2019 Grouse & Grazing Project
Vegetation Monitoring and Grazing Report
Big Butte 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).

Starting 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 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 BLM managers and permittees with management of their grazing and adherence to the Grouse & Grazing study design.

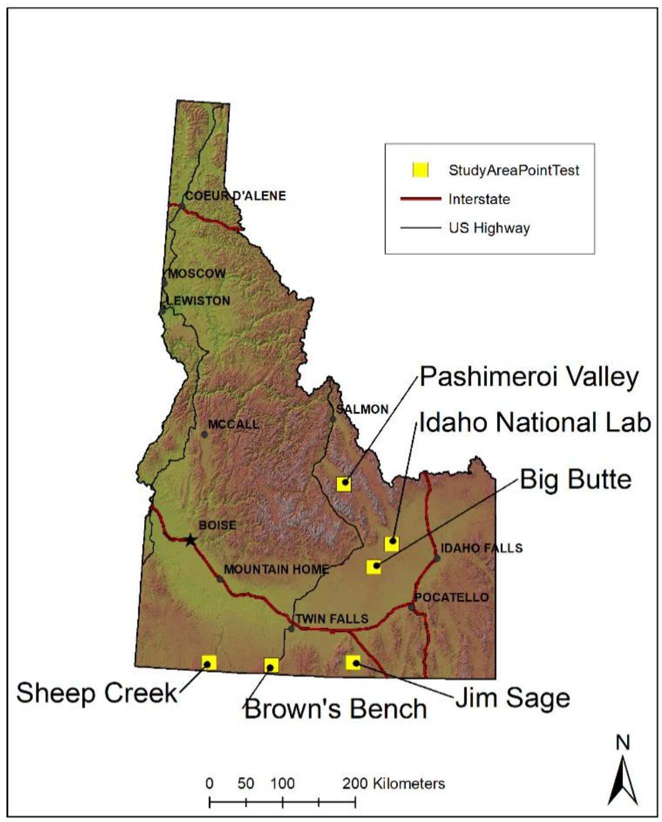

Figure 1. Six study sites in southern Idaho where field work has been conducted for the Grouse & Grazing project in 2019.

STUDY AREA

Big Butte

We began work at the Big Butte study site in 2015 and it was one of six study sites in 2019 (Fig. 1). Specific treatments at the Big Butte study site are shown in Figure 2. 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 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.

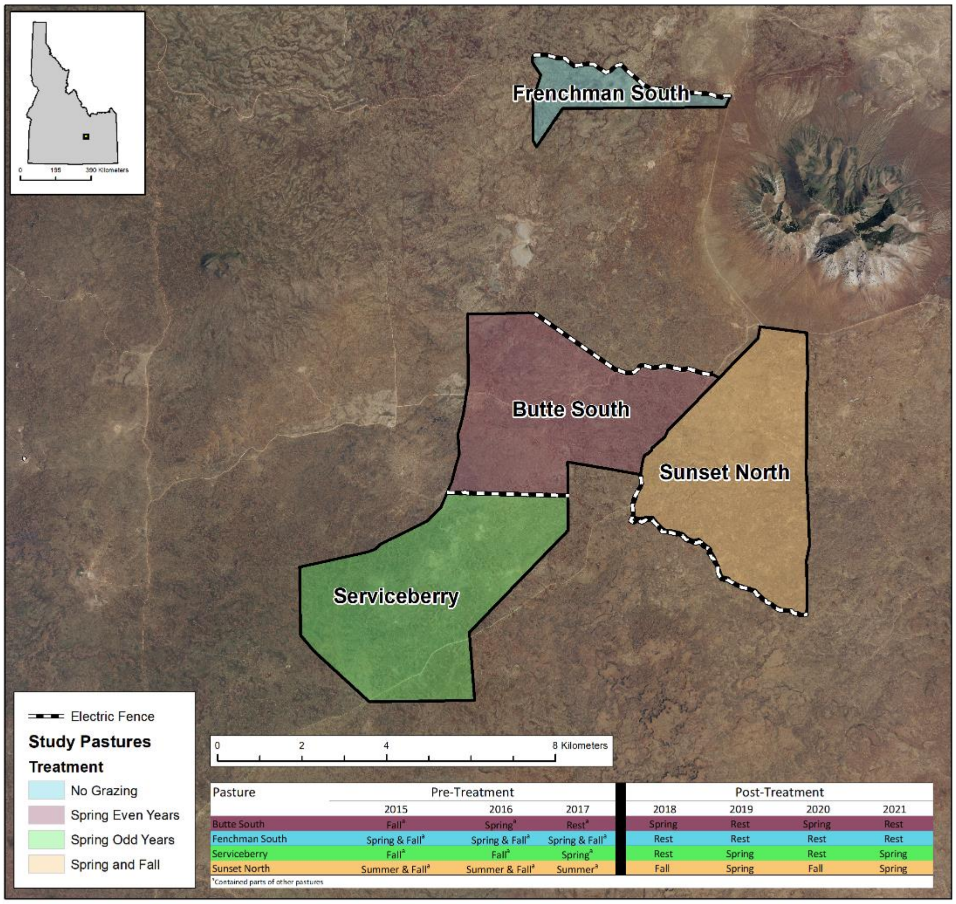

Figure 2. Map of experimental treatment pastures and timeline of treatments at the Big Butte study site, Idaho 2015-2021.

Precipitation comes primarily in the form of snow between November and March with 30-year normal (1980-2010; NOAA Online Climate Dataset) averaging 220 mm of precipitation per year. Monthly average temperature on an annual basis range from a low of -8.6° C (Jan) to a high of 20.3° C (Jul) based on the most recent 30-year monthly normals (1980-2010; NOAA Online Climate Dataset). Bureau of Land Management (BLM) manages the Big Butte allotment 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 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 6 study sites in southern Idaho, 2014-2019.

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 – 2019	Quantify vegetation characteristics when hen is selecting nest site
Nesting Season Vegetation Monitoring	April - July	Nests from current year & random plots[1]	2014 – 2019	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 – 2019	Quantify vegetation at brood locations
Post-Growing Season Vegetation Monitoring	July - August	Random plots	2015 – 2019	Quantify height, obstruction, and utilization of grass
Utilization/Pattern Use Monitoring	July - August	Systematic transects throughout experimental treatment pastures	2015 – 2019	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 – 2019	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. 2019). 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
- 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 three types of plots: nest plots, paired non-nest plots (hereafter referred to as 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 (100-200 m 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 2017-2019 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, and 3 in 2019.

Nest plots were centered on the nest. 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) because 99% of nests from prior years were at the base of a shrub. At each plot, we spread two 30-m tapes that intersected at the 15-m mark over the focal shrub in each cardinal direction (Fig. 3).

