Project Title: Rainbow Trout Refugia Mapping in Southern California via GIS Framework
Partners: California Trout w/ PSMFC (Holycross) and CDFW R5/R6 biologists (Barabe, Hemmert)
Report Date: 9/10/2021 by Sandra Jacobson, California Trout, Director - South Coast and Sierra Region

Project Overview: Few native rainbow trout populations remain in Southern California. These native trout are remnant populations of steelhead runs from the last century and are typically trapped in the headwaters of rivers behind barriers. These trout comprise the last of distinct genetic identities of anadromous steelhead who migrated by the tens of thousands in coastal rivers and reproduced in upper freshwater reaches. Due to impacts of climate change, there is a sense of urgency to safeguard the remaining populations and their habitat. Environmental events such as fire and drought in Southern California can abruptly extirpate these vulnerable populations. To address this, CalTrout is collaborating with Pacific States Marine Fisheries Commission and CDFW to develop a native trout refugia prioritization methodology that can be used to proactively plan for translocating trout into new habitat patches to maximize the success of survival. A GIS framework called the Baseline Fish Habitat Layer, developed by Brett Holycross at Pacific States Marine Fisheries Commission, was tailored for this purpose whereby Southern California streams were initially screened for gradient and streamflow characteristics, then geospatially referenced with rainbow trout presence/absence data and other attributes including genetic lineage, proximity to natural springs, in-stream fish passage barriers, fire history maps and accessibility. The goal is to develop a platform that CDFW can use in forward planning to identify native trout refugia locations in the mountains of Southern California and statewide. This pilot study focused on the San Bernardino Mountains and San Jacinto Mountains where survey and stream data were readily available, to be followed by application of this methodology to San Gabriel Mountains, Santa Ana Mountains and other regions. Refugia identified by this method will be ground-truthed by field teams. The top twenty-six refugia locations identified here will lead to a prioritized set of Top 10 sites for site visits by CalTrout, CDFW and volunteers to assess rainbow trout presence and habitat conditions. The prioritized list will be further vetted in consultation with state and federal agencies to protect T&E species that may be impacted by trout translocation.

GIS Framework Development 4/1/2020 – 12/31/2020

1. Develop GIS-based FISHPass framework for prioritizing refugia sites for rescued trout.

▪ Topographic maps for San Jacinto Peak in Riverside County in the San Bernardino National Forest, San Jacinto Peak in the San Jacinto Mountains, and the San Gabriel mountains in Los Angeles County in the Angeles National Forest, were examined by Coalition field technician Ken Sankary as pilots to identify streams with the desired characteristics (gradient, water flow and quality data, proximity to springs, proximity to access points). This desktop effort was performed during the early stages of the COVID pandemic and cast a wide net of possible locations which helped inform subsequent steps. Spreadsheets and the process is documented at:
https://californiatroutinc.box.com/s/mymedoxf40nwg59vs7ukqcwq3oxphzos

▪ The locations identified by topo map were sequentially screened through CEDEN (California Environmental Data Exchange Network), then mapped onto the CDFW Bios website using the California Streams layer, then mapped onto CA Fire History maps in the area. The resulting layer illustrates target translocation sites in the context of species locations, local stream network and fire perimeters. Locations where fires have occurred within the last 10-20 years are preferable to those that have not burned in 20 years (higher likelihood of burn) or those that have burned in the last seven years (still

exhibiting fire scars). The resulting sites were then compared in some cases with available data for fire severity from USFS BAER reports.

▪ A spreadsheet of >200 candidate mountain streams was compiled with this data and GPS locations.

▪ The GPS locations of candidate translocation sites were then mapped onto the GIS Fish Habitat layer constructed by Brett Holycross, (Pacific States Marine Fisheries Commission) using a gradient filter of 10%.

▪ Trout survey data for the San Bernardino Mountains was sent to Brett Holycross by Jen Hemmert (CDFW fisheries biologist Region 6).

▪ CDFW survey data of trout presence/absence in San Jacinto region of the San Bernardino mountains was mapped onto the PSMFC GIS framework. The 10% gradient filter applied was assessed comparing trout survey data to Sankary analysis of candidate streams as described above. A significant number of survey sites above the 10% gradient limit held trout. Thus, the gradient was increased to 15%.

Prioritizing Relocation Sites (San Bernardino and San Jacinto Mountains) 1/1/2021 – 6/30/2021

2. Prioritize refugia locations for relocation of native rainbow trout

▪ The augmented Fish Habitat Layer was put into a web browser by Holycross for CDFW biologists and CalTrout to screen through multiple layers of attributes to help prioritize potential translocation sites. The image below is a screen shot of the interactive map spanning San Gabriel Mountains (upper left), San Bernardino Mountains (upper right), San Jacinto Mountains (lower right) and Santa Ana Mountains (lower left). The three most prominent attributes in this geographic overview are the blue lines (streamflow), green/red circles (presence/absence trout), and gradient-forced habitable area (orange).
https://psmfc.maps.arcgis.com/home/webmap/viewer.html?webmap=d4096f26d2424ccba119189c86861c5b#
Contact Brett Holycross at bholycross@psmfc.org for username and password to access the interactive map.

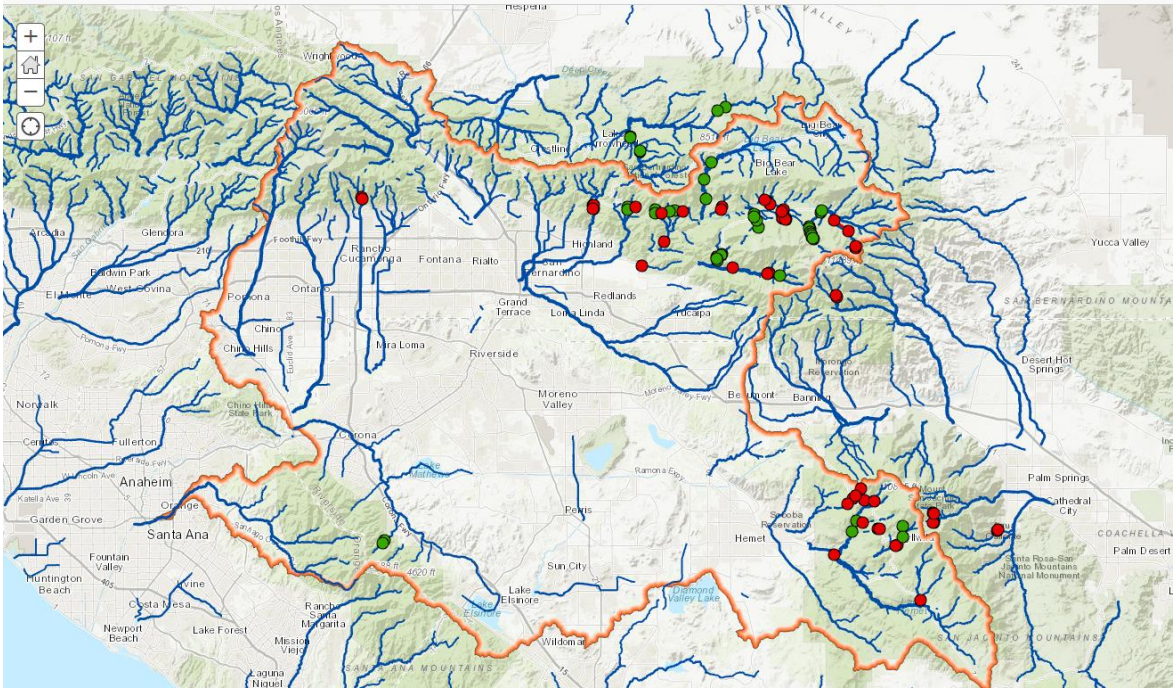

Figure 1. Southern California GIS framework overview for trout refugia identification.

Upon zooming in to various sections, starting at the upper right in the San Bernardino Mountains near Big Bear in the Santa Ana River drainage, a number of candidate refugia locations are discernable. Two CDFW fisheries biologists from different regions (Russell Barabe in R5 covering San Diego, Orange and Riverside area; and Jen Hemmert in R6 covering inland desert region including San Bernardino and San Jacinto mountains, and who led the trout population surveys and therefore knows this area very well) viewed different parts of the map sequentially. Based on their profesisonal judgement, they came to similar conclusions about which locations should be prioritized. Much of the site-specific information was provided by Jen Hemmert. The top 26 are described herein, and the characteristics that each of the biologists considered in their stream and reach choices are presented below.

Considerations for prioritizing sites (see legend Figure 3):

- streamflow: low threshold for potential set at 0.8 cfs (width of blue line increases with flow)
- trout absence (red circle) near reaches or tributaries with trout present (green circle)
- proximity to series of springs (diamonds)
- north facing aspect (colder)
- proximity to trail or mainstem of river, or point of interest (star) for translocation accessibility
- trout absent in fire scars where trout present in adjacent tribs, especially on same aspect indicates possible extirpation after fire, suitable for reintroduction
- upstream of gradient break for potential physical separation of trout populations

Starting in the northeast quadrant, south of the Santa Ana River and directly south of Big Bear, there are a number of trout streams near Barton Flats to the south of Rim of the World Scenic Highway. These streams are the SF Santa Ana River (lower right with series of green circles), Fish Creek to the east (red circles), Heart Bar Creek and Coon Creek (east of Fish Creek), EF and WF Barton Creek on the western edge (red circles). This area brings into consideration each of the factors above and has recurrent fires.

