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# Using GIS to Determine Trail Suitability for User-Created Trails

Photo courtesy of Tahoe Mountain Sports

## Introduction

Trail planning on national forest land takes more than just walking in the woods with pin flags and digging a rad trail in the dirt. When a new trail is laid out, you can plan around sensitive resources such as cultural sites, critical wildlife habitat, rare plants, and hydrologic concerns. When a trail is already on the ground, such as the hundreds of miles of user-created trail within the Truckee Ranger District of the Tahoe National Forest, some analysis must take place in order to determine if the trail alignment is in a suitable location.

# Purpose

For this project, I analyzed a network of trails to determine their suitability, looking at the potential impact on threatened, endangered, and sensitive (TES) wildlife species and cultural sites. I identified sections of trail that may need to be improved with tread armoring or a bridge, or that may need to be rerouted to avoid sensitive areas. I planned on making a handful of PDF maps because everything at the Forest Service has to be in "paper" form for meetings and proposal documents.

# Methods

Trail data was obtained from GPS tracks collected from Forest Service technicians and from CalTopo. Vegetation, road, and resource data is from the Forest Service. Trail data from CalTopo is a KML file, which must be converted into an Arc-readable file using the KML to Layer tool. To only focus on the trails in the Coldstream area, I selected desired trails from the attribute tables and exported data, then merged or appended all trail data into one feature class.

