Title

UC Santa Cruz Campus Grasslands Management Guidelines & Protection Prioritization Recommendations

Author

Luong, Justin C

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Justin Luong, M.A.
greenjustinluong@gmail.com

Advised by:
Dr. Karen Holl
kholl@ucsc.edu

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Executive Summary

UC Santa Cruz has unique grasslands that support high plant diversity and endangered species and are highly valued by campus communities. California's climate is dynamic and plant communities respond accordingly. As such, grassland managers should seek to adaptively manage meadows depending on annual weather patterns. Managers should also consider which management practices may be most suitable to different grasslands depending on varying cover of different plant lifeforms or sensitive species. Adaptive management prescriptions have been provided to promote both native plant diversity and cover and Ohlone Tiger Beetle habitat suitability, under varying rainfall patterns. UC Santa Cruz should invest more into campus stewardship and create an ecological restoration unit which will further improve campus sustainability goals and decrease natural resource management and mitigation costs for future expansion of the developed campus. Future increased enrollment goals of the University of California Office of the President will require additional student housing and support buildings, which in turn may require compensatory mitigation and protection in areas with sensitive habitat types or listed species. Several areas, especially Marshall Fields, Mima Meadow and Great Meadow, have been indicated as important areas for protection in this plan.

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UC Santa Cruz Sustainability, Enrollment and Long-Range Development Goals

The University of California is committed to increasing enrollment at all campuses in order to meet rising demands for higher education in California (University of California 2008). As part of this state-wide goal UC Santa Cruz is ideally projected to increase enrollment to 28,000 full time students as planned for by the UCSC Long-Range Development Plan (UCSC 2020). If the campus is to accommodate additional enrollments as outlined by the University of California Office of President, additional housing and academic support buildings will have to be constructed.

While undertaking new development projects, UC Santa Cruz will need to prioritize various campus lands in order to determine the best locations to develop with minimum impact to campus ecology, research, culture and aesthetics. Grasslands specifically are often overlooked making them more vulnerable to development, but are important for various ecological and cultural factors (Dasmann 1965b; Stromberg et al. 2007).

Protection of campus grasslands aligns with the *Natural Environment* goals in the Campus Sustainability Plan. These goals include an intersectional assessment of important campus natural lands, further development of experiential learning environments, control of exotic plant species invasions and improvement of the campus' brand by providing strong support of stewardship (UC Santa Cruz 2019). Protection of campus grasslands will also help UC Santa Cruz achieve *Climate* goals in the Campus Climate Sustainability Plan for carbon neutrality because grasslands provide substantial carbon storage (Jackson et al. 2007; Dass et al. 2018).

Introduction to California Grasslands

Grasslands are habitats dominated by grasses and herbaceous species with minimal cover of woody shrubs or trees. Grasslands are found across the globe and are often also known as prairies, steppes, meadows, rangelands or savannas. California grasslands are distinctive from other North American grasslands due to California's Mediterranean climate, which provides cool, wet winters and hot, dry summers. As such, grasses often grow deep, fibrous roots to reach sources of water, allowing for carbon storage at a deeper and more stable zone (Reever Morghan et al. 2007). Additionally, coastal prairies found in Santa Cruz and along the greater the central and northern California coast are considered the most diverse type of grassland in North America (Stromberg et al. 2001; Ford & Hayes 2007). Coastal prairies are an endangered habitat type that are rapidly disappearing (United States Fish & Wildlife Service 1995; California Department of Fish and Wildlife 2019). A survey of just 13 existing native California grasslands found that they harbor more than 40% of state's total native plant diversity (Schiffman 2007). Grasslands are important for ecosystem services such as carbon sequestration, wildlife habitat, soil stability, water quality and flood control (Binder et al. 2018; Tilman & Downing 1994; Conant et al. 2001; Lal et al. 2011).

Early evidence of grassland management can be seen from California indigenous tribes who stewarded the grasslands to maintain their productivity (Anderson 2007; Cuthrell et al. 2012; Cuthrell 2013). In Santa Cruz, ancestors of the Amah Mutsun Tribal Band likely stewarded and sustained the grasslands on campus. Furthermore, before human arrival, California grasses evolved with large herbivorous mammals and developed traits adapted to grazing over at least 20 million years (Edwards 2007; Wigand 2007). As such, grasslands require regular maintenance to prevent type conversion and are suitable for contemporary grazing.

Historically, approximately 25% of California was occupied by grasslands (Dasmann 1965b; Dana & Krueger 1958). Presently, half of this ecosystem type has been lost with only about 12% remaining (Jantz et al. 2007; Schiffman 2007). A loss of over 12 million acres puts the loss of California grasslands at a greater acreage than any other type of habitat in the United States. Even more alarming, only 1% of California native grasslands have resisted conversion into nonnative annual grassland (D'Antonio et al. 2007). This dramatic decrease in native grasslands highlights the importance of conserving remaining high quality habitat.

Native perennial grasslands, defined as having at least 10% native cover (Keeler-Wolf et al. 2007), may at first seem visually similar to invaded annual grasslands (Dasmann 1965b). Invasive nonnative species can transform native habitats into ruderal systems that support lower diversity and historical ecosystem functions (D'Antonio et al. 2016). Some invasive species, such as yellow star thistle, can even be neurologically damaging to horses while unpalatable to cattle. Yellow star thistle has also been found to deplete deep water resources to a greater extent than any native species, causing up to a 25% increase in loss of annual precipitation in the Sacramento Valley (Gerlach 2004). This study accounts for one region, yet economic damage is still extensive and was estimated to cost up to $75 million in water supply, arguably the most limited and valuable resource in the state (Dasmann 1965a; Meserve & Ringelberg 2010; Smith 1987; Starr 2004). Grassland restoration can help improve forage quality, erosion control and refuge for native pollinators (D'Antonio et al. 2007; Luong et al. 2019).

Due to the importance of native grasslands, I have developed this document to detail the ecological and cultural significance of UC Santa Cruz campus grasslands. The document discusses reasons different areas should be prioritized for permanent protection and conservation and also provides management recommendations for different aspects of campus grasslands. Some management aspects include: Ohlone Tiger Beetle habitat management, native plant diversity management, woody species encroachment and ecological restoration. The plan is informed by ecological surveys, interviews with relevant stakeholders and land managers and a campus wide survey of perceptions of and conservation values attributed to specific campus grasslands. It also discusses recommendations for current campus management of grasslands including, land clearing practices, restoration and use by Amah Mutsun Tribal Band members.

UC Santa Cruz Grasslands

Overview

Historically, approximately 40% of the UC Santa Cruz campus was covered by coastal prairies (Warrick 1982; Ford & Hayes 2007). Some grasslands on campus also host unique formations such as Mima mounds. Campus grasslands support rare species such as the large flowered star tulip (*Calochortus unifloris*), marsh silverpuffs (*Microseris paludosa*) and the endangered Ohlone Tiger Beetle (OTB; *Cicindela ohlone*) (**Table 2**). Some are located on the main residential campus (e.g. Great Meadow, Porter Meadow, East Meadow, Hagar Field and Inclusion Area D), within the coastal zone (Mima Meadow, Younger Lagoon Prairie), in upper campus (Marshall Fields) or at the coastal campus (Younger Lagoon Prairie). Most campus grasslands are a sensitive habitat type, the coastal prairie. These habitats are increasingly threatened and require mitigatory restoration to completed if they are affected by development (California Department of Fish and Wildlife 2019). Most of the main residential campus's grasslands have an underlying karst geographic formation on which it is difficult to design stable structures. Many campus grasslands are cultural sites which the Amah Mutsun use as a resource for their cultural revitalization efforts and contain archeological sites (R. Flores, pers. comm. 2020).

Data collection and analysis

I assessed trends in residual dry matter (RDM) in campus grasslands from 2008 to 2019. These data were collected primarily under the supervision of Bill Reid at UC Santa Cruz, Ground Services. Additional RDM and community composition data were collected annually since 2006 at Mima Meadows by Dr. Karen Holl's lab (2006-2016) and then by the UCSC Campus Natural Reserve under the supervision of Alex Jones as part of the requirements for the Ranch View Terrace Habitat Conservation Plan. I collected RDM from each previously sampled area in fall 2019. Additionally, I spoke to campus grassland managers, field workers and researchers with expertise in animal ecology, avian ecology and plant ecology to assess the important ecological aspects of each grassland (**Suppl. Table 1**). I surveyed each grassland in 2020 and consulted with local experts to a create plant species list for each management area. Between December 2019 and April 2020, I completed 7 wildlife surveys each at Porter Meadow, Great Meadow, Mima Meadow and Marshall Fields to provide further detail about wildlife use and diversity.

In order to gain community input about campus grasslands, I created a short survey distributed to the campus community (undergraduates, staff, graduate & post-docs, faculty, alumni, other campus community members). The survey was disseminated to campus communities through individual campus college email lists, individual department email lists, through staff email lists, student email lists, twice through the UC Santa Cruz Campus Tuesday newsletter and twice through the UC Santa Cruz Campus Sustainability newsletter. In Spring 2020, faculty and lecturers with courses greater than 100 students were emailed to ask for assistance distributing the survey. The survey opened on January 6, 2020 and remained open until May 22, 2020. Survey participants were asked if they knew of each grassland (no map was provided). Crown Meadow, Family Meadow, West Meadow and Inclusion Area D were excluded from the survey because they are much smaller areas. Respondents were also asked to

rank their use of the site (1 – never to 5 – very frequently). There were 272 responses, of which 29.0% were undergraduate students, 27.9% were graduate students or post-doctoral fellows, 17.6% were UC Santa Cruz staff employees, 16.2% were alumni, and 9.2% were faculty or lecturers. Of the 99 respondents who were affiliated with campus colleges, there was a slightly greater representation of Porter and Rachel Carson Colleges (by ~10% more than other colleges); Please note that this survey took place during the UCSC Graduate Student Worker's Strike concerned with rent burden, which could have affected how respondents perceived grassland protection and increased development.