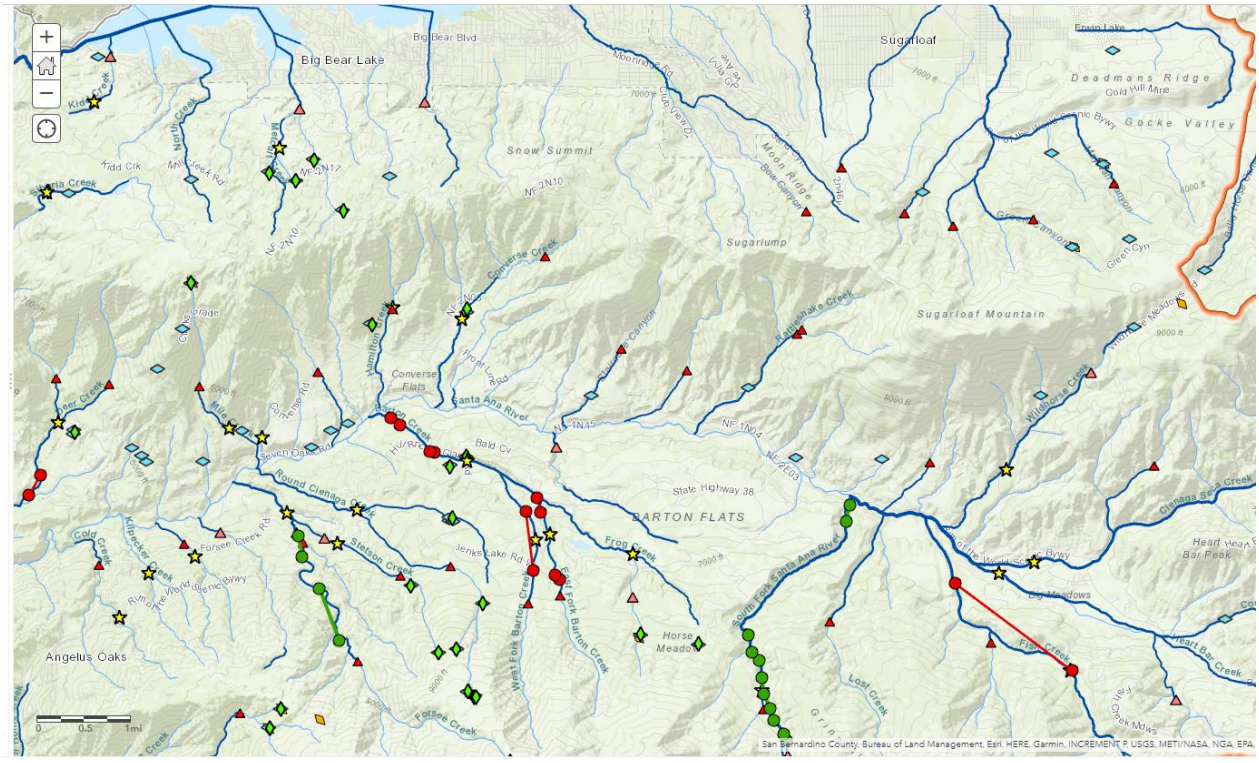

Figure 2. Barton Flats.

1. Fish Creek. The South Fork of the Santa Ana (line of vertical green circles indicating trout presence) in the center of the map indicates good trout habitat, but to the east in Fish Creek trout were absent where surveyed (red dots, one with a connector in it) even in the headwaters. Both SF Santa Ana and Fish Creek have similar flow and springs at the headwaters, and are in similar aspects. One possibility is that the Lake Fire in 2015 (large blue outline spanning from Barton Flats to Grinnell Mountain) burned hotter on the east edge and caused trout die off in that area, while the South Fork Santa Ana to the west had a lighter intensity or intermittent burn pattern. Fish Creek should be re-surveyed to further assess absence, and habitat typed, but is a high priority candidate for ground-truthing. According to CDFW, the Fish Fire extirpated trout in this stream, and there is incision near the confluence and significant flash flooding. There are frogs in the meadow. This stream is under consideration by CDFW for translocation. Temperature loggers have not been placed yet, but planned to get continuous data recording. Typical water temperatures are about mid-50 degree C. It's spring fed and channel is typically wetted year-round. Some volunteers active through USFS in the area to monitor the stream.

2. Heart Bar Creek and 3. Coon Creek. These two streams are to the east of Fish Creek but have the same aspect and apparent flow characteristics, with springs in the upper reaches.These streams were also impacted in the Fish Fire. There are USFS turnouts for access; and a set of roads near Heart Bar campground. According to CDFW, the habitat looks good. Food access should be easy. Barriers should be assessed to evaluate possibility of species separation (frogs in meadows, trout in gradient areas).

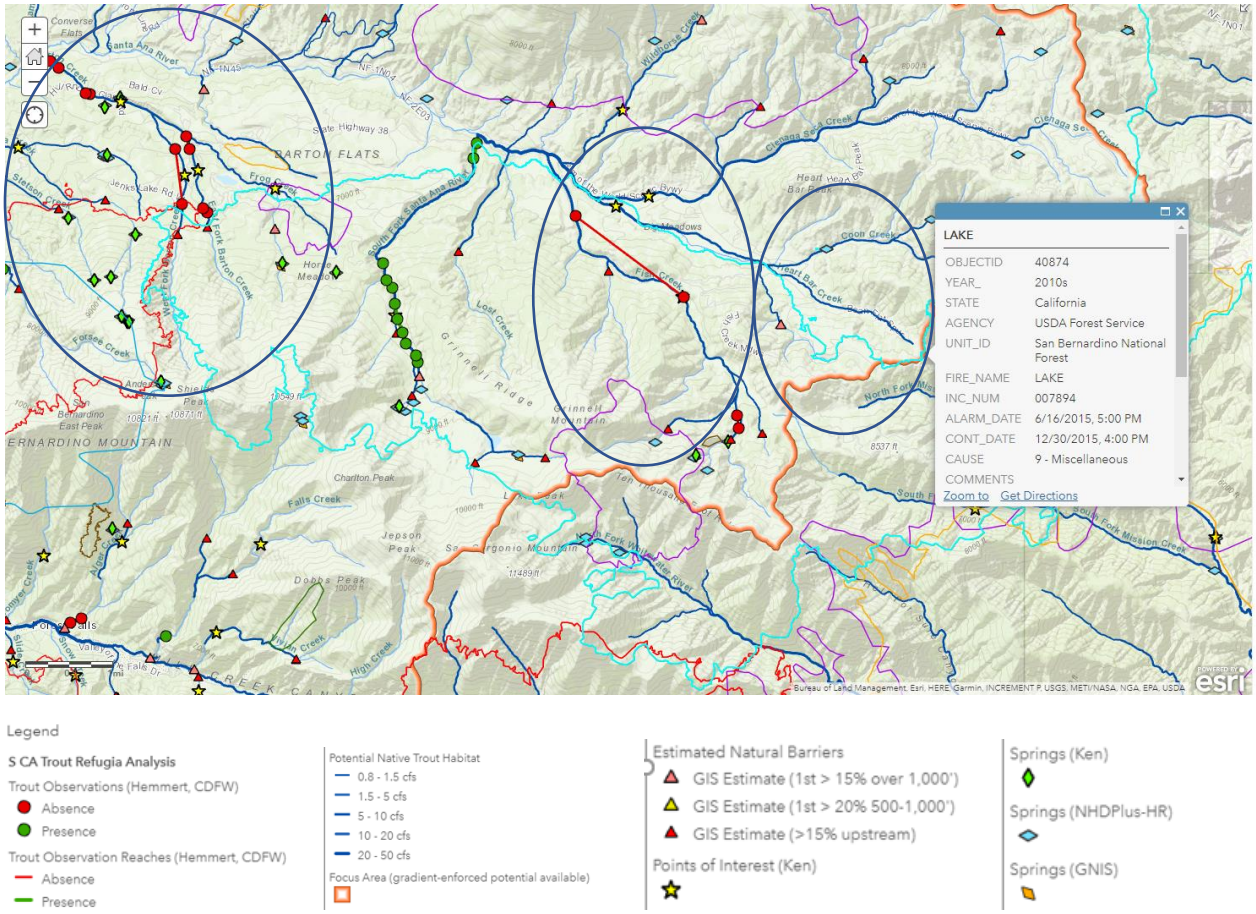

Figure 3. Fish Creek, Heart Bar Creek and Coon Creek including legend for symbols used in this study.

