2022 Grouse & Grazing Project
Vegetation Monitoring and Grazing Report
Brown's Bench 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 the Bureau of Land Management (BLM) managers and permittees with management of their grazing and adherence to the Grouse & Grazing study design.

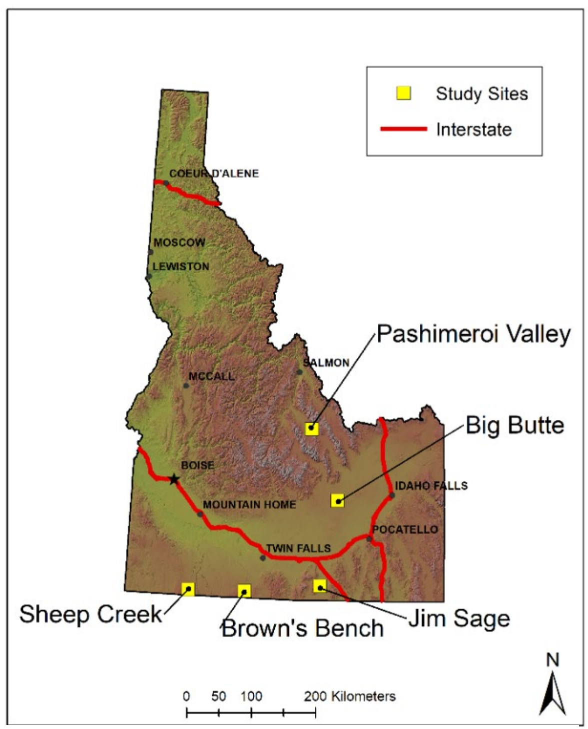


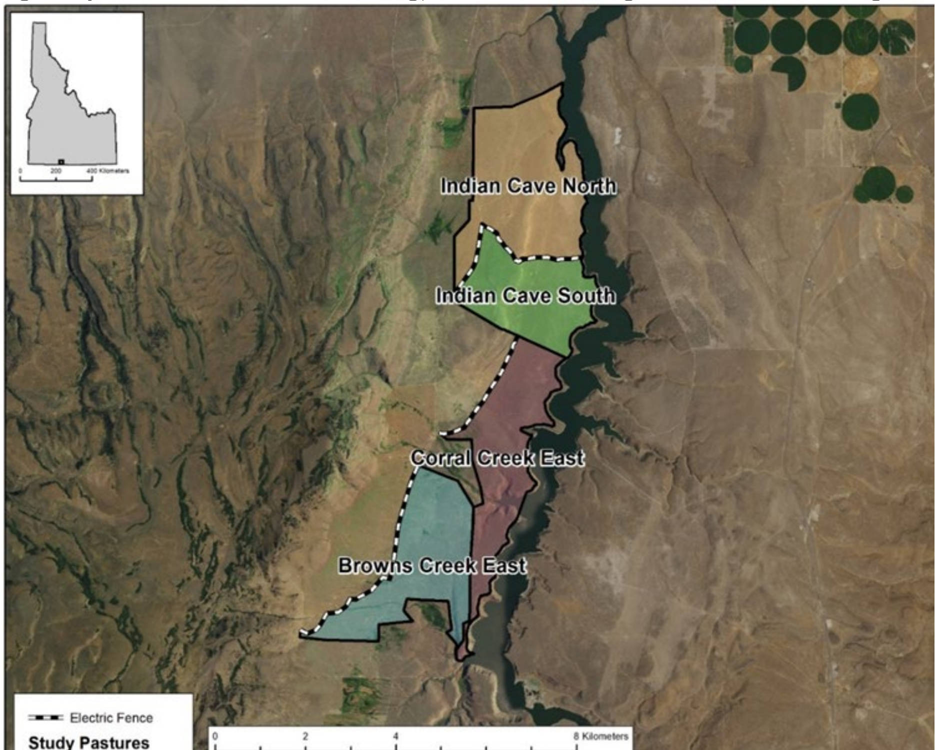
Figure 1. Five study sites in southern Idaho where field work has been conducted for the Grouse & Grazing Project, 2014-2022. We did not conduct field work at the Jim Sage study site in 2022.

STUDY AREA

Brown's Bench

We began work at the Brown's Bench study site in 2014. Brown's Bench is located approximately 14 km west of Rogerson, ID near the Idaho-Nevada border (Fig. 1). Topography at this site consists of rolling hills and canyons that drain towards Salmon Falls Creek Reservoir which creates the eastern boundary of the experimental treatment pastures. The western edge of the study area is defined by Monument Springs Mountain which rises ~500 m above the experimental treatment pastures. Soils primarily consist of the Ackett complex with slopes ranging from 2-10%, relatively shallow soil depth, and mostly gravely clay soils.

The plant community here is dominated by black sagebrush (*Artemisia nova*) and Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) with basin big sagebrush (*Artemisia tridentata tridentata*) in the bottoms of drainages and rubber rabbitbrush (*Ericameria nauseosa*) in areas with recent burns. Fire has reset plant communities and eliminated sagebrush on the western boundary of the 4 experimental treatment pastures. Few anthropogenic structures are near the experimental treatment pastures. Some irrigated agriculture exists on the eastern side of Salmon Falls Creek Reservoir. The primary human uses in the area are recreation (fishing on the reservoir, off-highway vehicle use, and hunting), cattle ranching, and some farming.



Pasture	Pre-Treatment		Post-Treatment							
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Corral Creek East	Fall[a]	Fall[a]	Spring	Rest	Spring	Rest	Spring	Rest	Spring	Rest
Brown's Creek East	Spring & Fall[a]	Spring & Fall[a]	Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
Indian Cave South	Spring & Fall[a]	Spring & Fall[a]	Rest	Spring	Rest	Spring	Rest	Spring	Rest	Spring
Indian Cave North	Spring & Fall[a]	Spring & Fall[a]	Fall	Spring & Fall	Fall	Spring & Fall	Fall	Spring & Fall	Fall	Spring & Fall

[a]Contained parts of other pastures

Figure 2. Map of the 4 experimental treatment pastures and timeline of treatments at the Brown's Bench study site, Idaho 2014-2023.

Elevation at the site ranges from 1,527 – 1,758 m (mean 1,624 m; USGS National Elevation Dataset). Precipitation comes primarily in the form of snow between November and March with 30-year normal averaging 269 mm (1980-2010; NOAA Online Climate Dataset). Monthly average temperatures range from a low of -4.2° C (Jan) to a high of 19.4° C (Jul) based on the most recent 30-year normal (1980-2010; NOAA Online Climate Dataset). The Brackett Bench allotment is managed by BLM and livestock grazing is allowed 1 March – 31 December. 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 a herd of 200-350 cattle each year on this allotment.

Table 1. Summary of the vegetation data collected for the Grouse & Grazing Project at 5 study sites in southern Idaho, 2014-2022.

