Escalante River Aquatic Assessment

Final Report

Prepared for the Escalante River Watershed Partnership and the Bureau of Land Management

By Trout Unlimited

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1.0 Introduction

In 2013 Trout Unlimited initiated a project with the Escalante River Watershed Partnership (ERWP) and BLM to complete a watershed assessment and compile a geo-spatial database for the Escalante River watershed. The database is a tool that the Partnership requested that will be used as a clearinghouse for working group data as it is collected. The Watershed Assessment is an effort lead by Utah BLM to identify and prioritize aquatic restoration and conservation opportunities for native fish communities and habitat in the watershed, with a focus on Colorado River cutthroat trout, flannelmouth sucker, bluehead sucker, and roundtail chub. Our objective is to compile all watershed-wide available data on habitat and fish populations and, using the conceptual framework of our Conservation Success Index, produce a roadmap of conservation strategies and restoration actions that can be used by the ERWP partner organizations to guide research and data collection, project work, and management actions within the Escalante River watershed.

2.0 Background and Objectives

The Escalante River watershed drains roughly 1.3 million acres of forested and desert landscape in southern Utah, and remains one of the last free-flowing rivers in the American Southwest. The headwaters are administered primarily by the U.S. Forest Service, but most of the watershed—including the impressive Grand Staircase-Escalante National Monument—is managed by BLM. The Escalante, like most rivers in the U.S., faces threats from past and ongoing human impacts and from future climate change, which current models project will reduce water availability by 30-50% in the upper Colorado River basin by the end of this century. These impacts affect both terrestrial and aquatic resources in the watershed, but are especially evident in changes to the river itself, where habitat degradation and modification due to human settlement, invasive species introductions, and changing ecological conditions (e.g., beetle invasion, aspen declines, and catastrophic fires) continue to hasten the decline of sensitive native fish species. Despite this, the Escalante remains a truly unique resource, and one of the few places in the Desert Southwest where a native fish community remains largely intact. Isolated populations of Colorado River cutthroat trout occupy the coldwater upper reaches of the watershed, and three species of native warmwater fish—flannelmouth sucker, bluehead sucker, and roundtail chub—persist in main stem habitats further downstream (Figure 1).

In June 2009, a grant from the National Park Foundation funded a workshop for Escalante River stakeholders to convene and discuss threats and opportunities in the watershed, with an eye toward developing an action plan to guide conservation and resource management activities. The group also formed the Escalante River Watershed Partnership (ERWP), and developed a mission statement to "restore and maintain the natural ecological conditions of the Escalante River and its watershed and involve local communities in promoting and implementing sustainable land and water use practices." The following year, the ERWP adopted the Conservation Action Planning (CAP) tool developed by The Nature Conservancy to guide the development of a watershed plan to help them achieve that mission. The CAP process identifies resources and values to be restored or maintained, current status of and future threats to those resources, and, ultimately, a suite of strategies to eliminate or mitigate those threats. Using the CAP tool, the ERWP identified both Cold Water Lotic and Warm Water Lotic as aquatic resources of value in the Escalante watershed. The status of those resources was then described in terms of specific attributes like fish community, floodplain function, water quality, flow condition, etc. The current conditions across the watershed for those resources ranged from 'fair' to 'good', with an ultimate target of improving each to a 'good' rating.

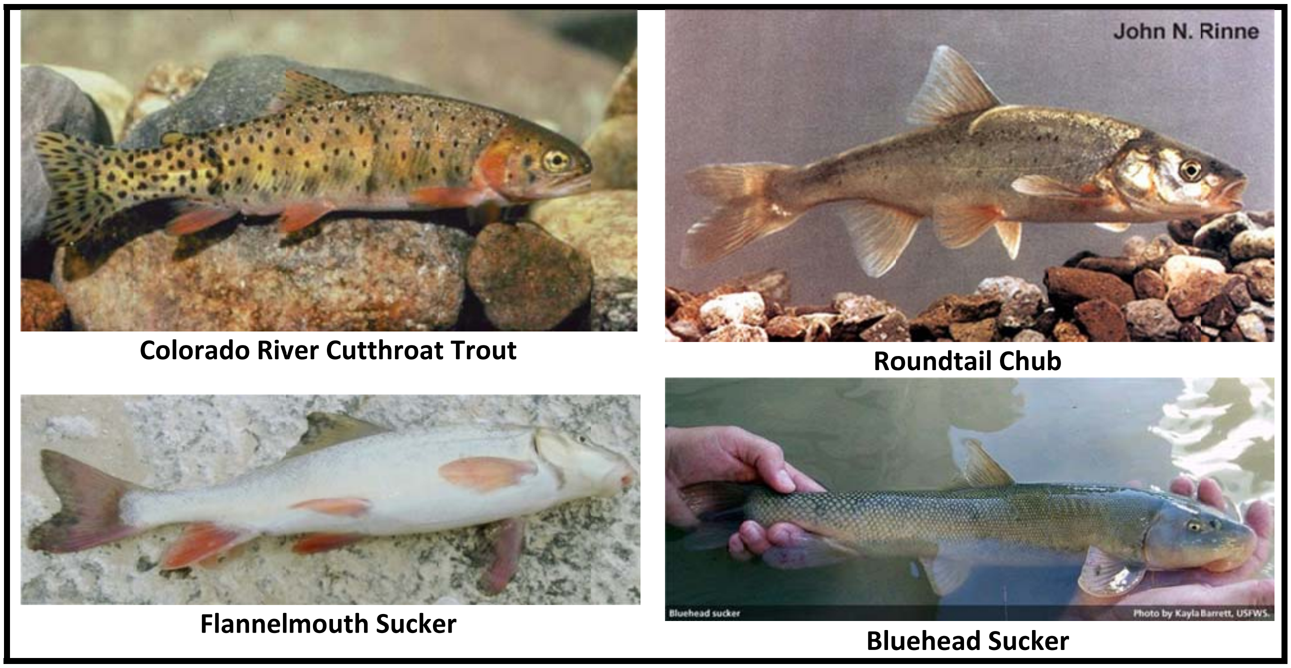

Figure 1. The four native fish species of interest in the Escalante River watershed.

The CAP analysis provides a valuable assessment of current conditions and threats at a watershed scale, but the ultimate goal of the ERWP is to develop a suite of strategies and actions for managers that are targeted at the subwatershed or stream-reach scale. To that end, TU (with BLM support) has developed this Escalante River Watershed Aquatic Assessment as the next step in the development of an action plan. The assessment identifies current conditions, threats, and conservation strategies at the subwatershed level, and provides a roadmap for action to restore and protect this unique landscape.