Management Recommendations for Campus Grasslands

Management Priorities: Promoting Native Plant Diversity and Preventing Woody Species Encroachment

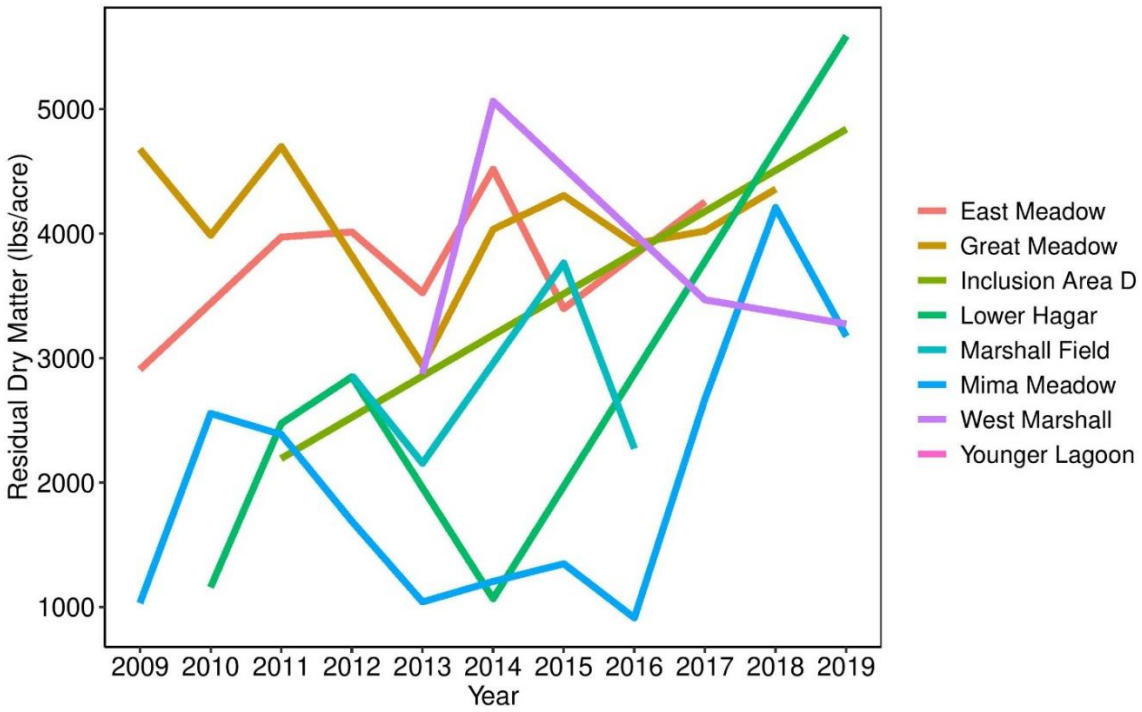

Figure 1 Change in residual dry matter at select sites from 2009 – 2019. Trends show residual dry matter increasing. Residual dry matter was collected in the fall before the first rain event of the upcoming hydrologic year.

Grasslands in California have evolved throughout time with regular disturbance from ungulate grazers and anthropogenic burning (Anderson 2007; Edwards 2007; Cuthrell et al. 2012). Due to a lack of periodic disturbance, woody species encroachment is currently an important issue in California grasslands. Many California grasslands are slowly being transformed into shrublands or Douglas-fir forests as time progresses (McBride & Heady 1968; Cocking et al. 2014). In the past, this transformation was likely slowed or halted through land management practices to be discussed.

A lack of disturbance in grasslands can also lead to a buildup of residual dry matter (RDM). In the case of UC Santa Cruz grasslands, there seems to be a slow increase in RDM over time (**Fig. 1**). Based on a 10-year average, campus grassland RDM appears to be higher than recommended in most areas (**Fig. 2**) As such, grasslands should experience regular disturbance to help regulate field residual dry matter (RDM), woody species encroachment and support native grassland diversity and productivity. In the case of campus grasslands, this will also help management for Ohlone Tiger Beetle. Management actions should also seek to reduce cover of nonnative species to the largest extent possible. Currently, all campus grasslands have some practice of annually clearing the vegetation for this purpose. Many campus areas are grazed, whereas others are mowed (**Table 2**). Campus managers also complete semi-regular coyote brush removal with a at most campus grasslands (R. Dillhey, Ground Services, pers. comm 2020). It will also be important to consider adaptive management actions based on weather patterns (**Fig. 3, 4**; **Table 1**). Timing of key phenological events, such as seed development, can vary across years due to changes in average annual temperature and precipitation patterns.

Grazing

Given that California grasslands evolved with large ungulates (Wigand 2007), grazing can be a useful way to help regulate residual dry matter and is a management practice that can also favor native grassland plants (Stahlheber & D'Antonio 2013). Grazing provides a different type of disturbance compared to mowing because it concentrates nutrient source points and provides heterogenous disturbance through cattle trampling. Ideally grazing should be matched to the timing of nonnative seed set (**Fig. 3**). For example, intensified grazing should be applied when possible when nonnative species start to bolt and produce flowering culms and removed when native bunchgrass start developing flowering culms. When applied successfully, grazing can help improve native forb diversity and abundance (Huntsinger et al. 2007; Collins 1987).

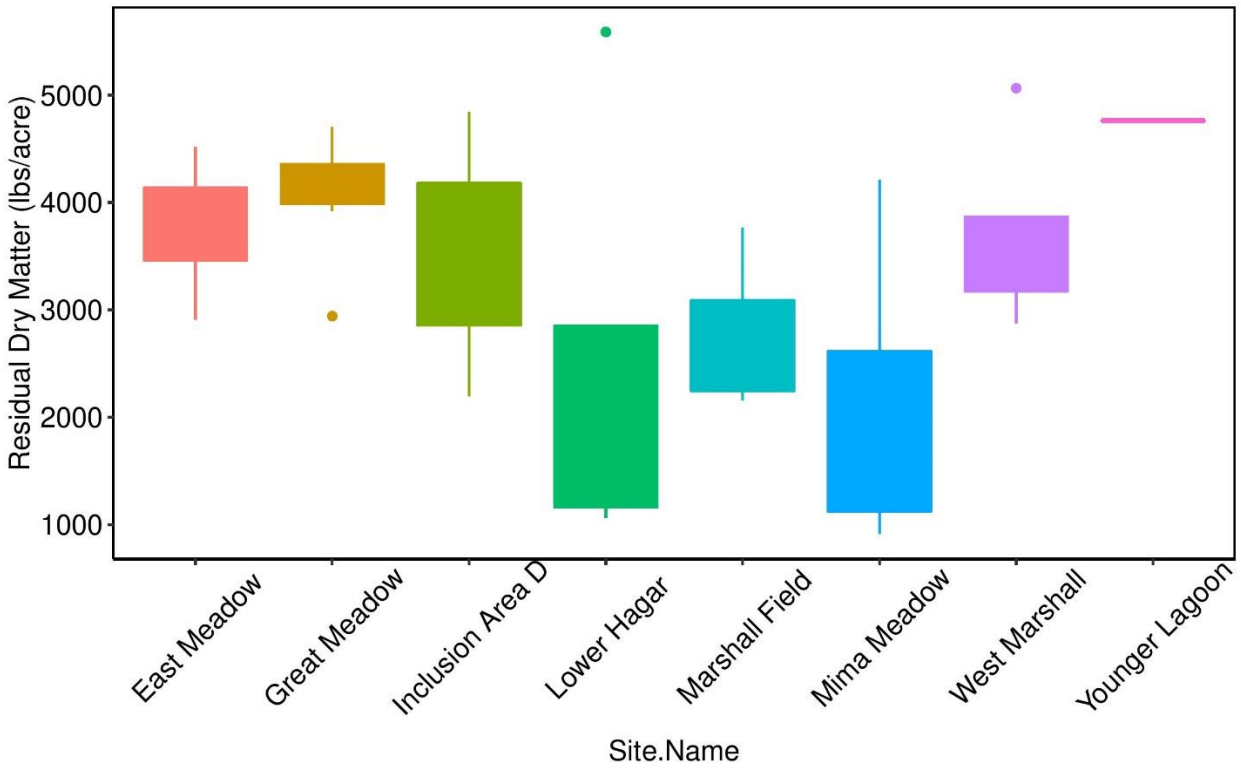

Figure 2 Average residual dry matter at each grassland site. Values are means of annual measurements from 2009-2019. Data were not collected at all sites in each year and so some sites have <10 years of data. The annual site RDM is determined by calculating the average of the RDM from all the transects at that given site in that given year.

Mowing

Some areas are mowed regularly in order to provide nonnative species control. Mowing should be timed according to the peak bloom season of annual grasses each year, which varies with annual weather. Sites should have management actions at least twice in the season: once after the first rainy period and flush of growth and again when temperatures start rising and annual grasses start flowering and begin to make seed. The first period is critical for grow-kill cycles and decreasing nonnative abundance in the long-term. The second period is a critical time for mowing because it can greatly reduce nonnative grass seed set, while minimally affecting native grasses that generally do not invest energy into flowering until approximately two weeks later. Practices may need to be adjusted for adaptive management depending on annual weather patterns (**Fig. 3**).

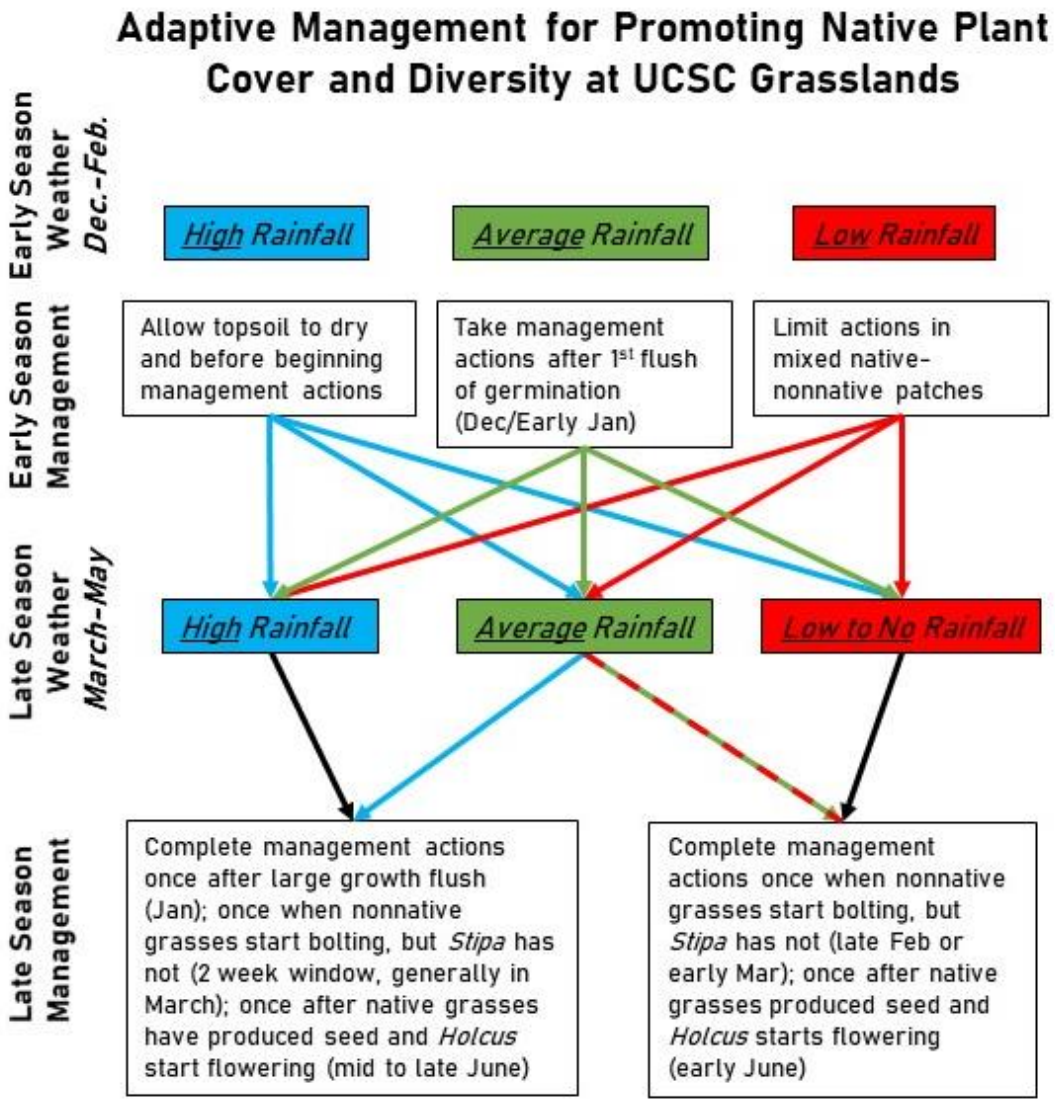

Figure 3 Adaptive management plan for promoting native plant cover and diversity with different management prescriptions for various climate scenarios. Blue, green and red arrows represent adaptive plans that originate from early season high, average and low rain fall, respectively. Dashed arrows with two colors represent management actions originating from two different early season precipitation events. Black arrows represent when all management actions overlap regardless of early season rainfall.