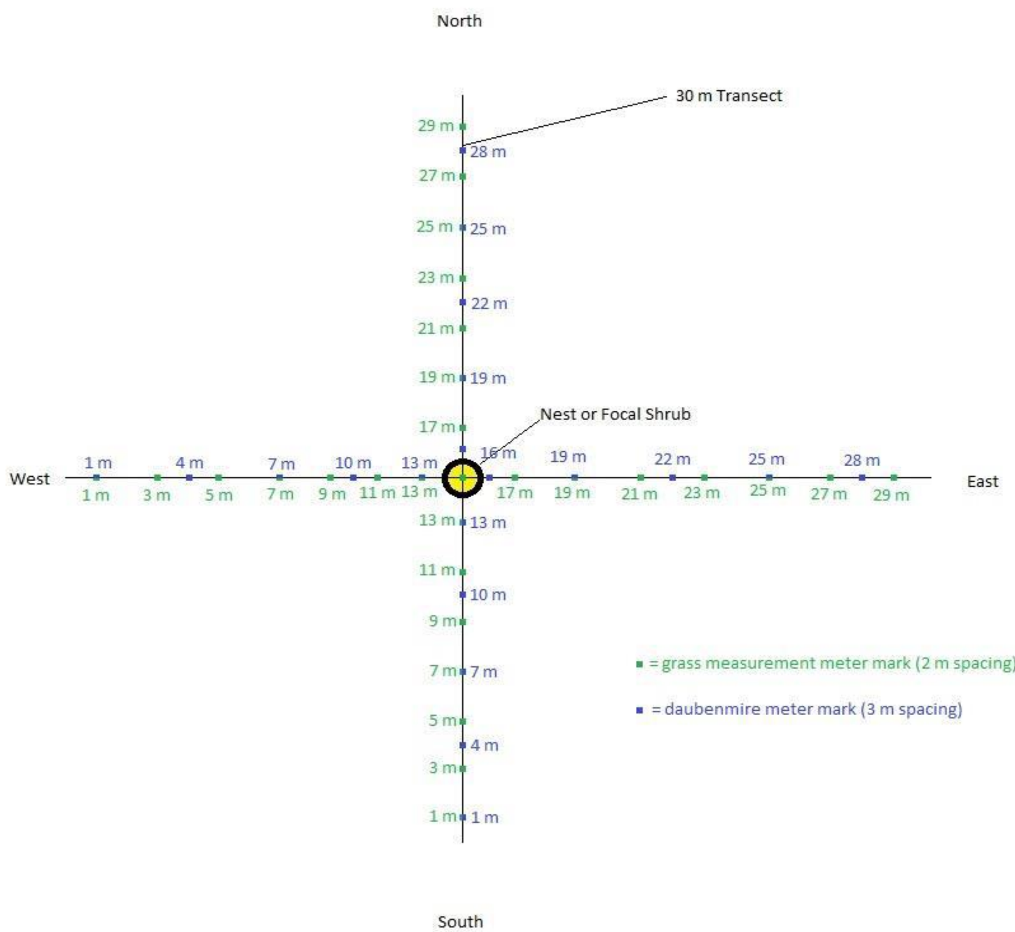

Figure 3. Visual depiction of the placement of two 30-m tapes stretched to conduct vegetation sampling at nest plots, random plots, and paired non-nest plots for the Grouse & Grazing Project in southern Idaho, 2014-2019.

Each plot (nest, 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), two 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. 2019).

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/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/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 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.

Cattle Use Metrics

Each year, we record the number and timing of cattle that graze each experimental treatment pasture and adjacent 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 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 (2019), 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 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 ≤50% obscured by the grass (Musil 2011; *detailed methods can be found in* Conway et al. 2019).

We used each of these 3 metrics to compare grazed and un-grazed pastures in 2019. 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. 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

We estimated utilization using 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 (2019). 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., 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) 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 head-months (HMs) for all years after our treatments began at each study site. We calculated HMs using the following formula: $\frac{n_c \times (t_2 - t_1)}{(\frac{365}{12})}$

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 added for the first 10 days and then 100 cows were added on the 11th day), we calculated HD-MO for each separate stocking rate and summed them together to report the stocking rate for the entire season.

RESULTS

Weather

Going into the 2019 growing season, Big Butte received slightly above-average overwinter precipitation (Fig. 5A) and average to slightly above-average temperatures (Fig. 5B). Rainfall in Feb-May of 2019 was greater than that in 2018 and much more consistent. We did not observe any abnormal spikes in precipitation like we did in May 2018. In general, the conditions going into the 2019 growing season were much more favorable and consistent with the 30-year average than 2018.