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 – 2022	Quantify vegetation characteristics when hen is selecting nest site
Nesting Season Vegetation Monitoring	April - July	Nests from current year & random plots[1]	2014 – 2022	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 – 2022	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 – 2022	Quantify height, obstruction, and utilization of grass
Utilization/Pattern Use Monitoring	July - August	Systematic transects throughout experimental treatment pastures	2015 – 2022	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
Biomass Clipping	July-August	Random plots that were sampled during the nesting season	2022	Quantify fire fuels levels across all treatments
Plant Collections	April - August	Experimental treatment pastures and surrounding areas	2017 – 2021	Create a DNA reference database and a library of voucher specimens to 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 that were surveyed during the nesting season
- 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
- Biomass Clipping Surveys
  - Random plots that were surveyed during the nesting season
- 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 any paired non-nest plots for the past 3 years (2020-2022). All random plots were within the experimental grazing pastures and were centered on a sagebrush shrub. We randomly generated 40 locations at the start of the project that were within each experimental treatment pasture that were no closer than 100 m from one another to create random locations to use for random plots. We sample the same 20 random plots within each pasture every year.

Plot Placement in the Field

Each year, including 2022, 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). In 2017-2019, we also measured paired non-nest plots when time allowed (we placed priority on nest plots and random plots) for a total of 53 plots across the 5 study sites. Non-nest plots were discontinued entirely in 2020.

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).

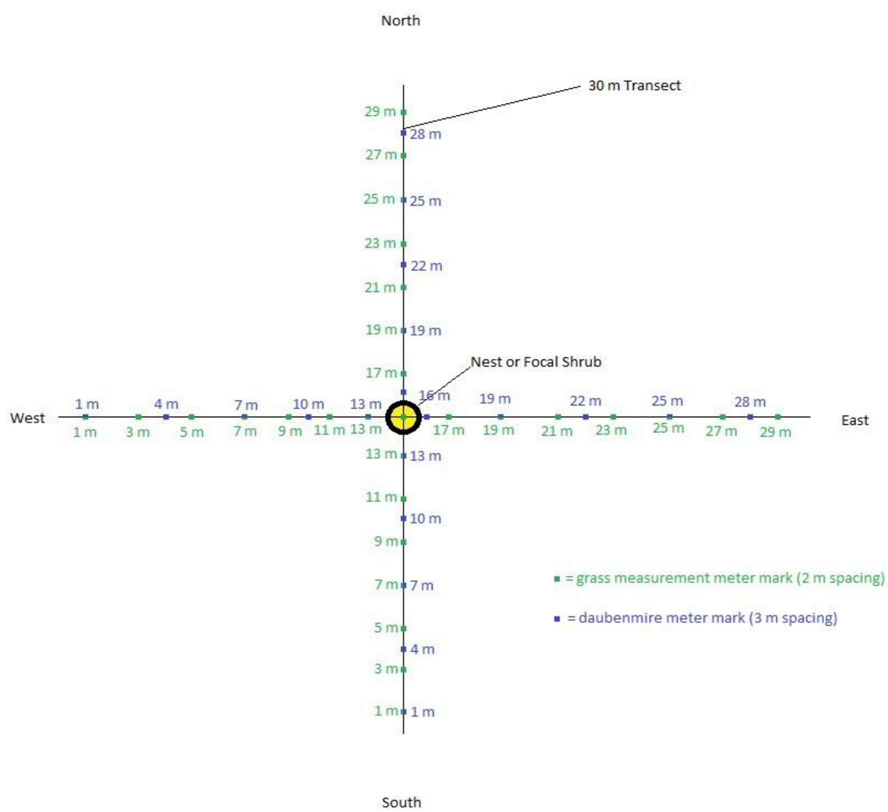


Figure 4. Visual depiction of the placement of two 30-m tapes stretched to conduct vegetation sampling at nest plots, random plots, and paired non-nest plots for the Grouse & Grazing Project in southern Idaho, 2014-2022.

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 cattle spent considerable time foraging 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). Moreover, we did not know which pastures were logistically feasible as experimental pastures at the outset of work in an allotment. 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 (2022), 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 ungrazed (rested) 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 (2022). 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 (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

Brown's Bench received above-average overwinter precipitation (Fig. 4A) and average temperatures (Fig. 4B) going into the 2022 growing season. Prior to this year, Brown's Bench had received substantial below-average overwinter precipitation for 3 years in a row. Brown's Bench received below-average precipitation during January-April leading into the 2022 breeding season but received above-average precipitation in the month of May. The site also received average overwinter temperatures, but below-average temperatures during the breeding season.

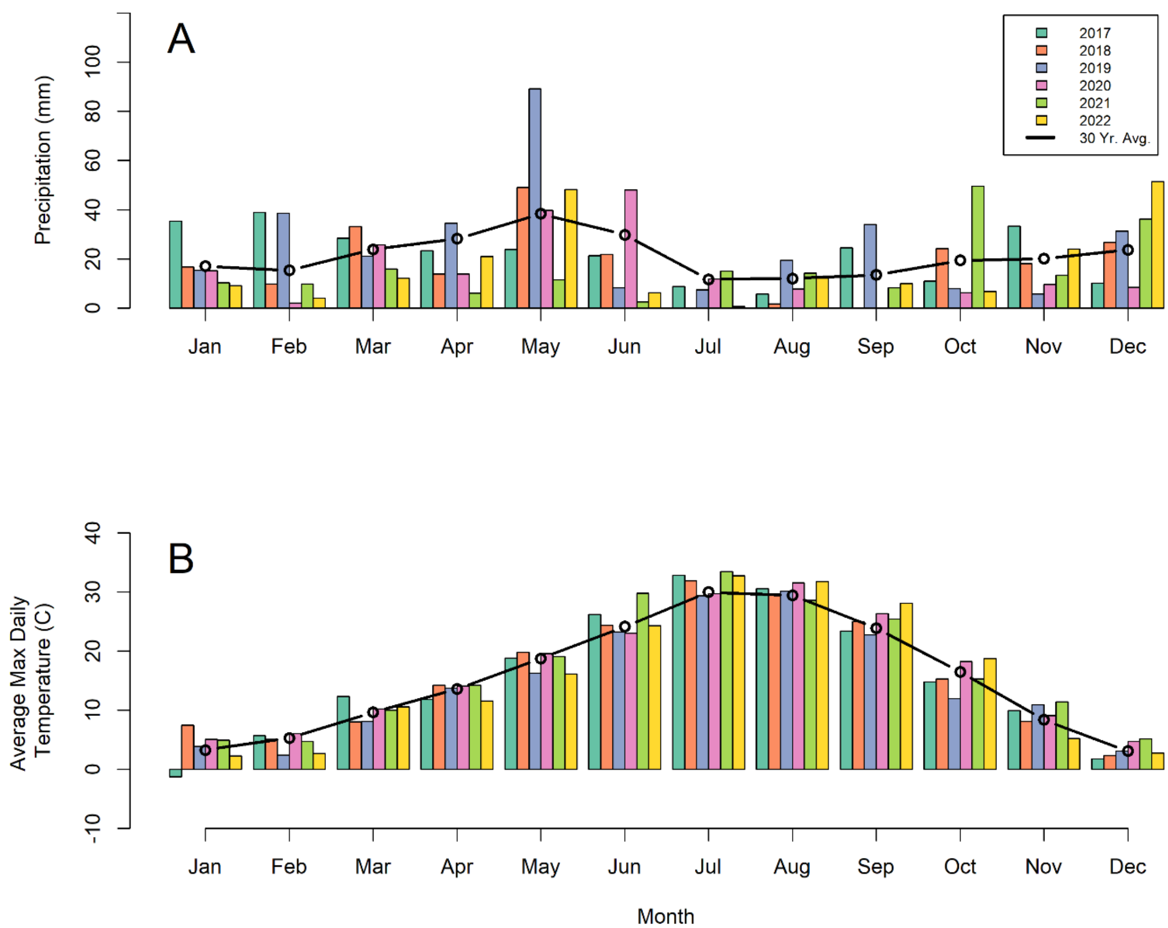


Figure 4. Monthly precipitation totals (A) and average max daily temperature by month (B) with 30-year average (dark line) at Brown's Bench, Idaho 2017-2022.