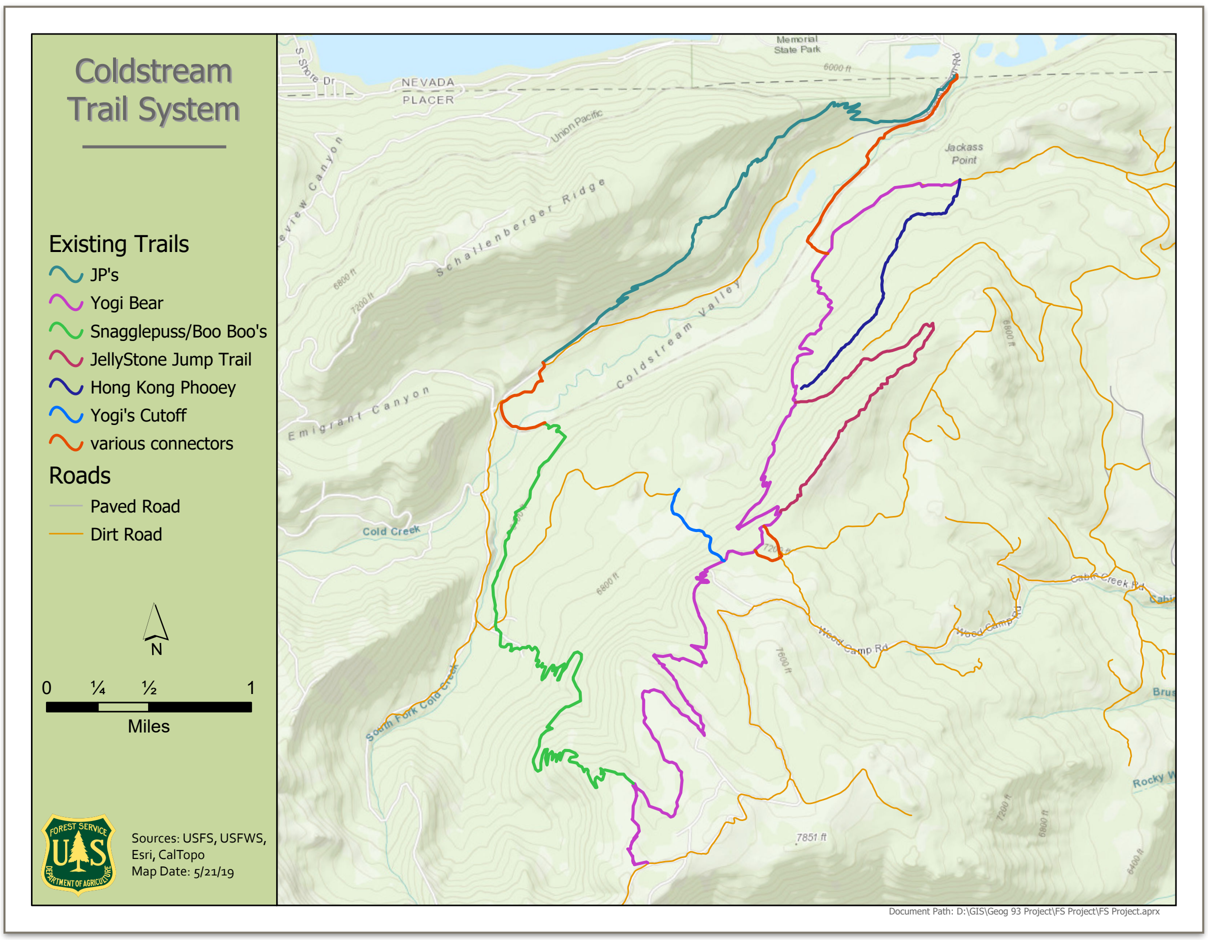


*Figure 1: Coldstream Canyon Trails*

## -CWHR types-

For terrestrial and aquatic species, the analysis area is 25 feet from center of trail, while for avian species, the analysis area is 1 mile from center. I made buffers of both distances, and then dissolved to a make cohesive polygon for each. On the second one, I realized there is an option within the buffer tool to dissolve the buffers so it does it all at once instead of two different processes.

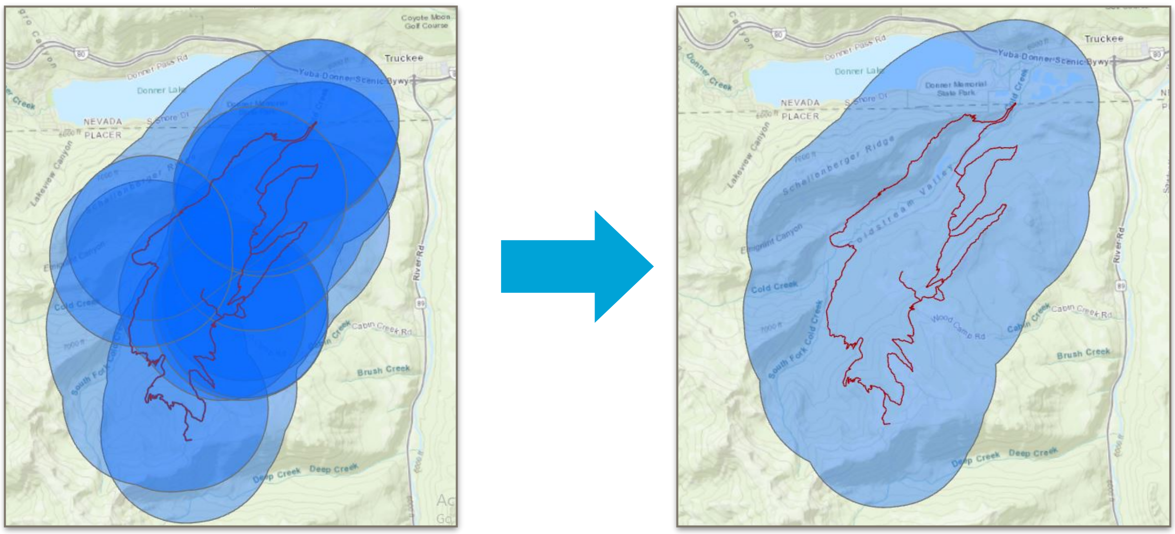


*Figure 2: Dissolving buffers*

For potential forested habitat, I used the Forest Service's LiDAR vegetation dataset, which I clipped to the trail buffers. I symbolized the vegetation data by California Wildlife Habitat Relationship (CWHR) classes, using tree size class (WHR size) and tree canopy cover (WHR density).