4. WF Barton Creek and 5. EF Barton Creek. To the west of Fish Creek and SF Santa Ana lies WF and EF Barton Creek. The northwest edge of the Lake Fire impacted EF and WF Barton Creek (trout absent, red circles). Given that this fire is now seven years past, it may be ideal to scope these places to see habitat conditions. They are similar aspects, with high density of springs, and accessible from the Santa Ana River via Barton Flats Road. The WF and EF Barton Creek are particularly intriguing since they overlap with the western perimeter of the Lake Fire in 2015 and the eastern edge of the Eldorado Fire in 2020.

6. Lower Forsee Creek and 7. Round Cienaga Creek. To the west of Barton Creek are Round Cienaga and Lower Forsee creeks (mid-right below). Both were impacted by the El Dorado Fire in their upper reaches, and should be investigated for trout presence post-fire, and habitat conditions in lower and upper reaches. Burned reaches without trout may be ready for tranlocation in the next several years. Round Cienaga does not have positive identification for trout, but neighboring Lower Forsee Creek showed presence along several sites surveyed (green circles extending into upper reaches) from years earlier. There's not a clear trail for Round Cienaga and no road. Forsee Creek is steep. CDWF has electrofished here. They have good collaboration with landowner.

8. Stetson Creek tributary should also be investigated for habitat typing and presence/absence trout surveys. There are good access points (stars) and natural barriers that could separate potential hatchery intruders from translocated native trout. The culverts should be evaluated for barrier status. Nearby Hamilton Creek and Converse Creek are also of interest.

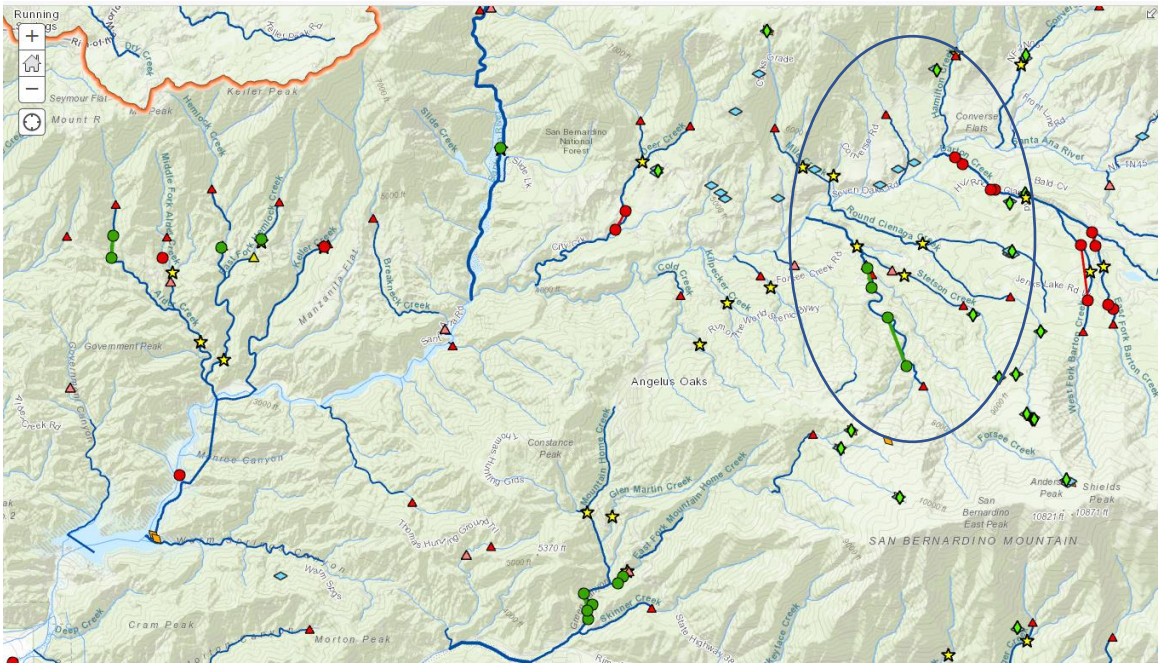

Figure 4. Barton Creek, Forsee Creek, Round Cienaga Creek, and Stetson Creek.

The fire perimeters of fires since 1950s are shown below in various colors. On the interactive map, one can press on the desired outline, and information regarding the fire will appear in a separate box.

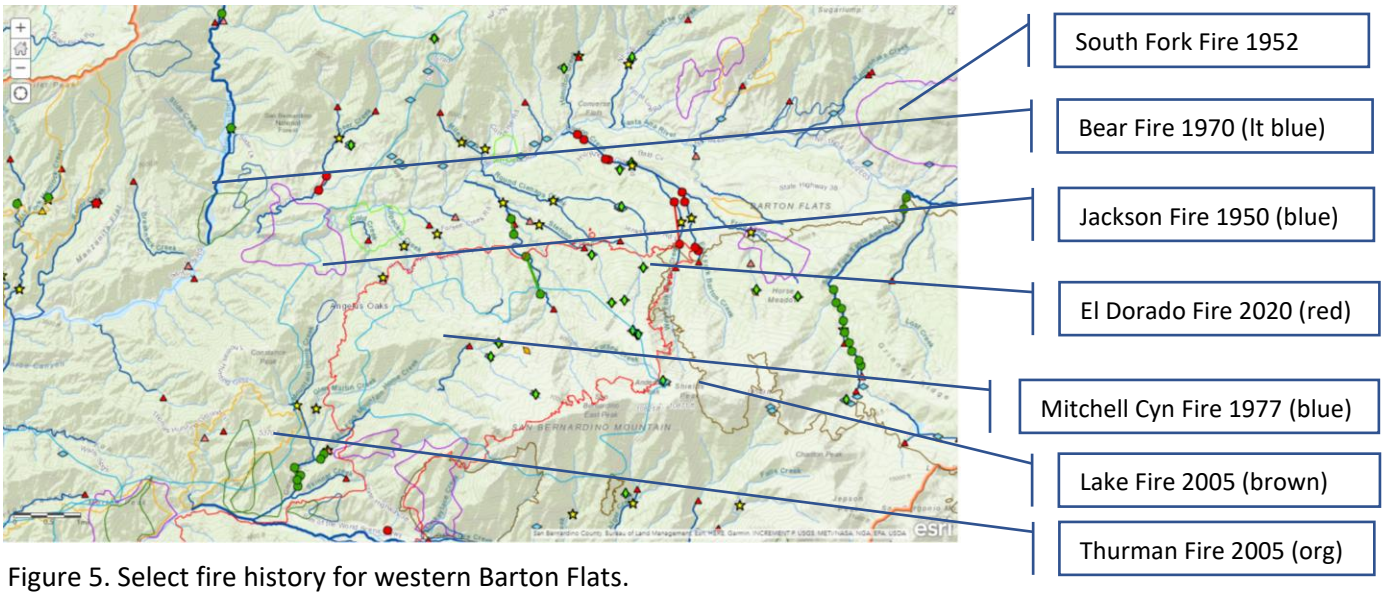

Figure 5. Select fire history for western Barton Flats.

9. Breakneck Creek. To the west of where Santa Ana River heads north to Big Bear Lake is Breakneck Creek that has a natural barrier close to the confluence. It is within the Bear Fire (1970) perimeter. This stream should be surveyed for trout, and if habitable considered a possible translocation site because native trout could be placed above the barrier for physical separation from hatchery plants. Nearby **Keller Creek** to the west should also be checked further. It was trout absent when surveyed earlier.

