

## **Festuca Californica Mapping at JRBP Is there a serpentine alliance?**

### **I. Introduction:**

The purpose of this project was to map identified patches of *Festuca Californica* at Jasper Ridge, to determine whether there is a correlation between their locations and underlying serpentine geology; and to identify relative characteristics of the habitats.

The question of serpentine alliance arose when comparing a local expert's notations of the FC patches against the Google Earth geology overlay of JRBP<sup>1</sup>. A preliminary review indicated that all but one patch might be serpentine allied. This was interesting to me because in the JRBP herbarium documentation and in other California databases, FC is not noted as serpentine restricted, nor necessarily serpentine allied. The Calflora status of FC is a 'weak indicator' (55-64%)<sup>2</sup> for ultramafics.

My goal was to more precisely map the patches of FC, compare those to the geology overlay in Google Earth and try to determine if the observable patches at JRBP today are, in fact, serpentine allied. (As well as gain more understanding overall of the patches of FC).<sup>3</sup>

As the project developed I used the Trimble GPS system and ArcGIS to pinpoint the FC patches more precisely; hence the final comparisons to geology and other factors at JRBP were against the ArcGIS database, rather than Google Earth.

The deliverables from this project are:

- This write-up, with summarized observations
- Five overall maps of JRBP *Festuca Californica* patches in Arc GIS
  - Locations, general shapes and size of FC patches overall against JRBP lands
  - Mapping of FC patches on the geology layer
  - Mapping of the FC patches on the soils layer
  - Mapping of the FC patches on the aspect layer
  - Mapping of the FC patches on the slope layer
- Detail maps of 4 specific locations (Trail 4/Road F; Trail c; Trail 15; Trail 5)
- Physical maps to transpose on sector maps (with notes)
- A map of areas surveyed that did NOT contain *Festuca Californica* populations
- A spreadsheet of compiled data
- A USB stick with all the data for ArcGIS, maps and documents (in the event the mapping data is useful in the future)

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<sup>1</sup> From the Coleman data, I believe

<sup>2</sup> Calflora system is based on: Safford, H. D., Viers, J. H. and Harrison, S. P. 2005 Serpentine Endemism in the California Flora: A Database of Serpentine Affinity Madrono, California Botanical Society, Northridge, Calif, Vol 52(4):222-257

<sup>3</sup> Sadly, when doing my research check I found a 1968 study of grasslands (serpentine and sandstone), conducted at JRBP; but *Festuca Californica* was not a species included in the study. This is most likely because *Festuca Californica* is not commonly found in the JRBP grasslands, but it would have been cool to have an older reference for comparison. That was good motivation to create some data for historical purposes.

## II. Methods:

### First determination: What constitutes a 'patch' for purposes of this mapping?

This is *partially* influenced by how FC reproduces<sup>4</sup>. The greatest likelihood is that windblown dispersal is the primary agent for both pollination and seed dispersal.

This conclusion is based on analyzing the grass morphology, and its adaptive nature.<sup>5</sup> FC has a long culm, open inflorescence rising quite a bit above the plant foliage, lightweight seeds, and a small lemma awn - all adaptations for windblown dispersal. Springtime observation of the flowering shows prominent anthers dropped below the florets, openly available for windblown pollen dispersal.

In addition, it is rated 'medium palatable' for browsing animals, not 'high'<sup>6</sup>. The inflorescence is too high to be reached by rabbits, and other small mammals, and the culms and spikelets are slender, light and drooping (nothing to attract or hold a pollinator). Typical of a windblown grass, the flowers are extremely tiny, protected by the lemma and palea. FC has no reported eliasome that would be designed to attract ants, nor rhizomes, nor is there any mention of cleistogenes in any published data.

It is also most likely for FC that the dispersal unit is the floret and/or the spikelet, for two reasons. First, greater than 75% of grasses disperse using these methods<sup>7</sup>, and observations of spent culms in the field and under a microscope support this. Spent FC usually showed only the remaining glumes on each spikelet branch, occasionally the entire branch had broken off below the lowest spikelet. There is no mention in the literature I studied that FC had any other unusual dispersal features.

It is possible that small animals, birds and/or ants could carry the seed further from the windblown location, but for the purpose of this mapping I assume that secondary dispersal would be important only to locate a patch further from its windblown distance. Therefore I'm assuming that groupings of FC beyond a rational windblown distance are a natural group<sup>8</sup> to be mapped independently from the first.

### How far does the windblown seed of FC disperse?

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<sup>4</sup> Note that seed dispersal and establishment can also be affected by several other factors, for example: density of adult population, environmental 'traps' of seeds, patterns of resource availability, habitat suitability, etc.

<sup>5</sup> Cheplick, G.P; editor "Population Biology of Grasses"; Cambridge University Press, 2016; Chapter 3 - Seed dispersal and seedling establishment in grass populations, pp 84-105

<sup>6</sup> Darris, Dale and Johnson, Sonja, USDA, Natural Resources Conservation Service, Plant Materials Center, Corvallis, Oregon; Fact Sheet, California Fescue, *Festuca Californica* Vasey; edited 7/31/07

<sup>7</sup> Cheplick, page 85

<sup>8</sup> Note that this mapping is about 'patches' - not populations.

There was no documented analysis of FC dispersal distance, specifically. There are studies of windblown grass dispersal distances, related to specific conditions and morphology; but these were done in laboratory conditions (seeds dropped from specific heights). This method might be useful for comparing between grasses, but didn't provide good data for seed dispersal in the wild of a single species. There were some useful guidelines/insights. As a proxy I am using observations from some of these studies to set an arbitrary distance and then validate or modify that in the field if observations support it.