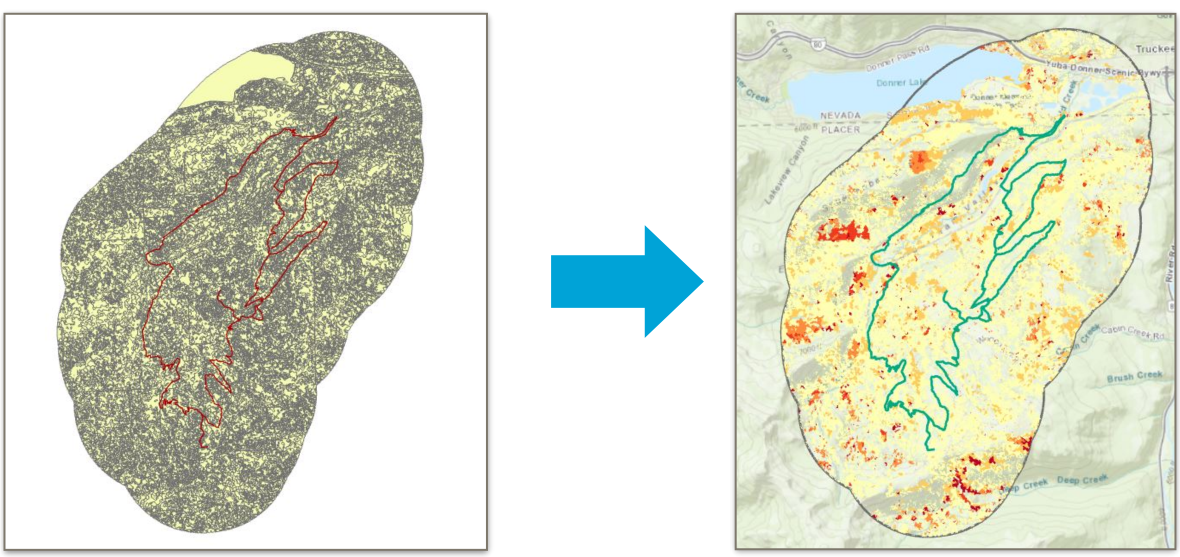

*Figure 3: Symbolizing LiDAR vegetation*

TES species such as northern goshawks, California spotted owls and American martens value 4M, 4D, 5M, 5D, and 6 habitat types, with increasing preference, because they provide high quality nesting/denning and feeding habitat. Due to this, it is necessary to only symbolize CWHR class 4M and above. I also queried only 4M and above for later calculations.

| CHWR Size | Description | Diameter at Breast Height (DBH) |
|---|---|---|
| 1 | Seedling | Less than 1 inch |
| 2 | Sapling | 1 to 5.9 inches |
| 3 | Pole | 6 to 11 inches |
| 4 | Small Tree | 11 to 24 inches |
| 5 | Medium/Large Tree | Greater than 24 inches |
| 6 | Multi-layered | |

*Figure 4: California Wildlife Habitat Relationship (CWHR) Size Classifications*

| Tree Canopy | Description | % Canopy Cover |
|---|---|---|
| S | Sparse | 10 to 24% |
| P | Open | 25 to 39% |
| M | Moderate | 40 to 59% |
| D | Dense | 60 to 100% |

*Figure 5: California Wildlife Habitat Relationship (CWHR) Canopy Cover Classifications*

To determine acreage and percentage of preferred habitat in each buffer, I had to add a field to the attribute table (Area_acres) and calculate geometry for the habitat layers, as well as for the 1 mile and 25 foot buffers to find the total area in each. I right-clicked on the Area_acres field and used the Summarize tool to determine total acres in each buffer. I used Summary Statistics to find the area of each category (4M, 4D, 5M, 5D, and 6).