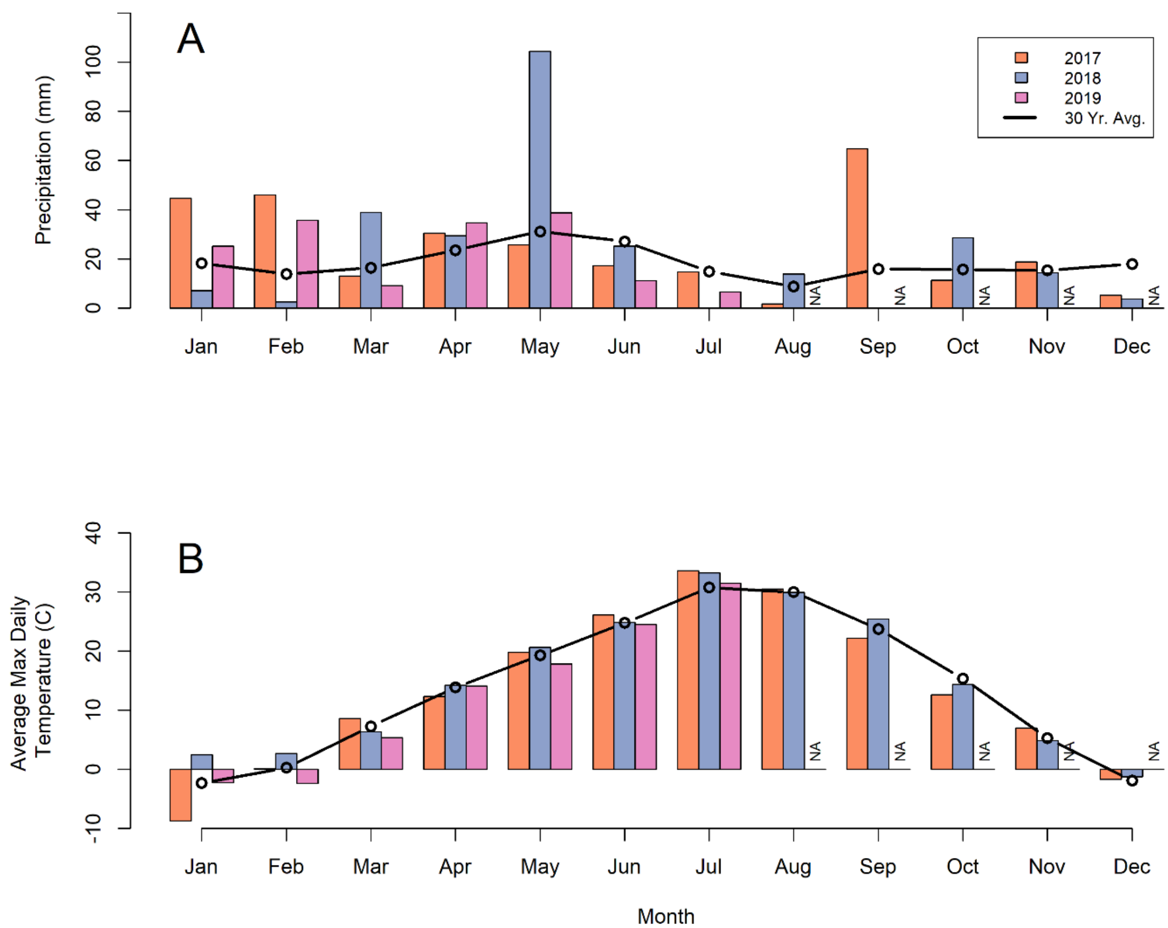

Figure 4. Monthly precipitation totals (A) and average max daily temperature by month (B) with 30-year average (dark line) at Big Butte, Idaho 2017-2019.

Descriptive Vegetation Characteristics

Pasture-level Comparison

Mean grass height at Big Butte varied each year with earlier and later years of the study having lower grass heights than those in 2017 (Fig. 6). Grass heights were highly dependent on overwinter precipitation and to a lesser extent on whether the pasture was spring grazed. In 2017, Big Butte received 260 mm of precipitation from Nov-Apr (prior to the 2017 growing season). This was also the year that we observed the highest grass heights in each of the experimental treatment pastures in post-growing season surveys. Precipitation leading up to the 2015 and 2016 growing seasons (143 mm and 163 mm between Nov-Apr respectively) was well below average and this was reflected by grass heights in post-growing season surveys. Serviceberry and Sunset North pastures were grazed in the spring of 2019. These pastures both had the lowest grass heights of all 4 experimental treatment pastures in 2019, but the difference between these 2 pastures and the pastures that were not grazed was small. A thesis by Janessa Julson (2017) documented the extent of variation in grass height among our study sites.

The droop height of grasses in the open (not under a shrub; red bars) was taller than the other 3 grass height categories in all pastures in both nesting and post-growing season surveys (Fig. 6). The remaining 3 categories (all perennial grasses, all perennial grass species excluding Sandberg bluegrass, and all perennial grass plants under a shrub; Fig. 6) were all very similar to each other in height in both nesting and post-growing season surveys. Grass droop height for all perennial grass species increased more in ungrazed pastures (3.2 cm increase in Butte South and 2.4 cm increase in Frenchman South) compared to grazed pastures (0.8 cm decrease in Serviceberry and 1.4 cm increase in Sunset North). Timing of grazing during the growing season can have a large impact on grass height of post-growing season surveys. When pastures are grazed prior to the end of the growing season (which is typically the case for spring grazed pastures in this study) there is an opportunity for re-growth to compensate for any height reduction due to grazing. Our surveys indicate that grazing had little effect on mean grass height in post-growing season surveys in 2019. It is important to note that cattle do not graze pastures evenly (Fig. 13) and there were areas within the experimental treatment pastures that had substantial grass height reduction due to grazing.

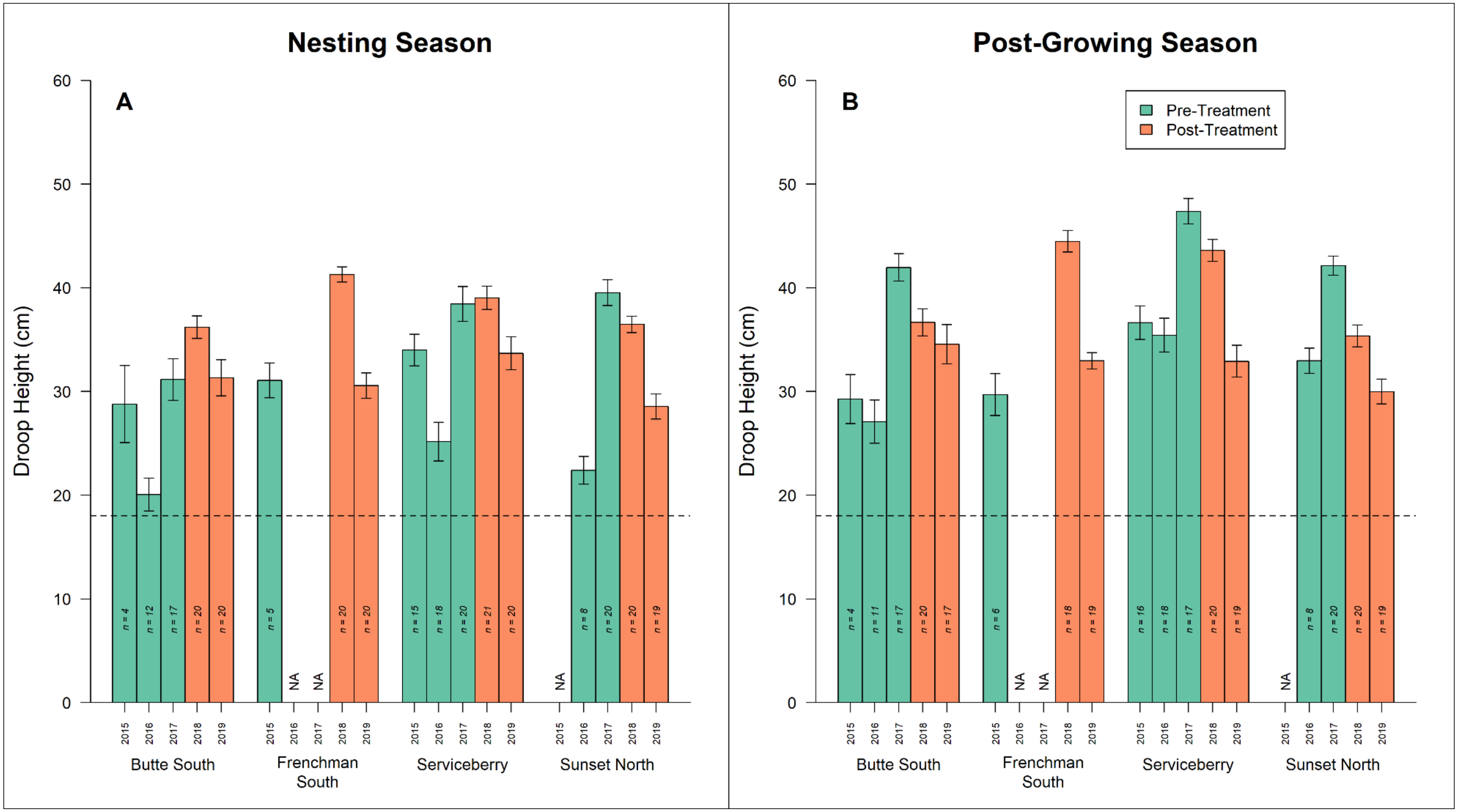

Figure 5. Mean droop height during the nesting season (A; Apr-Jun) and the post-growing season (B; Jul-Aug) for all perennial grass species combined in pre-treatment (green) and post-treatment (orange) years for 4 pastures at Big Butte, Idaho 2015-2019. Error bars indicate standard errors and means are 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).

