2021 Grouse & Grazing Project
Vegetation Monitoring and Grazing Report
Big Butte Study Site

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Suggested Citation: Tisdale C. A., C. J. Conway, K. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2021. Vegetation Monitoring and Grazing Report: Big Butte Study Site. College of Natural Resources, University of Idaho.

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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.

STUDY AREA

Big Butte

We began work at the Big Butte study site in 2015 and it was one of five study sites in 2021 (Fig. 1). Specific treatments at the Big Butte study site are shown in Figure 3. This site is located approximately 25 km southwest of Atomic City, ID in the Big Desert region of the Snake River Plain. Elevation at the site ranges from 1,537-1,642 m (mean 1,576 m; based on the USGS National Elevation Dataset). The topography is relatively flat, consisting of historic lava flows interspersed with areas of wind-deposited soils. Primary soils belong to the McCarey-Vickton-Lava flow and Splittop-Coffee complexes which consist of slopes ranging from 0-15% and relatively shallow soils consisting of loam and silt loam. The

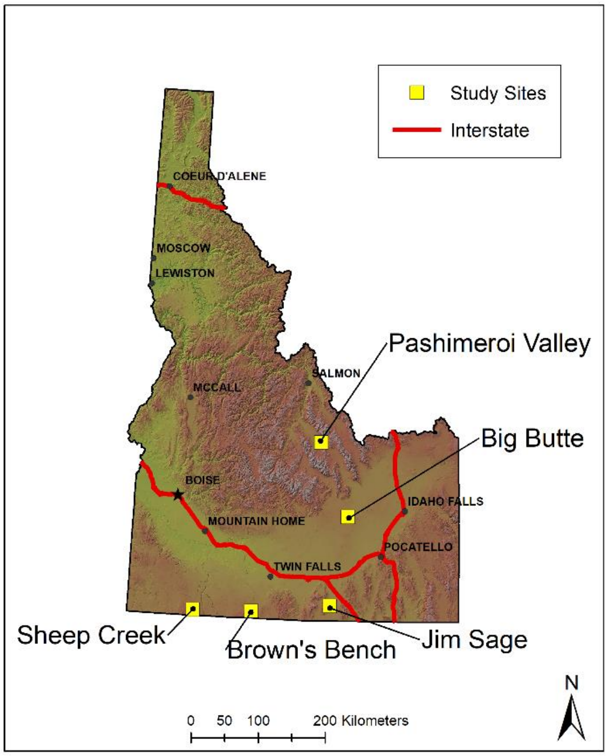

Figure 1. Five study sites in southern Idaho where field work has been conducted for the Grouse & Grazing Project 2014-2021.

plant community is dominated by three-tip sagebrush (*Artemisia tripartita*) and basin big sagebrush (*Artemisia tridentata tridentata*) with understory grasses consisting of Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and crested wheatgrass (*Agropyron crestatum*). Cheatgrass (*Bromus tectorum*) is present but is not the dominant grass cover in most areas.

Figure 2. . Map of the Wildhorse Fire that burned a portion of the study pastures at the Big Butte study site in the summer of 2017.

Wildhorse Fire

The Wildhorse fire was caused by lightning on 30 July 2017 and burned just over 27,000 acres before it was controlled on 1 August 2017. The fire burned 6,903 acres of the area planned for our experimental treatments (Fig. 2). Due to this large swath of pasture burned, we were forced to alter our experimental plan. The altered treatment plan halved the size of one pasture in order to avoid the burned portion, and replaced another (Fig. 3).

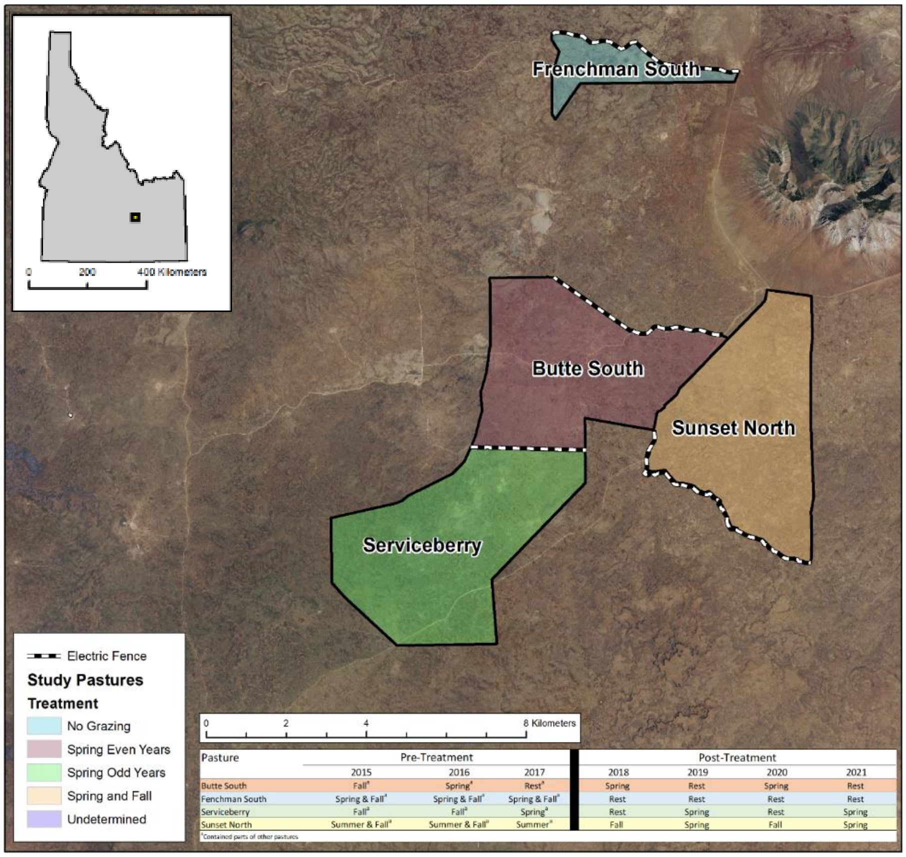

Figure 3. Map of the 4 experimental treatment pastures and timeline of treatments at the Big Butte study site, Idaho 2015-2021.

Precipitation comes primarily in the form of snow between November and March and the 30-year average (1980-2010; PRISM Climate Group) is 239 mm of precipitation per year. Monthly average temperatures on an annual basis range from a low of -7.1° C (Jan) to a high of 20.3° C (Jul) based on the most recent 30-year monthly averages (1980-2010; PRISM Climate Group). The Big Butte allotment is managed by BLM and livestock grazing is allowed to occur between 1 Apr – 15 Nov. Prior to our study, these pastures were rested at least once every 3rd spring to allow forage species to be periodically undisturbed during the growing season. The permittee at this site runs approximately 450-600 feeder cattle each year.

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).