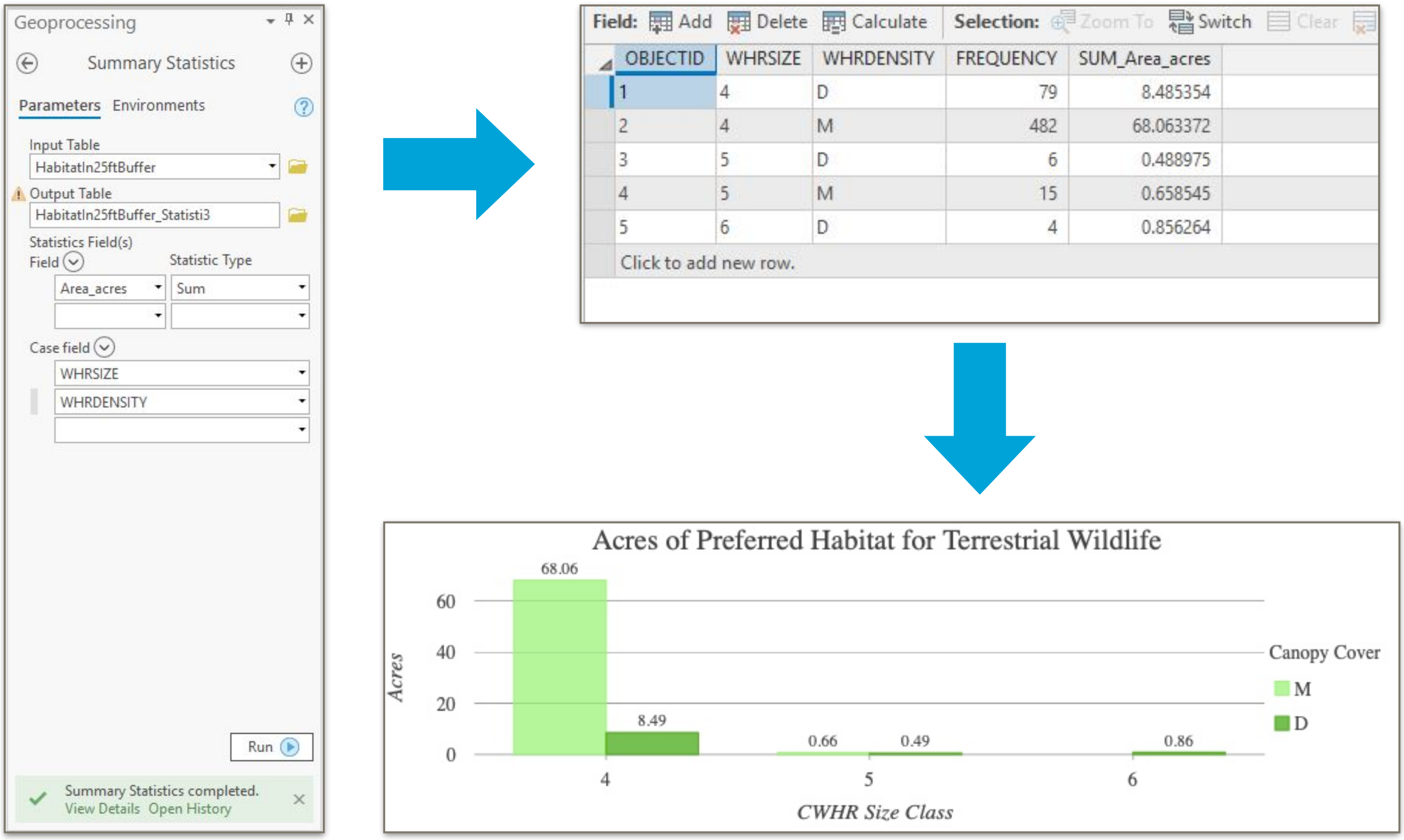


*Figure 6: Using Summary Statistics for 25 foot trail analysis area to create a bar graph*

I created simple bar graphs to show the distribution of area for each CWHR type analyzed. I wanted to make a pie chart, which I found ArcGis Pro cannot do yet, so I added the data to the Numbers app (Excel for Macs) to create a pie chart there.

