SOUTHERN ROCKIES
Landscape Conservation Cooperative

CLIMATE & LAND-USE CHANGE IN THE SOUTHERN ROCKIES

Using Satellite Imagery to Inform Mule Deer Conservation

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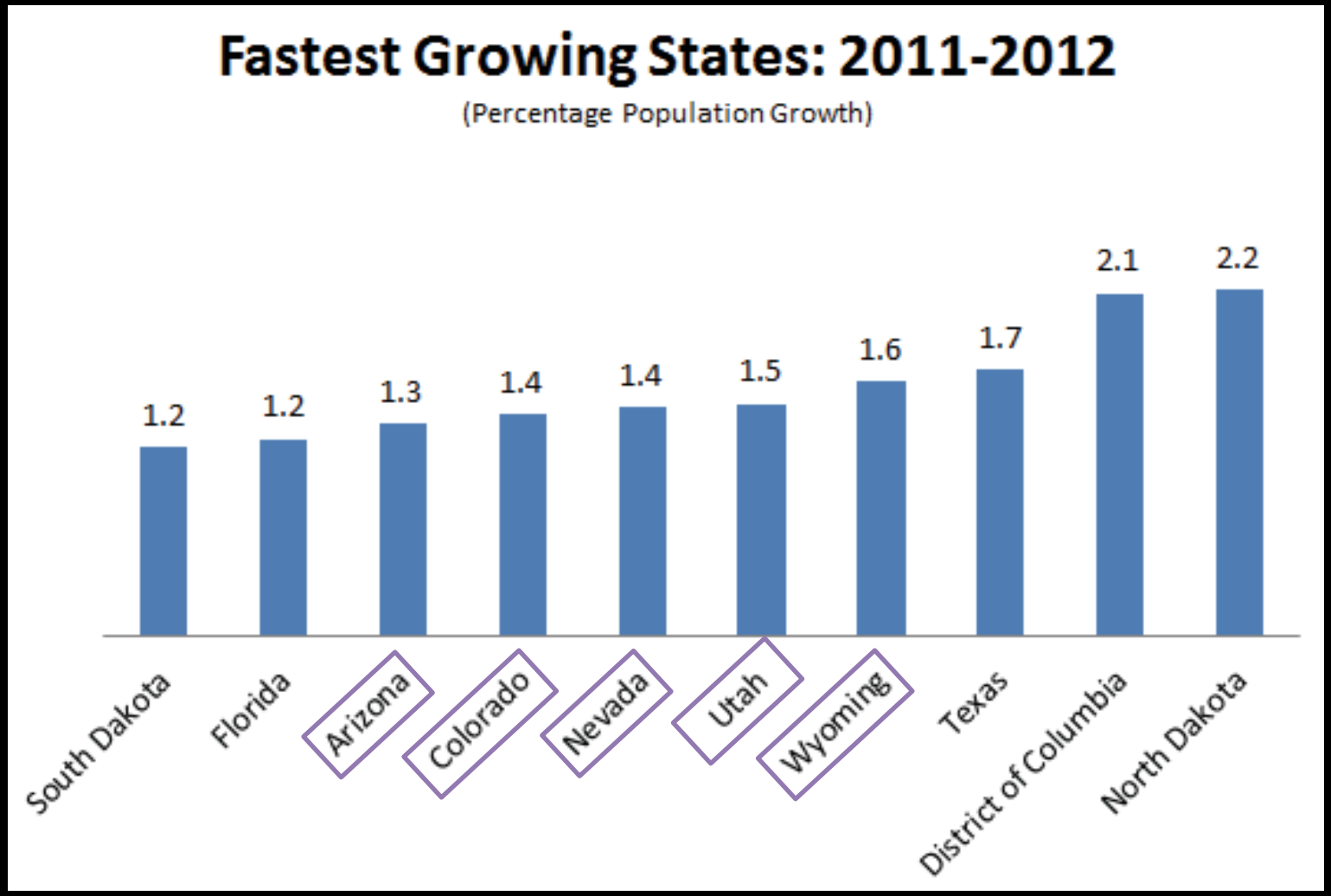
Science Needs Identified by the Mule Deer Focus Group

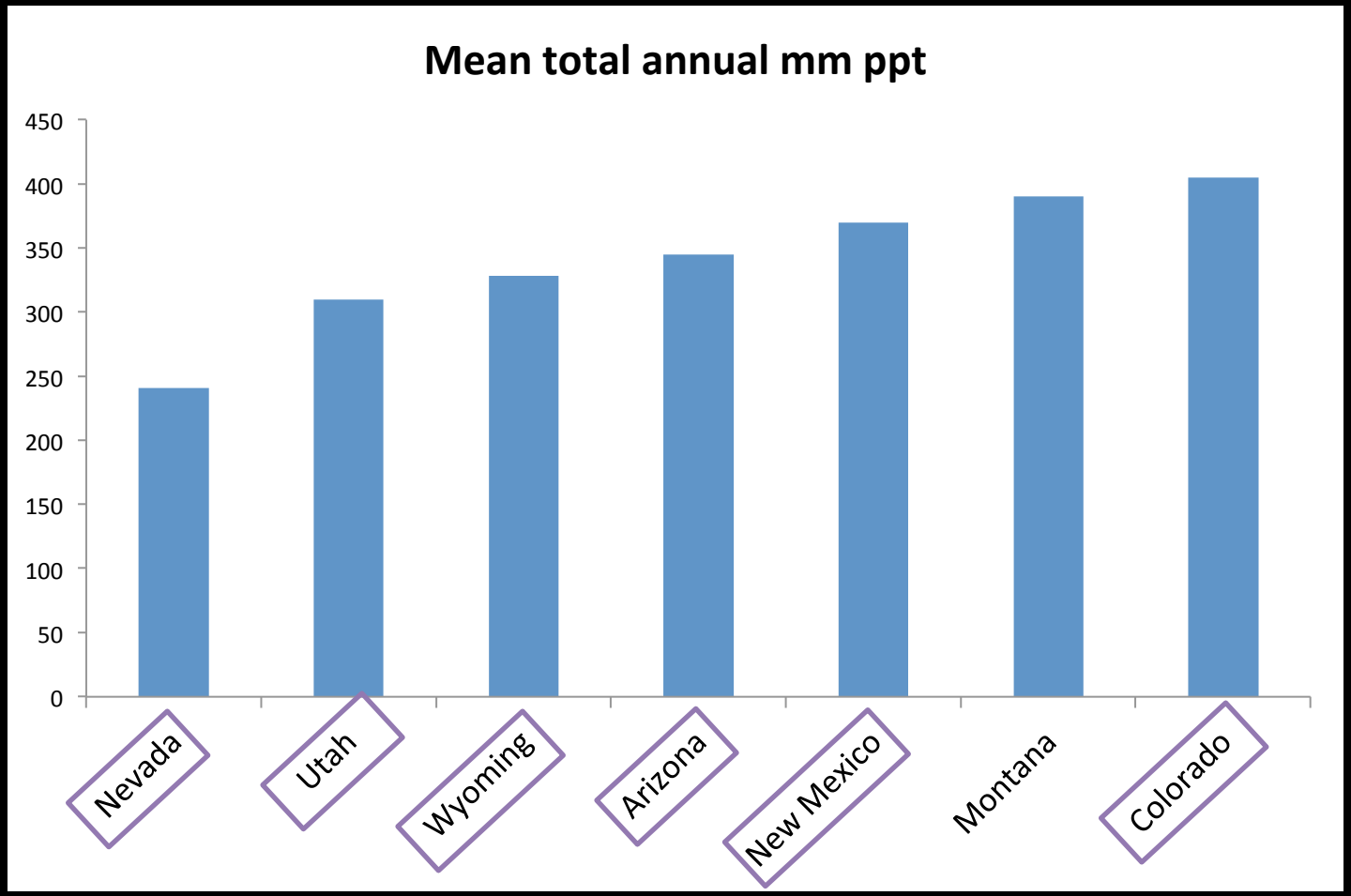
1. Synthesis / delivery of information pertaining to factors limiting mule deer populations;
2. Development of tools that use remotely sensed data to assess mule deer habitat quality;
3. Improve the efficiency, accuracy, and cost effectiveness of mule deer population monitoring

i.e. use of satellite imagery to monitor mule deer habitat and demography

States in the SRLCC are the fastest growing…

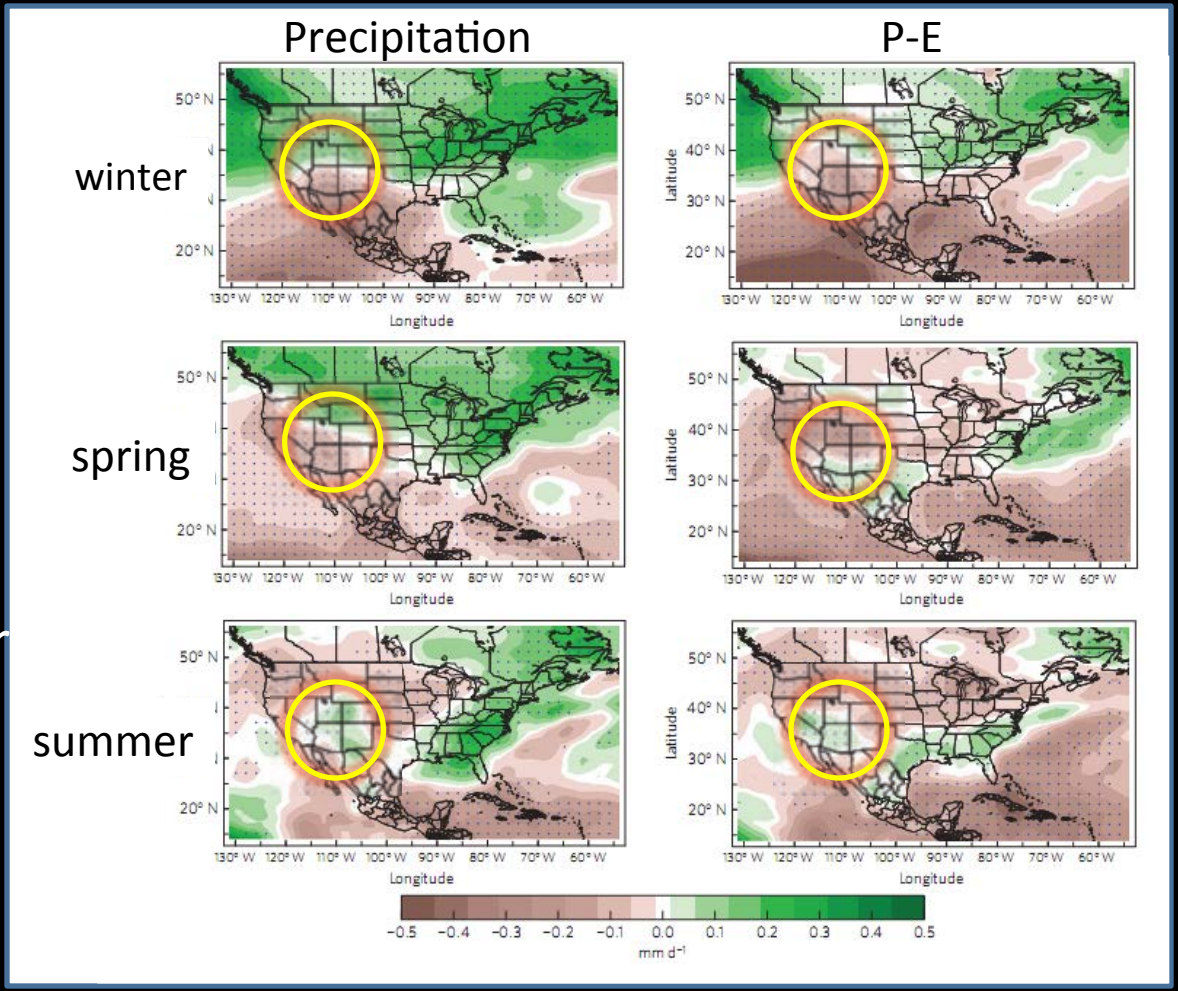


….the driest …


Mean total annual mm ppt
450
400
350
300
250
200
150
100
50
0
Nevada
Utah
Wyoming
Arizona
New Mexico
Montana
Colorado

…and getting drier

- **Temp:** warmer
- **Precip**: less in winter & spring, *more in summer*
- **P-E**: higher in winter & spring, *lower in summer*

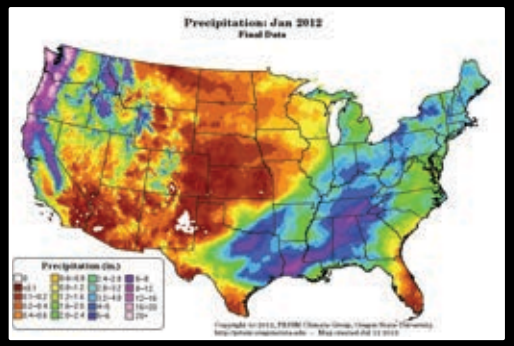


Climate projections: 2021-2040 (Seager et al. 2012)

More people * less water – what does this mean for large, migratory mammals ?

