Herbaceous Biomass, Forage Production and Vegetation Height in Grazing Pilot Areas on San Bruno Mountain

Submitted to:

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Introduction:

This report presents results from rangeland monitoring conducted in June 2020 for two proposed pilot grazing areas on San Bruno Mountain: the Northeast Ridge and the Southeast Slope. This monitoring was conducted for San Mateo County Parks Department (SMCPD) prior to commencement of grazing in the pilot grazing areas. The purpose of this monitoring is to provide information to inform grazing capacity estimates, stocking rate estimates and grazing strategies in the pilot areas; and to provide baseline information for future assessment of the effectiveness of the grazing program to meet project goals and to evaluate impacts to target species.

Background

San Bruno Mountain (SBM) is home to three federally-listed butterfly species: the Mission Blue Butterfly (*Icaricia icariodes missionensis,* federally endangered), the San Bruno Elfin Butterfly (*Callophrys mossii bayensis*, federally endangered), and the Callippe Silverspot (*Speyeria callippe callippe*, federally endangered). In 1982, a Habitat Conservation Plan (HCP) was established for SBM to preserve and enhance habitat for the endangered Mission Blue Butterfly. Principal management concerns are the control of excess growth of non-native grassland plants, maintenance of beneficial grassland characteristics, and avoiding displacement of larval host plants for the endangered butterflies, including: Johnny jump-up (*Viola pedunculata*), lupine (*Lupinus albifrons, Lupinus formosus* and *Lupinus variicolor*), and plantain (*Plantago erecta* and *P. lanceolata*). The HCP outlined several potential habitat enhancement mechanisms, including the reintroduction of livestock grazing, as a tool for managing and enhancing butterfly habitat on SMB. It also stressed that habitat enhancement programs be monitored for effectiveness and for use by endangered species (SBMHCP 1982).

San Bruno Mountain was grazed by livestock from the late 1700s to the early 1960s (Amme 2002). After the removal of livestock in the 1960s, there was a significant loss in grassland vegetation and a simultaneous expansion of woody vegetation types on SBM. Between 1932 and 1981, grassland vegetation extent decreased by 55% (1811 acres) on San Bruno Mountain, while shrub and woodland vegetation extent increased by 117% (1753 acres, HCP 1982 [Vol I]). In the San Francisco Bay Area, shrub encroachment rates into grasslands are higher in the absence of grazing (Ford and Hayes 2007, McBride and Heady 1968). Although moderate densities of shrubs can provide important habitat elements for the listed butterflies (such as perching structures and nectar sources), shrub encroachment can negatively impact butterfly habitat when shrub densities increase to the point that they outcompete butterfly host and nectar plants (TRA 2007).

In 2002, a grazing management plan was written but never implemented (Amme 2002). Its main objective was to: “restore and enhance the vitality of native prairie resources” on San Bruno Mountain. Key to this goal was enhancing endangered butterfly habitat. This plan suggested a 3-year pilot grazing study to evaluate the efficacy of grazing to manage grassland habitat.

Since grazing was removed from SBM, there has been no livestock grazing on the mountain, with the exception of a pilot goat grazing study in 2003-2004 (San Mateo County 2005) in a 3-acre area on the Southeast Slope (southwest of Juncus Ravine and east of Tank Ravine). The purpose of this study was to evaluate the effectiveness of goats for controlling weeds and reducing shrub cover. Results of the of the study were not conclusive (TRA 2007), however,

spring herbaceous biomass was measured in March of 2003, showing total biomass between 5000 and 9000 pounds per acre. While these results indicate very high levels of herbaceous biomass, they represent conditions in a relatively small area (outside of the grazing pilot areas), making extrapolation to other areas on San Bruno Mountain difficult.

A pilot study to test the efficacy of cattle grazing for endangered butterfly habitat enhancement is still considered essential (Weiss et al. 2015). In 2018, SMCPD convened a Technical Advisory Committee (TAC) to study and advise the implementation of a three-year cattle grazing pilot study at two locations on SBM. The work described in this report was done to support planning by SMCPD and inform grazing and habitat management studies to be performed by butterfly scientists as well as grazing ecology and management scientists, including members of the TAC.

Purpose and Goals

This report describes the distribution and amount of total herbaceous biomass, forage production, and vegetation height in the two grazing pilot areas at the time of peak spring growth, prior to the commencement of livestock grazing. The purpose of describing these physical attributes of herbaceous biomass is to inform the livestock grazing strategy (including initial stocking rates and other elements of a Grazing Management Plan for the study areas), grazing contract specifications, and future evaluation of effectiveness of the pilot grazing program. The three monitoring variables each have different implications for planning and analysis:

- **Herbaceous biomass** is a measurement of the weight of the total aboveground herbaceous plant material. It is expressed in units of pounds per acre. This variable accounts for current-year vegetation production and also previous-year litter accumulation. Measuring pre-grazing levels of herbaceous biomass will provide baseline data that can be compared to post-grazing biomass levels to determine the effect of grazing on total biomass in the pilot grazing areas. Dense grasses and excessive thatch are thought to reduce butterfly host plant density (Weiss et al. 2015), so understanding how (and where) grazing reduces herbaceous biomass demonstrates the efficacy of grazing at enhancing butterfly habitat. Total herbaceous biomass also directly relates to fire behavior and fire risk. Understanding the distribution of fine fuels can show the effect of the pilot grazing program on managing wildfire risk.
- **Forage production** is a measurement of the amount of herbaceous plants (pounds per acre) that are suitable for livestock forage produced in the past growing season. It is expressed in terms of pounds per acre. Forage production is a subset of total herbaceous biomass and *productivity* (pounds of forage produced per acre) is the basis of determining livestock grazing capacity and stocking rates.
- **Vegetation height** is a measure of the visual obstruction height of herbaceous vegetation (inches). Vegetation height is a structural aspect of vegetation that will likely be impacted by the pilot grazing program. Obstruction height is generally used as a metric to assess herbaceous and woody habitat for vertebrate wildlife, but it has characteristics that make it useful for monitoring structural change in extensive annual dominated grasslands like those on San Bruno Mountain. While not previously demonstrated, obstruction height may relate to host plant or butterfly occupancy or density in this case. It was therefore measured to allow for future tests of the relationship between height, total biomass and host plant and/or butterfly occurrence.

Methods

Fieldwork occurred on June 11th, 24th, and 25th 2020. It was conducted by Lawrence Ford and Felix Ratcliff (of LD Ford), accompanied by Hannah Ormshaw and Evan Cole (of SMCPD). This time period was chosen because it coincides with peak standing crop (the time of year when annual grasses are senescing, and the maximum amount of herbaceous vegetation is present), and before the bulk of summer decomposition has occurred. As such, it is the best time of year to evaluate maximum biomass, forage production and height.

Sampling occurred in the two pilot grazing areas: the Northeast Ridge and the Southeast Slope. Within the pilot grazing areas, samples were taken at set locations on a ¼-hectare grid established by Creekside Center for Earth Observation to survey for butterfly host plants in 2019 (Figures 1 and 2). Grid points were selected to represent different landscape features (topographic and hydrologic), and to representatively sample across each of the pilot areas. In all, 24 locations were sampled in the Southeast Slope and 22 locations were sampled in the Northeast Ridge.