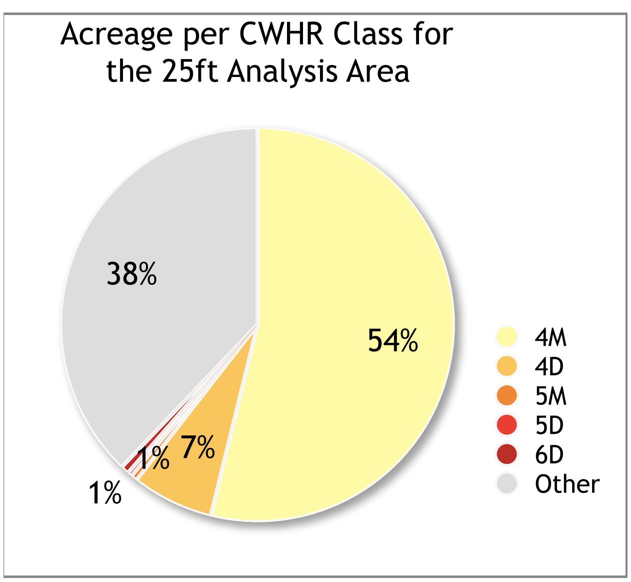


*Figure 7: Percentage of Acreage Preferred by Terrestrial TES Species*

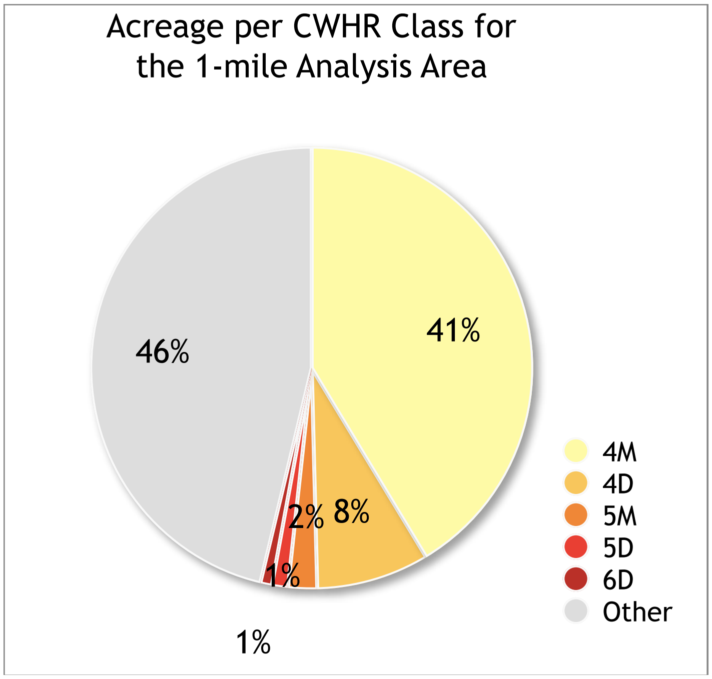


*Figure 8: Percentage of Acreage Preferred by Avian TES Species*

The analysis shows that while a total of 62% of the 25-foot terrestrial species analysis area contains preferred habitat, most of that is in the least preferred habitat type (4M). Of the 78.55 acres of preferred habitat in that area, 68 acres are 4M. For the avian species, of the 11,006 total acres, almost 54% of the one-mile analysis area is potential habitat, while again, most of that is in 4M at about 4,550 acres. The most preferred habitat, 5D and 6D, accounts for only about 1% of the habitat in the 25-foot terrestrial species analysis area, and about 2% of the one-mile avian species analysis area.

