2021 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 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).

Starting in 2018, we split our annual report for this project into several reports: one that summarizes field methods, sage-grouse demographic traits, and other data streams for all study sites, and a set of vegetation and grazing reports that summarize the habitat measurements and grazing metrics that we collect at each study site. Our goal in the vegetation monitoring 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 Bureau of Land Management (BLM) managers and permittees with management of their grazing and adherence to the Grouse & Grazing study design.

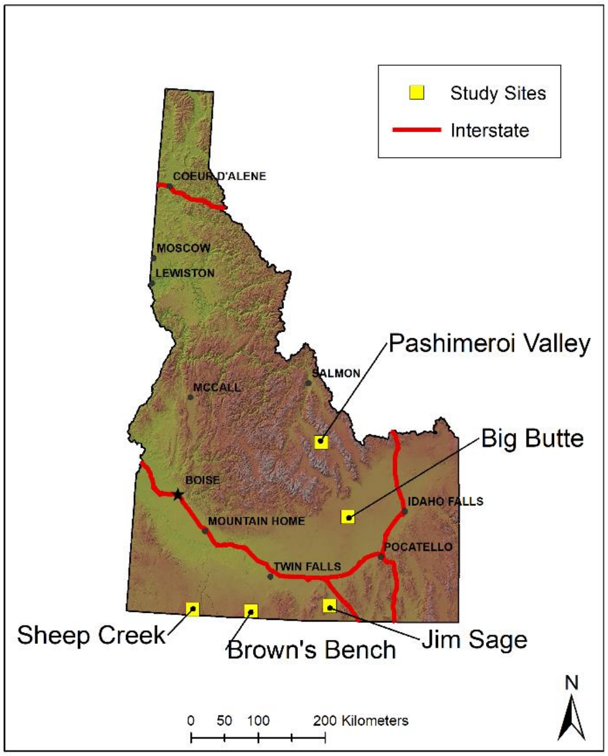
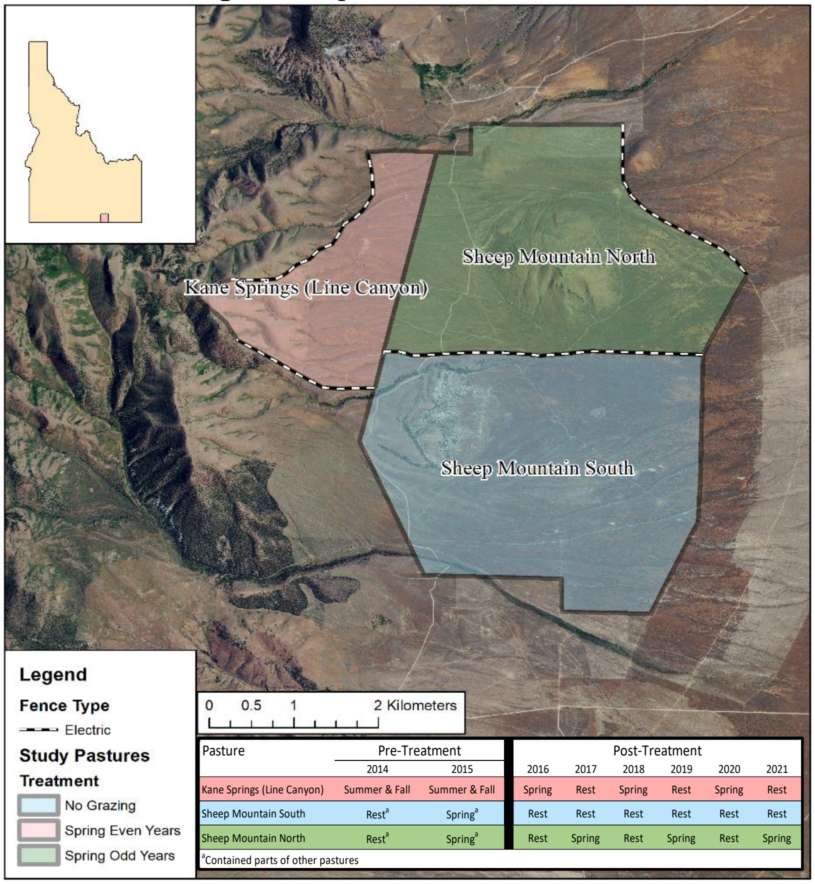


Figure 1. Five study sites in southern Idaho where field work has been conducted for the Grouse & Grazing Project, 2014-2021.

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 (Figs. 1-2). 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 sagebrush (*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.



Pasture	Pre-Treatment		Post-Treatment					
	2014	2015	2016	2017	2018	2019	2020	2021
Kane Springs (Line Canyon)	Summer & Fall	Summer & Fall	Spring	Rest	Spring	Rest	Spring	Rest
Sheep Mountain South	Rest[a]	Spring[a]	Rest	Rest	Rest	Rest	Rest	Rest
Sheep Mountain North	Rest[a]	Spring[a]	Rest	Spring	Rest	Spring	Rest	Spring

[a]Contained parts of other pastures

Figure 2. Map of current 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 and the 30-year average annual amount is 254 mm per year (1980-2010; PRISM Climate Group). Monthly average temperatures range from a low of -3° C (Dec) to a high of 20° C (Jul) based on the most recent 30-year normal (1980-2010; PRISM Climate Group). The Jim Sage allotment is managed by BLM and livestock grazing is allowed to occur 1 April – 30 November 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 herds of 100-200 cow/calf pairs each year.

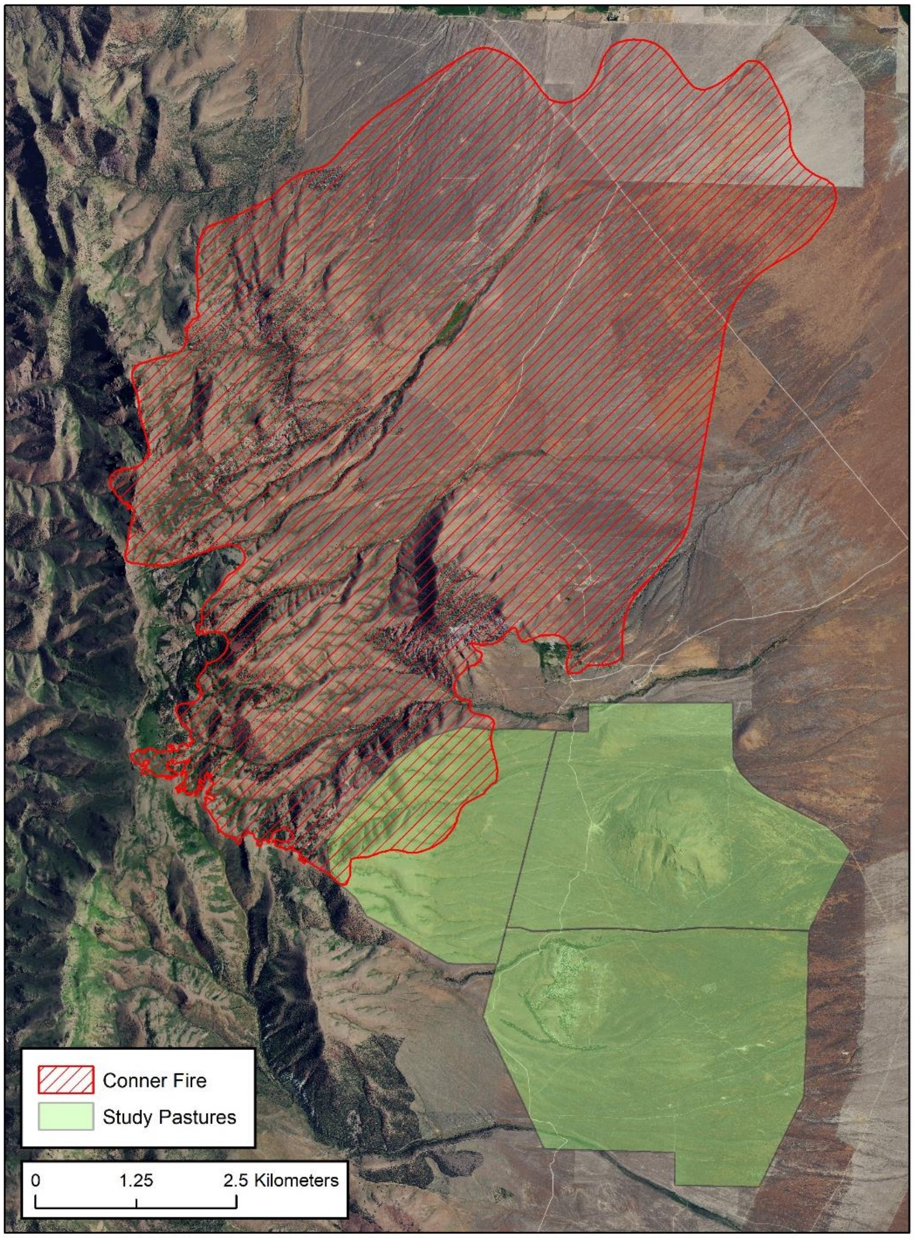


Figure 3. Map of the Conner Fire that burned a portion of the study pastures at the Jim Sage study site from 22 Sep – 3 Oct 2018.