Soils in the two grazing areas differ somewhat from one another. Soils in the Northeast Ridge are almost exclusively in the Barnabe-Candlestick complex (30 to 75 percent slopes). Soils in the Southeast Slope are largely Candlestick-Kron-Buriburi complex (30 to 75 percent slopes). Though related, these two soil complexes differ in proportions of constituent soil types; the Northeast Ridge soils tending to be more gravelly and thinner than those in the Southeast Slope. The USDA Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) provides forage production estimates for many rangeland soil types in California, however neither of the major soil complexes in the pilot grazing areas have USDA production estimates.

Total Herbaceous Biomass & Forage Production. Measurement of total herbaceous biomass and forage production utilized the same basic methodology. A circular 0.96-foot^2 hoop was placed on the ground at a location that represented biomass conditions within 50 feet of the grid point. Herbaceous vegetation in the hoop was clipped to the ground and placed in a bag to weigh. Samples were weighed in the field and also collected, dried and re-weighed. All results in this report use the dry weights (not field weights).

Total herbaceous biomass is the total weight of all biomass at each sampling location. To measure forage production, previous-years' litter was separated from vegetation produced in the current growing season and weighed separately. Non-forage species, largely thistles and summer annuals (plants that germinate in spring and grow throughout the summer), were also removed from the production estimate (Bartolome et al. 2006). The forage production component of the clip was all the herbaceous biomass produced in the past growing season (minus non-forage species). Forage production was measured at a subset of the total biomass measurement sites. Fewer production measurements were required because production measurements are not anticipated to be used for evaluating impacts of the grazing program, or for evaluating the influence of biomass on host plants. Since the pilot areas are not currently grazed, there was no need to protect forage clip locations from livestock grazing prior to sampling. And because of the time of year, no thatch had developed from this material.

Obstruction Height. To measure obstruction height, a one-inch wide Robel Pole was placed vertically in the ground. Observers stood 20 feet from the pole and crouched down so that their eyes were horizontally in line with the height of the vegetation. The pole is graduated with black

and white inch-long segments (checkerboard pattern), and the observer noted the topmost graduated section of the pole that was at least 80% visually obstructed by vegetation from their vantage. The measurement was taken from two or more opposite sides and averaged. This measurement differs from "average vegetation height," which can be measured using some version of point-intercept sampling. Individual point-based estimates of vegetation height in grasslands are generally highly variable, so determining average vegetation height through point-based methods takes intensive sampling to reduce statistical error. Obstruction height, on the other hand, is less variable, easily replicated and rapid to assess; and it is used broadly to represent visibility to wildlife.

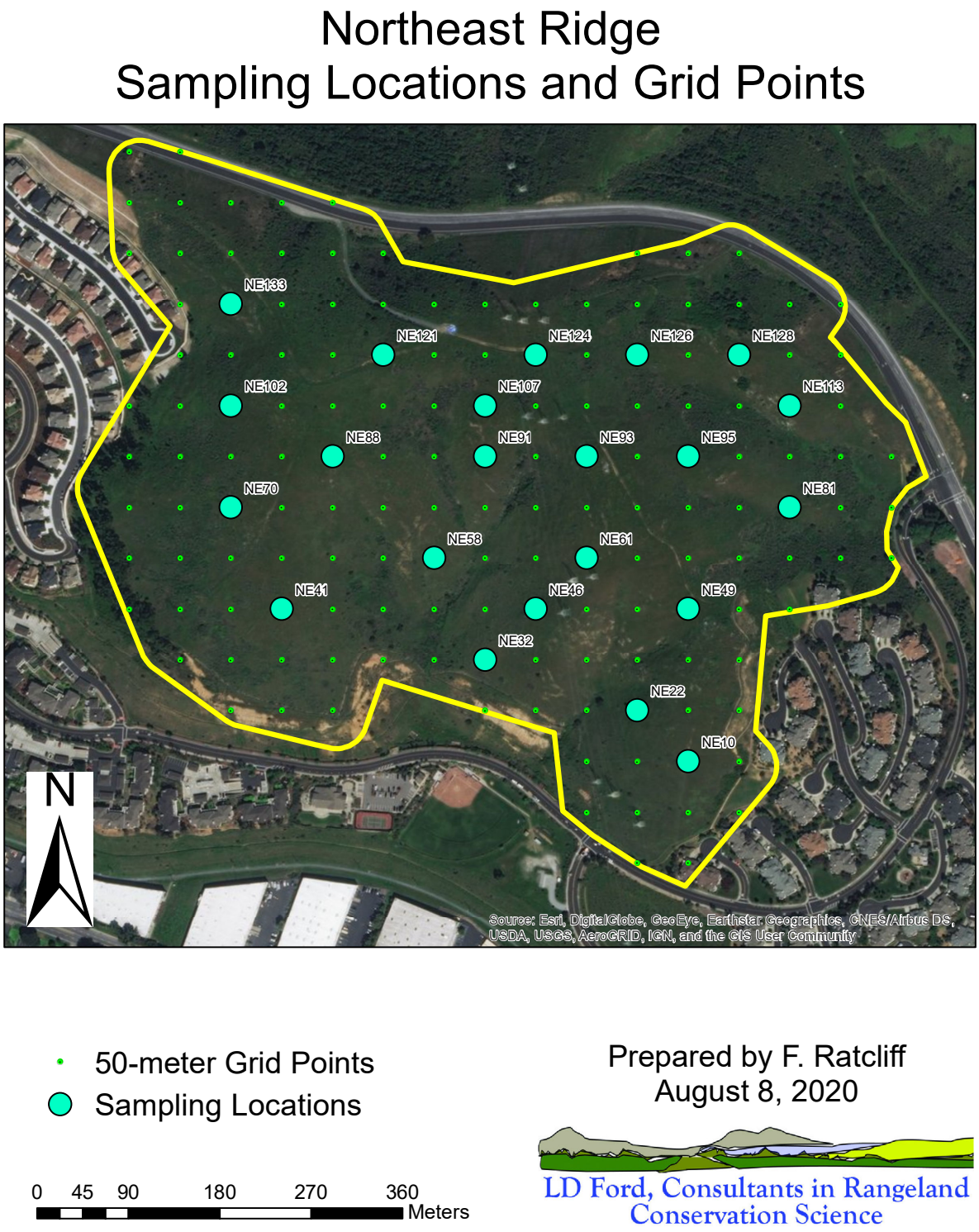

Figure 1. Northeast Ridge Sampling Locations and Grid Points (from Creekside Center for Earth Observation).