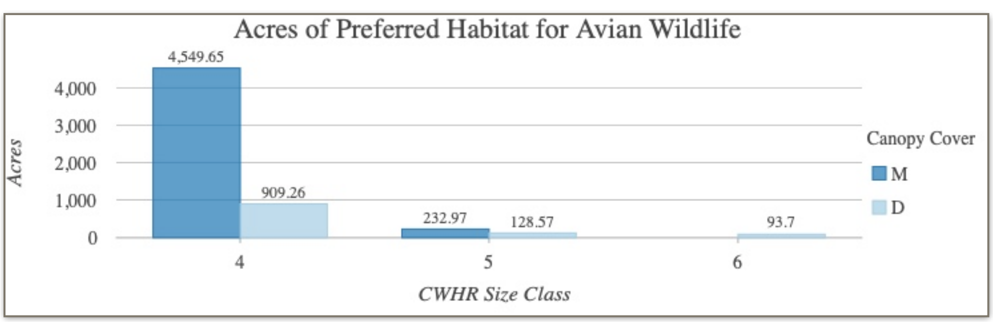


*Figure 9: Acres of Preferred Habitat in 1 mile Analysis Area*

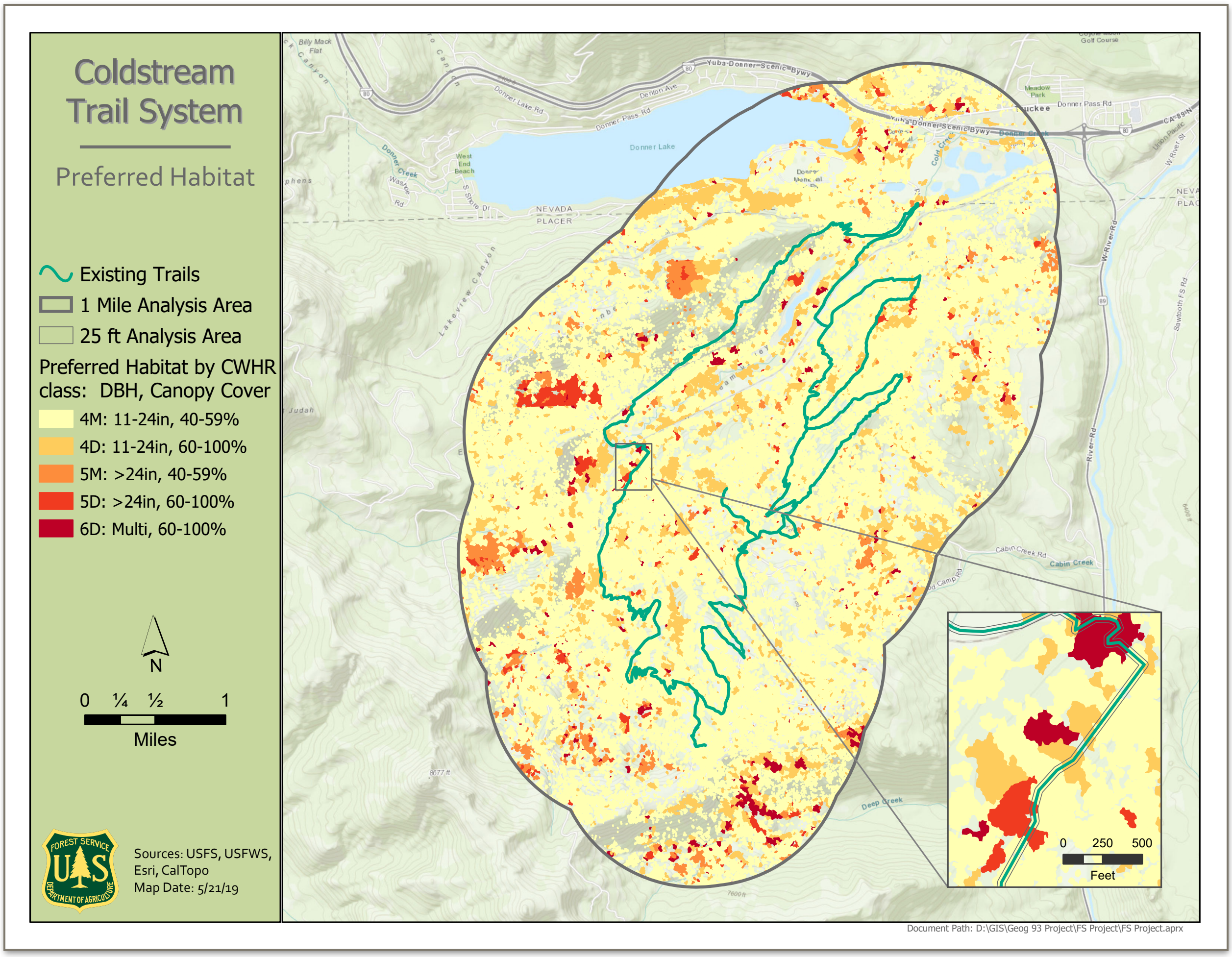


*Figure 10: Preferred Habitat*

## -Protected Resources-

For known areas to avoid, such as archeological sites, den/nest sites, wildlife PACs (protected activity centers), and other sensitive areas, I merged all of those datasets together to protect their individual resource identity and reduce bias to create a polygon layer of areas to avoid. In reality, some of those areas would be classified as soft boundaries (avoid if possible) and hard boundaries (must avoid). Because these trails already exist, I am classifying all as soft boundaries.

In addition, I added suitable habitat for the endangered Sierra Nevada Yellow-Legged Frog as a separate layer from the Sensitive Resources. This data does not contain known locations of SNYLF, only areas they may occur in the Sierra. This layer is essentially a buffer of 82 feet around high water mark for and streams or water bodies.