Prescribed fire

Prescribed fire can be another useful tool for managing grasslands for improved functioning and supporting native biodiversity (Reiner 2007). Prescribed fire can be used in selected areas to reduce RDM and can sometimes kill nonnative seeds in the seedbank if the fire reaches high enough temperatures (Levine 2011). Additionally, fire could help increase native biodiversity by providing germination cues needed by some native plants, which might cascade

and bring in more wildlife or birds because of increased food resources (Williams 1993). Burning also creates bare ground areas which is important for the persistence of the Ohlone Tiger Beetle. Indigenous burning in local coastal grasslands has resulted in increased native plant diversity (Cuthrell et al. 2012). Using prescribed fire as a management tool will likely be unsuitable for every location due to nearby development or other concerns. Prescribed fire might be most ideal at Marshall Field and portions of Mima Meadow and could be used to help further Amah Mutsun cultural revitalization efforts.

Preventing Woody Species Encroachment

Locally, the most common encroaching woody species is coyote brush. Coyote brush is a widespread native species and can be important in low abundance in grasslands to provide shelter to small mammals and songbirds (Tietje et al. 2008; McBride & Heady 1968), which serve as prey for larger wildlife. However, too much coyote brush will convert grassland to shrubland, which will decrease native plant diversity. Although there will be more shelter for small mammals, there will be less available forage because there will be less grass and herbaceous species.

Because of the dynamic role of coyote brush in California grasslands, I recommend that it be controlled with management interventions, but not be completely removed from every grassland, given its ecological value. Coyote brush is a dioecious plant which means that individual plants only produce one type of sex organ of the two required to create seeds (Bogler 2012). As such, I would recommend focusing on removing seed-bearing plants from campus grasslands to prevent future recruitment of coyote brush. Seed-bearing and pollen-bearing shrubs are easily distinguishable from a distance in late summer and early fall. An alternative prioritization method would be to remove uphill populations of coyote brush and leave downhill populations intact. Seeds often disperse downhill more easily from wind than uphill allowing for coyote brush patches to be in isolated areas. In OTB habitat areas, I recommend removal of all coyote brush individuals. Removal should be undertaken using manual methods (e.g., weed wrench) or chemical means (e.g. cut and paint herbicide application). Use of large machinery (e.g. excavators or masticators) is not recommended as it could compact the soil and cause unintended consequences for the grassland soil and ecology.

Douglas-fir (*Pseudotsuga menziesii*) is another woody species that encroaches in coastal California grasslands (Cocking et al. 2014). Douglas-fir forests support a different type of understory community from coastal prairies that are not as threatened and are less diverse. Douglas-fir could change soil chemistry due to the acidic nature of conifer leaves and further facilitate plant community change. Woody species encroachment will decrease the habitat available to the endangered Ohlone Tiger Beetle by decreasing the available open bare ground habitat within a grassland. Douglas-fir encroachment can become extremely difficult to handle if

left untreated initially. For example, if annual or biannual removals were conducted, it would be relatively easy to remove small saplings. If they were left for multiple years, they would reach a size that would require specialized machinery. It is important for grassland managers to remove young Douglas-fir saplings whenever possible in campus grasslands. As such, the UC Santa Cruz campus should provide support for the Campus Natural Reserve to obtain a Timberland Conversion Permit, which is required to remove any commercial tree species.

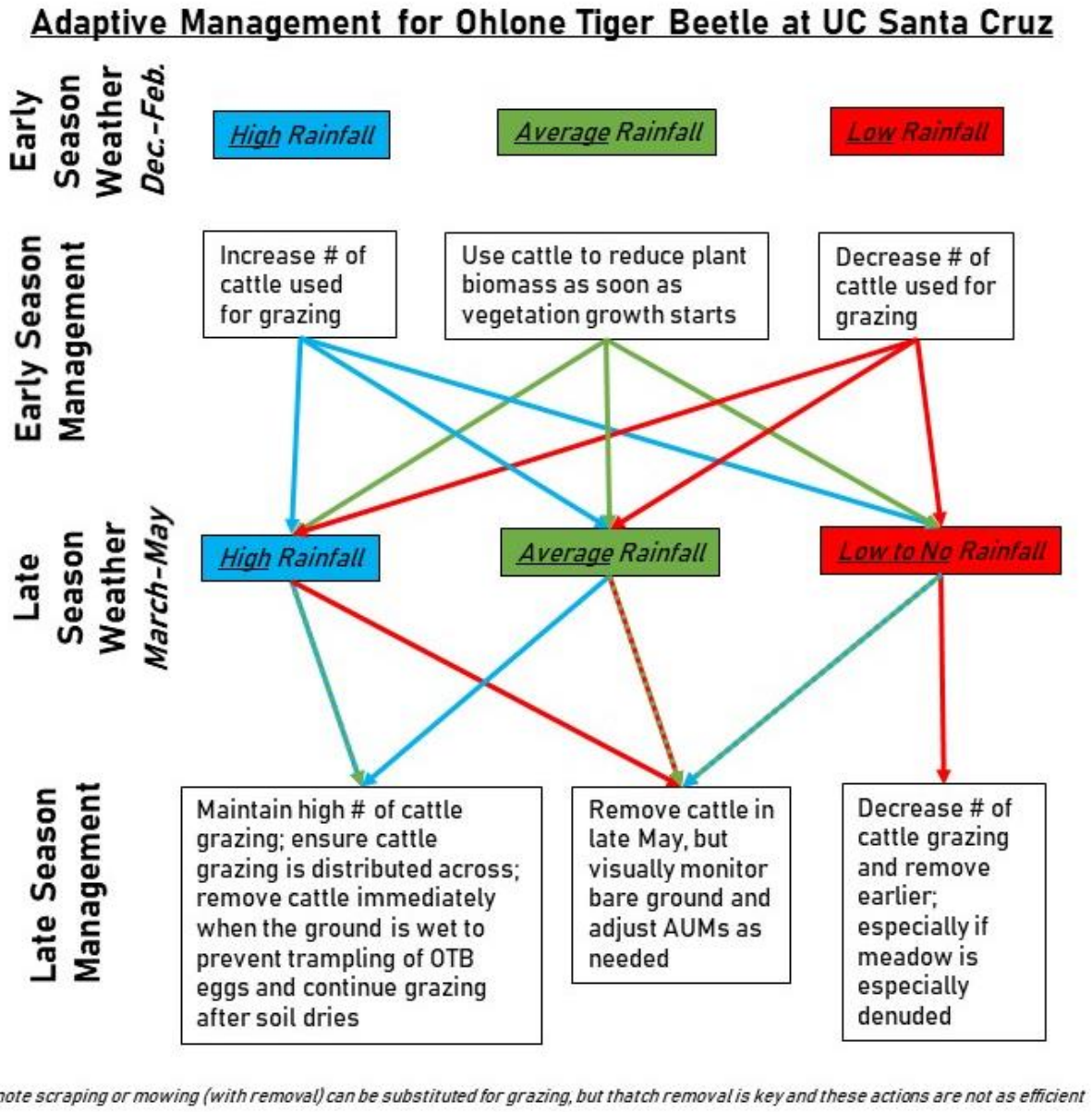

Figure 4 Adaptive management plan for promoting Ohlone Tiger Beetle populations with different management prescriptions for various climate scenarios. Blue, green and red arrows represent adaptive plans that originate from early season high, average and low rain fall, respectively. Dashed arrows with two colors represent management actions originating from two different early season precipitation.

Table 1 A description of different management actions and ideal scenarios for use.

MANAGEMENT ACTION	DESCRIPTION	PROS	CONS	IDEAL SCENARIO FOR USE
Hand Removal	Hand removal of target species with roots when possible; removal offsite if flowering or seeding	Highly effective and allows for targeted and precise work	Labor intensive	Areas with high forb diversity or cover; areas with sensitive or rare plants; small areas; all seasons; not ideal for large woody species
Mechanical	Use of string trimmers or similar mechanical tools	Allows for targeted work, relatively quick, easy to access	Labor intensive (less than hand removal); weeds may resprout	Areas with high native or nonnative grass cover; areas where native forbs are isolated; small areas; ideal in winter, spring and summer
Grazing	Use cows, sheep or goats to consume standing plant material and partial ground disturbance	Effective for large areas; allows for continuous management; can promote native annual forb diversity	Ranchers can be hard to reach for coordination; little infrastructure for targeted grazing	Areas with high nonnative grass cover; areas with mixed cover of nonnative and native grasses; areas with scattered forb cover; large areas; Ohlone Tiger Beetle habitat areas; ideal in winter and spring
Chemical	Use of broadband or lifeform specific herbicide with dye	Labor and time efficient; allows for targeted and precise work; easy to access	Neighborhood concerns; effects on non-target species; human health risks; requires training and permit for use	Areas with high native cover and diversity and few isolated, but hard to remove nonnative species; large areas with high native cover and high scattered abundance of nonnative species; ideal to use when target species is vegetatively growing
Mowing (with or without removal)	Use of a mower to cut standing plant material; always ideal to mow with removal	Labor and time efficient	Noise and dust concerns; effect on non-target species; requires coordination to access; difficult in uneven terrain	Areas with high nonnative grass cover; areas with mixed cover of native and nonnative grass; large areas with low forb cover; ideal in late winter, spring, early summer
Prescribed Fire	Use of prescribed fire to burn existing biomass in an area	Efficient at removing plant material in large patches; can promote native plant diversity	Neighborhood concerns; air quality; difficult to obtain permit, coordinate, and execute	Areas with mixed cover of native and nonnative species; areas with high nonnative cover; large or small areas; ideal in fall
Mastication	Use of machinery to cut and shred woody plants	Efficient at removing woody plants	Specialized use; effect on non-target species	Areas with high cover of conifer saplings or *Baccharis pilularis*; ideally done every ~5 years
Tarping	Use of tarping to prevent growth or to eliminate nonnative species	Useful for patches of high cover weeds; can be placed and does not need to be checked for months; helps with grow-kill	Execution takes several months; no other actions can be taken in the area while tarping; plastic may shred; effect on non-target species	Areas with high nonnative species cover; areas that are not flooded; ideally set in fall or winter prior to bolting and removed 6 – 9 months later depending on air temperature
Ground Scrapes	Using of machinery or hand tools to scrape bare ground	For grow-kill cycles; useful site-prep for planting or seeding	Can be labor intensive (hand tools) or hard to access (machinery), only can be done at small scales due to the disturbance caused	Areas with high nonnative cover; areas to be planted or seeded with native species; ideal in fall, winter

