

2018 Grouse & Grazing Project Vegetation Monitoring and Grazing Report Jim Sage Study Site



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INTRODUCTION

Livestock grazing is a common land use within sage-grouse (*Centrocercus urophasianus*) habitat, and livestock grazing has been implicated as one of numerous factors potentially contributing to sage-grouse population declines (Beck and Michell 2000, Schroeder et al. 2004). However, there are also numerous mechanisms by which livestock grazing might benefit sage-grouse (Beck and Michell 2000, Crawford et al. 2004). Livestock grazing on public lands is often restricted so as to limit negative effects on populations of plants and animals (including sage-grouse), but we lack experimental studies that have explicitly examined the effects of livestock grazing on sage-grouse. The objective of the Grouse & Grazing Project is to document the relationship between cattle grazing and sage-grouse demographic traits, nest-site selection, and habitat features. We focus on grazing regimes that include spring cattle grazing because spring is thought to be the time when livestock grazing is most likely to adversely affect sage-grouse (Neel 1980, Pedersen et al. 2003, Boyd et al. 2014).

In 2018, we split our annual reports for this project into two separate reports: one that summarizes field methods, sage-grouse demographic traits, and other data streams and another that summarizes the habitat measurements and grazing metrics that we collect at each study site. Our goal in the vegetation and grazing reports (one for each study site) is to: 1) document the plant community at each site, 2) quantify the % biomass removed or utilization of forage species by cattle at each site, and 3) provide detailed data to assist BLM managers and permittees with management of their grazing and adherence to the Grouse & Grazing study design.

Study Design

The Grouse & Grazing project uses a paired Before-After-Control-Impact (BACI) experimental design with spatial and temporal replication and a staggered-entry approach to evaluate the effects of cattle grazing on sage-grouse demographic traits and habitat characteristics. Paired BACI designs that include both spatial and temporal replication are considered one of the most rigorous experimental designs to assess the effects of a treatment or management action (Green 1979, Bernstein and Zalinski 1983, Stewart-Oaten et al. 1986). We plan to gather data at each study site for ≥ 6 years (≥ 2 years before experimental changes in grazing intensity and ≥ 4 years after experimental changes in grazing intensity). We are using a ‘staggered-entry’ design so that experimental changes in grazing intensity are not initiated at all study sites in the same year. Precipitation and temperature can have large effects on biomass of grasses and forbs and on sage-grouse demographic traits (Skinner et al. 2002, Moynahan et al. 2007, La Pierre et al. 2011, Hovick et al. 2015) and the staggered-entry design will also help us differentiate responses caused by the experimental changes in grazing intensity versus those caused by annual variation in weather. For example, this design ensures that all of the experimental changes in grazing intensity do not occur during a particularly wet or dry year (i.e., it allows separation of a ‘year effect’ from a ‘treatment effect’).

Treatment	Year 1	Year 2	Implement Grazing Treatments	Year 3	Year 4	Year 5	Year 6
Spring Odd Years	Current grazing	Current grazing		Spring Grazing	No Grazing	Spring Grazing	No Grazing
Spring Even Years	Current grazing	Current grazing		No Grazing	Spring Grazing	No Grazing	Spring Grazing
No Grazing	Current grazing	Current grazing		No Grazing	No Grazing	No Grazing	No Grazing
Spring and Fall	Current grazing	Current grazing		Spring Grazing	Fall Grazing	Spring Grazing	Fall Grazing

Figure 1. Experimental design to evaluate potential effects of cattle grazing on sage-grouse demographic traits and habitat features.

At each study site, we collect data (e.g., habitat measurements, utilization estimates, etc.) for ≥ 2 years prior to experimental changes in grazing intensity (Fig. 1). These initial years of field work and data collection at each study site allow us to identify grazing pastures that are appropriate for inclusion in the experiment (based on discussions with permittees and BLM managers and the presence of nesting sage-grouse) and they provide the “Before” measures of demographic traits for the BACI design. In the spring of the 3rd year of sampling at each study site, we alter the grazing regime in 4 pastures per study site and begin grazing those pastures according to 1 of 4 grazing treatments: 1) spring-only grazing in odd years, 2) spring-only grazing in even years, 3) no grazing, and 4) alternating years of spring-only grazing and fall-only grazing (Fig. 1). We define spring grazing as 1 March through 15 June and fall grazing as 1 September through 15 December.

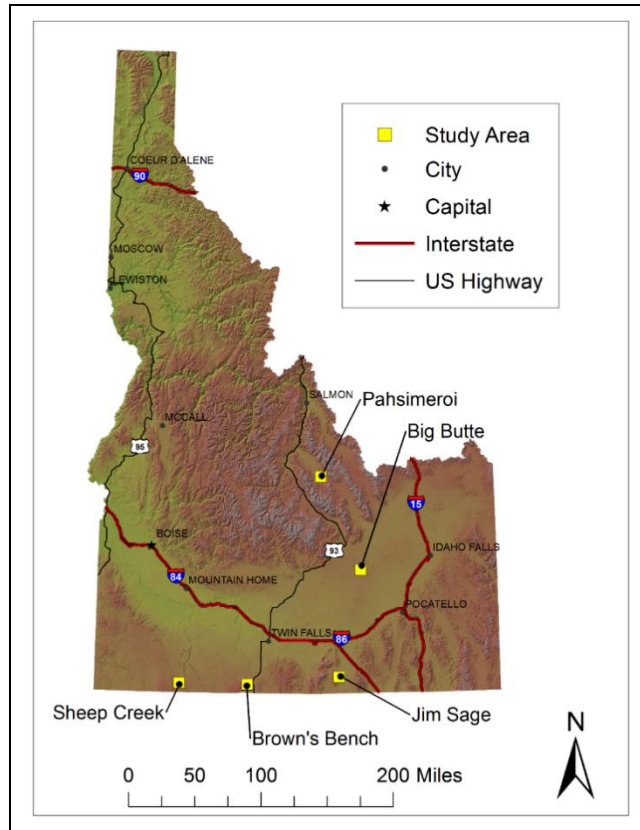


Figure 2. Five study sites in southern Idaho where field work has been conducted for the Grouse & Grazing project in 2018.

STUDY AREA

Jim Sage

We began work at the Jim Sage study site in 2014. The site is located 8 km south of Malta, ID on the east slope of the Jim Sage Mountains. The site has an east-facing aspect and gently slopes towards the Raft River Valley. Sheep Mountain is a lone butte that sits near the eastern edge of the experimental treatment pastures. Nearby human development includes several large dairies and agricultural fields that are roughly 5 km from the experimental treatment pastures. Soils belong primarily to the Womack, Nibbs, and Darkbull complexes which are characterized by slopes ranging from 1-8%, moderately deep to relatively shallow soil depths, and gravely loam to gravely silt loam textures. The plant community at this site consists primarily of low sagebrush (*Artemisia arbuscula*) on the mountain slopes changing to Wyoming (*Artemisia tridentata wyomingensis*) and basin big sagebrush (*Artemisia tridentata tridentata*) at the toe slopes. A hybridized version of Bluebunch wheatgrass (*Pseudoroegneria spicata*) is the primary perennial grass species. The eastern third of the experimental treatment pastures has increasing cheatgrass (*Bromus tectorum*) cover in the understory and it becomes the dominant grass species on the far eastern edge of the pastures.