3.0 Assessment Methodology

The assessment is based on the most consistent information available that occurs through the entire watershed. We acquired spatial and tabular data from state and federal agencies to support a reach-scale analysis of fisheries values and channel habitat conditions and a spatially distributed analysis of upslope conditions. In addition to compiling existing relevant information, we also developed several new spatial data sets using remote sensing and GIS processes. (See the text box at right for a complete

<u>Escalante Watershed Assessment Data</u>
Hydrography
- National Hydrography Dataset
- Perennial stream layer produced by TU
- Subwatersheds

Fisheries
- Point sampling locations including species found and abundance
- Species distributions extrapolated to stream reach – native and nonnative
- Colorado River cutthroat trout conservation populations

listing of the data layers used to support the watershed assessment.) Trout Unlimited did not have the resources to field-verify the data or results of the assessment but instead must rely on the local knowledge of ERWP stakeholders for validation.

Channel Habitat Conditions
- Fish passage barriers
- Riparian corridor vegetation classification, including Russian olive
- Russian olive treatment areas
- Stream reach sinuosity
- Livestock instream water rights
- UT DWQ water quality assessment 2014

Upslope Conditions
- 10 meter digital elevation model
- Roads and road density
- General land use
- General vegetation cover
- Livestock water sources
- Surface water diversions
- Underground water
- Springs

Remote Imagery
- 2011 NAIP imagery, 1 meter resolution
- Select historical aerial photographs, georeferenced

The underlying hydrography used in the assessment is from the National Hydrography Dataset (NHD) published by the USGS and edited by Trout Unlimited. TU staff extracted the known perennial streams based on their attributes in the NHD and verified by the Historical and Current Distribution Layers in the Colorado River Cutthroat Trout geodatabase. These two sources were used to develop a base stream layer for our reach-scale analyses. We acquired National Aerial Imagery Program (NAIP) photographs from the summer of 2011 for the basin at a resolution of one meter. The perennial streams data layer was then overlaid onto the imagery and manually edited to more accurately delineate the stream channel alignments.

We obtained a series of historical aerial photographs from 1951 and 1960 that cover most of the main stem of the Escalante River (Figure B-1). The photographs were georeferenced to facilitate comparisons with current conditions of the riparian corridor and stream channel alignment (Figures B-2, B-3, and B-4). Due to the incomplete coverage of the watershed, the historical imagery was not used in our assessment but the georeferenced images will be provided to the ERWP and BLM as part of the project database. Additional information on the historical imagery is provided in Appendix B.

3.1 Fishery Values

Native Fish
- Colorado River cutthroat trout
- Roundtail chub
- Bluehead sucker
- Flannelmouth sucker

Nonnative Salmonids
- Rainbow trout
- Brook trout
- Brown trout

Other nonnative fish
- Channel catfish
- Redside shiner
- Flathead minnow
- Common carp

We obtained point-data for the location and population densities of native and nonnative fish from several sources including the Utah Division of Wildlife Resources native and sport fish sampling programs and the Dixie National Forest, which had collected fish location and population data in the headwater tributaries. Data for Boulder Creek was available through a 2012 report by the Utah Water Resources Lab at Utah State University. The sampling data were reported with inconsistent metrics so we distilled the multiple metrics into a single and consistent data set for the watershed. For example, warmwater fish sampled in the Escalante River were reported as fish/m^3, while salmonid data in the headwaters were reported as # of fish/mile, # of fish/m^2 or #of fish/100m^2. We chose to use number of fish/mile as the preferred common metric because it is consistent with the three-species and CRCT geodatabases and will therefore simplify cross referencing of the population data. Next, we classified the fish population data into five density categories for each species.

pdsID	CRCTDBValue	PopDenDesc	PopDenClass
1	8	0-50 Fish per Mile	Very low
2	9	51-150 Fish per Mile	Low
3	10	151-400 Fish per Mile	Medium
4	11	Over 400 fish per Mile	High
5	12	Unknown	Unknown

Where:

- pdsID is the coded value recorded in the shape file attribute table
- CRCTDBValue references the coded value in the CRCT geodatabase
- PopDenDesc provides a quantitative range that describes the coded value
- PopDenClass represent the subjective classes of fish densities

Using the perennial stream layer as the base layer, we classified the fish distributions into populations by extrapolating species distributions between the point sampling events, depending upon stream connectivity. A population was defined where a given fish species had been recently sampled within a stream reach and where the perennial habitat is connected and available to the fish. If no complete barriers occurred between two sampling points, the stream segments between those two points were connected to define a single population. If a complete barrier was found between two sampling points then the barrier location was used to split the distribution into more than one population. If a population was sampled below a barrier but not above, we used our best professional judgment to determine the likely extent of fish populations upstream of barriers; however we attributed these populations as 'low confidence'. Different reaches with variable population densities were attributed accordingly within a single population, resulting in populations with heterogeneous densities. The certainty of the supporting data behind each population was attributed based on the source data from which the distribution was derived. Data quality ranged from extrapolation based on connectivity (low confidence) to high quality, major sampling efforts (high confidence). Figure A-1 shows the distribution of native and nonnative fish by stream reach.

3.2 Channel Habitat Conditions

Only limited and inconsistent information is available for channel habitat integrity across the entire watershed. As an alternative, we used surrogates to characterize conditions at the stream reach scale. The four indicators of channel conditions and the underlying data/surrogates used to characterize these factors are listed in the following text box.

Habitat Complexity
- Stream reach sinuosity

Connectivity
- Passage barriers

Riparian Condition
- % woody or emergent riparian vegetation
- % upland vegetation
- % Russian olive

Water Quality
- 2014 Impaired streams
- Livestock watering sites
- Dirt roads: stream crossings and within riparian corridor

Habitat complexity is an important factor in the overall health and long-term viability of aquatic species assemblages. However, characterizing it at a meaningful scale across a large landscape is typically not practical and requires the use of a surrogate. We chose sinuosity as a suitable surrogate under the assumption that the increased presence of meanders provides for more varied habitats. We calculated sinuosity for each reach using a simple mathematical equation that calculates a ratio between the actual stream length and the straight-line distance between the starting and ending points of the reach. We recognize however, that variability in the underlying geology of the tributaries and main stem Escalante River has an effect on the potential sinuosity of a given reach. Therefore, we calculated the range and mean sinuosity values for the tributaries and main stem Escalante independently of one another and used the resulting values to establish our classifications of high, moderate, and low sinuosity (Figure A-2). We also recognized that the geological constraints for the main stem of the Escalante River were different from the tributary streams. In general, the tributary streams were steeper and straighter. This analysis stratified between the two stream types (e.g. main stem and tributary), which prevented the inappropriate comparison between the two.