Descriptive Vegetation Characteristics

Pasture-level Comparison

Grass droop heights varied among years and pastures (Fig. 5). As expected, grass heights in the no grazing pasture (Browns Creek East) have generally been taller than the other 3 pastures in all years post-treatment. Corral Creek East has had the largest fluctuation in grass heights with spring grazing occurring in 2016, 2018, 2020, and 2022. Corral Creek East is also the pasture we tend to see the most intense grazing in each year as well (Fig. 13). During the nesting season, grass heights were higher in 2022 compared 2020 and 2021 (both years when the site received below-average amounts of overwinter and growing season precipitation; Fig. 4A). The biggest differences can be seen in the post-growing season heights, as we observed some of the tallest grass heights since the project began in 3 of 4 pastures at Brown's Bench. While Corral Creek East didn't experience grass heights as tall as the other pastures in 2022, we did observe the tallest grass heights in the pasture during a year it was grazed. A thesis by Janessa Julson (2017) documented the extent of variation in grass height among our study sites.

The mean height of grasses under shrubs (red bars) and all grasses excluding Sandberg bluegrass (yellow bars) were taller than the other 3 grass height categories in most pastures (Fig. 6). The difference in heights between grasses under shrubs and the other categories is greatest in the Corral Creek East pasture however, which was the only pasture grazed during the 2022 field season (Indian Cave North was grazed after the surveys were completed). In Browns Creek East, grasses excluding Sandberg bluegrass were much taller than all other categories, especially during the post-growing season surveys. In all 4 pastures in 2022, we documented an increase in grass heights in all categories between the two seasons of surveys. This increase was noticeably smaller in the only pasture that was spring grazed in 2022 (Corral Creek East) for 3 of the 4 grass height categories. We still observed an increase similar to other pastures in the height of grasses under shrubs in the grazed pasture, indicating cattle tend to graze on more easily accessible grasses.

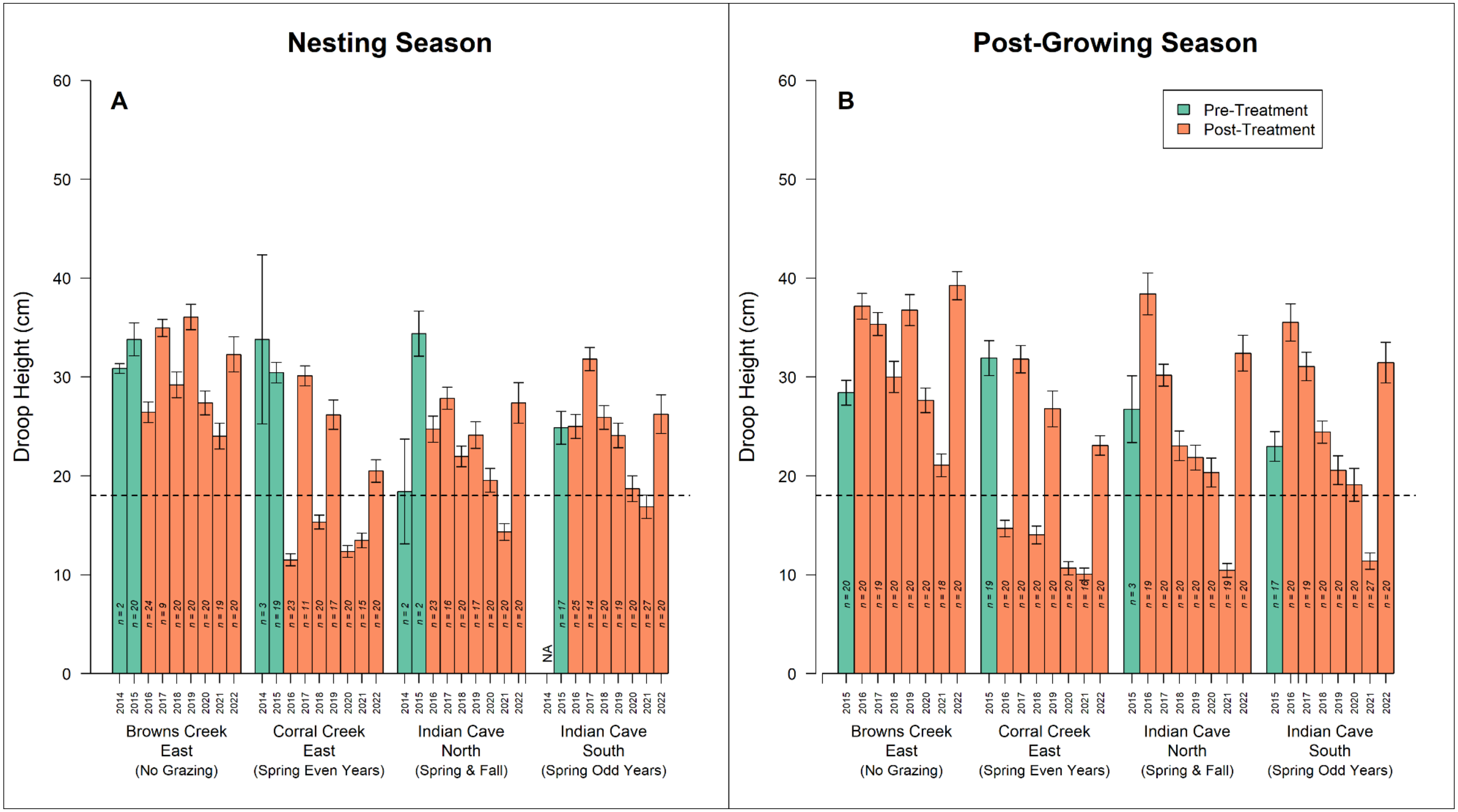


Figure 5. Mean droop height during the nesting season (A; Apr-Jun) and the post-growing season (B; Jul-Aug) for all perennial grass species combined in pre-treatment (green) and post-treatment (orange) years for 4 pastures at Brown's Bench, Idaho 2014-2022. Error bars indicate standard errors and means 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).