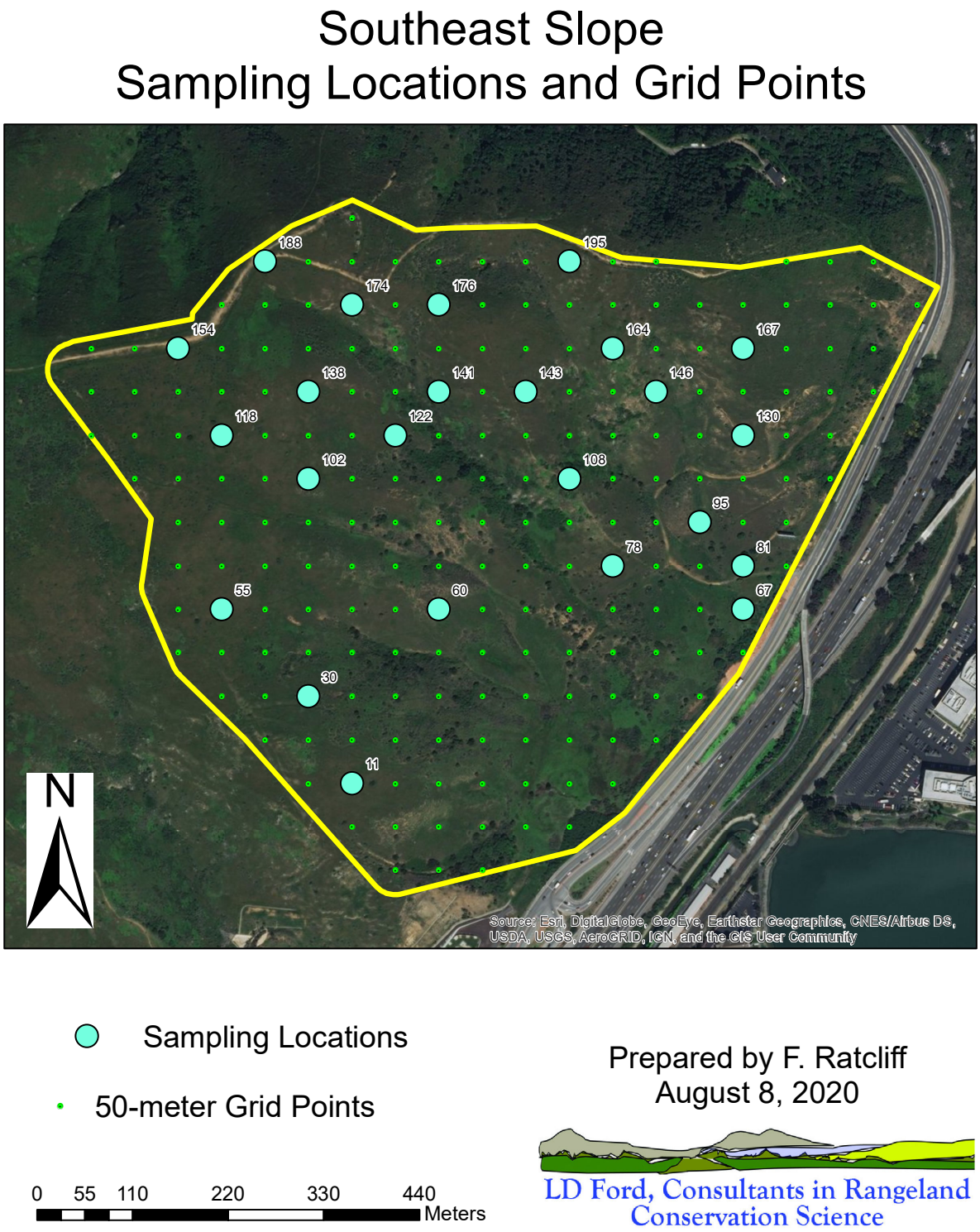

Figure 2. Southeast Slope Sampling Locations and Grid Points (from Creekside Center for Earth Observation).

Results

Overall, total biomass and production per acre were slightly higher in the Northeast Ridge than in the Southeast Slope. There was sufficient statistical error in these measurements to make the two areas virtually indistinguishable in terms of these two factors (Figures 3 and 4). Average obstruction height was significantly higher in the Southeast Slope compared to the Northeast ridge. This apparent contradiction with the biomass and production data is due to species composition differences. The Southeast Slope had large patches dominated by the tall annual grass wild oats (*Avena sp.*). While this species often forms comparatively taller stands of annual grass (we measured obstruction height of 44 inches at one location), it doesn't always form a dense lower thatch layer and can have lower amounts of total biomass compared to more thatch-forming species.

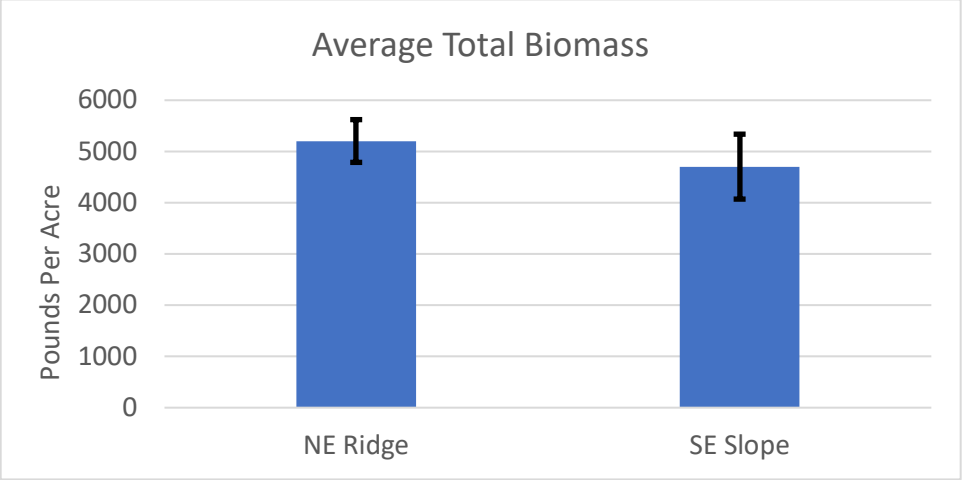

Figure 3. Average Total Biomass Pilot Grazing Areas.

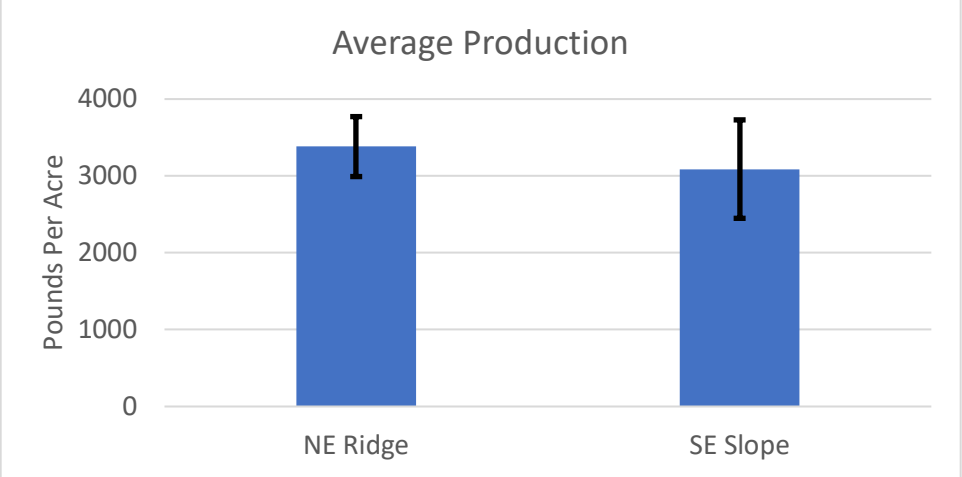

Figure 4. Average Forage Production in the Pilot Grazing Areas.

