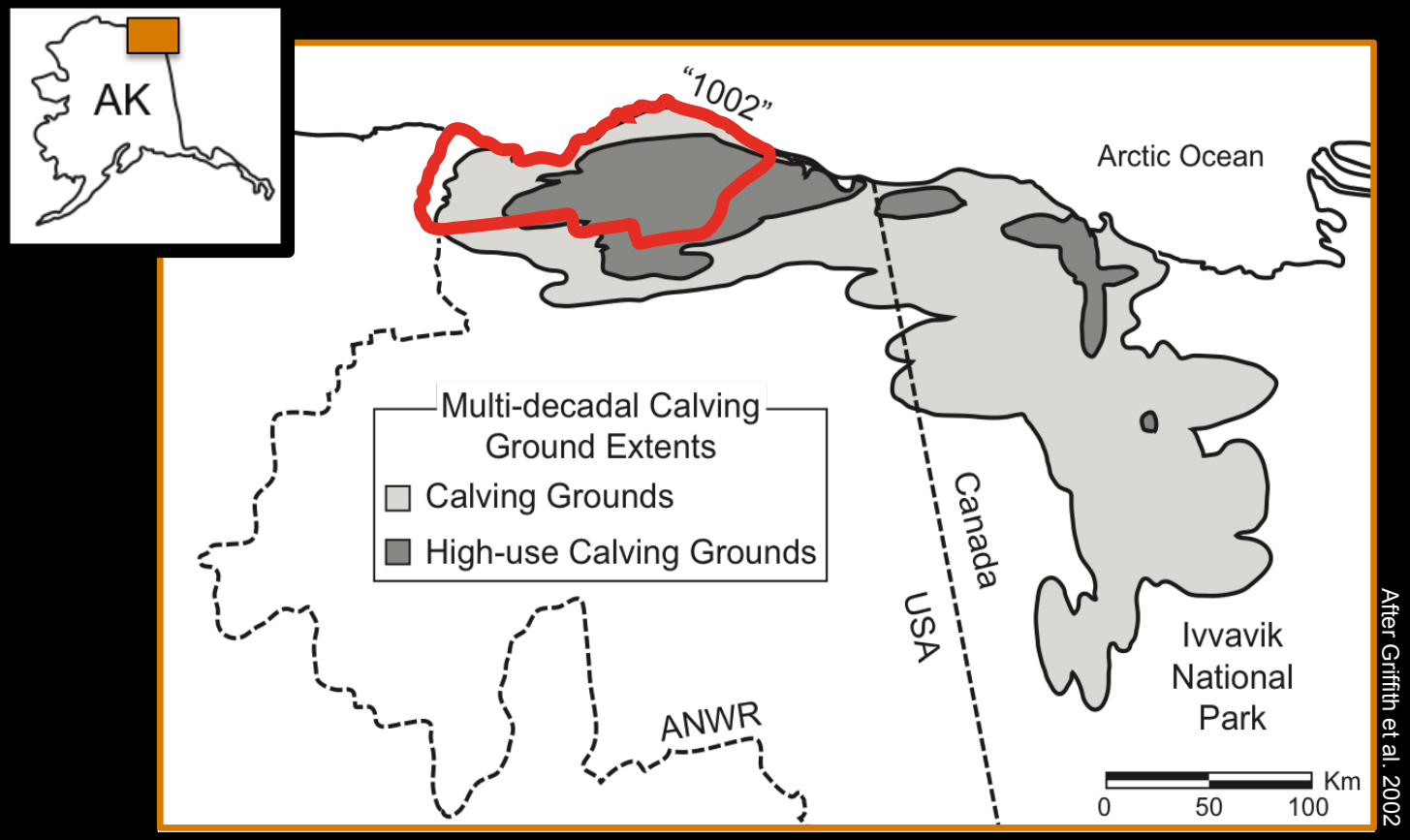
Arctic National Wildlife Refuge (ANWR)



Untapped terrestrial petroleum reserves ("1002" Area)

Calving grounds for ~196,000 caribou (Porcupine Caribou Herd)

Arctic National Wildlife Refuge (ANWR)

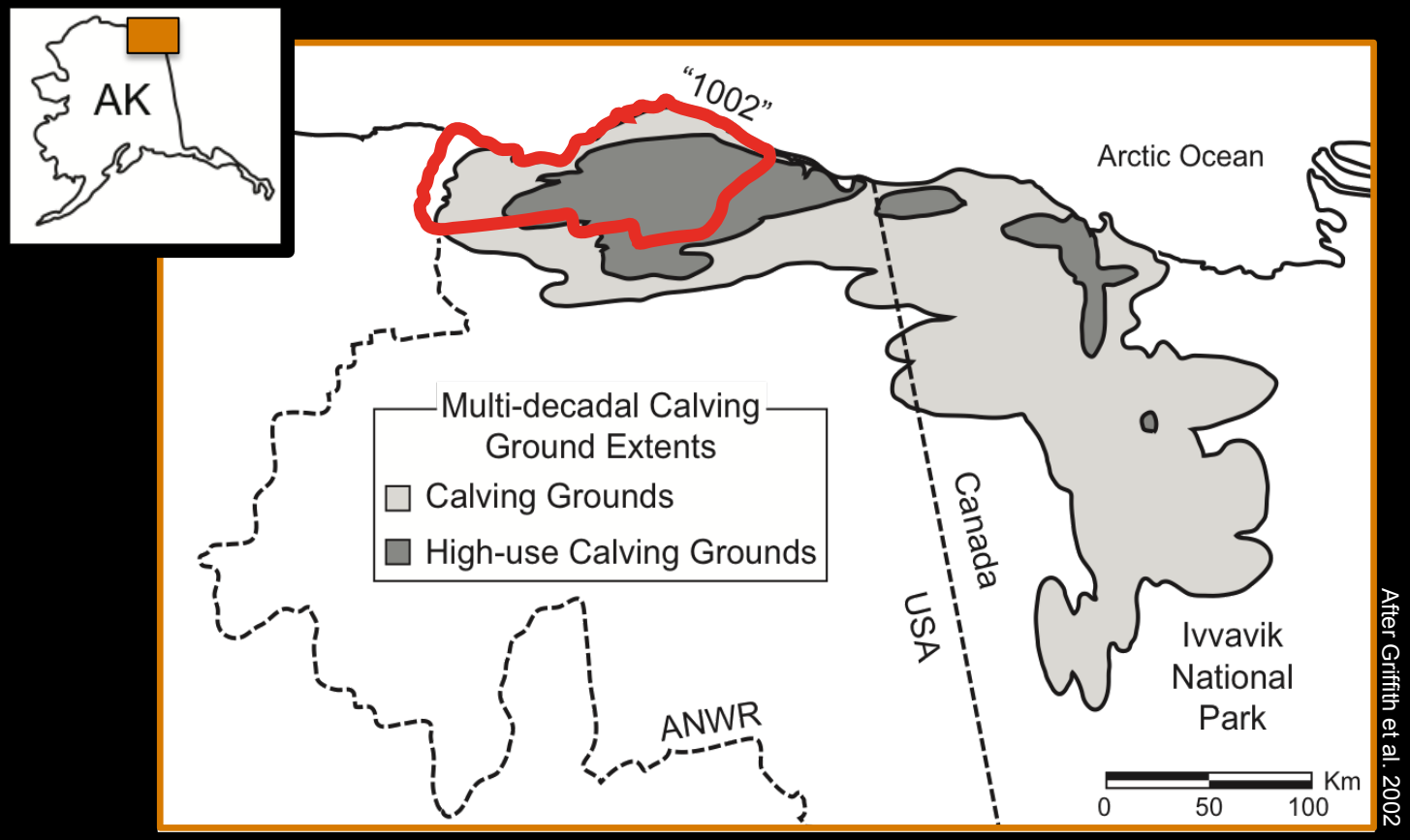


Untapped terrestrial petroleum reserves ("1002" Area)

Calving grounds for ~196,000 caribou (Porcupine Caribou Herd)

Surveys (~30+ years) show complex & variable calving patterns

Arctic National Wildlife Refuge (ANWR)



Untapped terrestrial petroleum reserves ("1002" Area)

Calving grounds for ~196,000 caribou (Porcupine Caribou Herd)

Surveys (~30+ years) show complex & variable calving patterns

Can skeletal records extend observational window?

Caribou Calving Grounds

Female caribou have antlers

Caribou Calving Grounds

Female caribou have antlers

↘

Migrate in concentrated female herds (with juveniles) to calving grounds

Caribou Calving Grounds

Female caribou have antlers

↘

Migrate in concentrated female herds (with juveniles) to calving grounds

↓

Female caribou shed antlers within **days** of calving

(Males shed antlers post-mating)

Caribou Calving Grounds

Female caribou have antlers

↘

Migrate in concentrated female herds (with juveniles) to calving grounds

↓

Female caribou shed antlers within **days** of calving

(Males shed antlers post-mating)

↓

Movement from calving sites is low for 48 hours post-birth, during which perinatal death is very high (Whitten et al. 1992; Griffith et al. 2002)

Ready-made skeletal signal of calving grounds?

Gender determination of caribou antlers

Male & female antlers differentiable by size & morphology

Complete antlers can be discriminated

Gender determination of caribou antlers

Shed antlers defined by presence of pedicle attachment

Gender determination of caribou antlers

Shed antlers defined by presence of pedicle attachment

Measured major and minor axes of attachment surface of known-gender antlers

31 males
24 females

(UAF, FMNH, AMNH)

Gender determination of caribou antlers

Shed antlers defined by presence of pedicle attachment

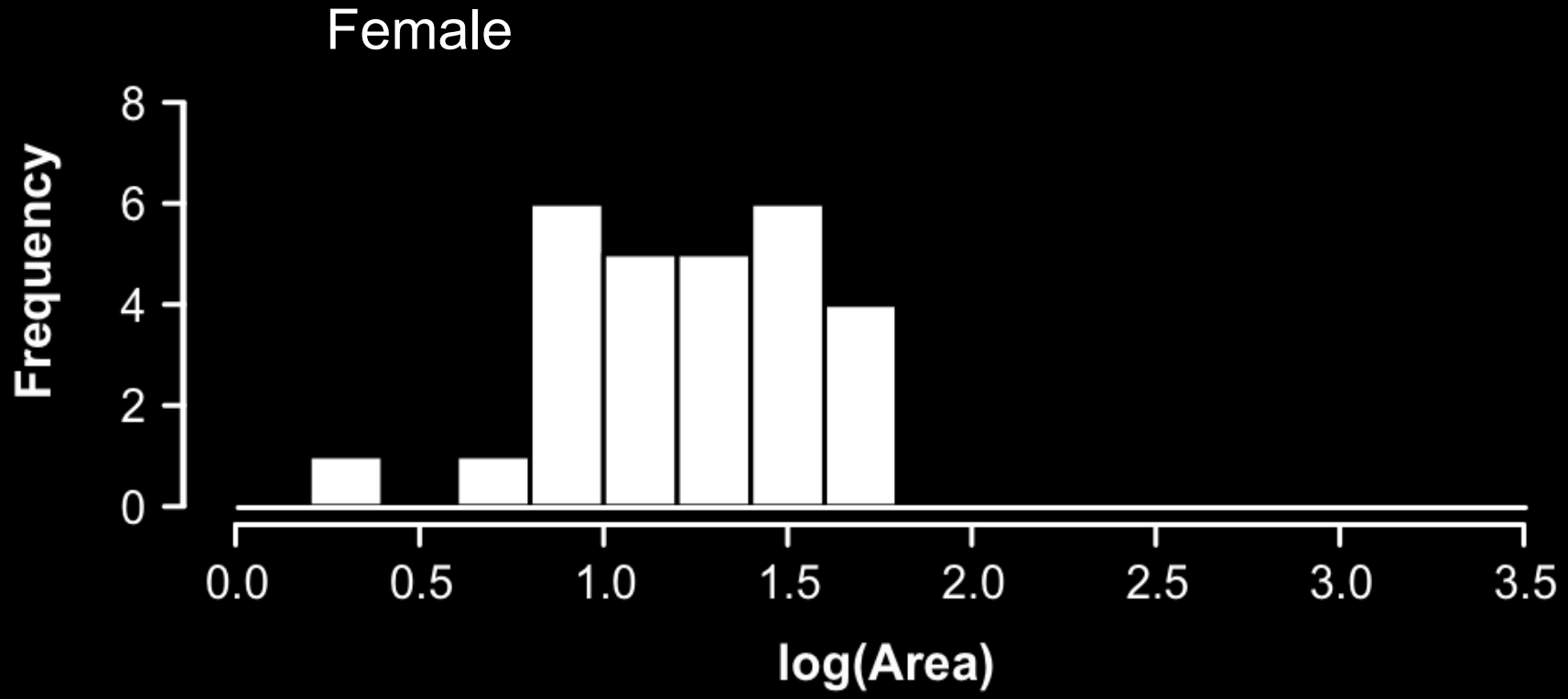
Measured major and minor axes of attachment surface of known-gender antlers

31 males
24 females

Calculate Area

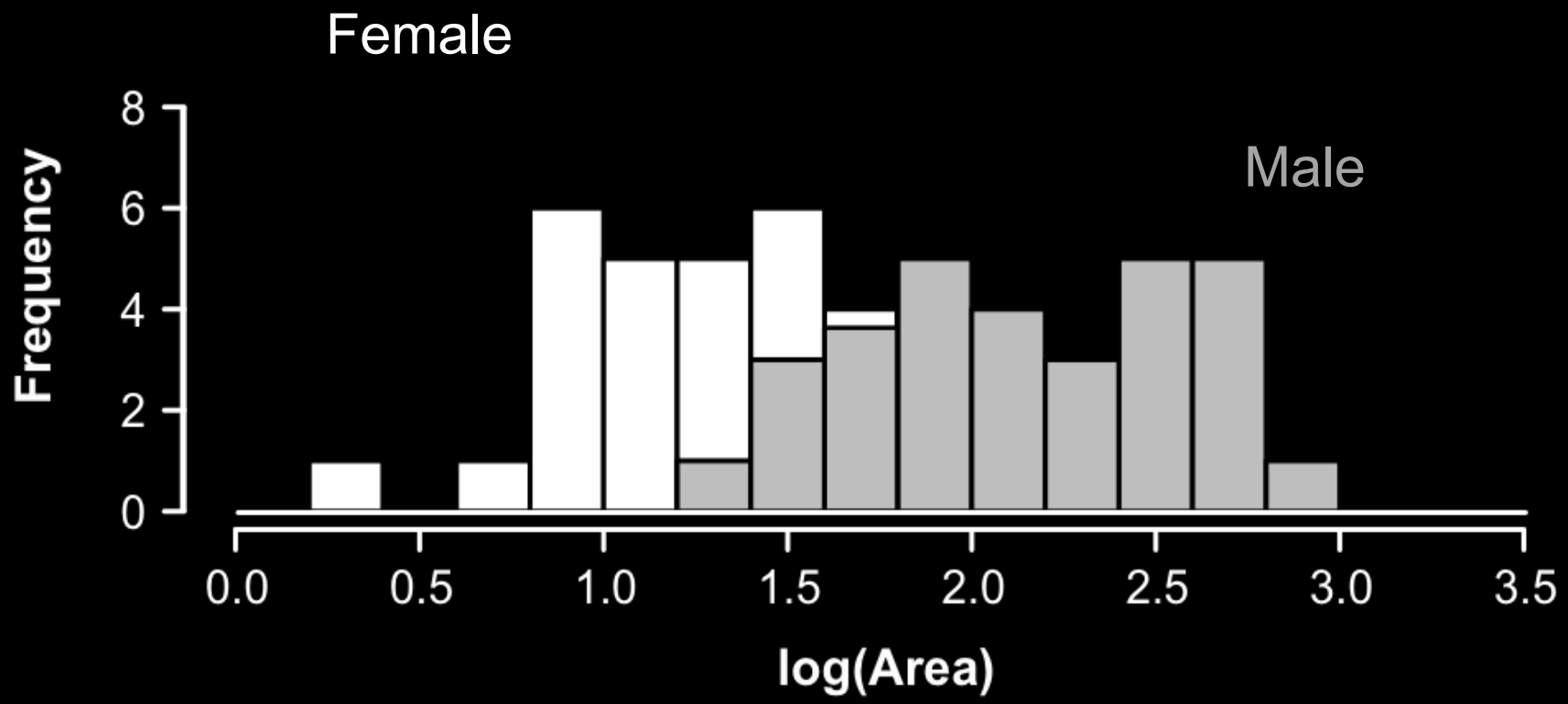
(UAF, FMNH, AMNH)

Gender determination of caribou antlers



(Miller et al. 2013)

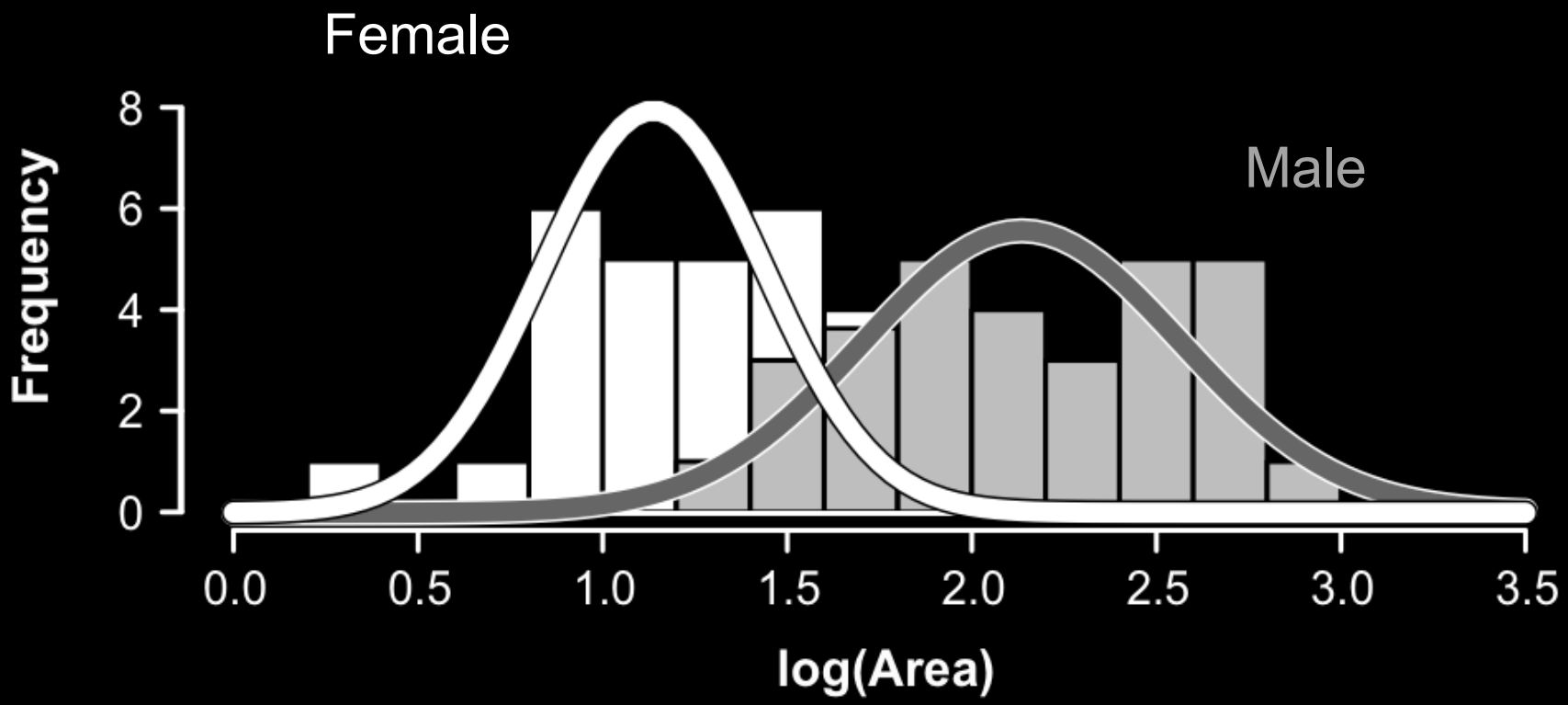
Gender determination of caribou antlers



Adult male antlers
well differentiated

(Miller et al. 2013)