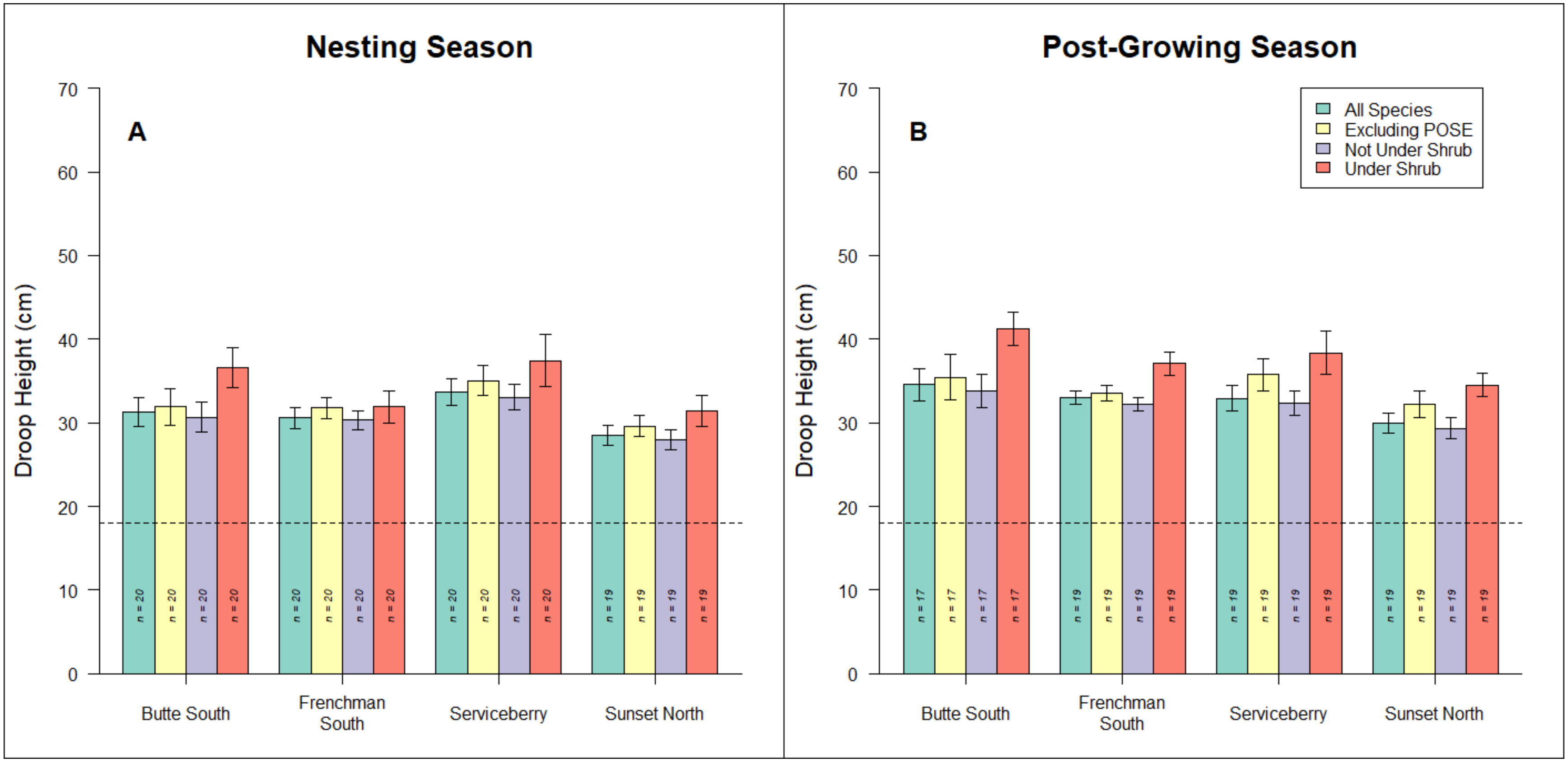

Figure 6. Mean droop height for 4 different subsets of grasses: all perennial grass species within a plot, all perennial grass species excluding Sandberg bluegrass (Poa secunda), all perennial grass plants that were under a shrub, and all perennial grass plants that were not under a shrub in both nesting season (A) and post-growing season (B) plots at Big Butte, Idaho 2019. 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, slender wheatgrass (*Elymus trachycaulus*), squirreltail (*Elymus elymoides*), and needlegrasses (*Achnatherum spp.* and *Hesperostipa spp.*) were the most abundant grasses in our post-growing season surveys at Big Butte in 2019. Grass height differed among species and differences were apparent for all three height metrics (Fig. 7). All grasses that were measured in grazed pastures were shorter than those in ungrazed pastures for the droop height measurements. Differences in leaf height and effective height were less prominant between grazed and ungrazed pastures for most species.

