Integrating nutrition, resource use, and population demographics to inform conservation of endangered species

Kristin Denryter[1], Thomas Stephenson[2], Kevin Monteith[1,3]

[1]Haub School of Environment and Natural Resources, University of Wyoming, Laramie, WY

[2]Sierra Nevada Bighorn Sheep Recovery Program, California Department of Fish and Wildlife, Bishop, CA

[3]Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY

Research Overview

Finding conservation actions and recovery goals for endangered species that are biologically sound requires thorough knowledge of ecology and habitat requirements and how changes in habitat affect population growth. One of the most profound ways by which habitat influences ungulates is through nutritional pathways (Monteith et al. 2014, Cook et al. 2016). Nutrition underpins growth, survival, and reproduction and because of its effects on demographic rates, nutrition is the fundamental building block of populations. Generally, implications of nutrition to conservation of wildlife have not been realized because data needed to establish cause-and-effect links between nutrition and population trajectory either are underappreciated or only exist conceptually. We aim to bridge the fields of nutrition and population ecology tools to quantify nutritional values of 'foodscapes', nutritional status of populations, and explicitly assess potential benefits of conservation actions that manipulate food supplies (Fig. 1). 'Foodscapes' generated through our work will serve as innovative, yet tractable tools for conservation of endangered ungulates. Our work focuses on the federally endangered Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) in the Sierra Nevada of California (Fig. 2).