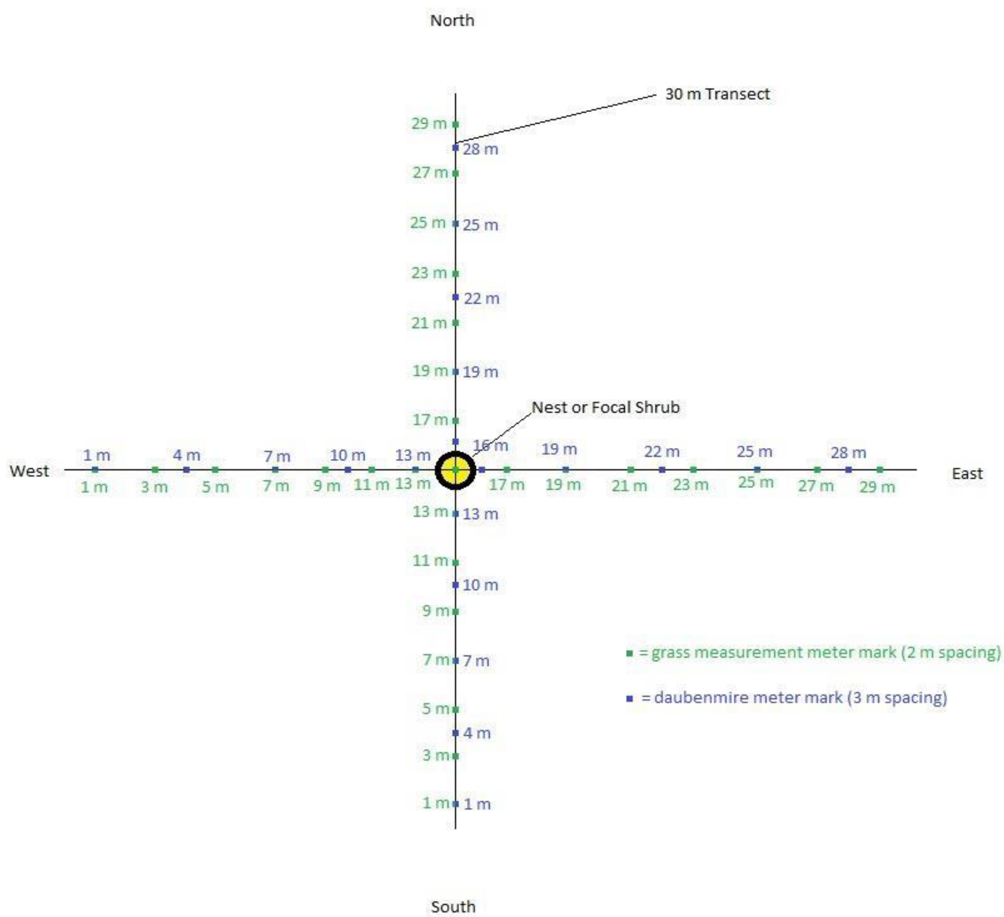

Figure 4. Visual depiction of the placement of two 30-m tapes stretched to conduct vegetation sampling at nest plots, random plots, and paired non-nest plots for the Grouse & Grazing Project in southern Idaho, 2014-2021.

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 (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 11th day), we calculated AUMs for each separate stocking rate and summed them together to report the stocking rate for the entire season.

RESULTS

Weather

Big Butte received well below-average precipitation (Fig. 5A) and slightly above-average temperatures (Fig. 5B) prior to and during the grouse breeding season in 2021 and above-average precipitation in August. This year was the driest season we have witnessed since the project began.

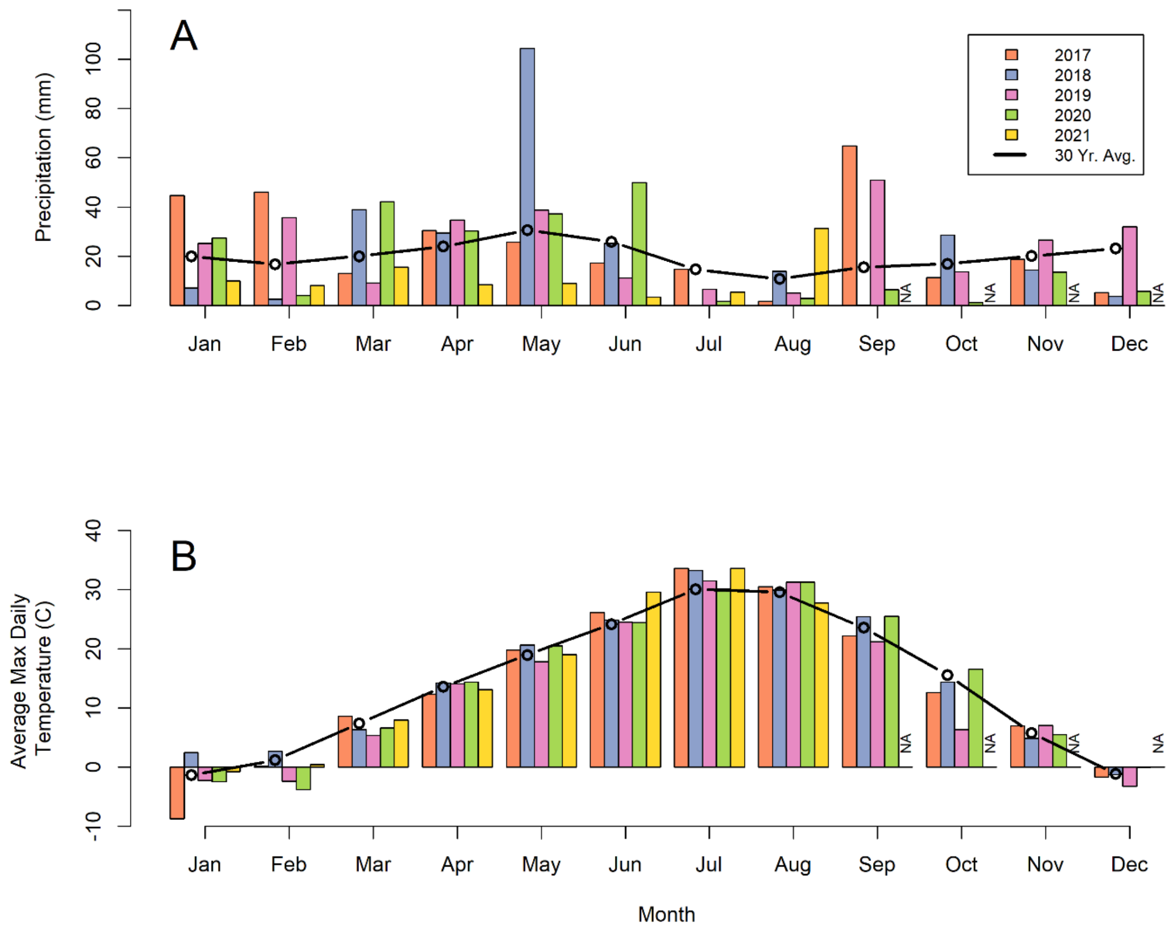

Figure 5. Monthly precipitation totals (A) and average max daily temperature by month (B) with 30-year average (dark line) at Big Butte, Idaho 2017-2021.

Descriptive Vegetation Characteristics

Pasture-level Comparison

Mean grass height at Big Butte varied among years and grass heights were tallest in 2017 for all pastures when the site received well above average precipitation leading up to the growing season (180 mm between Nov-Apr; Fig. 6). Grass heights were correlated with overwinter precipitation and also varied, but to a lesser extent, based on whether the pasture was spring grazed that year. Precipitation leading up to the 2015 and 2016 growing seasons (44 mm and 99 mm between Nov-Apr, respectively) was well below average and this was reflected by grass heights in post-growing season surveys. Leading up to the 2021 growing season, Big Butte received only 53 mm of precipitation. The effects of this low precipitation in 2021 can be seen in the low mean grass heights for all study pastures at Big Butte in 2021. In fact, mean grass heights in two pastures were the shortest they've ever been during the Grouse & Grazing Project. A thesis by Janessa Julson (2017) documented the extent of variation in grass height among our study sites.