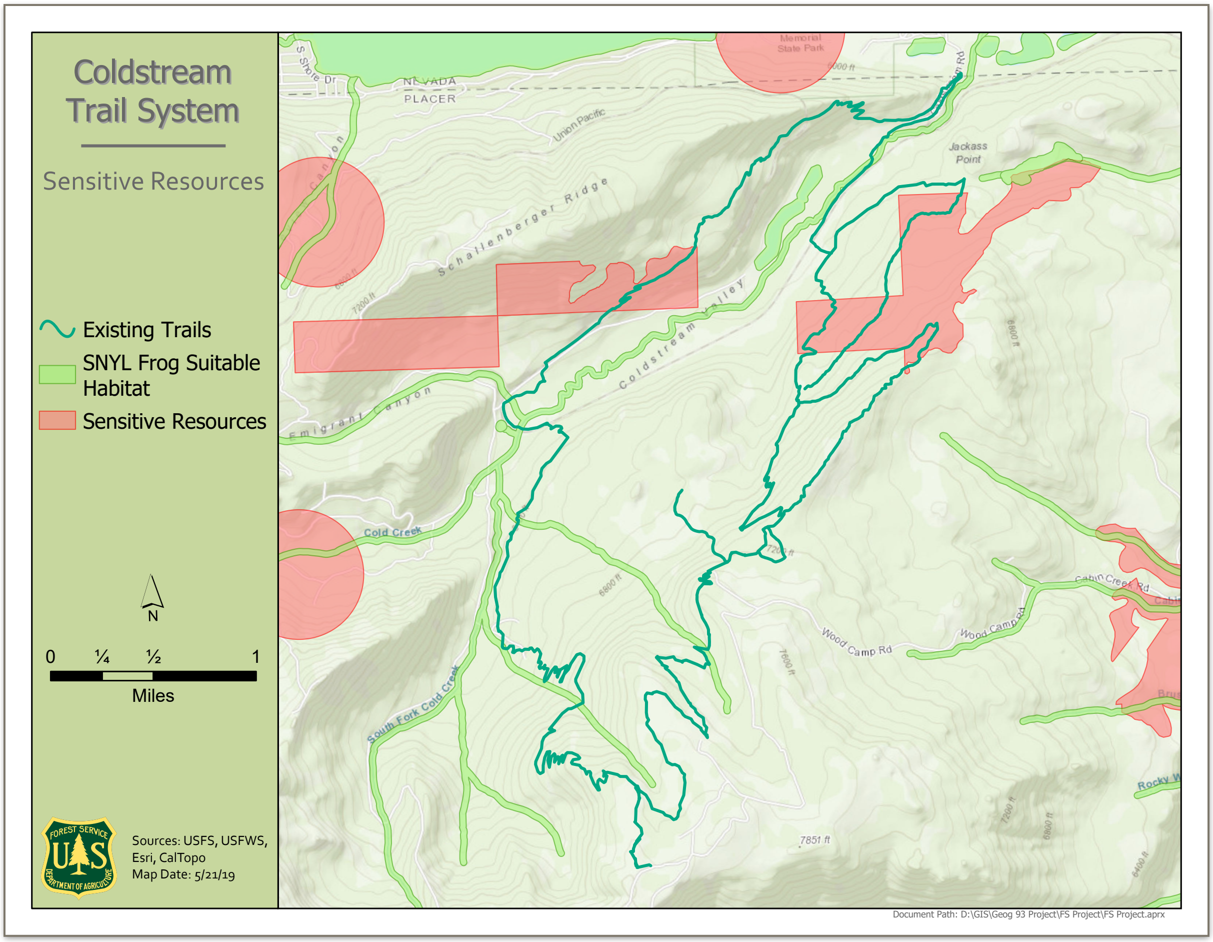


*Figure 11: Sensitive resources and suitable frog habitat*

## -Trail Improvements and Reroutes-

In some instances, resource specialists' mitigation measures may insist on a trail reroute or trail improvements in order to approve the trail alignment.

To find trail sections to reroute that go through preferred habitat, I first used Select by Attribute to select all highly preferred habitat (5D and 6D) and exported data. I then used the Intersect tool with that layer and the trails layer to get sections to reroute.

To get protected areas with trails going through them that may need to be rerouted, I intersected trails and sensitive resources.

I then merged both of those layers together to get trail sections to potentially reroute to avoid sensitive resources and preferred habitat.

For the Sierra Nevada Yellow-Legged Frog, I intersected the suitable frog habitat with trails. Trails must either avoid this area or certain trail construction techniques, such as tread armoring or bridges, may be implemented where trails cross streams at 90 degrees. Additional surveys may also be necessary to determine presence/absence of frogs.