Gender determination of caribou antlers



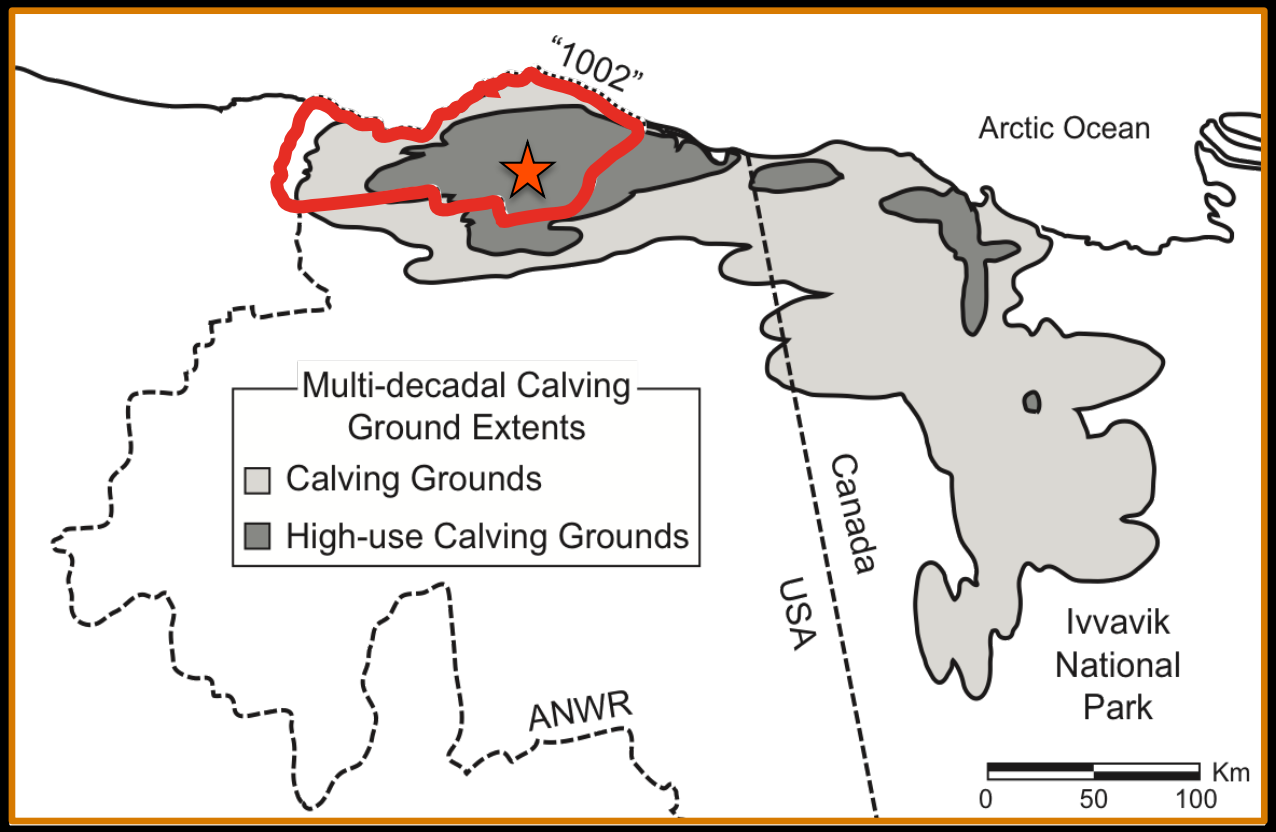
Adult male antlers
well differentiated

* Fit normal distributions

* Calculate prob. of gender for overlapping regions

(Miller et al. 2013)

Sampling the landscape



Important calving ground on the Jago River

In the heart of "1002"

Sampling the landscape

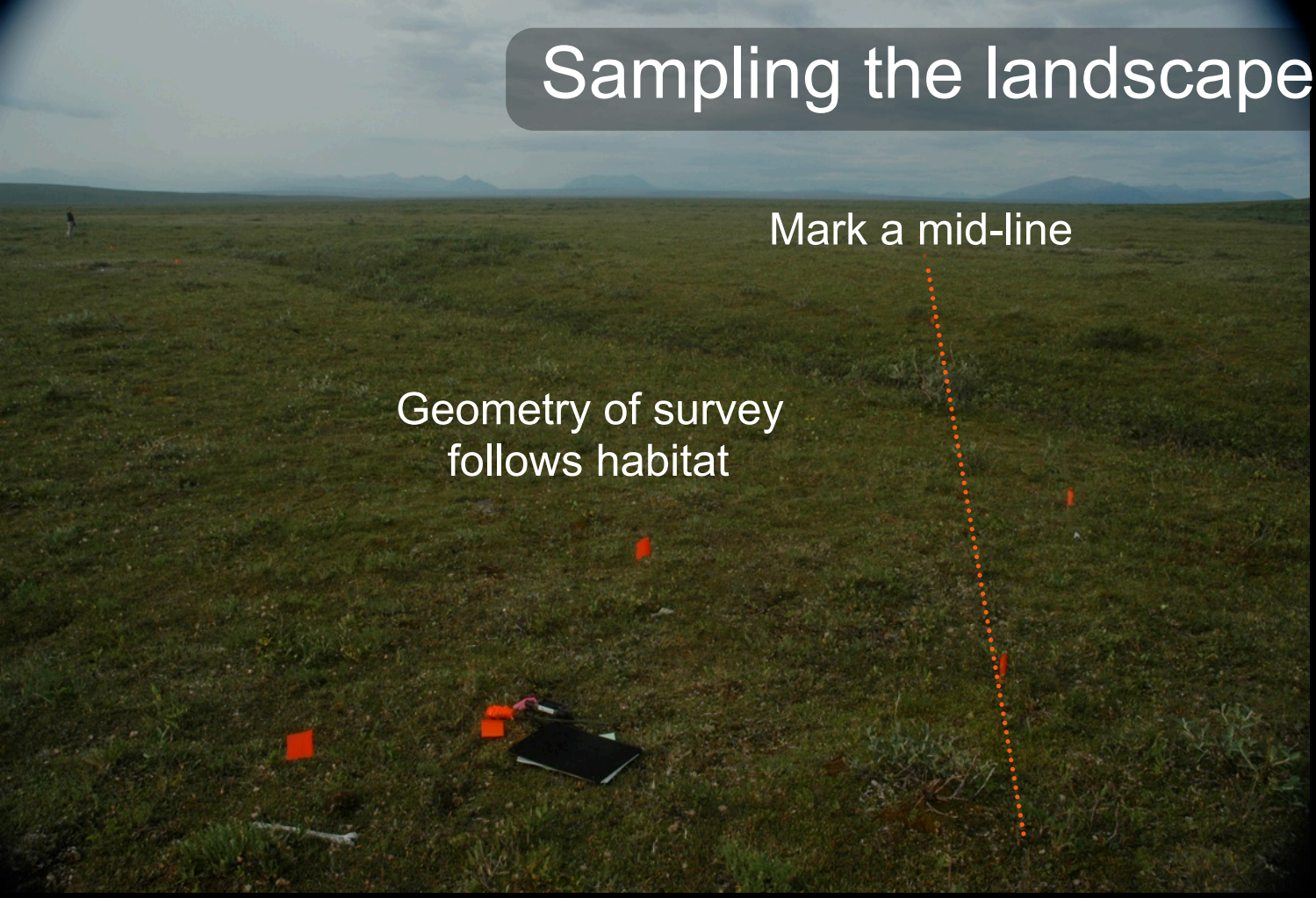
Dryas terrace

Good visibility

High use for calving habitat

(Miller et al. 2013)

Sampling the landscape



Data: taxon, element, age, WS, GPS, completeness, damage...

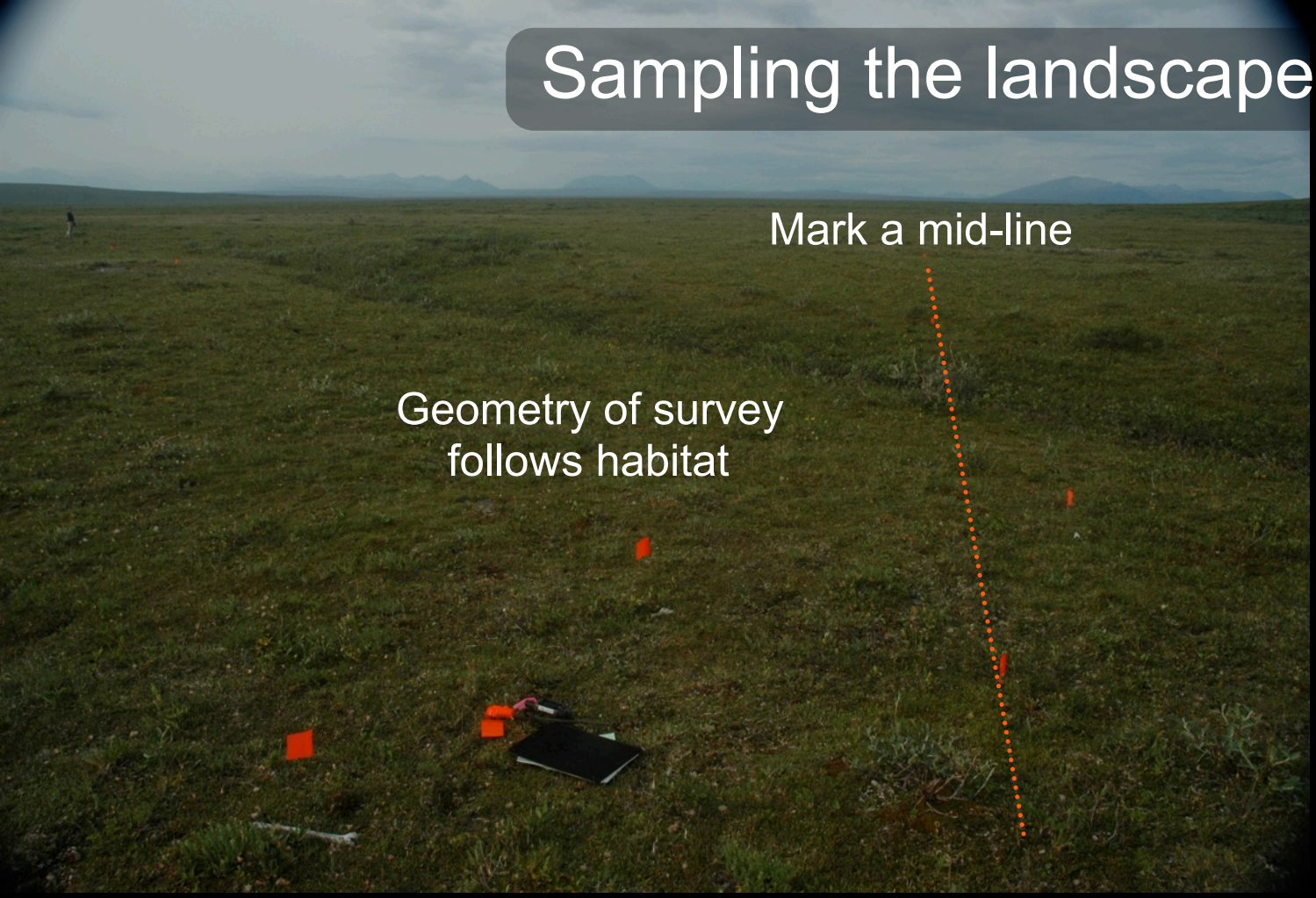
Dryas terrace

Good visibility

High use for calving habitat

(Miller et al. 2013)

Sampling the landscape



Data: taxon, element, age, WS, GPS, completeness, damage...

Dryas terrace

Good visibility

High use for calving habitat

Count antlers (standardized km^2)

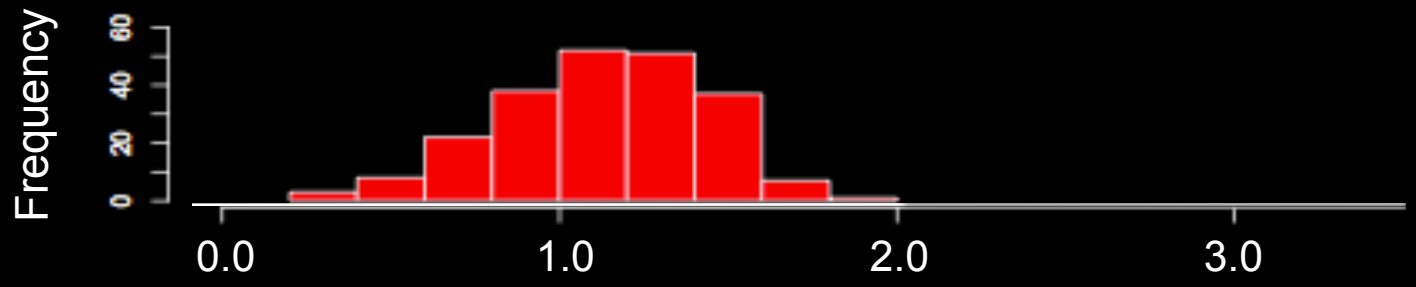
Convert bone sample → Minimum Number of Individuals (MNI)

(Miller et al. 2013)

Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers

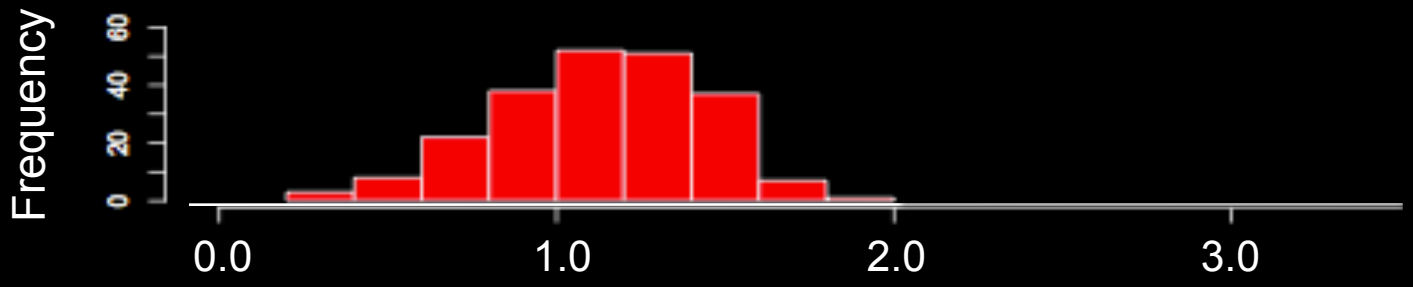


(Miller et al. 2013)

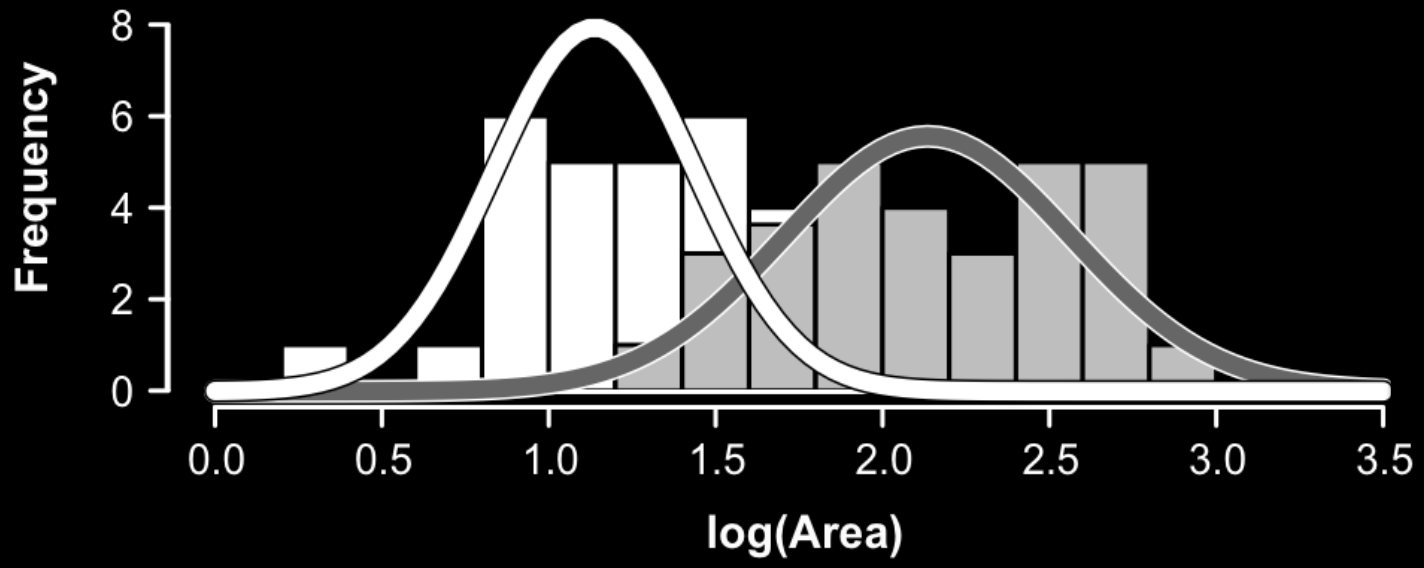
Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers



Museum specimens

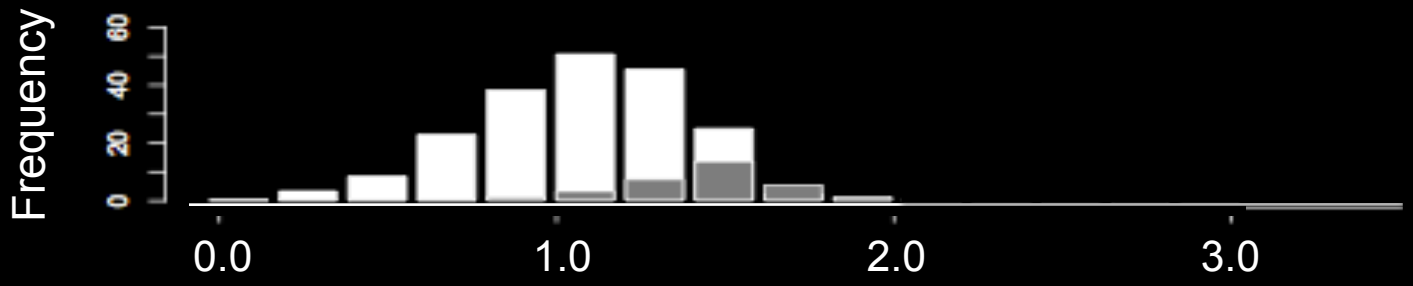


(Miller et al. 2013)