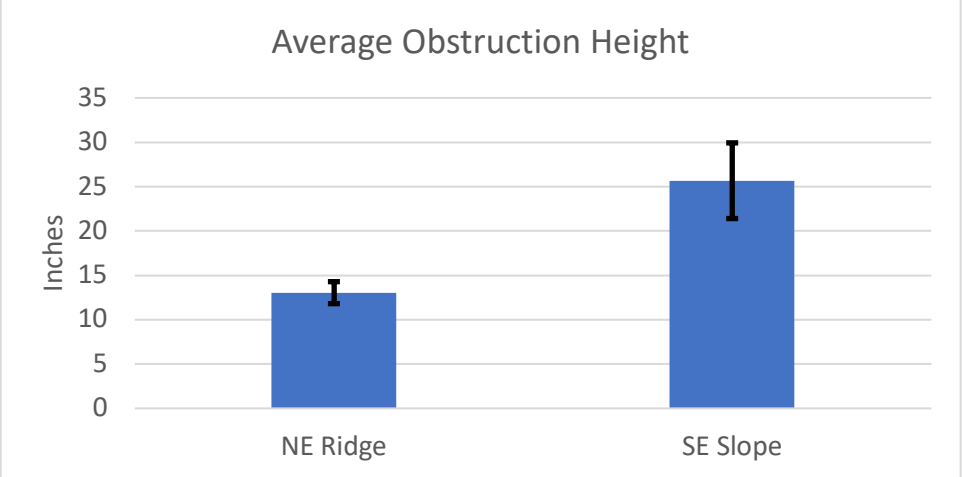

Figure 5. Average Obstruction Height in the Pilot Grazing Areas.

Northeast Ridge

In the Northeast Ridge Grazing Pilot Area, total biomass was 5200 pounds per acre on average (minimum = 3200, maximum = 7000 pounds per acre). Forage production was 3400 pounds per acre on average (minimum = 2400, maximum = 4900 pounds per acre), meaning that 1800 pounds per acre were thatch from previous years production or were unpalatable species. The vast majority of this 1800 pounds per acre was thatch however, as thistles, summer annuals, and other unpalatable herbaceous species were not abundant in this area.

There were lower levels of biomass on the thinner soils occurring on the top of the ridge, and more biomass on the sloped areas in the south half of the Northeast Ridge area (Figure 6). The spatial pattern of production was similar to that of total biomass, with higher production on the sloped areas occurring in the southern portion of the pilot grazing area (Figures 6 and 7).

Vegetation height seemed to vary mainly in response to differences in species composition. While most sampling plots in the Northeast Ridge area had a mixture of wild oats and big quaking grass (*Briza maxima*) as dominant species, the relative mix of these species appeared to influence obstruction height. The three plots in the south-central portion of the grazing area with the highest obstruction heights (17 to 19 inches), were also plots with strong dominance of wild oats. Several of the plots on the ridge tops appeared to have a more even blend of grass species, or were weighted towards cover of big quaking grass, and generally had lower obstruction height.

In 2019, Creekside Center for Earth Observation performed butterfly host plant surveys on the Northeast Ridge (but not the Southeast Slope) using the same sampling grid that we used for this study.[1] Their survey shows that narrowleaf plantain and Johnny jump-up were widespread in the area. Given the high biomass levels we observed, it is promising that these plants occur at their current rates. There were no significant relationships between the 2019 host plant data and the 2020 biomass or height data, which is not surprising given the overall high biomass conditions across the Northeast Ridge and the difference in sampling years. Narrowleaf plantain and Johnny jump-up occurred on 36 and 45% of the biomass and height sampling plots respectively. These frequency levels are a good starting place for evaluating changes in these species after the grazing pilot project commences. Lupines only occurred at 9% of the biomass/height sampling points, which could make it more difficult to assess changes in their numbers.

Forage Analysis. There were no large portions of the Northeast Ridge area that appeared to be too steep for cattle to access. In terms of forage utilization, we expect cattle will be able to access the grassland forage available in the area. There are significant patches of shrubs, in particular coyote brush (*Baccharis pilularis*) and gorse (*Ulex europaeus*). We estimate that 26.3 acres (29%) of the Northeast Ridge area (as currently defined) has >50% shrub cover and has little value for grazing. If we remove these areas from the total 91.5 acres in the grazing area, there are approximately 65.2 grazeable acres left in the grazing area.

[1] Field surveys of host plants and butterflies were conducted at both the Northeast Ridge and Southeast Slope grazing pilot study areas in 2011 and 2018, but not corresponding to the Creekside Center grid sampling points, and thus not lending to statistically rigorous comparisons. Nonetheless, no significant relationships are evident.

If we take the forage production estimates to represent a normal amount of forage production for the Northeast Ridge, then we would expect 3400 pounds per acre to be produced per year. The 2019-2020 rain year was unusual in the sense that there was an extended dry period during January and February, followed by well-spaced rainfall later in the spring. We are unaware of established production trends from similar rain years, but in our observations throughout the Coast Ranges (Monterey, Santa Cruz, Santa Clara, San Mateo, Marin, Mendocino, Alameda, Contra Costa, and Solano counties during more than 25 years consulting), forage production was average to above average in grasslands in the region in 2020.

There is not currently a grazing management plan for the pilot grazing areas that describes the appropriate preliminary amount of RDM to be left at the end of the growing season (that includes targeting grazing to benefit the host plants, minimize pest plants, protect soils from erosion, other conservation objectives, and adjustments for different weather years). However, if we assume that Annual Grassland RDM standards are used, then RDM standards would likely be between 600-800 pounds per acre depending on slope (Bartolome et al. 2006). If Coastal Prairie standards are used, then this would be significantly higher. This leaves somewhere on the order of 2600 pounds per acre available for livestock, or about 2.6 animal unit months (AUM) per acre. An animal unit month is the amount of forage it takes to support a cow and her calf for a month; roughly 1000 pounds (Bush 2006). If the Northeast Ridge has approximately 65 grazeable acres, it would support a maximum of 169 AUMs during a normal year. This is equivalent to 14 cows year-round or 28 cows for six-months. **This forage analysis is preliminary. A more comprehensive forage analysis should be performed as part of the grazing management planning process (see Conclusions and Recommendations).**