First, height of infructescence does correlate with dispersal distance.<sup>9</sup> Therefore, when determining any arbitrary guideline, I should take the height of the culm in to consideration. Secondly, seed weight and shape tends to impact seed dispersal - lighter, unadorned seed disperses further than heavier seed. Finally, some studies found (whether dropped at 1m, or inferred mathematically, etc.) that while most of the 'tested' seed dispersed relatively close to the parent plant, full dispersal 'range' is still a valid measurement for dispersal distance for windblown seed.<sup>10</sup>

*Festuca Californica* produces a very tall culm. The total height of infructescence ranges from approximately 60-140 cm and the caryopsis averages from 4.5-5.5 mm (light) and is unadorned by any significant dispersal morphology (small awn, lemma is smooth). I arbitrarily decided to start with a measurement of 3 meters (twice the height of the culm) as 'boundary' for measuring a grouping - meaning that if I found grasses further than 3 meters from my 'patch' I would consider that a second patch. I started with that as my field measurement.

In the field this observation generally held. Discrete patches of *Festuca Californica* were comprised of plants separated only a few feet from one another, and had relatively "distinct" patch edges that constituted a natural boundary separated clearly from any other patch<sup>11</sup>.

The arbitrary distinction of 3 meters served as a useful guideline, although in the larger 'area' patches I mapped (off Trail 4 and Road F) it is possible that this guideline is not entirely strict. The presence of plant growth within parts of those patches (particularly toyon bushes, poison oak and small coast live oak) made this difficult to verify.

I initially thought I would exclude individual plants from my mapping, as they are not 'patches' but after encountering a number of individual plants/small patches in the field I also decided to include them. This proved valuable in overall observations.

### **Process of identifying the locations of *Festuca Californica* at Jasper Ridge:**

Local expert John Rawlings supplied me with a general map of the locations of observed *Festuca Californica*, from the herbarium database. I used this map as a starting guideline, but further refined the locations to specific JRBP sector and sub-sector locations, including a more

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<sup>9</sup> Cheplick, p91

<sup>10</sup> Rabinowitz and Rapp - Dispersal abilities of Seven Sparse and Common Grasses from a Missouri Prairie; *American Journal of Botany*, 68(5) 1981, p 621; [http://www.jstor.org/stable/2442788?seq=1&cid=pdf-reference#references\\_tab\\_contents](http://www.jstor.org/stable/2442788?seq=1&cid=pdf-reference#references_tab_contents)

<sup>11</sup>The arbitrary decision is based on ability to delineate groupings; not necessarily assigning any distinct population characteristics. "Patches" are used in other studies.

precise location on the road or trail, patch size and other habitat factors and finally, GPS coordinates.

A copy of that starting map is attached. Each 'area' identified by John Rawlings is numbered (JR1, JR2. etc.). A summary excel table identifies those and correlates them to the mapped patches and GPS coordinates. (FYI, I picked "JR" to note John's identifications, a deserved homage, but then realized it also stood for Jasper Ridge - fun.)

Prior to each field outing I prepared a detailed sector 'map' of the expected trail/road area, transferring the sector and sub-sectors (from the Sector Map Book) to tracing paper and added the topographic elevation lines from the JRBP map, to use in identifying the more precise locations.

### **The field procedure:**

1. Use my detailed traced map. Walk the identified location trail/road in its entirety (all of trail or road) one full direction - observe for plants and populations of *Festuca Californica*. Use binoculars to scan for patches out of close range of each observed spot (hence I sometimes ended up walking down a ridge from patch to patch). Place a landscape 'flag' on the route to mark any location found.
2. Walk the same trail/road section in the reverse direction to help precisely pinpoint the location on the sector map, and observe from the opposite direction.
3. For each population do the following:
  - Identify the perimeter of the population. Place landscape flags at some outermost points of the 'patch', in whatever shape that might be. Observe for any 'further' patches beyond those perimeter boundaries.
  - For some small discrete patches use a transect tape to measure the distances between each landscape flag, creating an irregular 'polygon' shape to gain rough 'area'.
  - For medium patches use the transect tape or pace the distance to develop rough length and width measurements; again to estimate patch 'area'
  - For large patches leave the estimate to the GPS process
  - Use a digital level to measure the slope of the patch. If large, take a few measurements to gain a general range.
  - Use a compass (yes, old school) to measure the aspect, taken within the patch and facing the downward slope.
  - Observe and record the local plant habitat, particularly significant local species surrounding or within the patch. Include any significant visually identifying plants (e.g. "Large California Bay Laurel, Tall Blue Oak") located on the perimeter or within the patch (to assist with finding/observing later on).
  - Make any other relevant location/patch notes.
  - Using the Trimble GPS device, take the GPS coordinates of the patch. For 'smaller' patches and single plants I used a 'point' mapping, for patches whose areas were 'navigable' as areas I walked the perimeter; for really large patches I used a line measurement and noted the approximate breadth of the patch on either side of the line in my notes, or walked the perimeter if possible (vegetation).
  - For many of the patches I took identifying photos.

4. Note all this information on the detailed hand drawn map - each sector mapped has a manual map with all notations and measurements included.
5. Note trails/roads walked that did NOT contain *Festuca Californica*, as part of each field exercise.

**Post field procedure:**

1. Downloaded the GPS data to the JRBP workstation.
2. Reviewed any documentation of my FC locations against other notes in the herbarium with regard to location, particularly early on, to validate my abilities to locate the patches.
3. Reviewed the observations, data and compared against the sector map for aspect.
4. Entered the patch location information, GPS tag (identifying number to relate back to my notes and handmade map), and other data in to my 'Mapping Spreadsheet'.
5. Downloaded and identified my photos.
6. If there was a particularly important plant species I could not identify I asked assistance from other docents/resources to help identify. This was most important early on, particularly for leather oak as an indicator species for serpentine.

Note: this procedure was refined over subsequent outings, when I learned the following.

- A transect reel tape is much better than a garage measuring tape
- GPS is even better than a transect reel tape if the patch is really large
- Temporary landscape flags are very useful (I used sticks the first time out)
- Deet and Tecnu are your friends
- More photos are better
- Nature is VERY patchy
- Each patch needs two visits (at least)

**Post mapping data processing - GPS**

Thanks to awesome device and procedure training from Trevor Hebert, my GPS data was very accurate. Post mapping GPS processing indicated that once 'corrected' against the base data from Pigeon Point only 37 of 1252 data points were filtered out (each mapping had several data points, this did not affect any one particularly). Greater than 2/3 of the data points are accurate to within .5 meters.