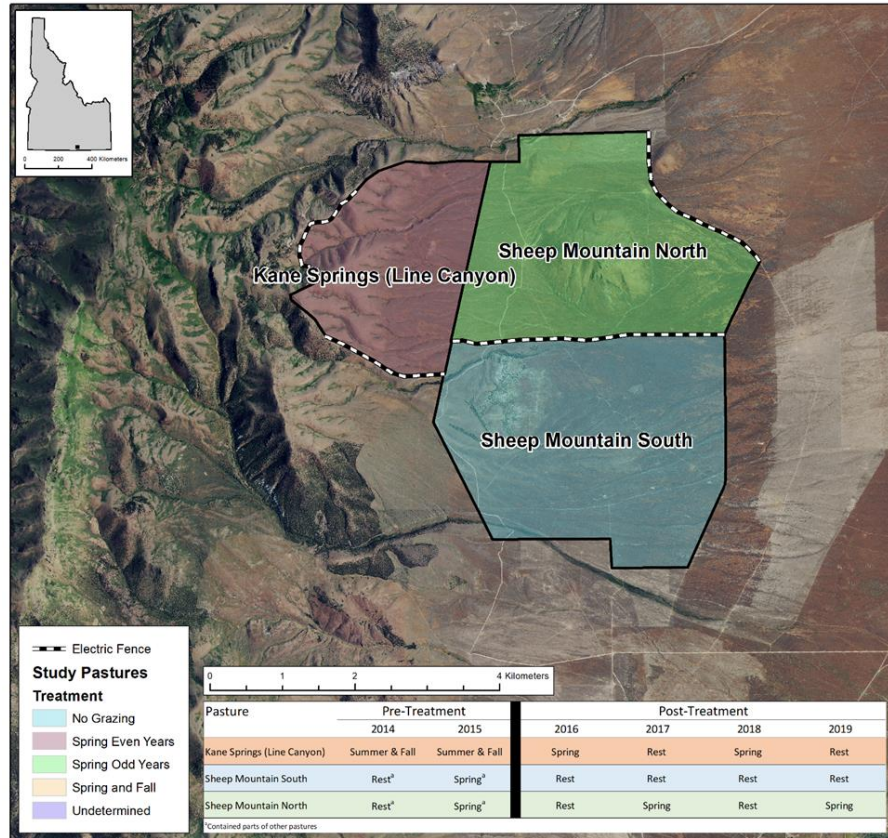


Figure 3. Map of experimental treatment pastures and timeline of treatments at the Jim Sage study site, Idaho.

Elevation at the site ranges from 1,507-2,087 m (mean 1,653 m; USGS National Elevation Dataset). Precipitation comes primarily in the form of snow between November and March with 30-year normal annual amount averaging 247 mm (1980-2010; NOAA Online Climate Dataset). Monthly average temperatures range from a low of -2.5° C (Dec) to a high of 20.7° C (Jul) based on the most recent 30-year normal (1980-2010; NOAA Online Climate Dataset). The Bureau of Land Management (BLM) manages the Jim Sage allotment and livestock grazing is allowed to occur April 1 – November 30 each year. Prior to the study, these pastures were rested at least once every 3rd spring to allow forage species to be undisturbed during the growing season. The permittees in this area run a herd of 100-200 cow/calf pairs each year.

Table 1. Summary of the vegetation data collected for the Grouse & Grazing Project at 5 study sites in southern Idaho, 2014-2018.

Data Stream	Time of Collection	Sample Locations	Years Collected	Purpose
Early Season Vegetation Monitoring	March - April	Nests from previous year and paired random plots	2017 – 2018	Quantify vegetation characteristics when hen is selecting nest site
Nesting Season Vegetation Monitoring	April - July	Nests from current year & random plots ¹	2014 – 2018	Quantify vegetation characteristics of current year nest sites and experimental treatment pastures
Brood Vegetation Monitoring	May - July	Locations where a hen with a brood was confirmed	2016 – 2018	Quantify vegetation at brood locations
Post-Growing Season Vegetation Monitoring	July - August	Random plots	2015 – 2018	Quantify height, obstruction, and utilization of grass
Utilization/Pattern Use Monitoring	July - August	Systematic transects throughout experimental treatment pastures	2015 – 2018	Quantify utilization and grass height
Utilization/Biomass Removal (grazing exclosure cages)	April (cages placed), August (clipped)	Random plots in spring grazed (current year) experimental treatment pastures	2016, 2018	Quantify utilization and biomass removal
Plant Collections	April - August	Experimental treatment pastures and surrounding areas	2017 – 2018	Create a DNA reference database and a library of voucher specimens to confirm plant ID and use as a training guide

¹From 2014-2017, we also measured nesting season vegetation at paired non-nest plots associated with each nest plot (100-200m away from each nest plot).

FIELD METHODS

We have written detailed field sampling protocols for all aspects of the Grouse & Grazing Project, including vegetation sampling protocols (Conway et al. 2018). We are collecting the following vegetation data to help quantify sage-grouse habitat selection and cattle grazing intensity on the experimental treatment pastures associated with the Grouse & Grazing Project (Table 1):

- Early-season Vegetation Surveys
 - Nest plots from prior years
 - Paired random plots
- Nesting-season Vegetation Surveys
 - Nest plots from current year
 - Paired non-nest plots
 - Random plots
- Brood Vegetation Surveys
 - Plots at sites used by hens with broods <42 days of age
- Post-growing Season Vegetation Surveys
 - Random plots
- Utilization Transects
 - Landscape appearance estimates along transects
 - Grass height and percent removal estimates along transects
- Grazing Exclosures
 - Clipping above-ground biomass within grazing exclosure cages
 - Clipping above-ground biomass in paired grazed plots adjacent to cages
- Plant Collection Surveys

For sake of organization, we describe the nesting-season vegetation surveys first because they are the most detailed and subsequently we describe the other types of vegetation surveys since many of them are a reduced version of nesting-season vegetation surveys.

Nesting-Season Vegetation Surveys

We measured nesting-season vegetation (at estimated hatch date for sage-grouse nests) at 3 types of plots: nest plots, paired non-nest plots (100-200 m from each nest), and random plots. Nest plots were centered on sage-grouse nests. Each paired non-nest plot was associated with a specific nest plot (100-200m away in a random direction and centered on a sagebrush shrub that was large enough to contain a sage-grouse nest). Each nest plot had only one paired non-nest plot associated with it. Random plots were at randomly generated locations and were also centered on sagebrush shrubs. All random plots were within the experimental treatment pastures. We randomly generated 40 locations within each experimental treatment pasture that were no closer than 100 m from one another to create random locations to use for random plots.

Plot Placement in the Field

Each year, we strived to conduct vegetation sampling at a minimum of 20 random plots in each pasture (except at Pahsimeroi Valley in 2017-2018 because we monitored 7 pastures and did not have the personnel to complete 20 per pasture; we completed 10-15 per pasture instead). Starting in 2017, we only measured paired non-nest plots when time allowed (we placed priority on nest plots and random plots). We completed 50 paired non-nest plots in 2017 and 0 in 2018.

All plots were centered on a focal shrub. Nest plots were centered on the shrub (or rarely clump of grass) in which the hen built its nest. Paired non-nest and random plots were centered on a focal shrub that was suitable for a sage-grouse nest (based on prior years' nest plot data). At each plot, we spread 2 30-m tapes that intersected at the 15-m mark over the focal shrub in each cardinal direction (Fig. 4).