- **Population growth;**
  - urbanization
  - energy, water development
  - weeds, fire, recreation, etc.
  - *> increased fragmentation*

- **Climate projections;**
  - warmer temps * bimodal ppt regime
  - *> increasing aridity*



Why is understanding the drivers of deer abundance so important?

I. Ungulate abundance a central concern for ***ALL WESTERN WILDLIFE AGENCIES***

II. Economic impacts

- Hunting, highways, agriculture

III. Ecological impacts

- Biodiversity (aspen, predator control)

IV. Social conflicts:

- "More deer!" vs. "Too many deer [*in my backyard*]!"

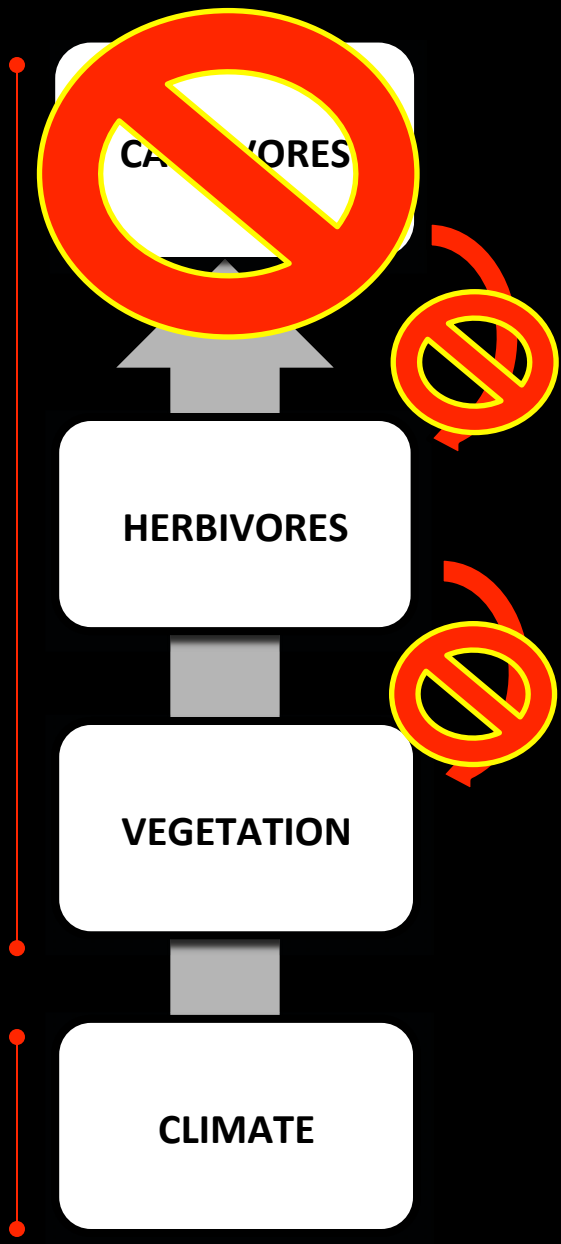
Research Concept:

Predator Density & Distribution

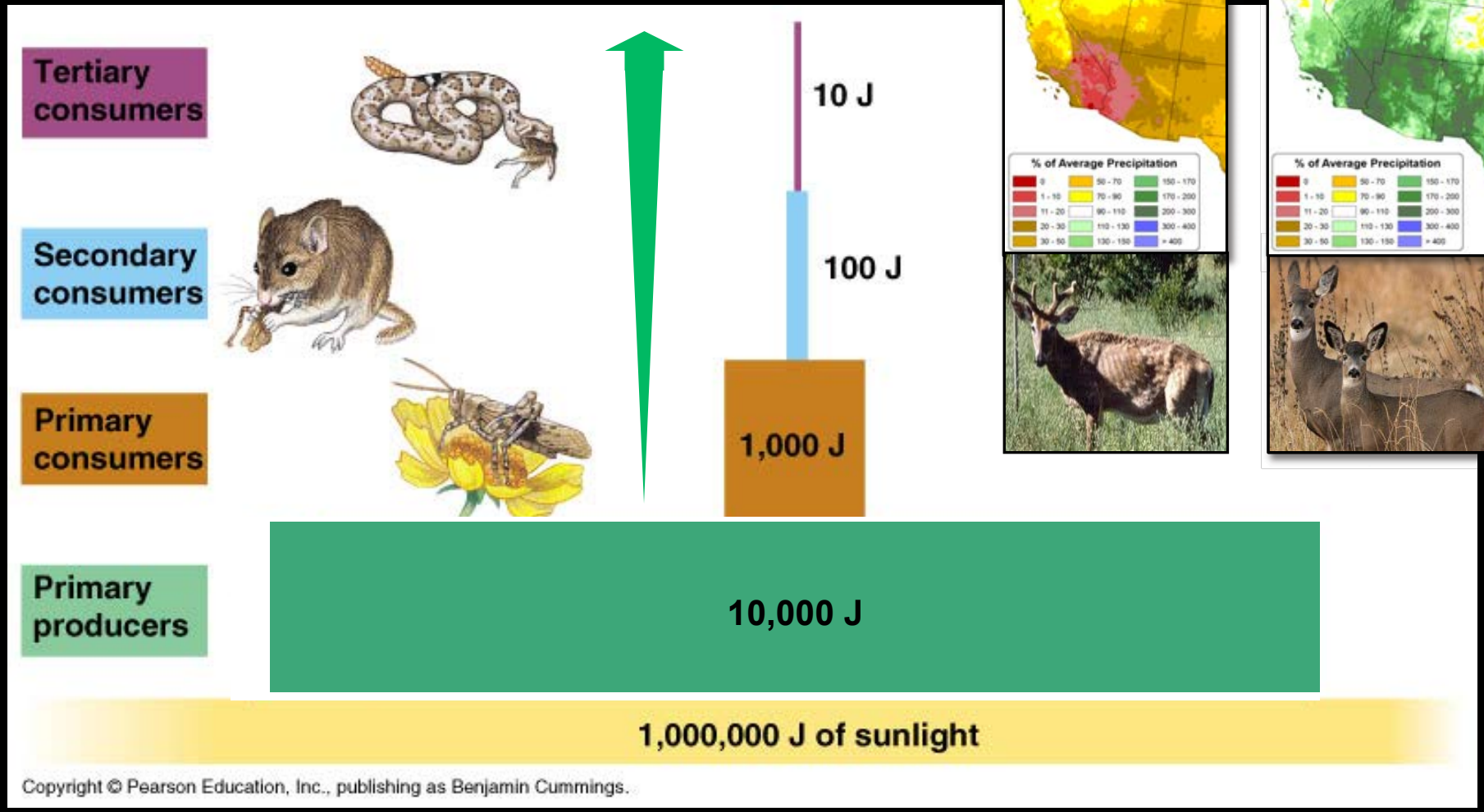
Prey Density & Distribution

Management
(manipulation)

No control
(prediction)



Changes in primary production transfer across trophic levels



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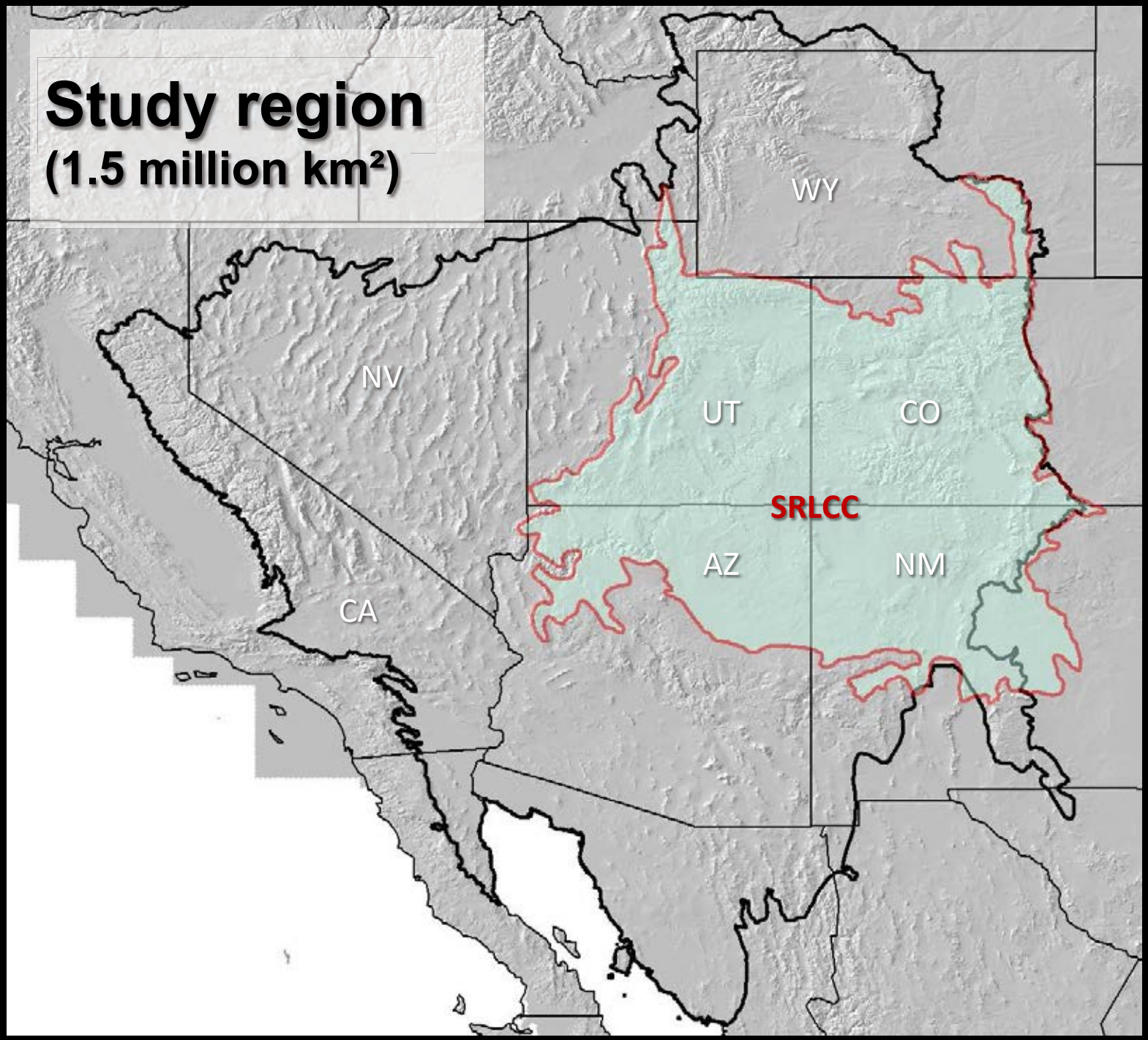
Research Questions

Use NDVI to evaluate mule deer abundance, migration, and habitat use with respect to climate and land-use;

I. How does climate affect mule deer demography?
II. How do climate and land-use influence mule deer migration?
III. How can satellite observations of vegetation phenology inform wildlife management?