Managing for the Ohlone Tiger Beetle

The endangered Ohlone Tiger Beetle is limited to coastal grasslands in Santa Cruz County. Due to the predatory ecology and reproductive habitats of the OTB, the beetles require grasslands that have some bare ground habitat (Cornelisse et al. 2013). Loss of habitat occurs through a lack of land disturbance which coastal grasslands in California and the OTB have evolved with for hundreds of years. Management will have to be adapted annually based on weather patterns (**Fig. 4**). Open bare ground habitat is continuously lost in native coastal grasslands due to noxious nonnative grasses which tend to produce more above-ground plant material compared to native species (D'Antonio et al. 2007; Hayes & Holl 2003). Increased plant growth will increase residual dry matter (RDM) at the end of the growing season. For the OTB, ideal levels of RDM are 1500 lbs/acre (Cornelisse 2009). Therefore, it is important to continue management actions to reduce RDM at key areas such as Mima Meadow, Marshall Fields and Great Meadow. Management at Inclusion Area D is currently mandated. These actions should seek to reduce standing plant matter, especially as RDM has had an upward trend in the past decade (**Fig. 1**). In fact, at Mima Meadow, an area of especially high concern for the OTB, surveys from 2017-2019 found RDM to be 2000 lbs/acre higher than the decadal average (**Fig. 2**). As such, I recommend there be greater management actions in Mima Meadow in the form of increased, earlier grazing after wet years, or mowing or ground scraping to create OTB habitat. In Marshall Fields, RDM is always higher on average compared to Mima Meadow, indicating that more active management is needed. Marshall Fields does not currently have the capacity to support cattle grazing, so fire may also be a useful tool.

The timing and specific steps around each management action are also important considerations for OTB populations (**Fig. 4**). Animal units months should be adjusted as needed to manage for RDM levels. Given increasing RDM levels in past years, I recommend increasing animal unit months for Mima Meadow. Burns should only take place between October to December to limit fire risk and harm to OTB populations. Mowing can be used to at both areas to reduce RDM, but the litter must be removed. Ground scrapes can also be used as a supplemental method to any of these RDM reduction methods but is not a full substitute (**Fig. 4**). Instead it can be used to create additional bare ground habitat early in the season (Cornelisse et al. 2013).

Partnerships with the Amah Mutsun Tribal Band

Marshall Fields and West Meadow are both highly used in partnership with the Amah Mutsun Tribal Band for ethnobotanical field collections by the greater tribal community and for the Amah Mutsun Relearning Program. A collaboration with the UC Santa Cruz Arboretum, the Relearning Program was created to assist the Amah Mutsun Tribal Band in their efforts to

revitalize their culture through the relearning of traditional ecological knowledge. In addition to these existing partnerships, UC Santa Cruz can further improve their collaborations by working towards developing a land-sharing stewardship program. This program should be administered through Amah Mutsun Relearning Program at the UC Santa Cruz Arboretum.

For example, UCSC could partner with the Amah Mutsun Tribal Band to create a local native seed farm. Plants could be used ethnobotanically or they could be grown to harvest native plant seeds to be used in other projects. One way these seeds could be used is through the partnership the Amah Mutsun have with California State Parks at Quiroste Valley Cultural Preserve where tribal members are restoring an area of the valley using locally gathered or raised seed. Both models of collaboration can help support tribal relearning and social justice, but also improve local ecology. For example, if native seed farms of species of interest to the Amah Mutsun were started on one of the campus grasslands, such as Marshall Fields, seeds could potentially be shared with the Campus Natural Reserve and Natural Reserve System to improve the quality of local and on-campus restoration – further contributing to UC Santa Cruz's campus sustainability goals (UC Santa Cruz 2019)

Campus Natural Reserve Ecological Restoration Unit

In order to better ensure that the campus will reach Campus Sustainability and the 2020 Long Range Development Plan goals, it may be prudent for UC Santa Cruz to create and fund a campus-based ecological restoration unit, similar to The Cheadle Center for Biodiversity and Ecological Restoration (CCBER) founded in 2005 at UC Santa Barbara. CCBER was created at UC Santa Barbara because it is located in the coastal zone and all new development projects require mitigation for sensitive coastal habitat. At UC Santa Cruz, parts of the campus are located within the coastal zone. Additionally, many portions of the campus require compensatory mitigation for any development due to the classification of the coastal prairie as a sensitive habitat (California Department of Fish and Wildlife 2019) and to the presence of critical habitat for the threatened California red-legged frog and endangered Ohlone Tiger Beetle.

Accordingly, in order to ensure restoration is completed by those well-versed in local ecology, it may be more efficient for UC Santa Cruz to develop its own ecological restoration unit. For example, this new unit could be a branch of the Campus Natural Reserve. This could potentially save time and funds on future development projects because it removes the need for an open bid process and retains money within different sectors of the university. Similar to UC Santa Barbara, it may be ideal to provide funding in a rechargeable account in perpetuity to allow the needed flexibility to effectively conduct restoration in variable climate years. In areas where mitigation was required for development, such as faculty housing, Homeowner's Association (HOA) fees were partially given to the restoration unit for restoration site

maintenance. The Ranch View Terrace endowment fund for management and HOA fees could go towards founding this unit.

A localized restoration unit could increase restoration success by allowing for improved planning, localized knowledge and specialized management (pers. comm., CCBER, L. Stratton, 2020). In addition to improving management of campus lands, it provides opportunities for field-based learning, as evidenced by the large number of classes and interns that work on the restoration at Younger Lagoon Reserve. For example, several years after the creation of CCBER, its staff created and taught a new course at UCSB allowing students to learn about on-the-ground application of restoration techniques. This could also create additional jobs on campus and help support the campus sustainability mission. In 2019 alone, CCBER at UCSB was able to support 16 full time staff (through a combination of continually acquired external grant funding and an annual recharge rate from UCSB), over 50 student interns for class credit, and over 300 volunteers.

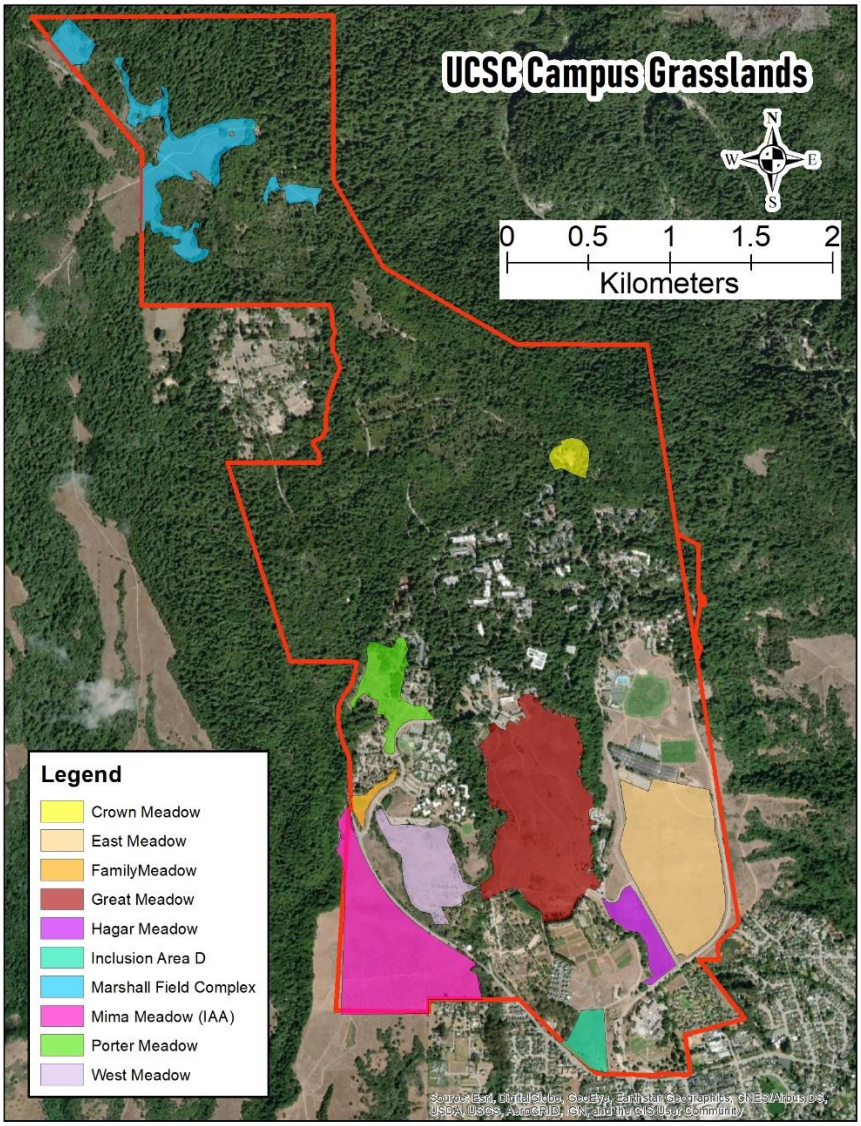

Figure 5 A map showing the various grasslands of UC Santa Cruz.

Prioritization of Campus Grasslands

Table 2. General characteristics of each campus grassland detailed in this plan. Sites highlighted in green are high priority for protection. Sites highlighted in blue are moderate priority for protection. Sites highlighted in white are low priority areas.