Once processed and subsequently converted from X, Y, Z coordinates measured by the Trimble device to ArcGIS X, Y coordinates<sup>12</sup> my data was available as a mapped layer for comparison to the JRBP ArcGIS database for geographic, topographic and environmental variables.

After the first complete compilation of data it became apparent that data from Road F and Trail 4 was incomplete. A second, more complete GPS mapping was done for this area. "Once more unto the breach, dear friends, once more."<sup>13</sup> That data was subsequently updated on the mapping spreadsheet.

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<sup>12</sup> Trevor taught me this conversion and directed me to the appropriate coordinate sectors (e.g. UTM, North America, Zone 10; etc.)

<sup>13</sup> "Henry V, Act III, Scene I, William Shakespeare, 1564 - 1616" (I wonder if Henry meant ticks and poison oak?)

**Final Identification of FC ‘patches’.**

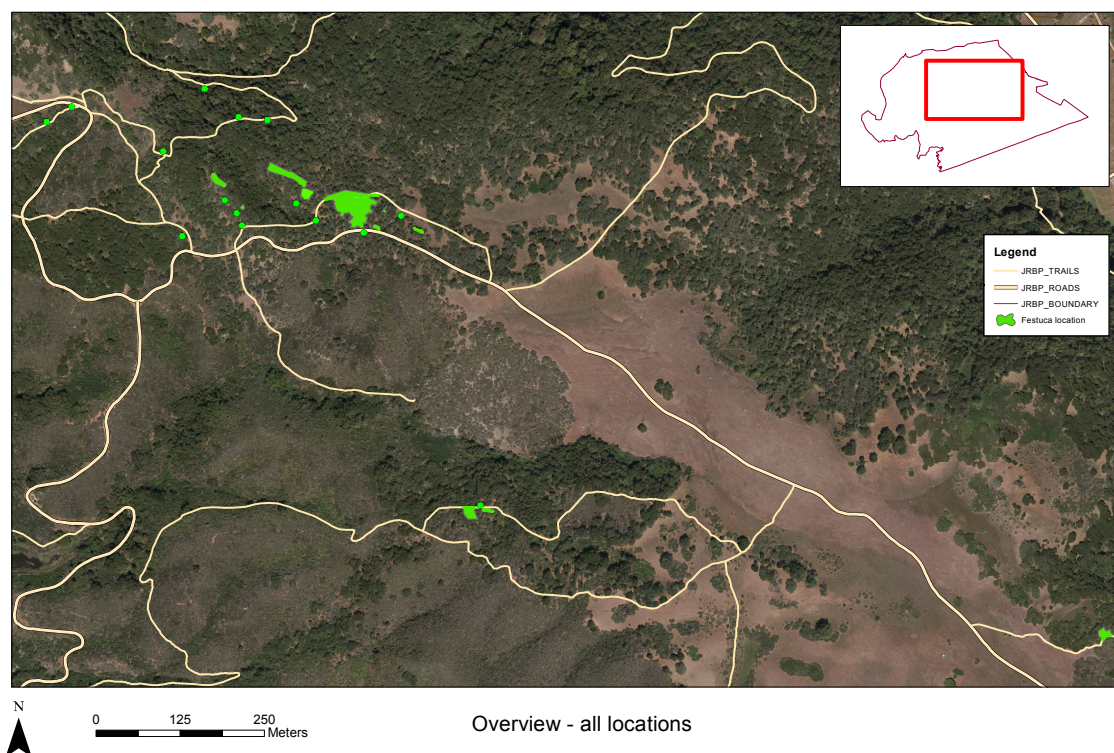
My summary spreadsheet includes the observations of each of the mapped patches. The list of Roads/Trail by Sector/Sub-sector with mapped patches is:

Trail 15	Sector 34c3
Trail c	Sector 32c1, 32d1
Road F	Sector 23a1, 23a2, 23b1, 23b2
Trail 4	Sector 22e1, 22e2, 23a1, 23a2, 23b1, 23b2
Trail 5	Sector 13d4, 13e5, 22c1
Trail 6	Sector 22d2
Trail 8	Sector 13 b5

A rough approximation of the area covered by FC is 4400 sq. meters<sup>14</sup>

The final resulting mapped data shown below includes:

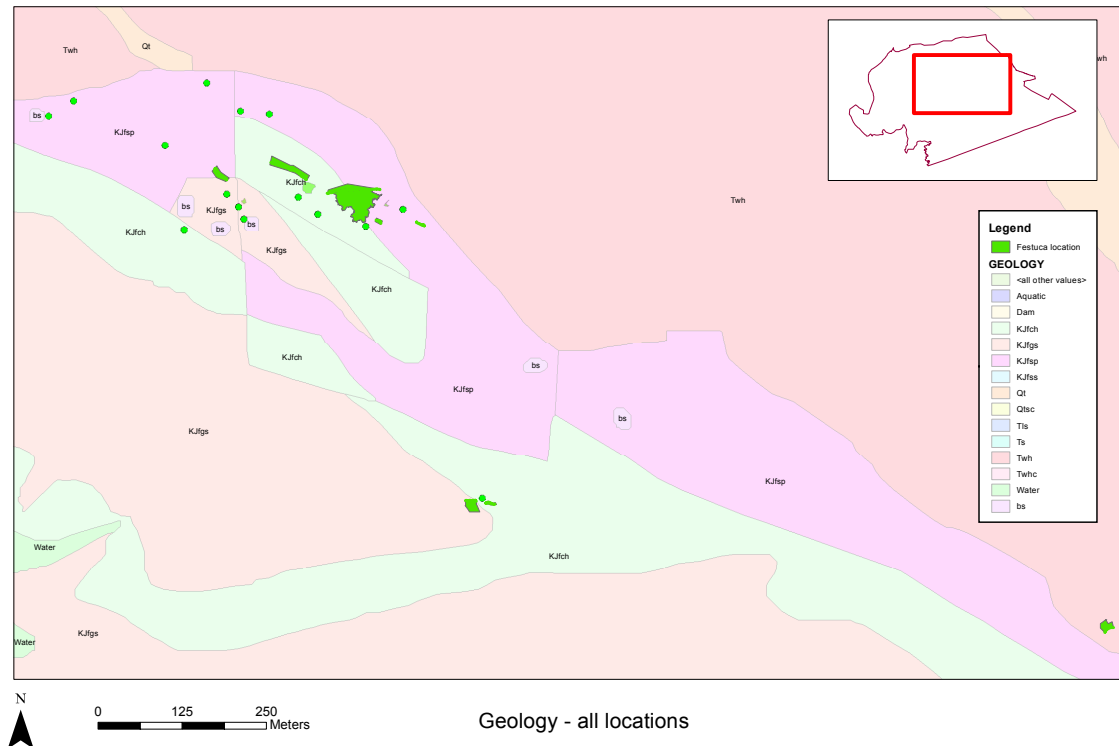
- Points for small clusters or single plant locations
- Lines for larger, slim contiguous patches
- Polygons created from manual measurement data to ‘draw’ a resulting polygon over the mapped GPS coordinates; as another layer (shape file) in the dataset
- Areas which resulted from walking around a large patches