Trout Unlimited staff used the perennial stream layer to locate all known fish passage barriers across the watershed. An important component of this analysis included the consolidation of fish passage barrier data from various sources into a single GIS layer. Over the past several years the UDWR, TU, BLM and the Dixie National Forest have all engaged in barrier assessments in parts of the watershed. However, the data and measurements were inconsistent and housed in different GIS databases. TU staff compiled the information into a single spatial data set where each barrier is referenced to a specific NHD stream reach, and is classified according to several attributes, including the extent of blockage (partial or complete) and the type of barrier (i.e. Water Diversion, Culvert, Manmade Dam, etc.). In order to provide consistency with the CRCT and Three-Species Databases, the attribute classes and barrier ID's in those data sets were carried forward in the new data layer. This allows for the cross-referencing of individual barriers between the datasets. Finally, we completed a remote barrier assessment using high resolution aerial imagery to fill in the gaps in coverage primarily associated with private lands. Figure A-3 shows the location of passage barriers within the watershed by barrier type and extent of blockage.

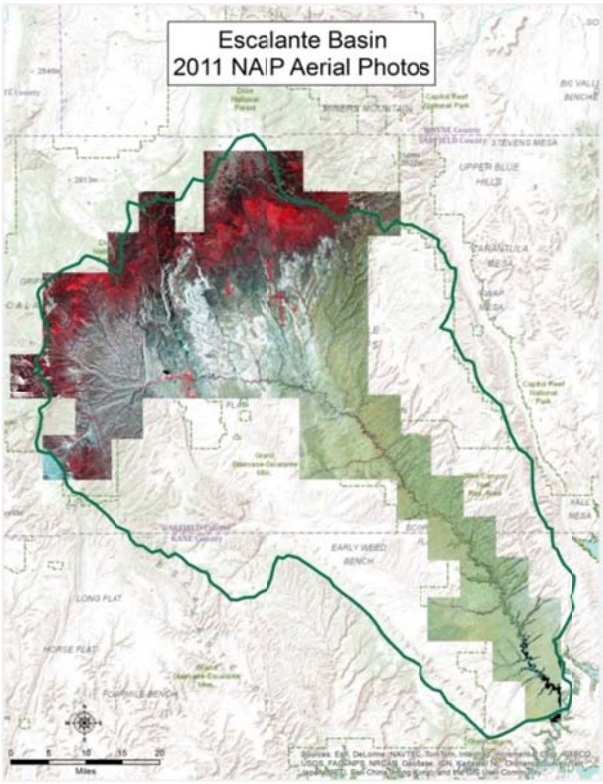

Figure 2. Coverage of NAIP imagery.

In order to characterize the riparian vegetation we completed a vegetation classification using the feature extraction tools within the Feature Analyst GIS software package. These tools use the spectral information from sample polygons delineated by GIS technicians for each vegetation type, and perform statistics on the NAIP imagery (Figure 2) to cluster pixels within the entire image into land cover classes based on common signatures. Our classification is limited to the floodplain area and includes the following classes:

- woody riparian vegetation,
- emergent riparian vegetation,
- upland sagebrush shrubland/grassland,
- bare ground/sand/rock,
- agriculture,
- roads,
- water,
- Russian olive.

The results of the image classification were then summarized by stream reach as a percent of the floodplain associated with each reach. The floodplain was generated from a 10 meter digital elevation model. Although this resolution may not be detailed enough to capture all of the topographic complexity of the Escalante landscape, it did allow for more refinement of the floodplain delineation than can be obtained with a simple buffering of the stream reaches. Figures A-4, A-5 and A-6 show the results of our analysis for the presence of emergent/woody riparian vegetation, upland vegetation, and Russian olive, respectively. Figure A-6 also shows the percentage of treated lands within each of the treatment areas from data provided by The Nature Conservancy. Many of the stream reaches within the Russian olive treatment areas were found to have less than 1% Russian olive within their associated floodplain. When interpreting these results it is important to keep in mind that the percentages are based on the area of the floodplain associated with each stream reach. In canyon reaches the floodplain area may be quite small so that a high percentage value may only represent a very small land area. We applied the results to the entire stream reach in order to support the integration of the riparian data with other reach-scale analyses.

Water quality was evaluated only at the stream reach scale and did not account for cumulative downstream impacts. Although water quality impacts propagate downstream, the intent of the analysis was to identify the important reaches that are most likely to be contributing to water quality issues within the watershed and may also have significant localized water quality problems. Data on impaired rivers and streams from the Utah Division of Water Quality 2014 Integrated Report was obtained. Upper Valley Creek, Birch Creek and North Creek were all identified as not supporting beneficial uses due primarily to dissolved oxygen levels and temperature. Additional water quality factors include local effects from concentrated livestock utilization and dirt roads. Livestock utilization was characterized based on water rights data from the Utah Division of Water Rights database. The database locates 'point to point' diversions that are described in the database documentation as undeveloped '*points of diversion….[associated with] a stream segment from which stock may drink.*' Although the actual location of these points is imprecise – they are typically designated within a 40 acre parcel – by definition they are associated with a natural water feature and are therefore relevant to our water quality analysis. Figure A-7 shows the relative concentration of instream water rights for livestock.

Finally, dirt roads are a well-known source of sedimentation for aquatic systems, particularly when they intersect or are in close proximity to a water source. The number of stream crossings and linear extent of dirt roads within the riparian corridor normalized by the length of the stream reach was calculated for each reach. Figure A-8 shows the potential relative impact from dirt roads by stream reach.

3.3 Upslope Conditions

We characterized the upslope conditions by incorporating an analysis of water quantity and sedimentation risk as two factors with far-reaching implications for native fish conservation in the watershed. The text box to the right lists the data elements incorporated into these two elements of the assessment.

Water Quantity
- Surface diversions
- Reservoir storage
- Groundwater wells
- Water intensive land use

Sedimentation Risk
- Ungulate grazing suitability
- Density of dirt roads
- Land use

Much of the data for the water quantity analysis comes from the UT Division of Water Rights database which includes spatial and tabular data for all of the existing water rights within the watershed. For the purposes of this analysis we selected all active surface and underground water rights and summarized the total water right for each subwatershed within the study area. Figures A-9, A-10 and A-11 show the cumulative water rights for surface diversions in both cfs and acre-feet and underground water rights in cfs, respectively. An additional factor included in the assessment of potential water quantity limitations is the presence of water intensive land use, primarily irrigated agriculture (including irrigated pasture) and municipal use. Figure A-12 shows the distribution of these land uses within the watershed.

Recognizing the importance of soil characteristics to sedimentation risk, we obtained soil survey data for the watershed. However, the soils data from the Dixie National Forest was incomplete, with virtually all of the forest lands within the Escalante River watershed classified as 'unrated' for erosion hazard. Therefore, in order to apply a consistent methodology across the entire watershed for each of the indicators analyzed, we had to rely on other surrogates for sedimentation risk that incorporate human activities on the landscape in which the associated surface disturbances may contribute to an increased risk of erosion.