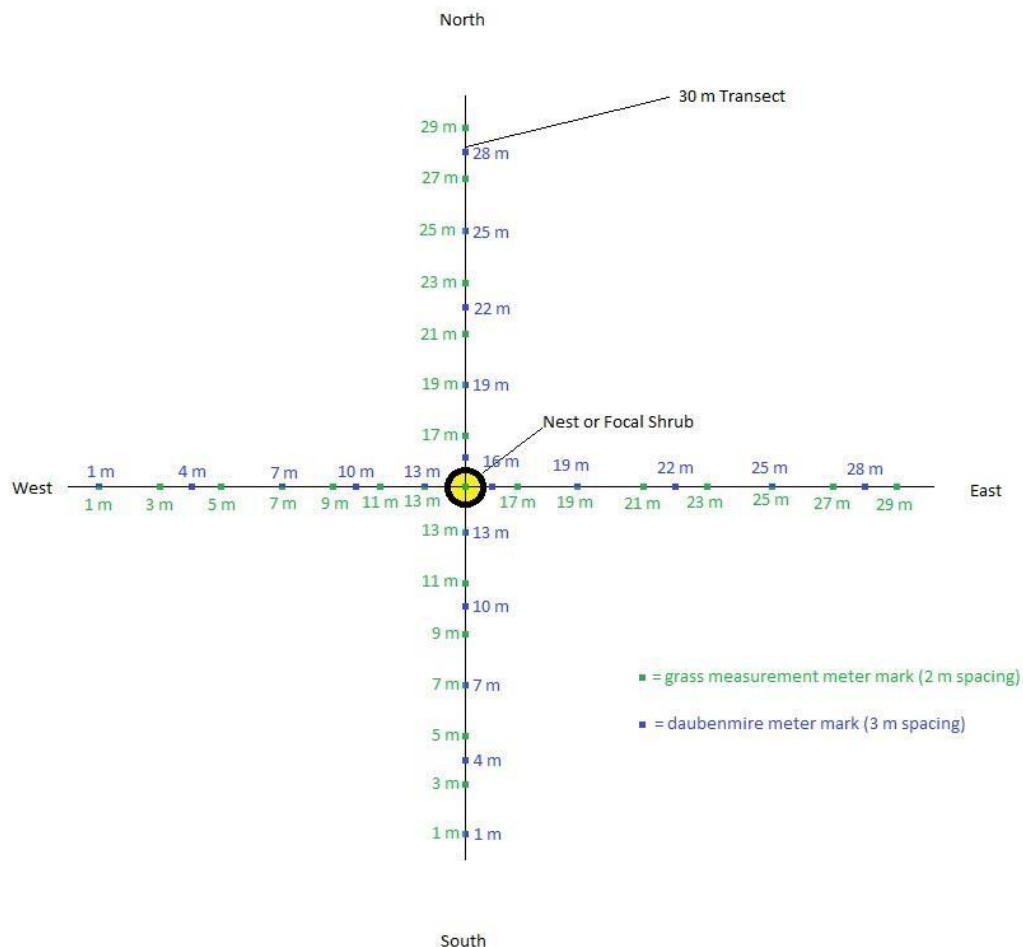


Figure 4. Visual depiction of the placement of 2 30-m tapes stretched to conduct vegetation sampling at nest plots, random plots, and paired non-nest plots for the Grouse & Grazing project in southern Idaho, 2014-2018.

Each plot (nest, paired non-nest, and random plots) consisted of 6 types of data collection: a set of 5 photographs to estimate percent nest concealment, measurements of the nest or focal shrub (or the patch of shrubs), 2 line-intercept transects to estimate percent shrub cover, estimates of perennial grass height (we do not measure heights for cheatgrass, *Bromus tectorum*, or other annuals) and grazing intensity (by species) along the line transects, Daubenmire plots to estimate percent ground cover, and a count of herbivore fecal droppings along the line transects. Detailed descriptions of each of these 6 components are in our vegetation sampling protocols (Conway et al. 2018).

Landscape Appearance

We used the landscape appearance method (Coulloudon et al. 1999) to estimate utilization in experimental pastures (and potential experimental pastures at sites where the experimental pastures had not been selected yet). We used ArcGIS to randomly place a grid of north-south transects in experimental pastures and potential experimental pastures. If the pasture was grazed by livestock during spring or summer, we placed transects 300 m apart and sampled at 200-m intervals along each transect. If the pasture was not grazed by livestock during spring or summer that year, we instead placed transects 500 m apart and sampled at 200-m intervals (because we were expecting minimal utilization in pastures that did not have cows in them). At 200-m intervals along each transect, the observer stopped walking and estimated utilization according to the utilization classes in Coulloudon et al. (1999) within a 15-m radius half-circle in front of them (Table 2). The observer also estimated the percent cover of cheatgrass and the most dominant overstory shrub and perennial grass within the same 15-m radius half-circle in front of them at each sample point along the transect (i.e., every 200 m).

Table 2. Utilization classes that we used to estimate percent utilization along landscape appearance transects (based on Coulloudon et al. 1999).

Utilization	
Class	Description
0-5%	The rangeland shows no evidence of grazing or negligible use.
6-20%	The rangeland has the appearance of very light grazing. The herbaceous forage plants may be topped or slightly used. Current seed stalks and young plants are little disturbed.
21-40%	The rangeland may be topped, skimmed, or grazed in patches. The low value herbaceous plants are ungrazed and 60 to 80 percent of the number of current seedstalks of herbaceous plants remain intact. Most young plants are undamaged.
41-60%	The rangeland appears entirely covered ^a as uniformly as natural features and facilities will allow. Fifteen to 25 percent of the number of current seed stalks of herbaceous species remain intact. No more than 10 percent of the number of low-value herbaceous forage plants are utilized. (Moderate use does not imply proper use.)
61-80%	The rangeland has the appearance of complete search ^b . Herbaceous species are almost completely utilized, with less than 10 percent of the current seed stalks remaining. Shoots of rhizomatous grasses are missing. More than 10 percent of the number of low-value herbaceous forage plants have been utilized.
81-94%	The rangeland has a mown appearance and there are indications of repeated coverage. There is no evidence of reproduction or current seed stalks of herbaceous species. Herbaceous forage species are completely utilized. The remaining stubble of preferred grasses is grazed to the soil surface.
95-100%	The rangeland appears to have been completely utilized. More than 50 percent of the low-value herbaceous plants have been utilized.

^a "covered" means that foraging ungulates have passed through the area.

^b "complete search" means that foraging cattle have spent considerable time foraging in the area and were not just passing through.

Stocking Level

Each year, we record the number and timing of cattle that graze each experimental treatment pasture and those that are near these pastures. We communicated with range management specialists and permittees at each study site to document the number and dates for which cattle were turned out and removed from each pasture. We collected this data for every year of the study at a given field site and ≥ 3 years prior to when we began field work.

SUMMARIZATION METHODS

Pasture Boundaries

The boundary of the pastures in the pre-treatment years was often not the same as the boundary of the pastures after the treatments were implemented. This was typically due to the installation of electric fences to cut existing pastures into 2 halves so that we could concentrate grazing pressure and allow ranchers more flexibility to meet the needs of the study while also achieving the goals of their operation (i.e., so that they only had to adhere to the study design within one half of a pasture). We used the boundary of the post-experimental treatment pastures for all comparisons, even those that included years prior to the treatments.

Pasture Level

For comparison of grass metrics between pastures, we first calculated a mean for each sampling plot because plots were our primary sampling unit. We then used this plot mean to calculate a mean among all plots for an entire pasture. We compared mean droop height of grasses among pastures and years at each study site. For the current year (2018), we also compared grass droop heights within a pasture based on 4 categories: 1) all species combined, 2) all species excluding Sandberg bluegrass, 3) all grasses that were not under a shrub (out in the open), and 4) all grasses that were under a shrub. For the latter 2 categories (under and not under a shrub), we used all perennial grass plants measured regardless of species (i.e., we included Sandberg bluegrass).

Grass Height Measurements

We measured the height of each perennial grass plant in an individual transect in 3 separate ways:

- Droop height – The tallest part of an individual perennial grass (including the flowering stalk)
- Leaf height – The tallest part of the grass plant excluding the flowering stalk (i.e., just the leaves)
- Effective height – A visual obstruction measurement created by placing a meter stick behind the grass plant and recording the lowest interval bar that was $\leq 50\%$ obscured by the grass (Musil 2011; *detailed methods can be found in* Conway et al. 2018).

We compared the differences of these 3 measurements between grazed and un-grazed pastures in 2018. We used the individual grass as the sample unit, not the plot, for this comparison.

Shrub Cover

We compared shrub cover from the line-intercept transects among pastures and years. Cover was estimated by taking the length of the transect that was intercepted by shrubs and dividing it by the length of the entire transect (60 m or 6,000 cm).

Utilization

We estimated utilization based on 3 different methods for this report: 1) Average of ocular estimates of biomass removed for individual grass plants on random vegetation plots, 2) proportion of grazed grass plants (i.e., proportion of grass plants with >0 biomass removed), and 3) utilization estimates via the landscape appearance method (Coulloudon et al. 1999). We compared estimates of biomass removed (via ocular estimation) and proportion of grazed plants at the pasture level for the current year (2018). These estimates were generated at the plot level from the post-growing season vegetation surveys. Those plot-level means were used to calculate pasture-level means. This was done to avoid pseudoreplication because the plot is our sampling unit.

For utilization estimates from the landscape appearance transects, we obtained pasture-level estimates by taking the mean of all points sampled within that pasture. We used the mid-point of the ranges outlined in Table 2 to represent each of the 6 categories (i.e., the “slight” category was the mid-point between 6 and 20, or 13).

We created maps of pattern use by herbivores in each pasture based on our visual estimates of utilization from the landscape appearance transects. We used the Inverse Distance Weighted (IDW) tool in ArcGIS (version 10.4). IDW interpolation is based on the assumption that points closer together are more alike than those further apart. An advantage of using IDW interpolation is that it is an exact interpolator (i.e., the interpolated value at each point where a measurement was taken will line up directly with what was actually measured at that point). We used the 12 nearest neighbors to interpolate each pixel of the resulting raster surface. The resulting maps were then classified into the 6 categories used to estimate utilization in the field (see Table 2).