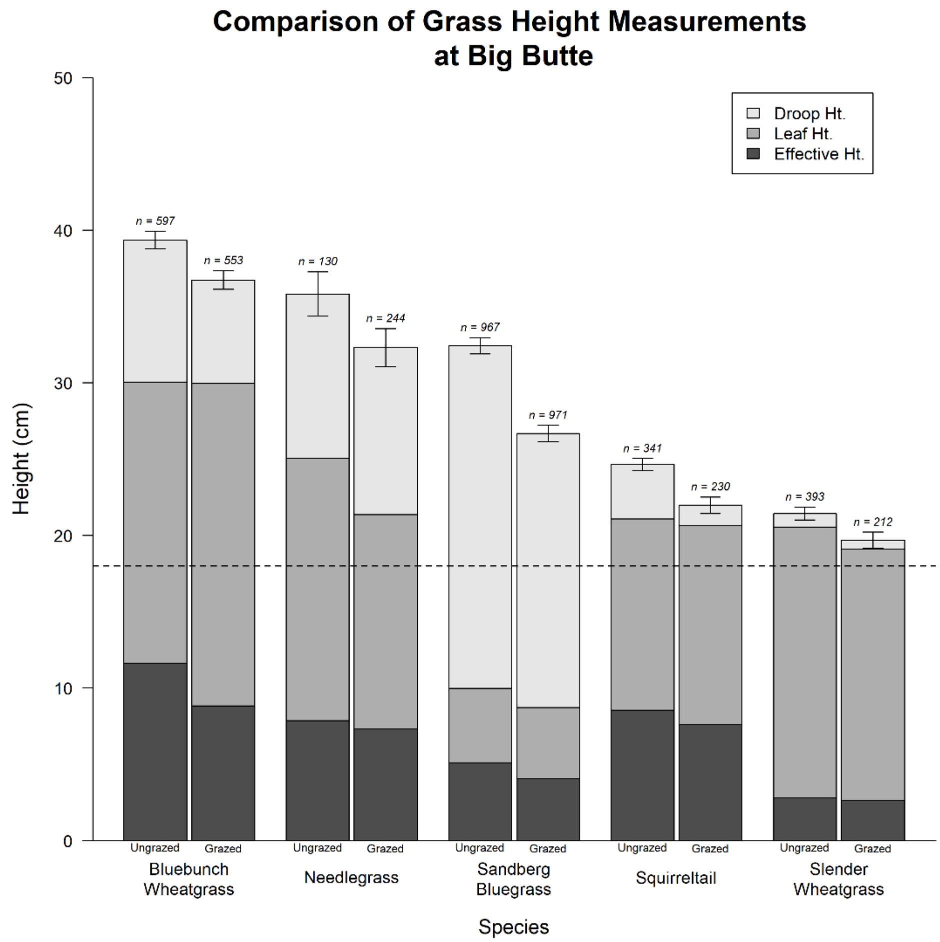

Figure 7. Mean height of the 5 most common species of perennial grasses based on 3 height metrics on post-growing season (Jul-Aug) random plots at Big Butte, Idaho in 2019. Heights compared were droop height (using highest part of plant) = "Droop Ht.", droop height excluding the flowering stalk = "Leaf Ht", and effective height (modified visual obstruction for an individual plant) = "Effective Ht". Heights were compared seperately for plants in ungrazed and grazed pastures based on whether they were grazed in 2019 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

In general, shrub cover within most pastures at Big Butte has remained relatively consistent between years (Fig. 8). The exception is the Butte South pasture where sagrbrush cover has steadily increased since the beginning of our work at Big Butte. The likely explanation for the increase in shrub cover at Butte South is 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. When we compared these 12 plots across years there was little change in sagebrush and other shrub cover). Sagebursh species, including three-tip sagebrush and basin big sagebrush, make up the majority of shrubs at Big Butte in all years. On all of our treatment pastures, we expect to see only small changes in shrub cover between years; changes caused by annual variation in precipition.

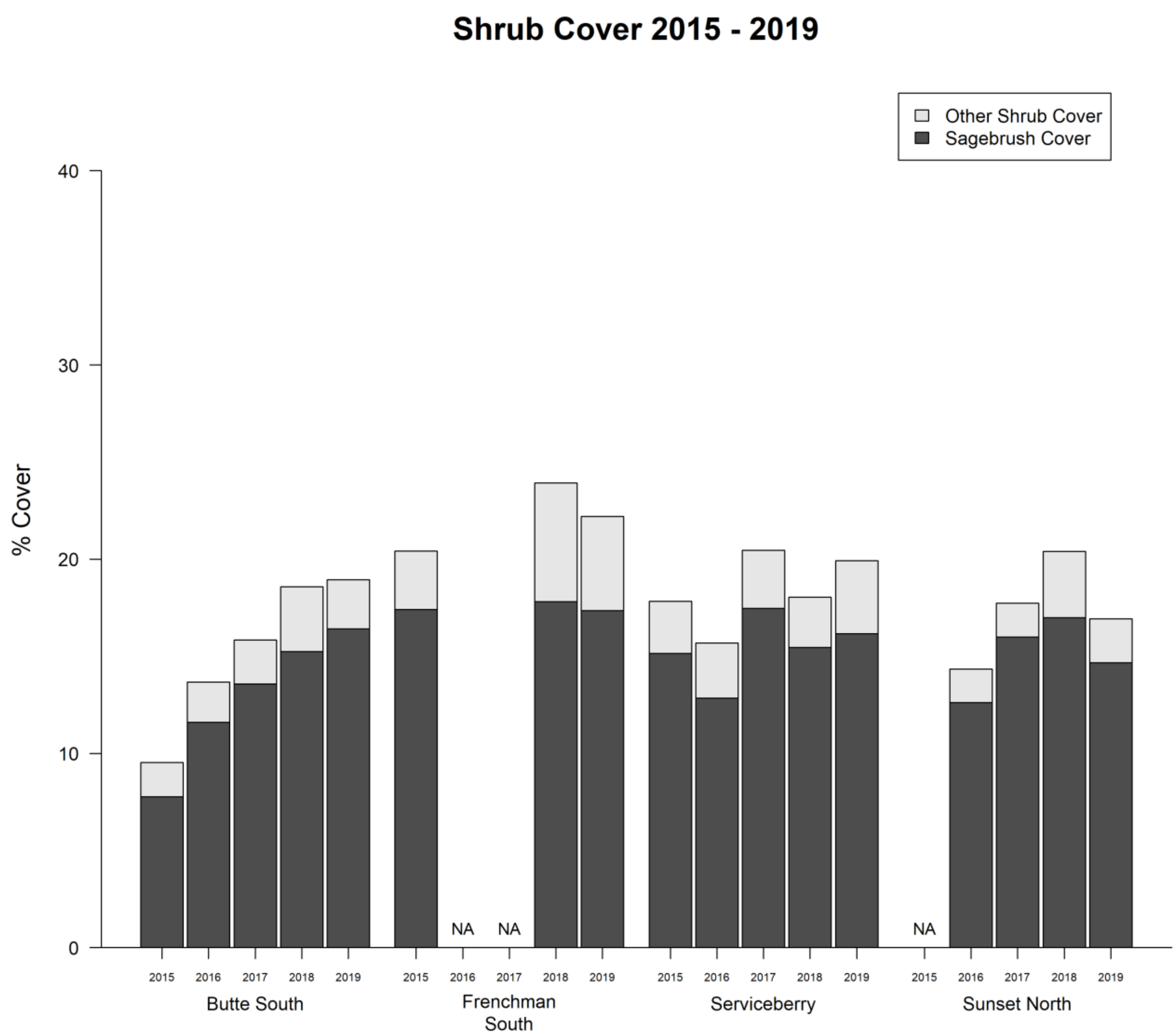

Figure 8. Shrub cover (split into sagebrush and other shrub cover) in each of 4 experimental treatment pastures at Big Butte, Idaho 2015-2019.