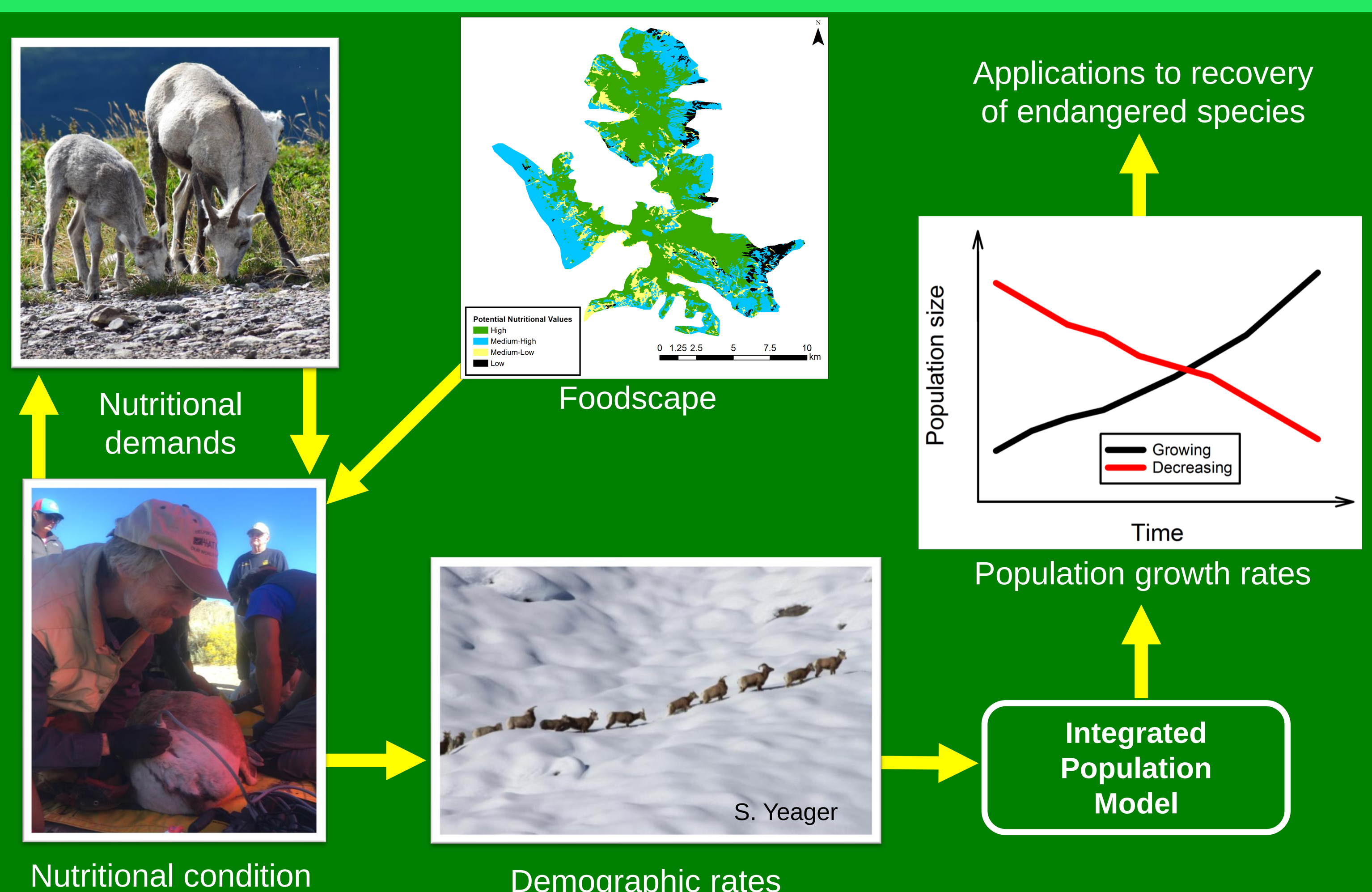


Figure 1. Conceptual diagram illustrating how we plan to bridge nutritional and population ecology to better inform recovery and conservation efforts for endangered species. Previous work typically has focused only on relating foodscapes and nutritional condition (as measured using ultrasonography of body fat) or relating nutritional condition to demographic rates, but our work will explore how all of these factors are related.