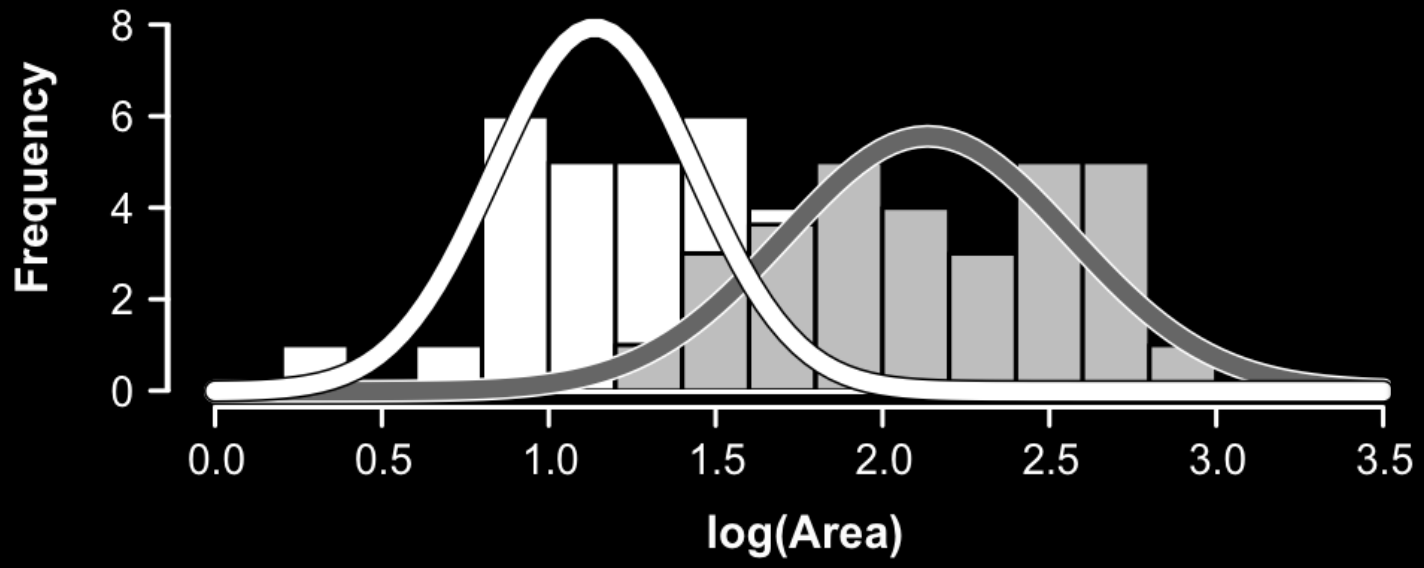
Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers



Museum specimens

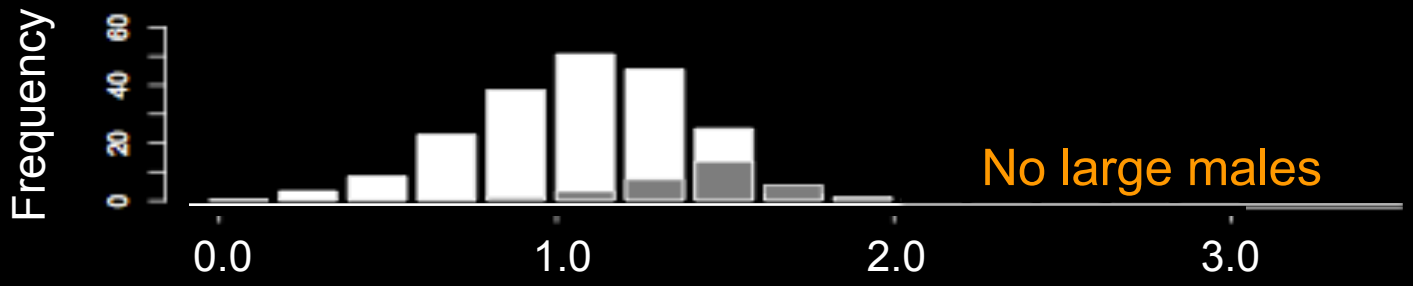


(Miller et al. 2013)

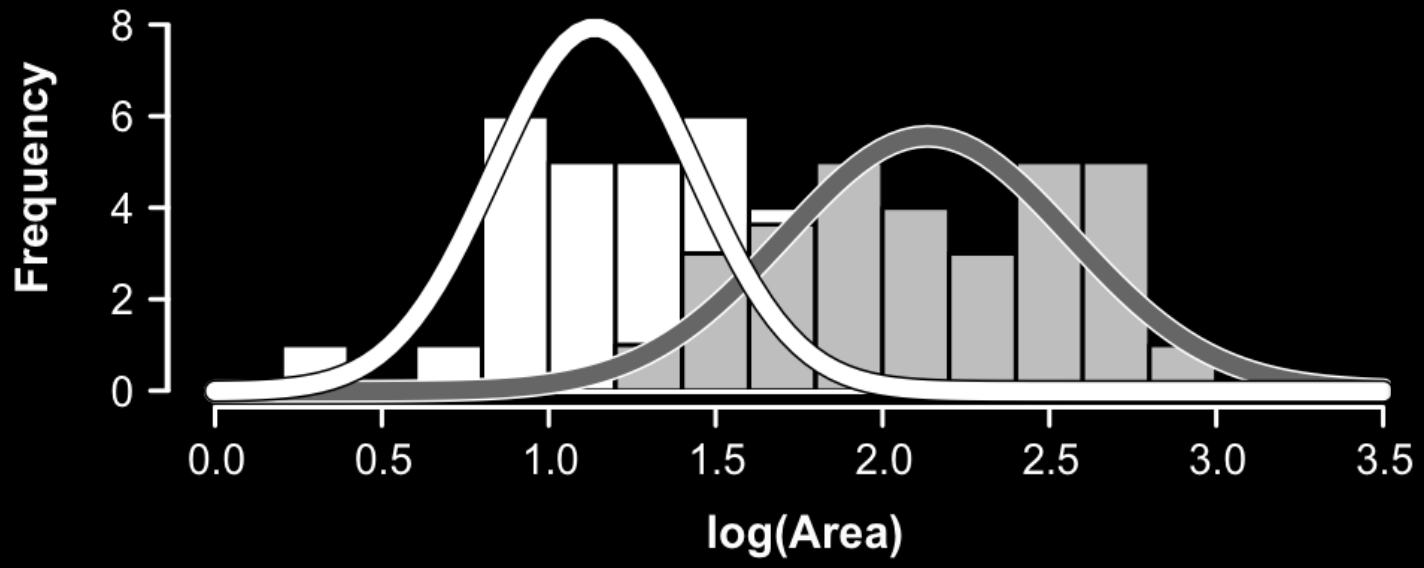
Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers



Museum specimens



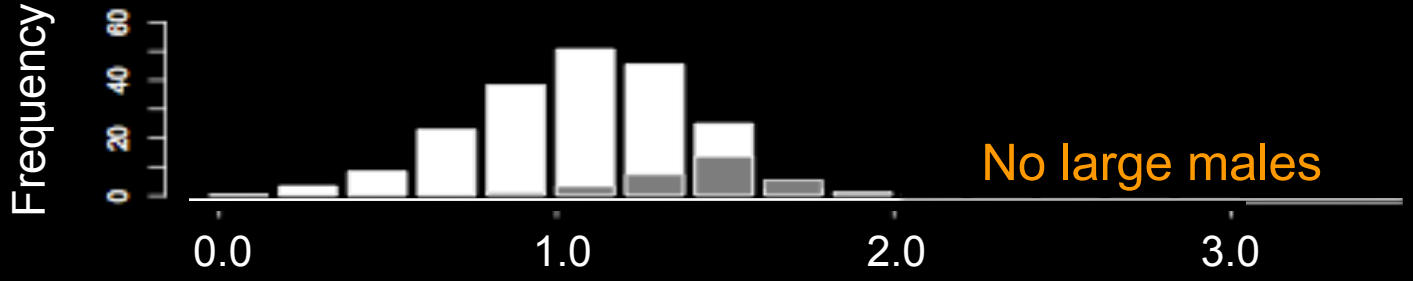
(Miller et al. 2013)

Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

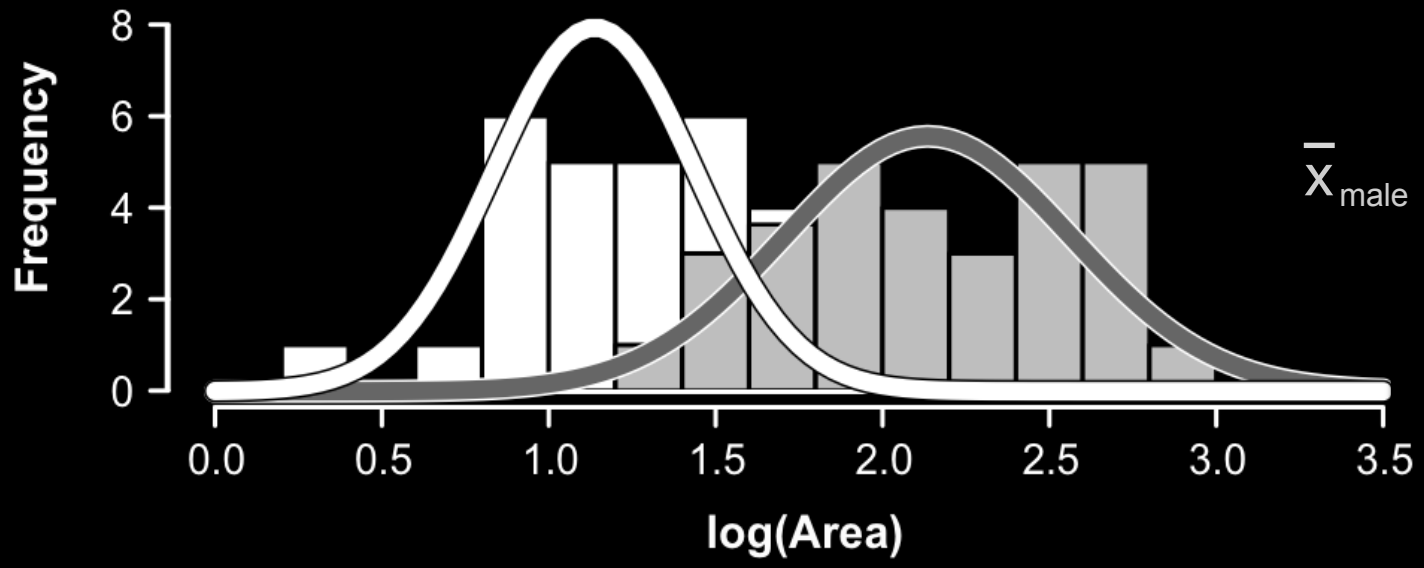
ANWR Antlers

$\bar{x}_{ANWR}$ = 1.137 +/- 0.309



Museum specimens

$\bar{x}_{female}$ = 1.138 +/- 0.301



$\bar{x}_{male}$ = 2.137 +/- 0.430

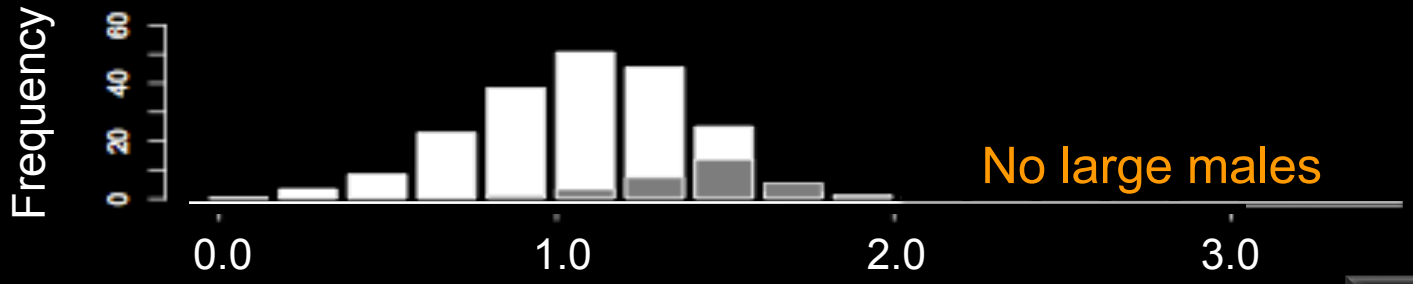
(Miller et al. 2013)

Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers

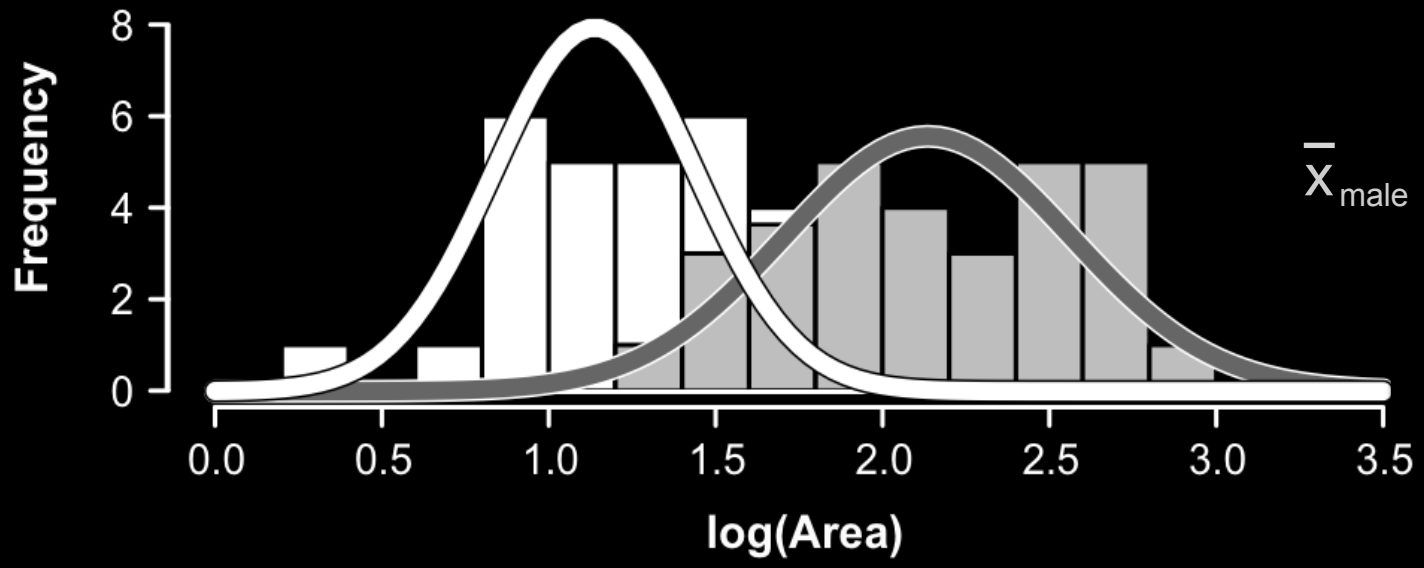
$\bar{x}_{ANWR}$ = 1.137 +/- 0.309



Antler concentrations:
10^3 antlers/km^2

Museum specimens

$\bar{x}_{female}$ = 1.138 +/- 0.301



$\bar{x}_{male}$ = 2.137 +/- 0.430

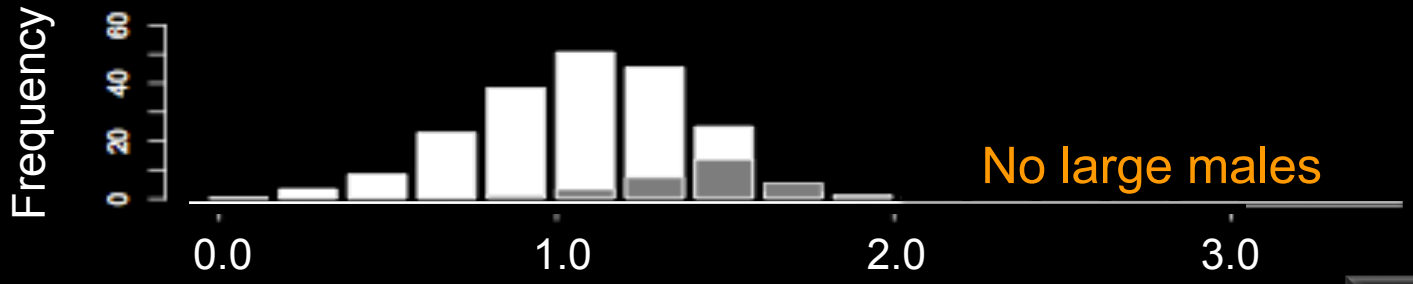
(Miller et al. 2013)

Skeletal signatures of calving grounds: Antlers

4 bone surveys (Jago Bitty)