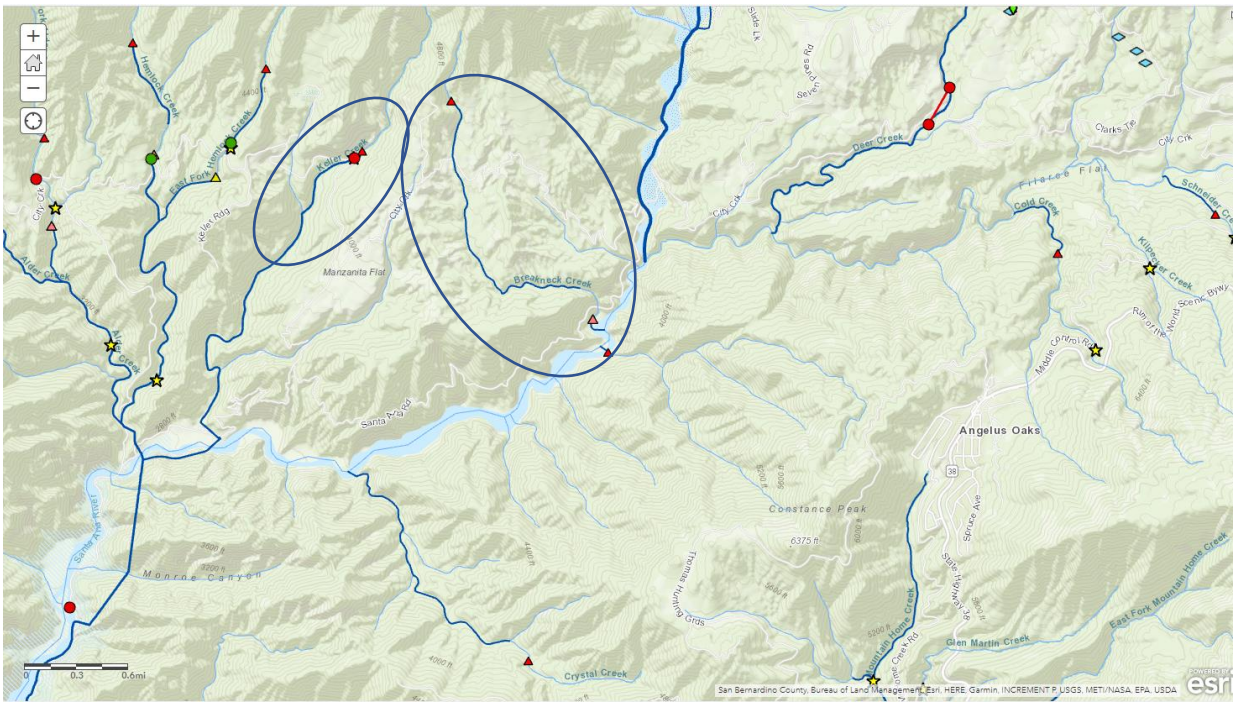

Figure 6. Breakneck Creek, Keller Creek.

10. Alder Creek. Just to the west of Breakneck Creek is a series of tributaries to the Santa Ana River, including Alder Creek which flows through steep canyons in a south facing aspect. Upper Alder Creek is in the extensive Bear Fire (1970) perimeter. The adjacent forks of **Hemlock Creek** also appear to be good sites for further investigation. They are within the Hemlock Fire (2001) perimeter and have documented trout presence (green circles). There are good access points near the confluence (stars), although road maintenance may be an issue. There are sections near the access points good for electrofishing. According to CDFW, middle Alder Creek has good habitat. Habitat is variable along Alder Creek due to differing canopy cover.

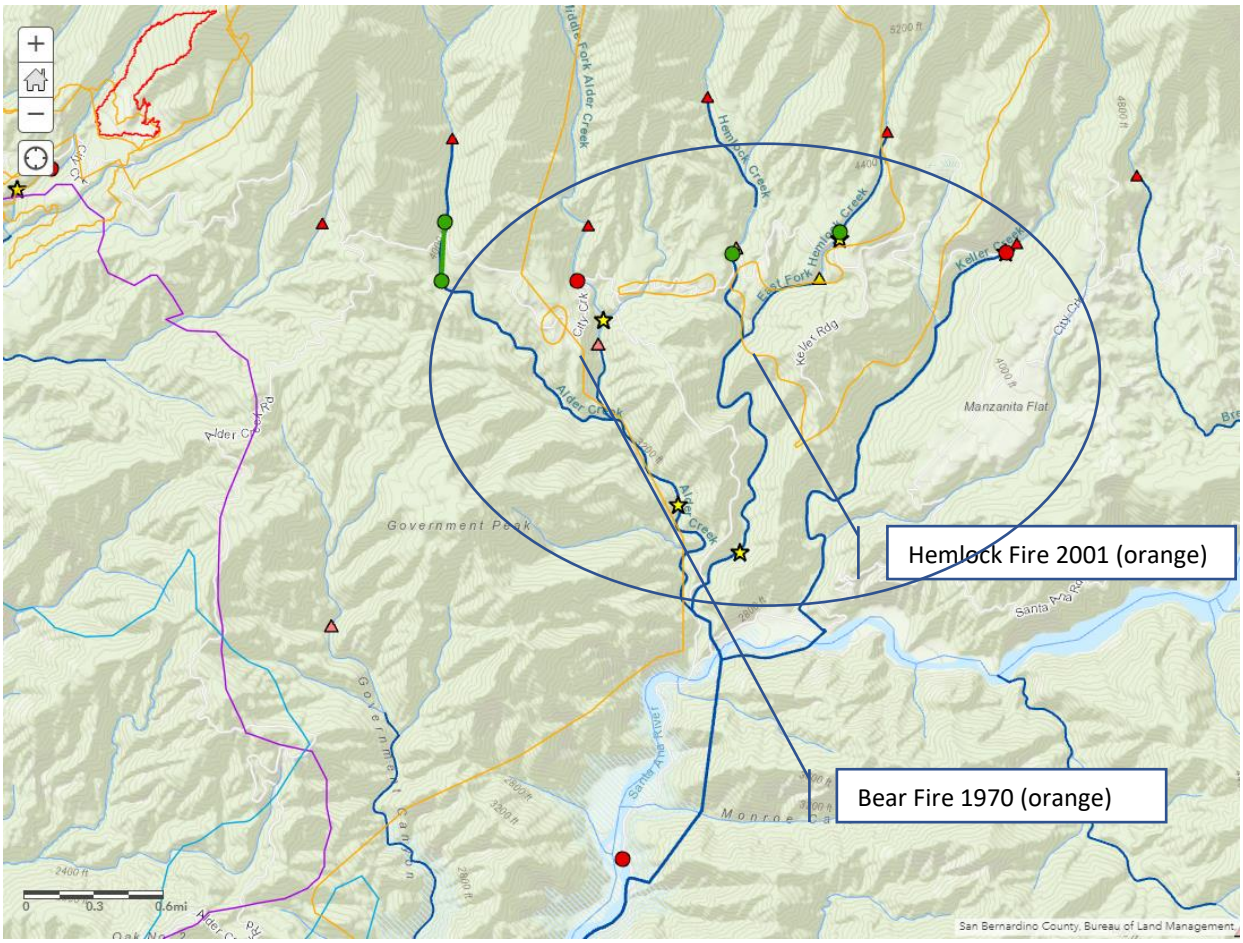

Figure 7. Alder Creek, Hemlock Creek.

11. Deep Creek tributaries: Sheep Creek and Shake Creek. To the northwest of Running Springs, west of Big Bear and east of Lake Arrowhead, Deep Creek is a cold trout stream that runs through the hills. Trout presence has been documented at two reaches surveyed (green circles). There is hatchery stocking in the stream, but the Sheep Creek tributary is at the western edge of the Slide Fire in 2007 and may have vacant reaches upstream suitable for native trout relocation. The adjacent Shake Creek also has a north facing aspect and apparent adequate stream flow, with good accessibility in the lower area.

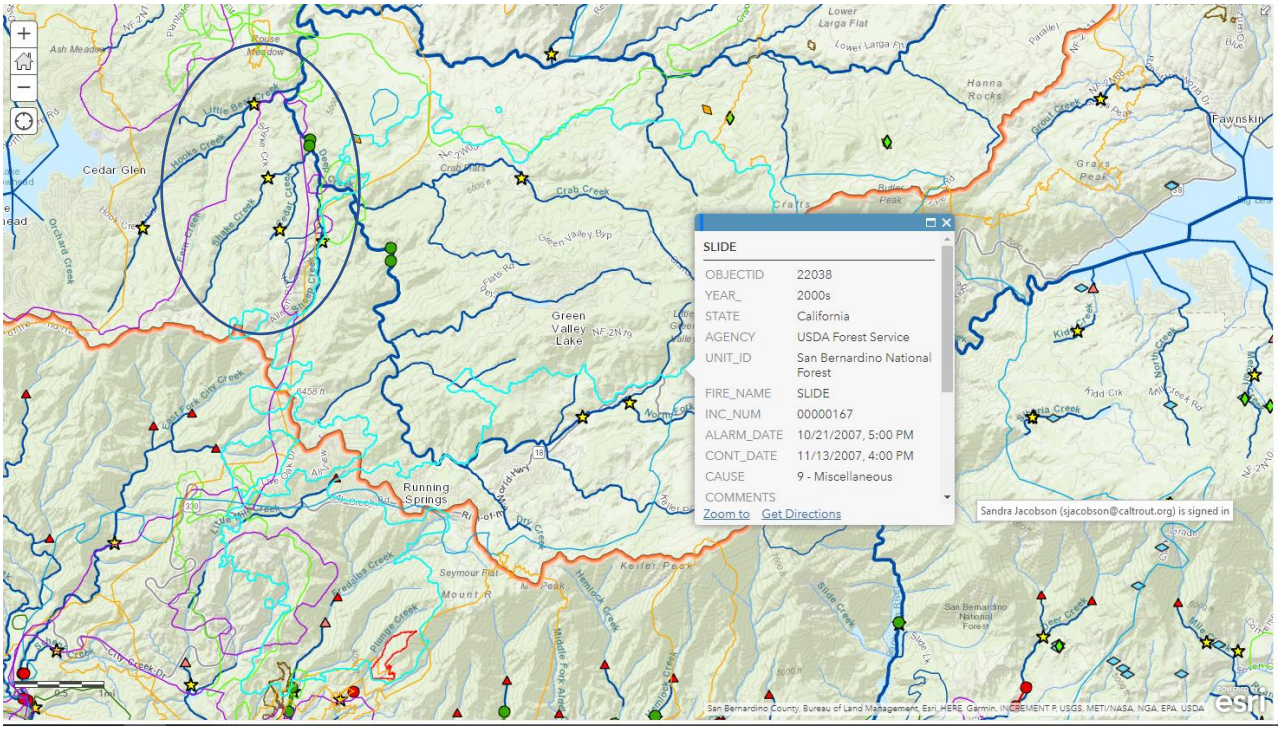

Figure 8. Deep Creek and tributaries.