Site Name	Management Practice	OTB Record	Potential OTB Habitat	Native Plant Cover	Native Plant Diversity	Wildlife Connectivity	Wildlife Abundance	Education and Research	Cultural and Aesthetic	Amah Mutsun Use
Crown Meadow	Mowed	NO	NO	Medium	Medium	Medium	Low	**YES**	Low	Low
East Meadow	Grazed	NO	NO	Medium	Medium	Medium	Medium	**YES**	Medium	None
Family Meadow	Mowed	NO	NO	Medium	Medium	Low	Medium	**YES**	Low	None
Great Meadow	Grazed, Mowed, Shrub Mastication	**YES**	**YES**	Medium	Medium	**High**	**High**	**YES**	**High**	None
Hagar Meadow	Grazed	NO	NO	Low	Low	Low	Low	**YES**	Low	None
Inclusion Area D	Grazed	NO	**YES**	Medium	Medium	Medium	Low	Once	Low	None
Marshall Fields	Fire, Mowed	**YES**	**YES**	**High**	**Very High**	**High**	Medium	**YES**	**High**	**High**
Mima Meadow	Grazed	**YES**	**YES**	**High**	**High**	**High**	Medium	**YES**	**High**	None
Porter Meadow	Mowed, Shrub Mastication	NO	**YES**	**High**	**High**	Low	**High**	**YES**	**High**	None
West Meadow	Mowed, Shrub Mastication	NO	**YES**	Medium	Medium	Low	Medium	**YES**	Low	**High**
Younger Lagoon	Mowed	NO	NO	**High**	**High**	Medium	Medium	**YES**	**High**	None

Prioritizations and management recommendations for campus grasslands were created from ecological field data (vegetation surveys, residual dry matter sampling, wildlife surveys and interviews with experts and managers), community views of campus grasslands (campus survey and interviews with experts and managers) and special considerations (endangered species and special habitat types or topographical formations). Most recommendations are in agreement with land protection actions laid out in the 2020 Long Range Development Plan, but some additional areas are recommended. However, in addition to land designation from the 2020 LRDP, I recommend these areas be protected in perpetuity through the reserve system or through a habitat conservation plan. I strongly recommend high and moderate priority grasslands be protected from any future development on the basis of their ecology and cultural value. Permanent

protection and stewardship should be led by the Campus Natural Reserve with a coordinated partnership with Ground Services.

Table 3. Percentage of the 272 survey respondents that know of these grasslands, believe they should be protected, believe they have no ecological or sociocultural function.

Site Name	Know of This Grassland	Believe Grassland Should Be Protected	Believe Grassland Has no Function	Have Never Used This Grassland	Infrequently Used This Grassland	Moderately Used This Grassland	frequently Used This Grassland	Very frequently Used This Grassland
East Meadow	73.9%	67.4%	4.8%	30.1%	24.6%	19.5%	12.9%	12.9%
Great Meadow	72.8%	73.2%	4.4%	33.8%	15.8%	16.5%	12.1%	21.7%
Hagar Meadow	60.7%	61.0%	6.3%	49.6%	18.8%	16.9%	5.50%	9.20%
Marshall Fields	52.2%	71.3%	5.5%	47.4%	15.1%	17.3%	8.10%	12.1%
Mima Meadow	41.5%	67.3%	5.8%	58.5%	15.4%	10.3%	7.40%	8.50%
Porter Meadow	84.6%	68.8%	4.8%	33.5%	31.3%	14.7%	7.70%	12.9%
Younger Lagoon	59.2%	79.8%	5.5%	48.2%	18.0%	13.2%	6.60%	14.0%

High Priority Grasslands

Based on current ecological, cultural and social value (**Table 2, 3; Supp. Table 1**), I strongly recommend permanent protection of Marshall Fields, Mima Meadow and Great Meadow, by incorporating these lands into the University of California Natural Reserve System or Habitat Conservation Plan. Conversely, UC Santa Cruz, could provide the local Campus Natural Reserve greater autonomy and authority by placing campus lands for permanent protection under their management. Permanent conservation of these areas and management by UCSC Natural Reserve staff would further the UC Santa Cruz mission of sustainability and demonstrate its leadership in environmental and ecological research planned for in the Campus Sustainability Plan (UC Santa Cruz 2019). The Younger Lagoon grasslands are already protected permanently through the UC Natural Reserve System as the Younger Lagoon Reserve (YLR) and have high ecological value. The Coastal Act of 1976 (California Coastal Commission 2018) also required compensatory restoration of some grasslands at YLR to offset the development of the Coastal Campus (Holl et al. 2010).

All of these areas are important for outdoor learning and experiential education (**Table 2**; **Supp. Table 3**) which is part of the UC Santa Cruz mission and campus sustainability goals (UC Santa Cruz 2019). In addition to regular field trips for university courses, the Campus Natural Reserve also hosts educational tours of Mima Meadow and Marshall Fields for internship programs and campus events. Marshall Fields is the site of long-term research drought plots that

are part of a global experimental design (Knapp et al. 2017). Other research has also occurred intermittently at Marshall Fields and Mima Meadows over the years.

Additionally, adult populations of the endangered Ohlone Tiger Beetle have been observed at Marshall Fields and Mima Meadow. An adult has been observed at Great Meadow, but it unclear if it is a stable population (Arnold et al. 2012; pers. comm. T. Cornelisse, 2020; pers. comm., A. Jones, 2020). Any development would require further permitting or may not be legally feasible due to the federal Endangered Species Act (16 U.S.C. § 1531). The Great Meadow, on the other hand, is not in the coastal zone and does not host the endangered Ohlone Tiger Beetle but has high potential as OTB habitat. In fact, the CNR Manager observed an adult OTB in this meadow in March 2012. As such, the area should be considered as part of a campus Habitat Conservation Plan (HCP) to ensure population viability of and allow mitigation for the Ohlone Tiger Beetle habitat if other nearby development takes place.

Marshall Fields

Marshall Fields is an 87.5-acre coastal prairie complex located around the Twin Gates area of Empire Grade, in the Upper Campus north of Cave Gulch. West Marshall Field is part of the Campus Natural Reserve (2005 LRDP designation), but all other areas of the Marshall Fields complex currently are not. All areas are of high quality and should be protected permanently.

The area is not grazed due to a lack of available fresh water for cattle. In recent years, land managers have occasionally used prescribed fire and mowing as a management technique. Marshall Fields is a high-quality prairie with high diversity and abundance of native flora (**Supp. Table 1**). Marshall Fields has common bunchgrasses such as purple needle grass (*Stipa pulchra*), blue wild rye (*Elymus glaucus*), California brome (*Bromus carinatus*) and less common species such as tufted hair grass (*Deschampsia cespitosa*) and western panic grass (*Panicum acuminatum*) and California oat grass (*Danthonia californica*) – as such it would be classified as a sensitive coastal prairie by CDFW (California Department of Fish and Wildlife 2019). In addition to a diversity of bunchgrasses, Marshall Fields also hosts a diversity of wildflowers such as blue eyed grass (*Sisyrinchium bellum*), prairie mallow (*Sidalcea malviflora*), witch's teeth (*Hosackia gracilis*);sensitive species like large flowered star tulip (*Calochortus unifloris*), marsh silverpuff (*Microseris paludosa*), Kellogg's yampah (*Perideridia kelloggii*); and rare geophytes like harvest brodiaea (*Brodiaea elegans*) and wild hyacinth (*Triteleia hyacinthia*). The area also maintains a diversity and abundance of native rushes and sedges. In addition to hosting a diversity of flora, Marshall Fields is an important area for large mammals, such as deer, small mammals and carnivorous mammals. Marshall Fields has a high diversity of birds, some of which are not as common in other parts of campus. Marshall Fields also hosts populations of the endangered Ohlone Tiger Beetle (OTB), making it an extremely important and sensitive habitat within UC Santa Cruz's grasslands. Breeding populations have been known here since at least 2000 (Arnold & Knisley 2018) making this a key OTB habitat. Marshall Fields would be another ideal area to include within a campus-wide HCP. Alternatively, Marshall Fields could be

considered for permanent protection through swapping protection status from Inclusion Area D, which was set aside as OTB habitat, but has never supported adult OTB. Campus surveys also indicate respondents strongly support the protection of Marshall Fields (**Table 2**).

Marshall Fields is also an important educational and research area within campus grasslands (**Supp. Table 3**), supporting numerous courses. Marshall Fields helps support experiential natural resource internships through the Campus Natural Reserve and is an important area for campus researchers for topics such as predatory mammals, avian ecology or ecological restoration experiments. Additionally, there are drought shelters at Marshall Fields that are part of a global experiment designed to determine the effect of drought on global plant productivity and plant composition. The site also has extremely high native plant cover and would be classified as a sensitive coastal prairie habitat (California Department of Fish and Wildlife 2019). Marshall Fields is also an important site for the Amah Mutsun Relearning Program, a partnership created by the Amah Mutsun Tribal Band and UC Santa Cruz Arboretum to assist the Tribe in efforts of cultural revitalization.

Mima Meadow

Mima Meadow is located adjacent to the UC Santa Cruz main residential campus, southwest of the Arboretum and west of Empire Grade. Mima Meadow is ~129-acres and is within the California Coastal Zone (California Coastal Commission 2018), which affords the grassland extra protection. This makes Mima Meadow an ideal site for permanent conservation which would align with campus sustainability goals and save financial resources for a more cost-effective development elsewhere. Mima Meadow has unique pocket mound formations. The cause of these formations is still debated, but it is thought to be created partly or in combination by pocket gophers, extreme shrink-swell clay soils, and seismic activity. These mounds have persisted and provided unique microhabitats for native plants and animals (**Supp. Table 1**). Mima mounds do not occur regularly in California, and most occurrences in the U.S. are in Oregon and Washington State coastal prairies. In addition to the unique topographical formation, Mima Meadow also has the appropriate Watsonville Loam soil type that supports the endangered Ohlone Tiger Beetle (USDA NRCS 2020). Mima Meadow is a key habitat and breeding area for the OTB and has been found to host populations every year surveyed (2006-2020). Campus Grounds Services staff have collected data on residual dry matter (RDM) annually since 2006. A 12-acre portion of Mima Meadow is permanently protected through the Ranch View Terrace Habitat Conservation Plan, which restricts future development (Cornelisse 2009).

Mima Meadow is also an important area for wildlife and habitat connectivity because it creates a large contiguous wildlife corridor between the Santa Cruz Mountains within and surrounding campus, Wilder Ranch State Park, and Moore Creek Preserve. This is especially important for mountain lions (C. Wilmers, pers. comm. 2019). It supports habitat connectivity between Moore Creek and Wilder Ranch State Park OTB populations (T. Cornelisse, pers. comm. 2020). It also supports populations of small mammals, raptors, songbirds, coyotes and

deer. Mima Meadow has been used as a field location for a moderate number of courses (**Supp. Table 3**). According to campus surveys, Mima Meadow is the least known grassland to campus respondents, but even so, many of the survey respondents believed the area should be protected from future development (**Table 2**). This may be due to the fact that respondents did not know the name of this area, which is not clearly labeled at entrances.