Conner Fire

The Conner Fire burned from 22 September 2018 to 3 October 2018, and burned 13,617 acres. A total of 513 acres of this fire burned across the northwestern side of a study pasture (Fig. 3), forcing us to change the boundary of the pasture to exclude the burned area from cattle grazing. While the burn caused us to reduce the size of our experimental pasture, it did not influence our grazing schedule.

Table 1. Summary of the vegetation data collected for the Grouse & Grazing Project at 5 study sites in southern Idaho, 2014-2021.

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 – 2021	Quantify vegetation characteristics when hen is selecting nest site
Nesting Season Vegetation Monitoring	April - July	Nests from current year & random plots[1]	2014 – 2021	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 – 2021	Quantify vegetation at brood locations
Lek Vegetation Monitoring	May – July	Center of male display activity on lekking grounds	2020-2021	Quantify vegetation at lek locations
Cattle Vegetation Monitoring	May – July	At locations within treatment pastures that had the most cattle use	2021	Quantify shrub cover at locations with the most cattle use
Post-Growing Season Vegetation Monitoring	July - August	Random plots	2015 – 2021	Quantify height, obstruction, and utilization of grass
Utilization/Pattern Use Monitoring	July - August	Systematic transects throughout experimental treatment pastures	2015 – 2021	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, 2018-2019	Quantify utilization and biomass removal
Plant Collections	April - August	Experimental treatment pastures and surrounding areas	2017 – 2021	Create a DNA reference database and a library of voucher specimens to confirm plant ID and use as a training guide

[1]From 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 (*Sections 8-9 of* Conway et al. 2021). 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 dependent non-nest plots
  - Random plots
- Brood Vegetation Surveys
  - Plots at sites used by hens with broods <42 days of age
- Lek Vegetation Surveys
  - Plots centered on sage grouse leks
- Cattle Vegetation Survey
  - Plots centered on areas with the most cattle use within experimental pastures
- Post-growing Season Vegetation Surveys
  - Random plots
- Utilization Transects
  - Landscape appearance estimates along transects
  - Grass height and percent removal estimates along transects
- Grazing Exclosures (Discontinued after the 2019 season)
  - 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 then 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 three types of plots: nest plots, paired non-nest plots (hereafter referred to as non-nest plots), 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 large enough to contain a sage-grouse nest). We did not conduct surveys at non-nest plots in 2021. All random plots were within the experimental grazing pastures and were centered on a sagebrush shrub. 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, including 2021, we conducted vegetation sampling at a minimum of 20 random plots in each pasture (except at Pahsimeroi Valley in 2017-2019 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, 0 in 2018, 3 in 2019, 0 in 2020, and 0 in 2021.

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

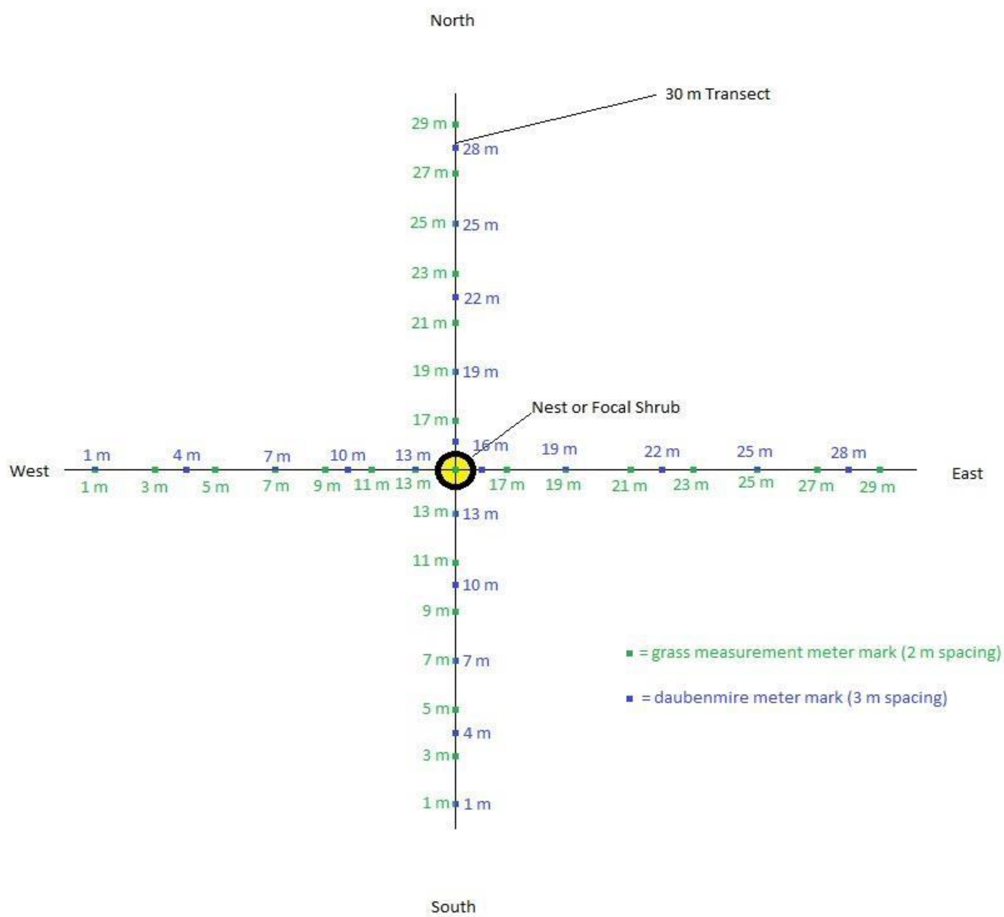


Figure 4. Visual depiction of the placement of two 30-m tapes stretched to conduct vegetation sampling at nest plots, random plots, and paired non-nest plots for the Grouse & Grazing Project in southern Idaho, 2014-2021.

Each plot (nest, non-nest, and random plots) consisted of 6 types of data collection:

1. a set of 5 photographs to estimate percent nest concealment
2. measurements of the nest or focal shrub (or the patch of shrubs)
3. two line-intercept transects to estimate percent shrub cover
4. estimates of perennial grass height (we do not measure heights for cheatgrass, *Bromus tectorum*, or other annuals) and grazing intensity (by grass species) along the line transects
5. Daubenmire plots to estimate percent ground cover
6. a count of herbivore fecal droppings along the line transects

Detailed descriptions of each of these 6 components are in our vegetation sampling protocol (Conway et al. 2021).

Landscape Appearance

We used the landscape appearance method (Coulloudon et al. 1999) to estimate utilization in experimental pastures (and potential experimental pastures in years prior to when the experimental pastures were selected). 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/summer of that year, 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/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) (Table 2) within a 15-m radius half-circle in front of them. 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 each 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.

Cattle Use Metrics

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

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 two 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-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 (2021), we also compared grass droop heights within a pasture based on 4 categories: 1) all perennial species combined, 2) all perennial species excluding Sandberg bluegrass (*Poa secunda*), 3) all perennial grasses that were not under a shrub (out in the open), and 4) all perennial grasses that were under a shrub. For the latter two 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 measure the height of each perennial grass plant along transects 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 ≤50% obscured by the grass (*based on* Musil 2011, *detailed methods can be found in* Conway et al. 2021).