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. Head-months were higher pre-treatment years (2015-2017) than in 2018 post-treatment (2019 data were not available at the time of this report). Pre-treatment head-months ranged from 89-1,085 (Fig. 9A-B) and post-treatment head-months from 96-631 (Fig. 19C-D). The reason for this is 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 head-months 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 HD-MOs per ha to help compensate for the differences in pasture size and make grazing pressure in post-treatment years comparable to pre-treatment years.

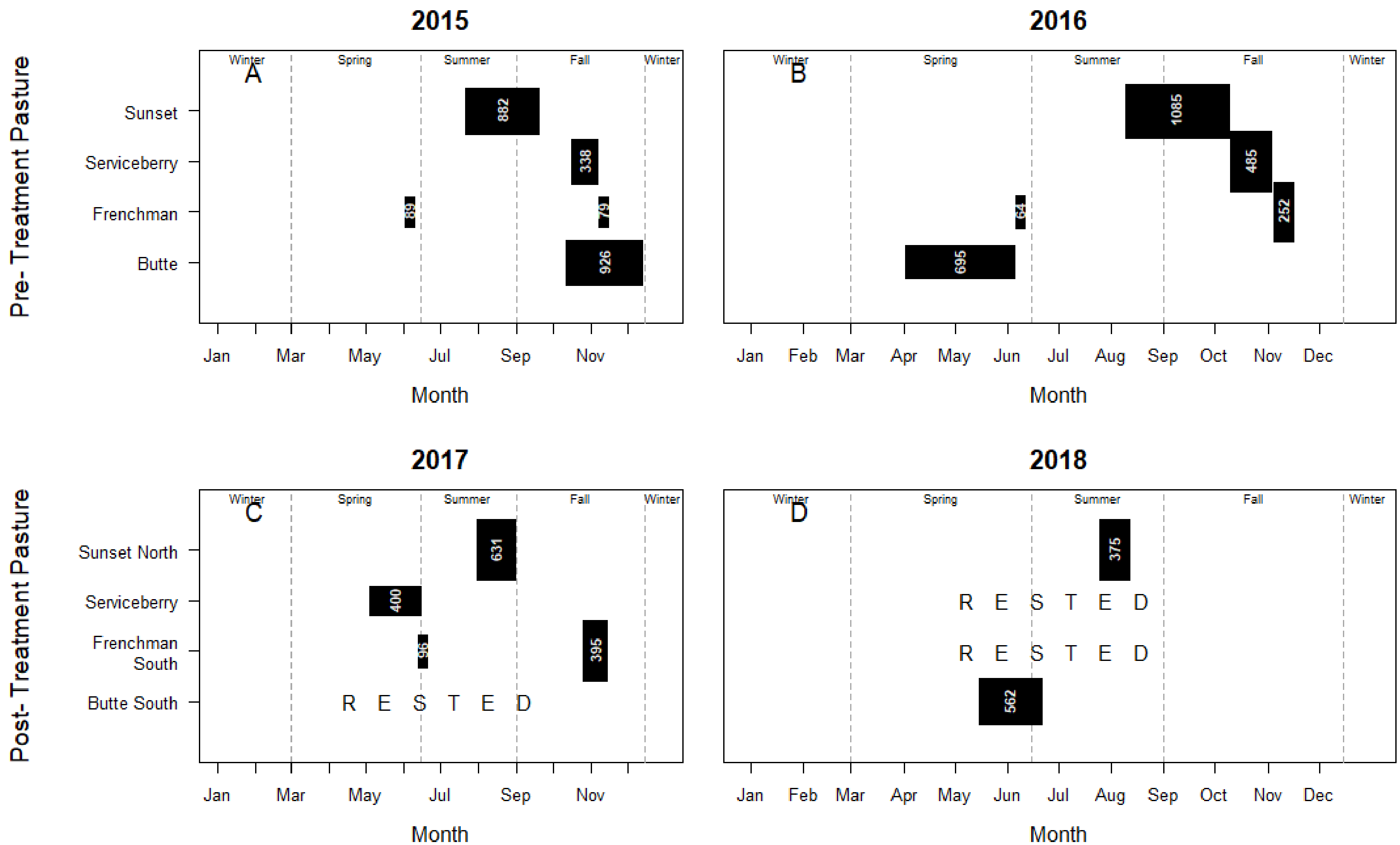

Figure 9. Timing and duration of cattle stocking at Big Butte during pre- and post-treatment periods of the study 2015-2018 (data for 2019 has not been reported yet). Width of black bars indicate the average number of cattle per day in that pasture. White numbers inside black bars represent the total head-months during that period. We attempted to begin treatments in 2017, but were forced to re-start in 2018 due to the Wildhorse Fire in July 2017.

In 2018, head-months in our experimental treatment pastures were comparable to surrounding pastures (those not part of our study; Fig. 10). Two of our experimental treatment pastures were rested in 2018. Two pastures to the south of our treatments were rested in 2018 due to the Wildhorse Fire in 2017. We did not having stocking rate information available for 2019 at the time of this report.