Great Meadow

The 174-acre Great Meadow lies at the heart of UC Santa Cruz. Portions of Great Meadow are used for cattle grazing. The Great Meadow supports native plant populations and at least a portion of the area would be an ideal location to be incorporated within the Campus Natural Reserve due to its ecological value and perception by the campus community (**Supp. Table 1**). It is an important campus area for wildlife, such as deer, small mammals, owls and raptors, as well as predatory mammals such as coyotes, bobcats, mountain lions, and rare, transient species like the American badger. The adjacent riparian corridor is often used by mountain lions, and provides an important wildlife corridor between the Ben Lomond Mountains, lower campus and Pogonip. Great Meadow is also important to the aesthetics and culture of UC Santa Cruz and is often photographed as an iconic location on campus. Great Meadow supports numerous courses, notable in the Arts and Environmental Studies departments (**Supp. Table 3**). Mammals are occasionally surveyed for research related to predator and prey movement dynamics. One adult Ohlone Tiger Beetle was observed at Great Meadow in 2012 (Alex Jones, pers. comm. 2020). Species experts remain optimistic about the potential of this habitat (T. Cornelisse, pers. comm. 2020).

Great Meadow is one of the most well-known campus grasslands to the campus community and it is a high priority for protection to respondents (**Table 2**). There are large drought shelters that are part of the International Drought Experiment at the western edge of Great Meadow (identical to Marshall Fields and Younger Lagoon) used to determine the global effect of drought on plant productivity and plant composition.

Younger Lagoon Prairie

Younger Lagoon Reserve has coastal prairie habitat, which was historically utilized for cattle grazing and then for tilled row crop agriculture before it became part of the UC Natural Reserve System in 1986. The site is dominated by invasive species, notably wild oats (*Avena barbata*), and wild radish (*Raphanus sativus*) with some persisting native species, such as coyote brush (*Baccharis pilularis*) and common yarrow (*Achillea millefolium*). Since the terrace lands became part of the Younger Lagoon Reserve in 2008, Younger Lagoon staff have completed large amounts of grassland restoration, greatly improving native plant populations (**Supp. Table 1**), particularly for purple needle grass (*Stipa pulchra*), California meadow barley (*Hordeum brachyantherum*), common yarrow (*Acheilia millefolium*), gum plant (*Grindelia stricta*) and pacific aster (*Symphyotrichum chilense*). Younger Lagoon prairies support a large abundance of

small burrowing mammals such as voles and shrews as well as a large abundance of raptors such as red-shouldered hawks, white-tailed kites, and occasional peregrine falcons.

Younger Lagoon is also an important area for research and education. Younger Lagoon supports multiple ongoing research projects from faculty members, graduate students, visiting scholars and undergraduates pursuing senior thesis projects. Research projects at the Younger Lagoon grasslands seek to understand the efficacy of different restoration methods and how to most cost-effectively restore a large population. There are also large drought shelters that are part of the International Drought Experiment at Younger Lagoon (identical to Marshall Fields and Great Meadow) used to determine the global effect of drought on plant productivity and plant composition. At Younger Lagoon, there are additional drought structures to determine the effect of precipitation on native restoration plantings. Younger Lagoon prairies also support a large number of internships every quarter, as well as UC Santa Cruz and Cabrillo College classes, through which students can learn more about natural resource/land management and ecological restoration (**Supp. Table 3**). It is also an area that engenders a high level of support and protection (**Table 2**).

Moderate Priority Grasslands

West Meadow is an area with moderate native plant diversity and cover and active research. It is partially used for the California Conservation Garden, is currently managed by the UC Santa Cruz Arboretum, and should remain in its management to ensure needed protection. Areas that are also prioritized for protection and conservation are Porter Meadow and the upper (northern) portion of the East Meadow. Porter Meadow is used for numerous classes and both are used for internships and independent undergraduate projects. Porter Meadow is important for many students that live nearby. East Meadow also provides an aesthetic that the campus community is accustomed to. Therefore, a compromise to the Student Housing West development may be to protect the northern portion of the East Meadow, which also serves to connect the wildlands of Pogonip city park and southern campus grasslands and riparian areas.

East Meadow

East Meadow is 126-acres and is located on the eastern end of the campus below the East Field recreational area. East Meadow is a special status habitat type consisting of coastal prairie due to occurrence of an indicator species California Oat Grass (California Department of Fish and Wildlife 2019). East Meadow also has abundant populations of purple needle grass and native wildflowers such as California poppy (*Eschscholzia californica*), checkerbloom (*Sidalcea malviflora*), and sun cups (*Taraxia ovata*) and is grazed each year (**Supp. Table 1**). East Meadow also provides habitat for deer, small mammals (CA ground squirrels, CA brush rabbits, CA voles), burrowing owls and raptors (Red-shouldered Hawks, White-tailed Kites, Golden Eagles and others). Burrowing owl habitat is especially important because it is a California Species of Special Concern. The East Meadow has also been used as an educational resource for

several courses and internships (**Supp. Table 3**). This site is especially important for nearby community members, particularly those who are a part of the East Meadow Action Committee. Correspondingly, the East Meadow is highly valued by the survey respondents as an important campus aesthetic resource, indicated as a highly used campus grasslands and nearly 70% of respondents thought it should be protected (**Table 2**).

The East Meadow includes a site that has been approved for housing development by the UC Regents. Development in this area will likely proceed but will require a mitigation project to restore *Stipa pulchra* grassland (UCSC 2020). I recommend that this mitigation restoration project be located east-west along the northern border of East Meadow adjacent to the East Remote Parking Lot (**Supp. Fig. 1**). This area would be ideal for conservation and restoration because it would provide needed habitat connectivity for wildlife between Pogonip and Great Meadow, ensuring wildlife habitat connectivity even with development. Additionally, this area already has high cover of native plants. The area suggested for conservation should be put under the management of the Campus Natural Reserve to maximize ecological and cultural benefits of protection. Additionally, needed mitigation should be completed by the Campus Natural Reserve through a newly funded small restoration unit, to further current and future mitigation efforts. Loss of this habitat connectivity could lead to less wildlife on campus. Furthermore, it will be important to keep, at minimum, portions of East Meadow open and continuous to help address ecological and community concerns.

Porter Meadow

Porter Meadow is a 34-acre grassland that is the most well-known grassland on campus (**Table 2**) and is important for the campus community through its aesthetic values and by providing a space for community gatherings. Porter Meadow is located between Porter College and Family Student Housing north of Heller Road. Other than these developments, the meadow is surrounded by forest. Porter Meadow supports abundant populations of wildlife such as deer, coyotes, foxes, small mammals, turkeys, songbirds and raptors. Porter Meadow also has abundant and diverse populations of native plants (**Table 1**; **Supp. Table 1**) including native bunch grasses like California oat grass and purple needle grass, classifying it as a sensitive prairie habitat (California Department of Fish and Wildlife 2019). It also hosts diverse wildflowers such as California poppy, prairie mallow, Sky Lupine (*Lupinus nanus*), yellow mariposa lily (*Calochortus luteus*), purple sanicle (*Sanicula bipinnatifida*) and rare geophytes like harvest brodiaea and pretty face (*Triteleia ixioides*). Additionally, Porter Meadow grasslands lie adjacent to a riparian corridor that hosts native salamanders, including the California giant salamander (*Dicamptodon ensatus*, a California Species of Special Concern) and newts. There have been records of the federally threatened California red-legged frog (*Rana draytonii*) near the lower south-east edge of the meadow where it can serve as continuous habitat to the known population at the Arboretum Pond (UCSC 2020). Porter Meadow is also used as an educational resource for numerous departmental and core classes (**Supp. Table 3**). Development of Porter

Meadow would require additional permitting and conservation planning due to its proximity to the habitat of the threatened California red-legged frog.

West Meadow

West Meadow is a 50-acre grassland located to the north of the fenced portion of the UC Santa Cruz Arboretum. It supports native plants such as purple needle grass, California poppy and sky lupine (**Supp. Table 1**). It is used by wildlife and could serve as a habitat corridor between the Great Meadow and Mima Meadow. West Meadow is the site of California Conservation Garden, managed by the UC Santa Cruz Arboretum, which further increases its ecological and educational potential. The program supports numerous student internships each year. The Conservation garden in West Meadow has also been used extensively by the Amah Mutsun Tribal Band for revitalization efforts since 2009. West Meadow was excluded from the campus community grassland survey due to its relatively restricted access and specialized use. The area should remain in the management of the UCSC Arboretum.

Low Priority Grasslands

Other grasslands that have a low priority for protection are the lower portions of the East Meadow, Hagar Meadow, Crown Meadow, Family Meadow and potentially Inclusion Area D. Inclusion Area D is currently protected as habitat for the Ohlone Tiger Beetle through the Ranch View Terrace Habitat Conservation Plan. It has been suggested that other areas may be more appropriate habitat protection for OTB populations (T. Cornelisse, pers. comm. 2020). Adult OTB have not yet been observed at Inclusion Area D. Therefore, transferring this protected status to Marshall Fields, which is a larger area where individuals have been repeatedly observed, may be more likely to provide habitat for OTB populations in the future. Mima Meadow and the Great Meadow would be secondary and tertiary choices for the protection-status swap from Inclusion Area D. Inclusion Area D does have good quality native plant habitat, but this was through restoration (Central Coast Wilds 1995), and could potentially be restored elsewhere as mitigation.

Crown Meadow

Crown Meadow is a small 11-acre grassland surrounded by forest north of Colleges 9 & 10. It has high diversity of native species (**Supp. Table 1**) but its cover is dominated by non-native species. Notably it has blue wild rye, witch's teeth, brown headed rush (*Juncus phaeocephalus*) and occasionally rare geophytes like brodiaea. It is the only meadow that has been documented to have any active planting and seeding ecological restoration efforts completed for non-mitigation purposes. These efforts occurred in 2016 and helped increase native cover by revegetating a frequently used gathering place. Although Crown Meadow is used by wildlife, due to its location on the edge of development and it being surrounded by other undeveloped areas, it is not as important for wildlife connectivity. Other natural areas near Crown Meadow could serve as wildlife corridors if the meadow was lost. Furthermore, it is

adjacent to development which further limits its benefit as a wildlife corridor. Crown Meadow was excluded from the campus community grassland survey due to its small size. Crown Meadow is used by several campus courses due to its proximity to undergraduate colleges (**Supp. Table 3**). Crown Meadow has the highest priority within the lower ranked grasslands for protection due to its educational use and high plant diversity.