Stocking Level

We calculated stocking levels in Head-Months (HMs) for all years after our treatments began at each study site. We calculated HMs by using the following formula:

$$\frac{n_c \times (t_2 - t_1)}{\left(\frac{365}{12}\right)}$$

Where n_c is the total number of cow-calf pairs turned into that pasture, t_1 is the initial turn-out date, and t_2 is the date they were removed from the pasture. If there were different stocking levels across a given season (e.g., 100 cows were added to a pasture for the first 10 days and then 100 more cows were added on the 11th day), we calculated HMs for each separate stocking level and summed them together to report the stocking level for the entire season.

RESULTS

Weather

Going into the 2018 growing season, Jim Sage had well below-average overwinter precipitation (Fig. 5A) and average temperatures (Fig. 5B). March brought a pulse of above average precipitation but April and May returned to below-average and average amounts respectively. Temperatures throughout the spring remained within a degree or two of average.

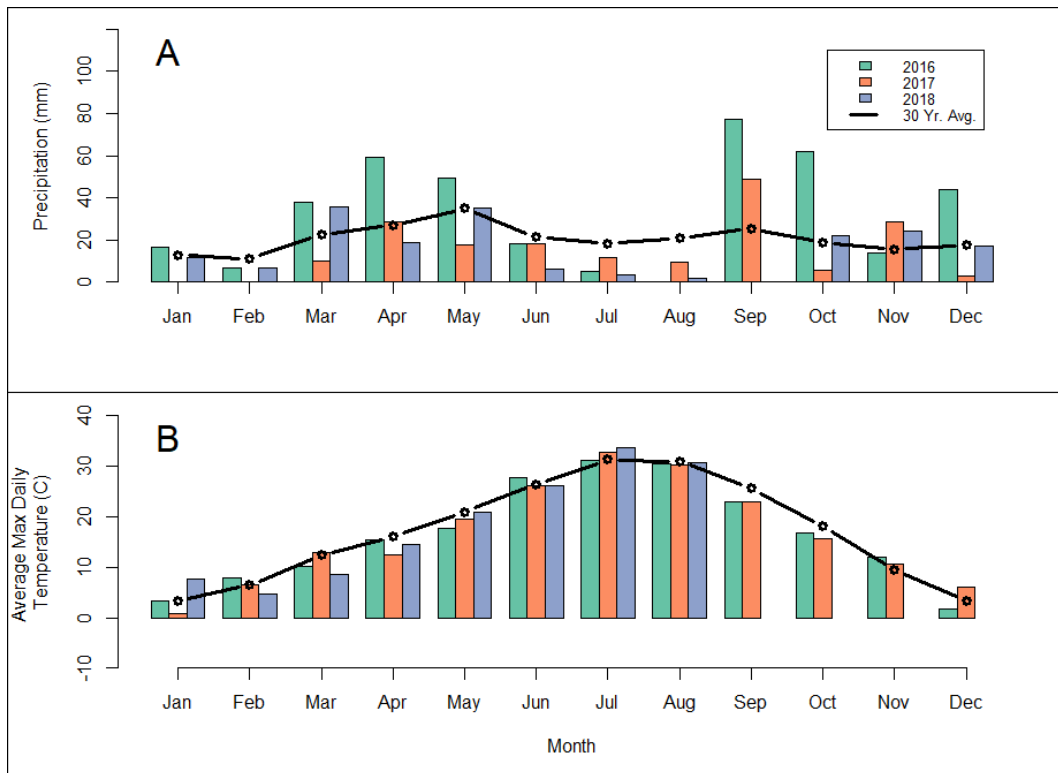


Figure 5. Total monthly precipitation (A) and average max daily temperature by month (B) with 30-year average (dark line) at Jim Sage, Idaho 2016-2018.

Descriptive Vegetation Characteristics

Pasture Level Comparison

Grass heights varied among years and were generally lower in 2014-2015 than after the treatments began in 2016 (Fig. 6). Grass heights were equal or slightly greater in height during post-growing season surveys as compared to nesting season surveys for all pastures. The only glaring exception to this trend was Kane Springs in 2018 when this pasture was grazed between nesting season and post growing season surveys.

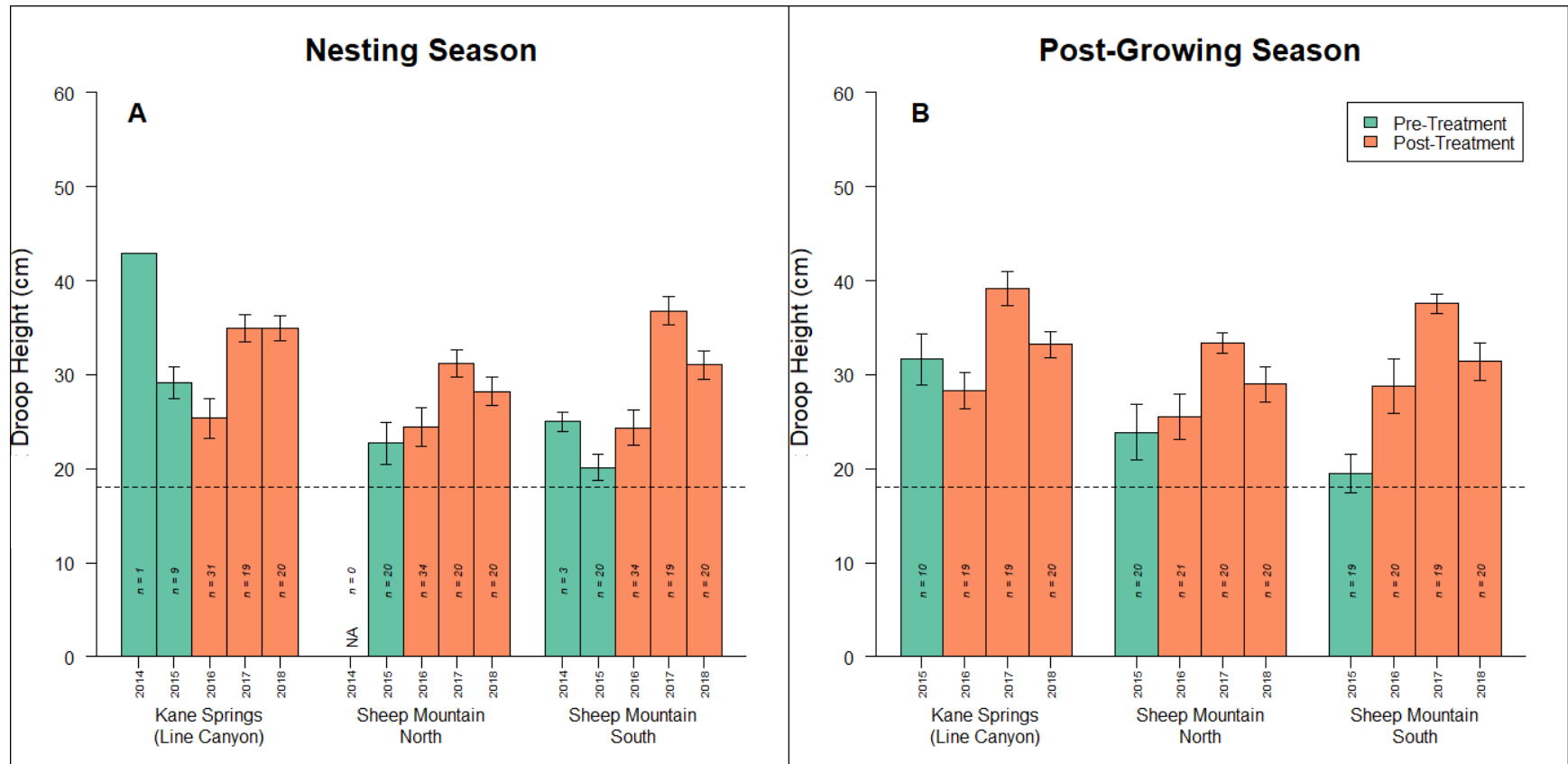


Figure 6. Mean droop height during the nesting season (A; Apr-Jun) and the post-growing season (B; Jul-Aug) for all grass species combined in pre-treatment (green) and post-treatment (orange) years for 4 pastures at Jim Sage, Idaho 2015-2018. Error bars indicate standard errors and means are based on random plots (excludes nest and non-nest plots). NA indicates a pasture that was not measured in that year. The dashed line represents 18 cm (7 in.), the grass height mentioned as a management target in the sage-grouse habitat guidelines (Connelly et al. 2000).