Study region
(1.5 million km²)
WY
NV
UT
CO
SRLCC
AZ
NM
CA

Vegetation metrics derived from "The Stacks"

YEAR

2014

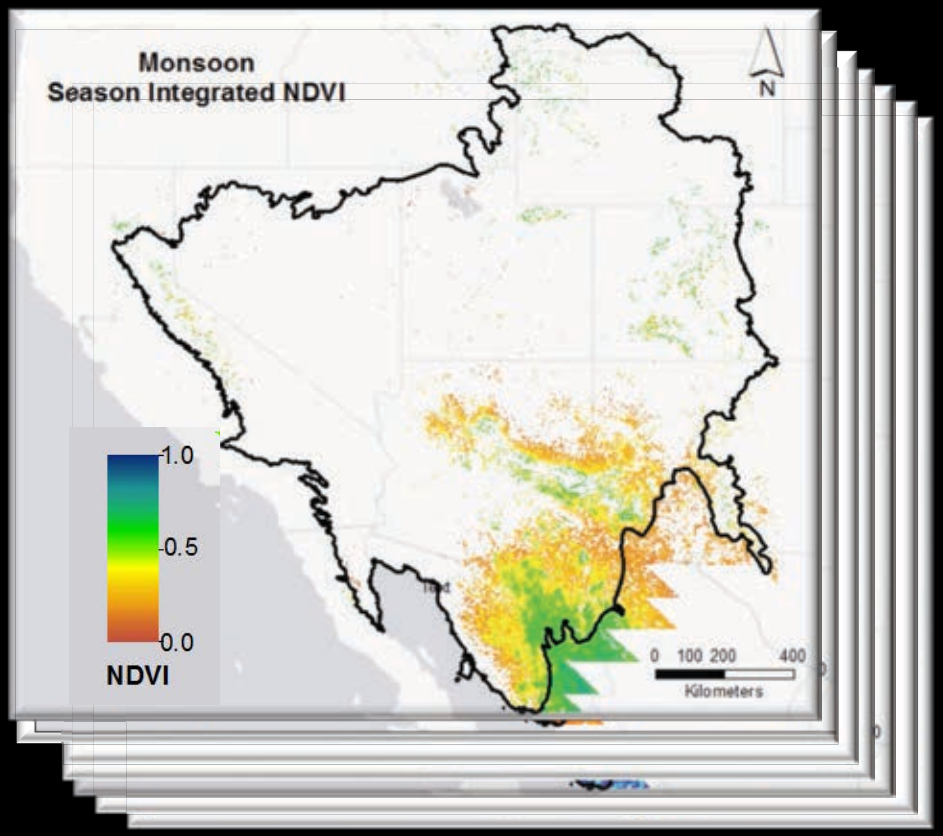
Julian dates 1–5,110
(1 Jan 2000 to 31 Dec 2014)

2000

MODIS NDVI (2000-2014, daily, 500 m)

Response Variable = NDVI; scaled 0-1

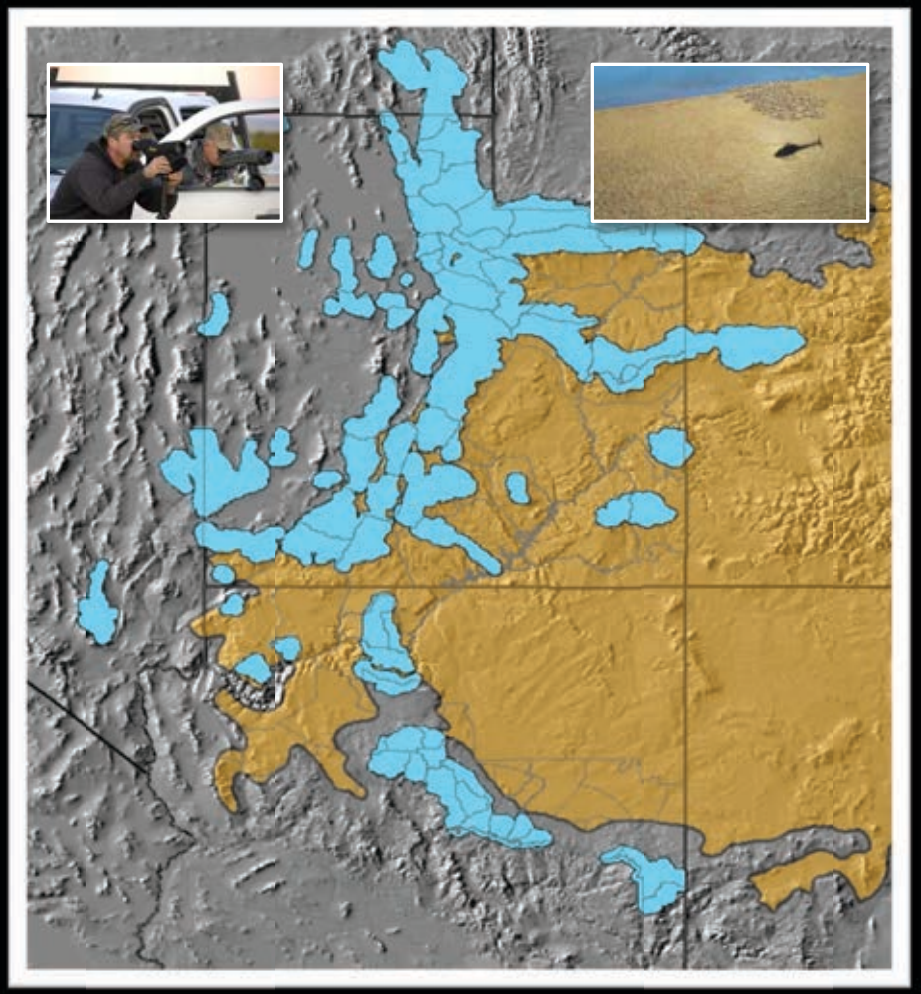
coarse spatial, fine temporal,



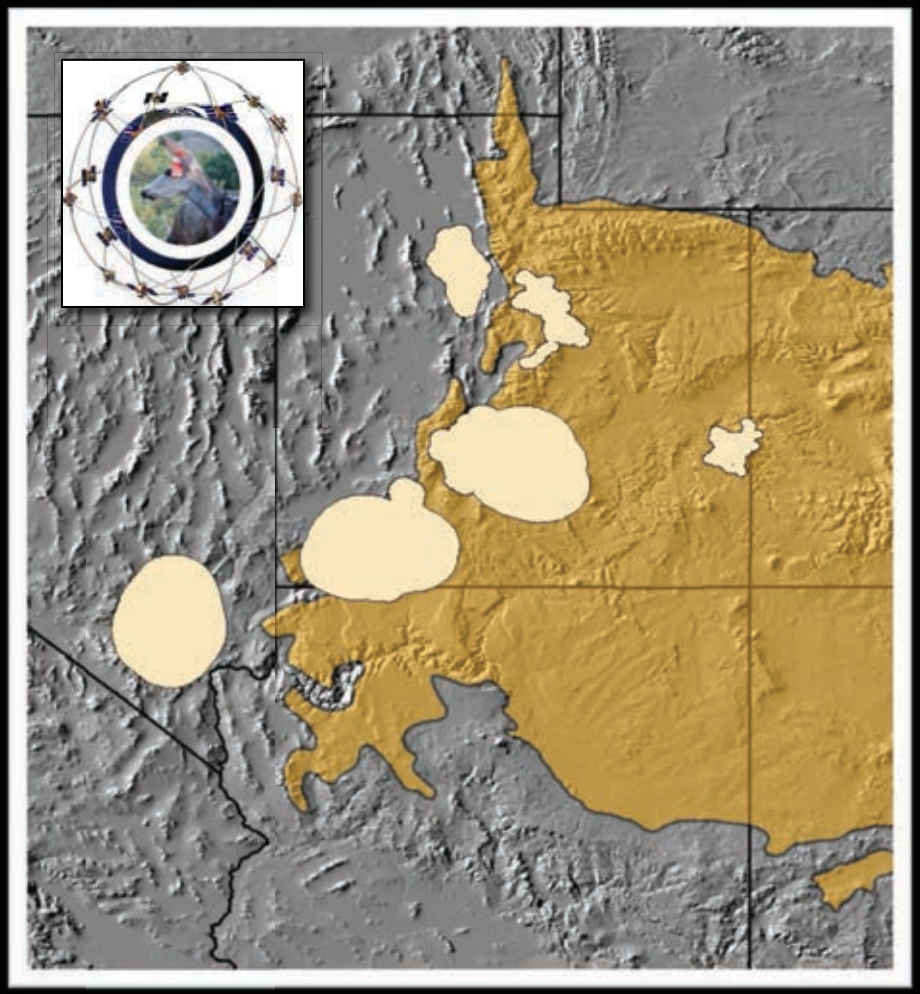
Derived data

Study areas & sampling polygons

Survey Data (n = 59 units)