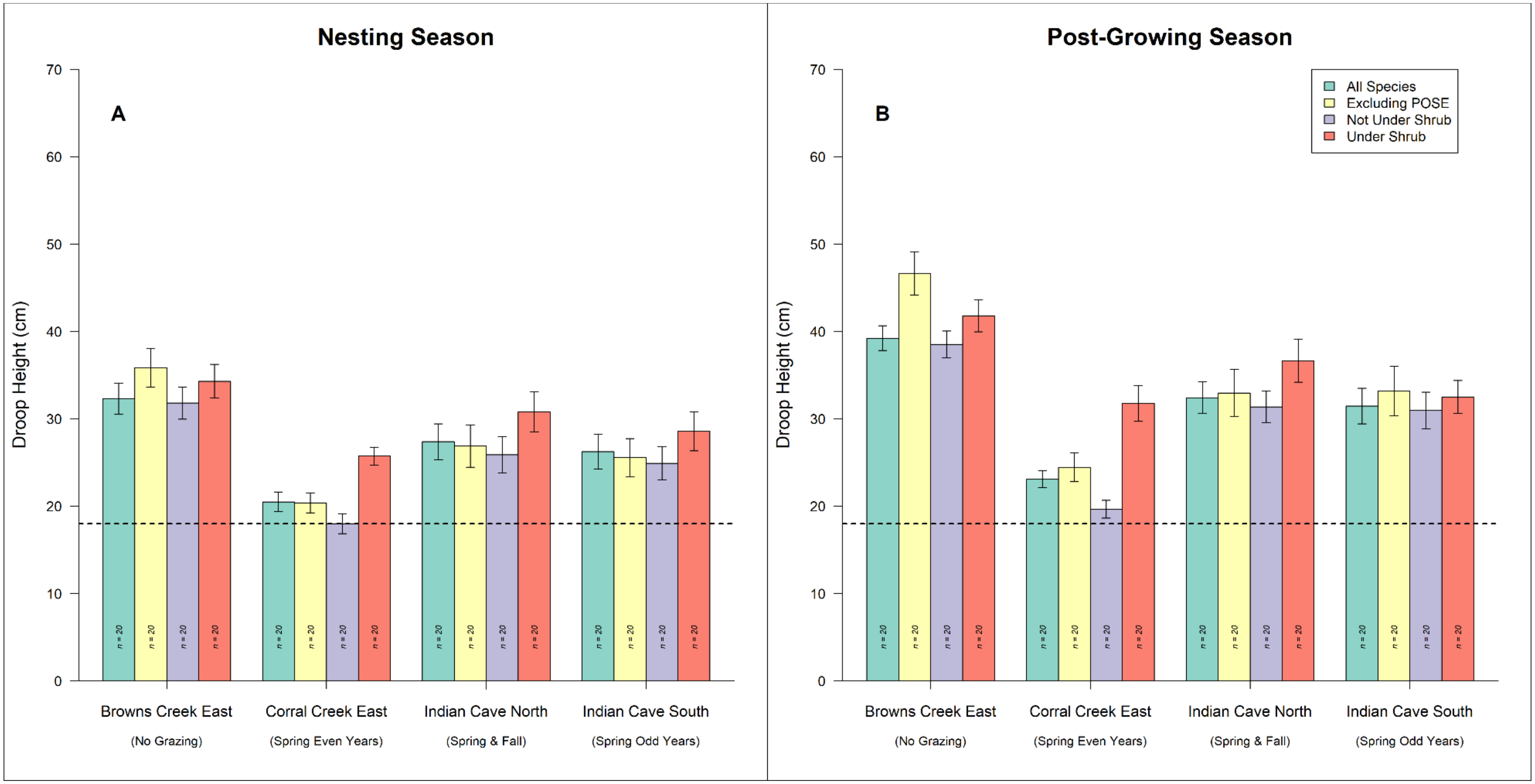


Figure 6. Mean droop height for 4 different subsets of grasses: all perennial grass species within a plot, all perennial grass species excluding Sandberg bluegrass (Poa secunda), all perennial grass plants that were under a shrub, and all perennial grass plants that were not under a shrub in both nesting season (A) and post-growing season (B) plots at Brown's Bench, Idaho in 2022. 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, squirreltail (*Elymus elymoides*), crested wheatgrass, needlegrasses (*Achnatherum spp.* and *Hesperostipa spp.*), and bluebunch wheatgrass were the most abundant grasses in our post-growing season surveys at Brown's Bench in 2022. Grass height differed among species and differences were apparent for all three grass height metrics in all 5 species of grass (Fig. 7). We observed over 250 individual plants of bluebunch wheatgrass in ungrazed pastures, but only 2 plants in grazed pastures. Similarly, we observed almost 400 needlegrass plants in ungrazed pastures and only 30 in the grazed pasture. This may be due to cattle grazing these two species heavily, but may also be due to the grazed pasture containing more areas of shallower, rockier soil unfit for larger bunchgrasses than the other pastures at the site, as it lies along a cliff edge. All grasses that were measured in grazed pastures were shorter than those in ungrazed pastures for all height measurements, but this difference was most pronounced in the droop height measurement and less pronounced in the leaf and effective height mesasurments.

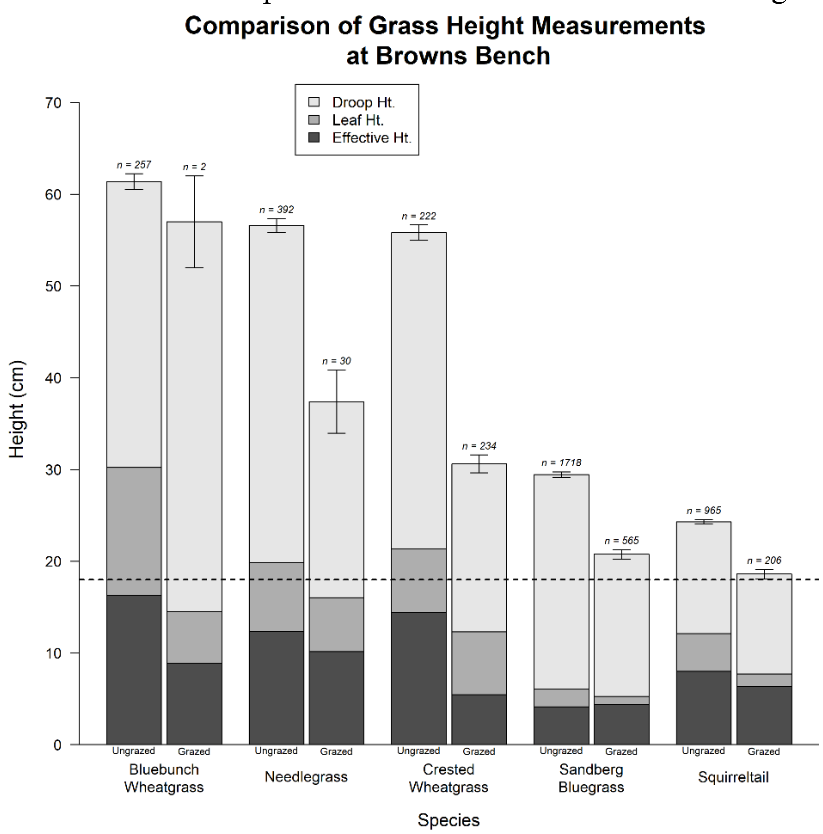


Figure 7. Mean height of the 5 most common species of perennial grasses based on 3 height metrics on post-growing season (Jul-Aug) random plots at Brown's Bench, Idaho in 2022. The three height metrics were droop height (using highest part of plant) = "Droop Ht.", droop height excluding the flowering stalk = "Leaf Ht", and effective height (modified visual obstruction for an individual plant) = "Effective Ht". Heights were compared seperately for plants in ungrazed and grazed pastures based on whether they were grazed in 2022 prior to post-nesting season surveys. 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 has fluctuated within each pasture annually (Fig. 8). The no grazing pasture (Browns Creek East) and Indian Cave South have had the most consistent estimates of shrub cover while Indian Cave North and Corral Creek East have had more fluctuation across years. We expect some changes in shrub cover between years with changing precipiation. In some cases, cattle and native ungulates may forage on shrubs which may also impact overall shrub cover estimates.