<sup>14</sup> This is an estimation consisting of a large area measured by ArcGIS as ‘area’, usage of .5 sq. meters for individual plants, actual measured areas (reel tape) and some estimates derived from breadth and length of particular patches. All mapped areas are included and the spreadsheet contains a column indicating the allocation of each patch to ‘serpentine alliance’.

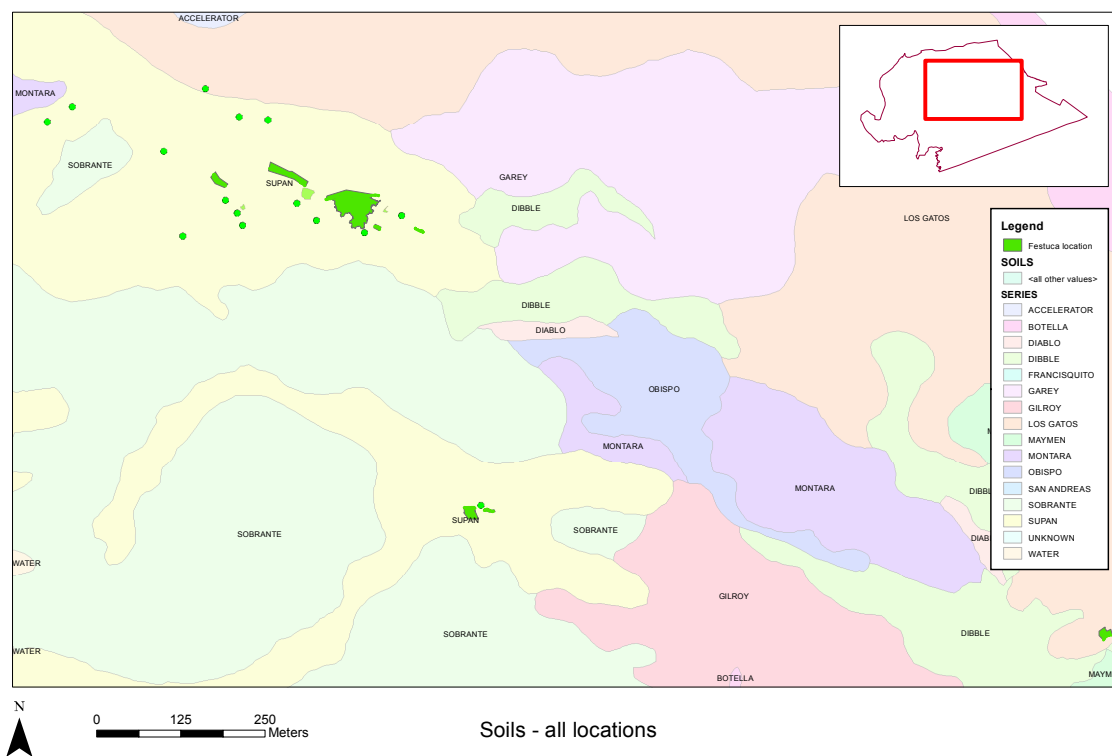
## Comparison of mapped data to existing geographic, topographic and environmental data

### *Festuca Californica* mapped against the Geology layer



1. I was surprised that there was a difference between the Google Earth overlay and the Geology layer in ArcGIS. I subsequently learned from Nona that this isn't unusual (nature is patchy; it isn't math; this is not exact).
2. It was clear that FC does, in fact, 'lie' on top of the serpentine rock layers as shown by the ArcGIS geology layer - but not exclusively. If one includes the area covered on Trail 15 (where the serpentine outcrop is evident) approximately 50% of the FC mapped overlies serpentine geology<sup>15</sup>. This is not an exact approximation because:
  - in reality, the mapped geographic lines/boundaries are not 'neat' on the landscape
  - my mapping of the total area of FC is not precise across all mapped areas
- In addition, previously identified "serpentine" spots of FC (Trail 1/intersection Trail 5) no longer existed (were not found).

<sup>15</sup> see footnote 11 regarding area measured and serpentine alliance calculations on the spreadsheet

**Festuca Californica mapped against the Soil layer:**

In an attempt to gain more insight to potential serpentine alliance I also compared my mapped data against the 'soil' mapping of JRBP, hoping that the soil information would disclose some data about soils with serpentine parent material content. This mapping revealed that:

1. All patches of FC mapped, with two exceptions, are shown on the Supan soil series. From the underlying 1980 soil survey this soil (the Supan variant for JRBP) is described as deriving from greenstone parent material.<sup>16</sup>  
(The above does not correlate to the underlying geology mapping. But one of the test pits identifying the Supan series for the 1980 survey was conducted on Road F, not far from the FC patches which are 'not' geologically aligned to serpentine. The extension of this soil series is extrapolated from that test pit; across a much larger area.)
2. Two patches are shown on the Los Gatos soil series, noted to be derived the hard fractured sandstone.<sup>17</sup> The test pit for this identification is located much further north on JRBP near Trail 1 and extrapolated broadly across the Ridge.  
(This more closely correlates to the geology mapping which shows the Whisky Hill Fm. turbidic sandstone and mudstone conglomeration.)