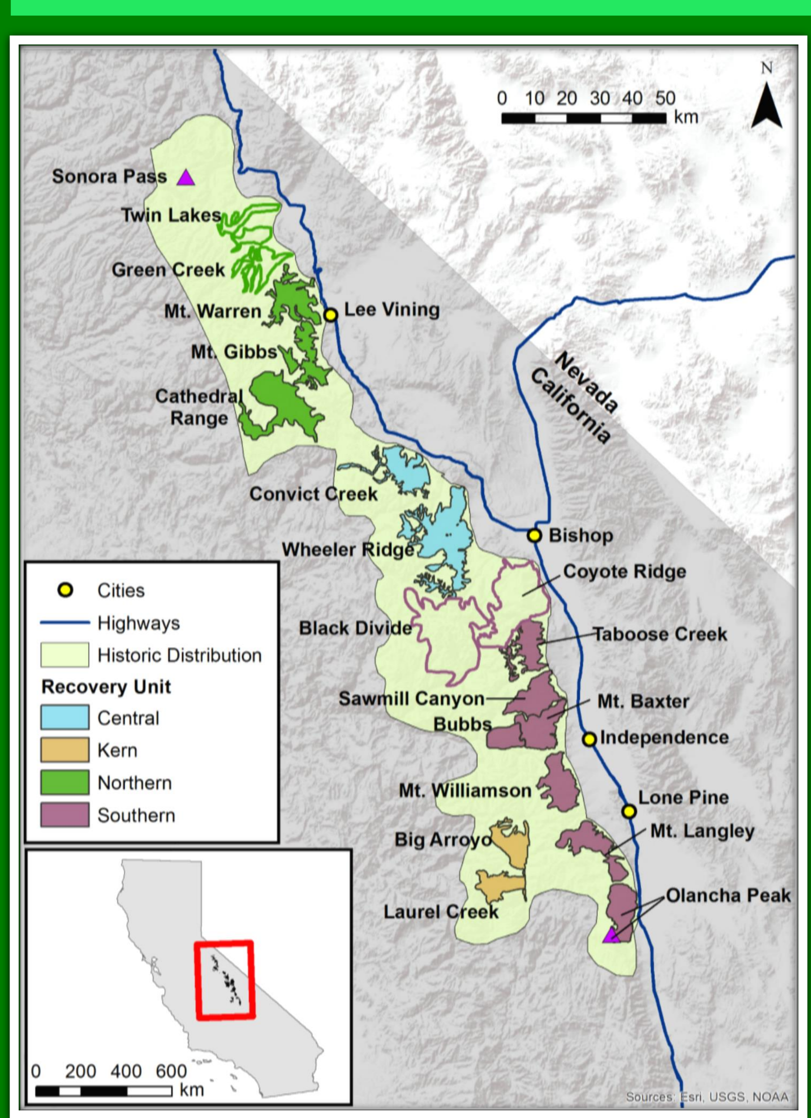
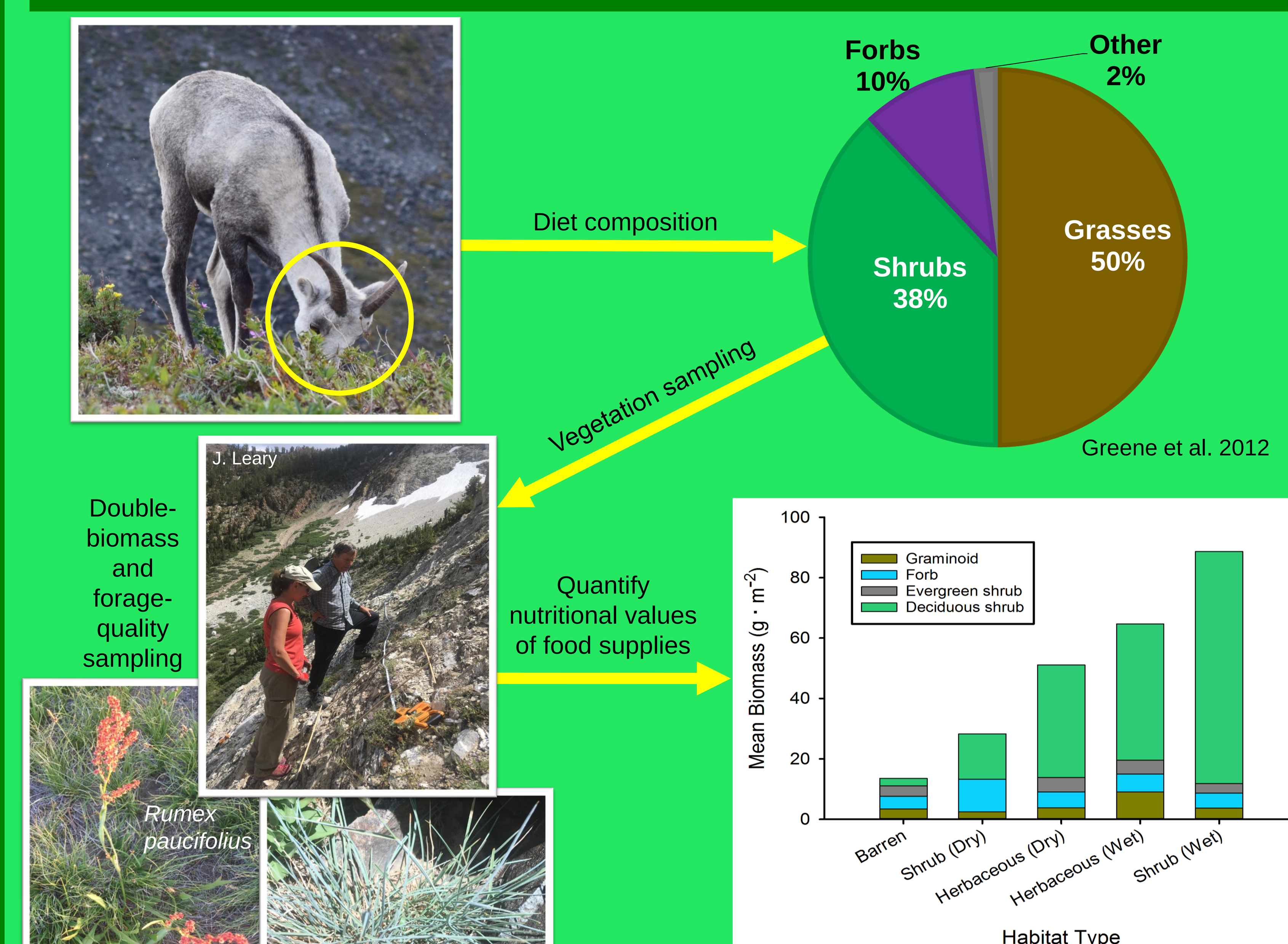


Figure 2. Historically, Sierra Nevada bighorn sheep ranged from Sonora Pass to Olancha Peak. In 1999, only 122 Sierra bighorn remained in the Baxter, Langley, Mono Basin (Mount Warren and Mount Gibbs), Mount Williamson, and Wheeler Ridge herds. Shortly thereafter, Sierra bighorn were federally designated as an Endangered Species. Recovery efforts led by the California Department of Fish and Wildlife, including augmentations and reintroductions (above), have helped grow the population to >500 animals dispersed across 14 herds in the four recovery units. Ranges outlined, but not colored in, represent unoccupied herd ranges.