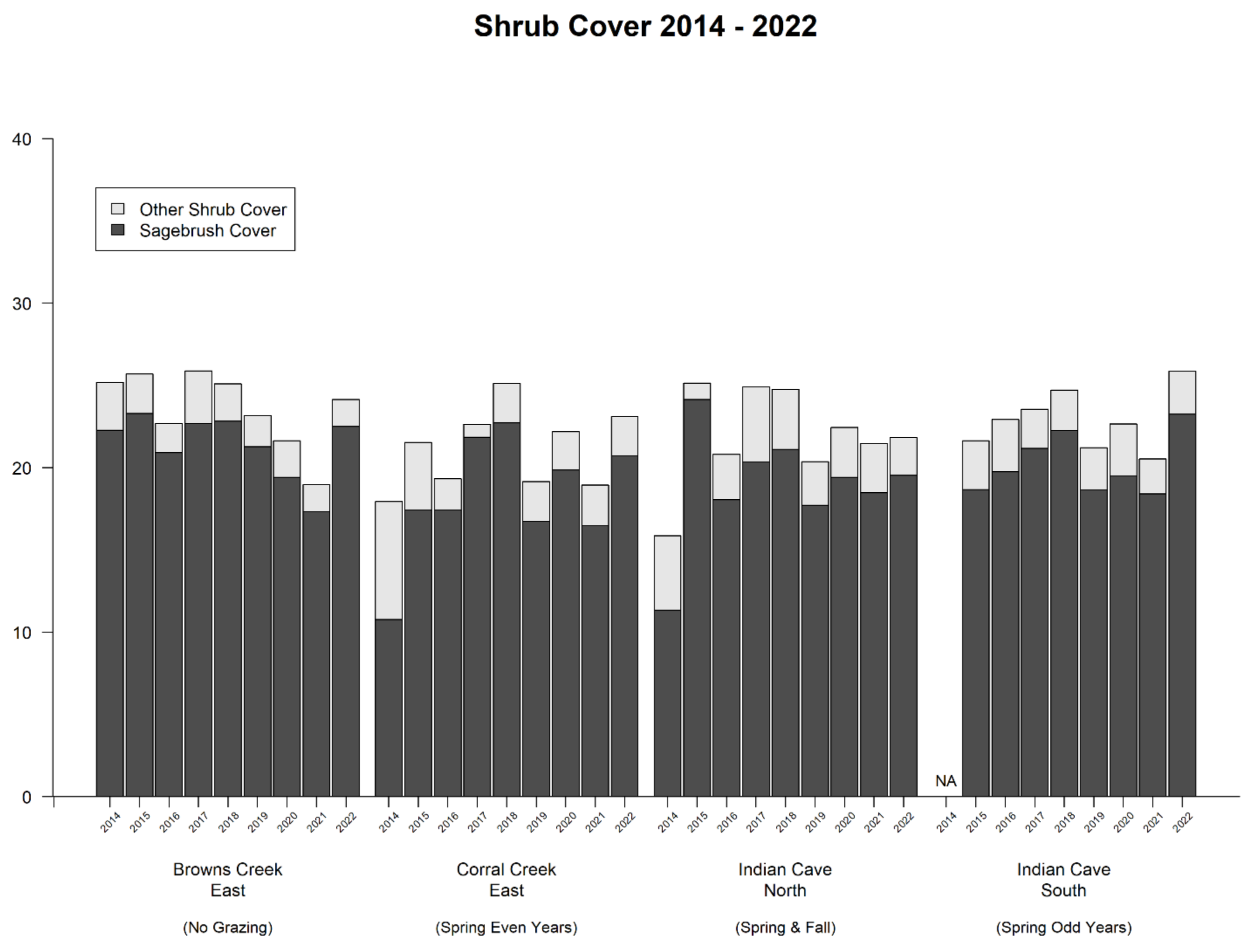


Figure 8. Shrub cover (split into sagebrush and other shrub cover) in each of 4 experimental treatment pastures at Brown's Bench, Idaho 2014-2022.

Stocking Rates and Grazing Pressure

Grazing treatments began at Brown's Bench in 2016. This site has followed the grazing plan exactly each year since the treatments were initiated. During pre-treatment years, seasonal cattle use ranged from 81-657 AUMs (excluding trailing events; Fig. 9A-B). Thus far in post-treatment years, cattle use ranged from 135-326 AUMs (Fig. 9C-F). Although the average AUMs were lower in post-treatment years compared to the 2 pre-treatment years, cattle use per ha is similar because post-treatment pastures are half the size of pre-treatment pastures (due to electric fencing).