ANWR Antlers

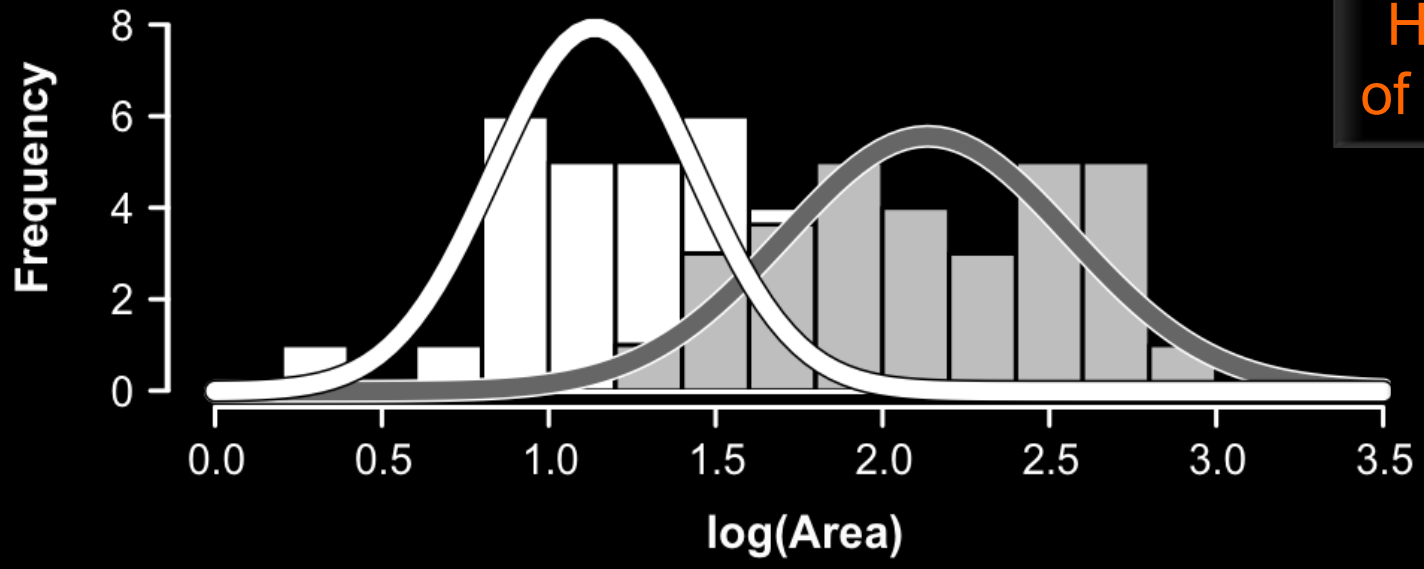
$\bar{x}_{ANWR}$ = 1.137 +/- 0.309



Antler concentrations: 10^3 antlers/km^2

Museum specimens

$\bar{x}_{female}$ = 1.138 +/- 0.301



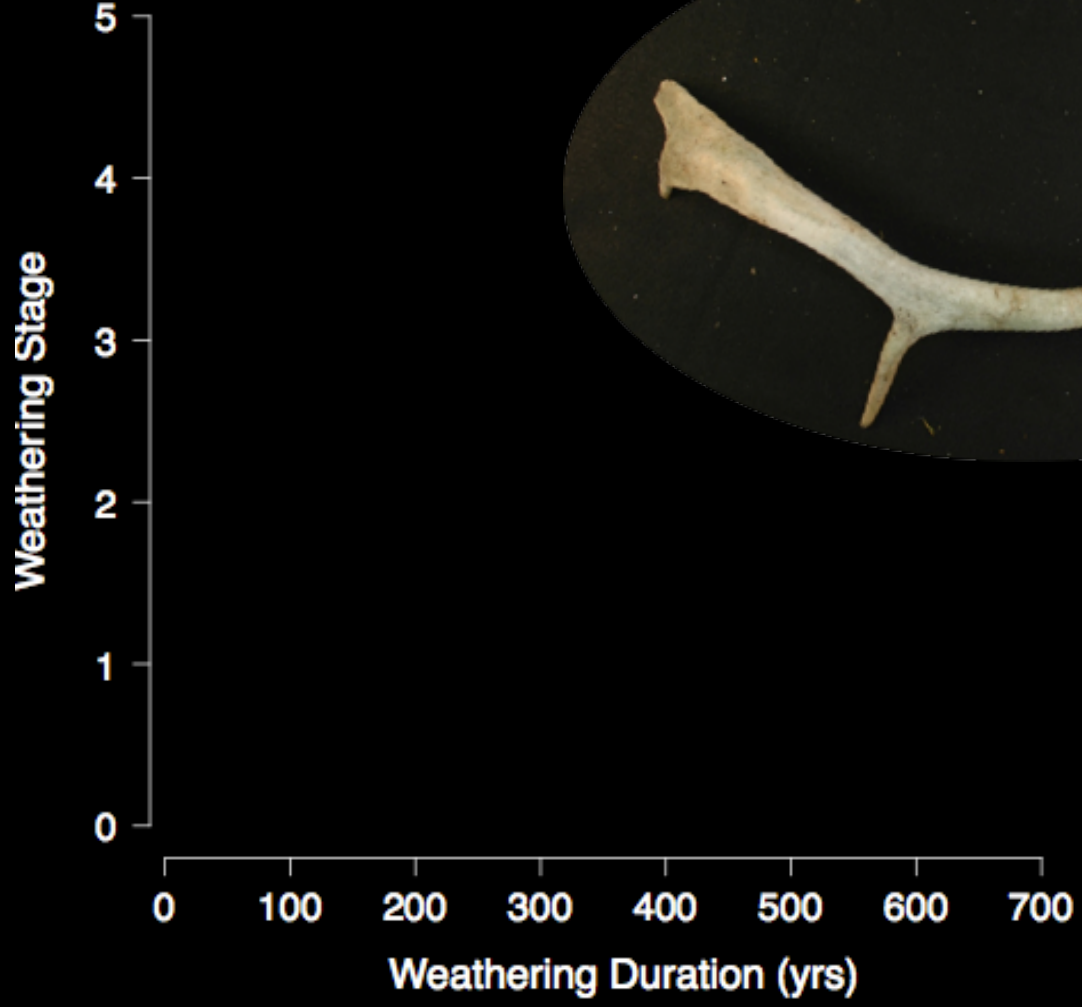
High concentrations of neonatal carcasses

(Miller et al. 2013)

WS Calibration

AMS ^{14}C-dated 39 antlers

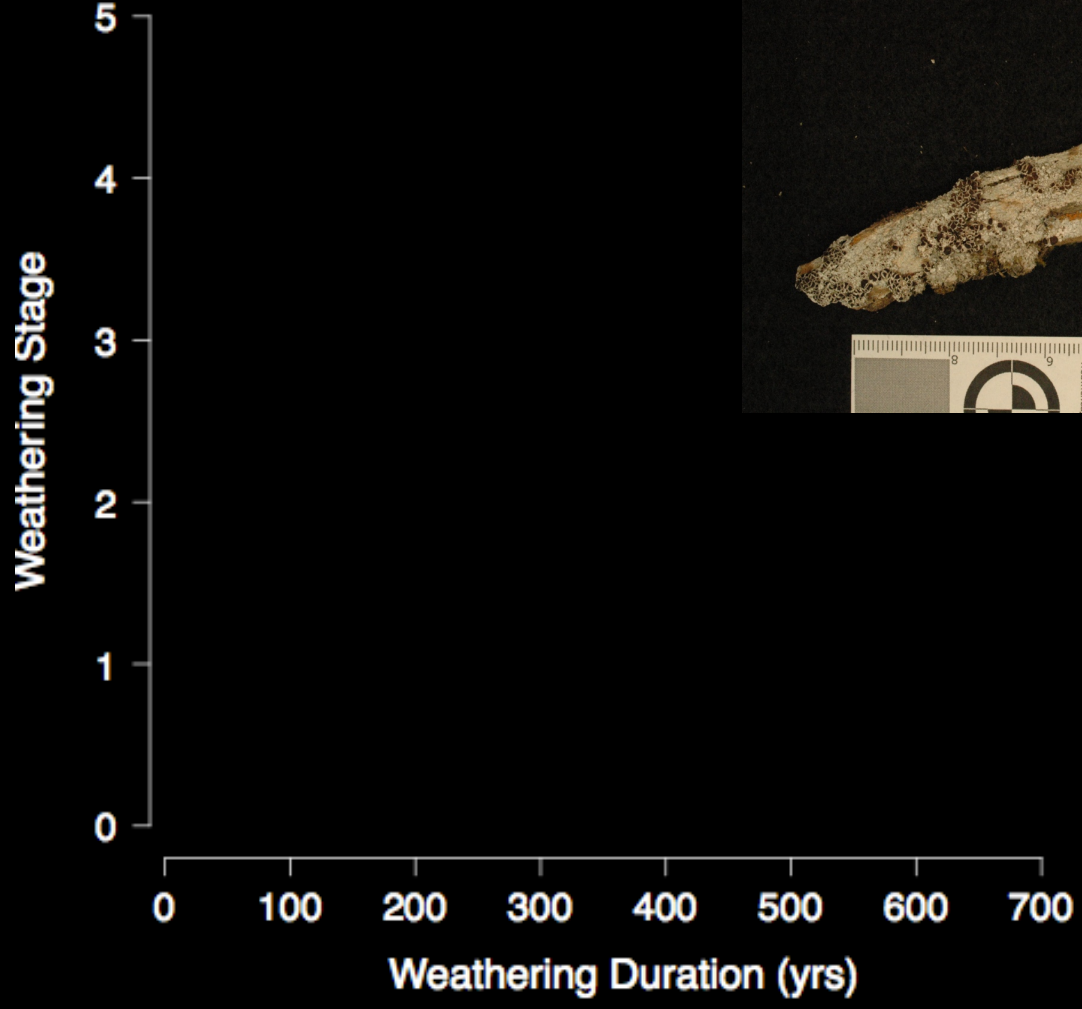
	n
WS 2	18
WS 3	15
WS 4	3
WS 5	3



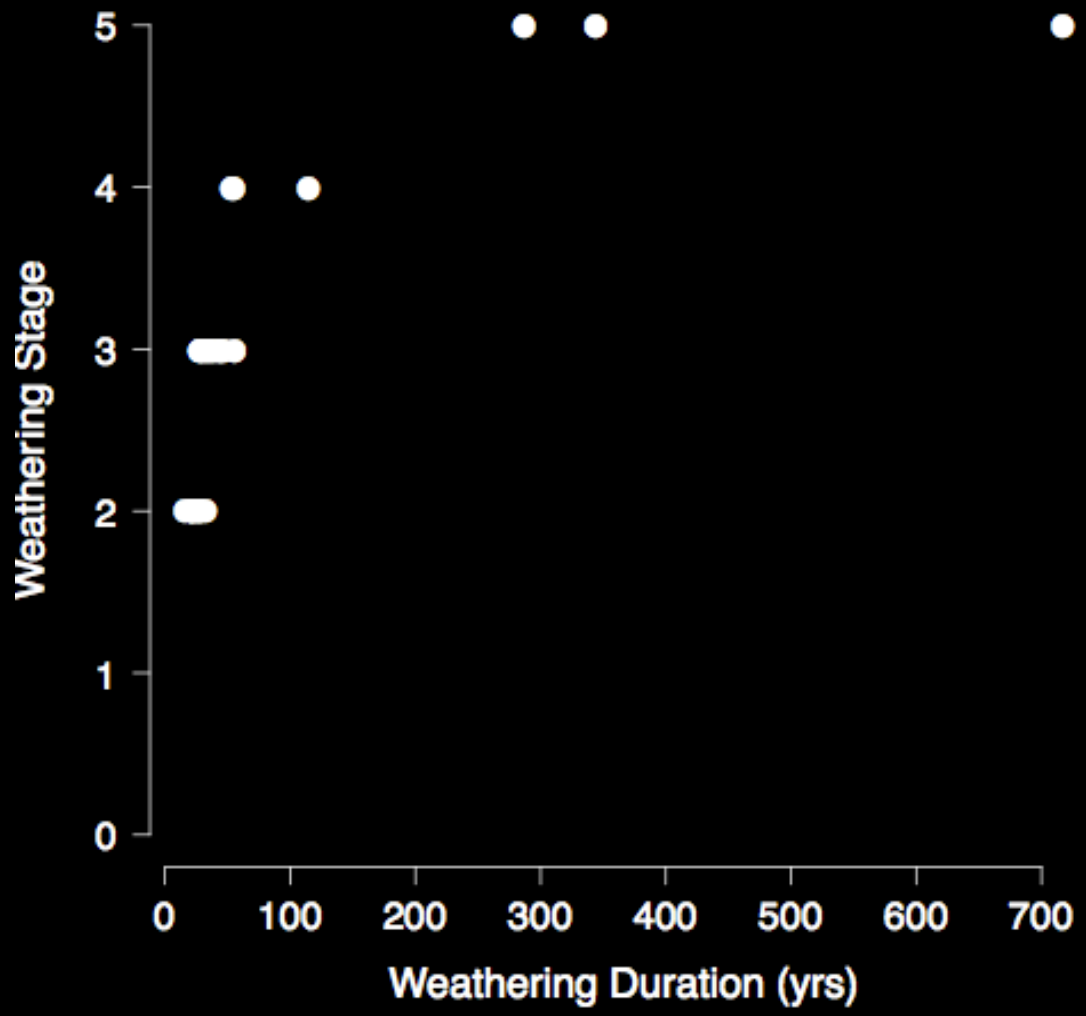
WS Calibration

AMS ^{14}C-dated 39 antlers

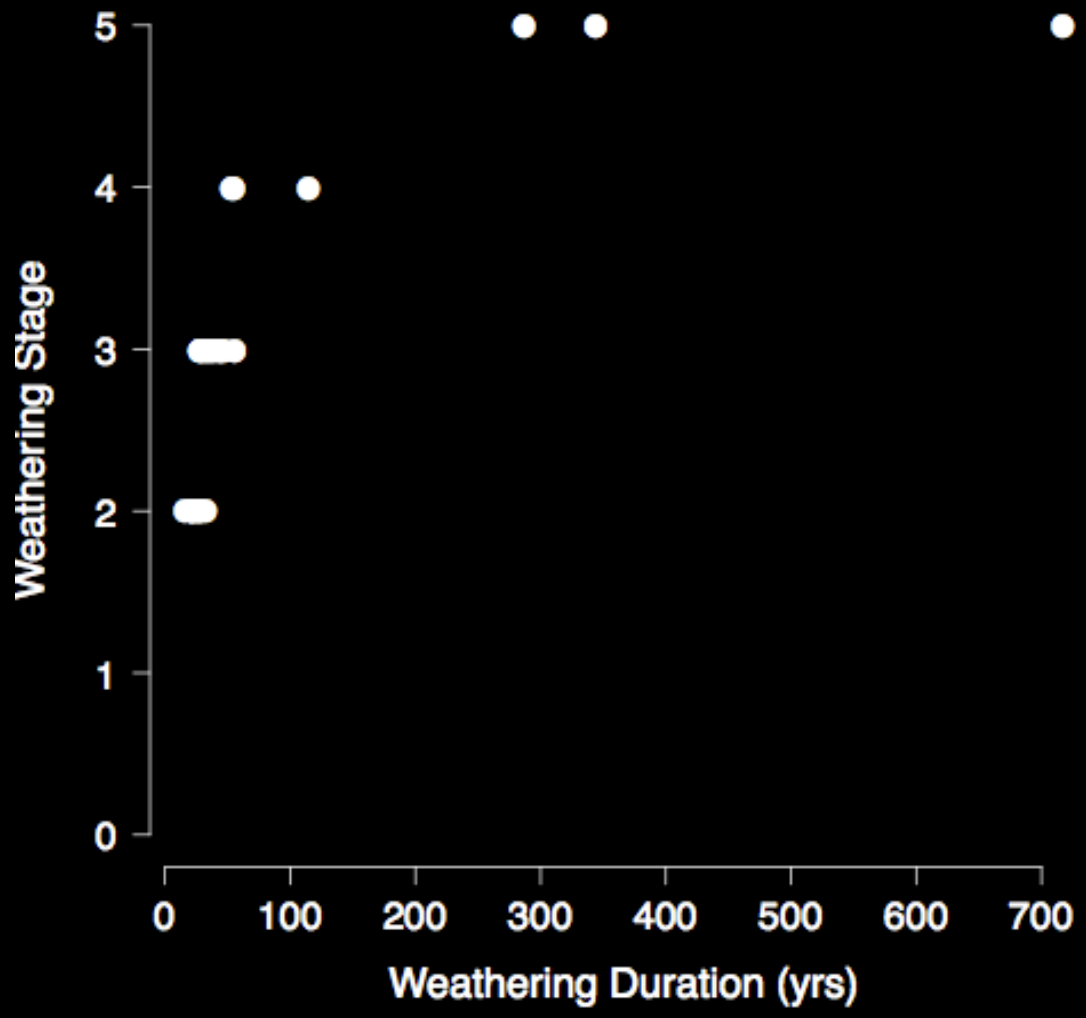
	n
WS 2	18
WS 3	15
WS 4	3
WS 5	3



WS Calibration

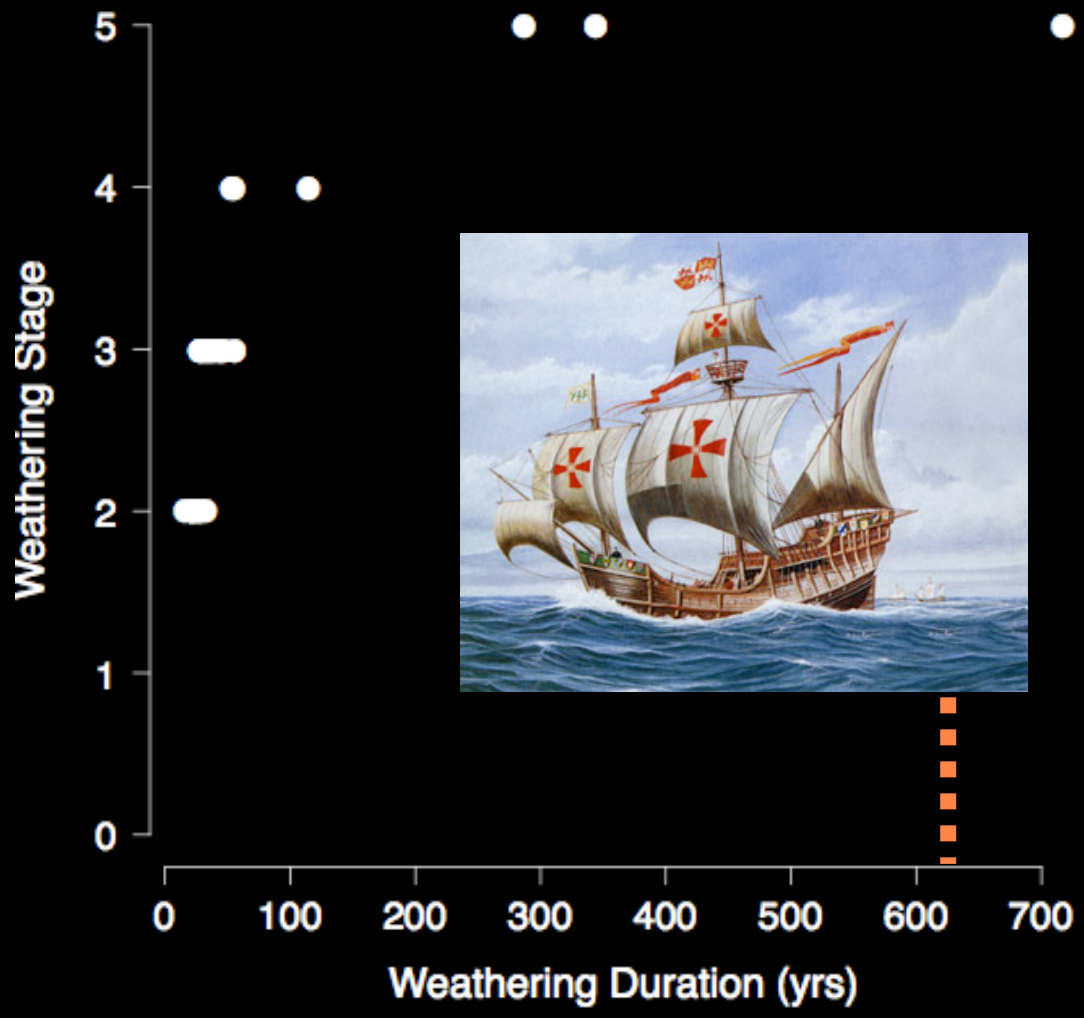


WS Calibration



Max. bone survival
over 700 years!