Objective 1: Quantify quality and quantity of food supplies available in different types of habitat available to Sierra Nevada bighorn sheep.



Preliminary data show that forage biomass is greatest in wet habitat types. Forage quality sampling will begin in 2018.

Figure 3. We will quantify available biomass of forage species consumed by Sierra bighorn and will determine digestible energy and digestible protein content of forage species. Energy and protein are important to growth, reproduction, and a host of physiological processes and are two of the most limiting nutritional currencies for wild ungulates (e.g., Verme and Ozoga 1980; Syrjälä-Qvist and Salonen 1983).

Objective 2: Map 'foodscapes' for Sierra bighorn based using quantity and quality data collected through on-the-ground sampling and evaluate links between nutritional condition and habitat use across foodscapes.

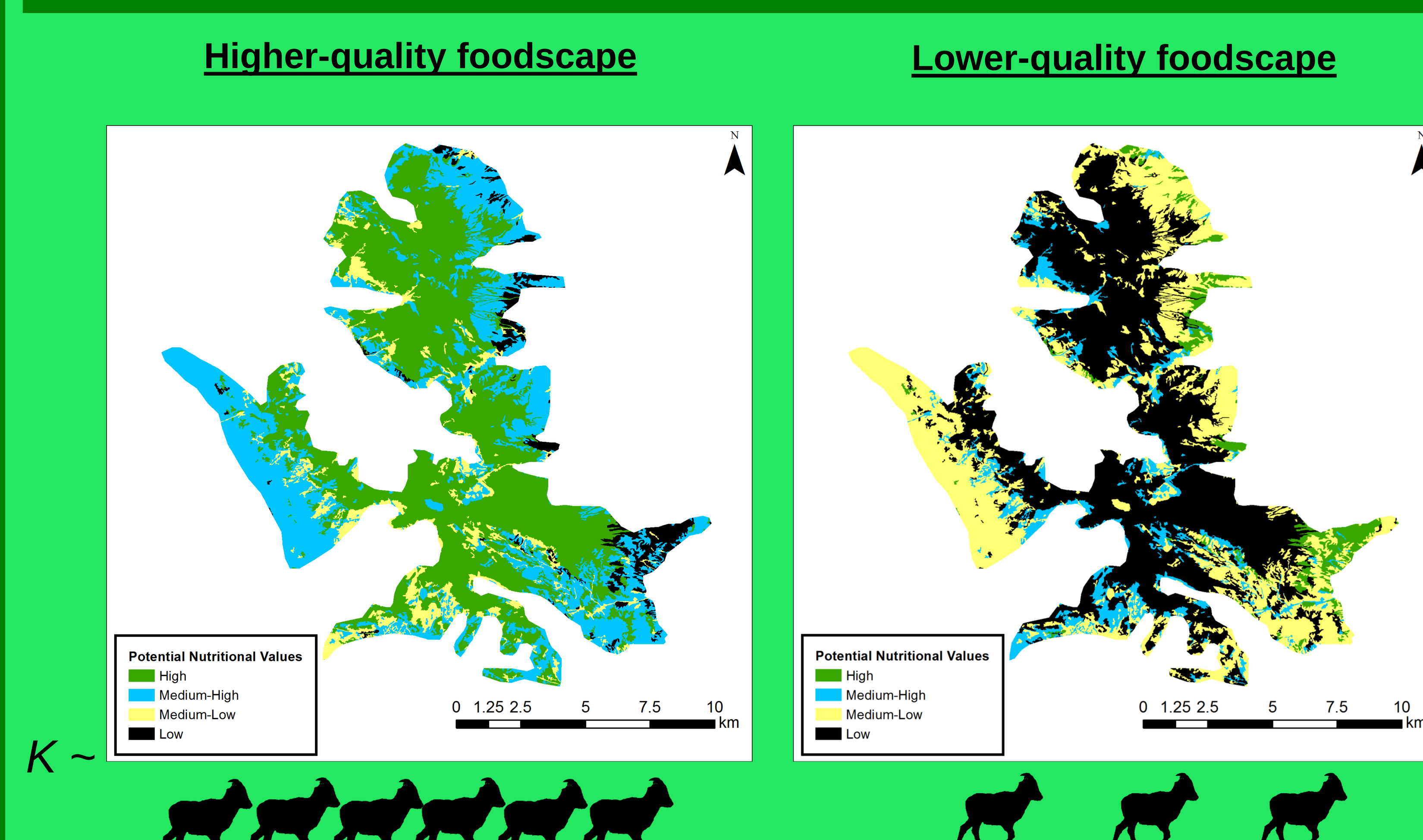