We compared these 3 different measurements between grazed and un-grazed pastures in 2021. We used the individual grass as the sample unit, not the plot, for these comparisons.

Shrub Cover

We compared shrub cover from the line-intercept transects among pastures and years. We estimated shrub cover by taking the length of the transects that were intercepted by shrubs and dividing it by the entire length of the 2 transects (60 m).

Utilization & Offtake

We estimated utilization and offtake via three 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 (2021). 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 since the plot is our sampling unit.

For utilization via 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., we used 13% for the "slight" category because it is the mid-point between 6% and 20%).

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 10.6) to interpolate utilization in areas between sampling points. 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 utilization categories to help visualize the spatial variation in utilization (see categories in Table 2).

Stocking Rate

We calculated stocking rates in Animal Unit Months (AUMs) for all years after our treatments began at each study site. We calculated AUMs by using the following formula:

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

Where n_c is the total number of cow-calf pairs turned out in 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 rates across a given season (e.g., 100 cows were added for the first 10 days and then 50 additional cows were added on the 11^{th} day), we calculated AUMs for each separate stocking rate and summed them together to report the stocking rate for the entire season.

RESULTS

Weather

Going into the 2021 growing season, Jim Sage received below-average overwinter precipitation (Fig. 5A) and slightly above average temperatures (Fig. 5B). In recent years, Jim Sage has consistently received higher precipitation amounts during the growing season than the other 4 study sites in the Grouse & Grazing Project. In 2021, the site received more precipitation than other sites, however this precipitation was still well below the 30-year average.

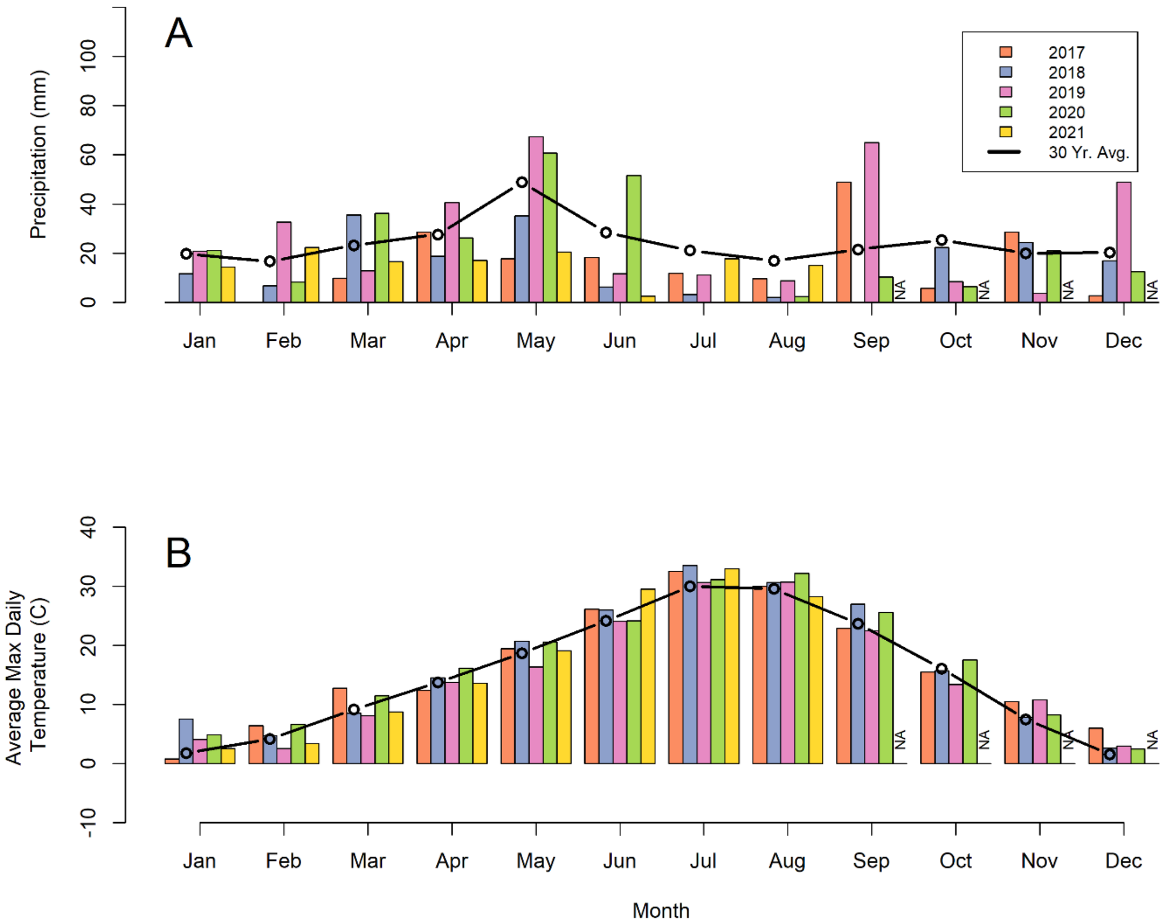


Figure 5. Monthly precipitation totals (A) and average max daily temperature (B) by month with 30-year average (dark line) at Jim Sage, Idaho 2017-2021.

Descriptive Vegetation Characteristics

Pasture-level Comparison

Grass heights varied among years and have generally correlated more with precipitation than grazing status (Fig. 6). Jim Sage received above average overwinter precipitation (170 mm) before the 2017 season, which led to the tallest grass heights observed at the site since the project began. In contrast, the site experienced below-average overwinter precipitation (87 mm) in 2021, the effect of which can be seen in the short grass heights observed during the nesting season. The grass heights in nesting season surveys were similar to those in 2020, but much lower during post-growing season surveys. This is likely due to the drought experienced across Idaho; grass heights were actually lower during post-growing season surveys as compared to nesting season surveys for all pastures. A thesis by Janessa Julson (2017) documented the extent of variation in grass height among our study sites.

Mean grass height under shrubs (red bars) and all grasses excluding POSE (yellow bars) were taller than the other grass height categories in all pastures for both nesting and post-growing season (Fig. 7). The mean grass height of grass not under a shrub (purple bars) was the shortest in all pastures for both nesting season and post-growing season surveys. Grass heights for all categories between nesting and growing season surveys remained the same or slightly decreased for all pastures. Typically, we see an increase in grass heights between nesting and growing season surveys, especially in rested pastures, but there was little grass growth in any of our pastures this year due to the lack of precipitation. Due to lack of new growth and forage, cattle only grazed in Sheep Mountain North for a short period of time, which may be the reason we don’t see much of a difference between rested and grazed pasture grass heights. It is important to note that cattle do not graze pastures evenly (Fig. 14) and some areas within the experimental treatment pastures have greater reductions in grass height than others due to spatial variation in grazing.