To the south, there is an area that has burned frequently just to the north of San Bernardino. A map of the fires since 1950 show a tangle of fire perimeters (below), indicating that this region is not suitable for relocation due to the proximity to urban centers and frequency of fires – similar to the San Gabriel Mountains near Azusa and Glendora.

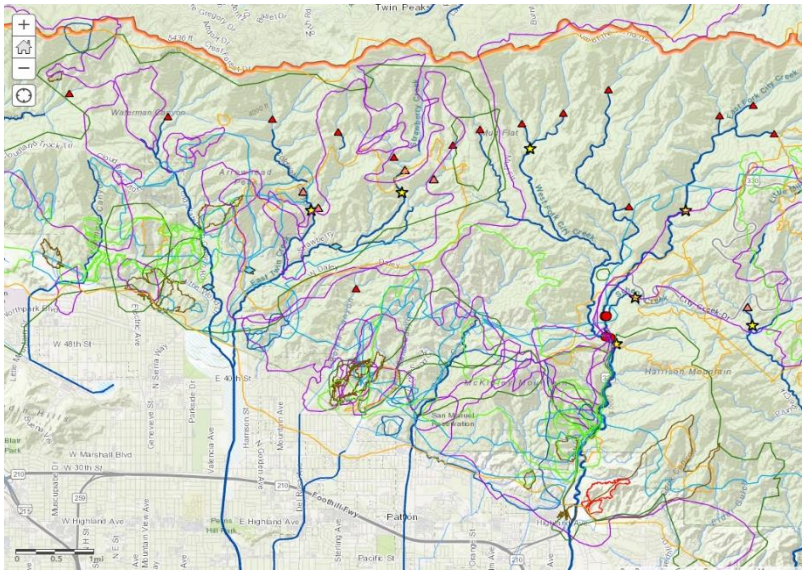

Figure 9. San Bernardino metro area recurring fire history.

12. Alger Creek in the Forest Falls area. Directly south from Barton Creek over the San Bernardino mountain, is a cluster of tributaries to Mill Creek, which runs E/W south of Santa Ana River. Alger Creek had vacant habitat above a naturally occurring barrier to Mill Creek which may be ideal for relocation. It is a steep canyon, and the neighboring stream to the east, Falls Creek, has trout present. In the Forest Falls area, some streams are dry.

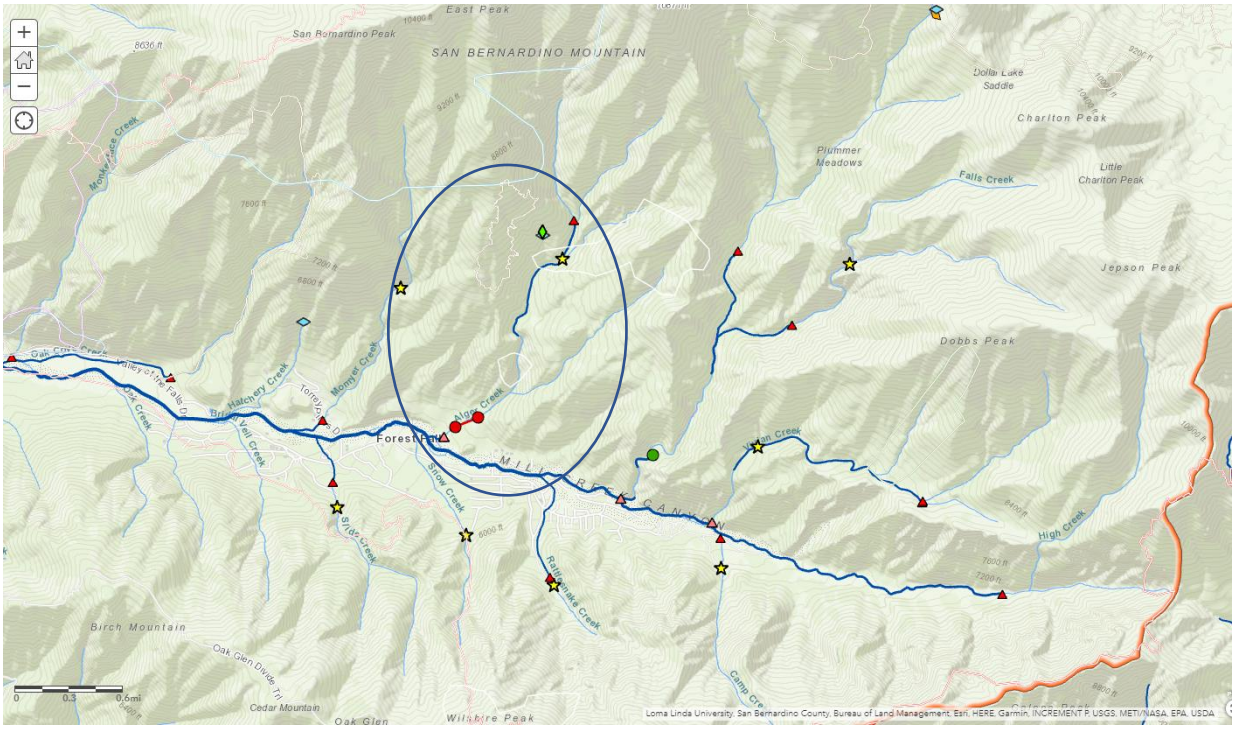

Figure 10. Alger Creek.

13. Upper Strawberry Creek in the San Jacinto Mountains and 14. Stone Creek near Idyllwild. These streams were surveyed to varying degrees by CDFW in preparation for translocation of Coldwater Canyon native trout from the Santa Ana mountains into Marion Creek (tributary to Strawberry Creek) after the Holy Fire in 2018. The upper sections of Strawberry Creek have multiple springs, reasonable access, and a natural barrier where multiple smaller streams come together. CDFW has e-fished Logan and Stone Creeks, no trout or frogs observed. The habitat is worth re-evaluating. Stone Creek is a local favorite for brown trout fishing. There's a water gauge on Logan Creek. The road is accessible.

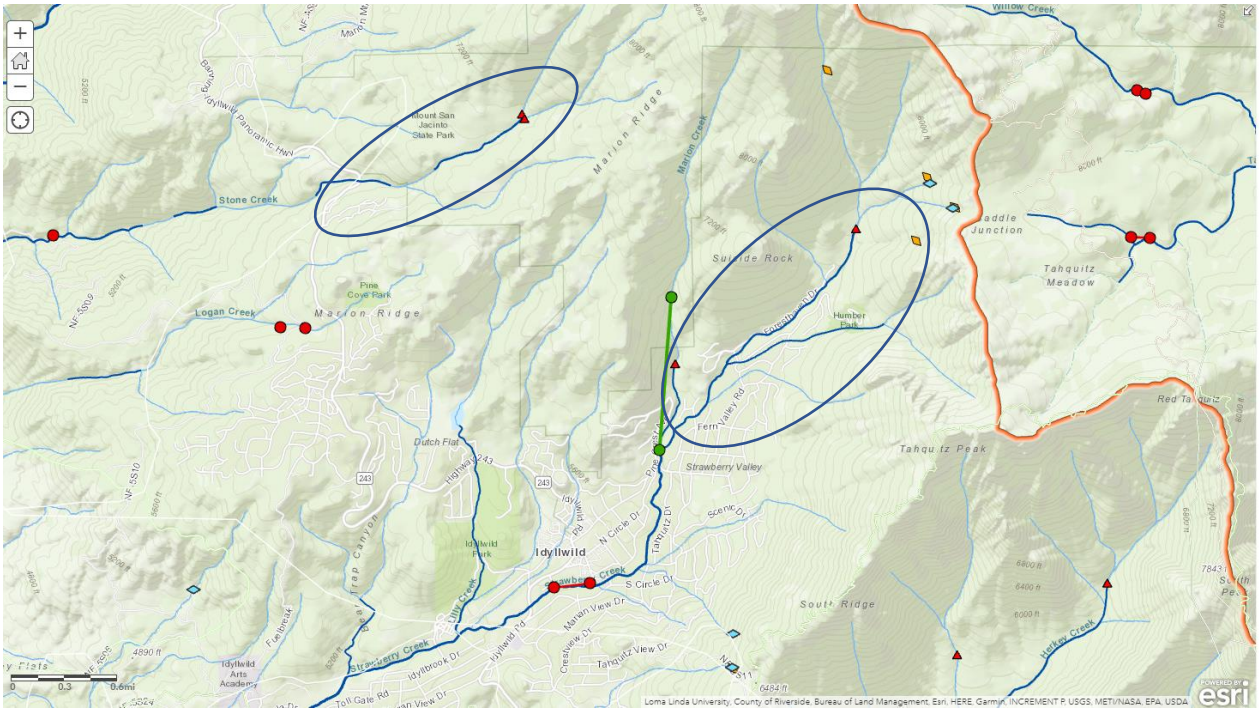

Figure 11. Strawberry Creek, Stone Creek.