The droop height of grasses under shrubs (red bars) was taller than the other 3 grass height categories in all pastures in both nesting and post-growing season surveys (Fig. 7). The remaining 3 categories (all perennial grasses, all perennial grass species excluding Sandberg bluegrass, and all perennial grass plants not under a shrub; Fig. 7) were all very similar in height within each pasture in both nesting and post-growing season surveys. While the height of grasses under a shrub did not change between nesting and post-growing season surveys, the remaining 3 categories all decreased between the first and second surveys. 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. 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.

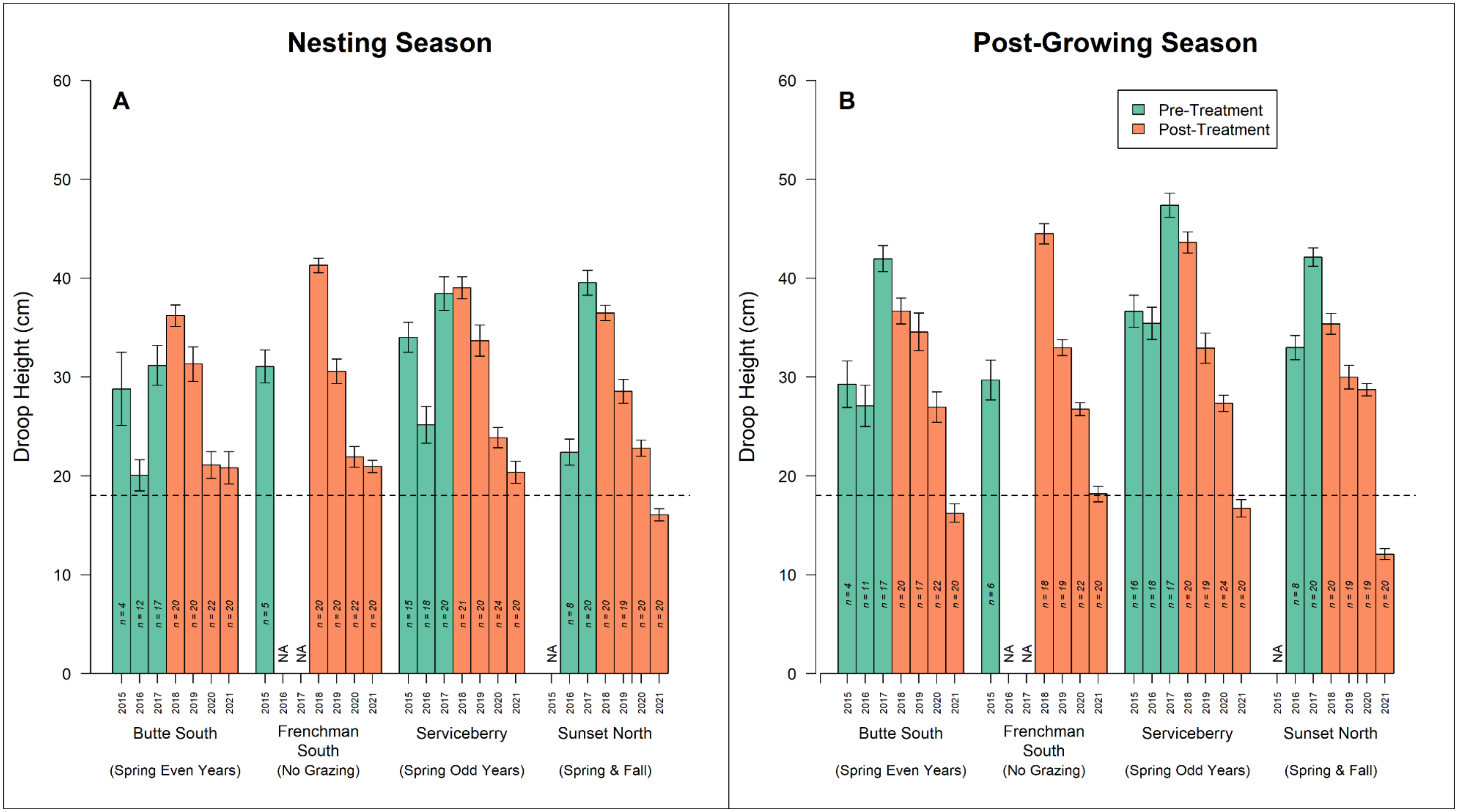

Figure 6. Mean droop height during the nesting season (A; Apr-Jun) and the post-growing season (B; Jul-Aug) for all perennial grass species combined in pre-treatment (green) and post-treatment (orange) years for 4 pastures at Big Butte, Idaho 2015-2021. Error bars indicate standard errors, and means 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).