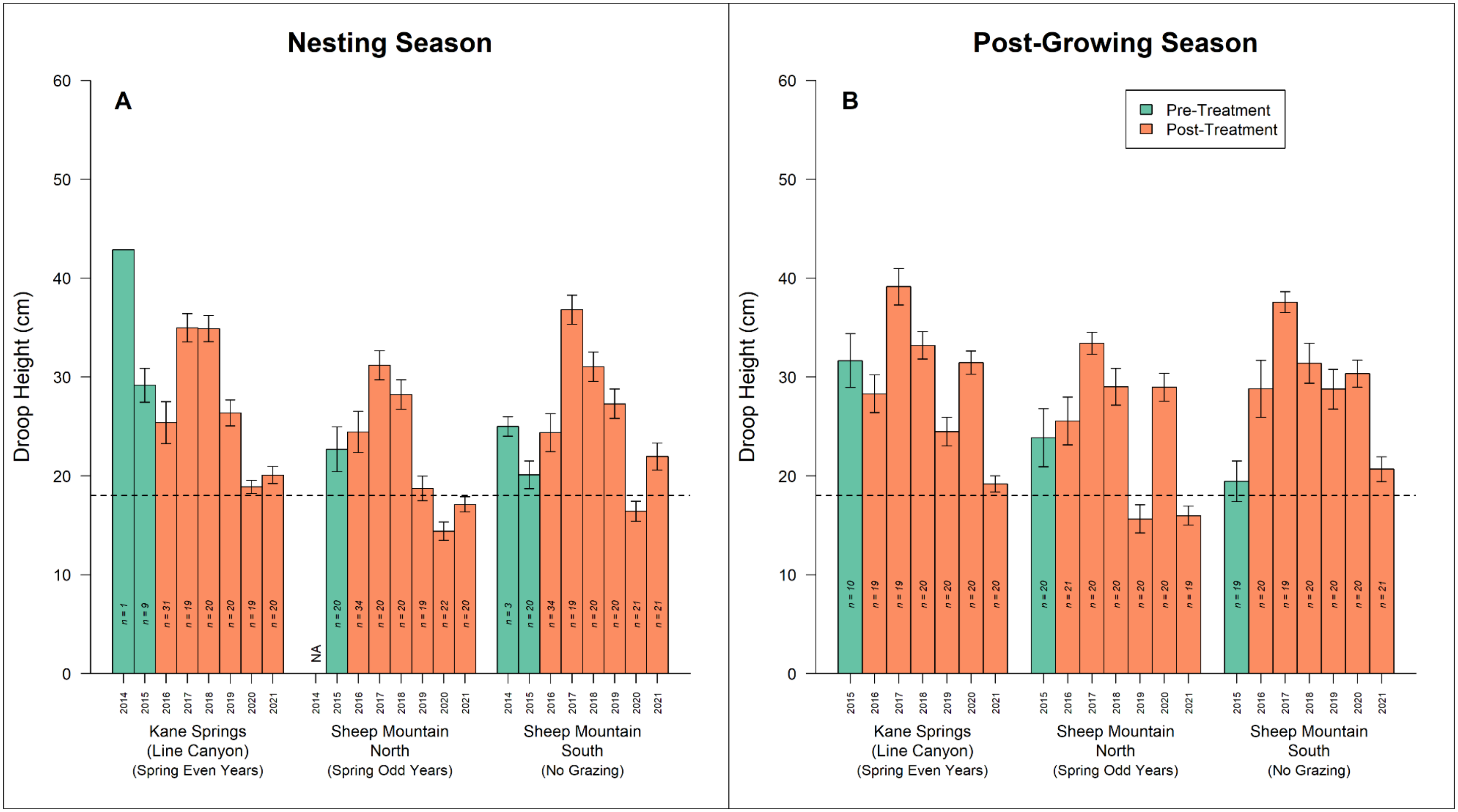


Figure 6. Mean droop height during the nesting season (A; Apr-Jun) and the post-growing season (B; Jul-Aug) for all perennial grass species combined in pre-treatment (green) and post-treatment (orange) years for 3 pastures at Jim Sage, Idaho 2014-2021. Error bars indicate standard errors, and means are 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 height mentioned as a management target in the sage-grouse habitat guidelines (Connelly et al. 2000).

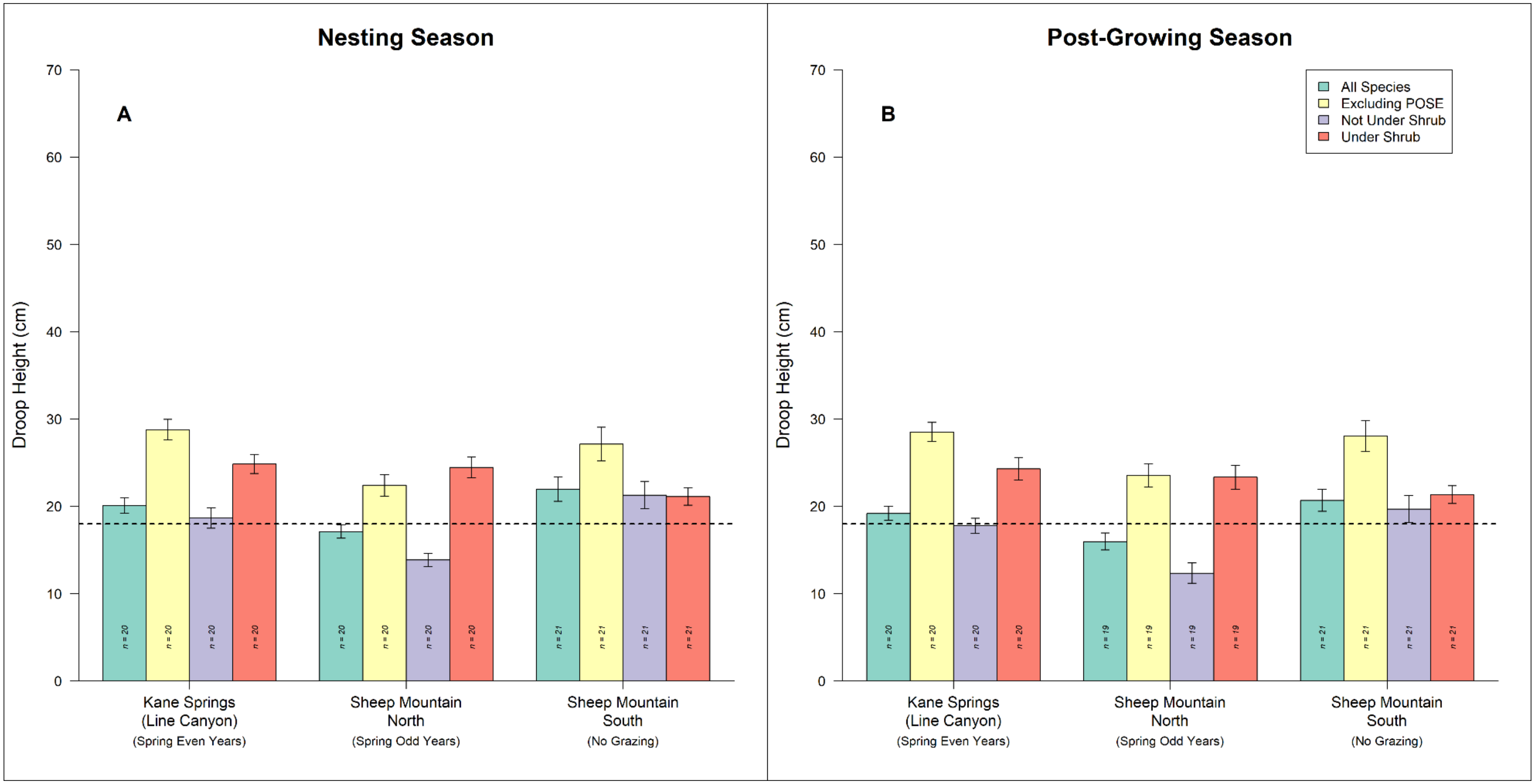


Figure 7. Mean droop height for 4 different subsets of grasses: all perennial grass species within a plot, all perennial grass species excluding Sandberg bluegrass (Poa secunda), all perennial grass plants that were under a shrub, and all perennial grass plants that were not under a shrub in both nesting season (A) and post-growing season (B) plots at Jim Sage, Idaho 2021. 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 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*), Indian ricegrass (*Achnatherum hymenoides*), and western wheatgrass (*Pascopyrum smithii*) were the most abundant grasses in our post-growing season surveys at Jim Sage in 2021. Grass height differed among species and differences were most apparent for droop height and leaf height (Fig. 8). With the exception of Indian ricegrass, all grass heights were shorter in the grazed pasture than the two rested pastures. Interestingly, very few instances of western wheatgrass and Indian ricegrass were found in the grazed pasture.