Comparison of different Grasses

Grass under shrubs was taller than grass in the other categories measured in all pastures except Kane Springs (Fig. 7). The other three categories were all very similar to one another within a pasture during the nesting and post-growing season surveys. The only exception was Kane Springs with the all grass excluding sandburg bluegrass (*Poa secunda*) category. This is likely explained by the fact the Kane Springs was grazed in 2018.

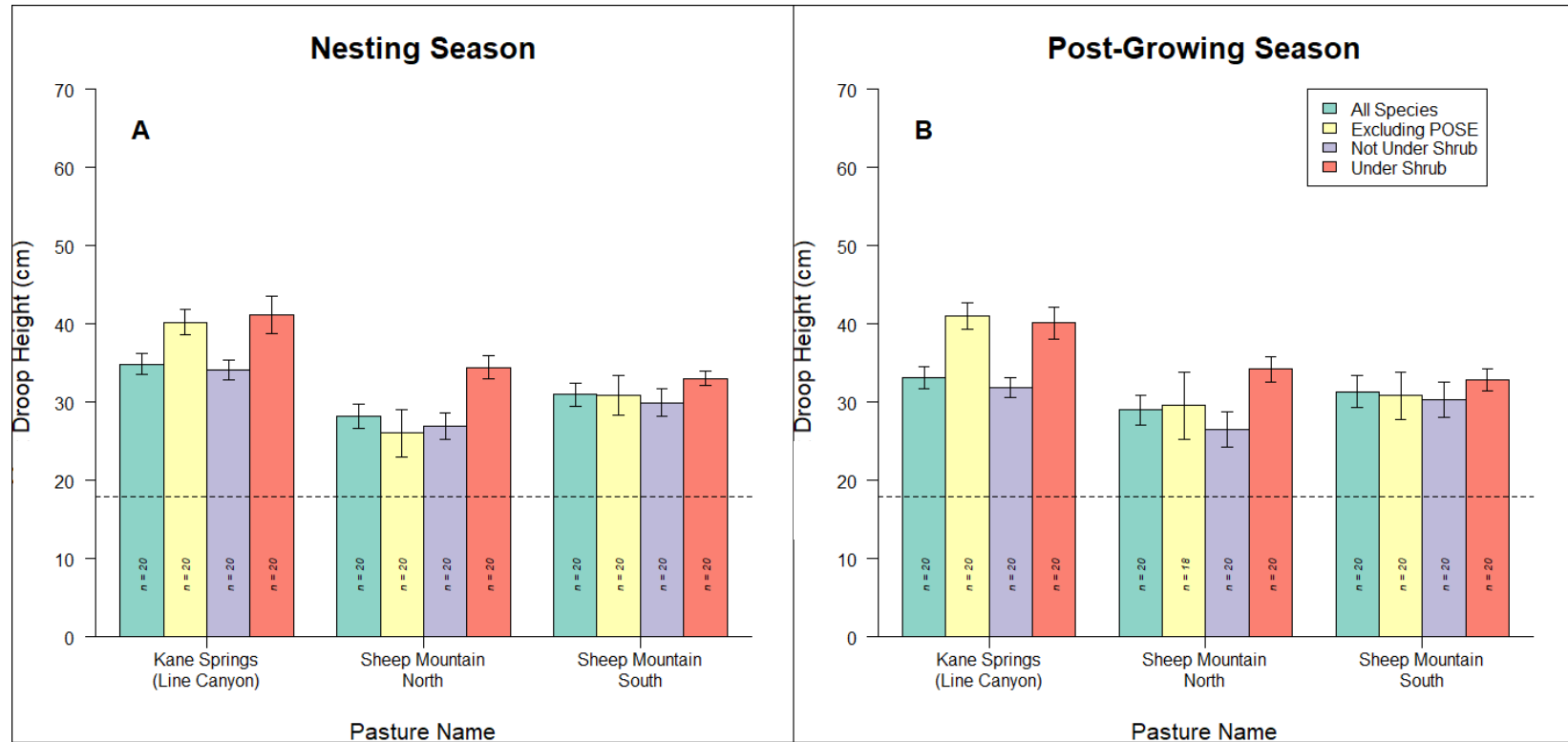


Figure 7. Mean droop height for 4 different subsets of grasses: all grass species within a plot, all grass species excluding Sandberg bluegrass (*Poa secunda*), all grass plants that were under a shrub, and all grass plants that were not under a shrub in both nesting season (A) and post-growing season (B) plots at Jim Sage, Idaho 2018. Error bars represent ± 1 standard error. Sample sizes (n) indicate the number of plots (not the number of grass plants) used to create the mean and standard error. The dashed line represents 18 cm (7 in.), a grass height mentioned as a management target in the sage-grouse habitat guidelines (Connelly et al. 2000).

Grass Height Measurement Comparison

Sandberg bluegrass, bluebunch wheatgrass, squirreltail (*Elymus elymoides*), prairie junegrass (*Koeleria macrantha*), and indian ricegrass (*Achnatherum hymenoides*) were the most abundant grasses in post-growing season surveys in 2018. Grass height differed among species and differences were apparent for all three height measurements (Fig. 8). All grasses that were measured in grazed pastures were shorter than those in ungrazed pastures for the droop height and leaf height measurements except for indian ricegrass. It is important to note that this species had a very small sample of ungrazed plants ($n = 4$). Interestingly for bluebunch wheatgrass we only observed a small difference (<2 cm) in effective height between plant in grazed vs. ungrazed pastures.

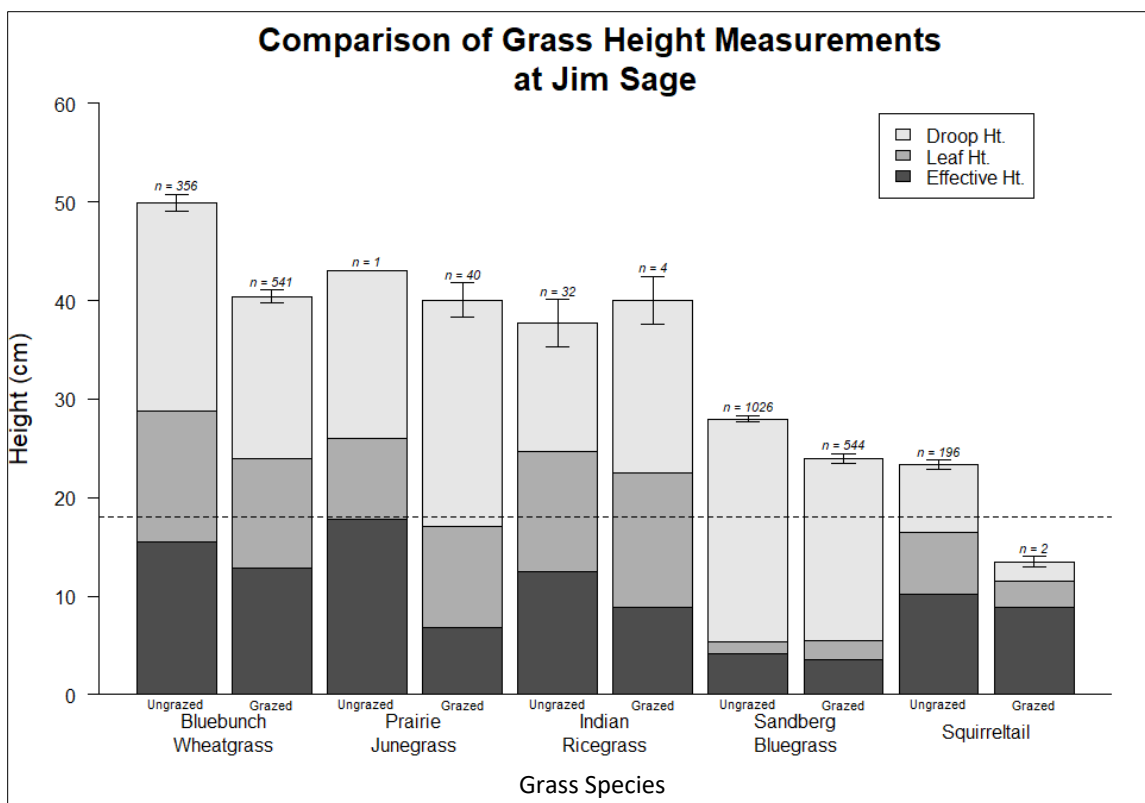


Figure 8. Mean height of the 5 most common species of perennial grasses based on 3 height metrics on post-growing season (Jul-Aug) random plots at Jim Sage, Idaho in 2018. Heights compared were droop height (using highest part of plant) = “Droop Ht.”, droop height excluding the flowering stalk = “Leaf Ht”, and effective height (modified visual obstruction for an individual plant) = “Effective Ht”. Heights were compared separately for plants in ungrazed and grazed pastures based on whether they were grazed in 2018 prior to post-nesting season surveys (denoted directly below each bar). Sample sizes are just below the top of each bar. Error bars denote ± 1 standard error of the droop height only. The dashed line represents 18 cm (7 in.), the grass height mentioned as a management target in the sage-grouse habitat guidelines (Connelly et al. 2000).