The upslope sedimentation analysis considers three potential anthropogenic sources of sediment to the drainage network: livestock grazing, dirt roads, and surface disturbing land uses. Our assessment of livestock grazing is based on the ungulate grazing suitability analysis developed by Joe Wheaton at Utah

State University (Macfarlane and Wheaton, 2013). The analysis is conducted as a spatially distributed model across the entire watershed incorporating data layers on distance to water, slope, and vegetation. We applied the criteria outlined by USU to develop a suitability index across the watershed for ungulate grazing (Figure A-13). We recognize that all suitable areas are not necessarily grazed by domestic livestock but we have been unable to obtain watershed-wide information on public and private land grazing. The results of our analysis should be interpreted within the context of local knowledge related to the grazing regimes currently in place within the watershed. To that end, the results can help to identify those areas most likely to be experiencing the greatest livestock utilization within a larger allotment.

Figure A-14 shows the density of unimproved dirt roads across the watershed. This analysis is different than the dirt roads in proximity to stream channels described previously. In this case we characterized the density of dirt roads over the entire subwatershed. Figure A-15 shows land use activities that have the potential to contribute sediment to the drainage system. This includes agricultural lands, both irrigated and non-irrigated, moderate to high density urban development and areas that have been logged. When compared to road densities and potential livestock utilization, these land uses represent a very small part of the watershed.

4.0 Assessment Results

After compiling data on fisheries and habitat conditions, we then conducted a series of analyses integrating the different spatial data layers in order to highlight those stream reaches and subwatersheds where targeted restoration work may yield the greatest benefit for native fish in the watershed based on the value of the fishery and the limiting factors. Table 1 provides a summary of fishery values and limiting factors at the subwatershed scale while the following sections and associated figures provide a more spatially explicit description of our findings from the different assessment components.

The results described in the sections below should be further informed by local knowledge before development of site-specific restoration strategies. We recognize that there may be local environmental factors as well as social considerations important to the development of reach-scale conservation actions that were not possible to include in this watershed-scale assessment.

4.1 Fishery Values

Figure 3 shows the results of our analysis of fishery values within the watershed. Stream reaches classified as high value (green on the map) support at least two of the three warmwater species of interest (i.e. bluehead sucker, flannelmouth sucker, and roundtail chub) or a genetically unaltered population of Colorado River cutthroat (CRCT) or a population of CRCT at high density. Streams classified as moderate value (blue on map) support only one of the warmwater species or a low density population of CRCT that may be hybridized or the genetics are unknown.

Based on these criteria, the mainstem of the Escalante River between Harris Wash and Pine Creek, as well as the headwaters of Pine Creek and Boulder Creek and the lower reaches of Calf Creek and Sand Creek, are of particularly high value for native fish. Several small tributaries to the upper end of North Creek are also of high value for CRCT and are protected from invading rainbow and brook trout by restoration barriers at the confluence with North Creek. The flannelmouth sucker is still present below Harris Wash, but warmwater nonnative species such as channel catfish are also prevalent.

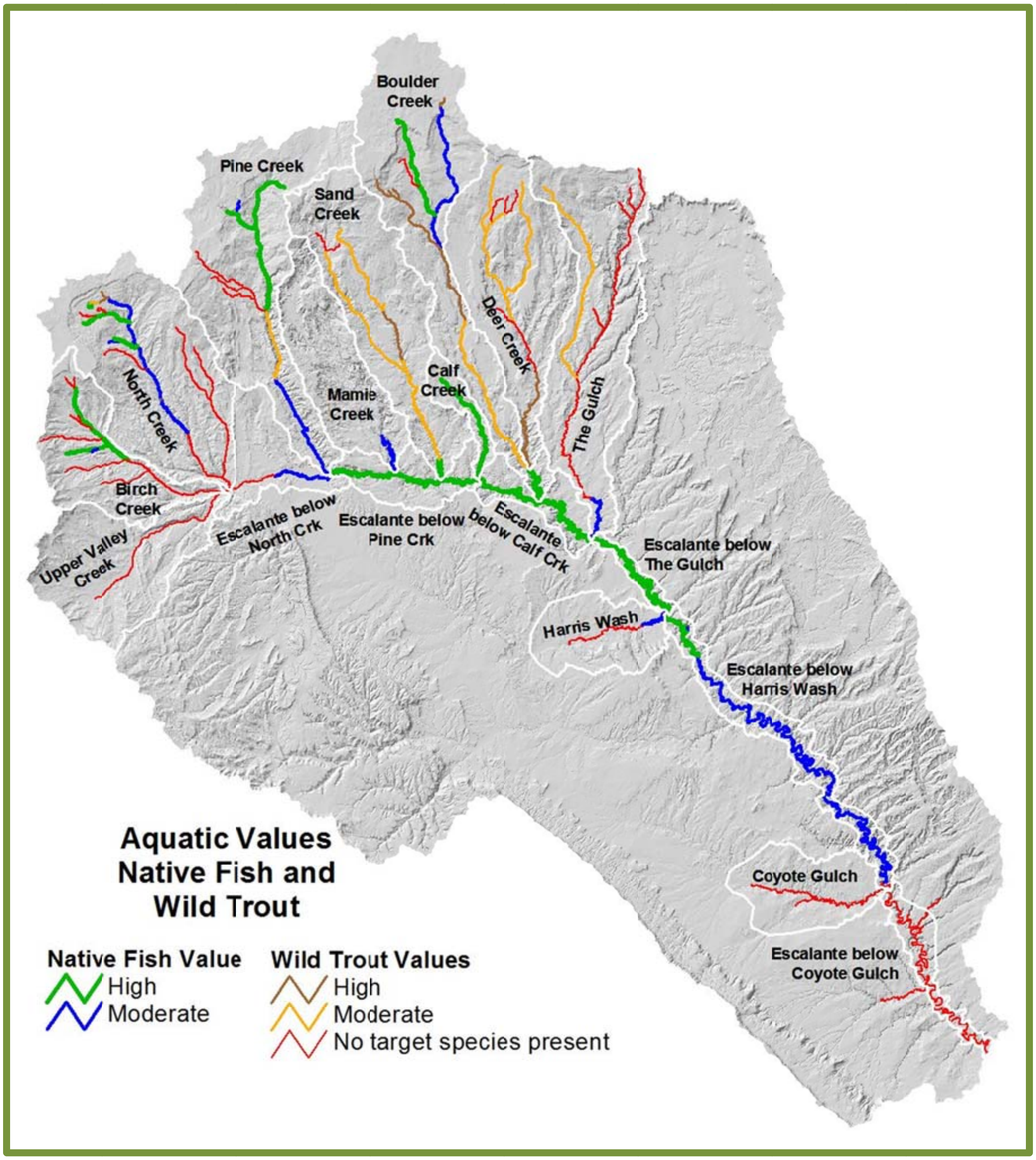

Figure 3. Native fish and wild trout values.