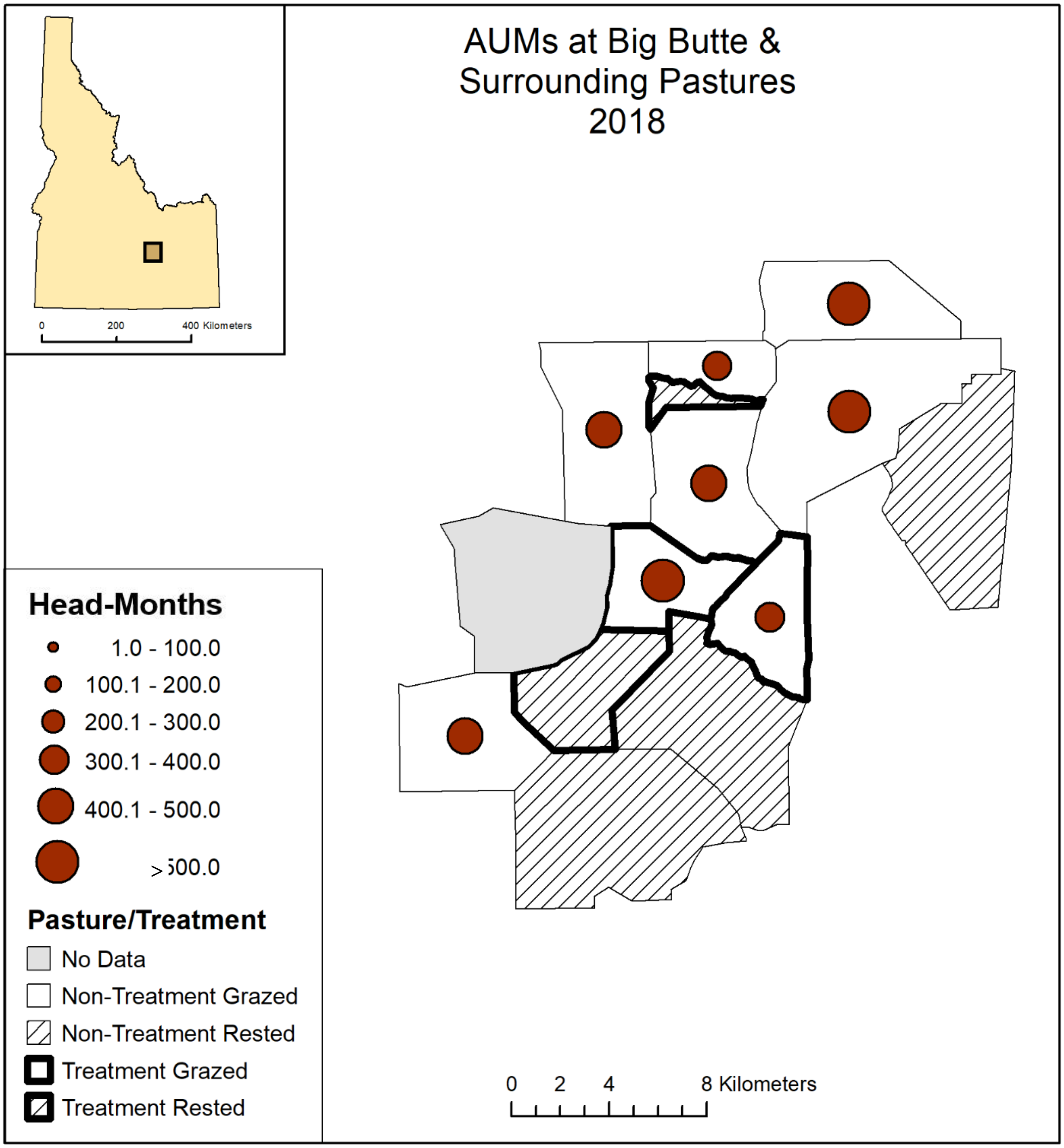

Figure 10. Stocking level in Head-Months in treatment and surrounding pastures at Big Butte, Idaho in 2018.

Estimates of Utilization

Visual estimates of utilization were negligible in both spring grazed pastures (Serviceberry and Sunset North) across all 4 categories in 2019 (Fig. 11). Proportions of grazed plants were also relatively low. Both of these pastures were relatively large and have limited water sources compared to pastures at other study sites used for the Grouse & Grazing Project. The estimates below were based on 20 sampling locations randomly distributed throughout each pasture. These summaries indicate that grazing patterns at Big Butte are likely more patchy than other study sites.

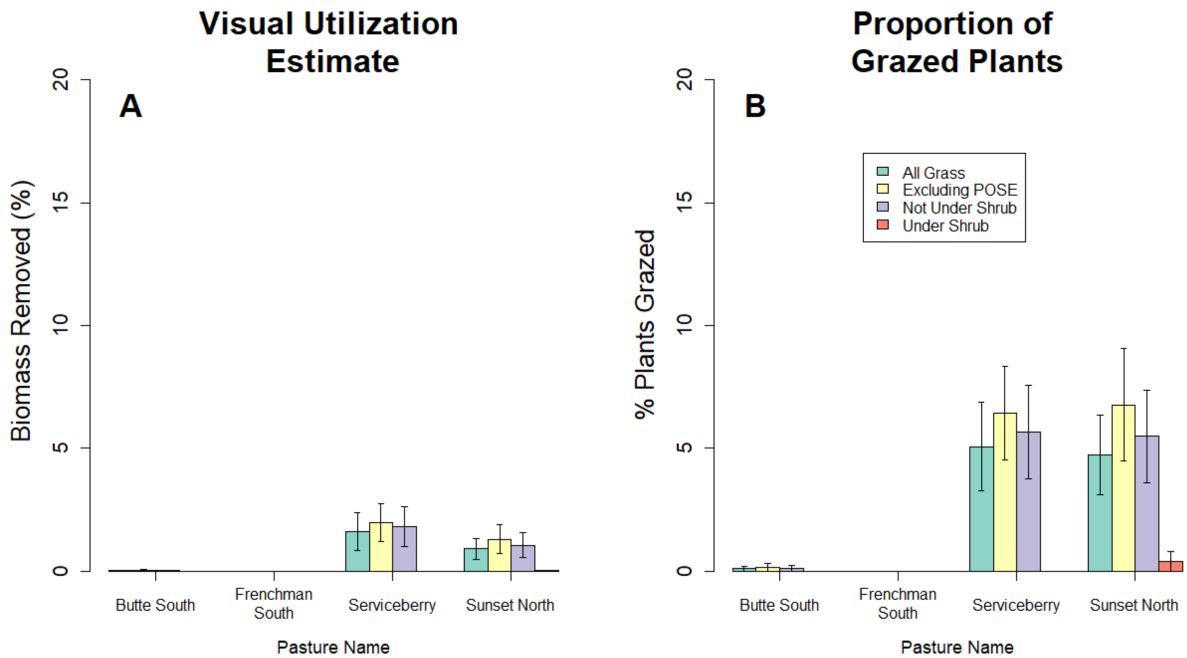

Figure 11. Grazing intensity based on visual estimates of percent biomass removed on individual grass plants and the proportion of grass plants grazed at random plots in 2019 at Big Butte, Idaho. Estimates were taken from the post-growing season surveys conducted in July – August 2019. In 2019, Serviceberry and Sunset North were grazed prior to post-growing season surveys.

Utilization estimates from the landscape appearance method varied among years (Fig. 12). Spring grazed pastures in 2019 (Serviceberry and Sunset North) had ~10% utilization. These are higher than our estimates of individual plants from post-growing season vegetation surveys (Fig. 11A), but exhibit the same pattern between pastures (Sunset North had slightly lower utilization than Serviceberry). The difference in these two methods may be explained by the larger amount of area covered in our landscape appearance plots (312 and 304 sample points in Serviceberry and Sunset North spread systematically over the entire pasture as compared to 20 plots per pasture).