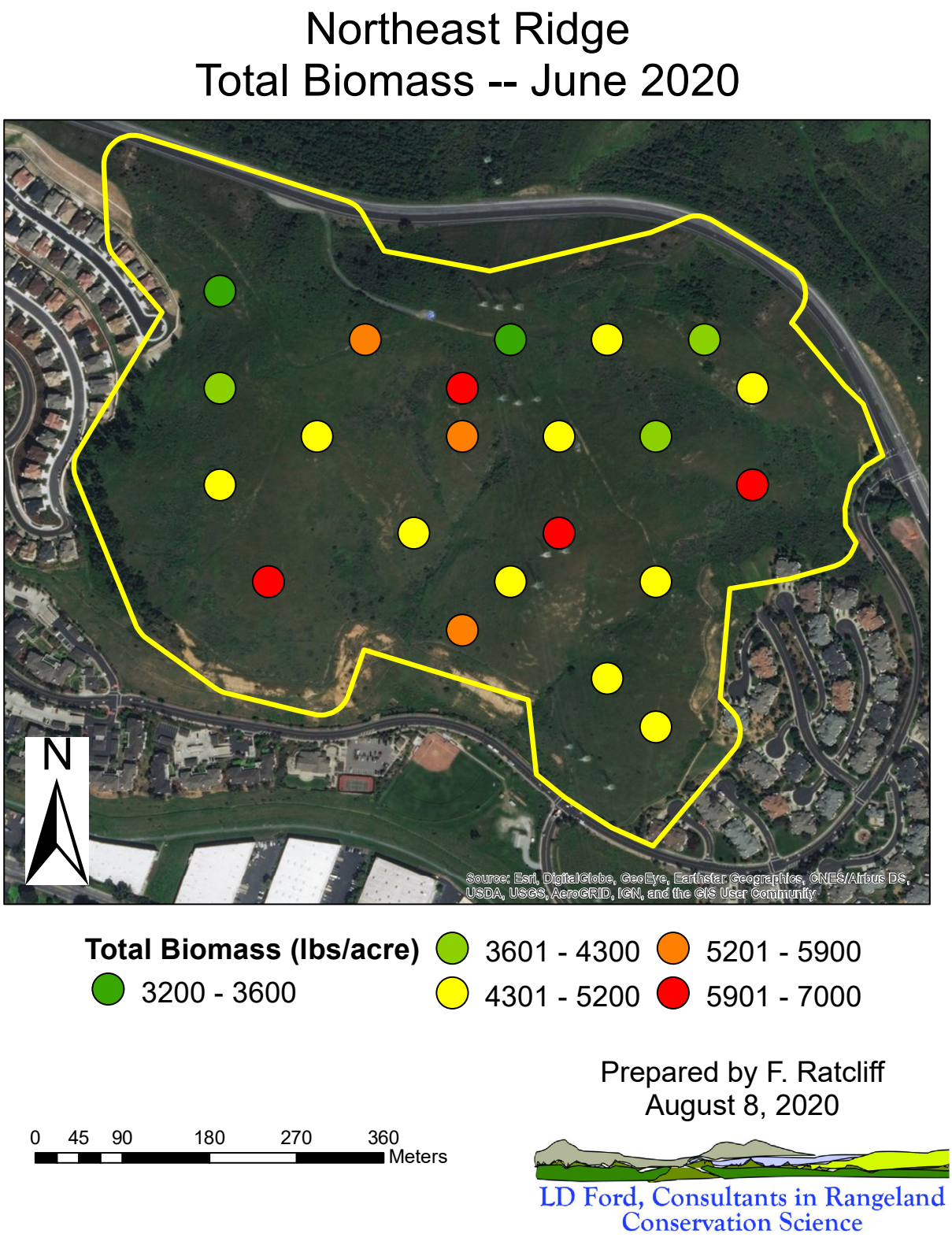

Figure 6. Map of Total Herbaceous Biomass in the Northeast Ridge Grazing Pilot Area