In recognition of the socio-economic value of a wild trout fishery, we have also identified potentially important wild trout fisheries in those streams where they do not conflict with native fish values. Rainbow, brown and brook trout are all present within the larger watershed. Stream reaches classified as high value for wild trout (brown on map) support either two species of wild trout or one at a high density. The remaining wild trout streams were classified as being of moderate value (orange on map) while the rest of the reaches (red on map) do not support any of our target species. Based on these criteria, Sand Creek, Deer Creek, and Sheep Creek (tributary to The Gulch) may provide opportunities for a wild trout fishery that does not directly impact native populations of CRCT. Rainbow, brook and brown trout are all present in Boulder Creek but here their presence directly threatens high value populations of CRCT.

4.2 Channel Habitat Conditions

Figure 4 represents the compilation of the four indicators used to characterize channel habitat conditions at the stream reach scale. These included water quality, sinuosity as a surrogate for habitat complexity, riparian vegetation, and connectivity. Each of the factors described in the methods section were broken into three categories based on the total range and mean of the values. Our intent is to provide a relative ranking of habitat conditions within stream reaches rather than calculate a significant quantitative measure. We then reclassified each of the variables on a 1 to 3 scale with 1 representing poor conditions and 3 representing good conditions, relative to the other reaches. These values were then summed across all of the factors for each stream reach.

The main stem Escalante below Deer Creek as well as The Gulch support some of the highest quality channel habitat conditions, while the main stem and headwater tributaries above Pine Creek are lower quality. This is generally a reflection of poor water quality in these upper reaches as well as the presence of dams, diversions and culverts that impede passage, particularly on the tributaries.

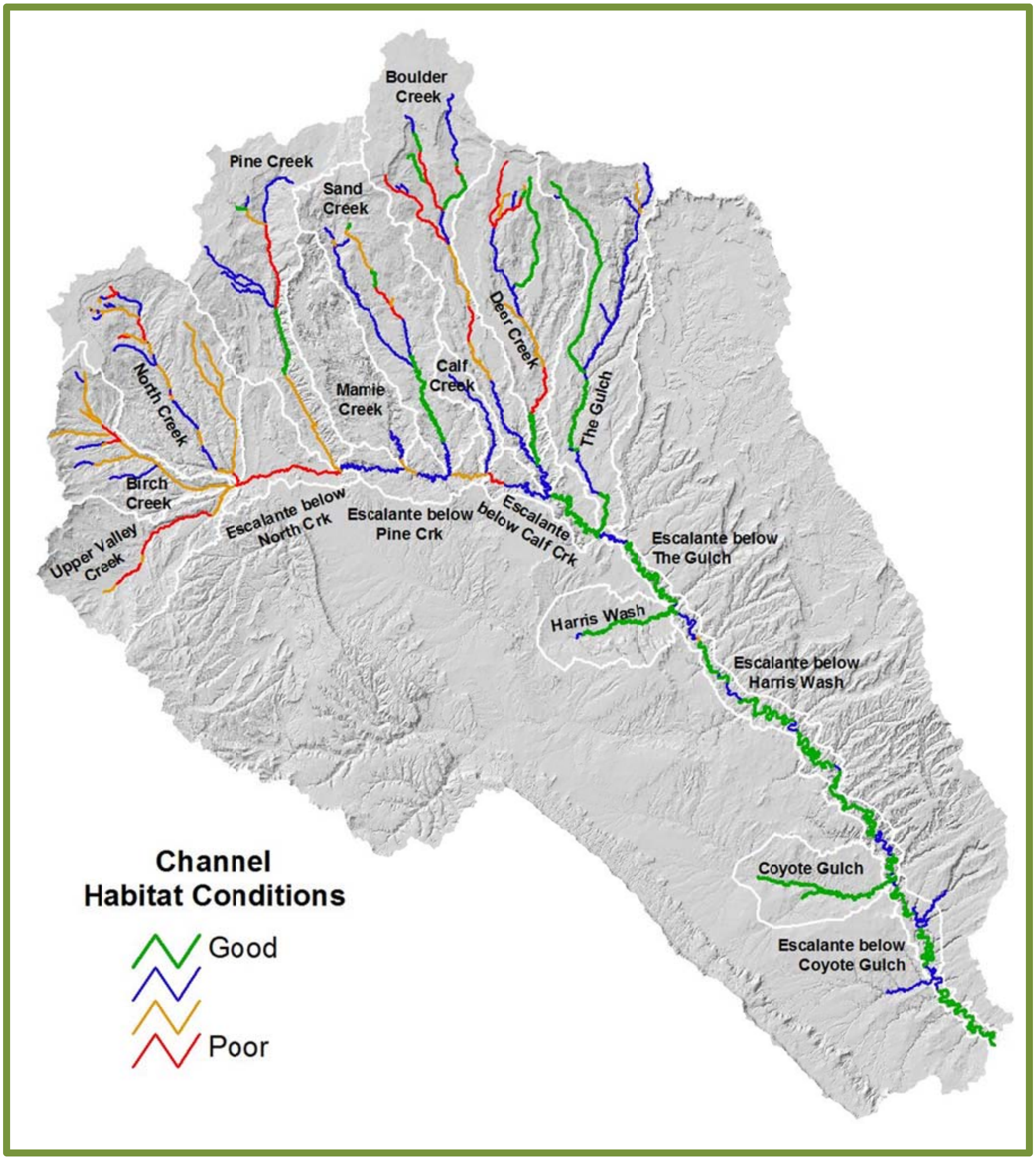

Figure 4. Channel habitat conditions. Composite of analyses on water quality, riparian vegetation, sinuosity and connectivity.

4.3 Upslope Conditions

Figure 5 provides the volume of surface and subsurface water withdrawals for each subwatershed. The surface diversions include both streams and springs as well as diversions associated with reservoir storage while underground diversions are primarily groundwater wells. (Measurements in acre-feet were converted to cfs to allow for a representation of the cumulative water rights associated with each subwatershed.) There are some diversions on the Escalante River, particularly above Pine Creek, but the majority of the surface diversions are found in the tributaries. Boulder Creek and the headwaters of Pine and North creeks have the highest cumulative water rights for surface diversions while Deer and Boulder creeks as well as the Escalante between North and Pine creeks have the greatest cumulative underground water rights.