Shrub Cover

Shrub cover was fairly consistent between years in the Kane Springs pasture. In general, shrub cover has increased slightly in both Sheep Mountain North and Sheep Mountain South as the study has progressed (Fig. 9). Low sage makes up a majority of the sagebrush cover in in the Kane Springs and Sheep Mountain South pasture while Wyoming and basing big sagebrush are found in the eastern portion of the Sheep Mountain North.

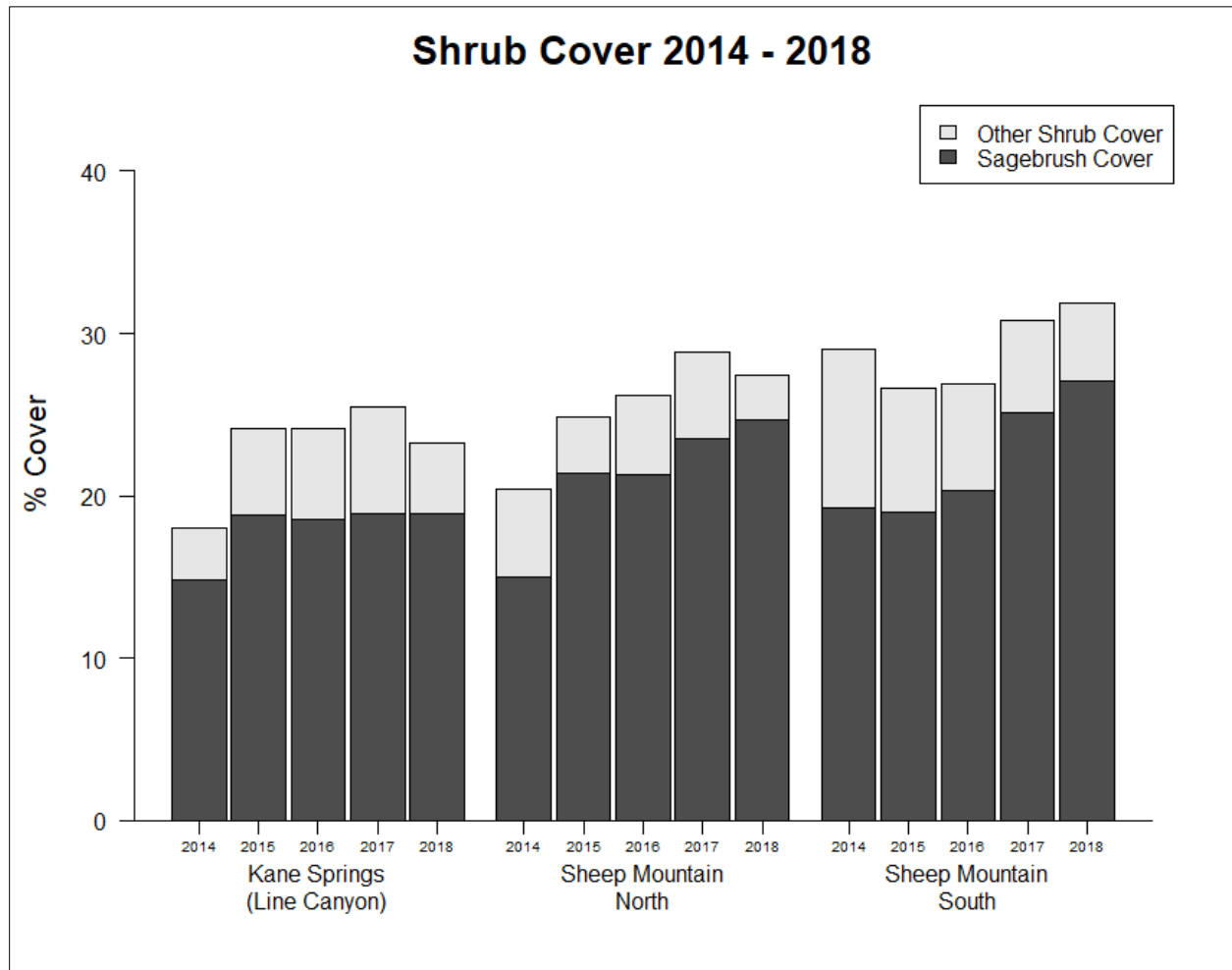


Figure 9. Shrub cover (split into sagebrush and other shrub cover) and in each of 4 experimental treatment pastures at Jim Sage, Idaho 2014-2018.

Stocking Levels and Grazing Pressure

Treatments began at Jim Sage in 2016 and have gone the smoothest of any of the study sites. Sheep Mountain South is our “no grazing” pasture, while Sheep Mountain North and Kane Springs are our alternating “spring only” treatments. Head-Months were higher in the Sheep Mountain North pasture in 2017 because that permittee runs a slightly large herd than the permittee in who uses the Kane Springs pasture. Head-months ranged from a low of 108 in 2018 to a high of 395 in 2017 thus far in the experimental treatment pastures (Fig. 10).

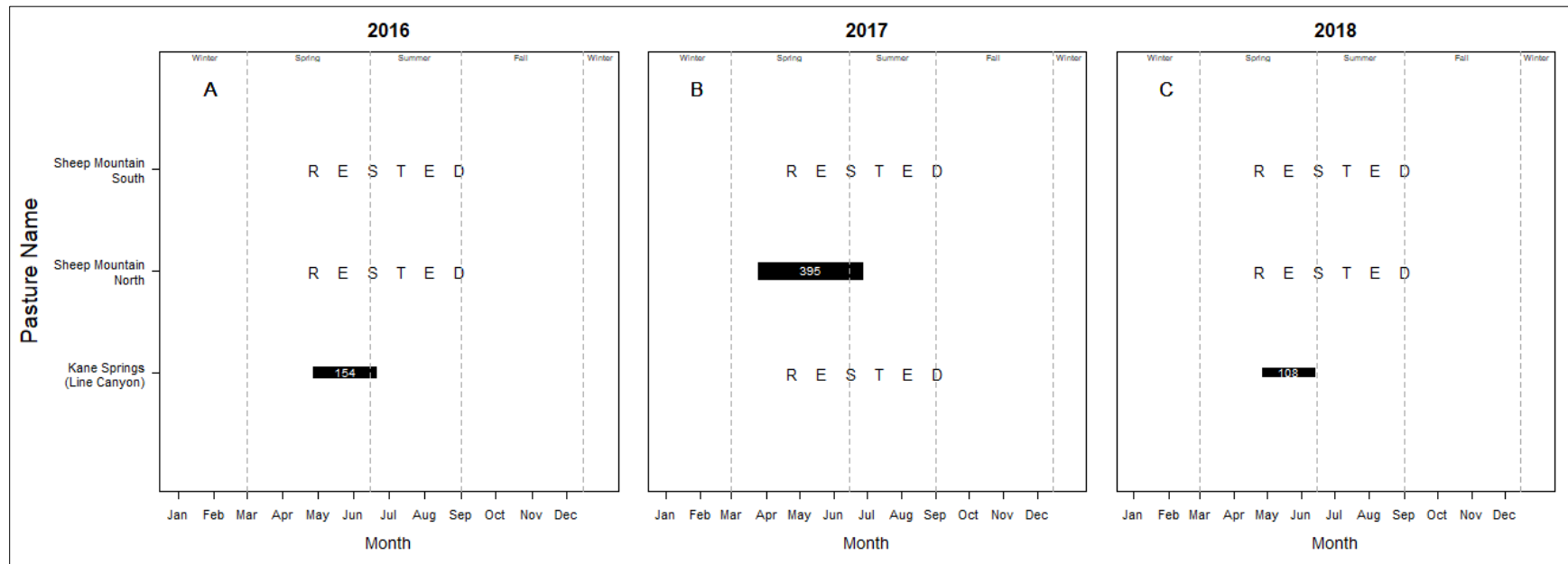


Figure 10. Timing and duration of cattle stocking at the Jim Sage study site during 2016-2018. Width of the black bars indicate the average number of cattle per day in that pasture. White numbers inside black bars represent the total Head-Months during that period.