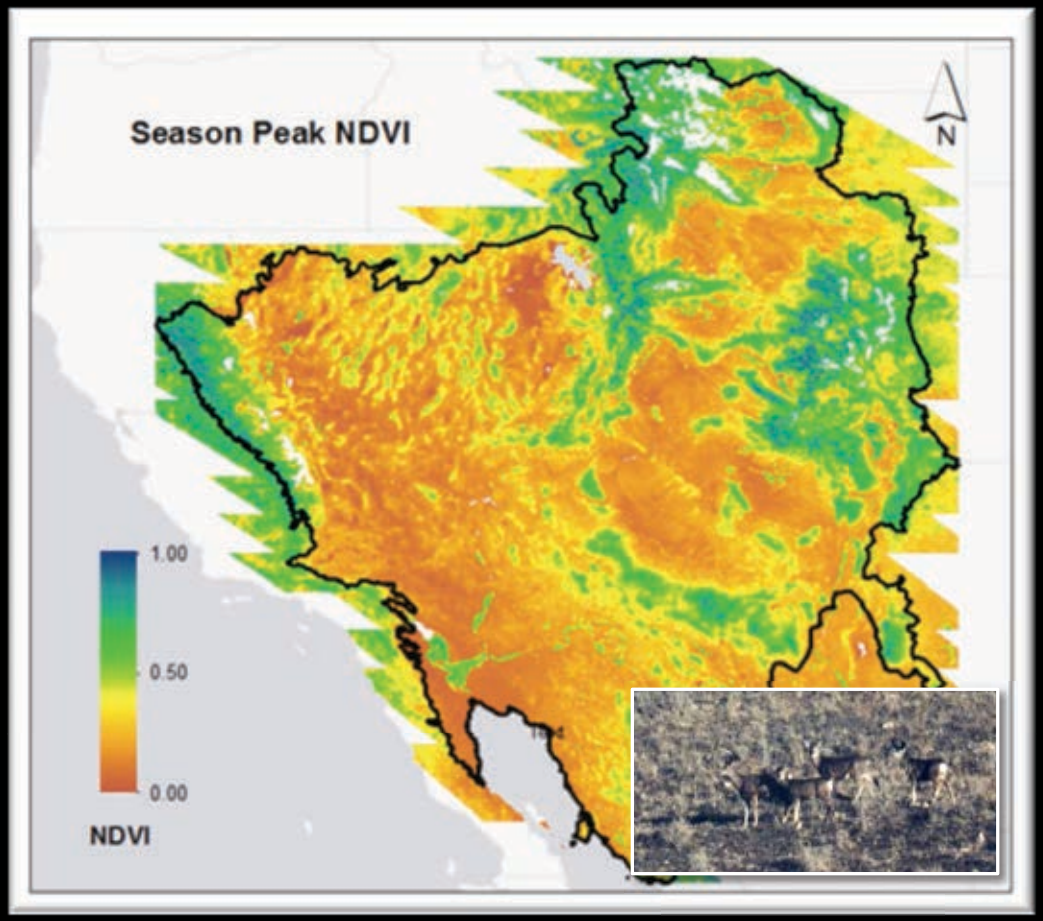
GPS Data (n = 6 units)



Response variables:

- Fawns / 100 does (UT, AZ)
  - 2004-2012
- MU population estimates (UT)
  - 2007-2013
- GPS from adult females (UT)
  - n = 100 animals
  - 2000-2015

Question 1: How does climate affect mule deer demography?



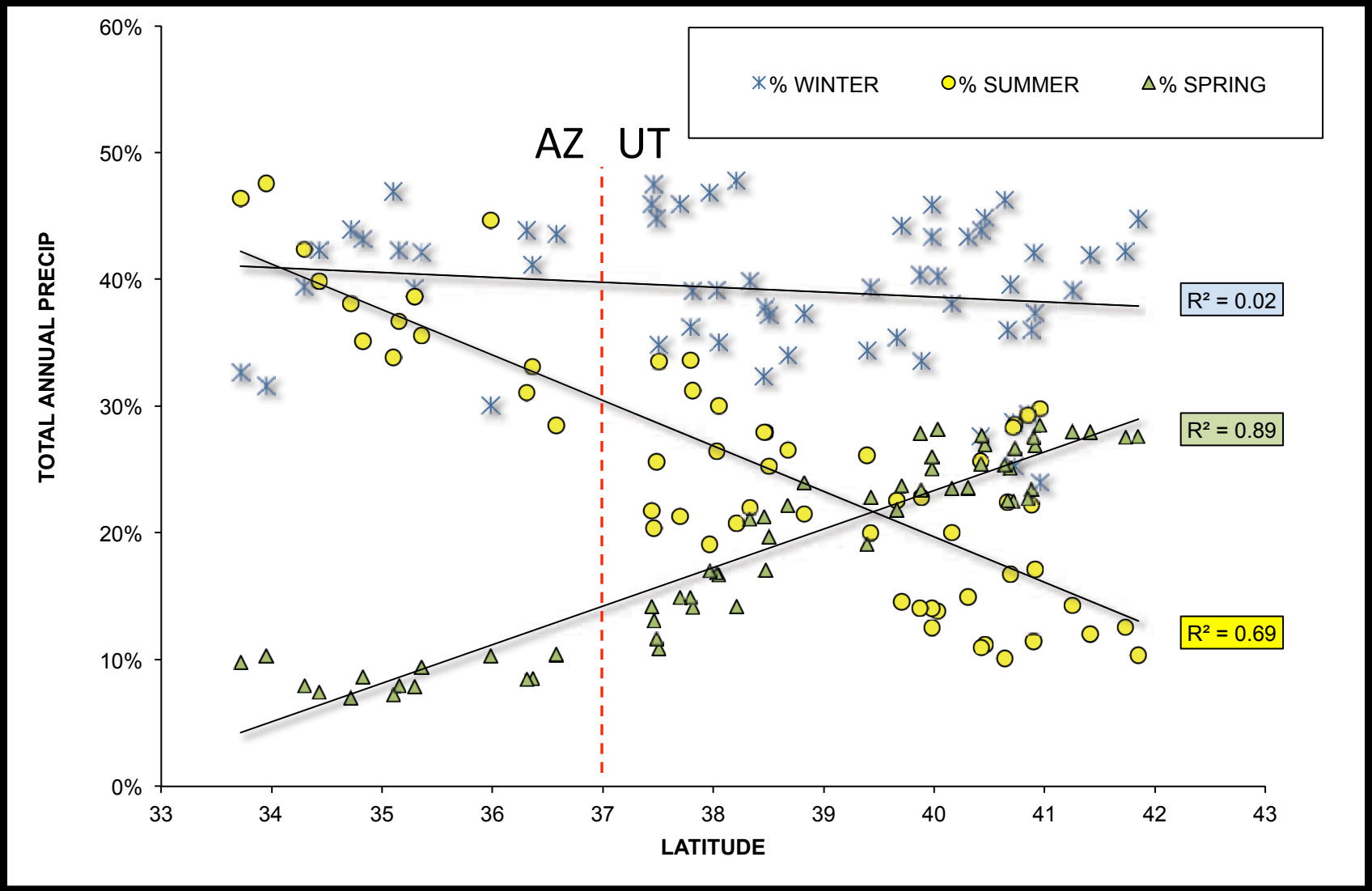
Climate varies along a latitudinal gradient within the study area:

http://www.youtube.com/watch?v=ZzHe2i_N30Y

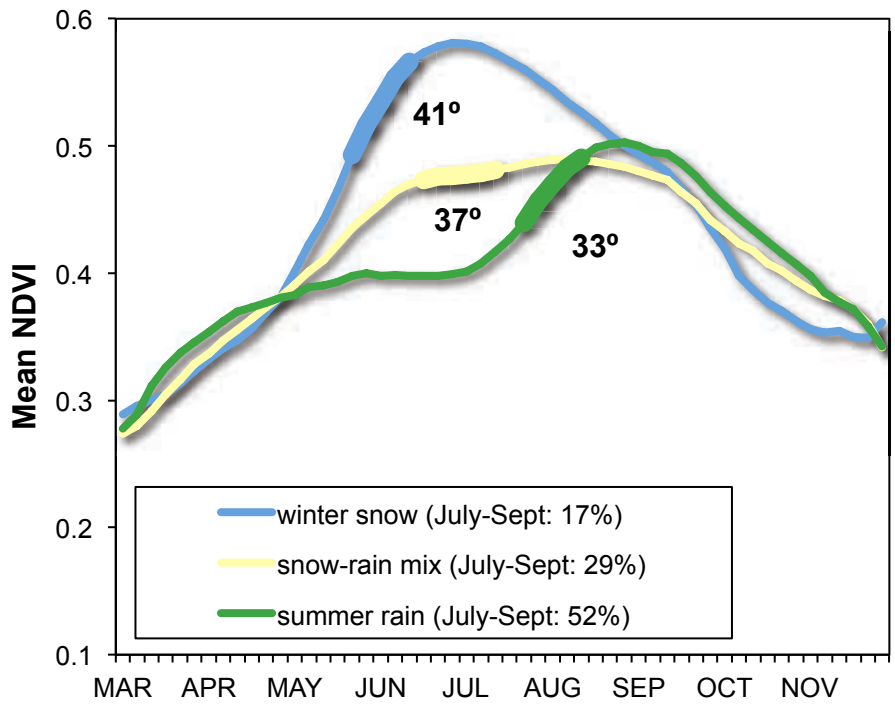
Note three seasonal patterns:

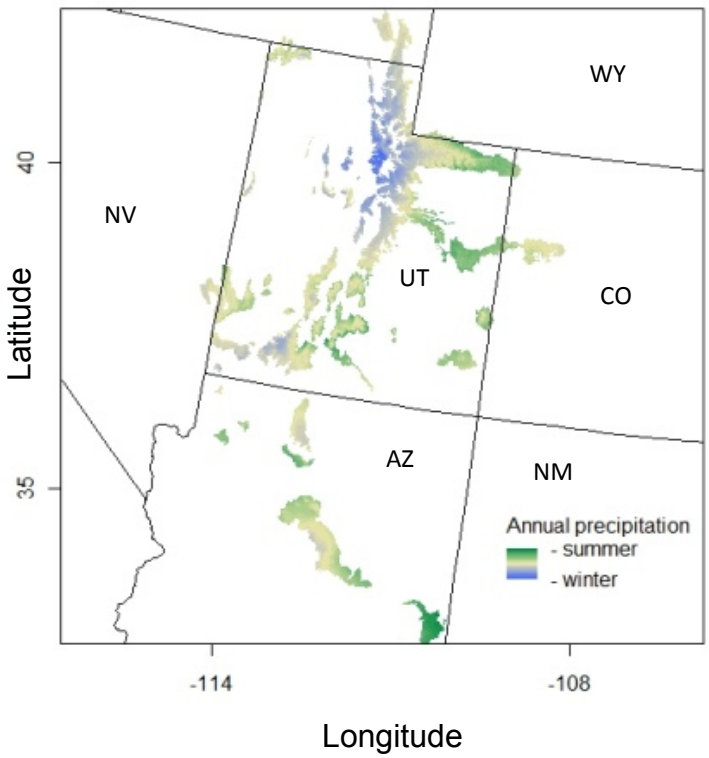
1. Winter snow proceeds from north to south
2. Heavy winter snowpack ends ~ 37° N
3. Monsoonal moisture progressing from south to north ~ mid-summer

Precipitation varies with latitude across the study region:

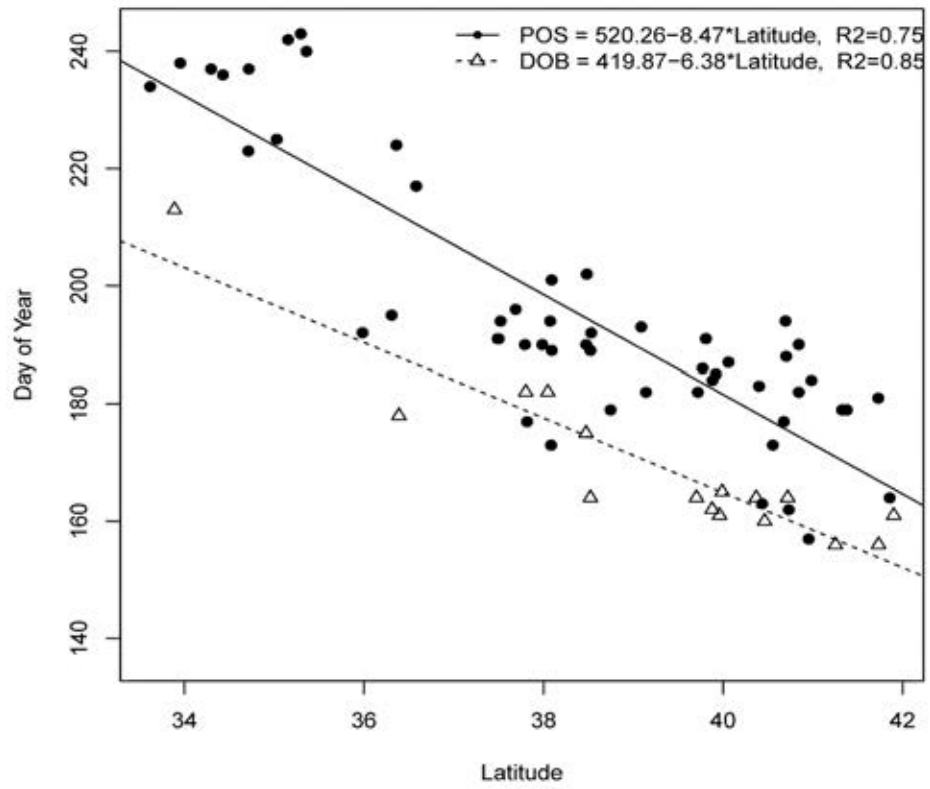


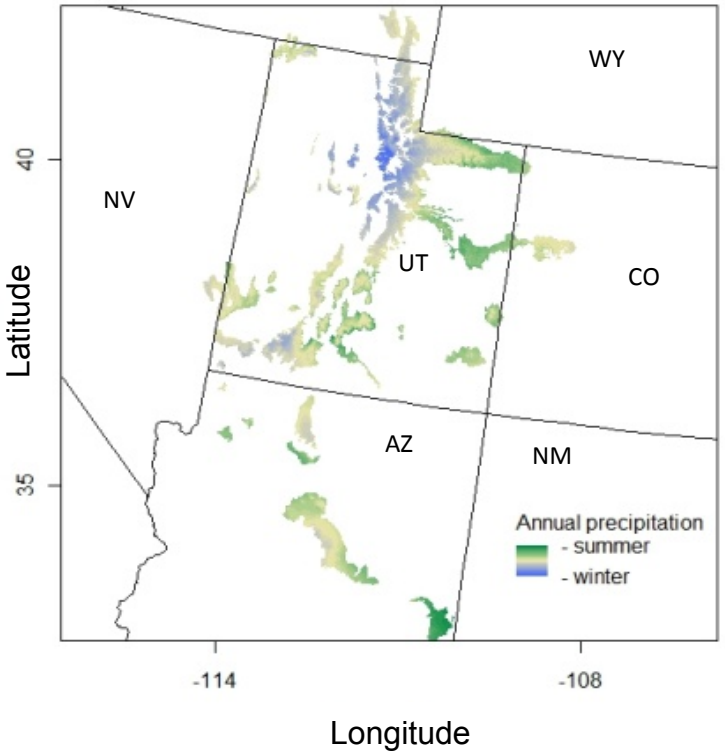
Timing of “green-up” (~ forage quality) varies with latitude:





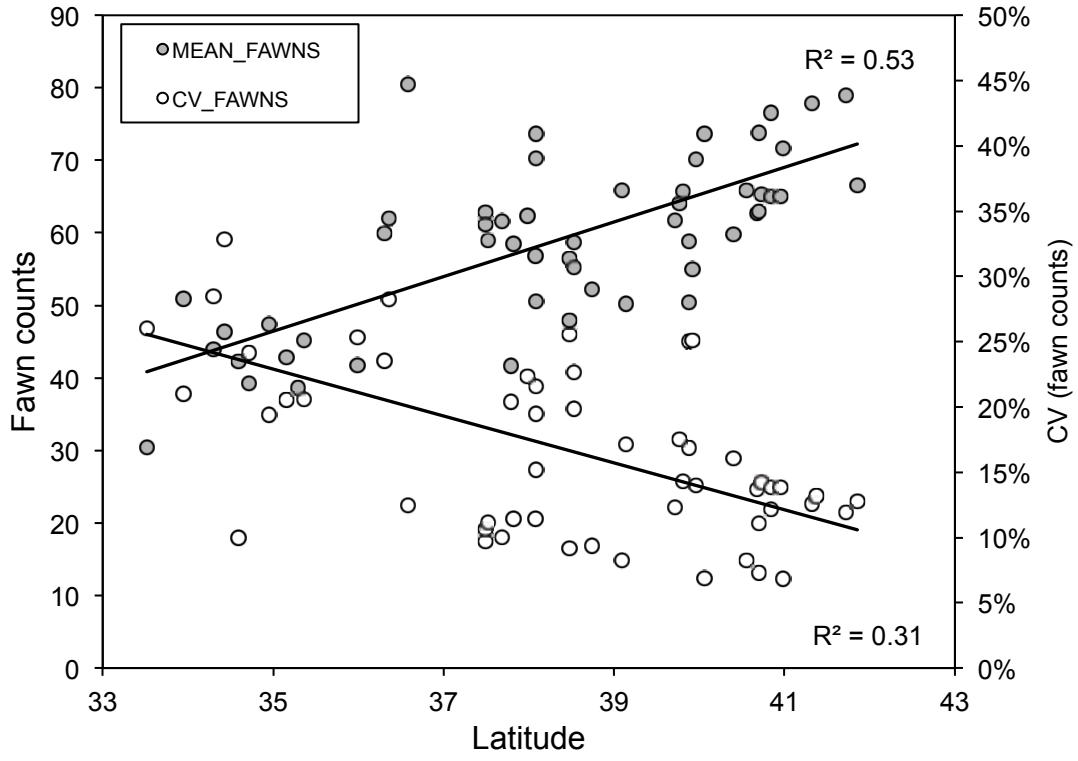
Birthing dates track Peak-of-Growing-Season across latitude:

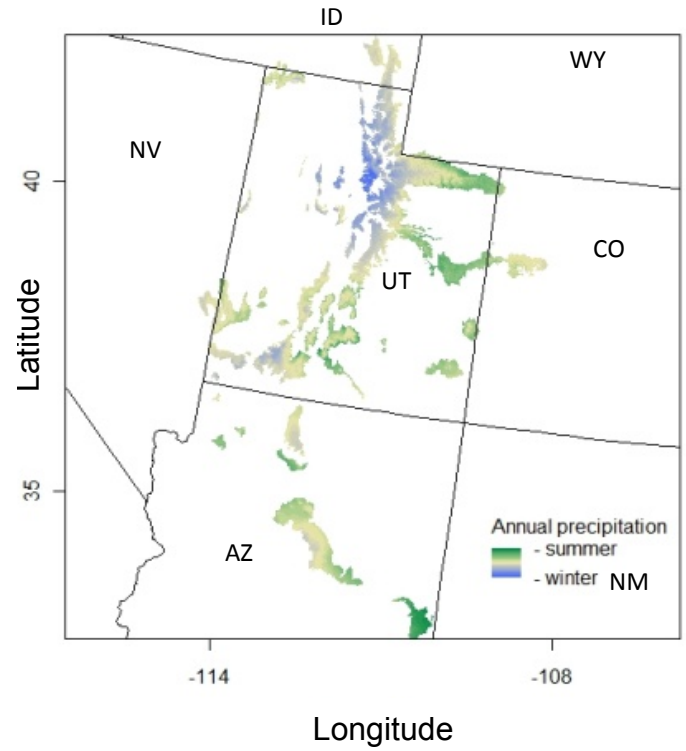




Southern deer time birthing to monsoonal moisture.

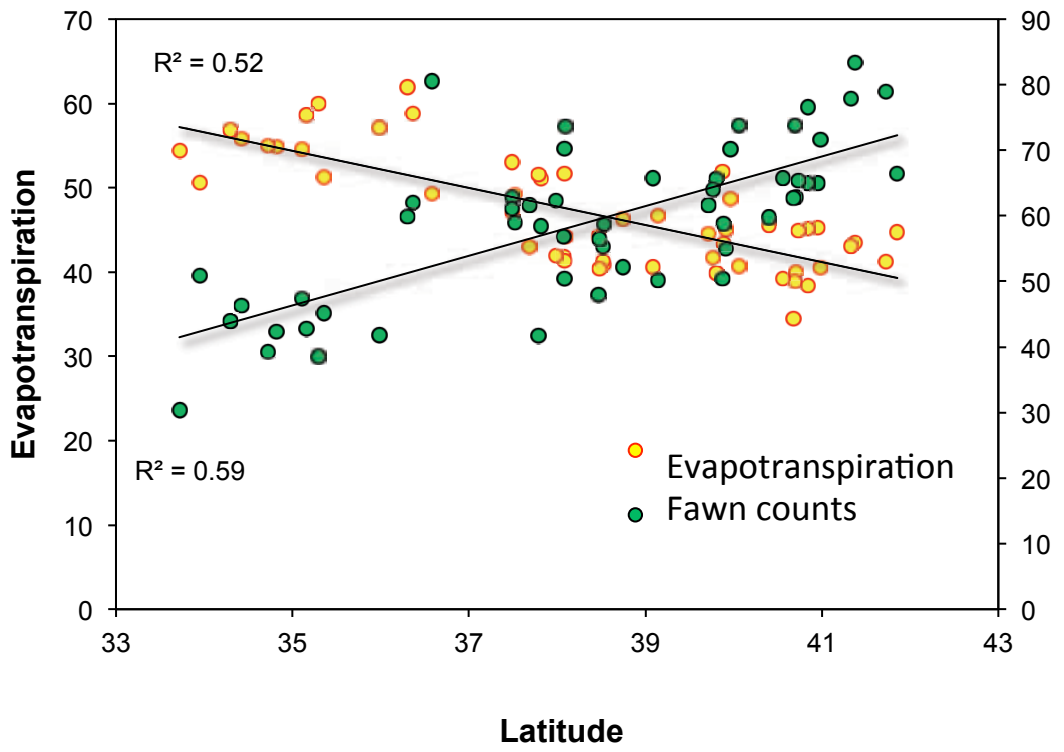
Fawn production varies with summer precipitation:

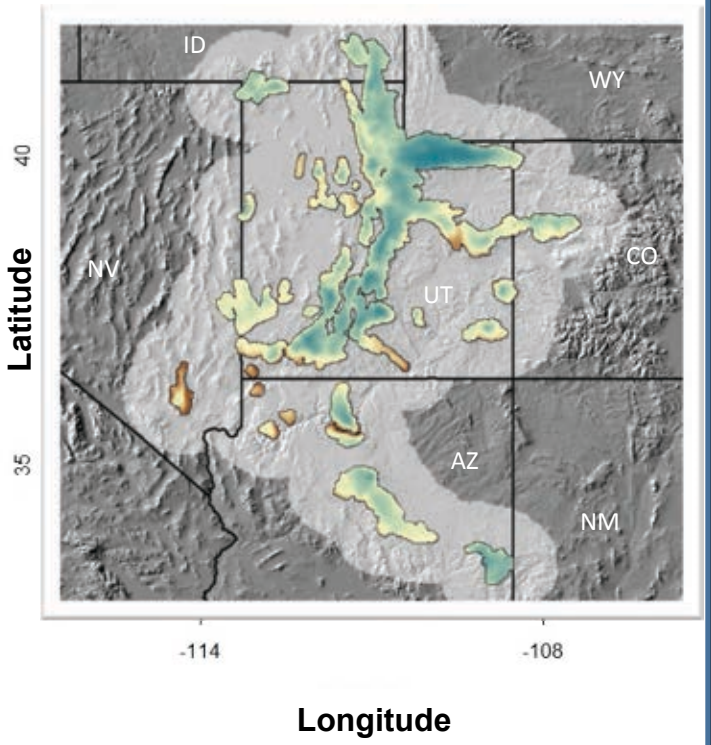




Snow dominated systems exhibit higher summer fawn survival and lower interannual variation.