<sup>16</sup> Kashiwagi, J. 1985. Soils map of the Jasper Ridge Biological Preserve. Soil Conservation Service Map - Jasper Ridge Biological Preserve Publication, Stanford CA.

<sup>17</sup> ibid



3. Note that 'standard' descriptions of these soil types do not include the soil chemistry<sup>18</sup>, although some variants described for JRBP include the parent material. This method of identifying these soil series to an associated parent material is a bit unusual. A more fine grained, local analysis would likely be much more revealing of the soil chemistry and any serpentine parent influence. Another soil chemistry project at JRBP<sup>19</sup> which compared serpentine based soil to nearby chert soil on both grasslands and woodlands found quite a bit of heterogeneity of soil characteristics over a small area; and also noted the vegetation impact on the soil characteristics (mutually reinforcing). I do not think the information from the soils layer as shown above lends any real conclusive value in this circumstance.

**Conclusions from the geology and soils comparisons:**

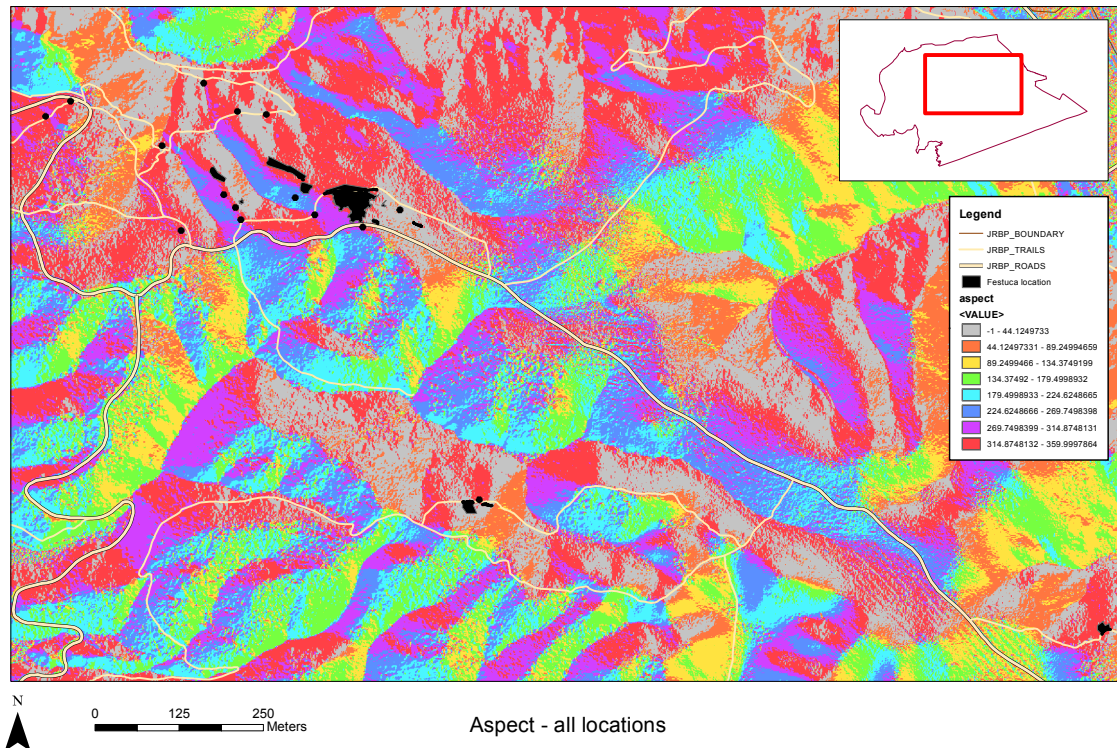
1. It is likely valid to include the patch on Trail 15 as having serpentine affiliation due to the existence of the visible serpentine outcrop evident at the site.
2. It is likely that a portion of the larger patches extending from Road F and therefore Trail 4 are NOT on serpentine, due to the geology mapping (and somewhat 'bolstered' by the local Supan soil pit identification).
3. Other important patches shown on serpentine geology (Trail 4, Trail 5, Trail 8 and Road F) are shown as Supan variant soil, but no test pits for that mapping are located nearby. This is not conclusive.
4. An approximation of 50% of the occurrences of FC 'allied' with serpentine geology is not unreasonable based on the geology comparison.
5. This 50% of occurrences is slightly less than the CalFlora/Safford based 'Weak Indicator' serpentine status of FC to ultramafics (55-64%); but not dramatically different (especially given the less than exact nature of measuring the percentages of the larger patches which straddle geological delineations on the map).

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<sup>18</sup>National Cooperative Soil Survey; Rev JEM/SBJ/RCH/ET, 2003; Supan Series; National Cooperative Soil Survey; Rev: WCL/RCH/GMK/ET, 2003 Los Gatos Series

<sup>19</sup> Chern, Claudia; Hennelly, Lucia; Lanas, Mattias; Liu, Owen - Soil Survey of Jasper Ridge, California, Escobar Gate Area; 2011

### **Festuca Californica mapped against the Aspect layer and conclusions:**



1. This was overwhelmingly dispositive. With the exception of one patch of 8 plants on Trail 4 which faces due south, every other patch of FC was NW/N/NE in aspect. (There were one or two meter portions of the very large patches which were west; but as whole the patches flowed northerly, these small west facing portions were part of an overall flow.)

### **Festuca Californica mapped against the Slope layer and conclusions:**

1. FC grows on slopes, but there was no indication from my process that any slope between 6-31% was favored. No part of my process allowed for any fine grained comparison of slope vs. plant density/scarcity comparisons. This information is interesting, but not really informative, at this point.