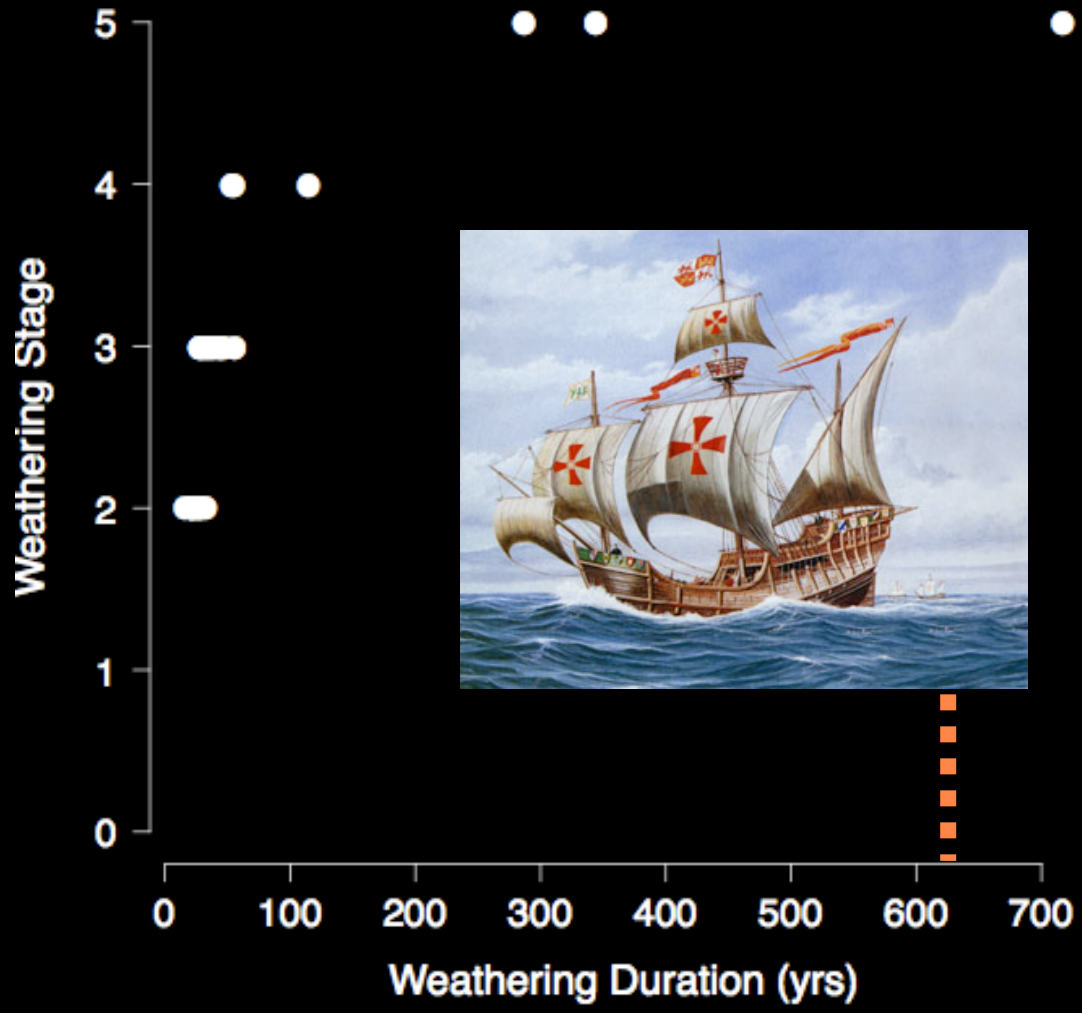
WS Calibration



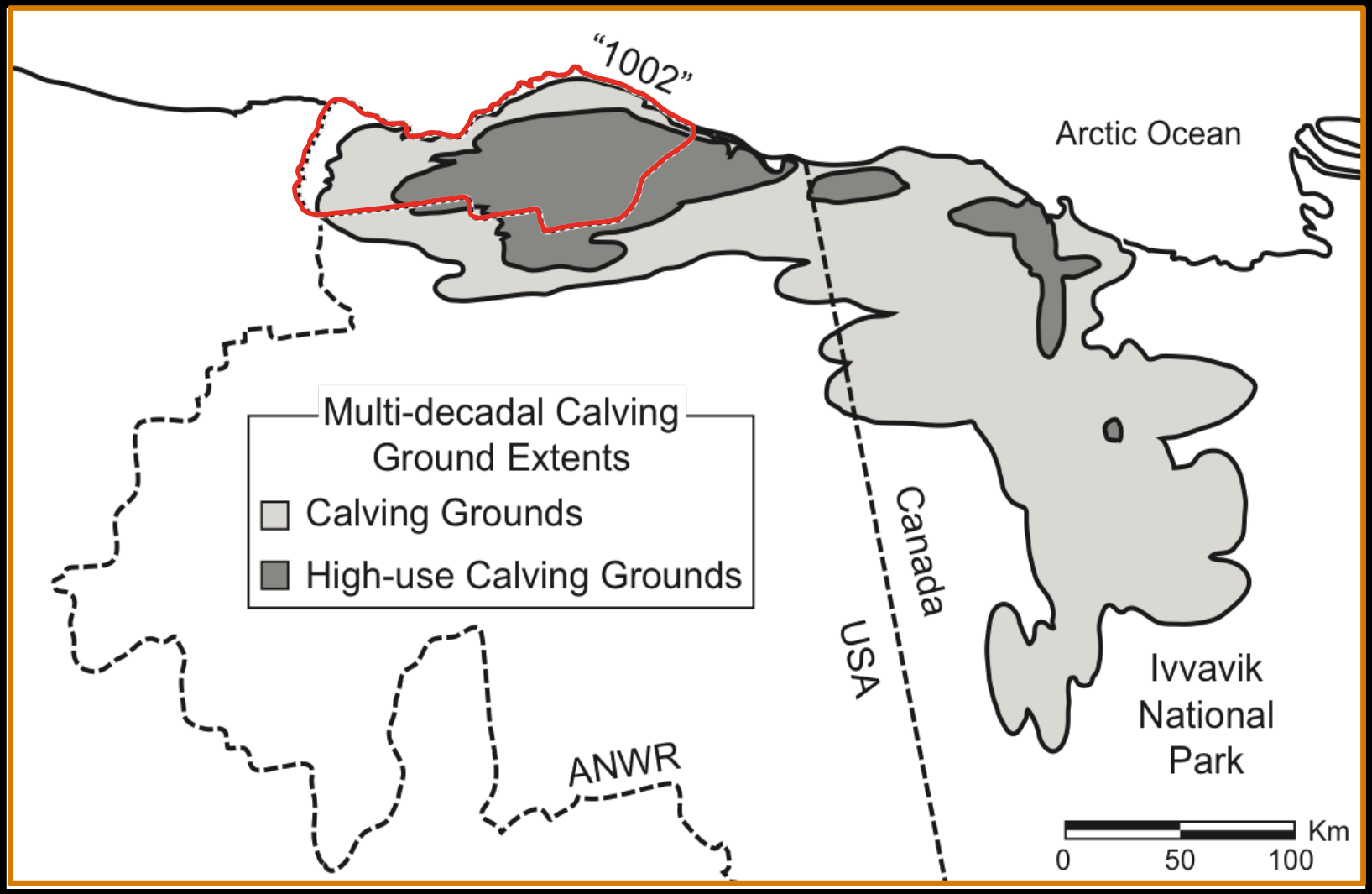
Max. bone survival
over 700 years!

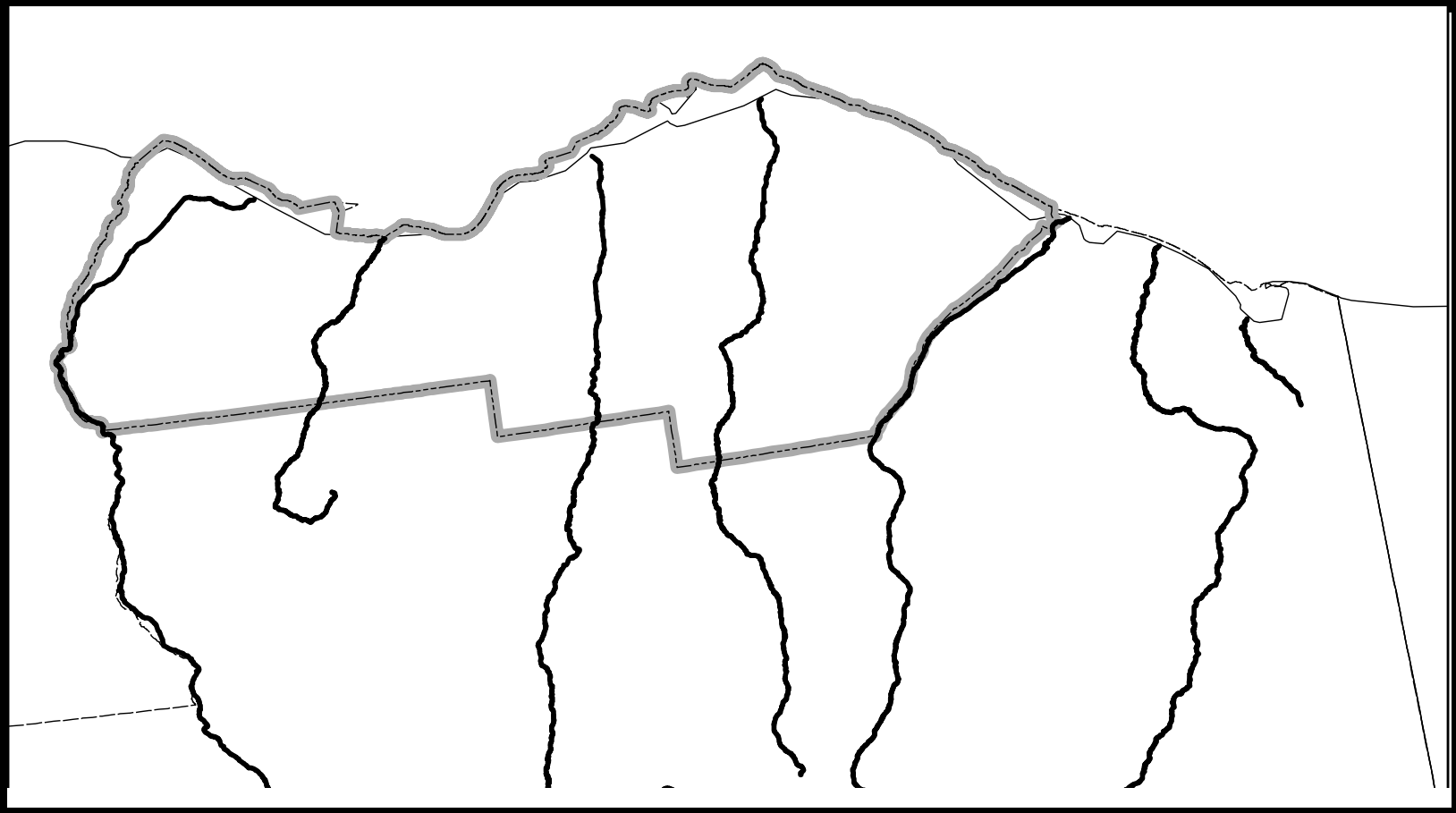
WS Calibration

~ 40% of antlers are pre-aerial survey (~ WS3 and older)

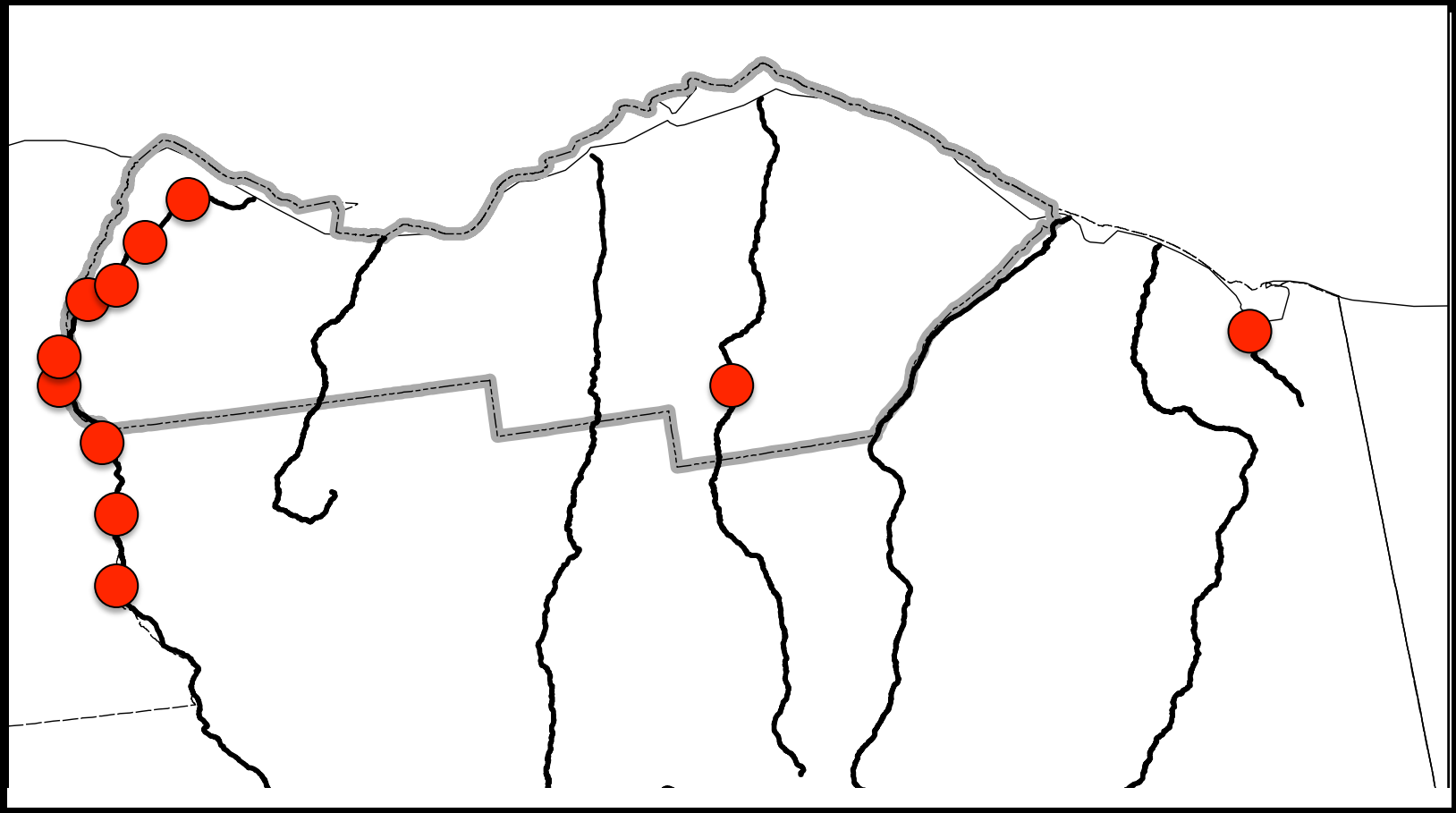


Max. bone survival over 700 years!

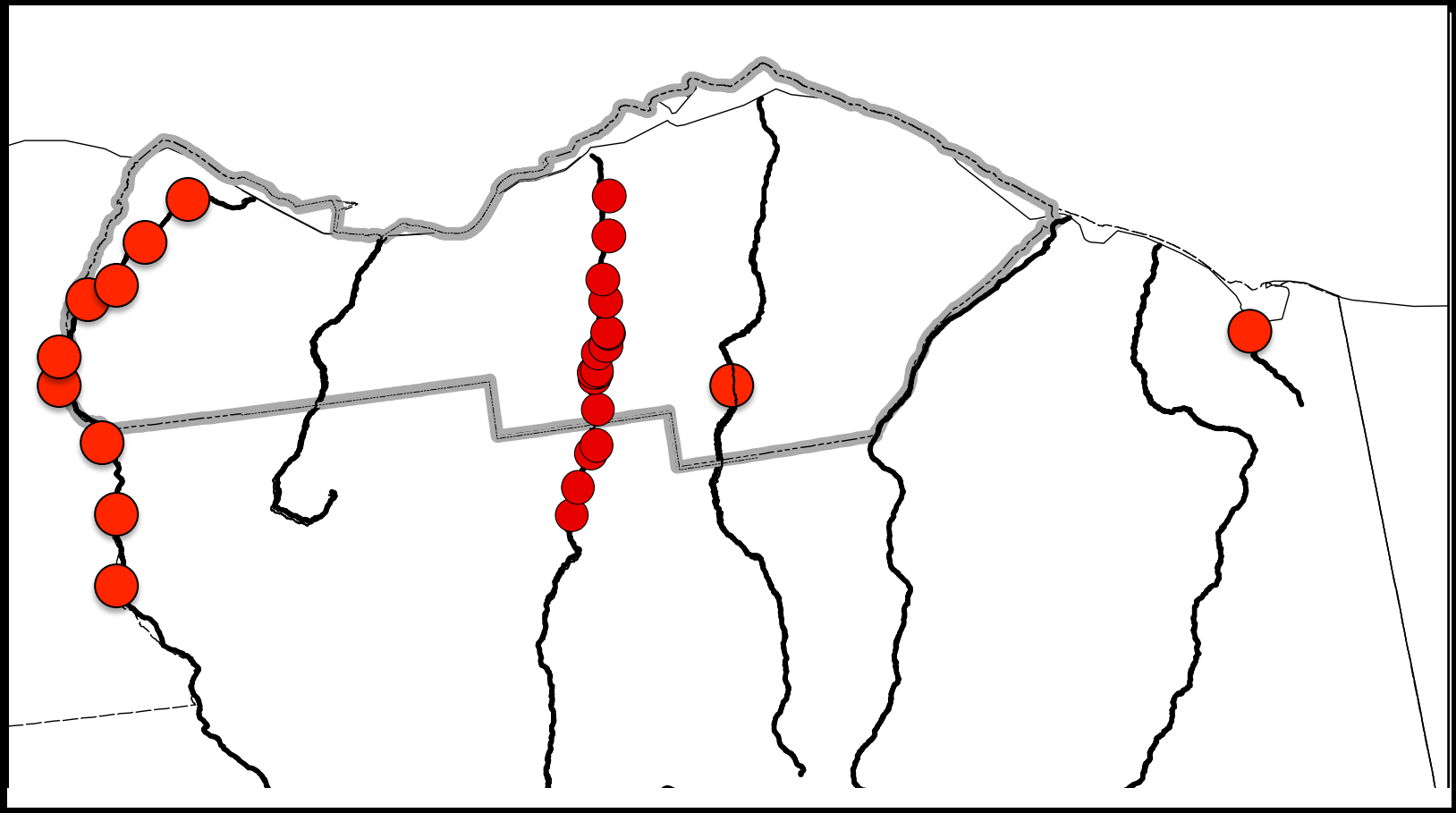

"1002"
Arctic Ocean
Multi-decadal Calving Ground Extents
Calving Grounds
High-use Calving Grounds
Canada
USA
Ivvavik National Park
ANWR
Km
0
50
100