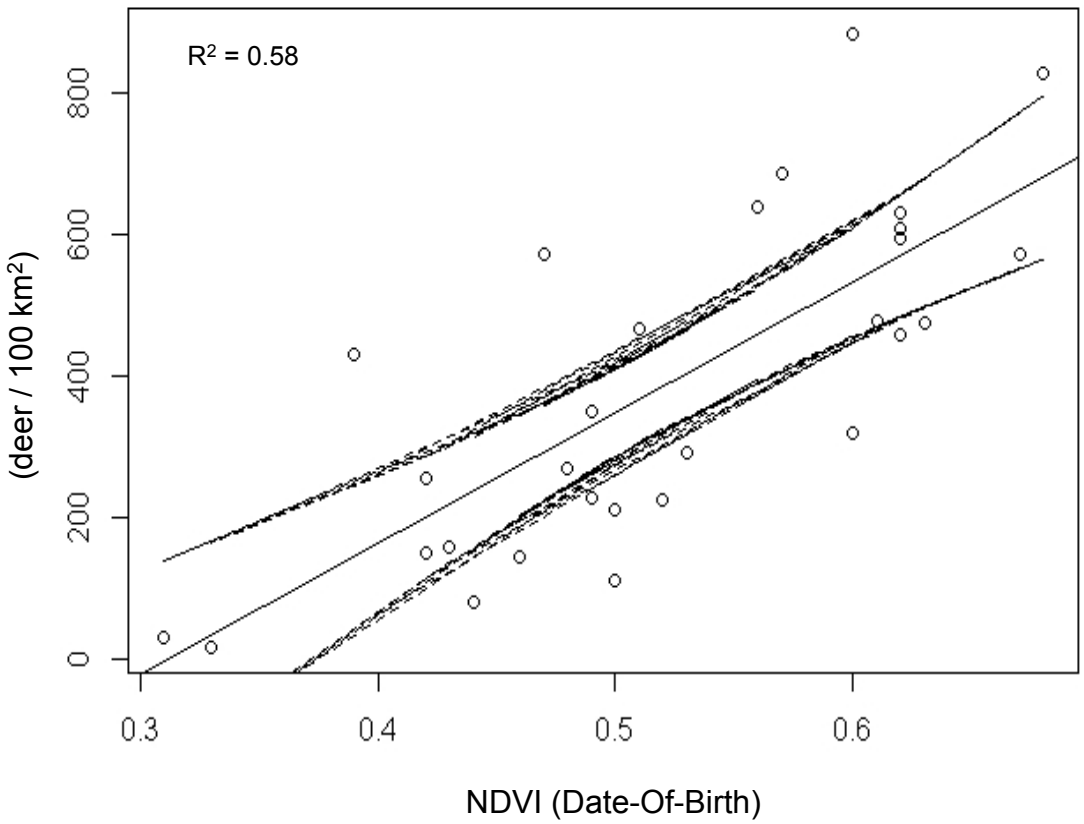
Fawn production varies with mean annual AET:

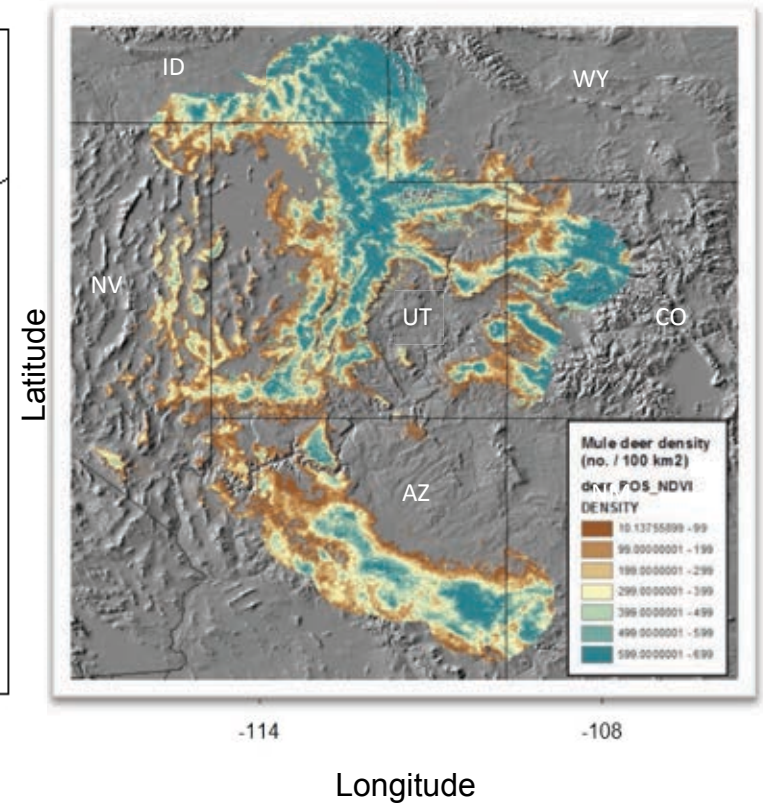




Fawn production varies inversely with mean annual AET.

Density varies with summer range NDVI during parturition:





Range conditions during birth predict population density.

Question 2: How do climate and land-use influence mule deer seasonal movements?

Monroe Mtn elk: spring migration in response to climatic factors

https://www.youtube.com/watch?v=-5JNrdK0iBE

Note two seasonal patterns:

1. Probing behavior to snowline during late winter;
2. Tracking green-up during late spring

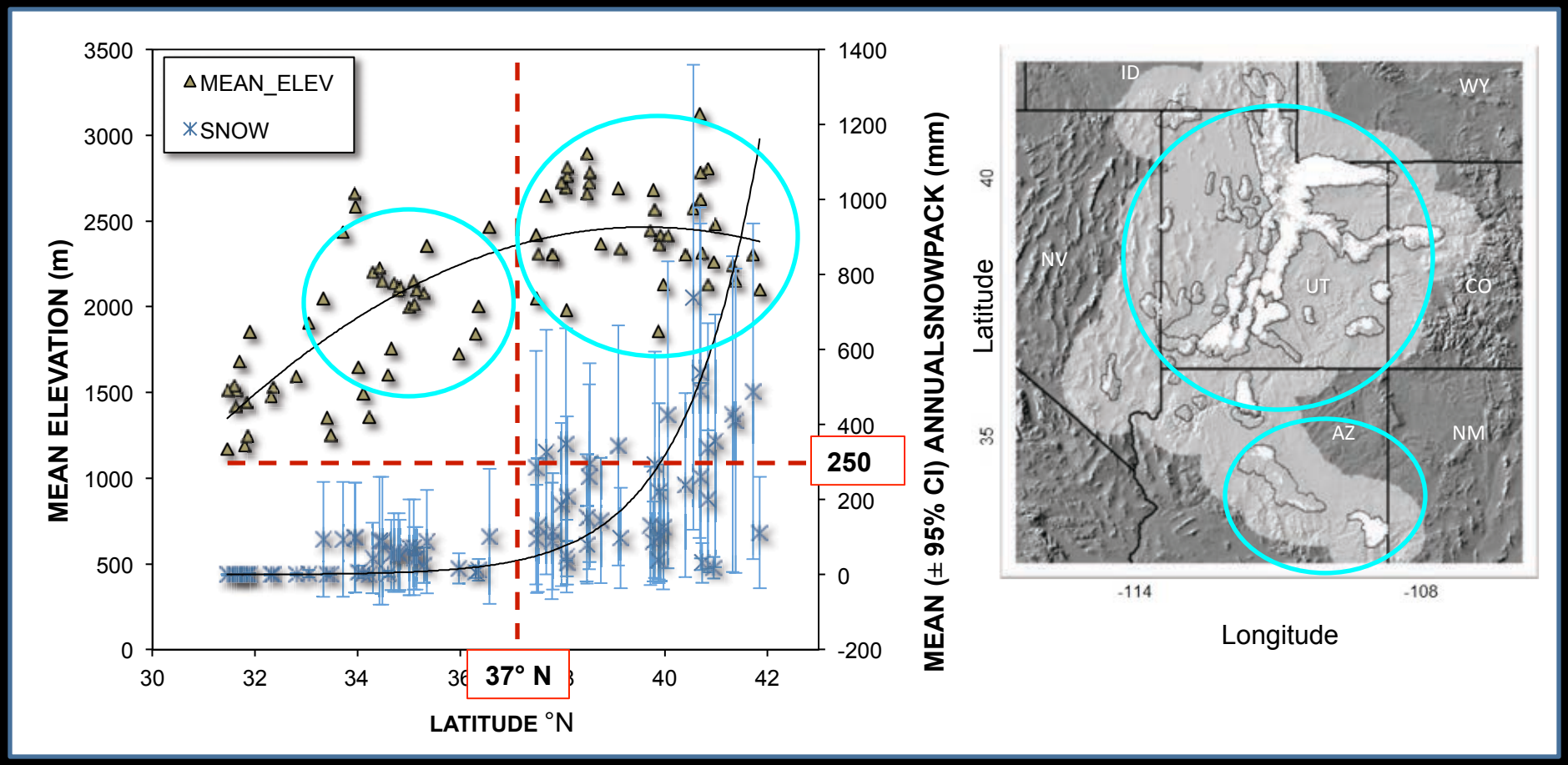
Cedar Mtn deer: migration in response to climatic factors

https://www.youtube.com/watch?v=B3Vkb9PGiqI

Note two seasonal patterns:

1. Spring migration initiated when summer range is green (May 4);
2. Fall migration initiated after first major snowstorm (October 20)