15. Fobes Creek and **16. Herkey Creek** are on the south face of San Jacinto Mountains and may have suitable habitat for trout. Fobes Creek runs through a nice valley, readily checked per CDFW.

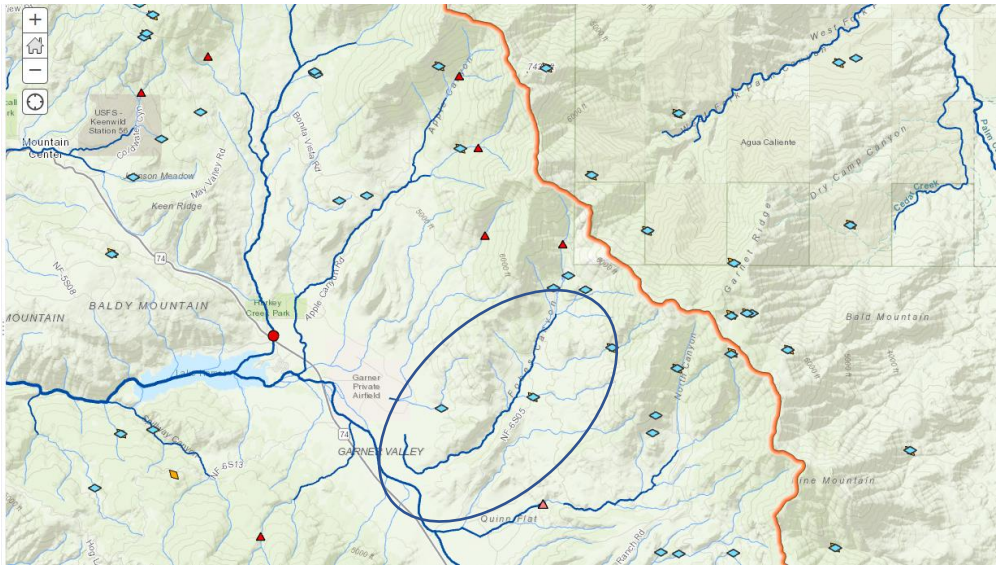

Figure 12. Fobes Creek, Herkey Creek.

17. Andreas Creek. To the east of Strawberry Valley, southwest of Palm Springs by Agua Caliente is Cahuilla tribal land through which Andreas Creek runs in to Palm Canyon Creek. It was impacted by the Dry Falls Fire (1980) and the resident trout were extirpated. A fishing club has access through the Cahuilla reservation. This is priority to follow up with these groups to learn status of rainbow trout and locations for translocation.

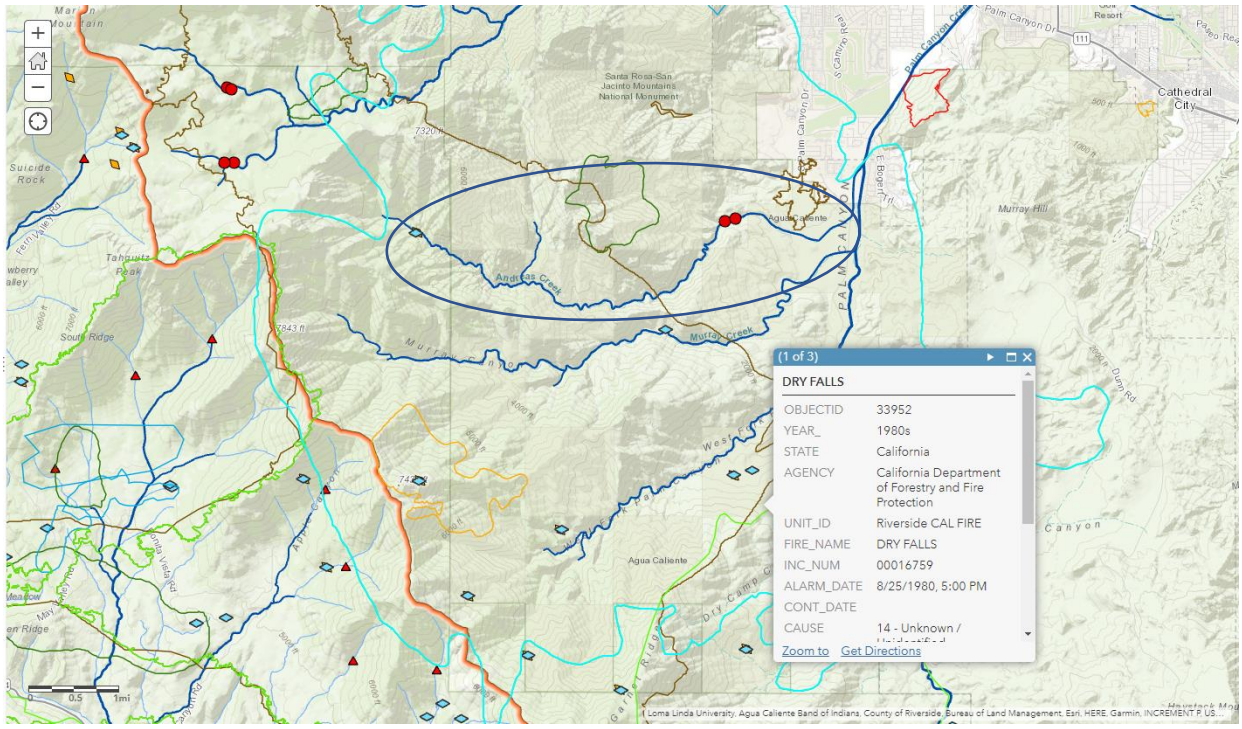

Figure 13. Andreas Creek.

18. Indian Creek. North of Stone Creek and NF San Jacinto River is a series of surveyed sites on Indian Creek which has intermittent flow, south facing aspect, and within the Soboba Fire perimeter (1974). This site looks promising above the natural barrier (triangle).

19. Fuller Mill Creek. East of Indian Creek is Fuller Mill Creek which was absent trout by survey in the lower section, but historically had trout that were genotyped as hatchery lineage in the So Cal O. mykiss population genetics study from older samples from Fuller Mill (2012) and NF San Jacinto (2009).

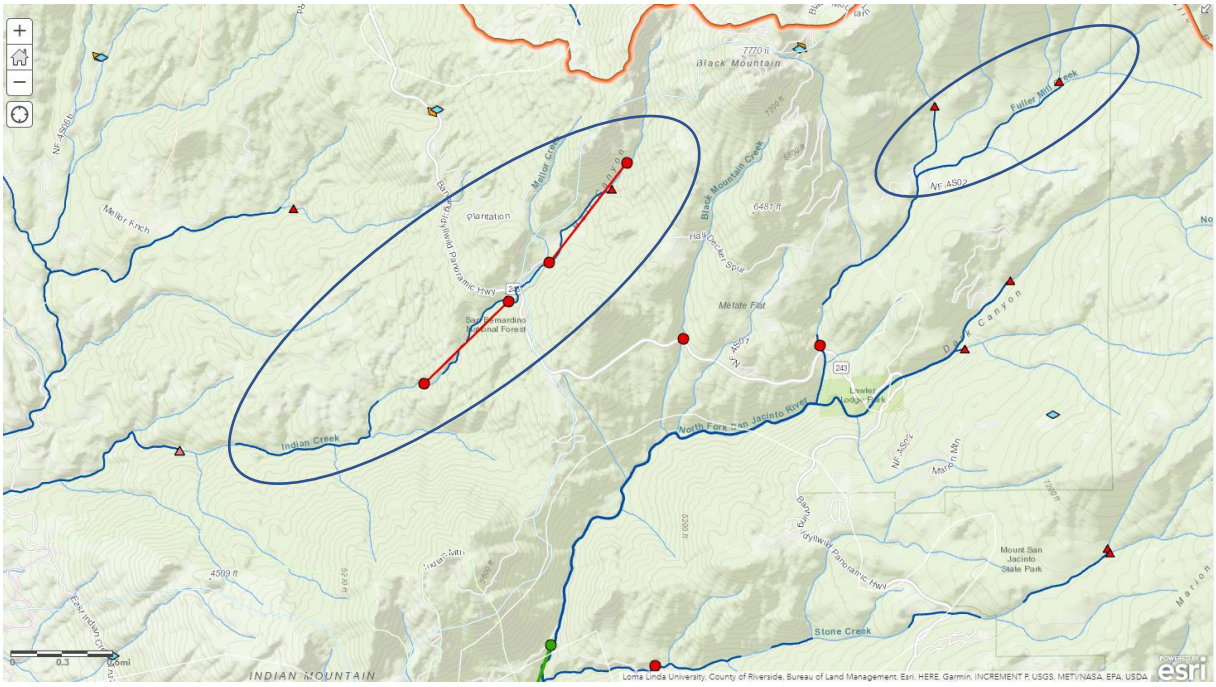

Figure 14. Indian Creek, Fuller Mill Creek.