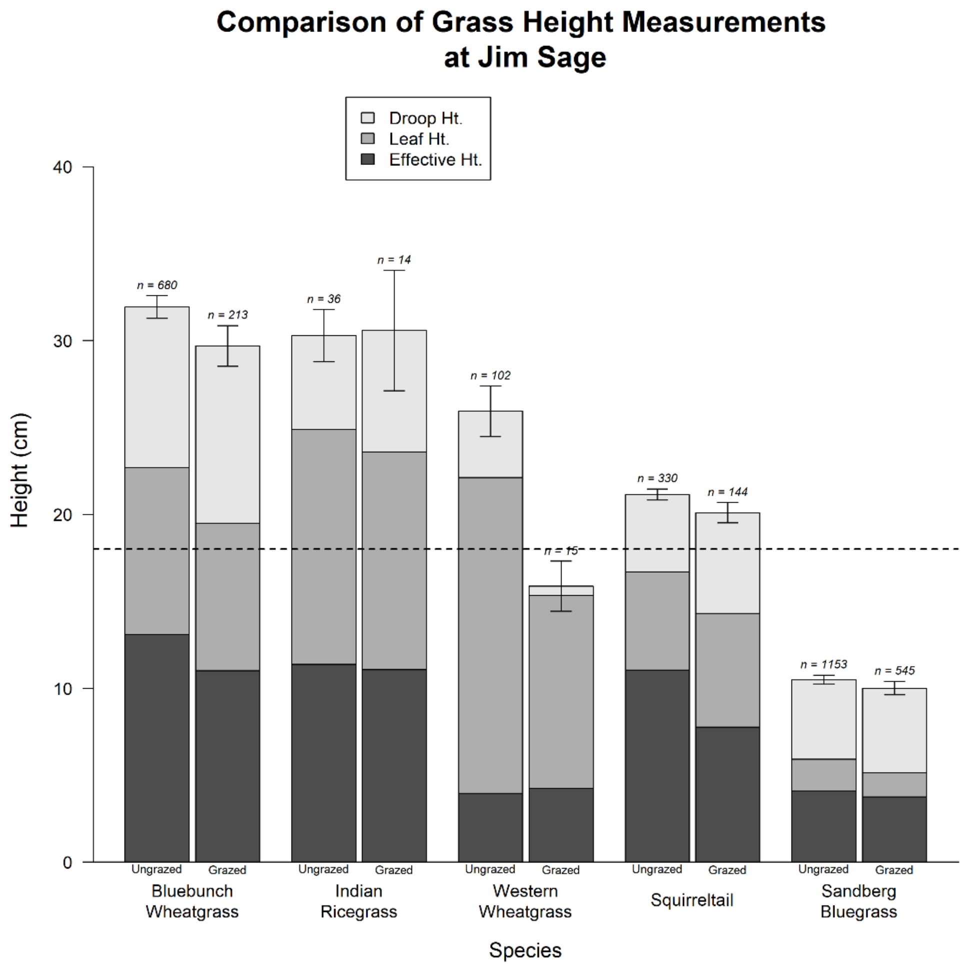


Figure 8. Mean height of the 5 most common species of perennial grasses based on 3 height metrics on post-growing season (Jul-Aug) random plots at Jim Sage, Idaho in 2021. The 3 height metrics were droop height (using highest part of plant) = "Droop Ht.", droop height excluding the flowering stalk = "Leaf Ht", and effective height (modified visual obstruction for an individual plant) = "Effective Ht". Heights were compared seperately for plants in ungrazed and grazed pastures based on whether they were grazed in 2021 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 across all pastures ranging from a high of 36% in the Sheep Mountain South pasture in 2019 to a low of 20% in the Kane Springs pasture in 2014 (Fig. 9). In general, shrub cover has increased slightly in all pastures since the experimental grazing treatments were implemented. Changes in shrub cover appear to be largest in the Sheep Mountain South pasture which is the non-grazing experimental treatment pasture. In 2021, shrub cover in Kane Springs remained similar to 2020, while the other two pastures decreased to the lowest cover we have measured in each since the project began. The Kane Springs pasture likely didn't see as much of a decrease in shrub cover as the others due to its higher elevation which may have mitigated some of the effects of the drought.

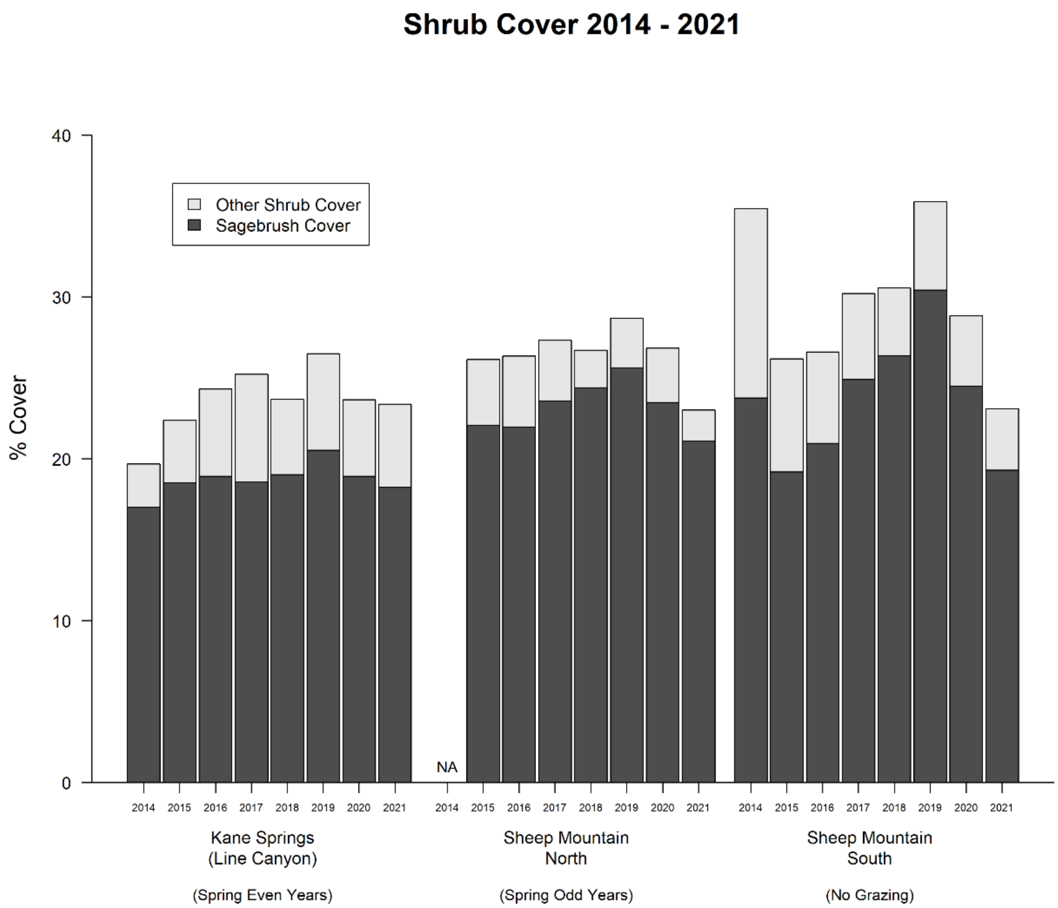


Figure 9. Shrub cover (split into sagebrush and other shrub cover) in each of 3 experimental treatment pastures at Jim Sage, Idaho 2014-2021.

Stocking Rates 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. AUMs were higher in the Sheep Mountain North pasture in 2017 (Fig. 10) because that permittee runs a slightly larger herd than the permittee who uses the Kane Springs pasture. Post-treatment AUMs ranged from a low of 108 in 2018 to a high of 395 in 2017 thus far in the experimental treatment pastures (Fig. 10).