### **Festuca Californica vegetation observation notes and conclusions:**

All patches of FC are growing in the Blue Oak woodlands with the following exceptions:

- Trail 4 - four large patches merged from the Blue Oak woodlands to the Coast Live Oak woodlands; ecotone edges noted because they are not entirely Blue Oak woodland
- Trail 4 - one plant under a Valley Oak and Madrones (no Blue Oaks)
- Trail 15 - edge of Leather Oak chaparral to Coast Live Oak woodland
- Trail 5 - 1 plant in Riparian woodland to edge of Coast Live Oak woodland; 3 plants under Bays and Live oaks
- Trail 8 - 13 plants - Coast Live Oak woodland, no Blue Oaks

**Final observations and next steps:**

The real learnings from this project came from the development/evolution of the process from a manual mapping process to the use of GPS techniques and the creation of ArcGIS maps. And also, that at JRBP our patches of FC are not too different from the accepted Stafford serpentine indicator.

I now, however, have a more accurate view of the locations of *Festuca Californica*, as well as some interesting future questions, such as:

**Aspect:**

- Why is FC growing in NW/N/NE areas?
- Is there something about the moisture of these areas?
- Do prevailing winds carry seed to the north?

The fact that one tiny patch of 8 plants is totally south facing does provide a basis for some comparative data in the future (against another similar sized north facing patch).

**Habitat:**

- Why the affinity for Oak Woodland, especially Blue Oak?
- Is there something about the Blue oaks themselves that is supporting the flourishing patches of FC?
  - Litterfall as a soil nutrient?
  - Deciduous nature of oaks creating optimal insolation?
  - Other shared habitat factors such as aspect?

Because of the existence of the Leather Oak Chaparral patch there is also a basis for some comparative data in the future (against another Blue Oak patch).

**Growth pattern:**

- Why is FC so 'patchy' in the oak woodland? Why large and small patches?
- Why not more uniform across the landscape?
  - Pattern of resource availability in the habitat?

This requires further investigation of the patch characteristics in the woodlands themselves.

Lastly, I need to walk Trails 10, 11, b and 1/2 of Trail 9 to confirm no additional *Festuca* sightings, as I was unable to complete that by the end of the quarter. Any additional data will be mapped.

Many thanks to John Rawlings (original FC location notes), Nona Chiarello (project guidance, geology and soils mapping information), Carl Cheney (oak identification lessons), Trevor Hebert (Trimble and ArcGIS training and mapping lessons), Amy Kim (project support and encouragement) and Cindy Wilber (project guidance and tools - tapes, Tyvek suits, GPS availability and overall 'enthusiasm').

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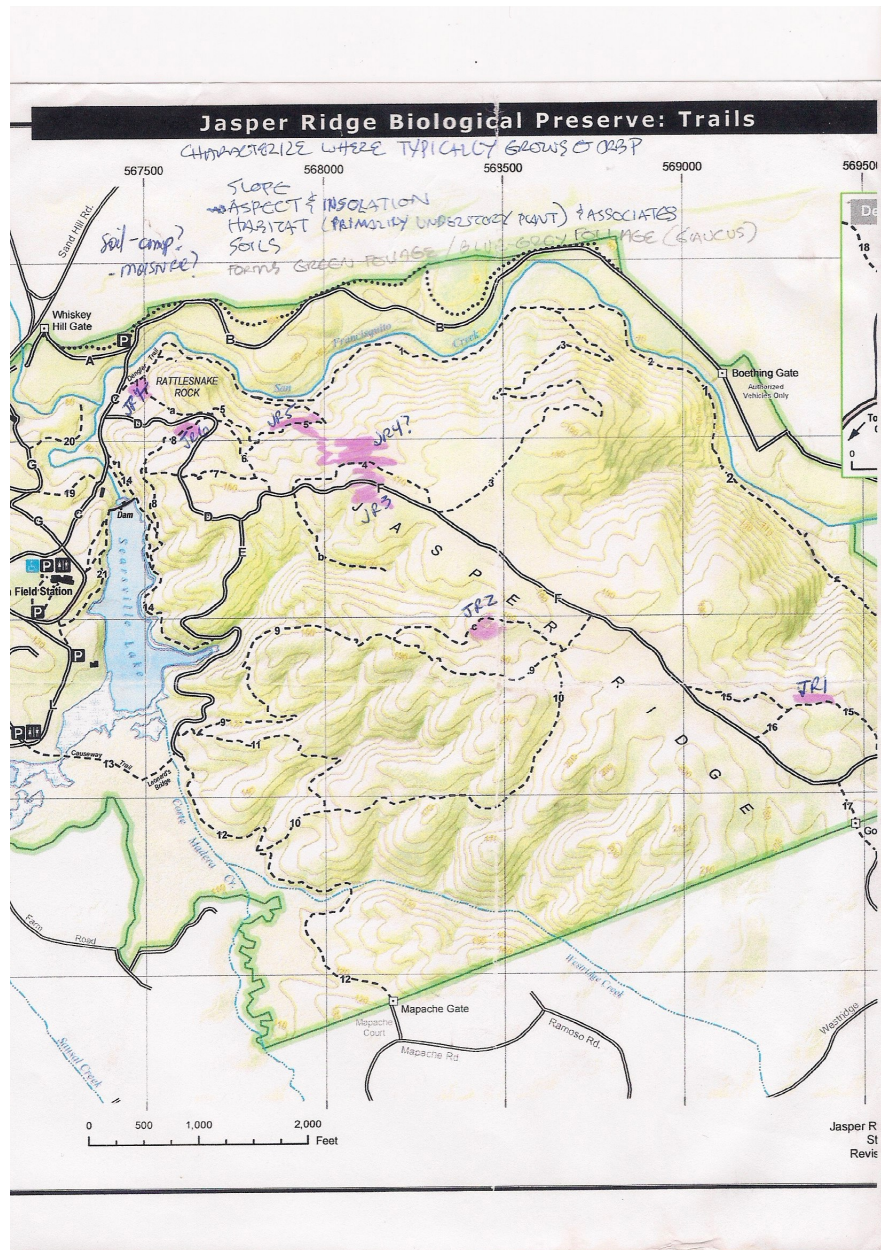
University of Idaho, College of Agricultural and Life Sciences, Plant, Soil and Entomological Science; The Twelve Soil Orders (online resource)