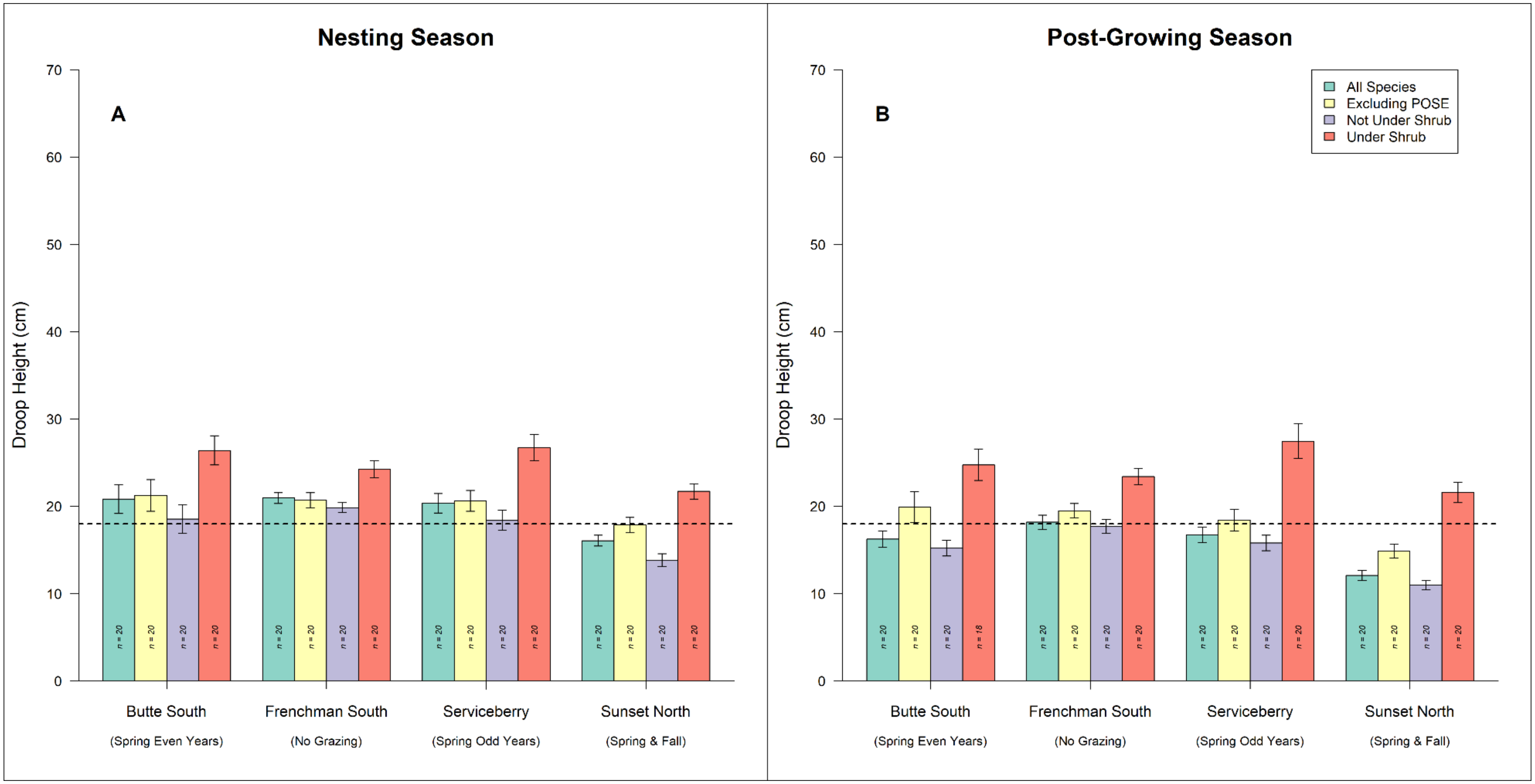

Figure 7. Mean droop height for 4 different subsets of grasses: all perennial grass species within a plot, all perennial grass species excluding Sandberg bluegrass (Poa secunda), all perennial grass plants that were under a shrub, and all perennial grass plants that were not under a shrub in both nesting season plots (A) and post-growing season plots (B) at Big Butte, 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, western wheatgrass (*Pascopyrum smithii*), crested wheatgrass, and needlegrasses (*Achnatherum spp.* and *Hesperostipa spp.*) were the most abundant grasses in our post-growing season surveys at Big Butte in 2021. Grass height differed among species and differences were apparent for all three grass height metrics (Fig. 8). All grasses averaged shorter heights in the grazed pastures compared to the ungrazed pastures. Grass height was below the 7-inch management target even in ungrazed pastures for 3 of the 5 species (Fig. 8). In Big Butte, livestock grazing appeared to have the biggest effect on heights of bluebunch wheatgrass, needlegrass, and Sandberg bluegrass (Fig. 8).

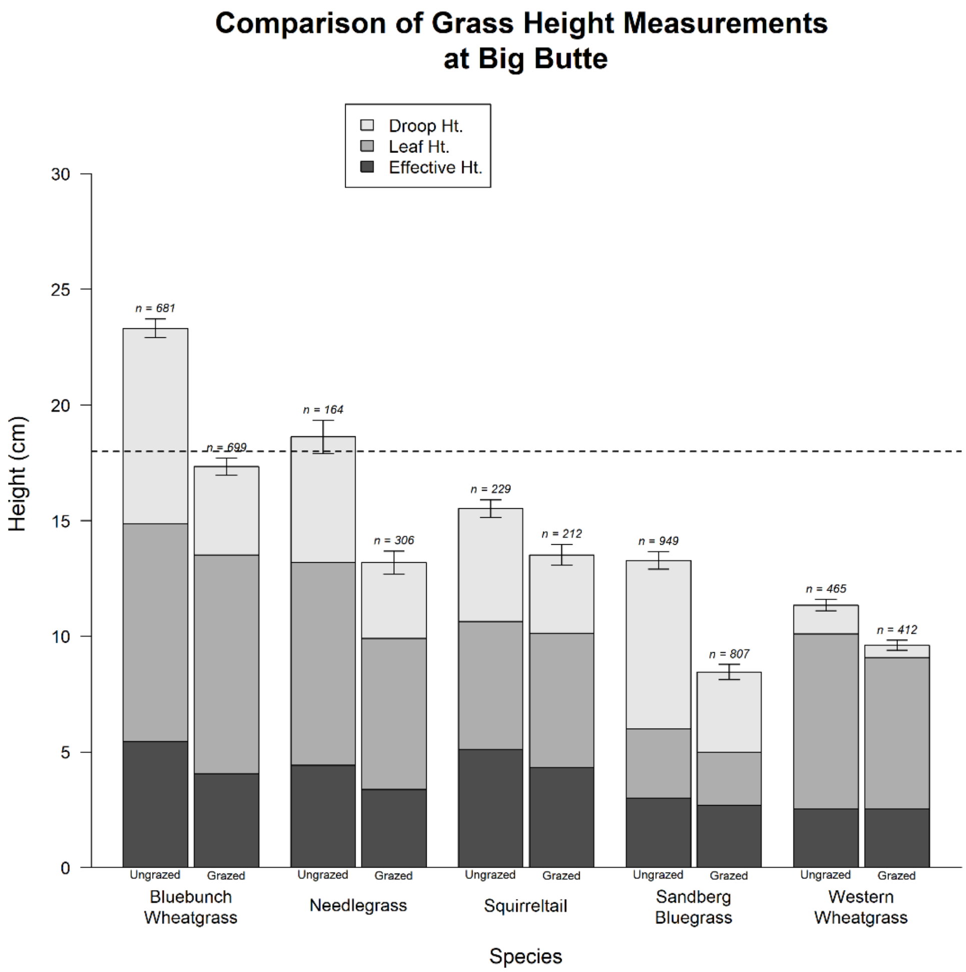

Figure 8. Mean height of the 5 most common species of perennial grasses based on 3 height metrics on post-growing season (Jul-Aug) random plots at Big Butte, Idaho in 2021. The three height metrics were droop height (using highest part of plant) = "Droop Ht.", droop height excluding the flowering stalk = "Leaf Ht", and effective height (modified visual obstruction for an individual plant) = "Effective Ht". Heights were goruped seperately based on whether the pasture was grazed in 2021 prior to post-nesting season surveys. 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

In general, the shrub cover at most Big Butte pastures has remained relatively consistent among years with some fluctuation (Fig. 9). The exception is the Butte South pasture where we have seen increasing sagebrush cover since 2015. Possibile explanations are increasing precipitation from 2015-2017 (which led to increased shrub growth) or an increase in plot covereage within that pasture (we increased the number of random plots in Butte South from 12 to 20 in 2017 when it was designated as a spring grazing treatment). In 2021, we saw a slight decrease in shrub cover at all pastures, except Butte South where shrub cover remained consistent with prior years. Sagebrush species, including three-tip sagebrush and basin big sagebrush, make up the majority of shrubs at Big Butte. On all of our treatment pastures, we expect to see only small changes in shrub cover between years; changes caused by annual variation in precipitation.