2014 Survey of Hulahula River



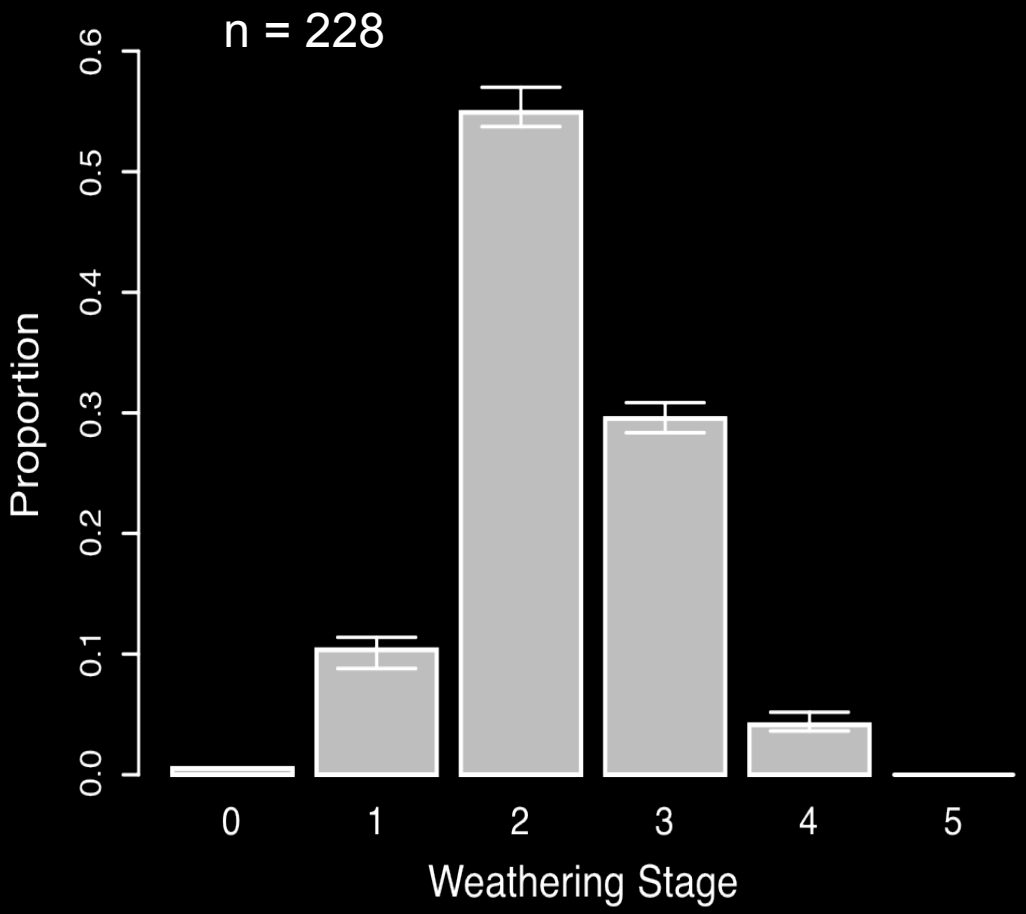
2014 Survey of Hulahula River



17 Bone surveys

Test for changes in concentration of modern vs. historical antler accumulations

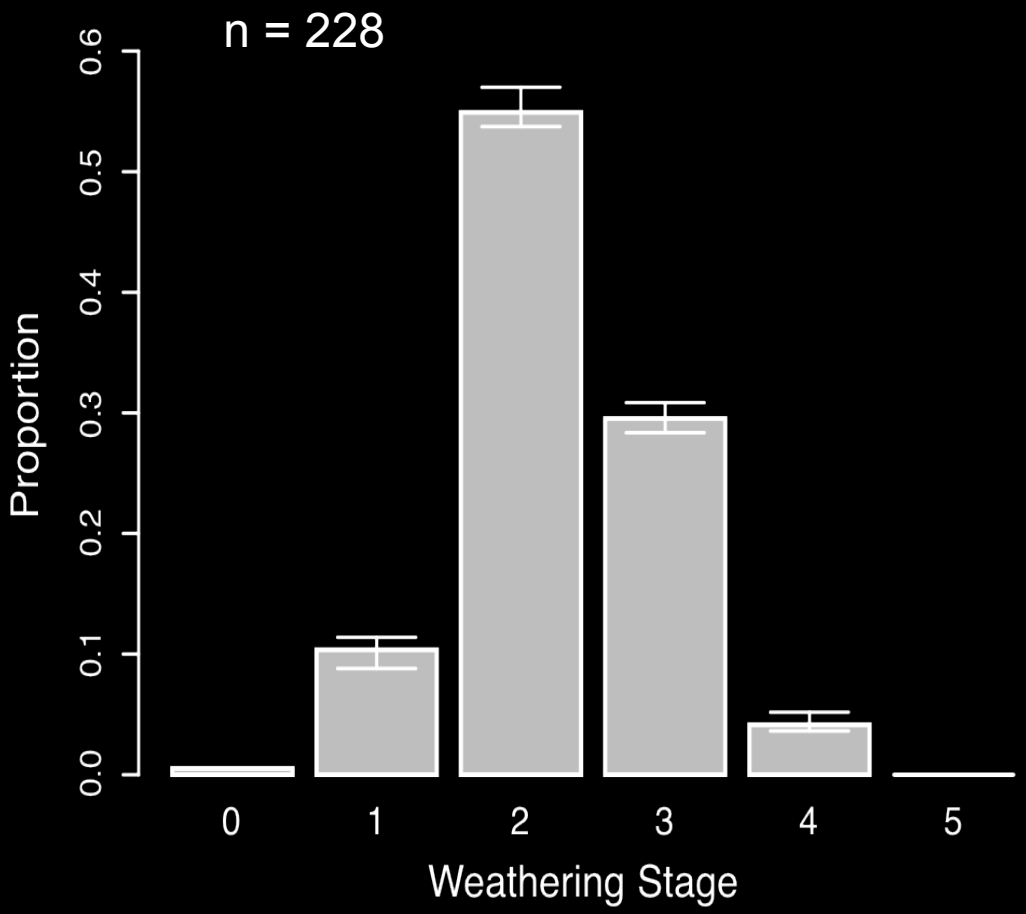
Assessing modern vs. historical calving activity



Assessing modern vs. historical calving activity

Compare relative concentrations (“abundances”) of historical vs. modern antler input for each site

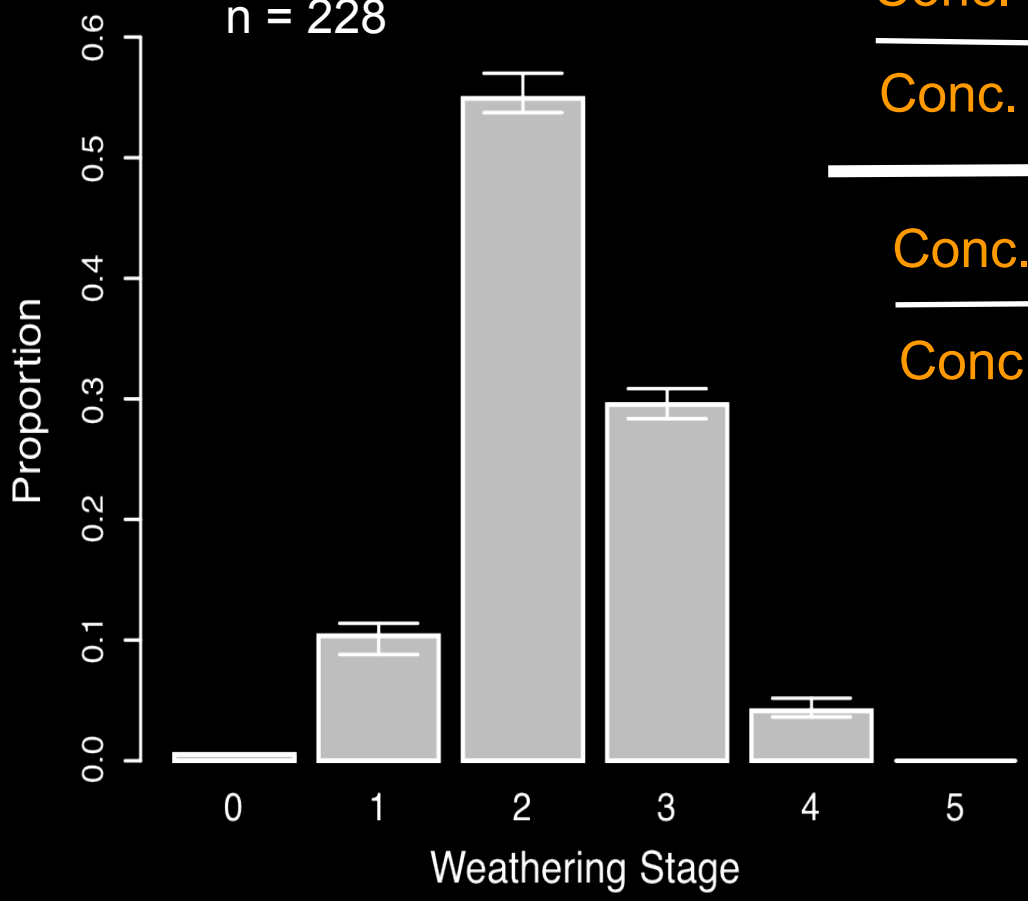
(Independently standardized for each portion of the dataset)



Assessing modern vs. historical calving activity

Compare relative concentrations (“abundances”) of historical vs. modern antler input for each site

(Independently standardized for each portion of the dataset)



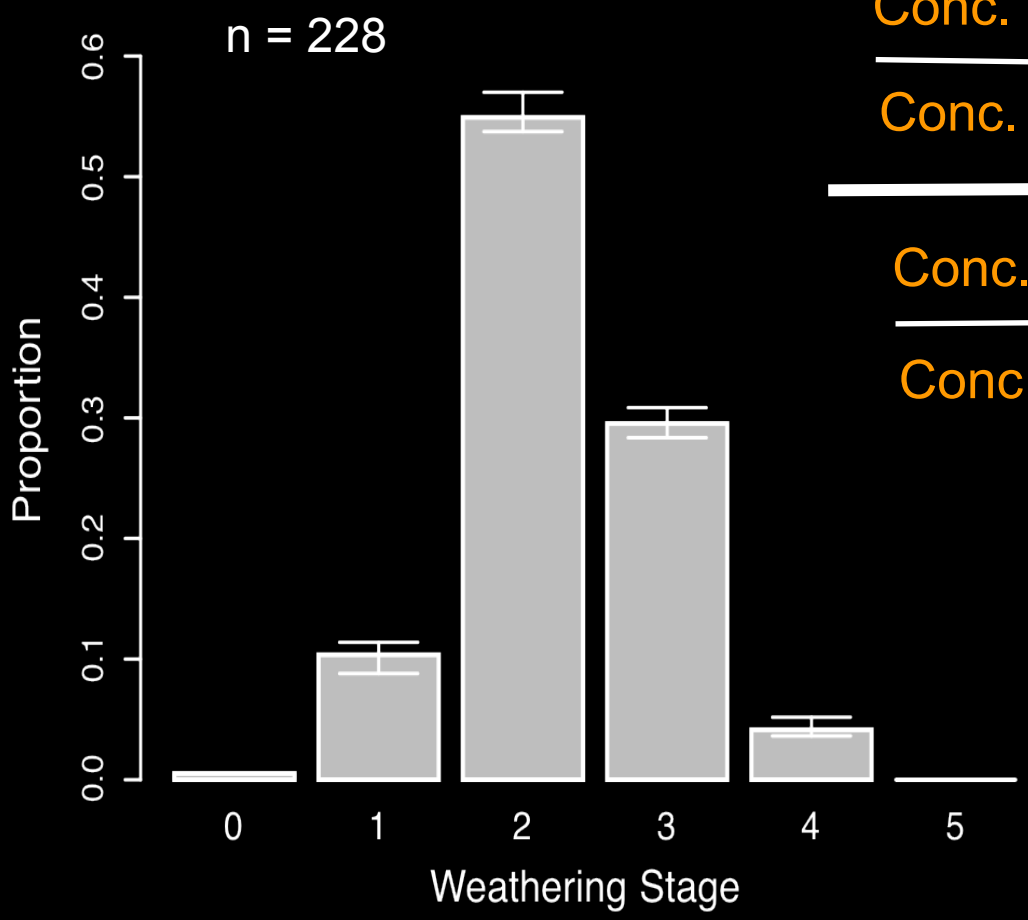
$$\frac{\dfrac{\text{Conc. (Historical)}_{\text{Site}}}{\text{Conc. (Historical)}_{\text{Total}}}}{\dfrac{\text{Conc. (Modern)}_{\text{Site}}}{\text{Conc. (Modern)}_{\text{Total}}}}$$

Limited to surveys
> 0.01 km^2

Assessing modern vs. historical calving activity

Compare relative concentrations (“abundances”) of historical vs. modern antler input for each site

(Independently standardized for each portion of the dataset)

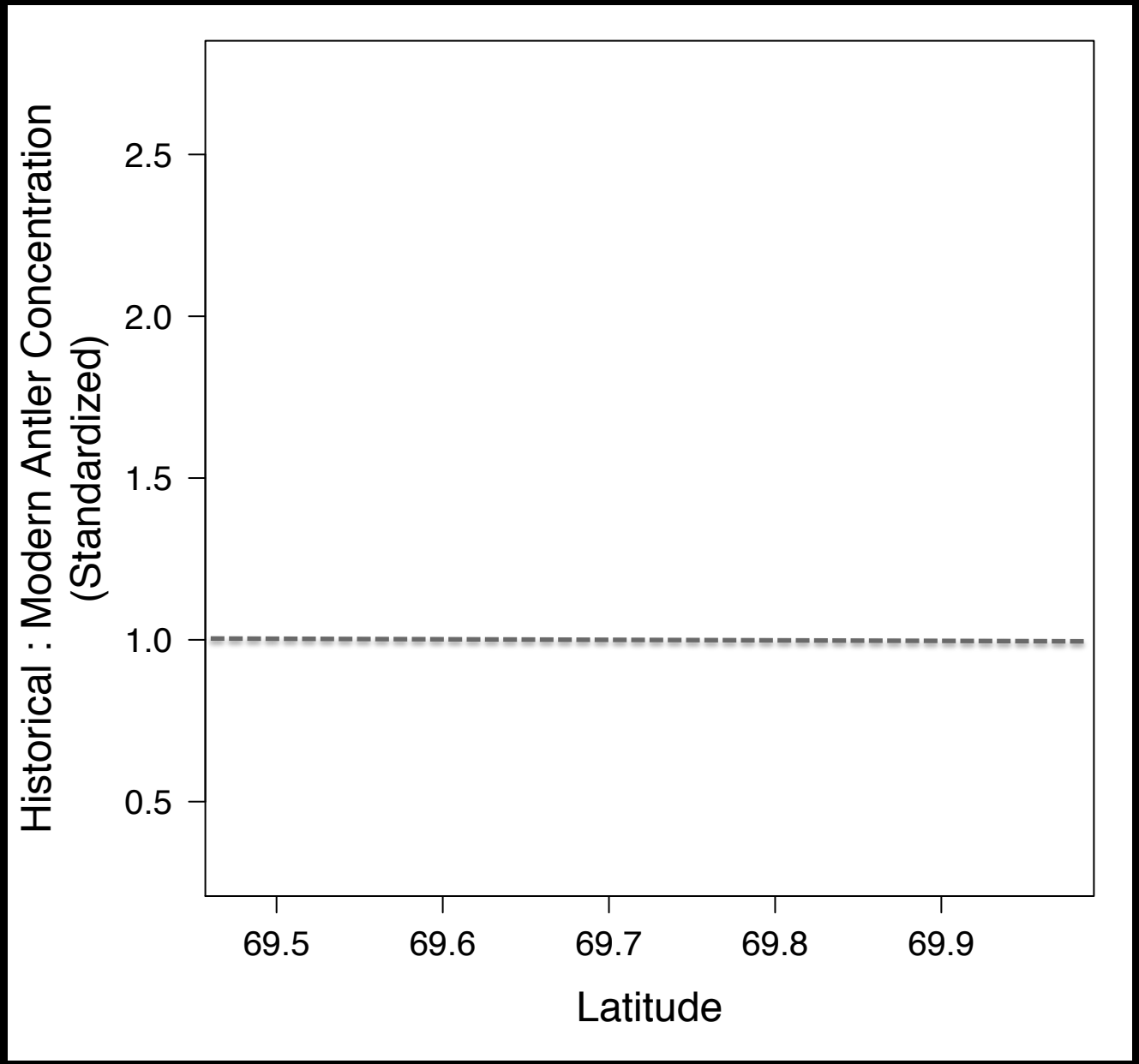


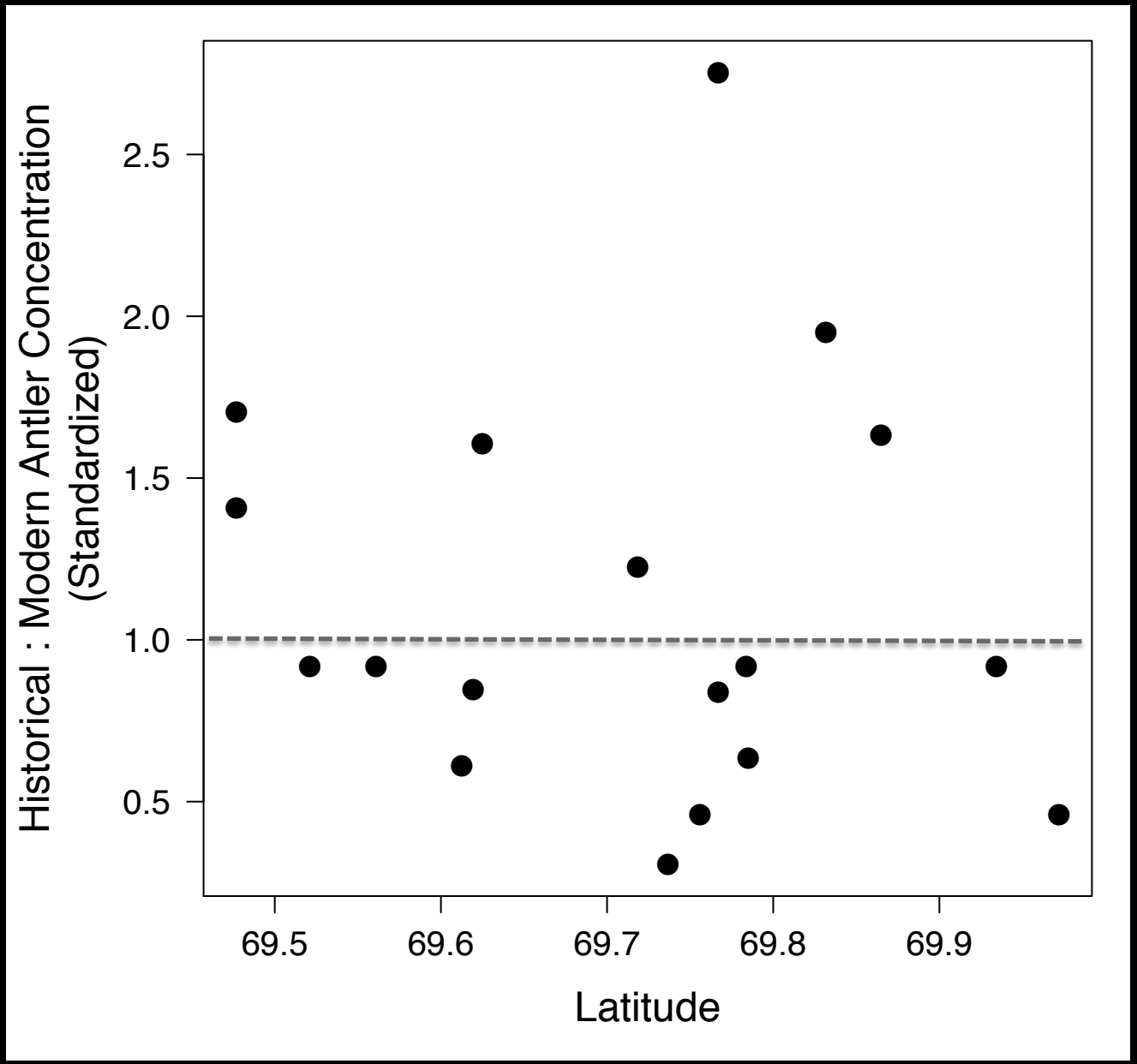
$$\frac{\dfrac{\text{Conc. (Historical)}_{\text{Site}}}{\text{Conc. (Historical)}_{\text{Total}}}}{\dfrac{\text{Conc. (Modern)}_{\text{Site}}}{\text{Conc. (Modern)}_{\text{Total}}}}$$