Migration is predictable in space…

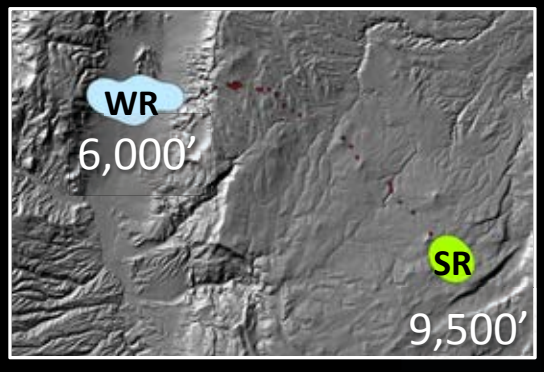


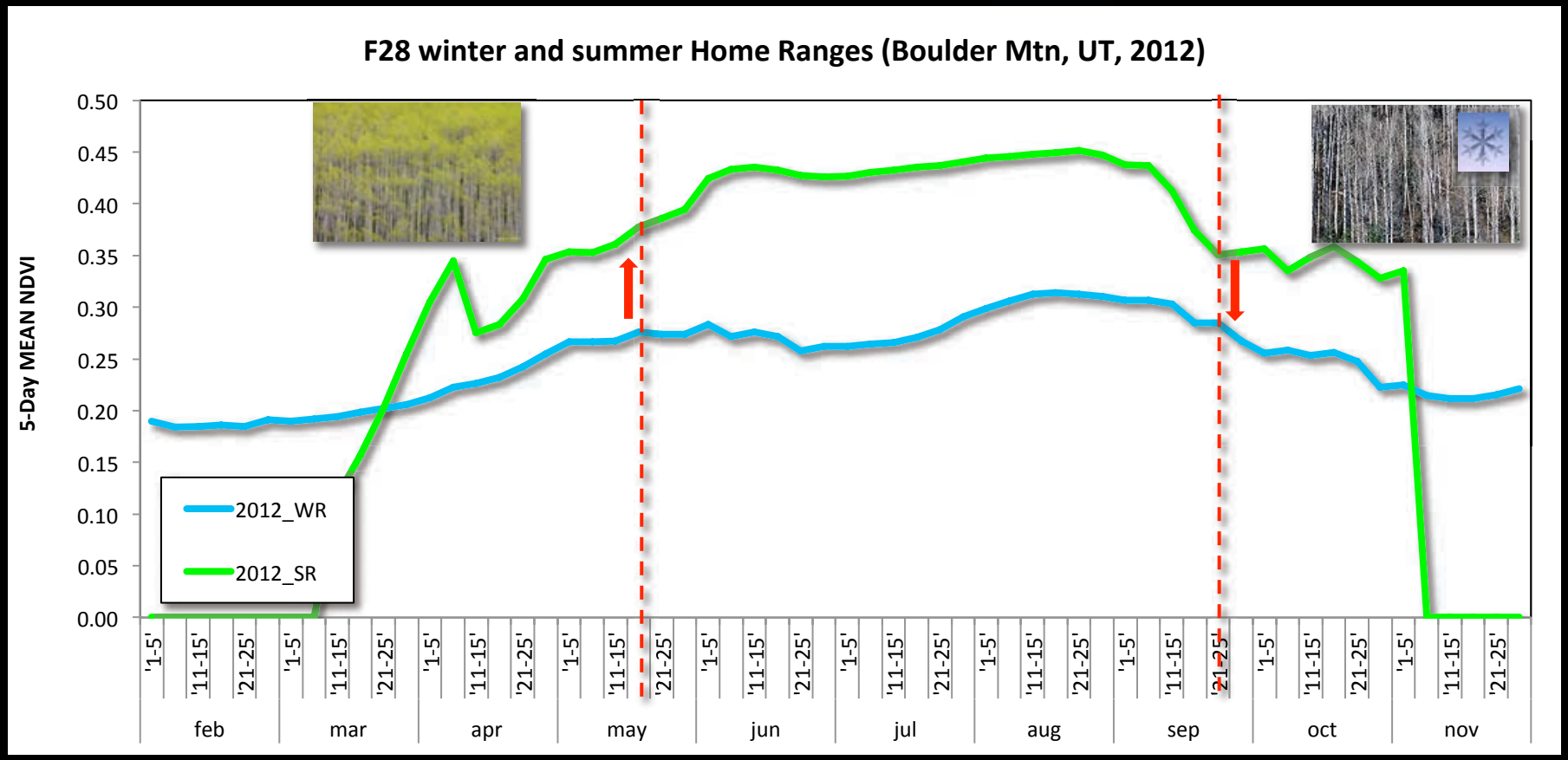
Deer migrate in areas where snow depth > 250 mm (~ 10”).

…and time:

Spring migration (5/14/2012):

Fall migration (9/24/2012):





Mule deer are vulnerable to land use change:

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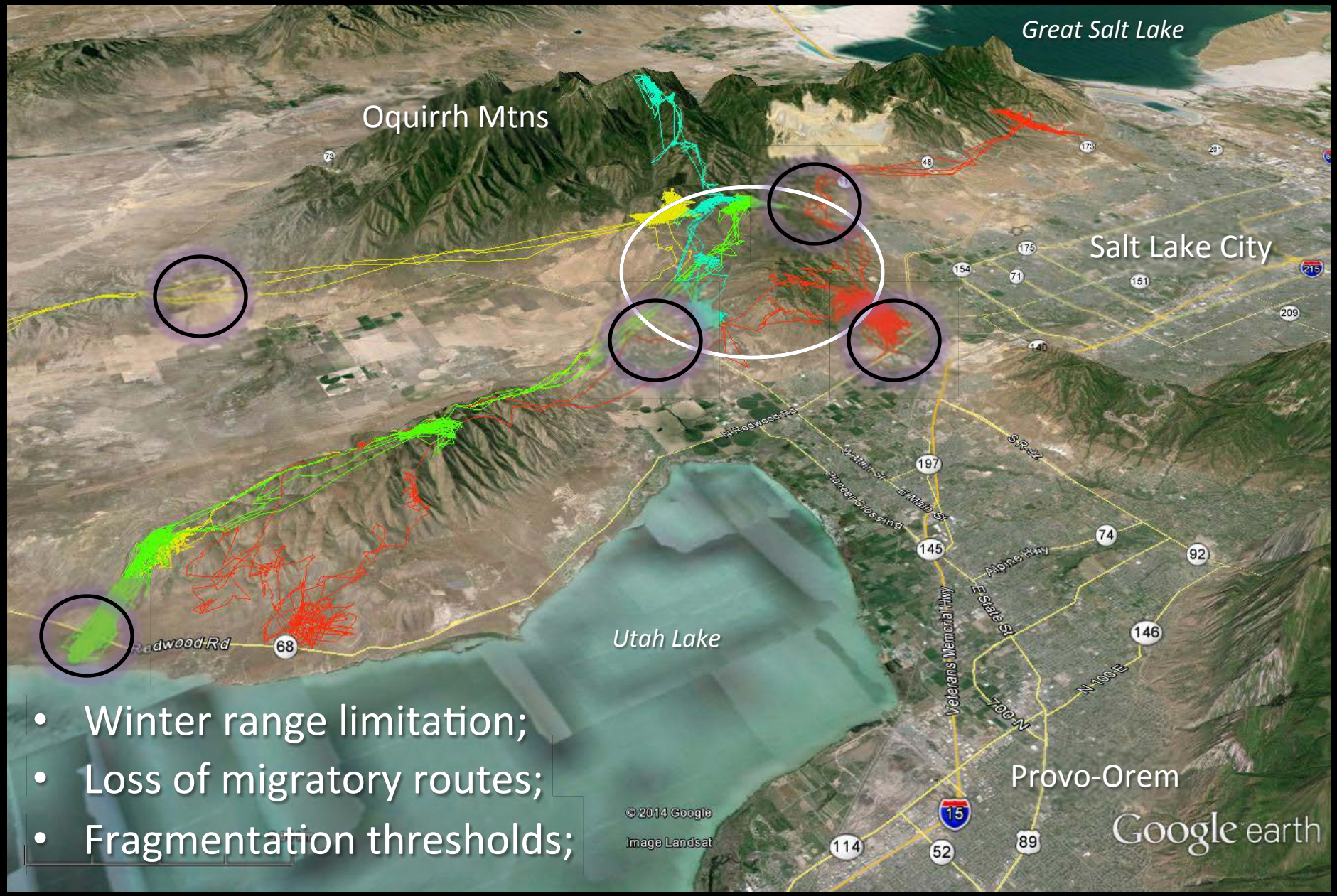
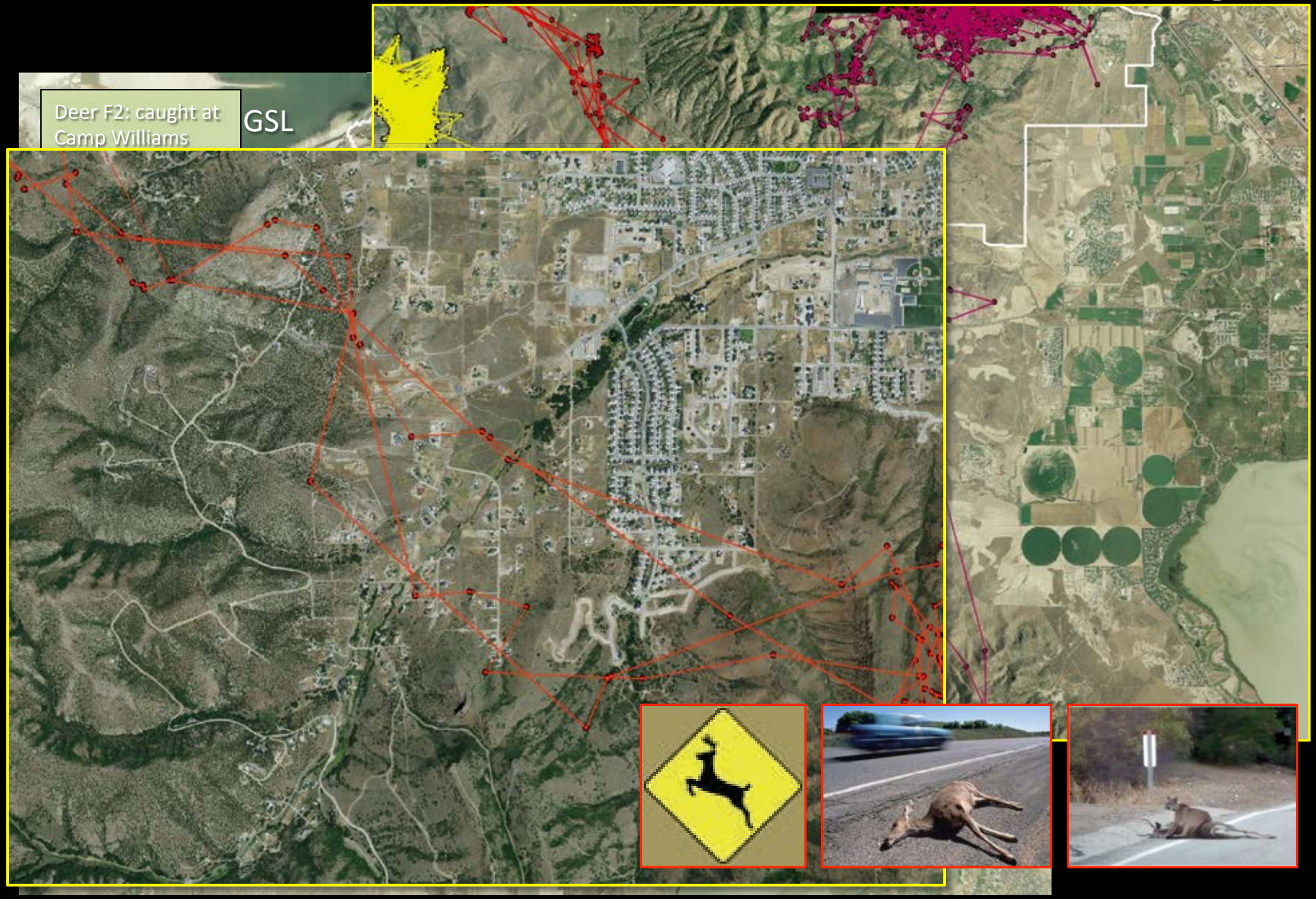


- Winter range limitation;
- Loss of migratory routes;
- Fragmentation thresholds;

Mule deer are vulnerable to land use change:



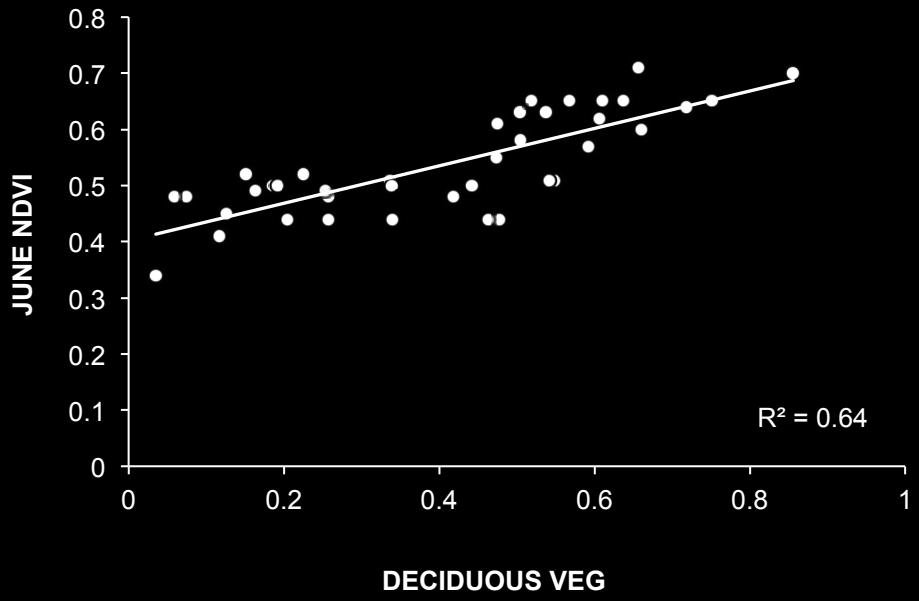
Question 3: How can satellite observations of plant phenology inform wildlife management?