Figure 4. We expect that animals using foodscapes with higher-quality resources (left) will achieve greater nutritional condition, higher fitness, and ultimately, these ranges will support larger populations than low-quality foodscapes (right).

Objective 3: Assess the capacity of available food supplies to meet nutritional requirements of individuals and to support population growth and determine habitat-based nutritional carrying capacity.

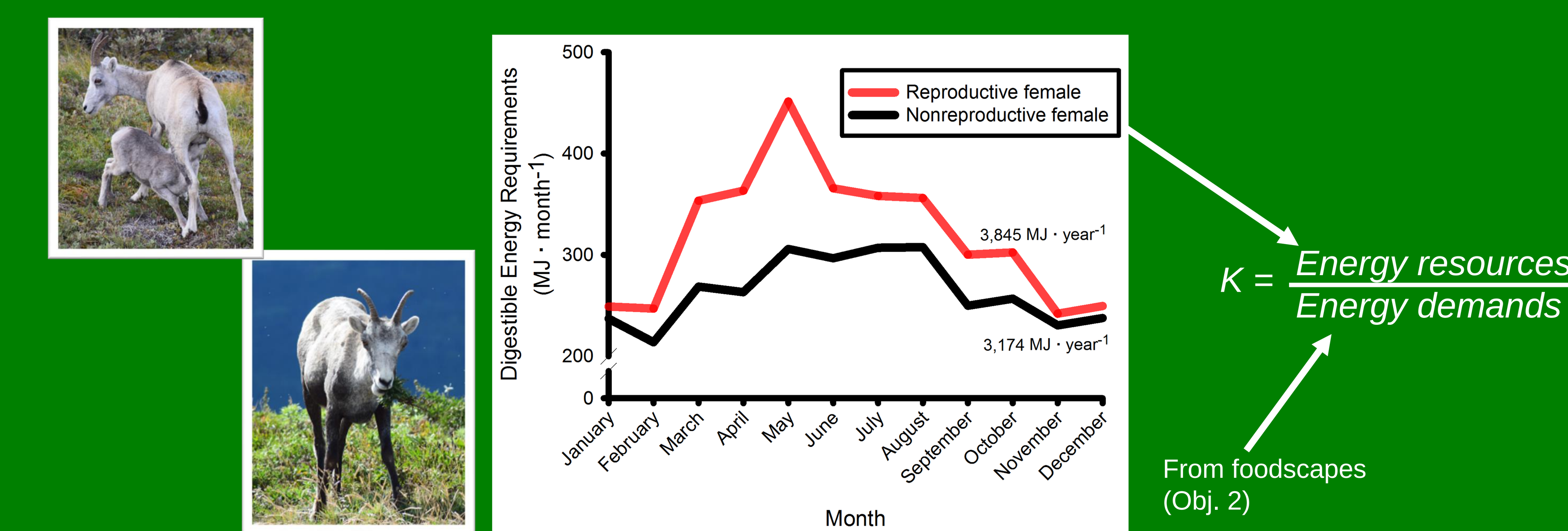


Figure 5. We are developing a dynamic model for determining energy budgets based on resting metabolic rates, with added costs for reproduction, fat gain, daily and seasonal movements, and seasonal changes in metabolic rates. Without incorporating movement rates, annual energy demands for reproductive ewes (gestating then lactating) are 21% greater than for non-reproductive ewes, though the greatest monthly difference occurs in May, coinciding with peak lactation.