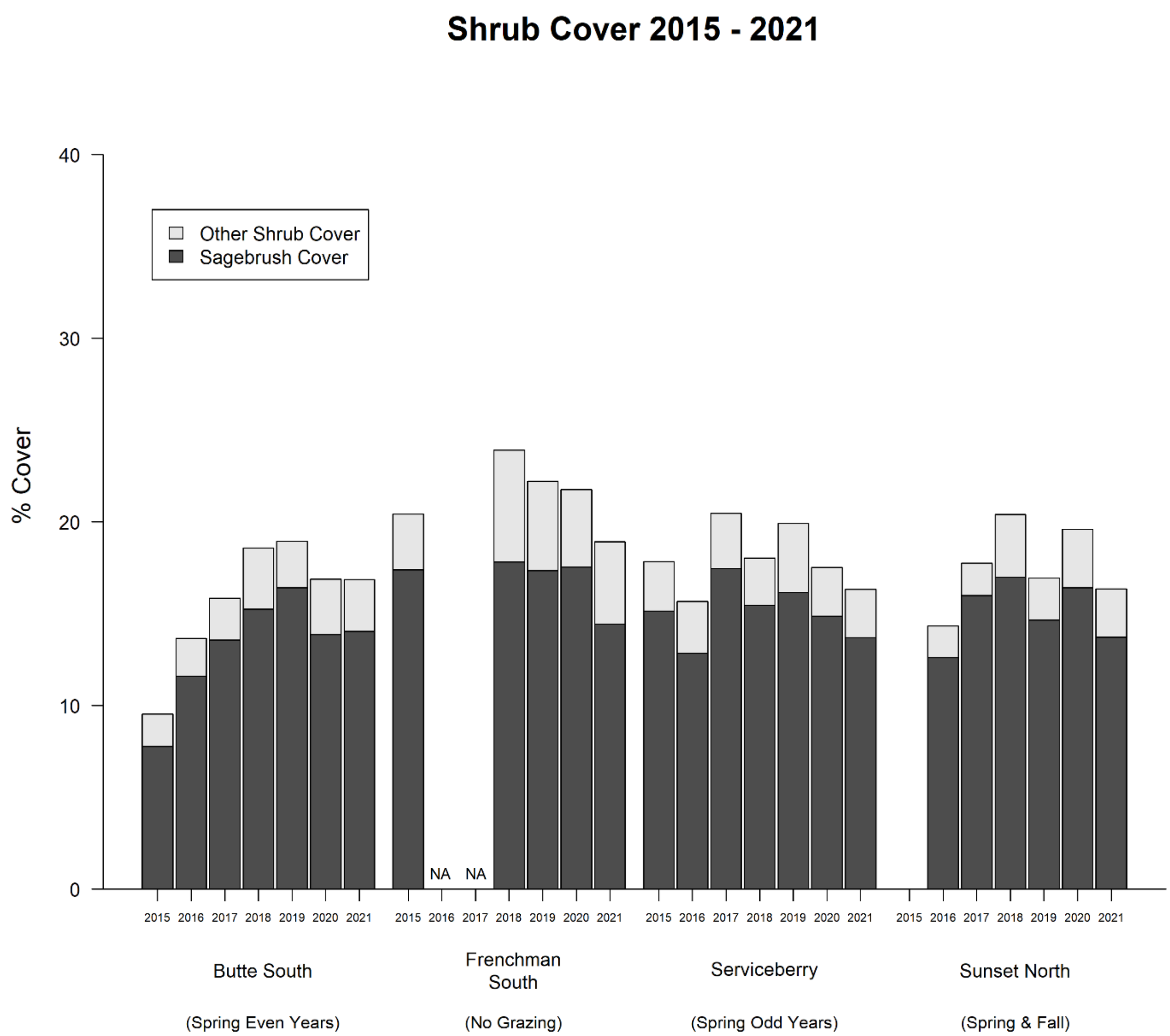

Figure 9. Shrub cover (split into sagebrush and other shrub cover) in each of the 4 experimental treatment pastures at Big Butte, Idaho 2015-2021.

Stocking Rates and Grazing Pressure

Originally our treatments were scheduled to begin at Big Butte in 2017. The Wildhorse Fire caused us to alter our experimental treatment pastures and put-off implementing the treatments until 2018. Treatments in Sunset North, Serviceberry, and Butte South all remained the same as in 2017. We added Frenchman South as a “No Grazing” pasture in 2018 which is why it had two separate grazing events in 2017. AUMs were higher during pre-treatment years (2015-2017) than in post-treatment years (2018 - 2020); 2021 AUM data were not available at the time of this report. Pre-treatment AUMs ranged from 89-1,085 (Fig. 10) and post-treatment AUMs ranged from 96-631 (Fig. 10). The post-treatment AUMs are lower because we split most of the pre-treatment pastures into two parts to implement the experiment (this gave the permittee flexibility in their operation). This resulted in the AUMs in the larger pre-treatment pasture being divided into two smaller portions over a smaller area in the post-treatment pasture. We will use metrics such as AUMs per ha to help compensate for the differences in pasture size between pre- and post-treatment years and make grazing pressure in post-treatment years comparable to that in pre-treatment years.

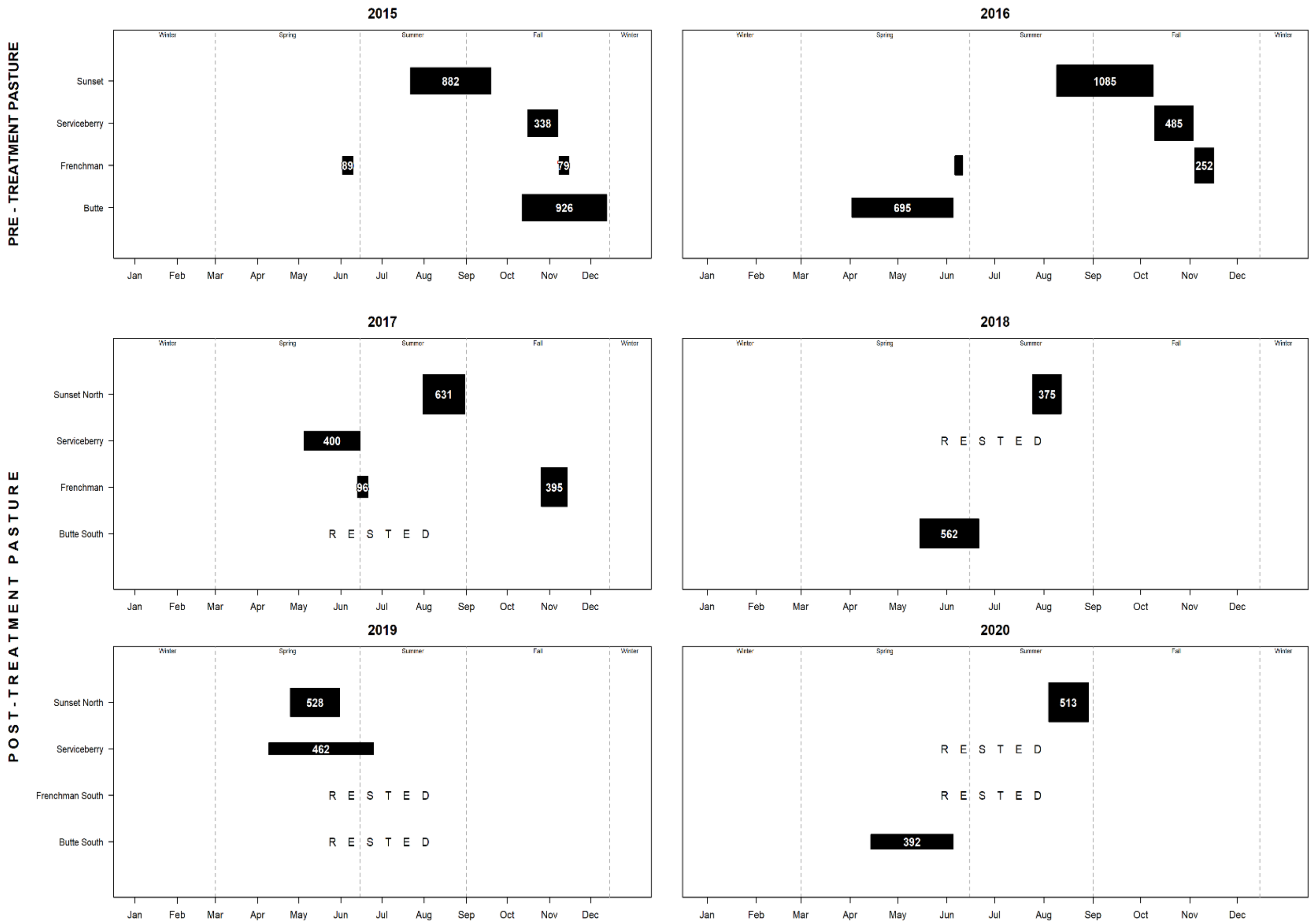

Figure 10. Timing and duration of cattle stocking at Big Butte during pre- and post-treatment periods of the study 2015-2020 (AUM data for 2021 has not been reported yet). Width of black bars indicate the average number of cattle per day in that pasture. White numbers inside black bars represent the total Animal Unit Months (AUMs) during that period. We attempted to begin treatments in 2017 at Big Butte but were forced to re-implement the treatments in 2018 due to the Wildhorse Fire in July 2017.