1. Habitat: conservation / restoration

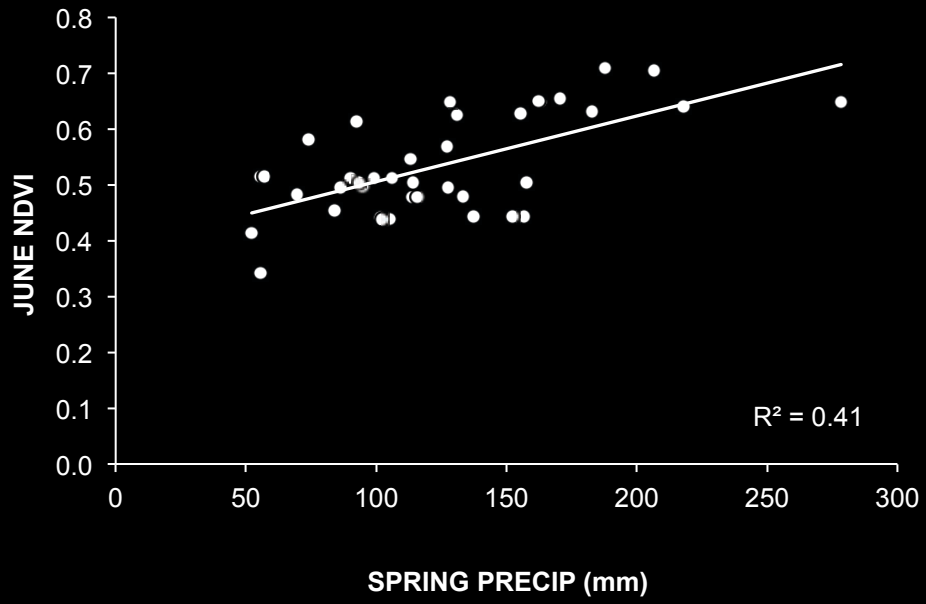
2. Demographics: population density / trends

Habitat: where possible, conserve / restore aspen communities

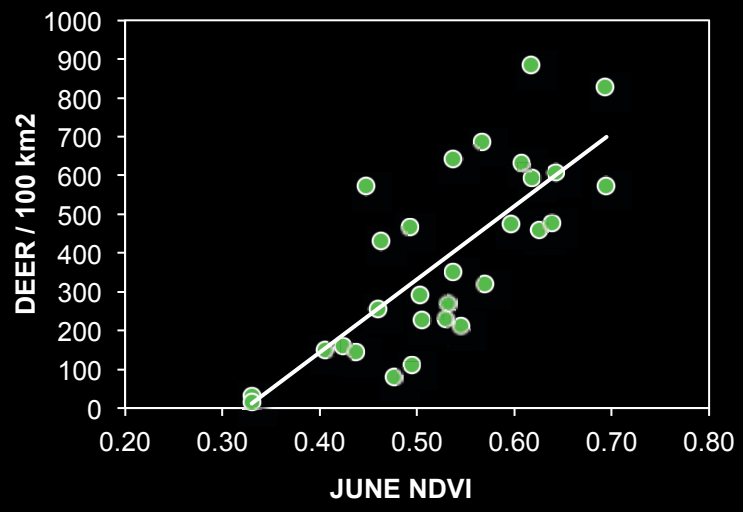
SPACE

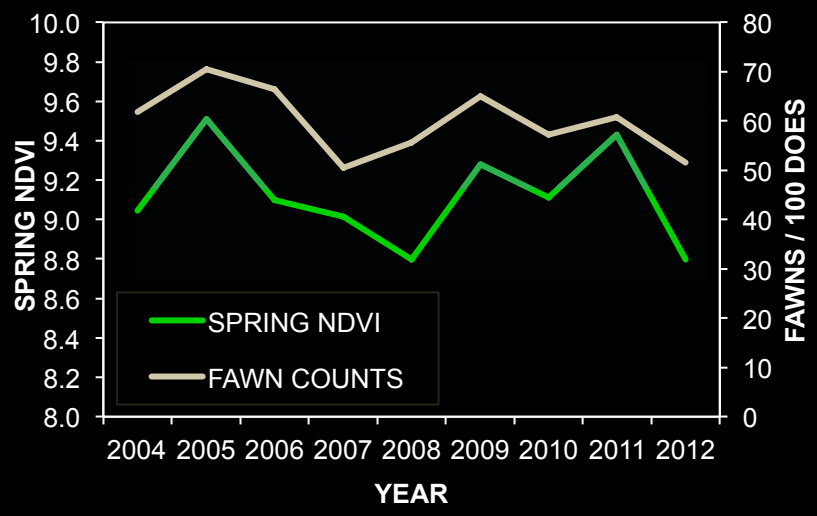


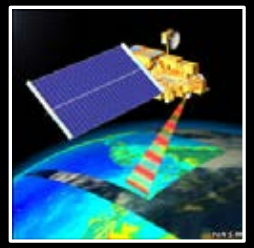
TIME



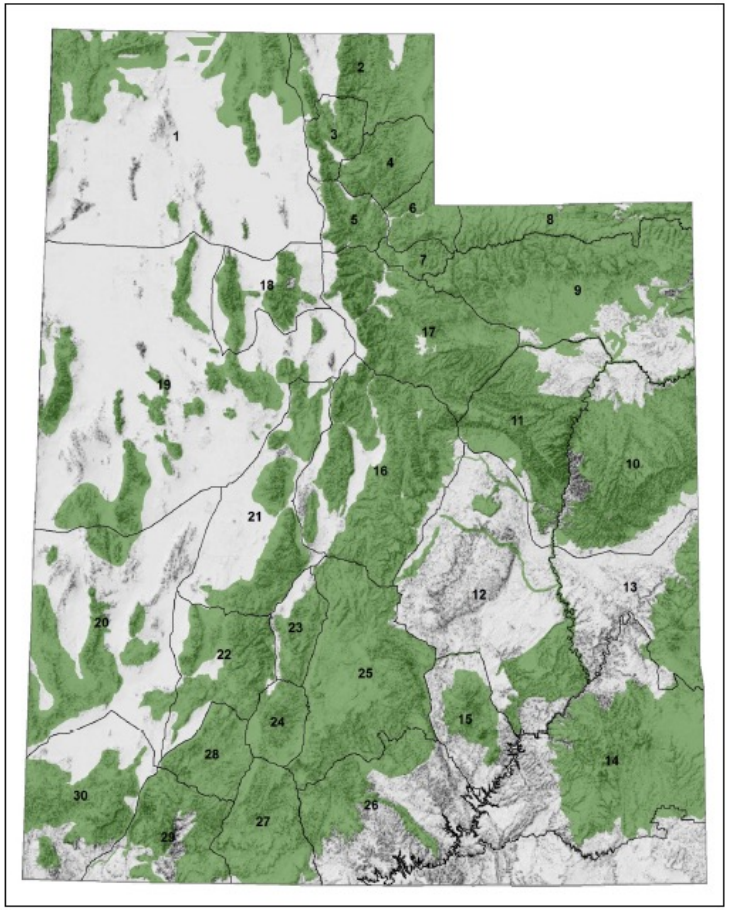
Demographics: combined with field data, NDVI can be used to predict population abundance / trends

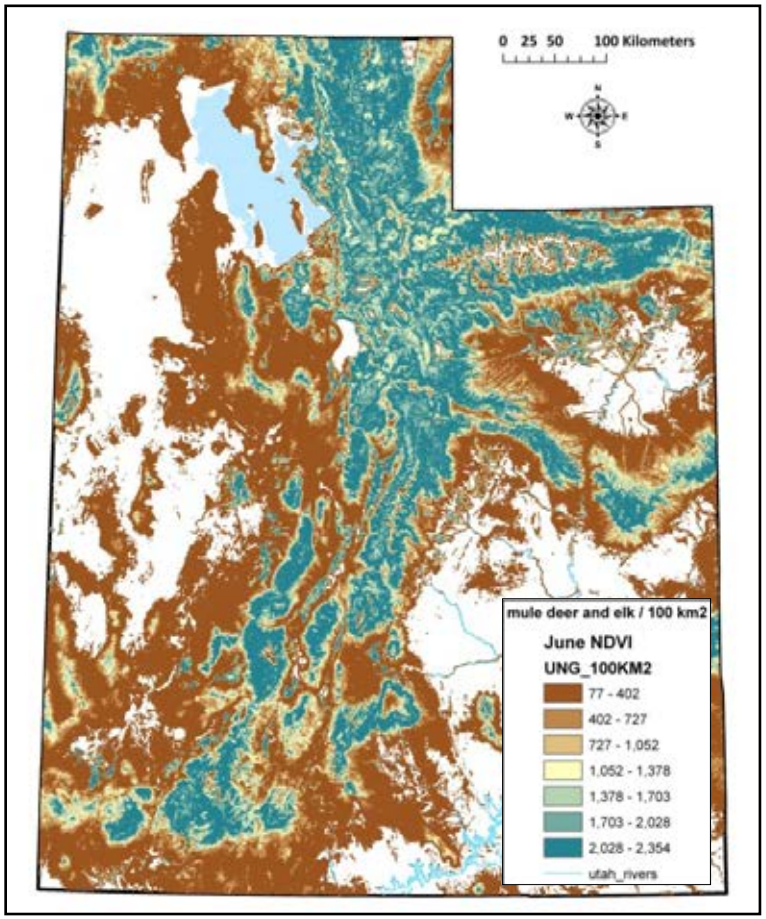






The goal is to improve p/a maps by including demographic parameters:





NDVI is correlated with density, productivity, and survival

Take Home Points:

I. Climate (~ vegetation) can affect mule deer demography; detectable through standard survey data;

II. Interannual variation in plant phenology is measurable with satellite imagery;

III. Deer abundance varies predictably with NDVI; can be used to estimate / calibrate population objectives;

IV. NDVI provides an affordable, timely, synoptic tool for indexing deer habitat (state, regional, MU scales); can be used to:

   I. predict deer movements / identify conflict hotspots / migration routes;

   II. Prioritize management actions (habitat restoration, predator control, harvest, etc.).

Acknowledgements

Utah State University
Utah DNR
NASA
Arizona Game & Fish
USGS science for a changing world
University of Maryland 1856
GLCF landcover.org
Ecology Center
Kennecott Utah Copper
Utah's Hogle Zoo
Forest Service U.S. Department of Agriculture
Utah National Guard
African Safari Club of Florida, Inc.