In 2018, Stocking level in the experimental treatment pastures were comparable to surrounding pastures (those not part of the study; Fig. 11). Two of the experimental treatment pastures were rested in 2018. All but one pasture near our treatments were grazed in 2018.

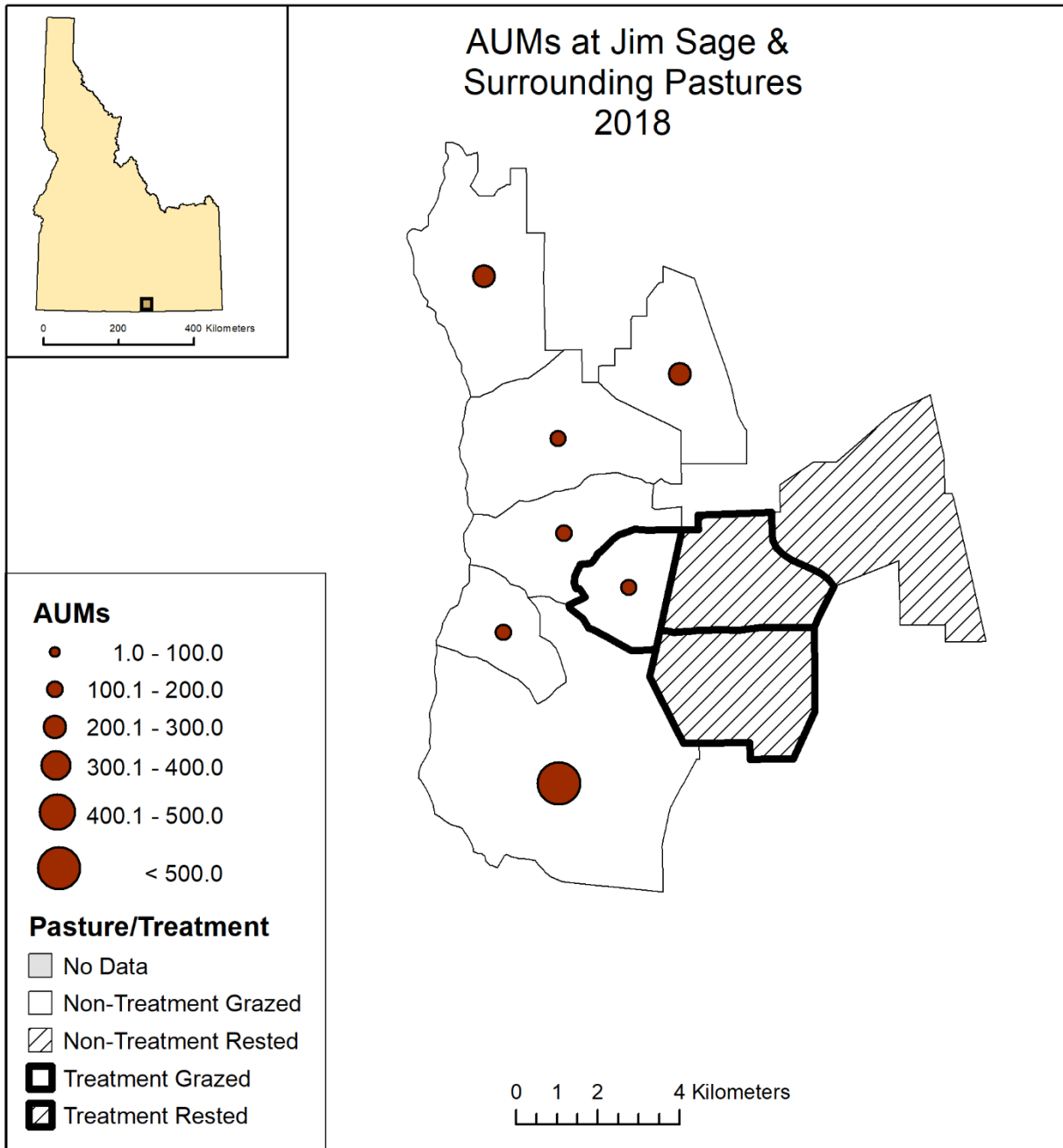


Figure 11. Stocking level in head-months in treatment and surrounding pastures at Jim Sage, Idaho in 2018.

Estimates of Utilization

Utilization estimates were negligible in Sheep Mountain South for the visual estimates of biomass removed on individual plants (Fig. 12A) and the proportion of grazed plants (Fig. 12B). For all measurements the proportion of grazed plants always yielded a higher estimate of utilization than the estimate derived from % biomass removed across all categories and pastures. Even though it was not grazed we did observe some evidence of grazing in the Sheep Mountain North pasture. This could have been from wildlife or when cattle were trailed out of Kane Springs to an adjacent pasture.

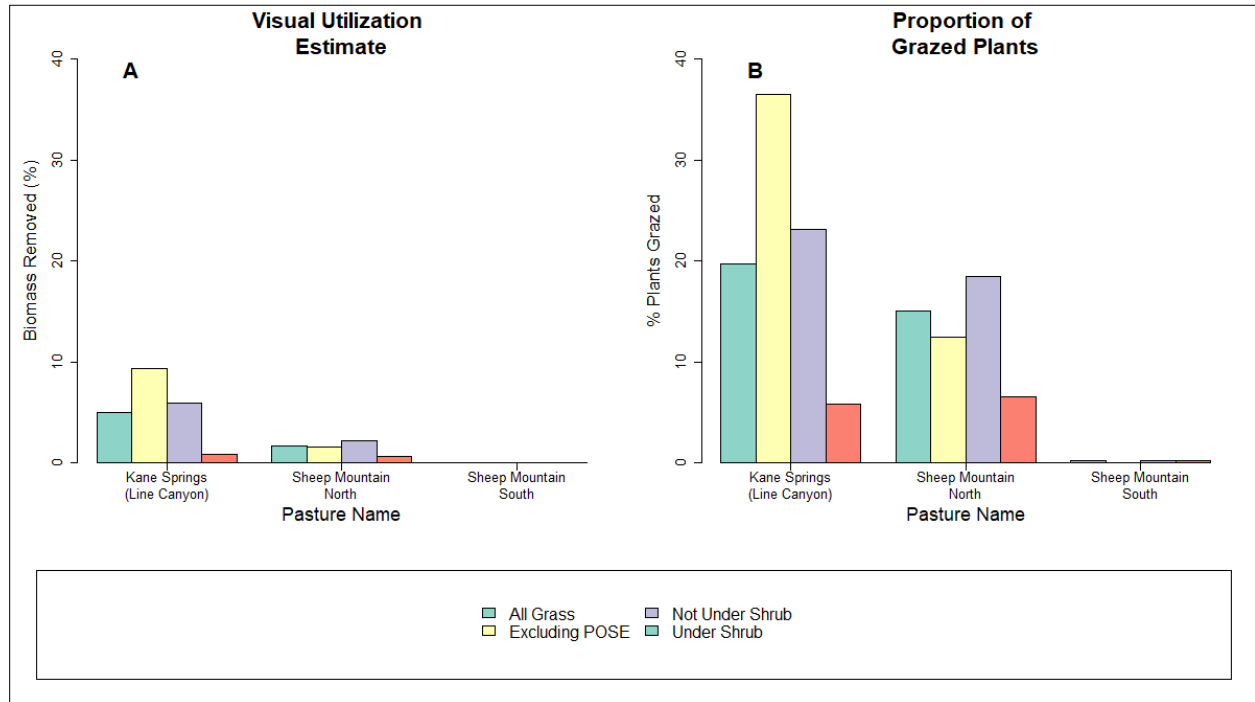


Figure 12. Utilization estimates based on visual estimates of percent biomass removed on individual plants and the proportion of plants grazed at random plots in 2018 at Jim Sage, Idaho. Estimates were taken from the post-growing season surveys conducted in July – August 2018. In 2018, Kane Springs (Apr-Jun) was the only pasture grazed prior to post-growing season surveys.