In 2020, AUMs in our experimental treatment pastures were comparable to surrounding pastures (those not part of our study; Fig. 11). Two of our experimental treatment pastures were rested in 2020. We did not have stocking rate information available for 2021 at the time of this report.

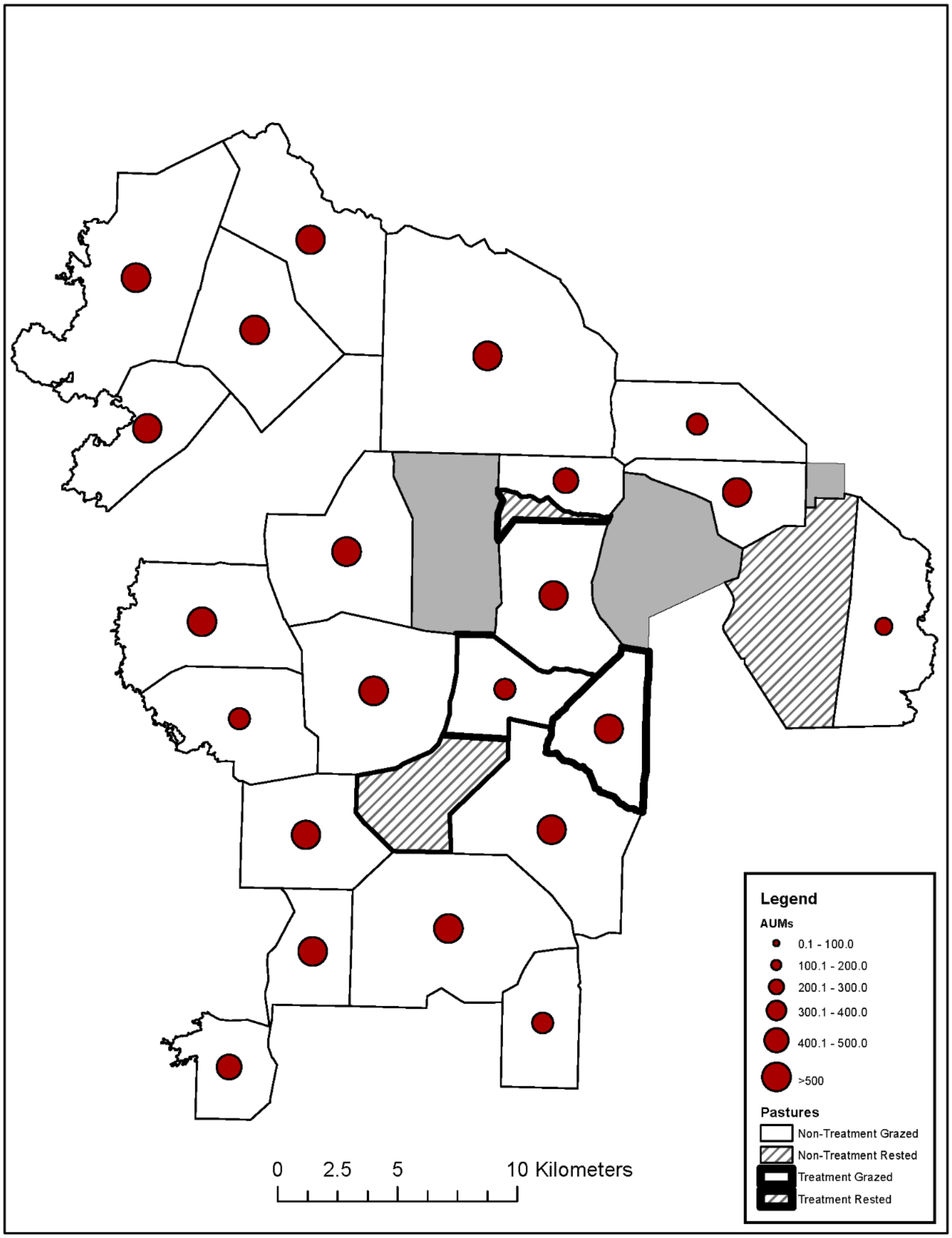

Figure 11. Stocking rate in Animal Use Months (AUMs) in 4 treatment pastures and in the surrounding pastures at Big Butte, Idaho in 2020.

Estimates of Utilization

Visual estimates of utilization were low (<10%) in both grazed pastures (Serviceberry & Sunset North) in 2021, while the other two pastures that were rested in 2021 saw even less (negligible) utilization (Fig. 12A). Proportion of grazed plants was higher in the two grazed pastures compared to the two rested pastures as well (Fig. 12B). Plants under a shrub across saw negligle grazing across all four pastures (grazed and ungrazed), while the All Grasses – Exclduing Sandburg bluegrass (POSE) indicated higher utilization than the other three metrics. While Butte South was not scheduled to be grazed in 2021, a southern portion of the pasture was opened up to grazing at the request of the rancher, due to the drought and lack of forage in the scheduled grazed pastures. This likely explains the higher proportion of grazed plants in Butte South compared to the other rested pasture (Frenchman South). The estimates below were based on 20 sampling locations per pasture which are randomly distributed throughout each pasture.