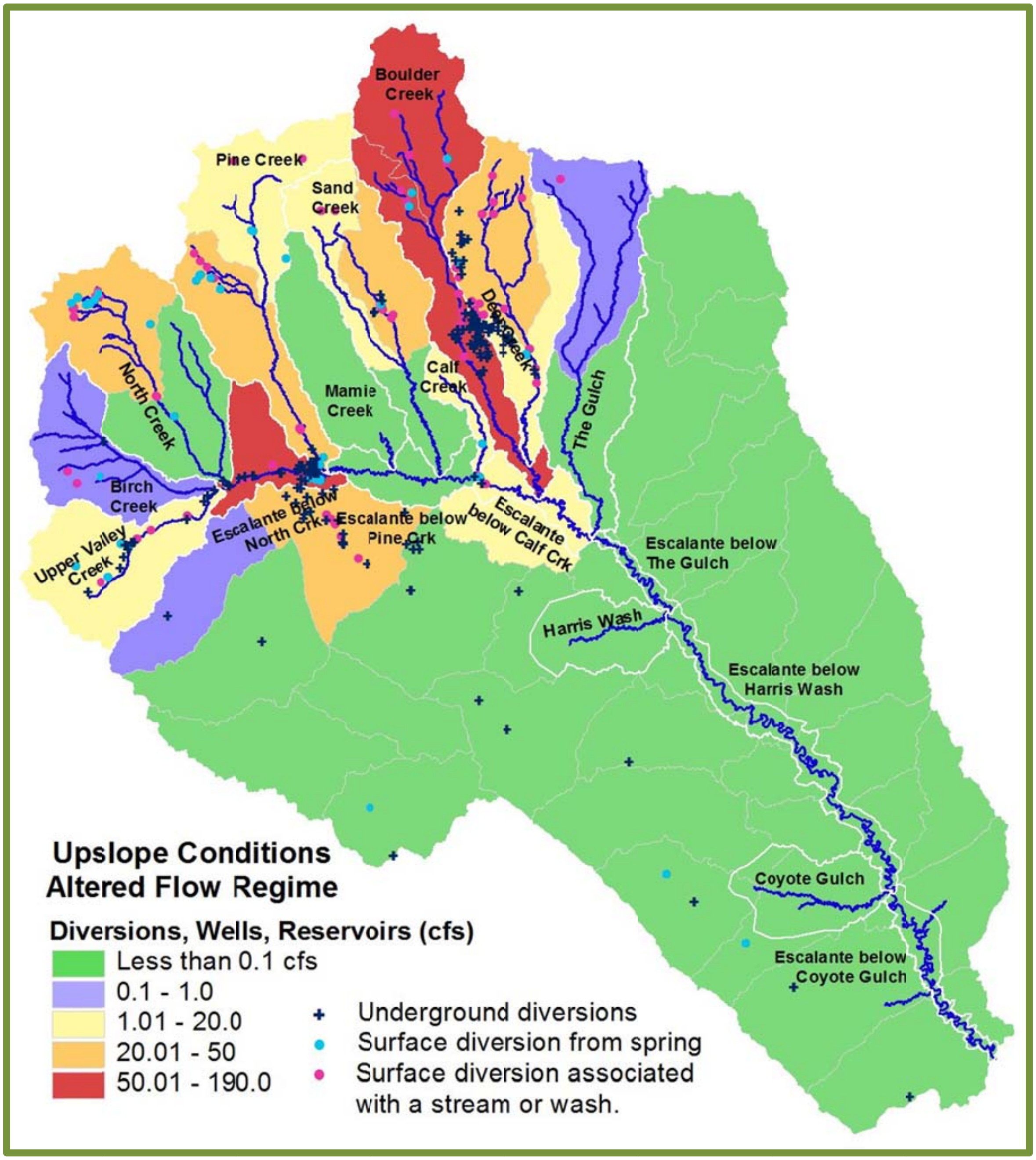

Figure 5. Cumulative water rights for each subwatershed. Includes all active water rights associated with surface diversions, reservoir storage and underground water rights.

Figure 6 is a combination of the three sedimentation assessments (dirt roads, grazing, and land use) with additional weight given to the presence of risk factors in the valley bottoms of perennial streams. The results represent the relative sediment risk for the watershed from anthropogenic sources. However, when interpreting the results it is important to keep in mind that this only depicts potential sources of sedimentation and does not take into account transport mechanisms which will ultimately determine whether or not the sediment is delivered into the drainage network.

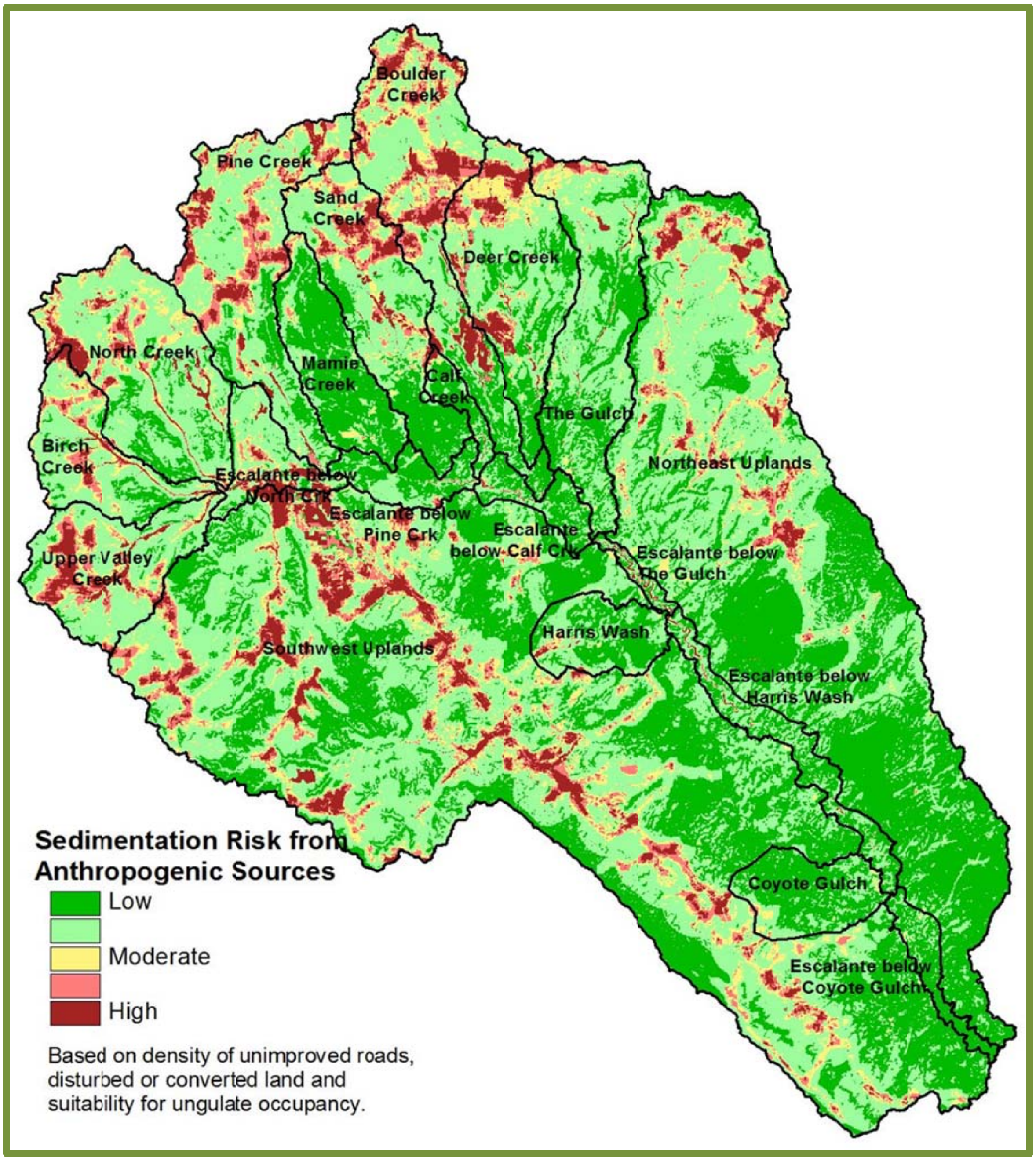

Figure 6. Cumulative risk for increased sedimentation from density of dirt roads, livestock grazing, and surface disturbing land uses such as agriculture and logging.