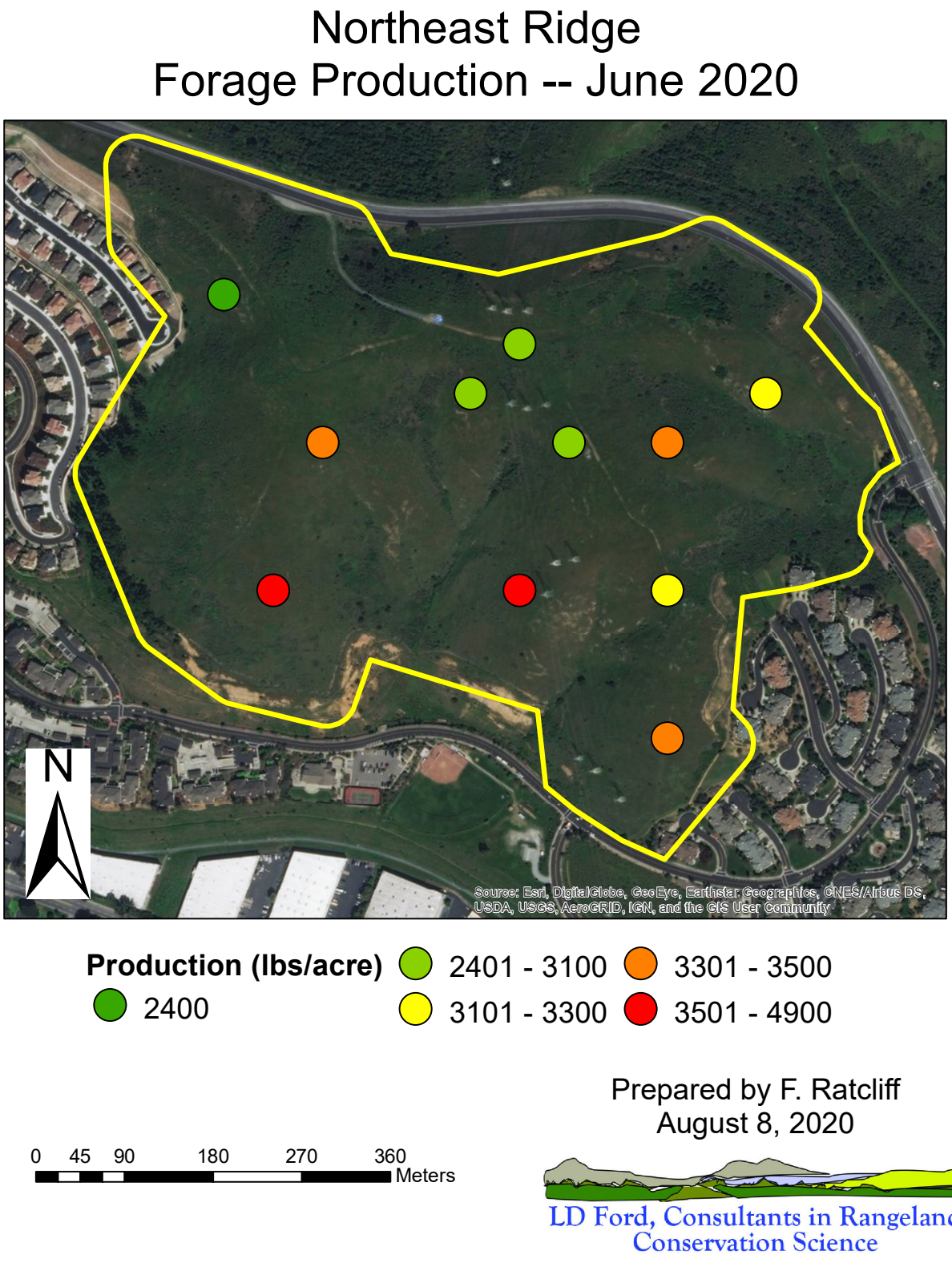

Figure 7. Map of Forage Production in the Northeast Ridge Grazing Pilot Area

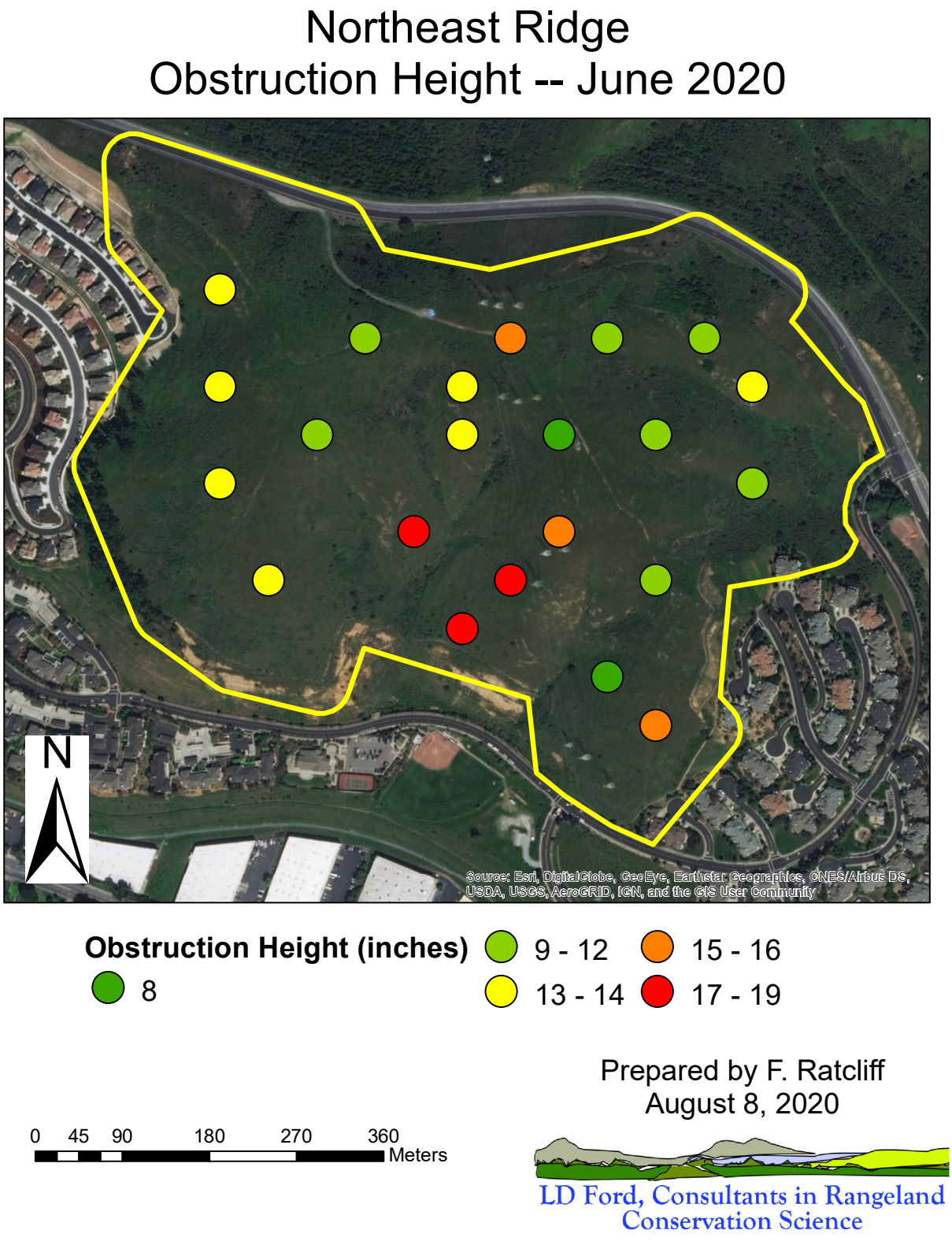

Figure 8. Map of Obstruction Height in the Northeast Ridge Grazing Pilot Area

Southeast Slope

In the Southeast Slope Grazing Pilot Area, total biomass was 4700 pounds per acre on average (minimum = 1500, maximum = 7700 pounds per acre). Forage production was 3100 pounds per acre on average (minimum 1800, maximum 4400 pounds per acre), meaning that 1600 pounds per acre were thatch from previous years production or were unpalatable species. Similar to the Northeast Ridge, the vast majority of this 1600 pounds per acre was thatch, not unpalatable live plants.

There was higher herbaceous biomass on the slopes in the western portion of the grazing area and in the flatter, wetter area in the southeast portion of the grazing area near the entrance from Bayshore Boulevard. There was less total biomass on the thinner, rockier soils along the ridges (Figure 9). The spatial pattern for forage production was similar to that of total biomass (Figure 10).

Similar to the Northeast Ridge, vegetation height varied in response to differences in species composition. While most sampling plots in the Southeast Slope had a mixture of wild oats and big quaking grass as dominant species, the relative mix of these species appeared to influence obstruction height. The plots with high obstruction heights in the western portion of the grazing area were strongly dominated by tall wild oats. The plot with the tallest vegetation on the flatter terrain by the entrance to Bayshore Boulevard was dominated by wild oats and also wild mustard (*Brassica sp.*).

Forage Analysis. There were large portions of the Southeast Slope area that appeared to be too steep for cattle to access. There are also significant patches of shrubs, in particular coyote brush. We estimate that 39 acres (31%) of the Southeast Slope area (as currently defined) is either too steep or has >50% shrub cover and therefore has little value for cattle grazing. If we remove these areas from the total 125 acres in the grazing area, there are approximately 86 grazeable acres left in the grazing area.

If we take the forage production estimates to represent a normal amount of forage production for the Southeast Slope, then we would expect 3100 pounds per acre to be produced per year. As noted for the Northeast Ridge, 2019-2020 was an unusual rain year, but we observed average to above average forage production in other grasslands in the region in 2020.

The absence of a grazing management plan limits our ability to describe the appropriate preliminary RDM targets to meet all the conservation objectives. If Annual Grassland RDM standards are adopted, this leaves somewhere on the order of 2400 pounds per acre available for livestock; equivalent to about 2.4 animal unit months (AUM) per acre. If the Southeast Slope has approximately 86 grazeable acres, it would support a maximum of 206 AUMs. This is equivalent to 17 cows (with calves) year-round or 34 cows for six-months. **This analysis is preliminary. A more comprehensive production, biomass, and height analyses should be performed as part of future studies of associations with host plant and butterfly habitat and populations and the grazing management planning process (see Conclusions and Recommendations).**