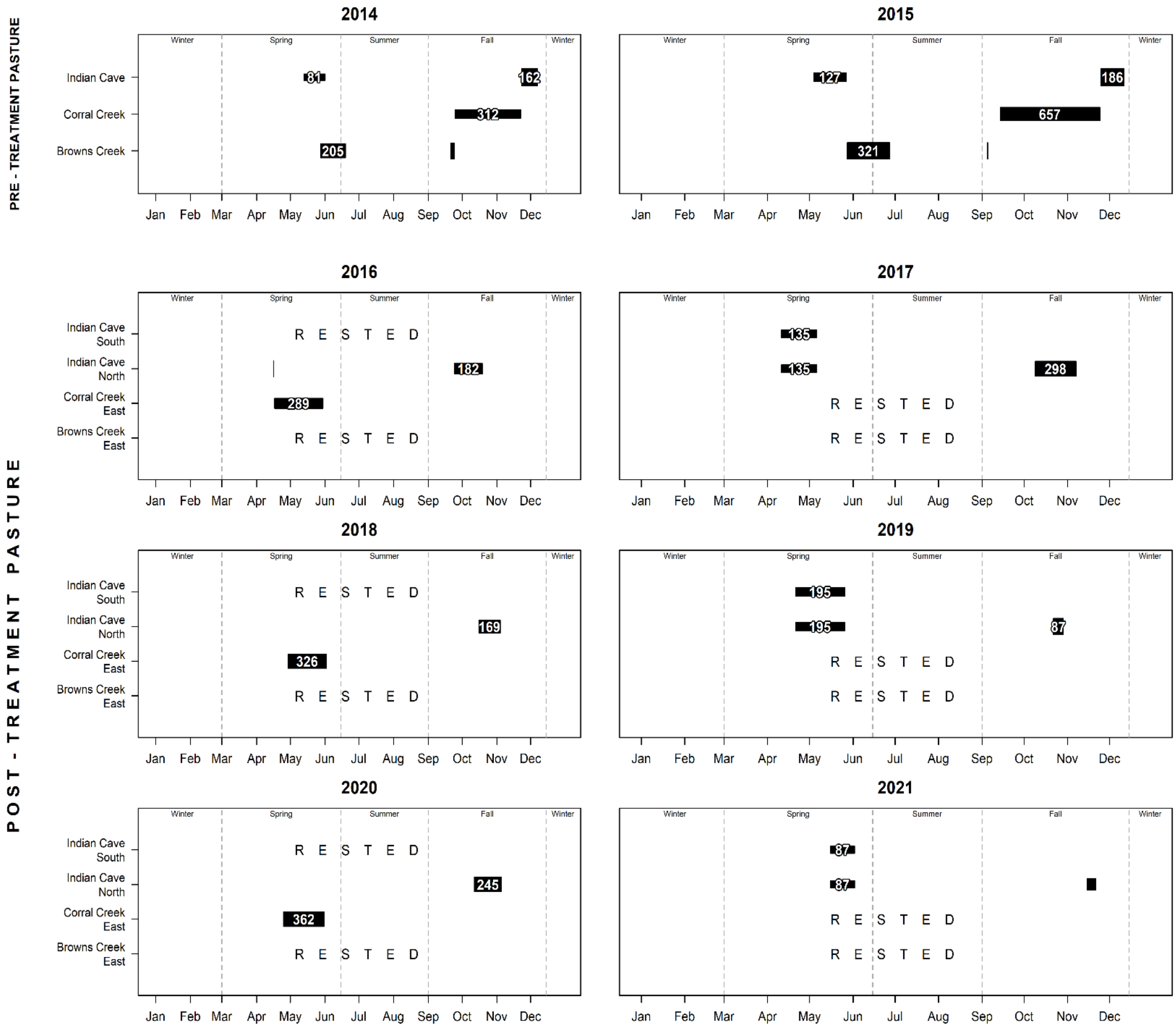


Figure 9. Timing and duration of cattle stocking at Brown's Bench during pre- and post-treatment periods of the study 2014-2021 (data for 2022 has not been reported yet). Width of black bars indicate the average number of cattle per day in that pasture. White numbers inside black bars represent the total Animal Unit Months (AUM) during that period.

In 2021, 2 of our experimental treatment pastures were rested and 2 were grazed. The amount of AUMs in our experimental treatment pastures were slightly lower than surrounding pastures in the Brackett Bench allotment (Fig. 10). However, AUMs in study pastures were comparable to that of similar sized pastures in nearby allotments. Overall, grazing pressure in the nearby Antelope Springs allotment was higher than Brackett Bench, but this permittee runs a larger herd. Smaller allotments (China Creek, North Fork Field, etc.) received comparable pressure to the Brackett Bench allotment. Data for 2022 use levels were not yet available at the time of this report.

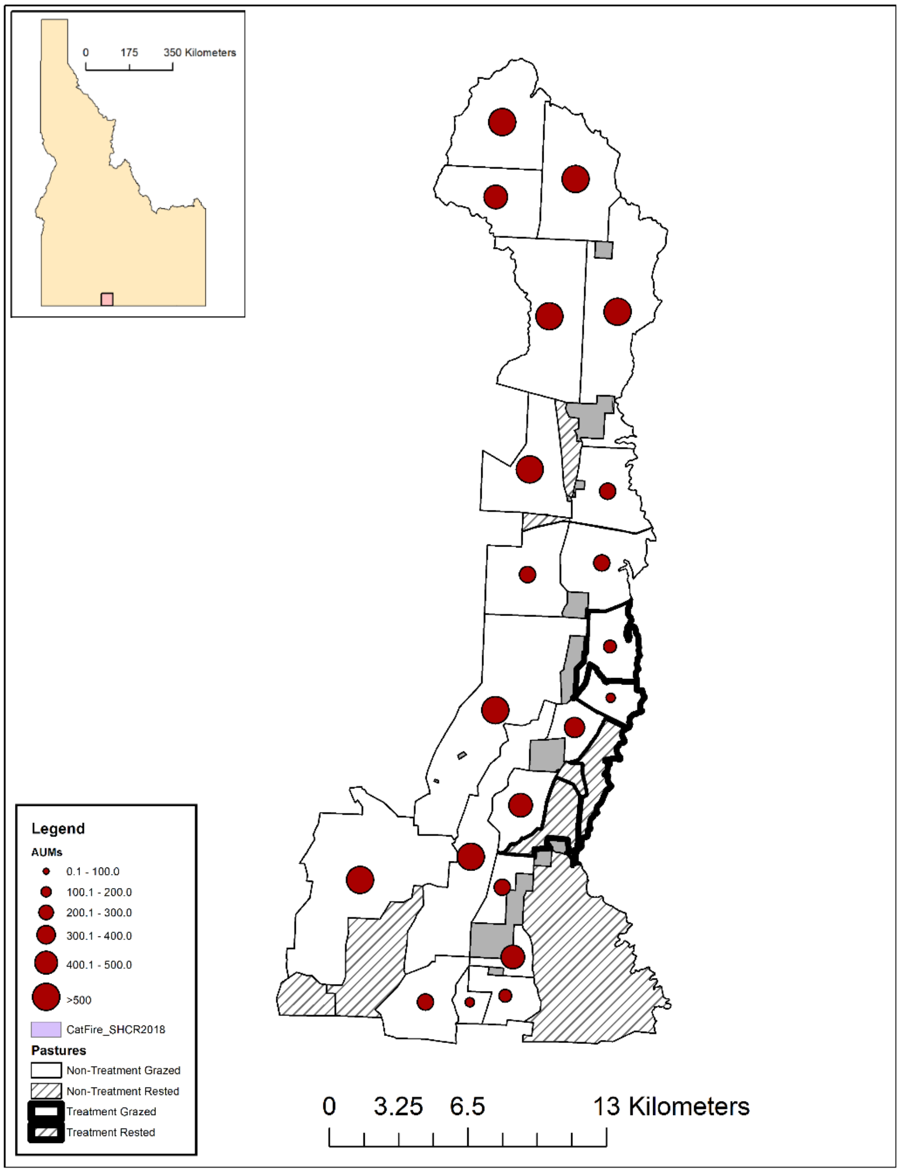


Figure 10. Stocking rate in Animal Use Months (AUMs) in treatment pastures and surrounding pastures at Brown's Bench, Idaho in 2021.

Estimates of Utilization

The proportion of grazed plants in 2022 were moderate in Corral Creek East (~25%), low in Indian Cave North and Indian Cave South (~10%), and negligible in Browns Creak East (Fig 11A). The visual utilization estimate in post-growing season surveys had a similar pattern to the proportion of grazed plants in all study pastures (Fig. 11B). All ungrazed pastures had lower estimates of utilization and proportion of grazed plants. The Indian Cave pastures were likely grazed by native ungulates more than the Brown's Creek East pasture, as most mule deer and pronghorn are observed on the north end of the study site in these two pastures.