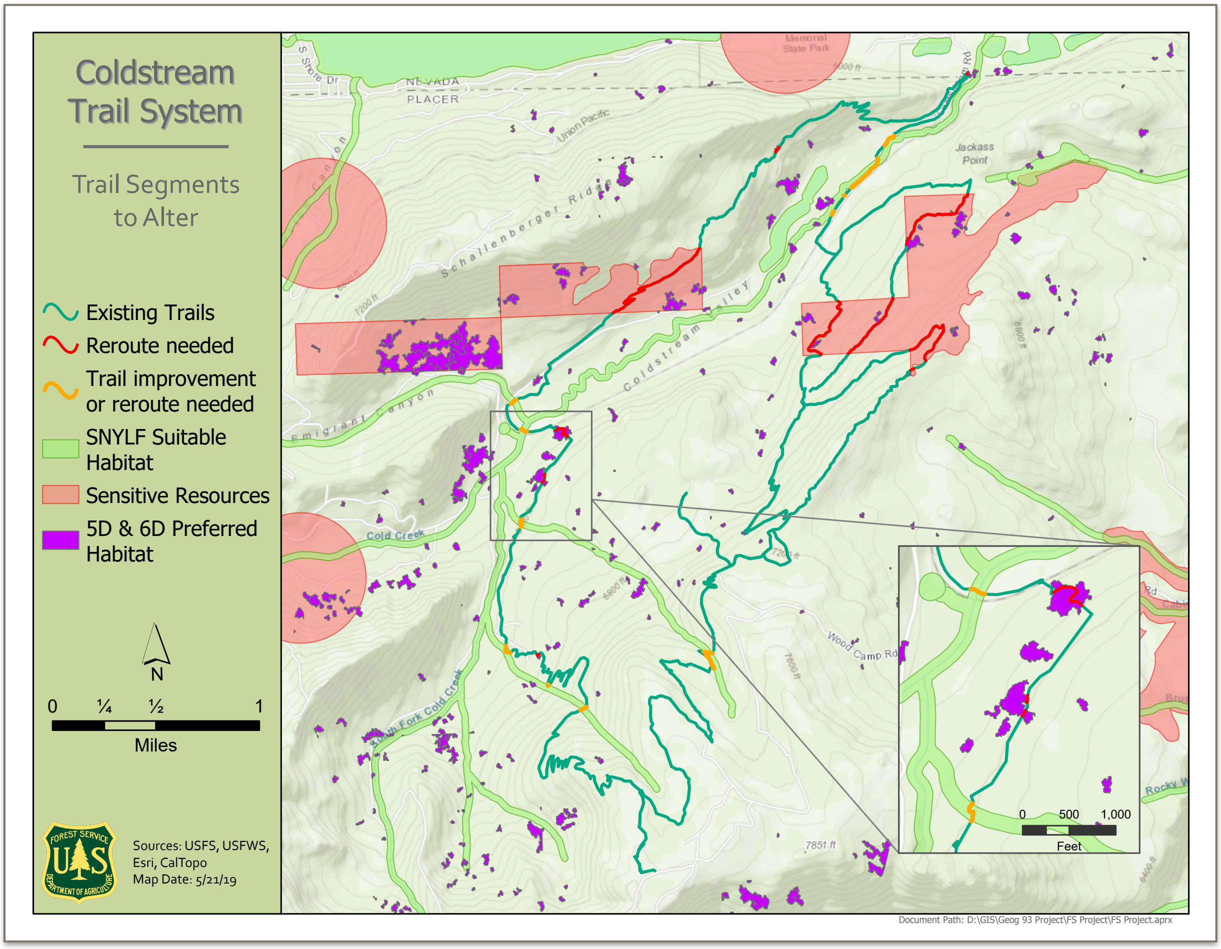


*Figure 12: Trails to Alter*

With the known protected areas and habitats to avoid, new sections of trail can be planned and implemented.

# Issues and Resolutions

As I currently only own a Mac computer, access to ArcGIS Pro outside of class was initially an issue. However, a fellow classmate introduced me to Parallels, a program that allows you to run Windows 10 as program on your Mac, without having to reboot. With that option, you can then download ArcGIS Pro through the Windows OS while still having access to all of the other Mac OS programs. It is normally $80/year but is $40 as a student. The problems arose when I started doing symbology on larger datasets and geoprocessing. I would often start some analysis, and by the time it finished I was distracted and had forgotten where I was in the process and what I was doing. For any future GIS needs, I now have access to ArcGIS Pro on my work computer, so I am not limited to just using ArcMap at work.

As expected, I had some issues using ArcMap at work and ArcGIS Pro at home, often within minutes of each other. I found that ArcGIS Pro was easier, as I sometimes had to google how to do something in ArcMap that is a simple task in ArcGIS Pro, such as adding a line to an existing feature class/shapefile.

When I initially tried to calculate area, I was getting incorrect values. I then realized that in my previous work session, I had only changed the symbology to show the data I wanted and therefore needed to query the needed data as well.

At one point, I was testing out how to make a model in ModelBuilder, and had gotten several steps done when Arc decided to unexpectedly close. I had not saved recently so I lost that model and did not end up attempting it again. If doing any analysis like this in the future that would be repeated, it would be nice to have a model to streamline the process.

## Learning Experiences

I learned out to import symbology from another layer, which was very helpful when dealing with complex symbology.

I learned how to use Summary Statistics to make a basic bar graph.

The append tool became very useful when adding trail data together into one shapefile/feature class. Merge works as well, but it creates a whole new shapefile, while append just adds data from one to an existing shapefile.

I figured out how to have multiple layouts in one project by making a master layout, saving a layout file, and opening that layout, toggling on/off layers. If additional analysis or map work needed to be done with a specific layout, I opened the map frame from the layout view to get a new map tab connected to that layout.

I thought I had learned last semester to SAVE SAVE SAVE. I had apparently not learned my lesson. At one point, I had been working for approximately two hours creating and fine-tuning two or three layouts and tricky legends when Arc crashed unexpectedly and I lost those layouts.

Finally, I learned that everything takes 5 times as long as you think it will.