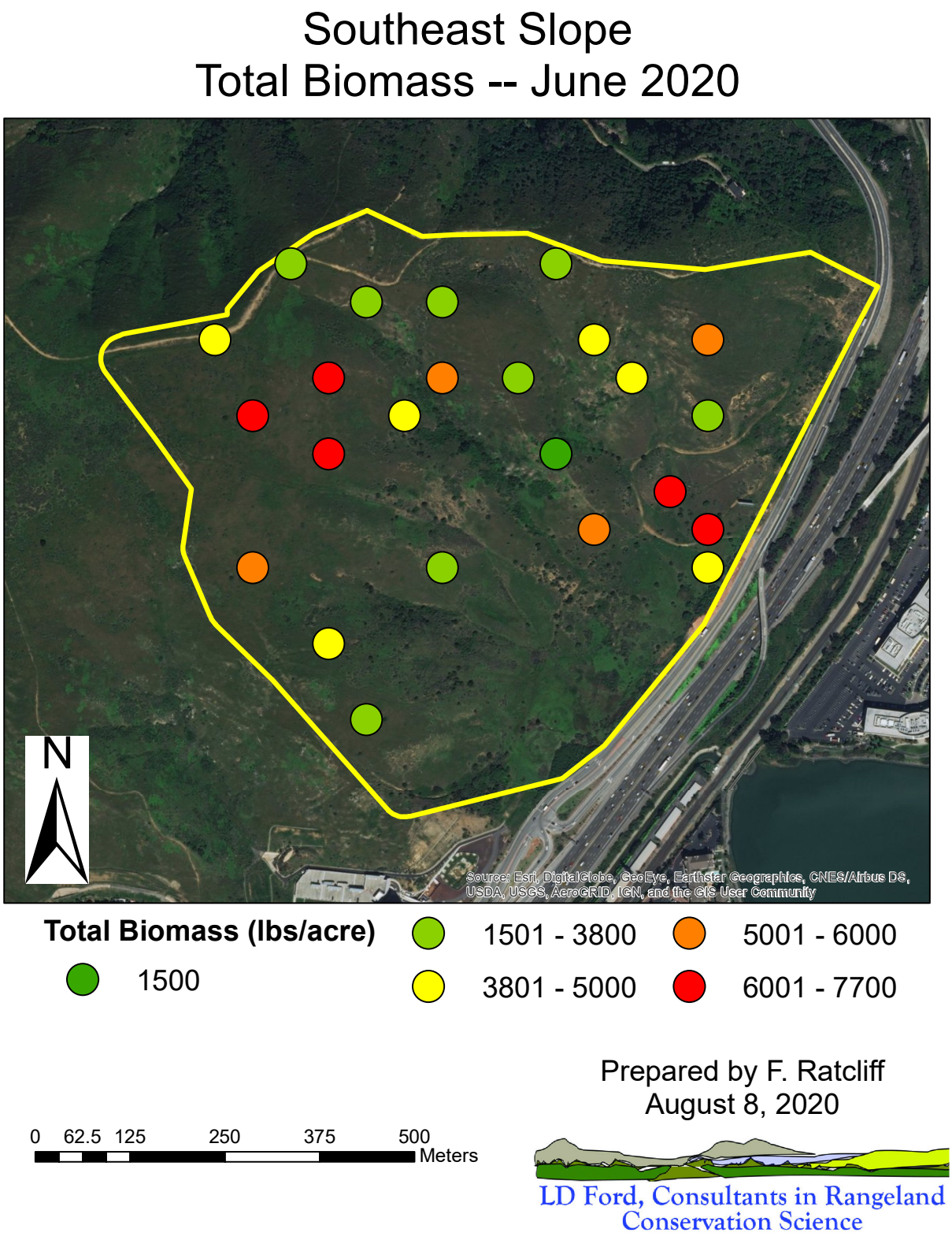

Figure 9. Map of Total Herbaceous Biomass in the Southeast Slope Grazing Pilot Area