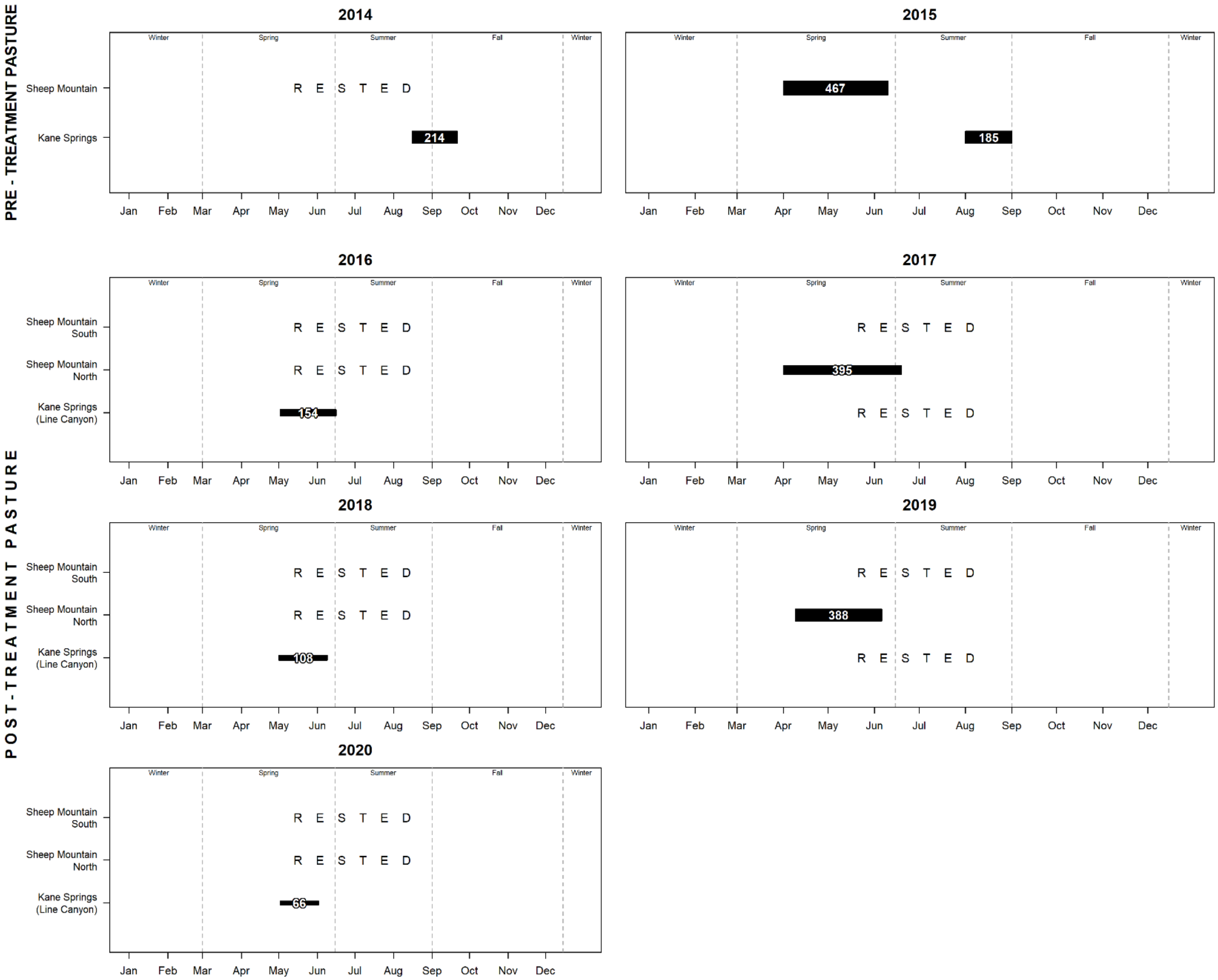


Figure 10. Timing and duration of cattle stocking at Jim Sage during pre- and post-treatment periods of the study 2014-2020 (AUM data for 2021 has not been reported yet). Width of black bars indicate the average number of cattle per day in that pasture. White numbers inside black bars represent the total Animal Unit Months (AUM) during that period.

At the time of writing, we did not have stocking rate information for the 2021 growing season. In 2020, AUMs in the experimental treatment pasture were lower than many of the surrounding pastures, but comparable to surrounding pastures of similar size (those not part of the study; Fig. 11). Two of the experimental treatment pastures were rested in 2020.

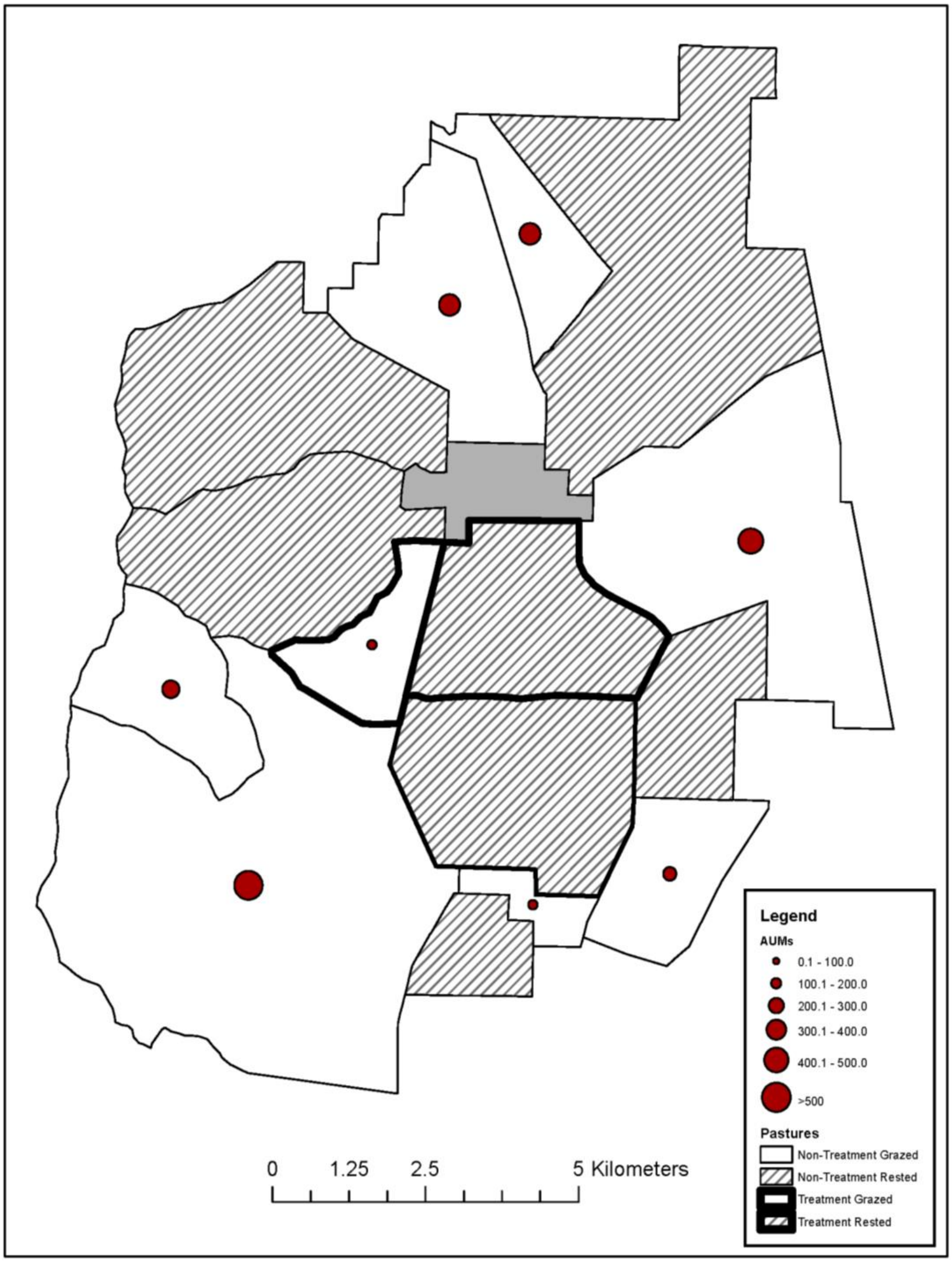


Figure 11. Stocking rate in Animal Use Months (AUMs) in the 3 treatment pastures and in the surrounding pastures at Jim Sage, Idaho in 2020.

Estimates of Utilization

In 2021, utilization estimates were negligibile in all the experiemental pastures based on visual estimates of individual plants (<5%, Fig. 12A). Sheep Mountain North was the only pasture that received any grazing in 2021, although for a shorter period of time than previous years and that was reflected in both estimates of utilization and proportion of grazed plants (Fig. 12A-B). The porportion of grazed plants in the Kane Springs pasture (the only grazed pasture) was ~30% for the all grasses excluding POSE category (yellow bars). Grasses under shrubs were barely grazed in all pastures (Fig. 12B).