20. Holcomb Creek. This stream is north of Big Bear Lake and has good flow as it traverses E/W near Holcomb Valley. This stream showed trout presence in several sites surveyed (green circles with line), but should be surveyed to the east, and has good access (star).

21. Cox Creek near Redondo Ridge. Just to the west of Holcomb Creek is Cox Creek which runs with good flow and has numerous springs along its length. No trout survey data is available for this stream, but holds promise as a cold water refugia in the Redondo mountains northeast of Deep Creek.

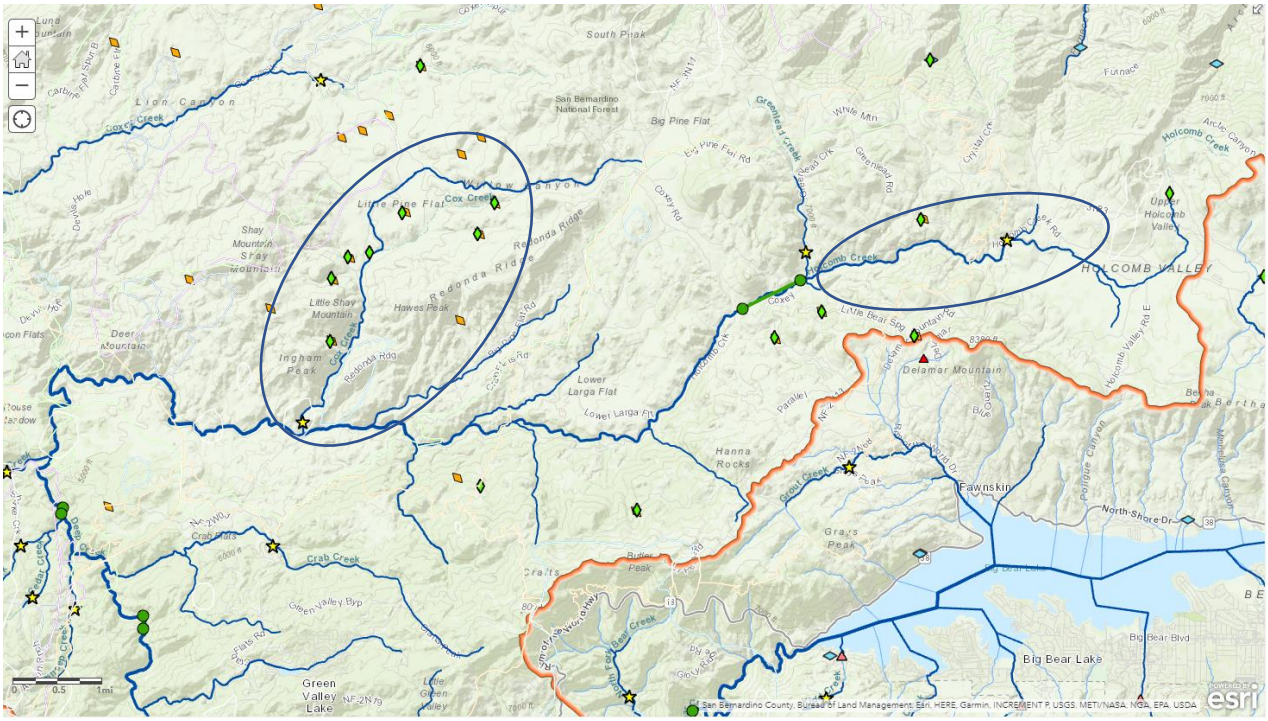

Figure 15. Holcomb Creek, Cox Creek.

Cucamonga Mountains in San Bernardino including:

22. Middle Fork Lytle Creek
23. North Fork Lytle Creek
24. Coldwater Canyon and Stockton Canyon (tributaries to NF Lytle Creek)
25. Icehouse Canyon east of Mt. Baldy and San Antonio Creek.

The Lytle Creek system historically held trout, and was targeted for fin clip collection in the So Cal O. mykiss Population Genetics study (2014) but was not accessible due to fire closure and private property access issues. This area should be re-evaluated for trout surveys and habitat typing, and flow monitoring year-round with water temperature loggers at selected locations. Middle Fork Lytle Creek has good access via road (star) and has several natural barriers that could separate translocated trout from wild trout of hatchery lineage. North Fork Lytle Creek and tributaries Coldwater Canyon and Stockton Canyon are also good prospects to the north. To the west near Mt. Baldy, Icehouse Canyon has several springs and apparently adequate flow, but less access to upper parts of the canyon.

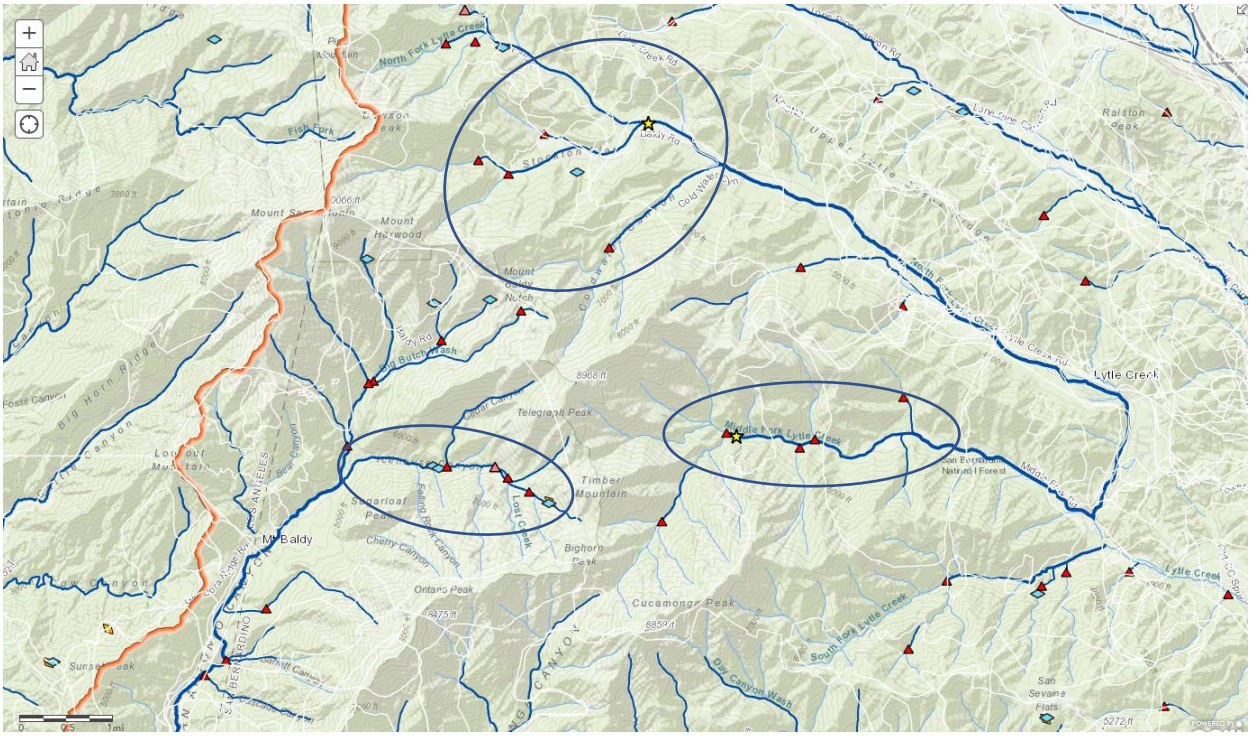

Figure 16. Cucamonga Mountains, Lytle Creek, Stockton Creek, Icehouse Creek.

Showing Fires since 1950 perimeters in color below. This area burns recurrently in Lytle Creek drainage.