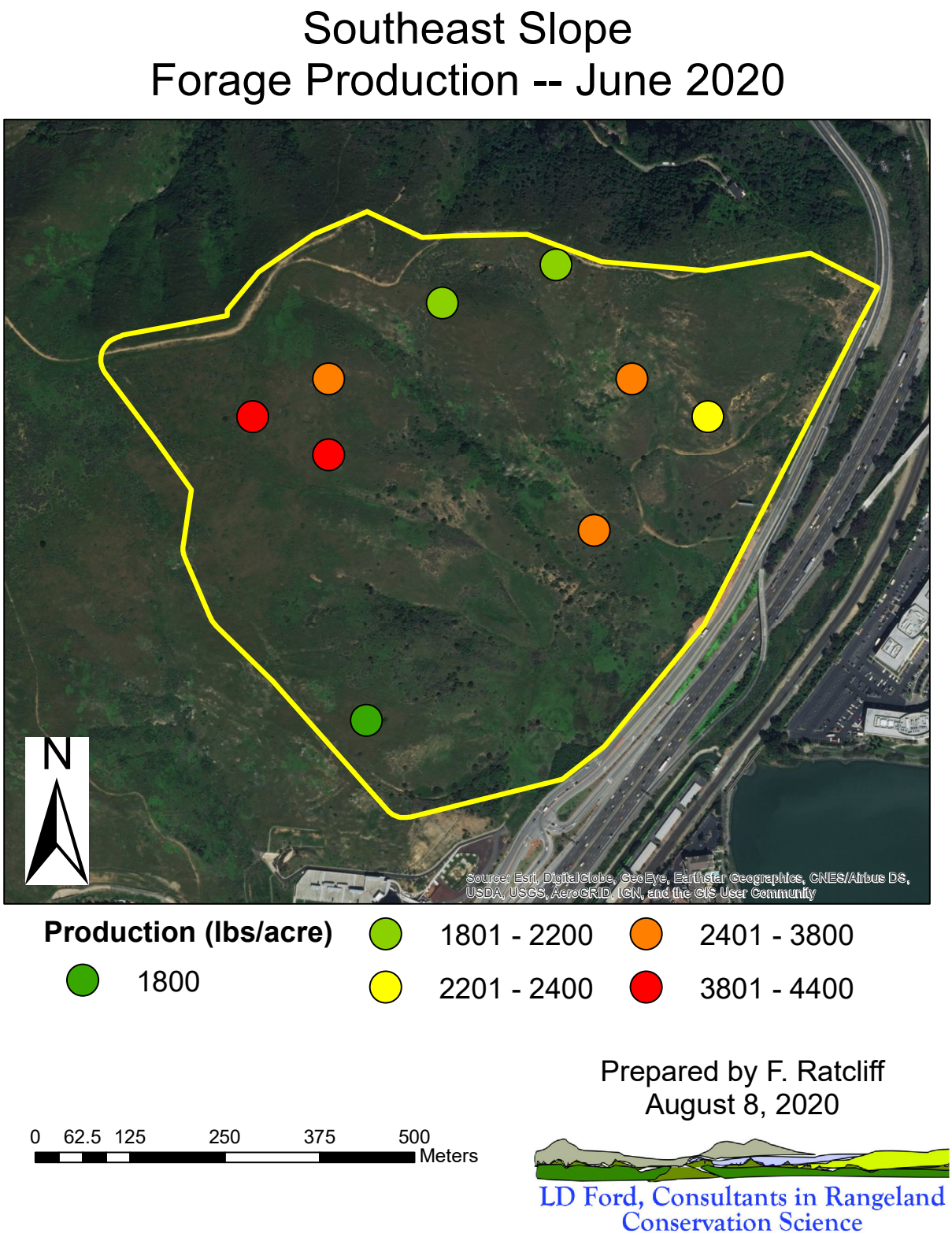

Figure 10. Map of Forage Production in the Southeast Slope Grazing Pilot Area

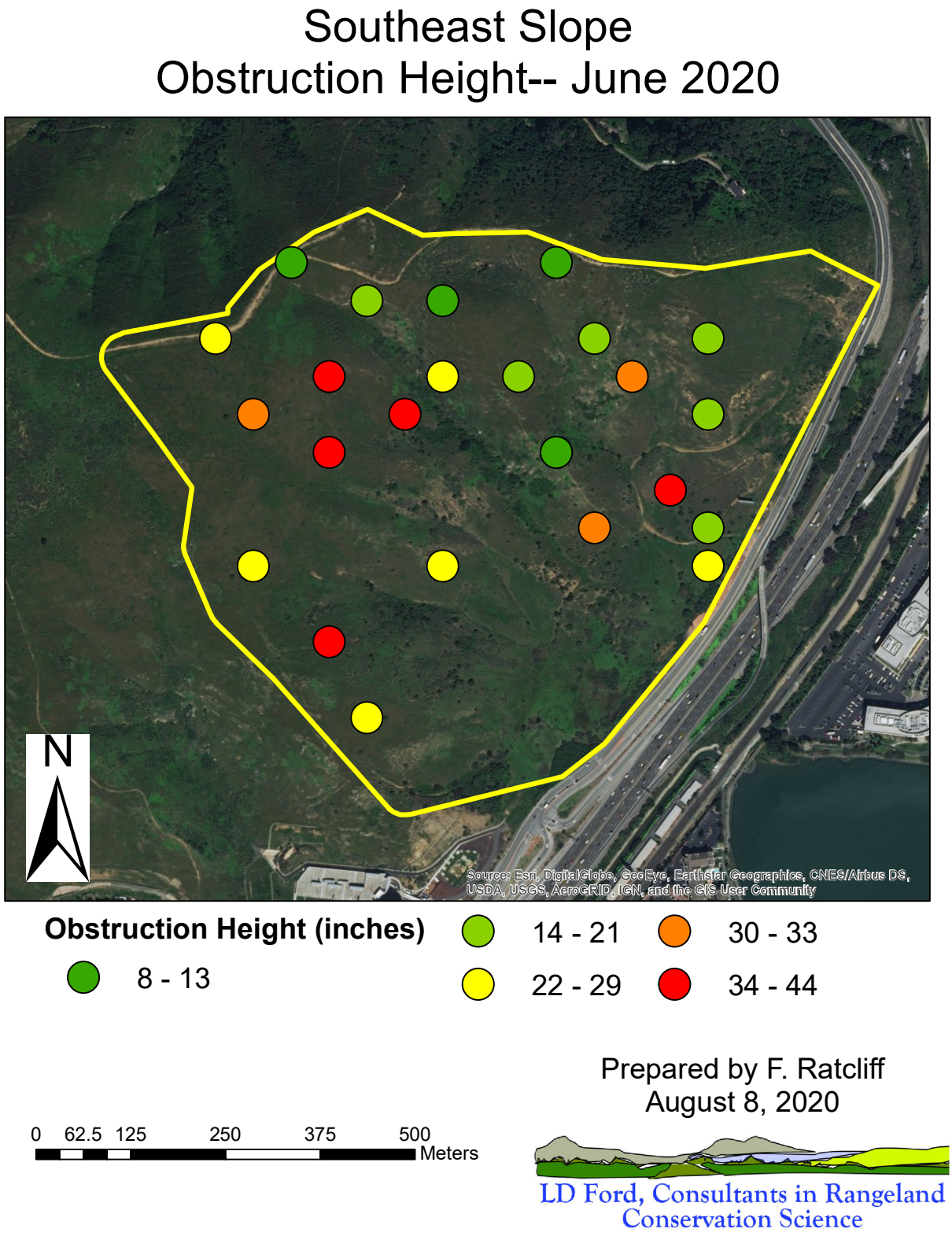

Figure 11. Map of Obstruction Height in the Southeast Slope Grazing Pilot Area

Conclusions and Recommendations

Total herbaceous biomass and forage production did not differ significantly between the two grazing areas, despite these areas having different soil types. Dominant vegetation composition was similar between the two proposed pilot grazing areas, and relationships between vegetation height and species composition were similar for the two areas. There were no strong relationships between biomass or height measured in 2020 and host plant occurrence measured in 2019 or earlier, however relationships between these variables will hopefully become clear as the range of height and biomass change during the continuing pilot grazing study.

We expect that significant differences in total herbaceous biomass and total vegetation height will be achieved with the grazing program, assuming that sufficient utilization by livestock occurs in the pilot grazing areas. If strong relationships are found between total biomass, obstruction height, and the host plants, then we would expect to see an influence of these variables on the host plant density. We also expect to see much less wild oats (an indicator of no or little grazing) after grazing has been occurring with sufficient intensity for several years, and thus less height. Testing this will require establishment of grazing exclosures in the grazing areas, and may require additional monitoring plots sited in the exclosure areas.

To best guide the grazing planning and inform analysis of the effectiveness of the grazing program, we recommend the following:

1. **Continue monitoring production, biomass and height in spring of 2021**
    a. Provide another year of biomass and height data prior to the commencement of grazing. Spring herbaceous biomass levels in the 2003-2004 goat grazing study (TRA 2007), while not taken from within either of the pilot grazing areas, suggest that total biomass may be higher in some years than reported for the pilot grazing areas in this report (2020). Additional total biomass and height measurements before the grazing program commences would add context about interannual variability of these values in the absence of grazing.

    b. Get production data for another year — annual forage production is highly variable and is influenced by the timing and amount of precipitation, as well as temperatures during the growing season (Becchetti et al. 2016). The 2019-2020 growing season was unusual: there was a severe drought in January and February that was followed by several well-spaced rains in March, April and May. What started as a bleak forage production year became a good production year in many parts of California.

    c. Consider adding sampling locations in spring of 2021. In particular, once grazing exlosure areas are selected, additional sampling plots should be sited in the exclosures.

2. **Pair with other natural resource studies in the pilot grazing areas**
    a. Surveys of host plants (*Viola, Plantago, Lupinus*) that are paired with biomass and height monitoring plot locations could be used to show the effectiveness of the management treatment at enhancing host plant habitat and populations, and could help refine management standards for biomass and height. Analysis of the relationship between biomass, height and the host plants over the course of the

pilot grazing study, would ideally result in recommendations for target conditions to achieve with grazing or other supplemental habitat enhancement measures.

b. Evaluate use of grazing areas by target butterfly populations by pairing butterfly transect data with changes in biomass and vegetation height in the two pilot grazing areas. This meets the requirement of the HCP that monitoring of habitat enhancement programs measure "the degree to which endangered species utilize the newly enhanced habitat".

3. Develop a grazing management plan/strategy

a. In preparation for the pilot grazing study, a grazing management plan (or similar strategic document outlining preliminary grazing management in the pilot areas) is essential. The previous plan (Amme 2002) was never implemented, and lacks specific information needed to guide grazing management in the pilot areas.

Part of developing the grazing strategy will include setting preliminary cattle stocking rates for the two pilot areas. The production estimates from this report can be used to generate those preliminary stocking rates, but before these are set, the following information must be available:

- the exact size and location of the grazing areas
- locations of key infrastructure (e.g., watering troughs)
- location and size of special management areas and flexible use fields (which will be essential to optimize grazing effects)
- the management standards and performance criteria that will be used to guide grazing management (e.g., RDM standards)

Additionally, while the production estimates from this study are a measure of the annual forage production, there is between 1600 and 1800 pounds of thatch per acre that should factor into the initial grazing strategy. The level of thatch will be reduced each year as the grazing program is implemented, and depending on weather and associated decomposition rates each year.

b. Once the grazing strategy is developed, a grazing lease, contract, or similar grazing agreement will also need to be created, which includes expectations for conservation services (such as infrastructure construction and maintenance, patrolling, and participation in public education) before the commencement of grazing.

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