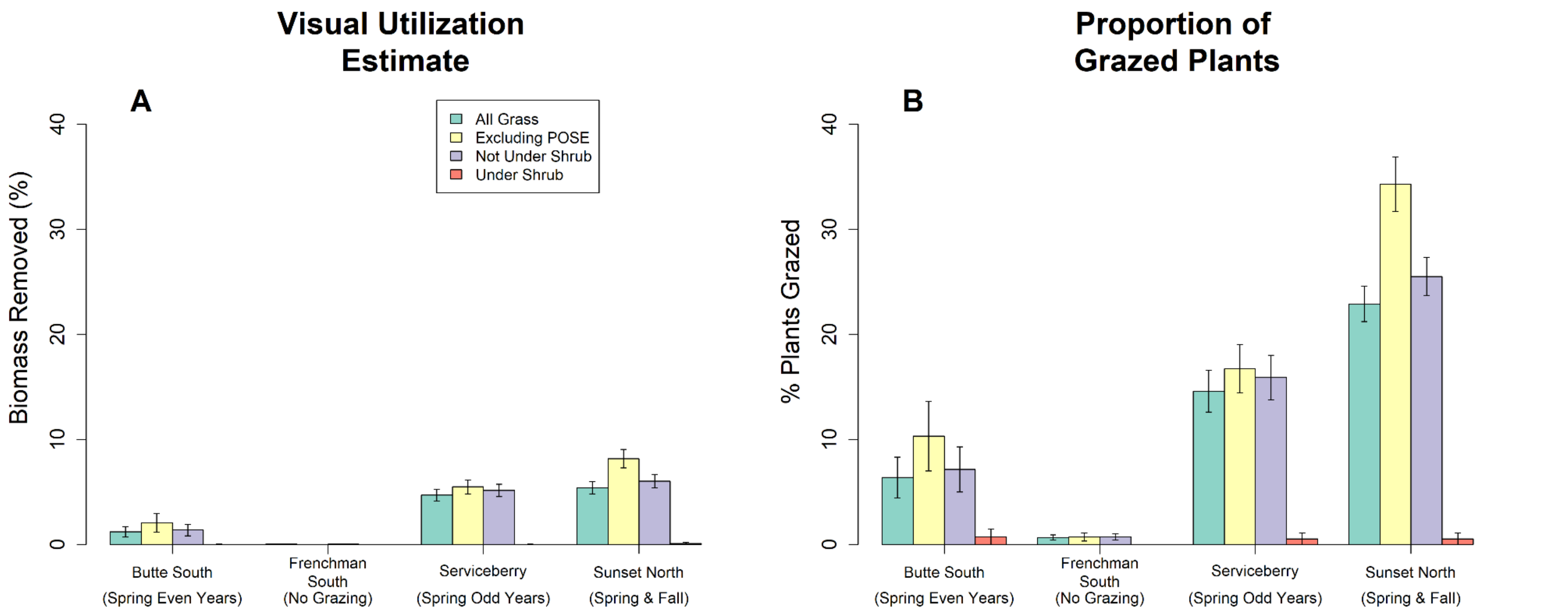

Figure 12. Grazing intensity based on visual estimates of percent biomass removed on individual grass plants and the proportion of grass plants grazed at random plots in 2021 at Big Butte, Idaho. Estimates were taken from the post-growing season surveys conducted in July – August 2021. In 2021, a portion of the Butte South pasture was grazed despite it being scheduled to be rested.

Utilization estimates from the landscape appearance method varied among years (Fig. 13). The spring grazed pastures in 2021 (Serviceberry & Sunset North) had ~40% utilization. One notable difference between the landscape appearance method (Fig. 13) and the proportion of grazed plants at random plots (Fig. 12B), is that the Serviceberry pasture has a much higher estimate of utilization via the landscape appearance method (Fig. 13). This was due to cattle concurrently grazing the pasture during our random plot surveys (grazed ~30 April-30 June; surveys conducted 18 May – 24 June) while our landscape appearance estimates were based on surveys done later in the year (conducted 19 July – 3 Aug).

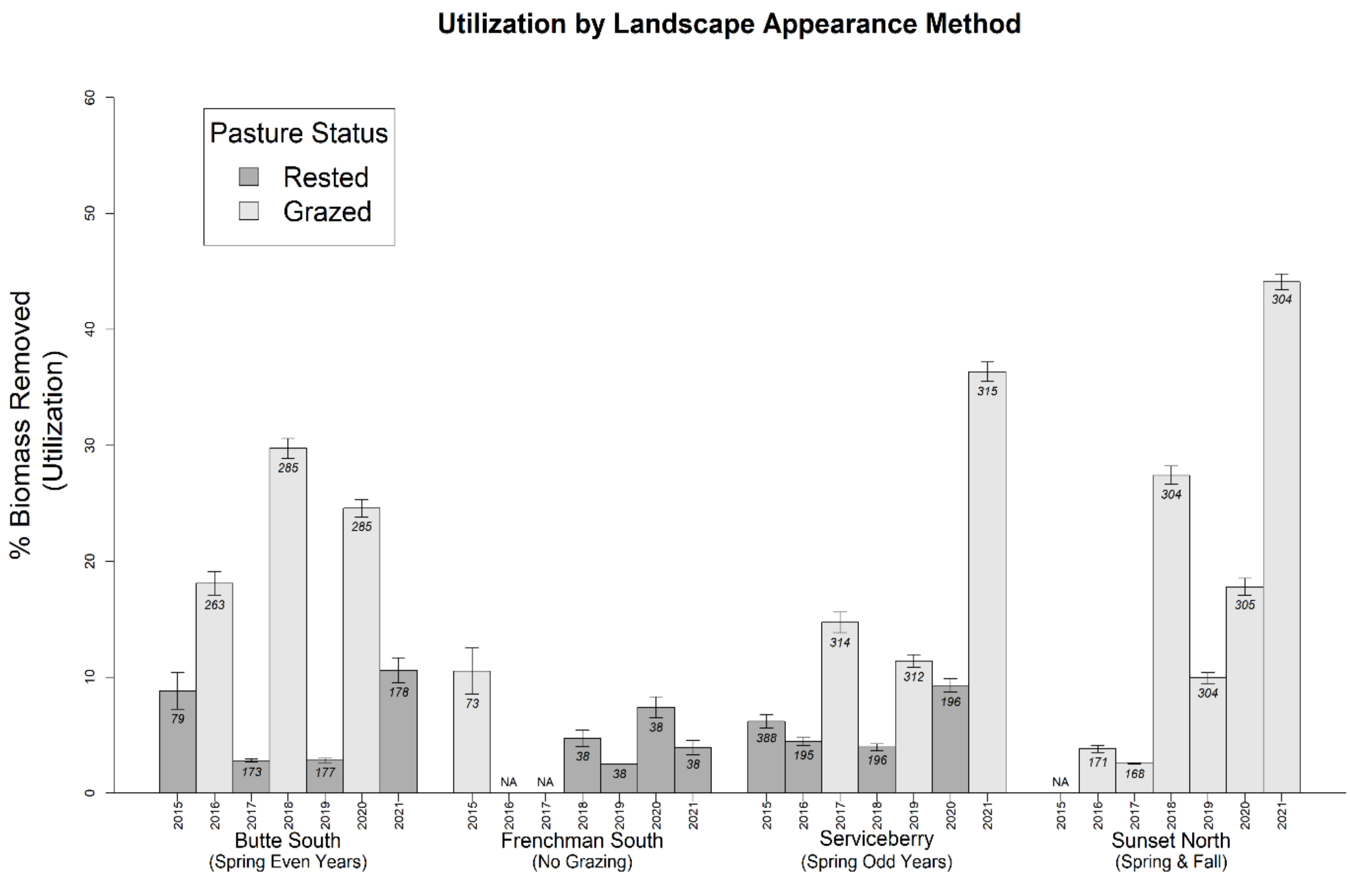

Figure 13. Utilization estimates based on the landscape appearance method for pre- and post-treatment periods at Big Butte, Idaho 2015-2021. Error bars represent ±1 standard error. NA indicates that pasture was not measured in that particular year.

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 treatment pastures (Fig. 15). At Big Butte, this is especially apparent (see the Butte South and Sunset North pastures in 2020; Fig. 14F). Most pastures at Big Butte have only 1-2 water sources available to cattle unless we have major rain events (as seen in May 2018: Fig. 5A). In 2021, Butte South was scheduled to be rested, however due to the drought, a portion of it was opened up to relieve grazing pressure in the Serviceberry pasture. This can clearly be seen when looking at the spatial patterns found using the landscape appearance method (Fig. 14G).