Wilson, M.F.; Dispersal mode, seed shadows, and colonization patterns; Vegetation 107/108 (1993) pp 261-280; published by Kluwer Academic Publishers

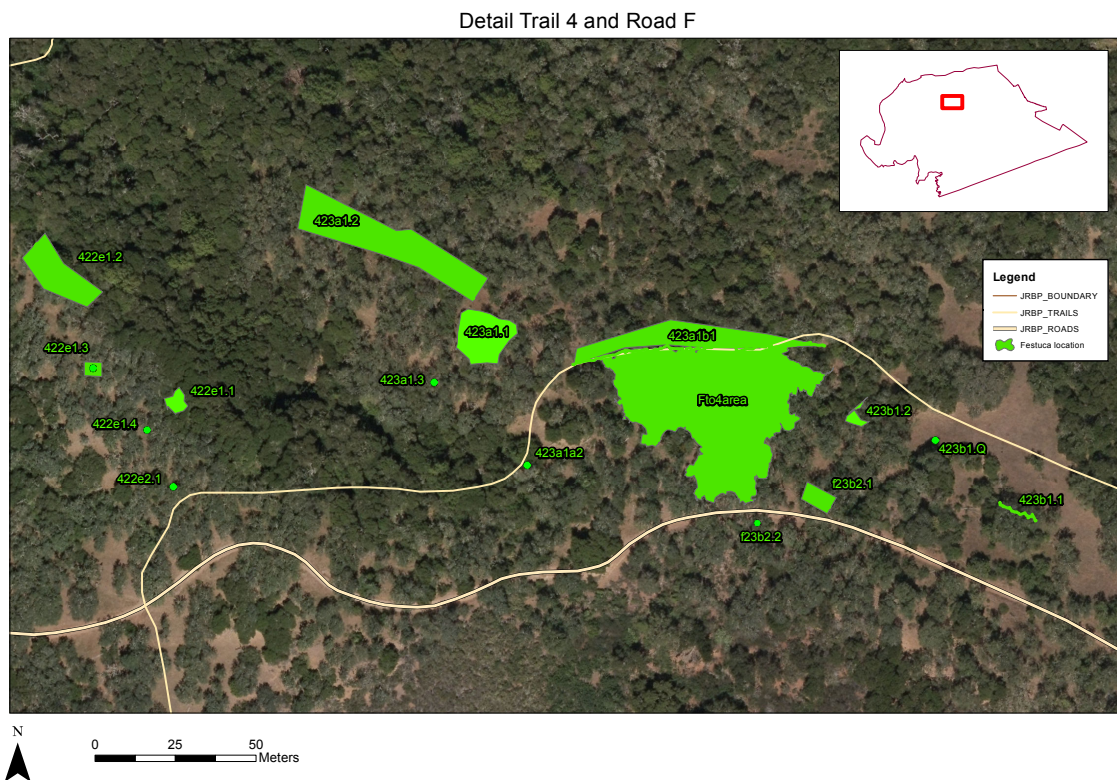
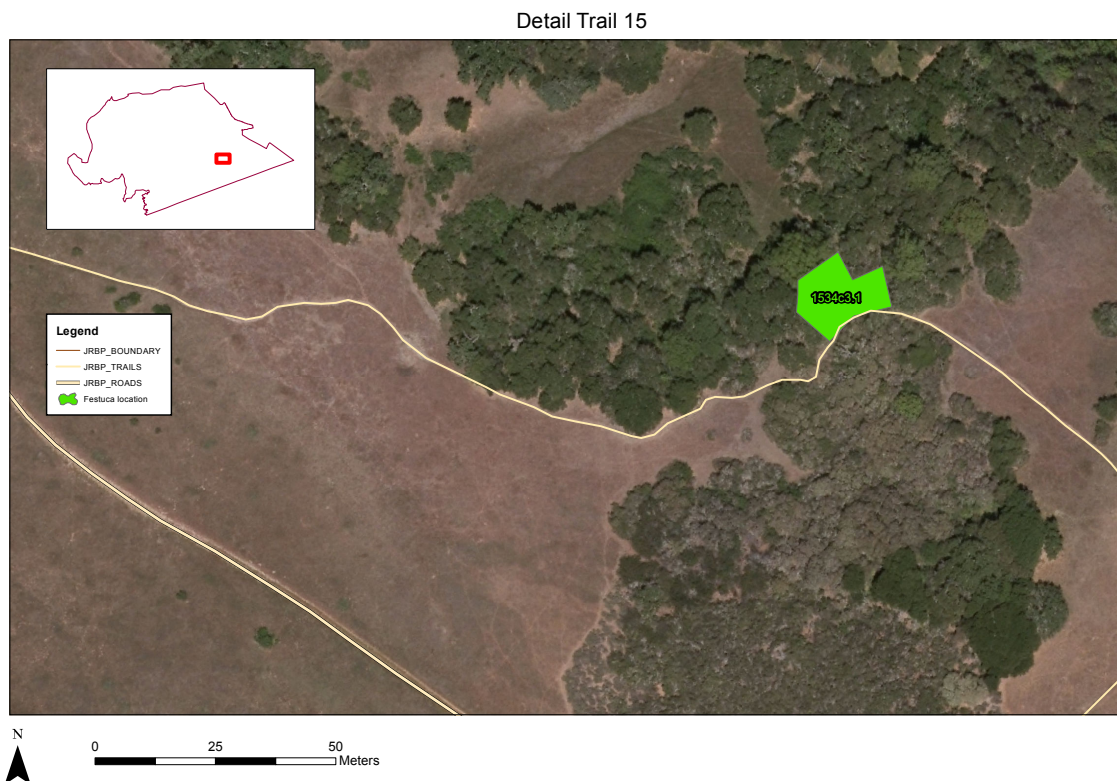