4.4 Limiting Factors

Table 1 identifies the target fishery and describes the limiting factors at the subwatershed scale for each of the analysis units of interest within the larger watershed. Figure 7 shows the threat to the four native species of interest from nonnative fish. The threat from nonnatives was classified as high if rainbow trout, brown trout, or channel catfish were present due to the potential for direct predation on warm water species by all of these fish as well risk of hybridization with CRCT by rainbow trout and competition with CRCT by brown trout. The nonnative threat was classified as moderate if brook trout or red shiners were present. Brook trout compete with CRCT while red shiners are very competitive with warm water species and may eat their eggs.

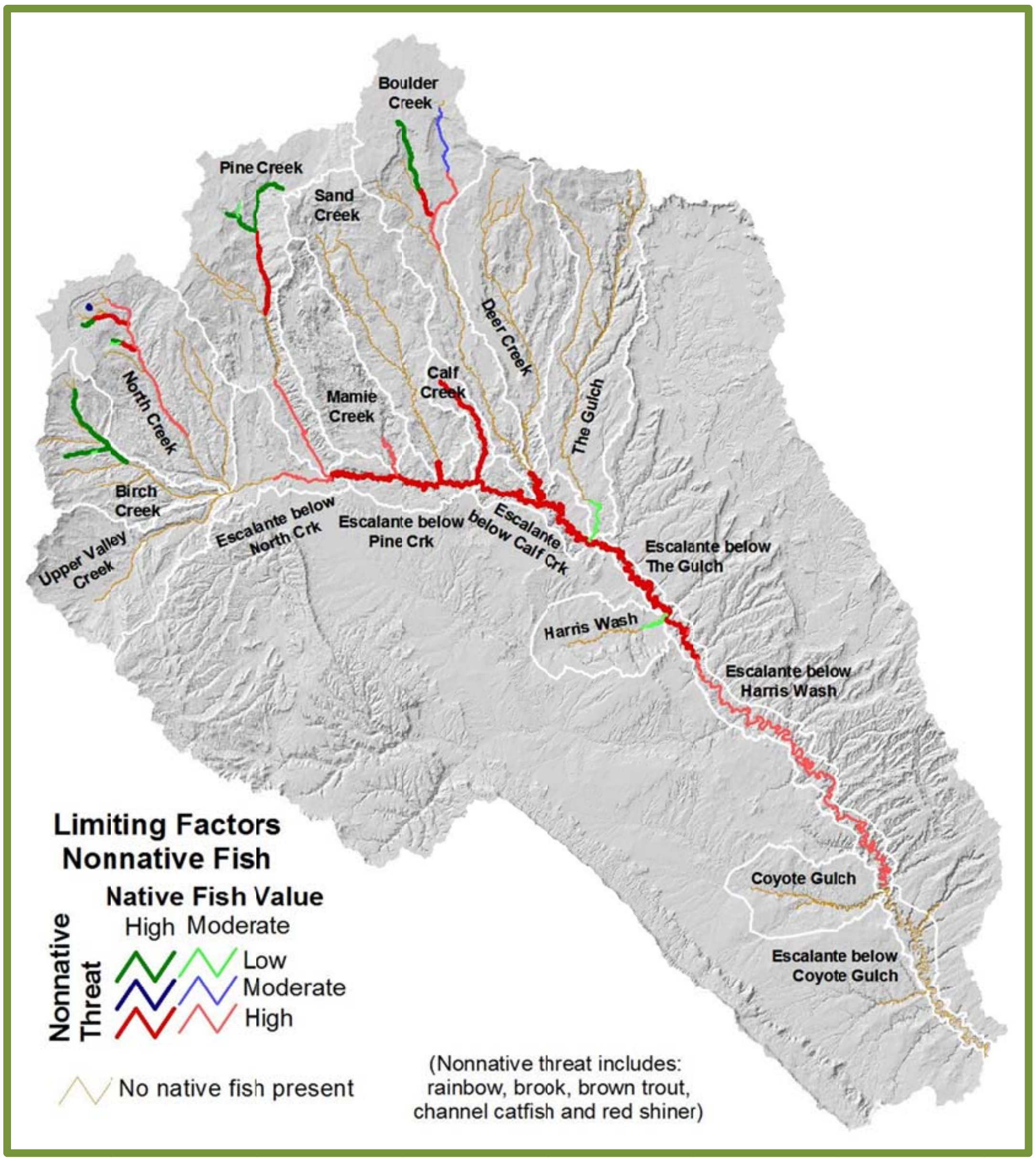

Figure 7. Limiting factors for native fish due to nonnative fish.

Figure 8 shows native fish values relative to overall channel habitat conditions. This represents the compilation of the channel habitat factors previously described (e.g. sinuosity, connectivity). Each of the factors was broken into three groups and given a score from 1-3 with 1 representing poor conditions and 3 representing the best conditions. The scores were summed by stream reach and the results are shown below.