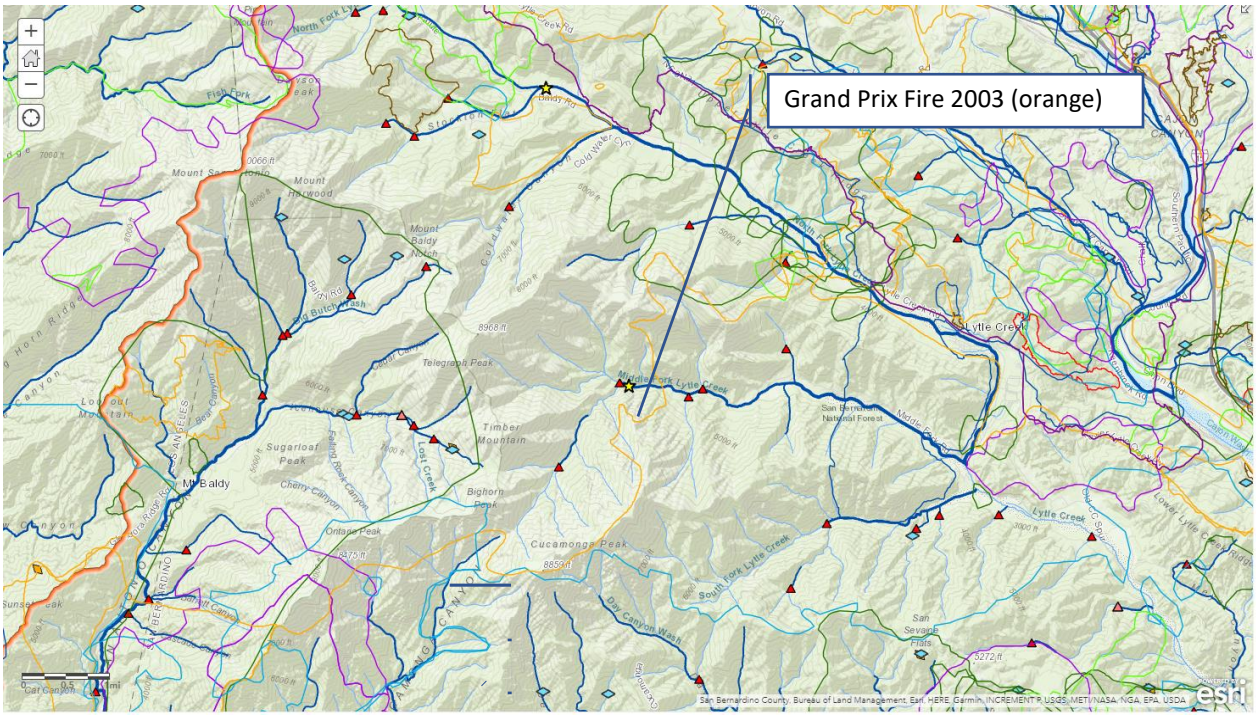

Figure 17. Fire history since 1950 in Lytle Creek drainage.

26. Snow Creek. Northeast of Fuller Mill Creek and San Jacinto Mountain are the forks of Snow Creek. Contact from locals indicate good possibility of trout present (native) and good flow, north facing aspect. The Snow Fire in 2020 may have affected various parts of the stream – the local Native American tribe and fishers should be contacted for more recent information.

From Robert Hepburn (2019) <roberthepburnjseven@live.com>
Here is a link to an article about Snow Creek in Palm Springs Life Magazine by Ann Japenga, and photos by Tom Brewster: https://www.palmspringslife.com/Bohemian-Rhapsody/
I have hiked with Tom to help him with some of his projects, and he did the cover on the ethnobotany book that I wrote. Ann wrote a brief biography of me for the ethnobotany book. The article has a lot of good contacts in Snow Creek who may have some information & photos of the fish in Snow Creek. Tim Hicks grandfather owned The Palm Springs Water Company. Today the Desert Water Agency controls the entrance to the forks coming down out of Snow Creek. Their security is strict there. The Hicks family still has a cabin there next to the Desert Water Company, and is in good standing with them because of who their grandfather was. Tim could be asked to guide a group up to where the trout are. He said that the trout are mostly in the West fork of Snow Creek, and also in the East Fork. But, he has never seen them in Falls Creek.The bad news is that he is sure that long ago there was a hatchery in Snow Creek, and they must have done some stocking. Perhaps, our best luck would be high up the in the creek, above where they could have stocked. Snow Creek is on the North facing slope and must have areas where the forks do not dry up….I spoke to a long term resident of Snow Creek named, Pete Wright. He did extensive fishing in Snow Creek in the 1980s & 1990s. He stated that he caught German Browns in the lower pools, and one weighed 8 pounds. But, up around 4,000 ft elevation he caught Rainbow trout. This is where I am hoping the native trout might be. This area is hard to access, and I think it is unlikely that anyone stocked up that high. I don't think it can be stocked from above. The mountain is so steep.

To note that Russell Barabe and Jen Hemmert responded to Mr. Hepburn in June 2019 with possibility of getting more info and survey volunteers; and making a decision whether to check further.

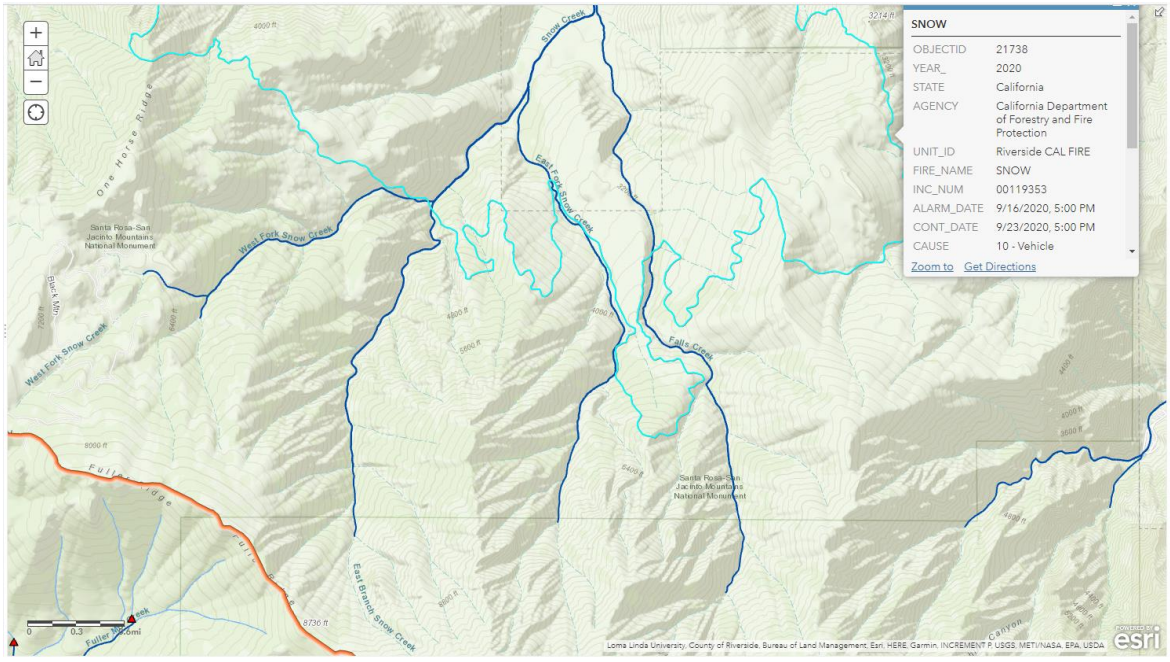

Figure 18. Snow Creek.

The next steps are to ground-truth at least the top ten candidate translocation sites (see below) and to apply this pilot analysis to other mountain areas of Southern California such as San Gabriel Mountains, Peninsular Range, Santa Ana Mountains, and extend to other parts of the state as appropriate.

Prioritize Top 10 Trout Translocation Sites 9/1/2021 – 4/30/2022

3. Ground-truth top 10 candidate native rainbow trout translocation sites; prioritize for assessment.

From a list of >200 candidate translocation sites for native trout in the San Bernardino and San Jacinto Mountains, 26 streams were identified as good candidates for further analysis based on information presented above. At least ten streams will be ground-truthed within the next eight months by CalTrout staff, agency biologist/s and volunteers. From this work, a prioritized list of the Top 10 translocation streams will be generated. The top 10 prioritized streams and selected reaches will be further analyzed by placing water temp loggers, and performing focused habitat and population surveys. Those locations that do not contain existing trout populations are preferred for translocation to avoid hybridization of native trout with hatchery stocked fish. The prioritized list will be further vetted in consultation with state and federal agencies to protect T&E species that may be impacted by trout translocation.

Data collected on-site via CDFW Habitat Restoration Handbook forms are comprised of habitat complexity (CDFW Habitat Inventory Form), stream channel morphology and flow regimes (Stream Channel Type Worksheet), trout and other fish abundance survey via snorkel survey (Stream Observation Form) and/or electrofishing (Electrofishing Form), fish passage barrier analysis (Fish Passage Inventory Form), and water chemistry (Field Data Sheet). Water temperature loggers will be placed as appropriate and available, and data downloaded at least annually. A final report will be generated describing these results.

This work was supported by a CDFW Fisheries Restoration Grant Program award #Q1950903 to California Trout for the South Coast Steelhead Coalition project (2020-2022) and by So Cal Edison for the Trout Refugia project (2020). Contact Sandra Jacobson at sjacobson@caltrout.org for more information. See https://caltrout.org/video for the Coldwater Creek Fish Rescue video (posted 9/7/2021) that describes the rescue, translocation and return of the native rainbow trout in Coldwater Canyon Creek in the Santa Ana Mountains after the Holy Fire by Riverside-Corona RCD, CDFW, USFS and local fire response personnel.