**Attachments:**

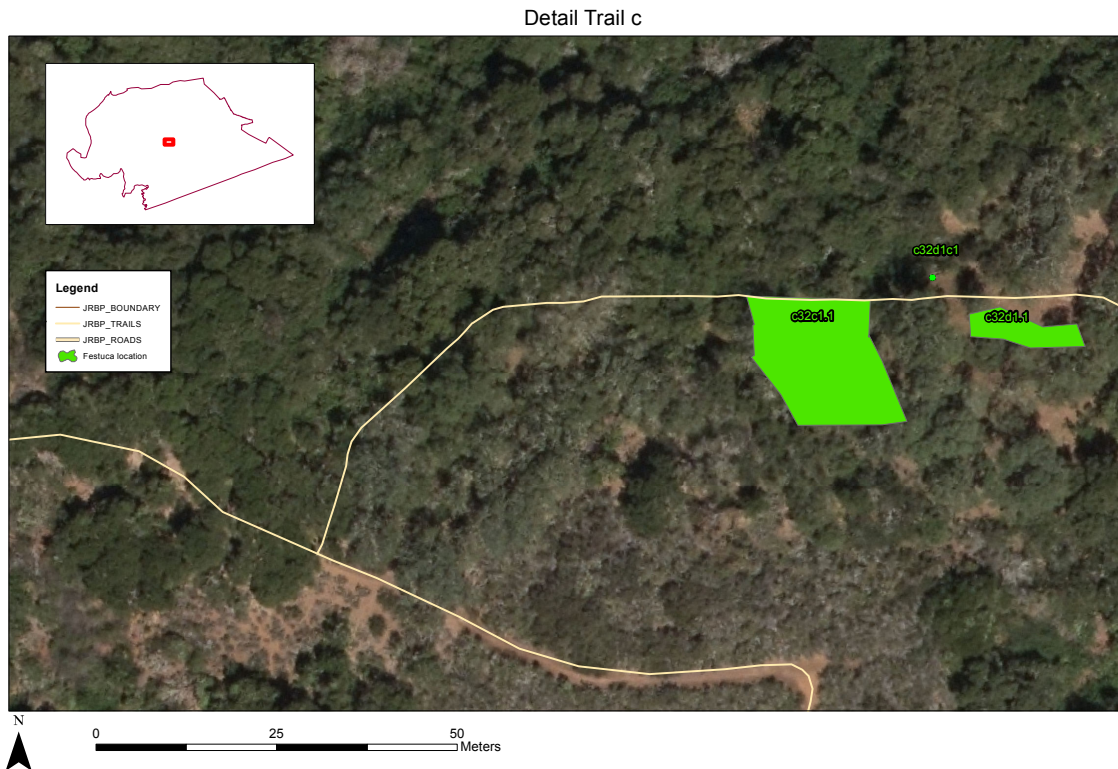
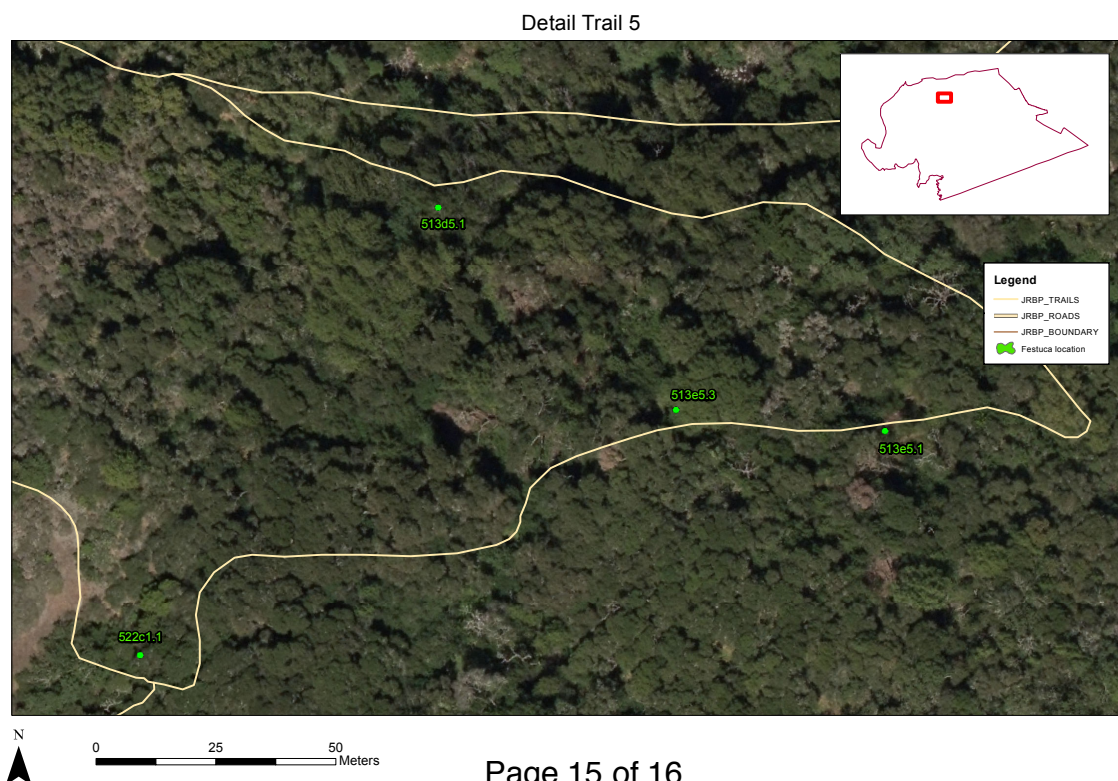
Starting map provided by John Rawlings





**Detail ArcGIS map, Trail 4 and Road F (labels correspond to spreadsheet descriptors)****Detail ArcGIS map - Trail 15 (labels correspond to spreadsheet descriptors)**



**Detail ArcGIS map - Trail c (labels correspond to spreadsheet descriptors)****Detail Trail 5 (labels correspond to spreadsheet descriptors)**

**A separate map for Trail 6 (1 patch) and Trail 8 (1 patch and 1 plant) were not produced.**

**Mapping Spreadsheet** - attached to the hard copy version of this report

**Hand drawn maps and notes** - attached to the hard copy version of this report

**A map of trails/roads containing no Festuca Californica** - attached to the hard copy version of this report

**11x17 printed versions of all the overview and detail maps** - attached to the hard copy version of this report