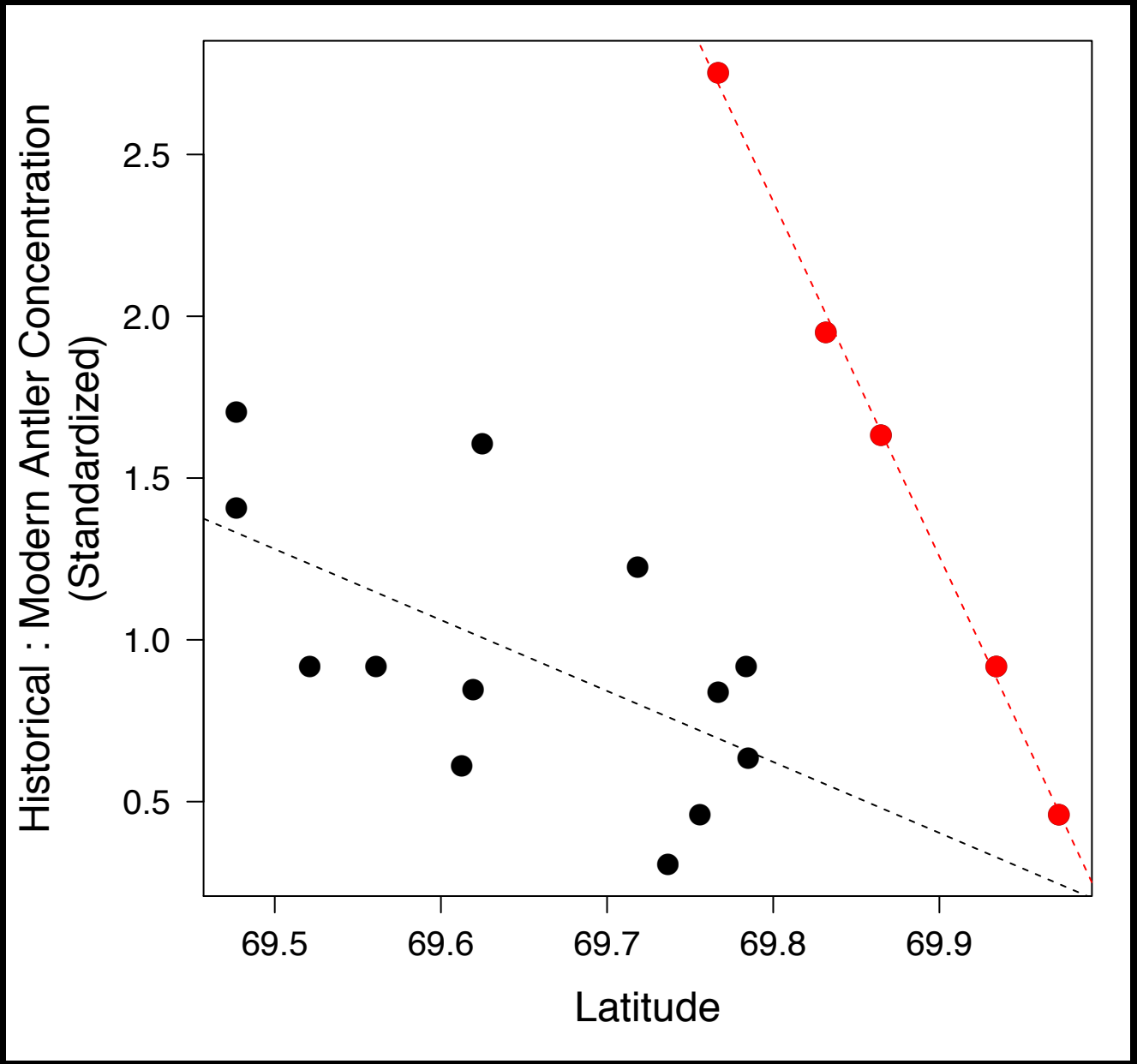
If 1.0:

Modern calving activity = Historical calving activity

Limited to surveys > 0.01 km^2


Historical : Modern Antler Concentration
(Standardized)
2.5
2.0
1.5
1.0
0.5
69.5
69.6
69.7
69.8
69.9
Latitude


Historical : Modern Antler Concentration
(Standardized)
2.5
2.0
1.5
1.0
0.5
69.5
69.6
69.7
69.8
69.9
Latitude



Gradient (near coast!) suggesting historical calving was more focused to the south, than currently observed.

Stable isotope analyses ($\delta^{13}C$, $\delta^{18}O$, $\delta^{15}N$, $^{87/86}Sr$)

A. Coleman (U Chicago)

Next steps

Continue bone surveys (into Ivvavik National Park, Canada)

Small mammal analysis (owl pellets) [and birds!]

Increase radiocarbon dating (optical confocal microscopy)

Stable isotope analyses ($\delta^{13}C$, $\delta^{18}O$, $\delta^{15}N$, $^{87/86}Sr$)

Population genetics (N_e cycling)

Integrate with TEK

Bone Decay – Weathering Stages (Behrensmeyer, 1978)

WS 0

WS 1

WS 2

Bone Decay – Weathering Stages

WS 3

WS 4

WS 5

Bone Decay – Weathering Stages

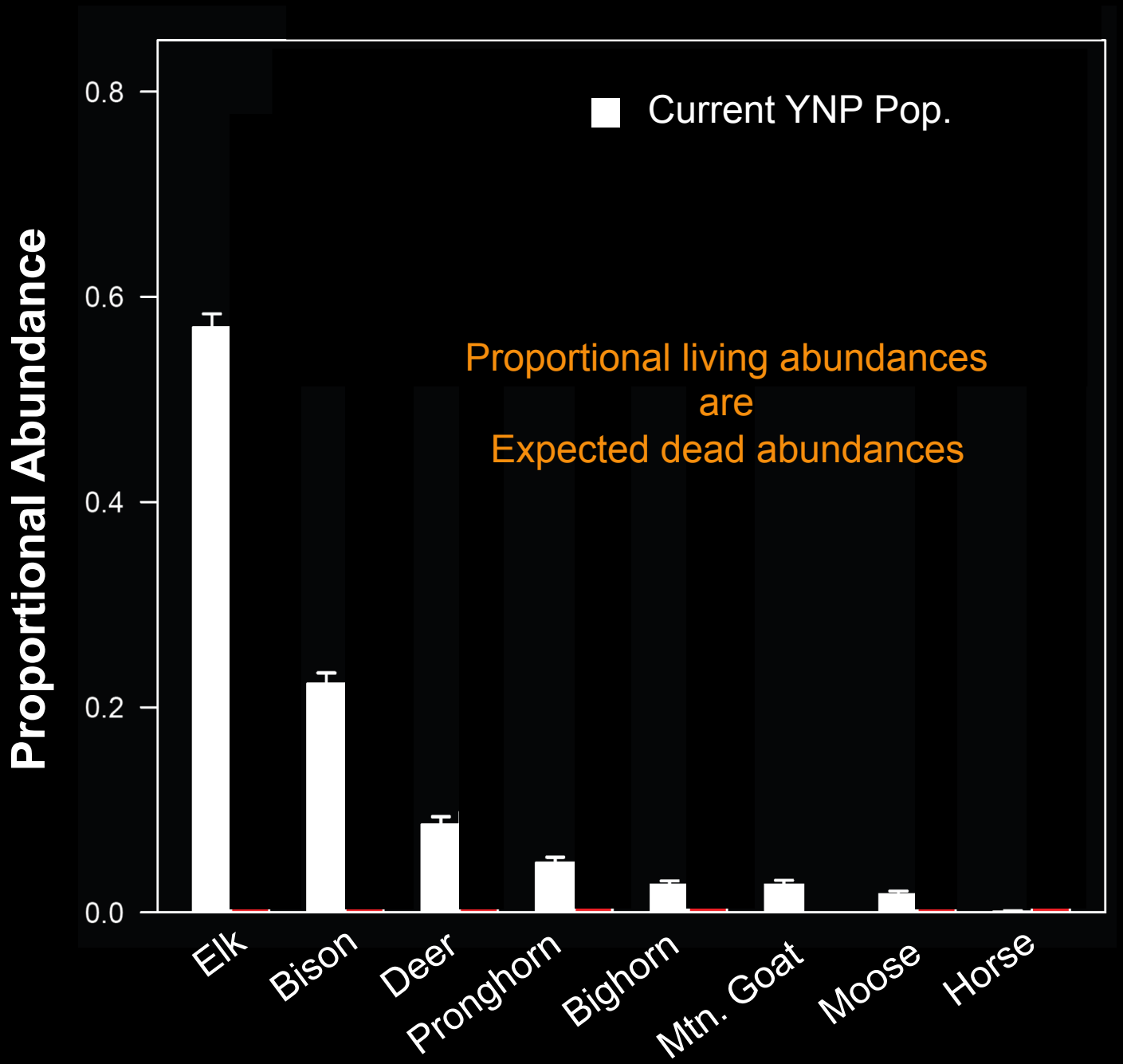
WS 3

How long
is this process
across the arctic?

WS 4

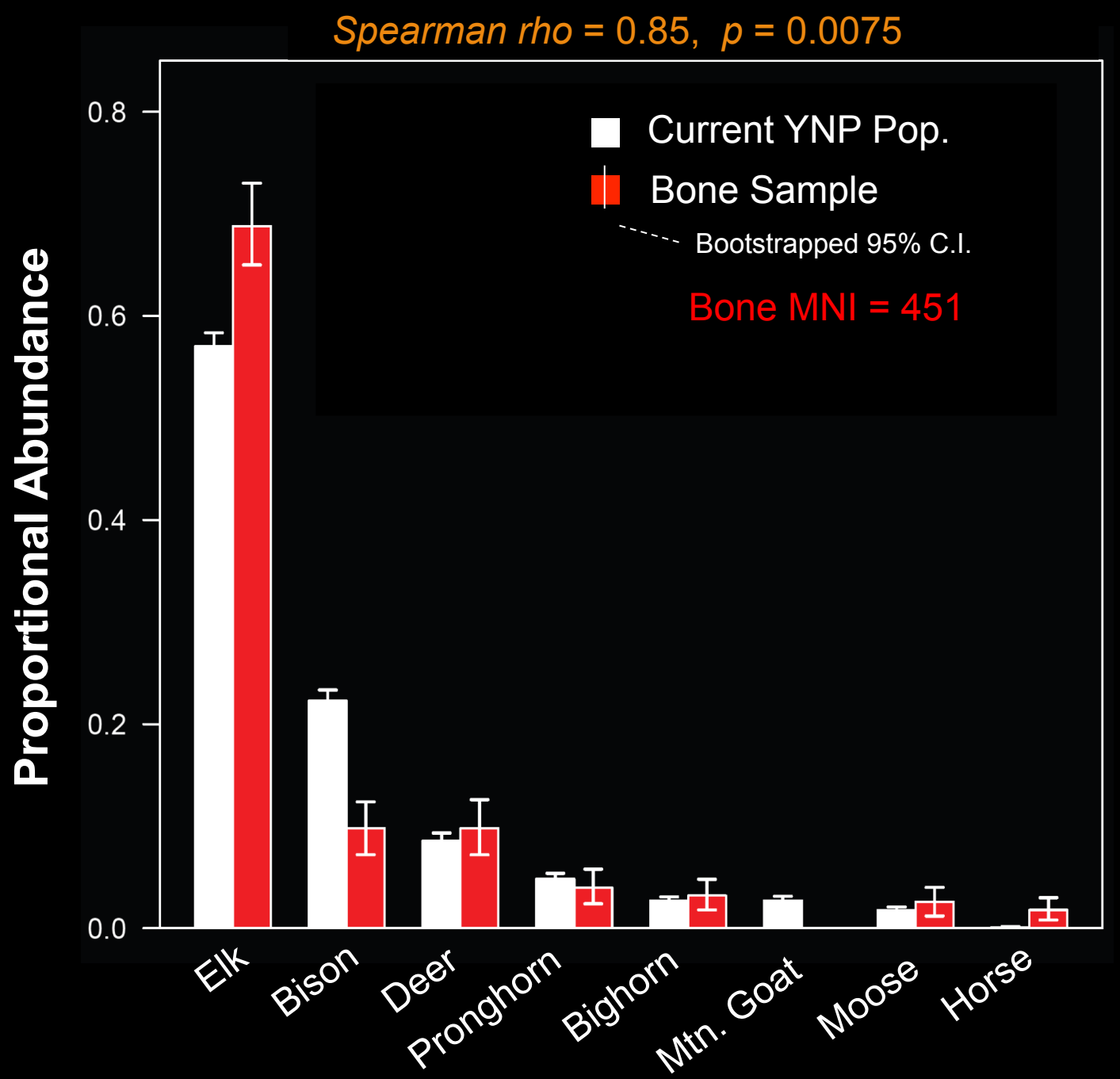
WS 5

Ecological Fidelity (Yellowstone National Park)



(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



Death Assemblage:

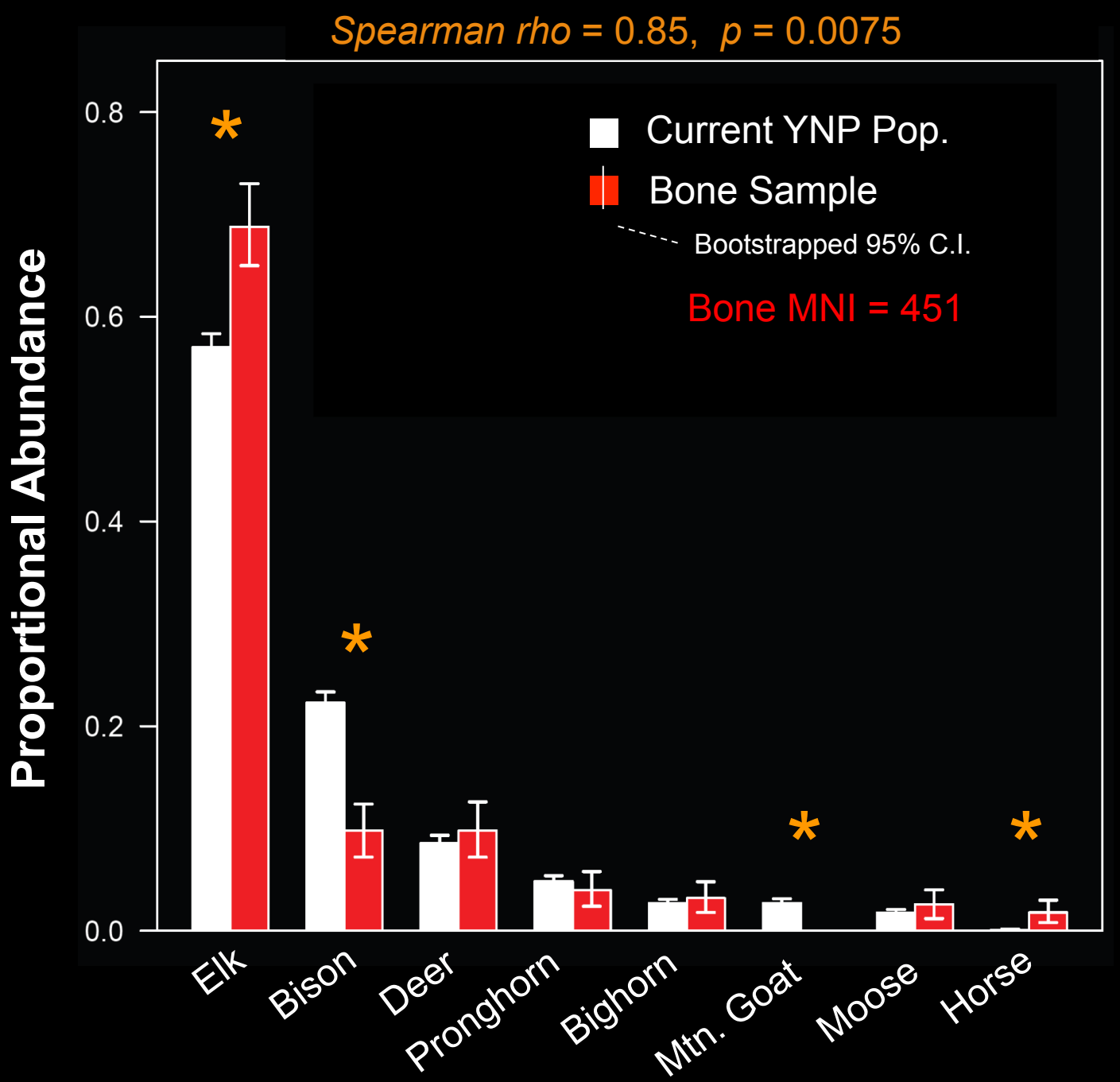
- Recovers Richness & Community Structure

$Evenness\ (PIE)_{live} = 0.51$

$Evenness\ (PIE)_{dead} = 0.68$

(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



Death Assemblage:

- Recovers Richness & Community Structure

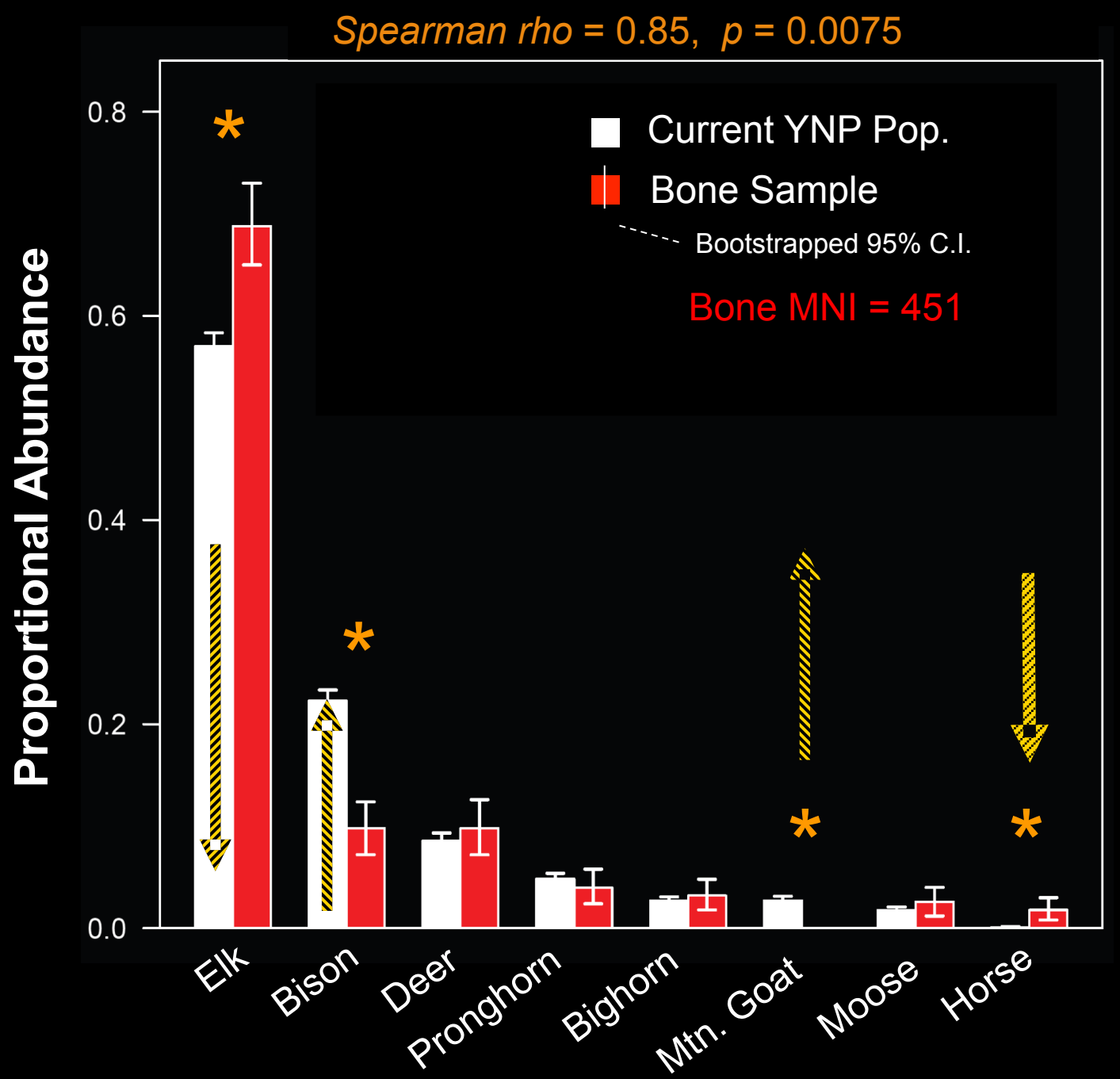
$Evenness\ (PIE)_{live} = 0.51$

$Evenness\ (PIE)_{dead} = 0.68$

* Chi-square p-value << 0.01

(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



Death Assemblage:

- Recovers Richness & Community Structure

Live-Dead:

- Population Changes

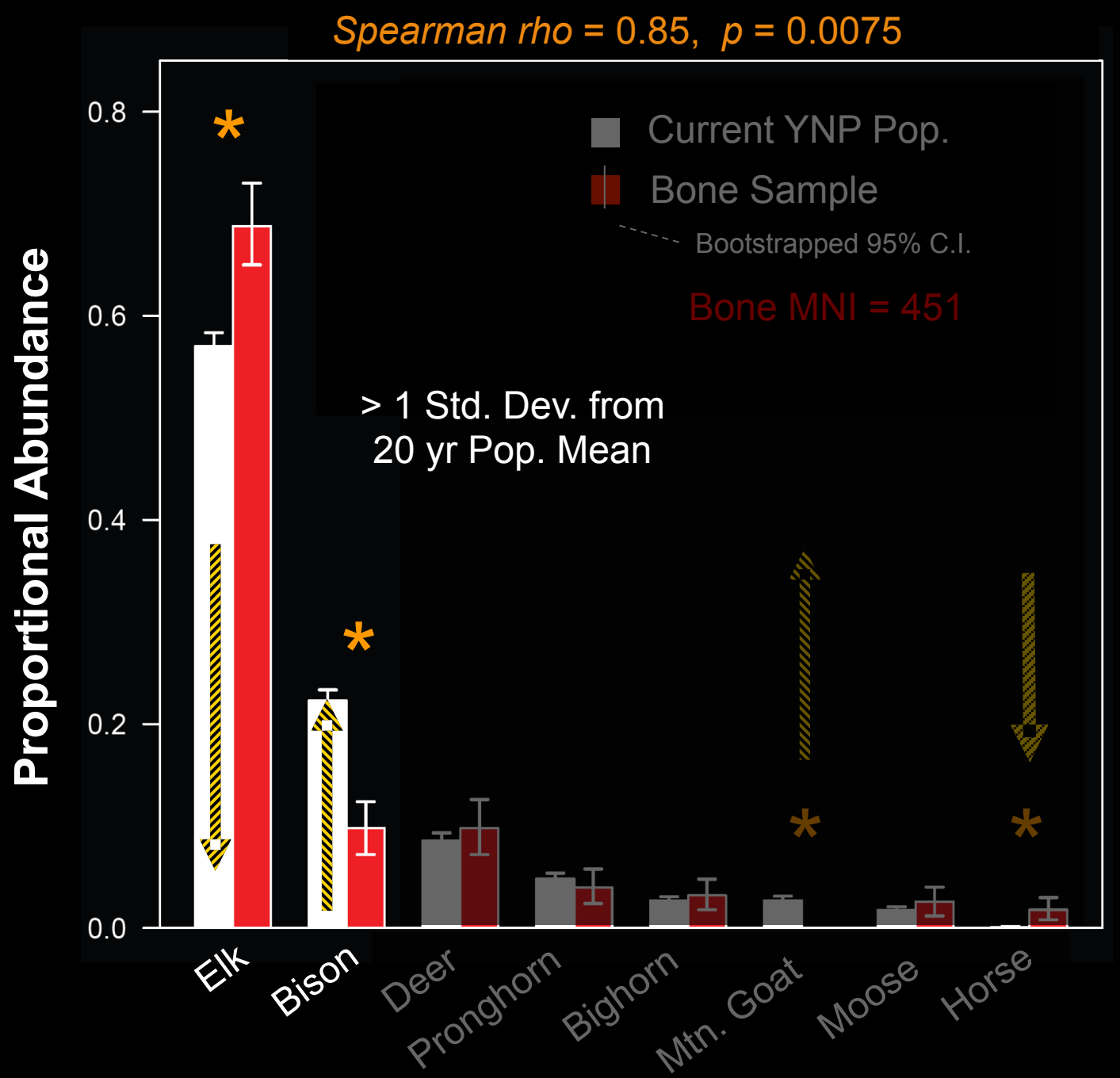
Evenness (PIE)$_{live}$ = *0.51*

Evenness (PIE)$_{dead}$ = *0.68*

* Chi-square p-value << 0.01

(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



(Miller 2011)

Death Assemblage:

- Recovers Richness & Community Structure

Live-Dead:

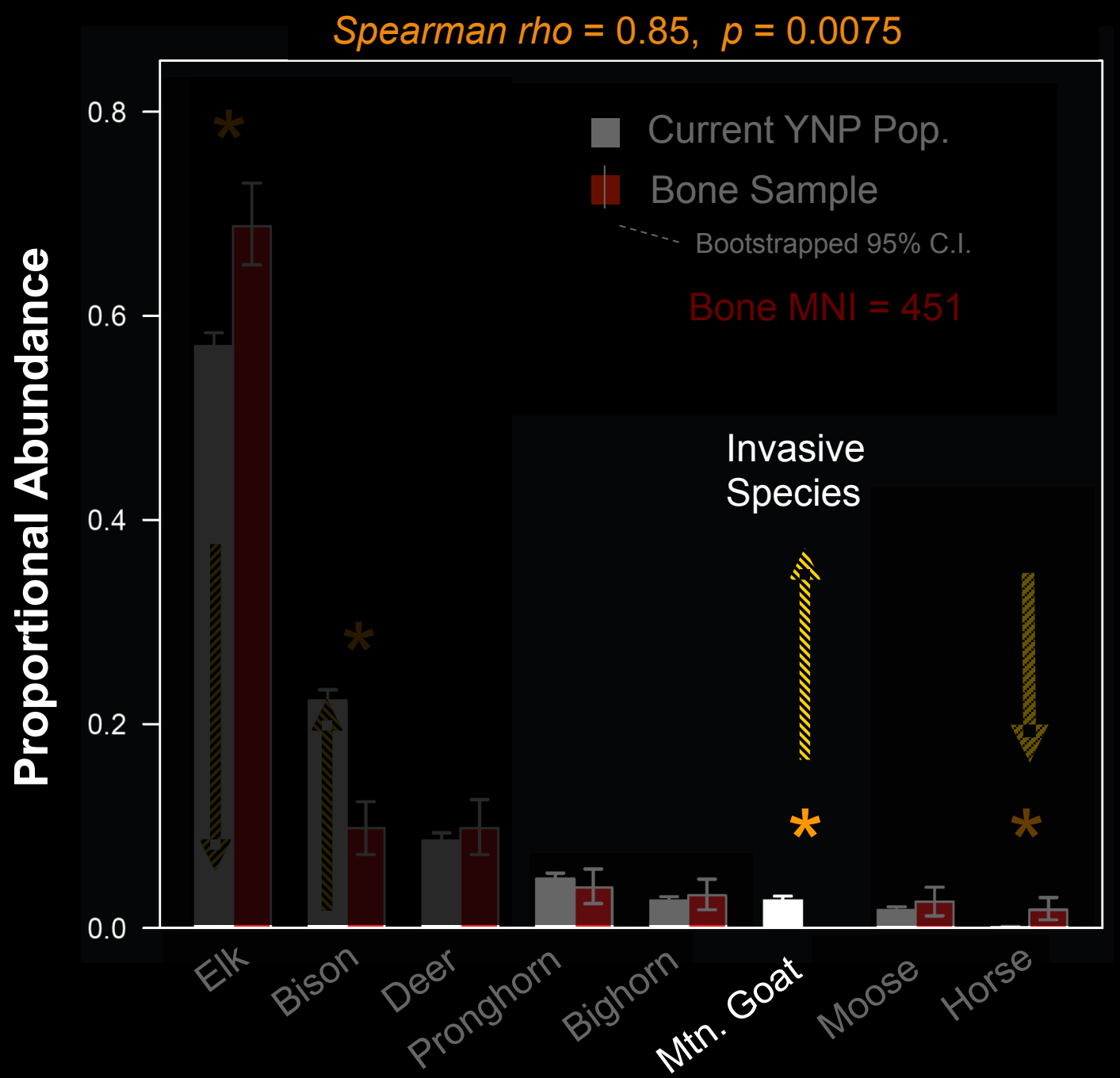
- Population Changes

Evenness (PIE)$_{live}$ = *0.51*

Evenness (PIE)$_{dead}$ = *0.68*

* Chi-square p-value << 0.01

Ecological Fidelity (Yellowstone National Park)



Death Assemblage:

- Recovers Richness & Community Structure

Live-Dead:

- Population Changes
  * Invasive Species

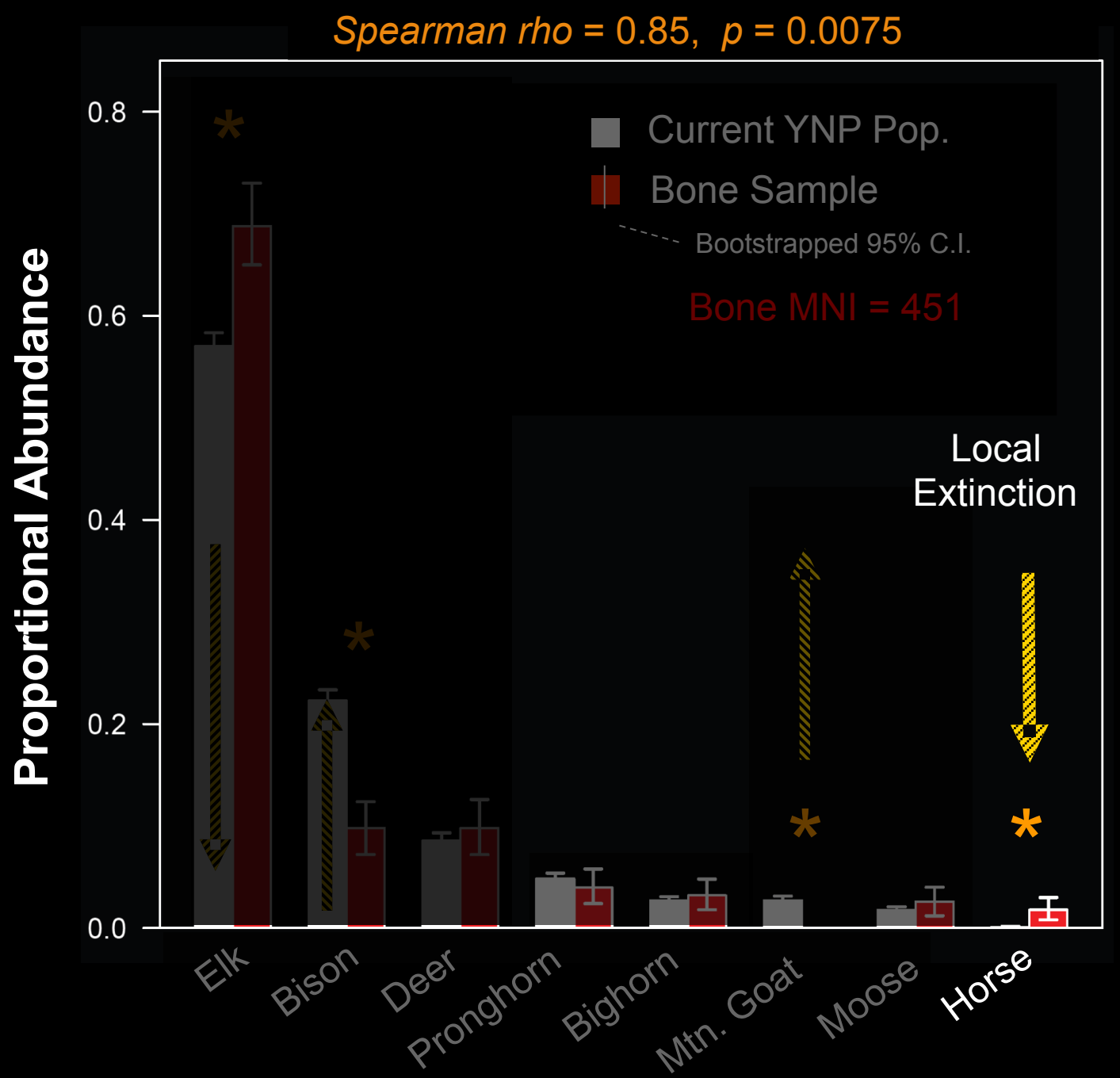
Evenness (PIE)$_{live}$ = *0.51*

Evenness (PIE)$_{dead}$ = *0.68*

* Chi-square p-value << 0.01

(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



Death Assemblage:

- Recovers Richness & Community Structure

Live-Dead:

- Population Changes
  - * Invasive Species
  - * Local Extinctions

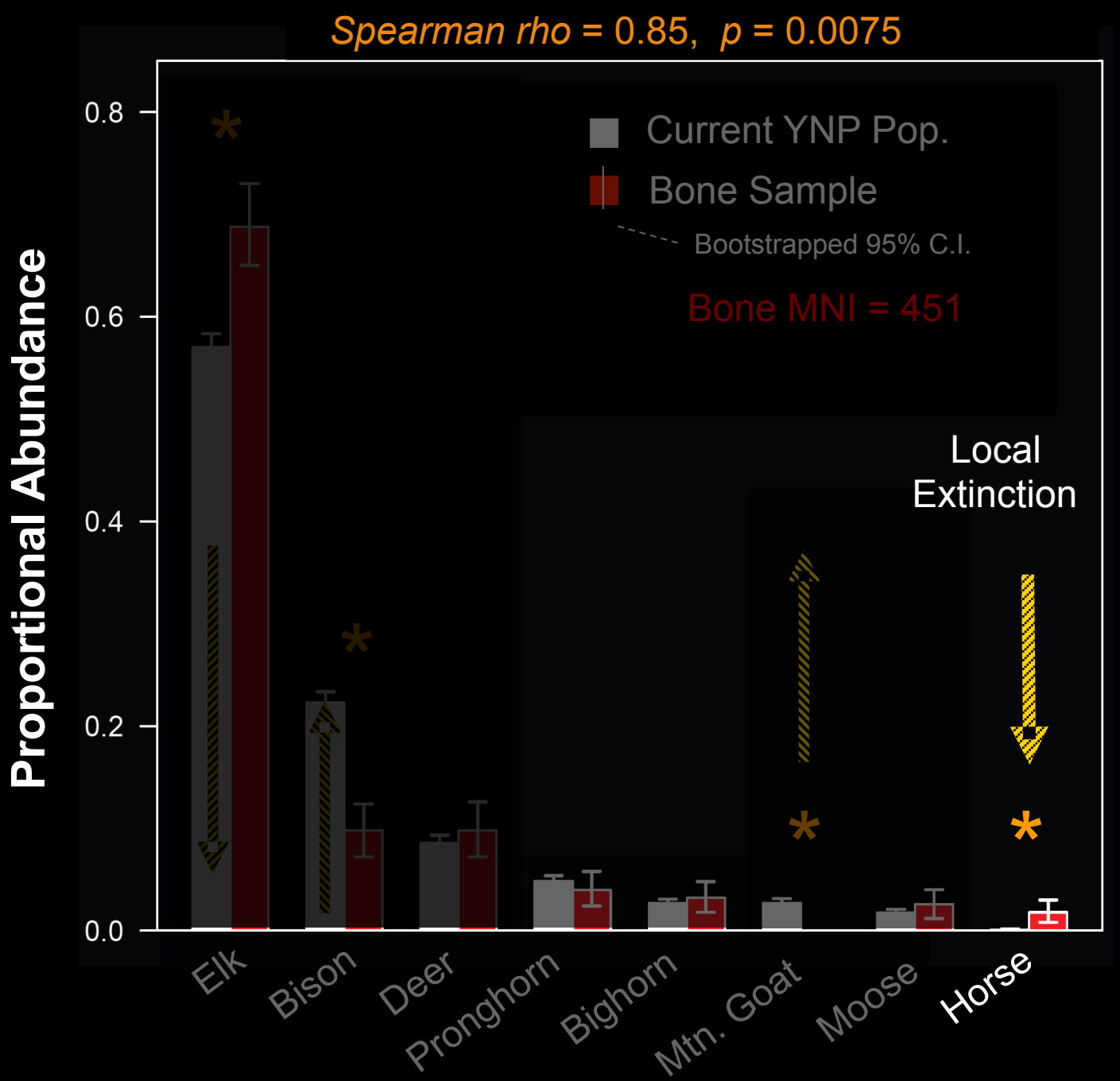
Evenness (PIE)$_{live}$ = *0.51*

Evenness (PIE)$_{dead}$ = *0.68*

* Chi-square p-value << 0.01

(Miller 2011)

Ecological Fidelity (Yellowstone National Park)



(Miller 2011)

Death Assemblage:

- Recovers Richness & Community Structure

Live-Dead:

- Population Changes
  - * Invasive Species
  - * Local Extinctions

AMS Radiocarbon Dating

135 +/- 35 yrs
140 +/- 30 yrs
150 +/- 35 yrs