Objective 4: Link nutritional condition to demographic rates through an integrated population model.

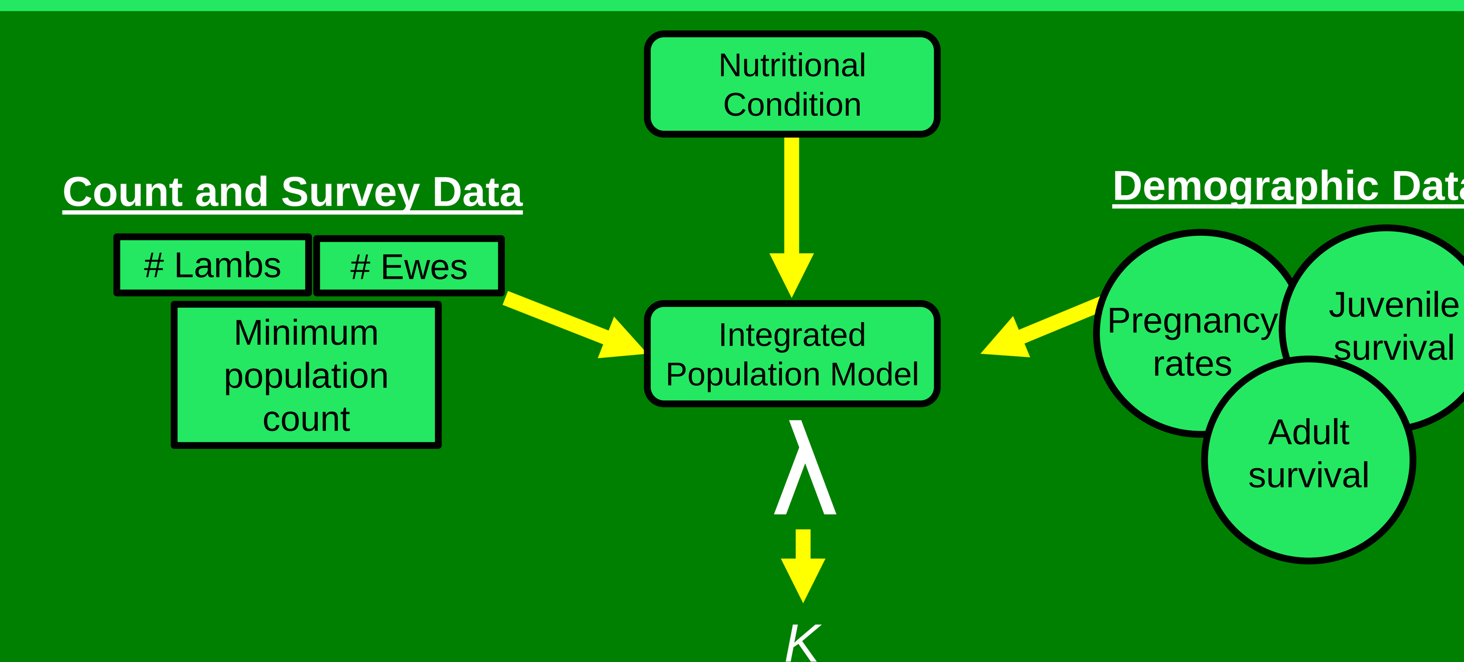


Figure 6. To understand implications of nutrition to populations, we will use an integrated population model to explore how changes in nutritional condition affect demographic and population growth rates. Integrated population models combine both population counts and demographic data to produce more robust, less biased estimates of lambda; lambda can then be used to quantify animal-indicated nutritional carrying capacity (*K*; Monteith et al. 2014).

Relevance to Conservation and Management

- Quantify cause-and-effect relationships between habitat change and population trajectories
- Identify areas with potential to support population growth and long-term persistence of species
  - Guide augmentations and reintroductions; set land-acquisition and habitat-restoration priorities
- Provide realistic estimates of λ and *K* given current foodscapes
  - Determine biologically justifiable timelines to meet numeric recovery goals (e.g., population size)
- Determine if habitat management is warranted or if recovery goals need to be re-evaluated

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