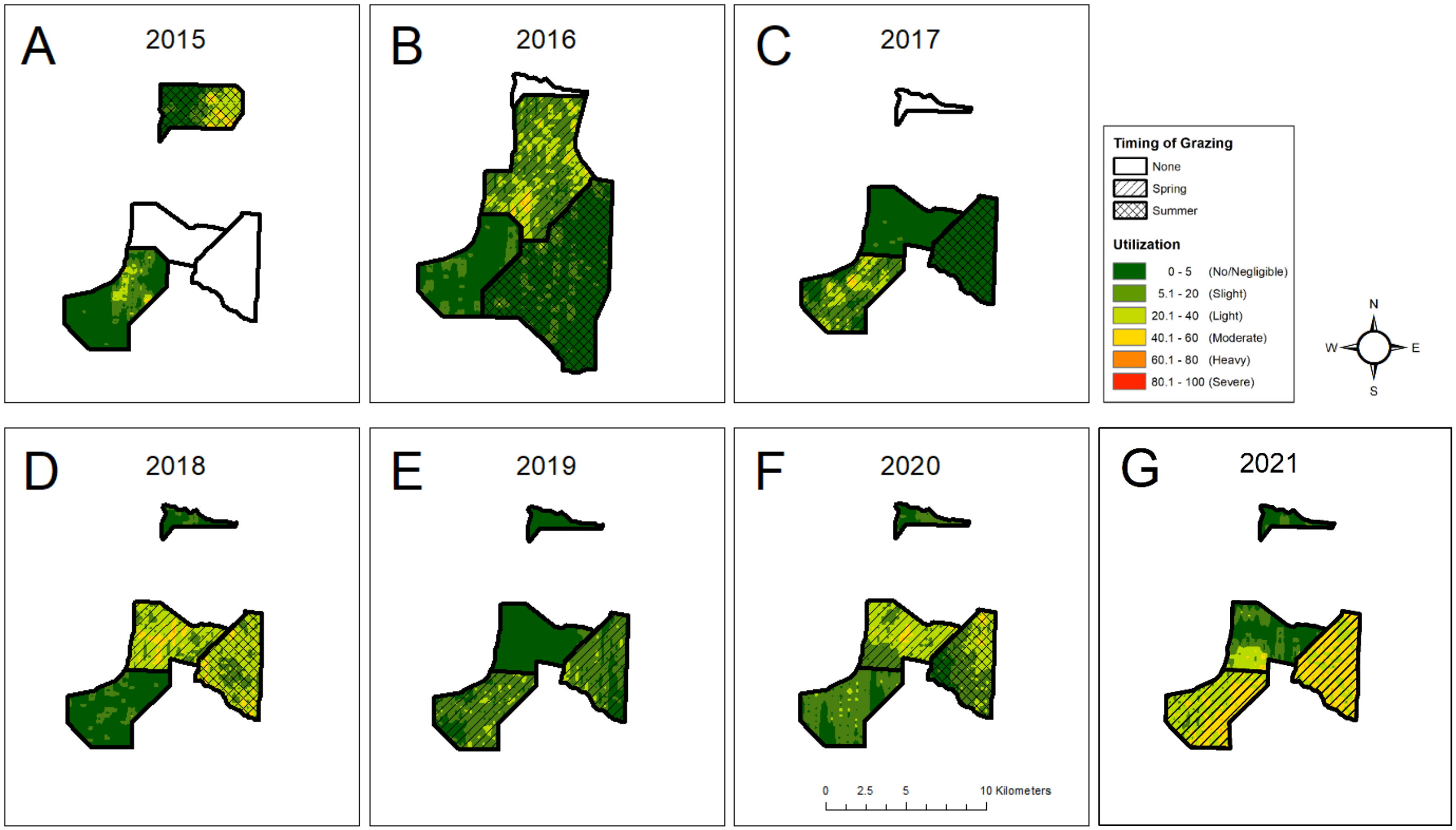

Figure 14. Pattern use mapping based on landscape appearance transects at Big Butte, Idaho 2015-2021.

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 measuring utilization on only 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 Big Butte.

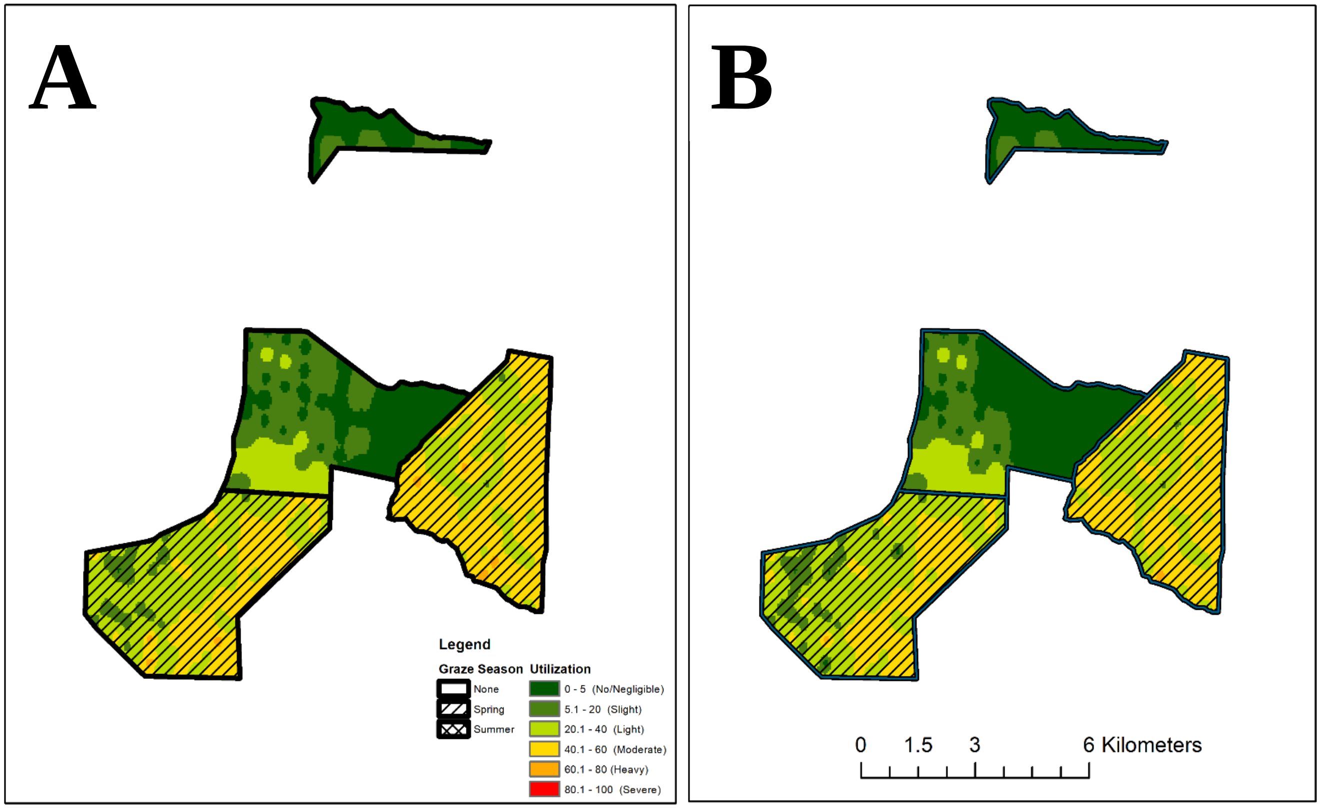

Figure 15. Pattern use mapping based on landscape appearance transects using estimates based on whole plant utilization (A) and utilization based on new growth only (B) at Big Butte, Idaho 2021.

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