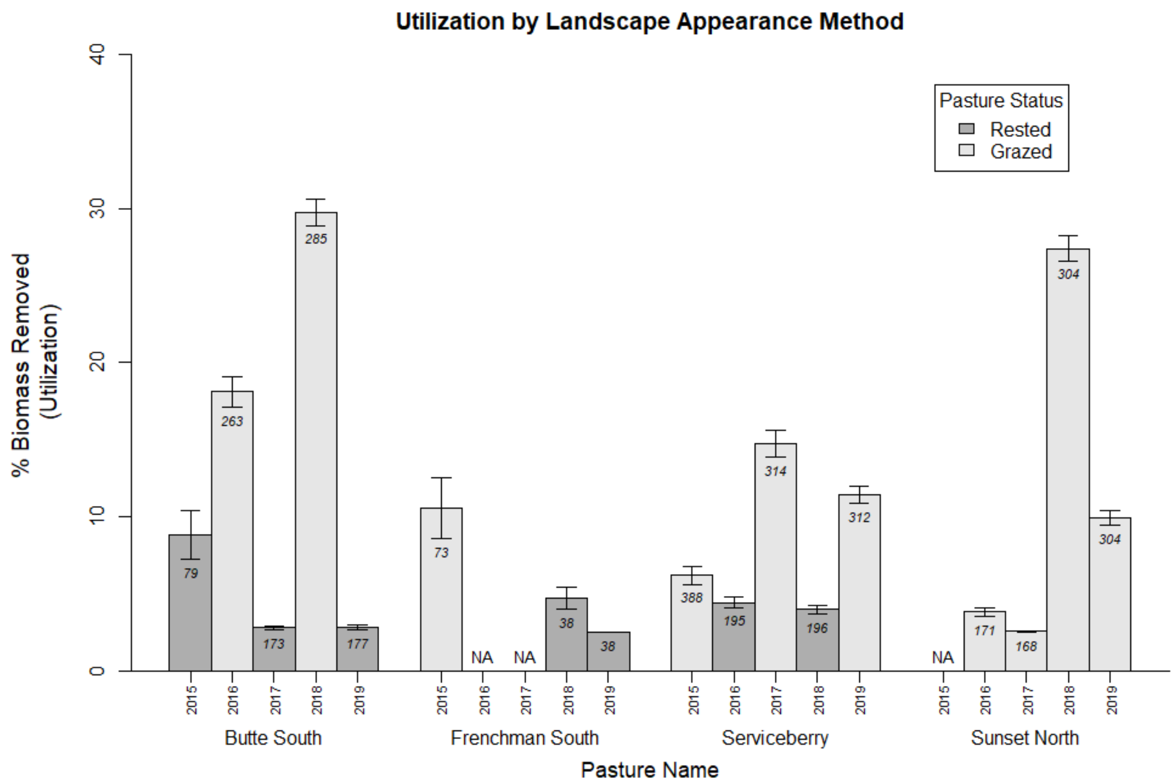

Figure 12. Utilization estimates based on the landscape appearance method for pre- and post-treatment periods at Big Butte, Idaho 2015-2019. Error bars represent ±1 standard error. NA indicates that pasture was not measured in that particular year.

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. 14). At Big Butte, this is especially apparent (see Serviceberry and Sunset North in 2019; Fig. 13E). Most pastures in Big Butte have only 1-2 water sources available to cattle unless we have major rain events (as seen in May 2018: Fig. 4A).

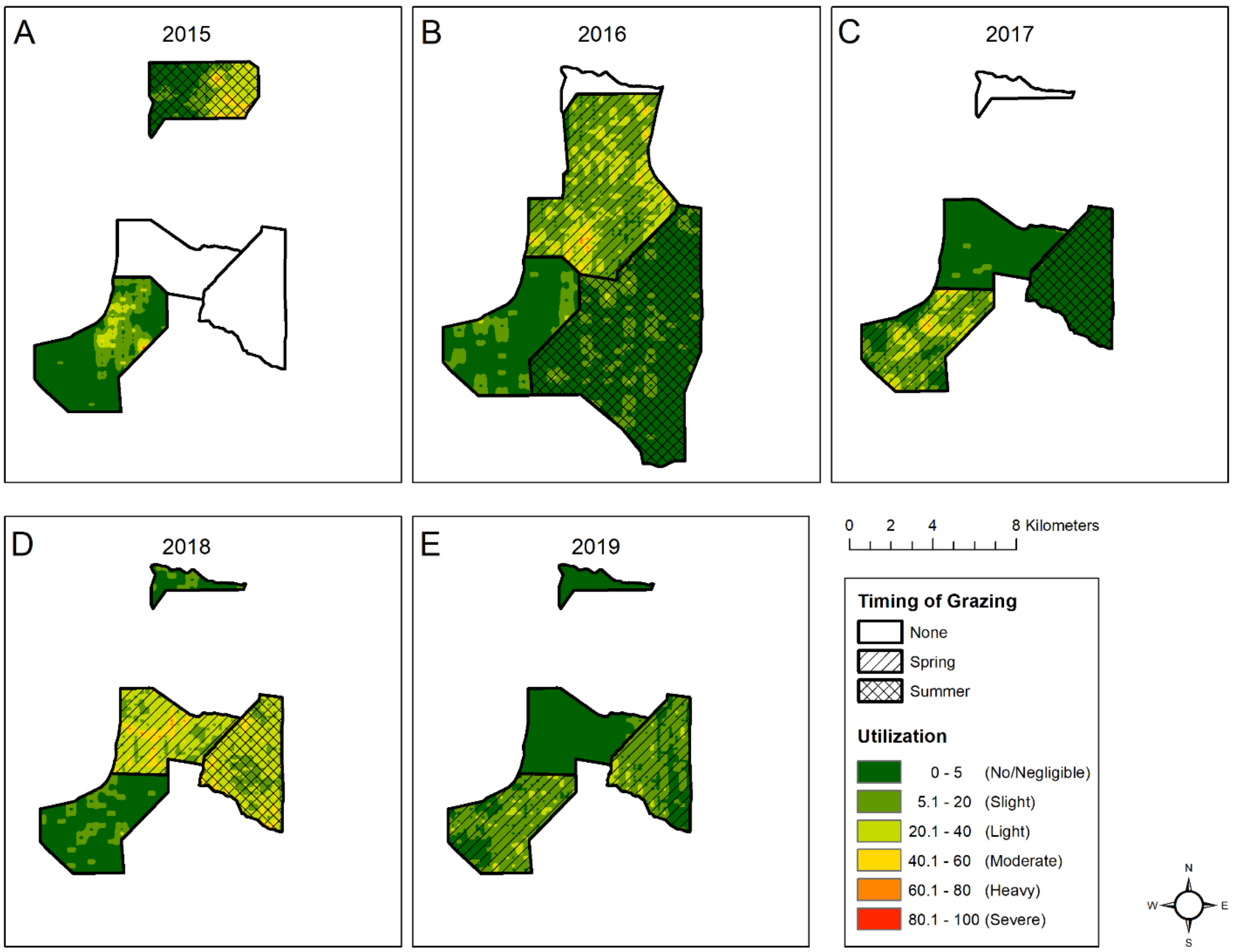

Figure 13. Pattern use mapping based on landscape appearance transects at Big Butte, Idaho 2015-2019.

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