Utilization estimates from the landscape appearance method varied among pastures and years. The difference between grazed pastures (Kane Springs 2016 & 2018 and Sheep Mountain North 2015 & 2017) and ungrazed pastures (Sheep Mountain South 2016-2018) was evident with this approach as well (Fig. 13).

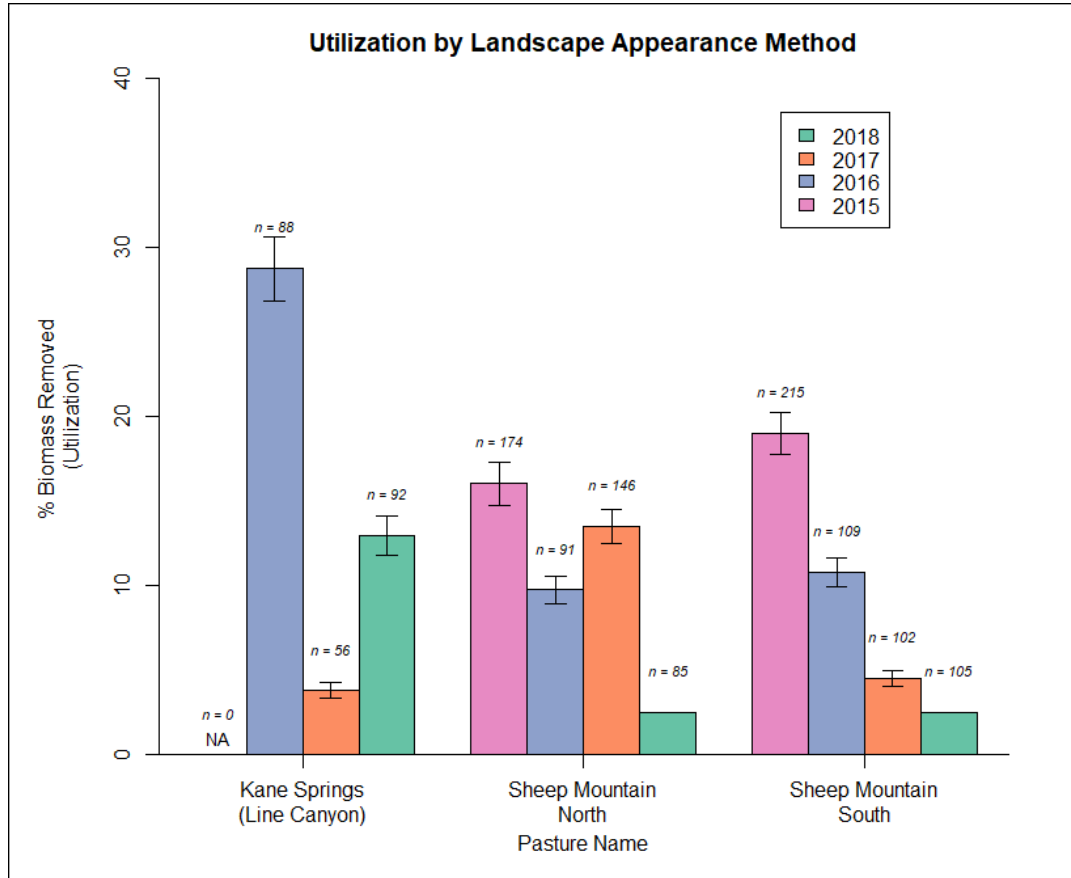


Figure 13. Utilization estimates using the landscape appearance method for pre- and post-treatment periods at Jim Sage, Idaho 2015-2018. Error bars represent ± 1 standard error. NA indicates that pasture was not measured in that particular year.

One of the advantages of using the landscape appearance method is that we can map spatial patterns of cattle use throughout each pasture. Not surprisingly, we found that cattle do not uniformly graze any of the experimental treatment pastures (Fig. 14). This is likely due to lack of uniform availability of water, topography, and grass. This was apparent in both Kane Springs in 2016 & 2018 as well as Sheep Mountain North in 2017 (Fig. 14); cattle had much higher use near water sources and typically left the interiors of these pastures or areas with steeper slopes less used.

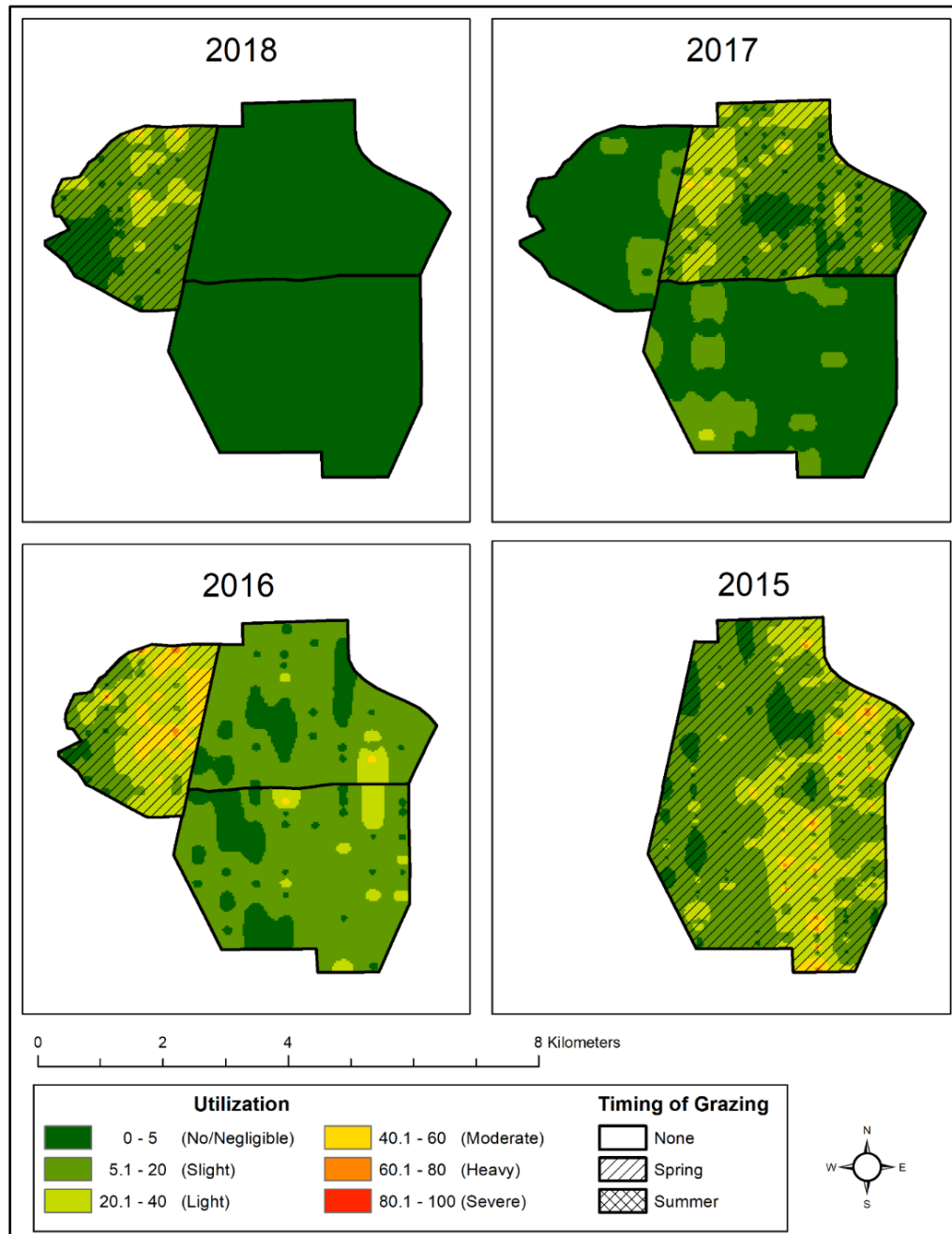


Figure 14. Pattern use mapping from landscape appearance method transects at Jim Sage, Idaho 2015-2018.

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