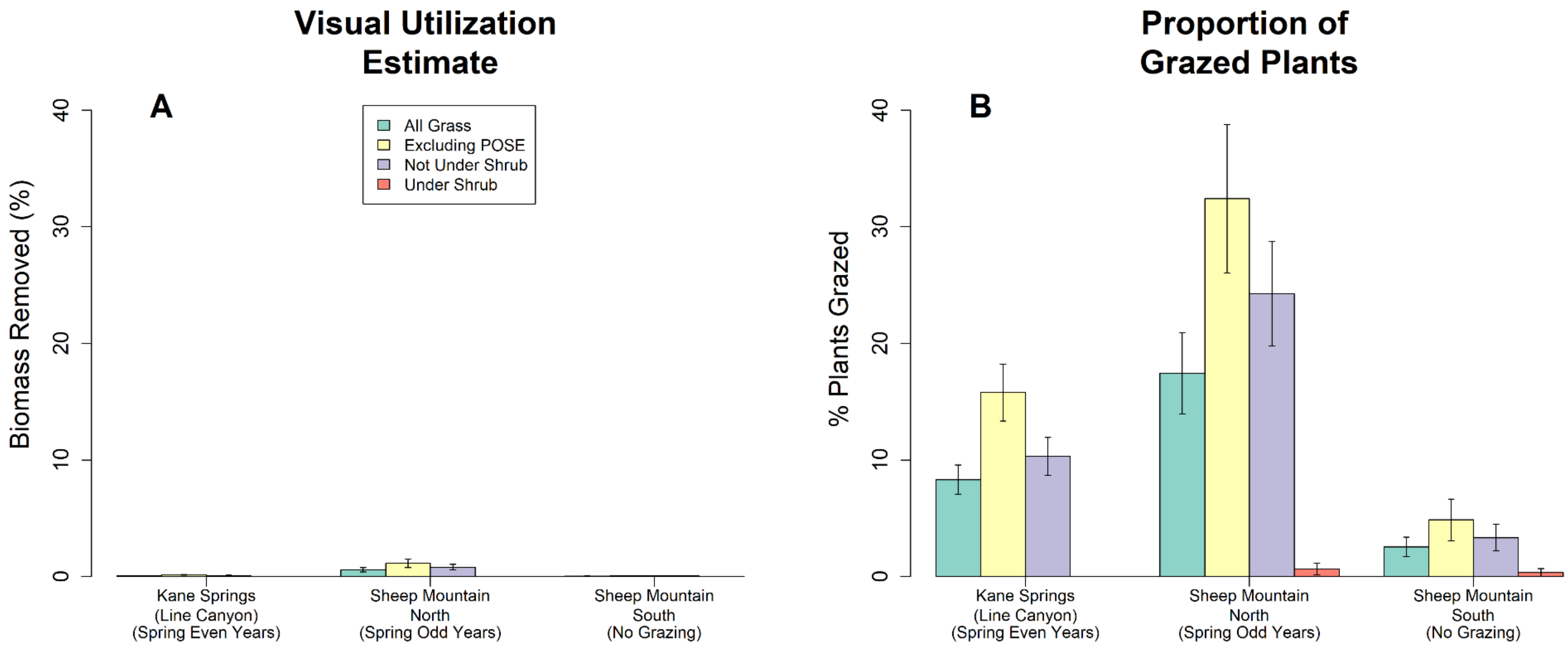


Figure 12. Grazing intensity based on visual estimates of percent biomass removed on individual grass plants and the proportion of grass plants grazed at random plots in 2021 at Jim Sage, Idaho. Estimates were taken from the post-growing season surveys conducted in July – August 2021. In 2021, only the Sheep Mountain North pasture was grazed prior to our post-growing season surveys.

Utilization estimates from the landscape appearance method varied among years (Fig. 13). In 2021, the Sheep Mountain North pasture had lower utilization than it did when it was last grazed in 2019, but similar to the utilization in 2015 and 2017. Estimates of utilization were negligible for both the Kane Springs and Sheep Mountain South pastures in 2021 (both pastures were rested). Measures of utilization using the landscape appearance method are potentially subject to observer bias; variability among observers and observer bias is one aspect that Alex Laurence-Traynor's (Laurence-Traynor 2020) master's thesis addressed.

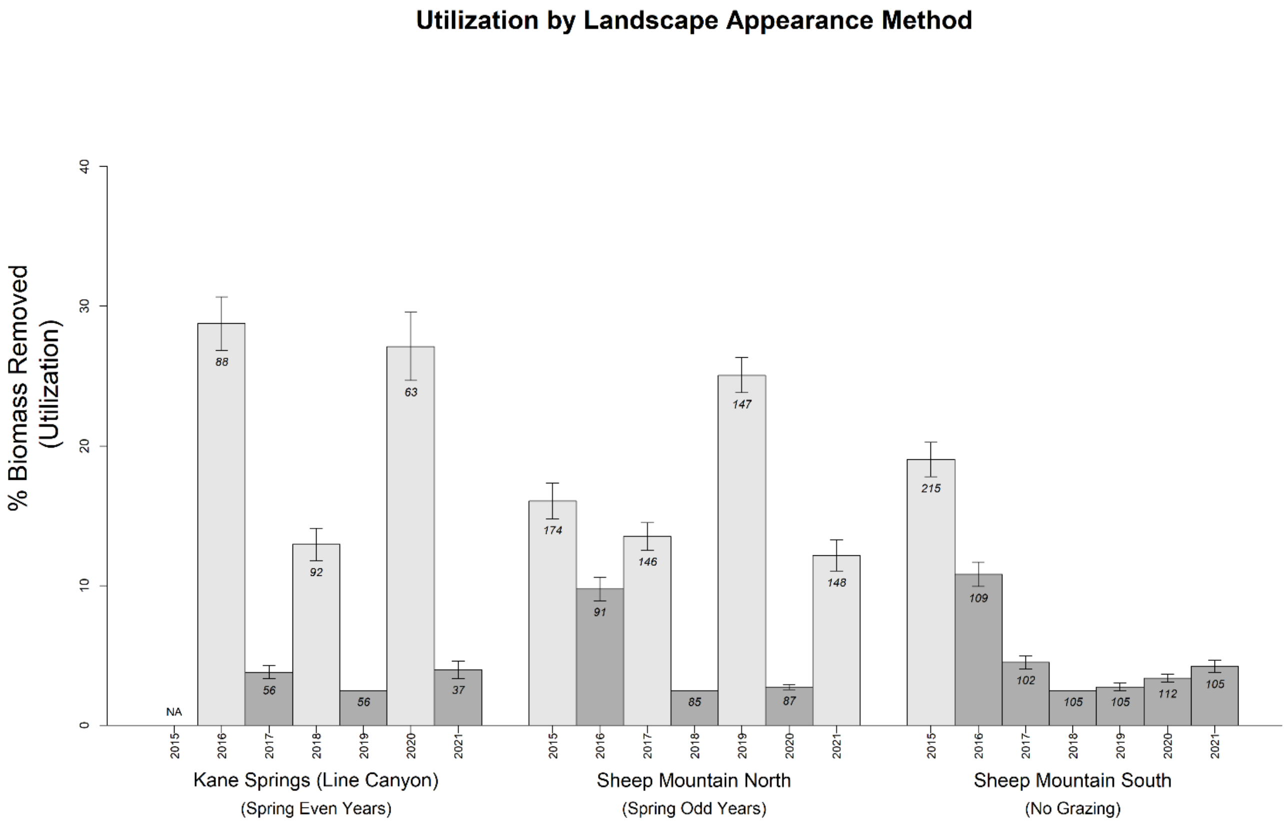


Figure 13. Utilization estimates based on the landscape appearance method for pre- and post-treatment periods at Jim Sage, Idaho 2015-2021. Error bars represent ±1 standard error. NA indicates that pasture was not measured in that particular year.

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 our experimental treatment pastures (Fig. 14). This is likely due to lack of uniform availability of water and grass, as well as topography. This variation was especially apparent in both of the spring grazing pastures (Kane Springs and Sheep Mountain North); cattle had much lower use levels on steep slopes (see the west side of Kane Springs and the south-central part of Sheep Mountain North) and lower use in areas further from water sources.