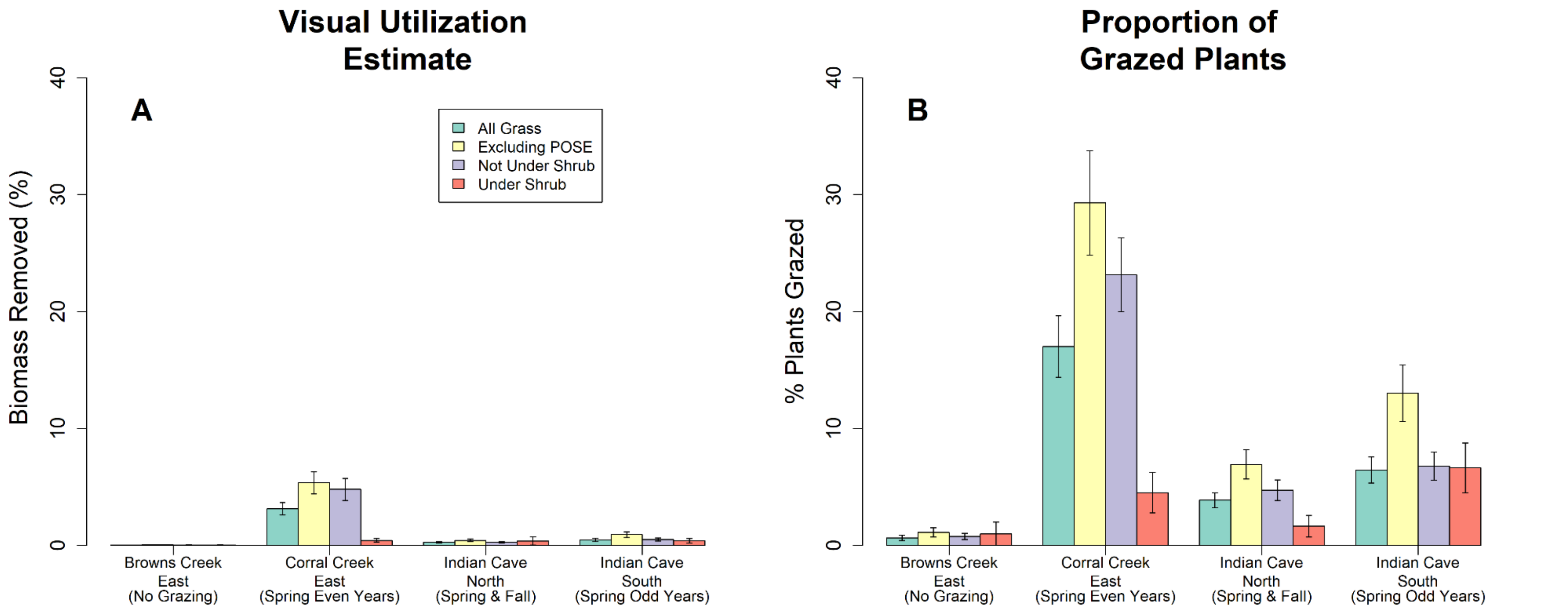


Figure 11. Grazing intensity based on visual estimates of percent biomass removed on individual grass plants and the proportion of grass plants grazed at random plots in 2022 at Brown's Bench, Idaho. Estimates were taken from the post-growing season surveys conducted in July – August 2022. In 2022, only Corral Creek East was grazed prior to our post-growing season surveys.

Utilization estimates based on the landscape appearance method were ~35% on the grazed pasture (Corral Creek East) and under 5% for the ungrazed pastures in 2022 (Fig. 12). This was close to the average utilization that we've observed in the Corral Creek East since the project began. Estimates based on the landscape appearance method were slightly higher than the proportion of grazed plants observed during post-growing season surveys (Fig. 11A). We observed similar estimates of utilization for all 3 ungrazed pastures using the landscape appearance method.

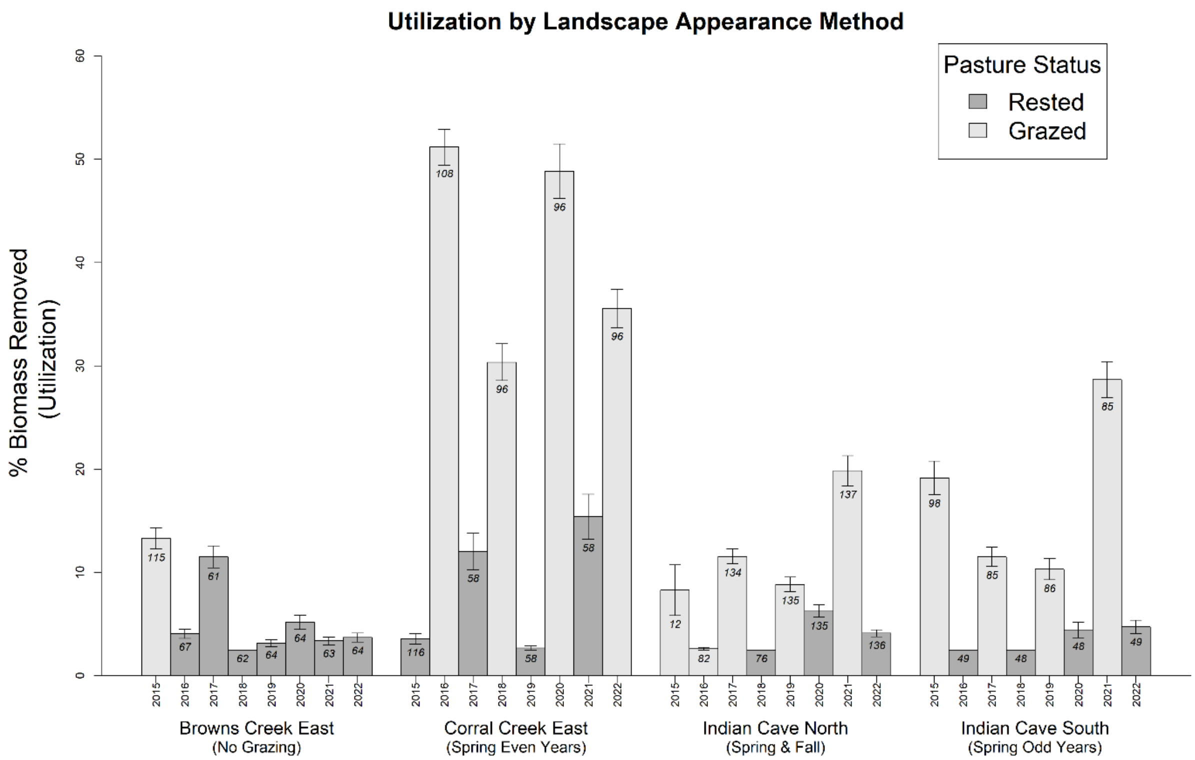


Figure 12. Utilization estimates based on the landscape appearance method for pre- and post-treatment periods at Brown's Bench, Idaho 2015-2022. Error bars represent ±1 standard error.