Family Meadow

Family Meadow is a 6-acre grassland between Family Student Housing (on Heller Drive), West Remote Parking Lot and Empire Grade Drive. It has high use by the nearby Family Housing community for recreational activities. It does host a notable population of purple needle grass and California oat grass, making it a sensitive habitat type (California Department of Fish and Wildlife 2019). It also has some native wildflowers such as blue-eyed grass, brodiaea and sun cups (**Supp. Table 1**). Although it is used moderately by wildlife, it does not have high habitat connectivity value. It is not located adjacent near any important wildlife areas, is located in a moderately developed area and other nearby areas could potentially be used as a corridor if it is developed. Family Meadow was excluded from the campus community grassland survey due to its specialized use.

Hagar Meadow

Hagar Meadow is a 21-acre grassland that is currently used for grazing near the southern end of main campus. It is located south of the on-campus housing community (The Village) and adjacent to the UC Santa Cruz Center for Agroecology and Sustainable Food Systems and directly west of the East Meadow. Hagar Meadow has a limited abundance purple needle grass and a very limited abundance of native wildflowers (**Supp. Table 1**). The area is degraded and primarily dominated by nonnative annual grasses and agricultural weeds. Hagar Meadow is thought to be low in wildlife use compared to other campus grasslands. Hagar Meadow has only scarcely been used by campus courses (**Supp. Table 3**), and is the least well-known grassland from campus surveys (**Table 2**).

Inclusion Area D

Inclusion Area D (IAD) is a 17.5-acre grassland area on campus located directly south of the Ranch View Terrace faculty housing development. It was designated as a protected area as part of mitigation efforts for the Ranch View Terrace housing development project in 2005, and is protected for the life of the Ranch View Terrace Habitat Conservation Plan as potential Ohlone Tiger Beetle and California red-legged frog habitat. It was planted with native flora by Central Coast Wilds in 1995 (Central Coast Wilds 1995) and currently has high quality stands of purple needle grass and California oat grass, with scattered forbs such as California poppies, sun cups, and blue-eyed grass (**Supp. Table 1**). It also has a natural seep which supports native rushes and sedges. The area is classified as a sensitive coastal prairie habitat by the habitat standards set by the California Department of Fish and Wildlife (California Department of Fish

and Wildlife 2019). Inclusion Area D hosts wildlife such as deer, coyotes, small mammals, and birds of prey. It has some habitat connectivity value because it lies adjacent to a riparian corridor and is often used by carnivorous mammals. The OTB has not yet been observed at IAD, but it has the appropriate soil type to host the endangered beetle. Inclusion Area D was not included in the community survey as public access is not allowed. It has been used on occasion by one class: Restoration Ecology (ENVS 160).

Conclusion

UC Santa Cruz has unique grasslands that support high plant diversity, endangered species, wildlife connectivity and are highly valued by campus communities. I have laid out several adaptive management prescriptions have been provided to promote both native plant diversity and cover and Ohlone Tiger Beetle habitat suitability for multiple rainfall scenarios. I highly recommend UC Santa Cruz invest more into campus stewardship and create an ecological restoration unit which will further improve campus sustainability goals and costs for future natural resource management. Several areas, especially Marshall Fields, Mima Meadow and Great Meadow, have been indicated as important areas and are recommended to be protected in perpetuity.

Online Campus Grassland Data Repository

All existing UCSC grassland data was digitized and compiled to be stored for public use within an online Google Shared Drive (https://drive.google.com/drive/u/1/folders/0ABkoKf8a_kr-Uk9PVA) held in ownership by Dr. Karen Holl. If you are interested in accessing the contents of this data repository you can contact her at kholl@ucsc.edu.

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Supporting Information

Supplementary Table 1 A checklist of native species found in various campus grasslands.
*Denotes rare species

Species	Family	Common Name	Crown Meadow	East Meadow	Family Meadow	Great Meadow	Hagar Meadow	Inclusion Area D	Marshall Fields	Mima Meadow (IAA)	Porter Meadow	West Meadow	Younger Lagoon
Achillea millefolium	Asteraceae	common yarrow							X	X			X
Agrostis pallens	Poaceae	leafy bent grass							X				
Allium unifolium	Alliaceae	one leaf onion							X				
Anagallis minima	Myrsinaceae	pearly everlasting							X				
Arbutus menziesii	Ericaceae	Pacific madrone							X				
Artemisia californica	Asteraceae	sagebrush						X					X
Baccharis glutinosa	Asteraceae	salt marsh baccharis											X
Baccharis pilularis	Asteraceae	coyote brush	X	X	X	X	X	X	X	X	X	X	X
Brodiaea elegans	Thermidaceae	harvest brodiaea			X	X			X	X	X	X	
Brodiaea terrestris	Thermidaceae	dwarf brodiaea	X						X		X	X	
Bromus carinatus	Poaceae	California brome	X	X	X	X		X	X	X	X		X
Calandrinia menziesii	Montiaceae	red maids				X			X	X			
Callitriche sp.	Plantaginaceae	water-starwort							X				
Calochortus luteus	Liliaceae	yellow mariposa lily							X		X		
*Calochortus unifloris**	Liliaceae	large-flowerd star tulip							X				
Cardamine oligosperma	Brassicaceae	little western bittercress				X			X		X	X	X
Carex brevicaulis	Cyperaceae	short stem sedge	X										
Carex densa	Cyperaceae	dense sedge					X			X			
Carex gynodynama	Cyperaceae	wonder woman sedge	X						X				
Carex hartfordii	Cyperaceae	Hartford's sedge											X
Castilleja densiflora	Orobanchaceae	dense flower owl's clover							X				
Castilleja exserta	Orobanchaceae	purple owl's clover							X			X	

Chlorogalum pomeridianum	Agavaceae	soap plant		X	X	X		X	X	X	X		X
Croton setiger	Euphorbiaceae	turkey mullein		X	X						X		
*Dantononia californica**	Poaceae	California oat grass	X	X	X	X		X	X	X	X	X	X
Deschampsia cespisota	Poaceae	tufted hair grass							X				X
Dichondra donelliana	Convolvulaceae	California's ponysfoot					X	X					
Dodecatheon clevelandii	Primulaceae	Padre's shooting star							X				
Elymus glaucus	Poaceae	blue wild rye	X		X				X	X	X		X
Elymus tritcoides	Poaceae	creeping wild rye											X
Epilobium canum	Onagraceae	California fuschia							X			X	
Epilobium ciliatum	Onagraceae	fringed willowherb	X						X		X		X
Erigeron canadensis	Asteraceae	canadian horseweed		X	X	X	X	X	X	X	X	X	X
Eryngium armatum	Apiaceae	coyote thistle	X						X	X	X		
Eschscholzia californica	Papaveraceae	California poppy		X		X	X	X		X		X	X
Galium aparine	Rubiaceae	common bedstraw				X			X	X	X		X
Galium porrigens	Rubiaceae	climbing bedstraw							X				
Heterotheca grandiflora	Asteraceae	telegraph weed			X				X		X		X
Hordeum brachyantherum	Poaceae	California meadow barley									X		X
Horkelia californica	Rosaceae	California horkelia											X
*Horkelia marinensis**	Rosaceae	Point Reyes horkelia							X				
Hosackia gracilis	Fabaceae	witch's teeth	X						X	X	X		X
Iris douglasiana	Iridaceae	douglas' iris							X				X
Juncus bufonis	Juncaceae	toad rush	X	X		X			X	X	X		X
Juncus patens	Juncaceae	common rush	X			X			X	X	X	X	X
Juncus phaeocephalus	Juncaceae	brown headed rush	X						X	X			X
Lasthenia californica	Asteraceae	goldfields							X				
Lupins variicolor	Fabaceae	many colored lupine											X
Lupinus arboreus	Fabaceae	bush lupine											X
Lupinus bicolor	Fabaceae	miniature lupine				X					X	X	

Lupinus nanus	Fabaceae	sky lupine		X	X	X	X	X	X	X	X	X	X
Luzula comosa	Juncaceae	wood rush	X						X	X	X		
Madia sativa	Asteraceae	coastal tarweed							X		X		X
Marah fabaceous	Cucurbitaceae	California man root	X						X	X			
Micropus californicus	Asteraceae	cotton top							X				
*Microseris paludosa**	Asteraceae	marsh silverpuffs							X				
Oxalis pilosa	Oxalidaceae	hairy wood sorrel			X	X		X	X	X	X		X
Panicum acuminatum	Poaceae	western panic grass							X				
Perideridia gairdneri	Apiaceae	Gardner's yampah							X				
Perideridia kellogii	Apiaceae	Kellog's yampah							X				
Plagiobothyrs diffusus	Boraginaceae	San Francisco Popcorn Flower							X				
Plantago erecta	Plantaginaceae	dotseed plantain				X			X	X			
Pinus pondersoa	Pinaceae	Pacific ponderosa pine	X						X				
Prunella vulgaris	Laminaceae	self heal	X						X	X			X
Psuedongna-phalium californicum	Asteraceae	California cudweed		X	X	X			X	X	X	X	X
Pteridium aquilinum	Dennstaedtiaceae	Bracken Fren	X			X			X	X	X	X	
Ranunculus californicus	Ranunculaceae	California buttercup	X	X		X			X	X	X		X
Rubus ursinus	Rosaceae	wild blackberry	X			X		X	X	X	X	X	X
Sanicula bipinfinnatifada	Apiaceae	purple sanicle							X	X	X		
Sanicula crassicaulis	Apiaceae	pacific sanicle	X	X	X	X			X	X	X		X
Sceptridium multifidum	Ophioglossaceae	leather grape fern	X										
Sidalcea malviflora	Malvaceae	checker-bloom				X			X	X	X		X
Sisyrinchium bellum	Iridaceae	blue eyed grass	X	X	X	X		X	X	X	X		X
Solidago spathulata	Asteraceae	dune goldenrod							X				
Spiranthes romanzoffiana	Orchidaceae	ladie's tresses							X				
Stipa pulchra	Poaceae	purple needle grass	X	X	X	X	X	X	X	X	X	X	X

Symphyotrichum chilensis	Asteraceae	pacific aster							X				X
Taraxia ovata	Onagraceae	sun cups		X	X	X	X	X	X	X	X	X	X
Toxicodendron diversilobum	Anacardiaceae	poison oak	X			X		X	X	X	X	X	X	X
*Toxicoscordion fontanum**	Liliaceae	marsh zigadenus							X				
Toxicoscordion fremontii	Liliaceae	death camas	X			X			X	X	X		
Trifolium barbigerum	Fabaceae	bearded clover							X				
Trifolium depauperatum	Fabaceae	cowbag clover		X		X			X	X	X		
Trifolium microcephalum	Fabaceae	small headed clover							X	X			
*Trifolium polyodon**	Fabaceae	Pacific Grove clover							X				
Triphysaria pusilla	Orobanchaceae	dwarf owl's clover							X	X	X		
Triphysaria versicolor	Orobanchaceae	yellowbeak owl's clover							X				
Triteleia hyacinthia	Themidaceae	wild hyacinth						X	X	X			
Triteleia ixioides	Themidaceae	pretty faces							X	X	X		
Triteleia laxa	Themidaceae	Ithuriel's spear							X	X			
Viola pedunculata	Fabaceae	Johnny jump ups							X	X			
Zeltnera davyi	Gentianaceae	Davy's centaury							X				
	Total Native Plant Diversity		26	16	16	28	8	16	77	42	39	18	40

Supplementary Table 2 A list of all experts consulted for this plan, the modes of communication and the topic they were consulted on. *Unless otherwise stated, each expert is part of UC Santa Cruz.