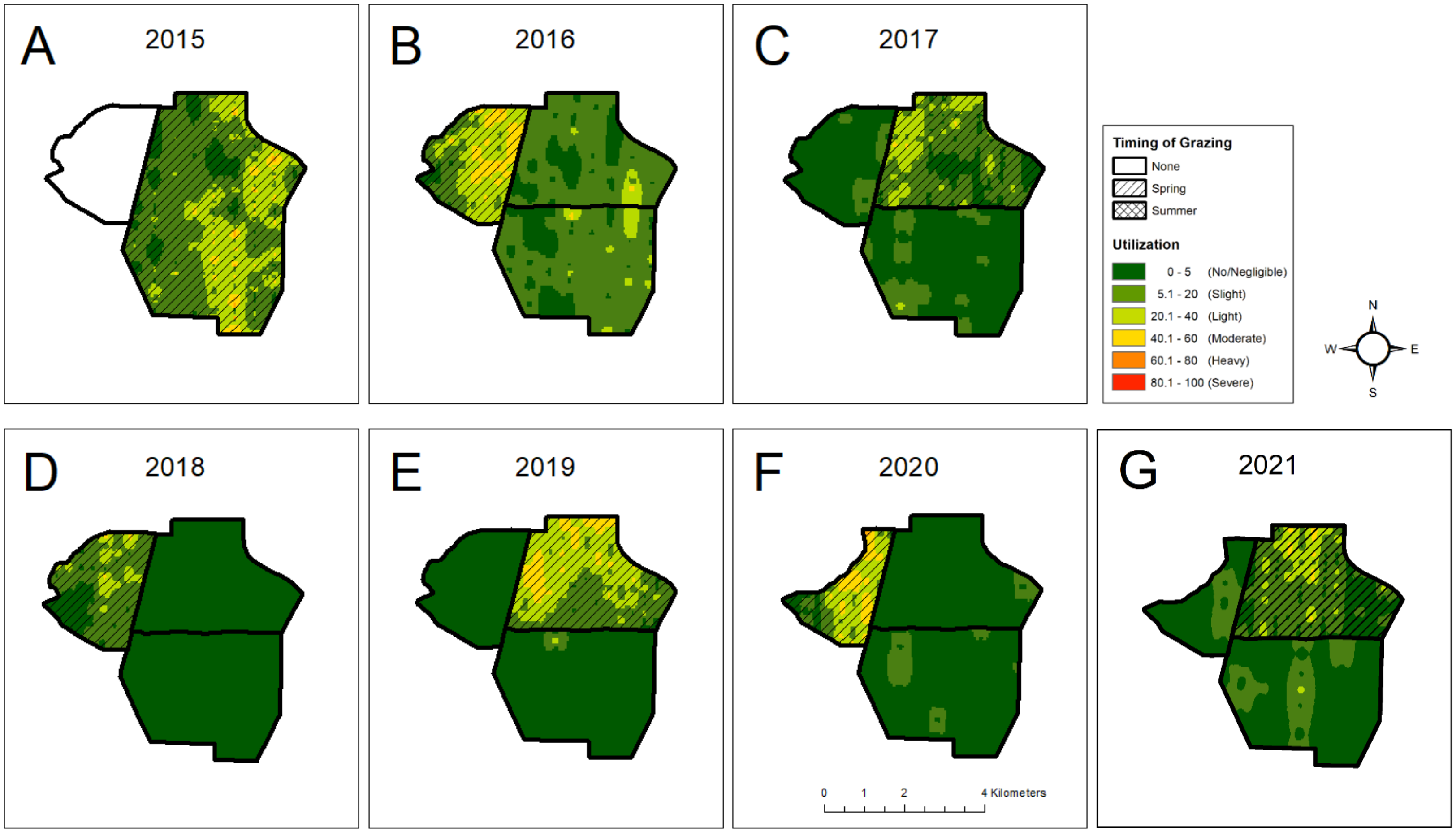


Figure 14. Pattern use mapping based on landscape appearance transects at Jim Sage, Idaho 2015-2021.

Typically, utilization is measured as the proportion of current year's growth removed from the plant. In 2021, the drought afforded very little growth from the current year at all 5 study sites. This led to concerns over the accuracy of our utilization measurements because few grasses produced flowering stalks and much of the biomass removed by grazing during the current season was likely biomass from previous year's growth. Thus, we measured utilization on both the whole plant, as well as just measuring utilization on current year's growth to help mitigate the biases potentially caused by these unusual circumstances. The two approaches produced fairly similar estimates of utilization and produced very similar spatial patterns (Fig. 15). Measuring utilization on only new growth led to slightly lower estimates of utilization, although this difference was not very apparent at Jim Sage.

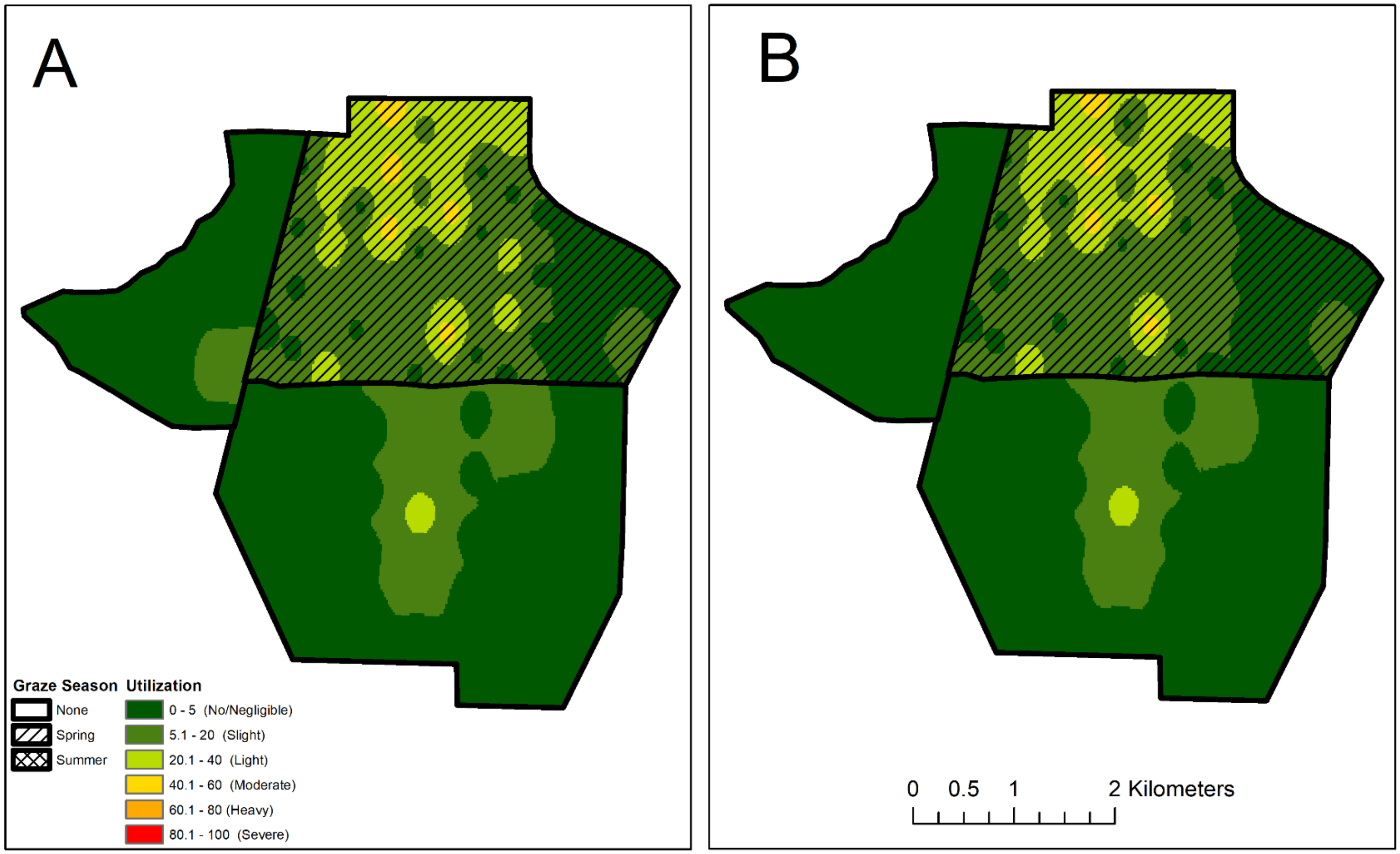


Figure 15. Pattern use mapping based on landscape appearance transects using estimates based on whole plant utilization (A) and utilization based on new growth only (B) at Jim Sage, Idaho 2021.

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