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. 13). This is likely due to the lack of uniform availability of water, and grass, as well as topography. Variable use patterns were evident in our grazed pastures in 2022 (Corral Creek East; Fig. 13H).

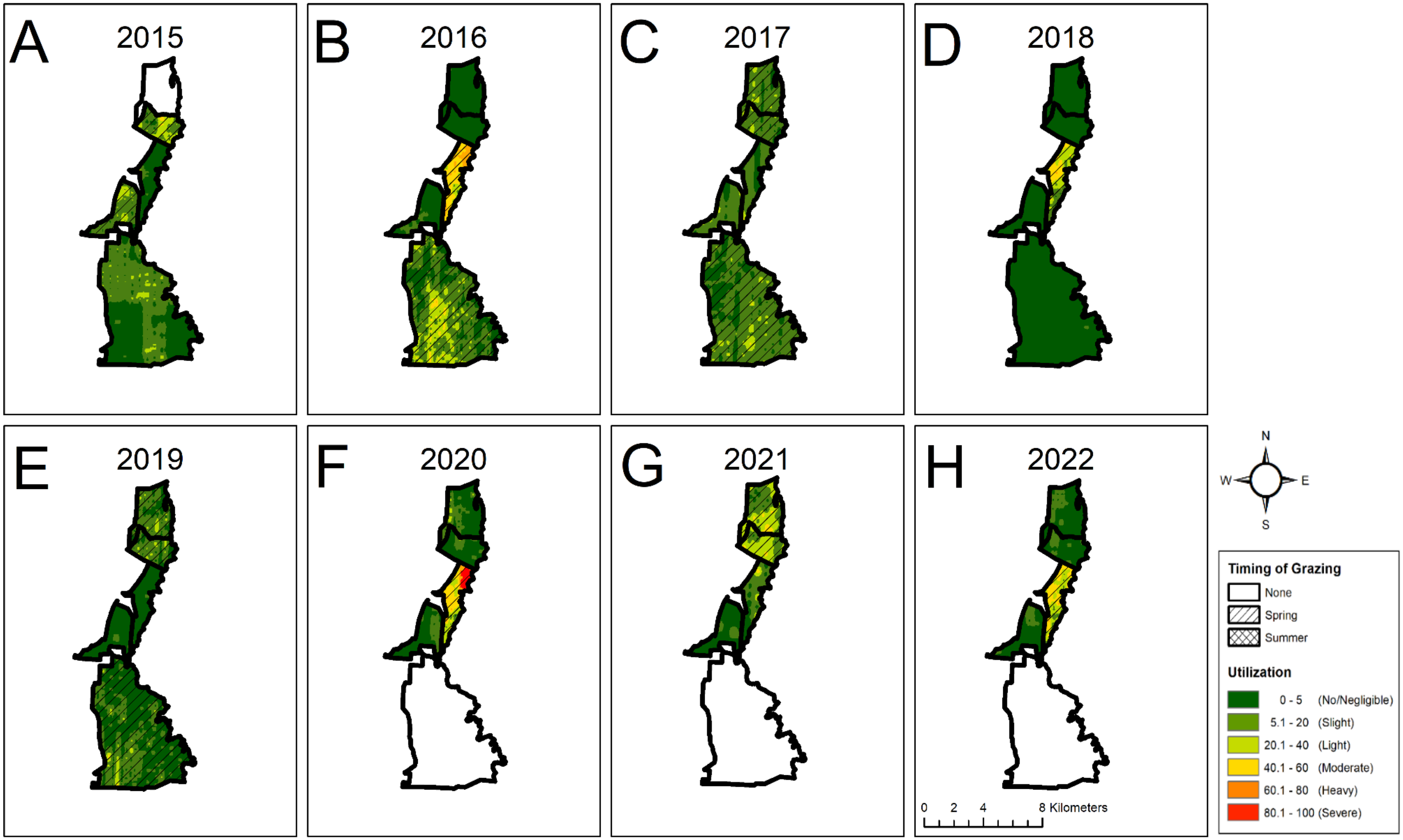


Figure 13. Pattern use mapping based on landscape appearance transects at Brown's Bench, Idaho 2015-2022.

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 utilization solely on the estimated current year's growth to help mitigate the biases potentially caused by these unusual circumstances. We continued this approach in 2022 to discover any differences in a year with more typical growth (Fig. 14). However, we observed very little differences in utilization estimates between the two methods in 2022.

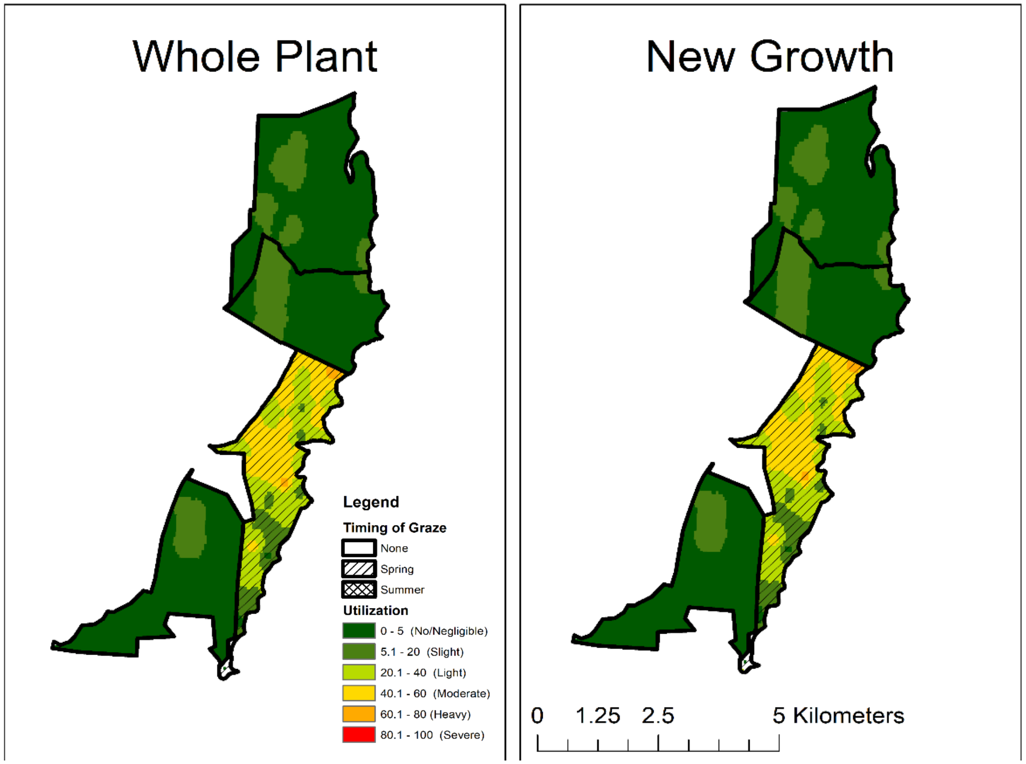


Figure 14. Pattern use mapping based on landscape appearance transects using estimates based on whole plant utilization and utilization based on new growth only at Browns Bench, Idaho in 2022.

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