Name	**Title***	**Communication Type**	**Dicussion Topic**
Erika Carpenter	Senior Environmental Planner	In-person, email, reviewed plan, Zoom call, reviewed plan	Campus development goals, LRDP goals, enrollment goals, discuss plan draft
Tara Cornelisse	Senior Scientist at the Center for Biological Diversity	Email, reviewed Plan	Ohlone Tiger Beetle, discuss plan draft
Gage Dayton	Campus Natural Reserve Director	In-person	Campus grassland use and management
Rick Flores	Arboretum Director of Horticulture	In-person, email, reviewed plan	Amah Mutsun usage of campus grasslands, discuss plan draft
Brett Hall	Califonia Native Plant Program Director	Email	Campus grasslands use and management

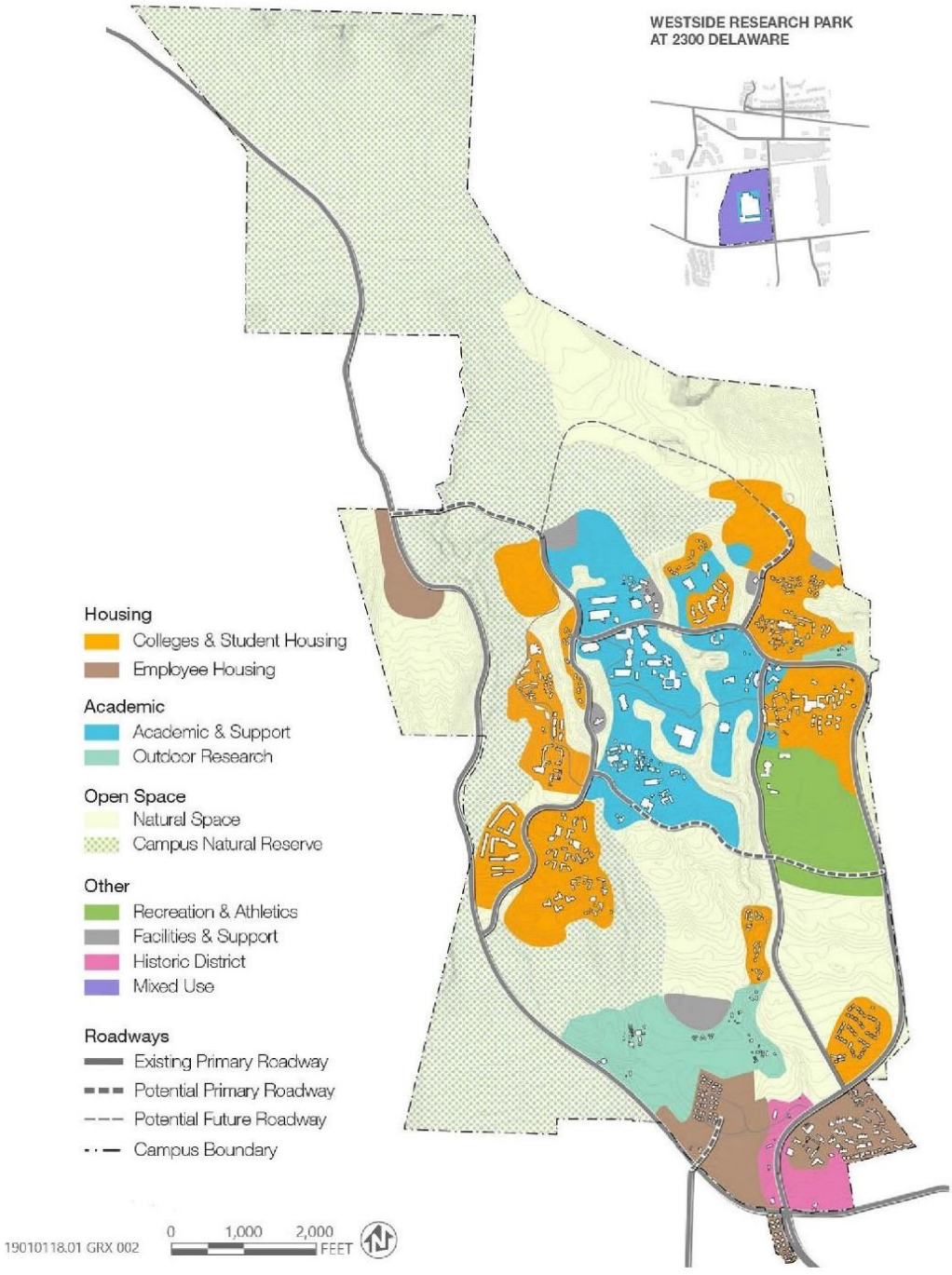
Name	Title*	Communication Type	Dicussion Topic
Grey Hayes	California Polytechnic San Luis Obispo Swanton Ranch Education and Research Coordinator	In-person, email	Campus grassland use and ecology, grazing and management
Karen Holl	Environmental Studies Professor	In-person, email, reviewed plan, zoom call	Campus grassland ecology and management, Ohlone Tiger Beetle, discuss plan draft
Elizabeth Howard	Younger Lagoon Reserve Director	Email	Younger Lagoon prarire
Alex Jones	Campus Natural Reserve Manager	In-person, email, reviewed plan, Zoom call	Campus grasslands use, ecology and management, restoration, discuss plan draft
Jolie Kerns	Senior Environmental Planner	Zoom call, email	Discuss plan draft
Alisa Klaus	Senior Environmental Planner	In-person, email	Campus development goals, LRDP goals, enrollment goals
Bruce Lyon	Ecology and Evolution Professor	Email	Campus grassland use by birds
Bill Reid	Ground Services Site Stewardship Program	Email	Campus grassland use, maagement and grazing
Alex Rinkert	Masters student at *San Jose State University*	Email, UCSC undergraduate senior thesis	Campus grassland use by birds
Paul Schoelhammer	Representative from East Meadow Action Committee	In-person, email, reviewed plan	Campus grassland use by local community
Katja Setlmann	Katherine Esau Director at *UCSB* Cheadle Center for Biodiversity and Ecological Restoration	Email	Campus restoration program
Lisa Stratton	Katherine Esau Director at *UCSB* Cheadle Center for Biodiversity and Ecological Restoration	Email	Campus restoration program
Chris Wilmers	Environmental Studies Professor	In-person	Campus grassland use by wildlife
Ron Dillehay	Grounds Services	Phone discussion	*Baccharis* mastication and management

Supplementary Table 3 A overview of course, other educational and research use of various campus grasslands.

SITE NAME	COURSES SUPPORTED	EDUCATIONAL TOURS & INTERNSHIPS	ONGOING/PAST RESEARCH
Crown Meadow	ANTH 2, ANTH 147, ANTH 176A, ANTH 176F, ANTH 194S, ANTH 287, BIOE 82, BIOE 107, BIOE 117, BIOE 20B, BIOE 85, EDUC 50C, ENVS 15, ENVS 23, ENVS 24, ENVS 120, ENVS 131, ENVS 157, ENVS 160, ENVS 167, ENVS 179, ENVS 184, ENVS 190, HIS 139, HIS 177, KRSG 3, KRSG 18, SCIC 106A, SOCY 125, WRIT 25, WRIT 26	No	No
East Meadow	ANTH 110J, BIOE 145, EART 5, ENVS 100, ENVS 123 and ENVS 160	Yes	No
Family Meadow	BIOE 109, BIOE 140, ENVS 123	No	Yes
Great Meadow	ANTH147, ANTH 176 ART 20H, 20I, 20K, ART 80B, 80D, 80E, ART 119, ART 125, ART 129, ART 150, ART 156, ART 158, ART 159, ART 165, ART 189, EART 5, BIOE 82, BIOE 85, BIOE 109, BIOE 117, BIOE 137, BIOE 140, BIOE 145, BIOE 151, EDUC 185, ENVS 19, ENVS 100, ENVS 106, ENVS 107, ENVS 123, ENVS 129, ENVS 167, ENVS 179, ENVS 184, ENVS 196, KRSG 3, KRSG 18, MUSC 80, MERR 1 and CRSN 1	Yes	Yes
Hagar Meadow	ANTH 110 and ENVS 123	No	No
Inclusion Area D	ENVS 160	No	No
Marshall Fields	ANTH 176A, 176F, ANTH 287, BIOE 82, BIOE 85, BIOE 124, BIOE 137, ENVS 18, ENVS 107 and ENVS 160	Yes	Yes
Mima Meadow	BIOE 117, BIOE 145, BIOE 151, ENVS 15, ENVS 100, ENVS 107, ENVS 120 and ENVS 179	Yes	Yes
Porter Meadow	ANTH 110, ANTH 147, ART 11, BIOE 114, BIOE 145, ENVS 15, ENVS 19, ENVS 100, ENVS 160, KRSG 3, KRSG 18, KRSG 64, KRSG 65, KRSG 72, KRSG 74, KRSG161, PRTR 18, PRTR 47, SOCY 125, WRIT 25, MUSC 80, MUSC 167	Yes	Yes
West Meadow	BIOE 114, ENVS 15, ENVS 19, ENVS 106A, ENVS 107A, ENVS 107B, ENVS 107C, ENVS 167, ENVS 179, KRSG 3	Yes	Yes
Younger Lagoon	BIOE 107, BIOE 108, BIOE 117, BIOE 121, BIOE 122, BIOE 125, BIOE 135, BIOE 137, BIOE 140, BIOE 145, BIOE 151A, BIOE 151B, BIOE 151C, BIOE 151D, BIOE 155,	Yes	Yes

	BIOE 165, CLEI 55, ENVS 18, ENVS 83, ENVS 84, ENVS 100, ENVS 104A, ENVS 15, ENVS 160, ENVS 162, ENVS 167, ENVS 183, ENVS 184, ENVS 189, OPERS Animal Tracking, UCSC Dorris Duke Conservation Scholars Program, BIO 11C (Cabrillo College)		

UC SANTA CRUZ
LONG RANGE DEVELOPMENT PLAN
DRAFT LAND USE PLAN
FEBRUARY 2020



Supplementary Figure 1 The 2020 Long Range Development Plan land use designations zoning campus areas for certain development types and for incoporation within the Campus Natural Reserve. Note that Younger Lagoon is not within the range of this map.

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