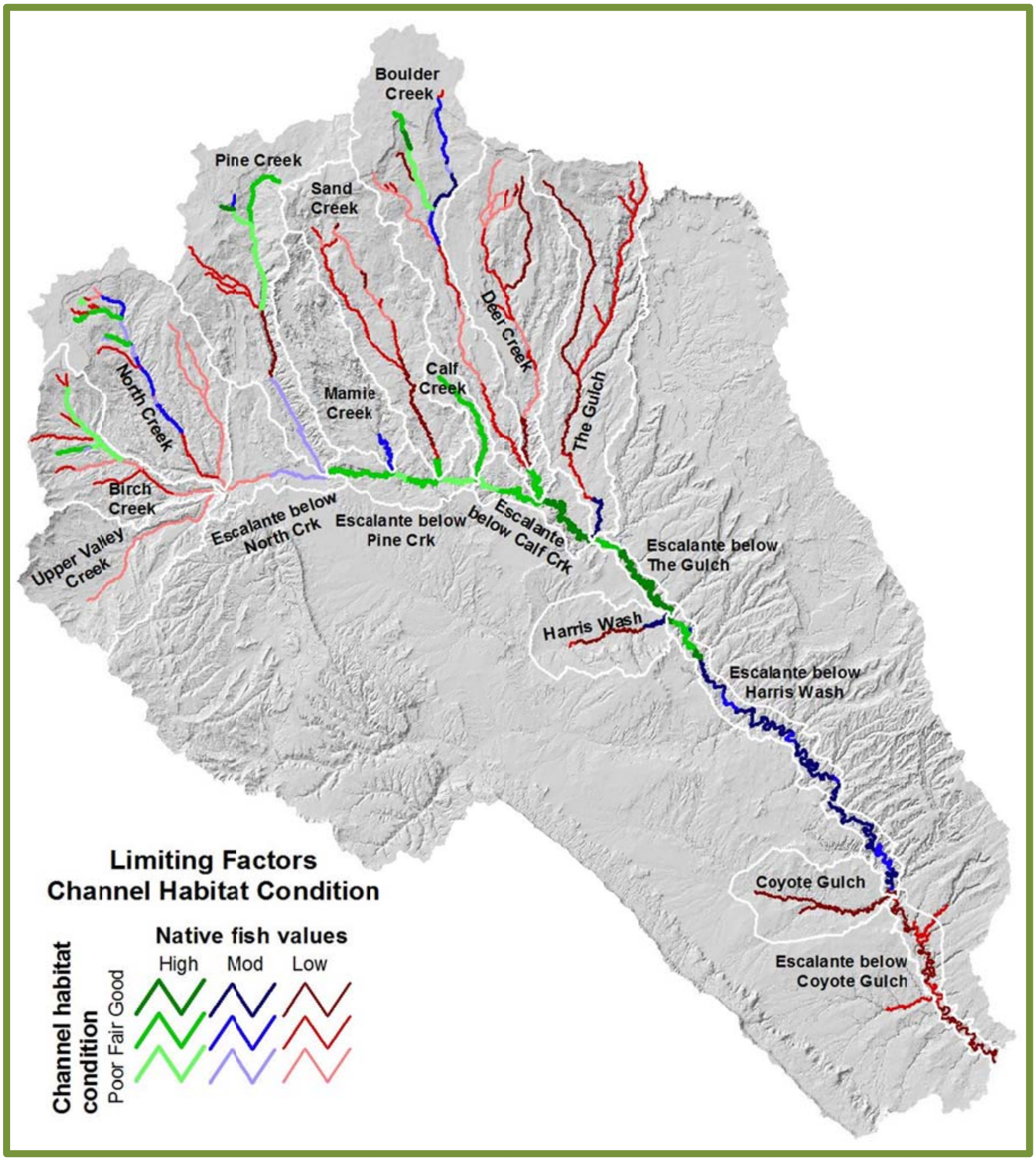

Figure 8. Limiting factors for native fish due to channel habitat conditions.

4.5 Climate Change

The climate change analysis in the Colorado Plateau Rapid Ecological Assessment (REA) projects increased warming and drying for the ecoregion along with changes in the seasonality and intensity of precipitation events (Bryce et al 2012). These climatic changes are likely to result in shifts in vegetation composition and diversity, increased frequency and intensity of wildfire, and changes in the hydrologic regime with more intense runoff and lower late season stream flows.

These changing regional environmental conditions have implications for the long-term management of the Escalante River watershed and the native species that have evolved within the watershed. An increase in high intensity precipitation events and the occurrence of an earlier and higher spring runoff have the potential to exacerbate sedimentation risks within the watershed. Reduced sinuosity and the channelization of the drainage network may also compound downstream flood effects resulting in increased bank erosion as well as channel scouring.

The flannelmouth sucker (FMS) and CRCT are both identified as conservation elements within the REA. The near-term (2025) risk to the FMS from development, fire, and invasive species within the Escalante is classified as very high while the longer term (2060) potential risk from climate change is classified as moderate to moderately low. This is in spite of the ecoregion-wide finding that 35% of the current distribution of FMS is at moderately high to very high risk for long-term potential impacts from climate change. This underscores the importance of the Escalante watershed to the long-term viability of FMS across its current range and highlights the need to minimize and mitigate the near term effects. In contrast the near term risk to existing populations of CRCT within the Escalante watershed is classified as moderately low while the long term risk ranges from moderate in Boulder Creek to very high in Pine, North and Birch creeks. Across the ecoregion about 25% of CRCT habitat was classified as moderately high to high risk for climate change. Riparian vegetation was also identified as a conservation element within the REA which found that about 1/3 of existing riparian habitat was at moderately high to very high risk from climate change across the ecoregion.

5.0 Application and Management Recommendations

Trout Unlimited has compiled the available data for the Escalante River Watershed and completed our Watershed Assessment. Like the TNC CAP report, we have described conditions and limiting factors (Table 1), but we have done so at a much finer spatial scale that informs specific management actions, or restoration strategies (Table 2). Our quantification of fisheries values suggests that restoration and protection of native fish communities will likely focus on the main stem Escalante River between Harris Wash and Pine Creek, and in the upper ends of tributaries like Pine, Boulder, Calf, and Birch creeks. In contrast, wild trout values are moderate to high throughout Sand, Sheep and Deer creeks, suggesting management of those drainages could focus on maintaining fishable wild trout populations. These high value sport fisheries represent good candidate waters where CRCT could be reintroduced if the social, financial and biological factors allow it. Boulder Creek presents an interesting case where native fish values are high in the upper reaches and wild trout values are moderate to high in the middle reaches. If ecological and social constraints could be overcome this system might lend itself to expansion of native trout downstream into middle reaches; if not, the stream could be dually managed for native trout and wild trout via the use of barriers.

Habitat integrity, like native fish and wild trout values, varies across the watershed. Riparian corridors along much of North, Pine, and Boulder creeks are dominated by woody and emergent vegetation and should be protected, while the main stem Escalante River and the lower ends of many tributaries appear to be likely candidates for riparian restoration and/or active management. Livestock and surface water diversion rights are concentrated in tributaries and the upper watershed, suggesting that agricultural impacts are likely greatest in those areas. A combination of improved grazing management to protect riparian areas and irrigation efficiency upgrade projects to restore fish passage and augment instream flows could address these limiting factors. Dirt roads also are concentrated in the upper reaches, so sediment delivery from a combination of grazing and recreation is likely higher there, as well. The lower tributaries and main stem reaches appear to have greater habitat complexity (as indicated by sinuosity), but also a higher concentration of groundwater pumping rights, which likely impact hydrologic function.

Lastly, non-native fish present a real threat to high-value native fish populations throughout the watershed, with the exception of native CRCT populations isolated by barriers in the upper ends of Birch, North, Pine and Boulder creeks. Unfortunately, this ubiquitous threat is among the most difficult to address via management, especially with regard to the three warmwater species (BHS, FMS, RTC) that don’t lend themselves well to protection via barriers. However, knowing where the native fish strongholds are should inform management decisions and allow managers to better target habitat restoration or protection efforts to benefit them.

References

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State of Utah, Department of Natural Resources, Division of Water Rights. 2012. Water Rights database.

Appendix A: Supporting Maps

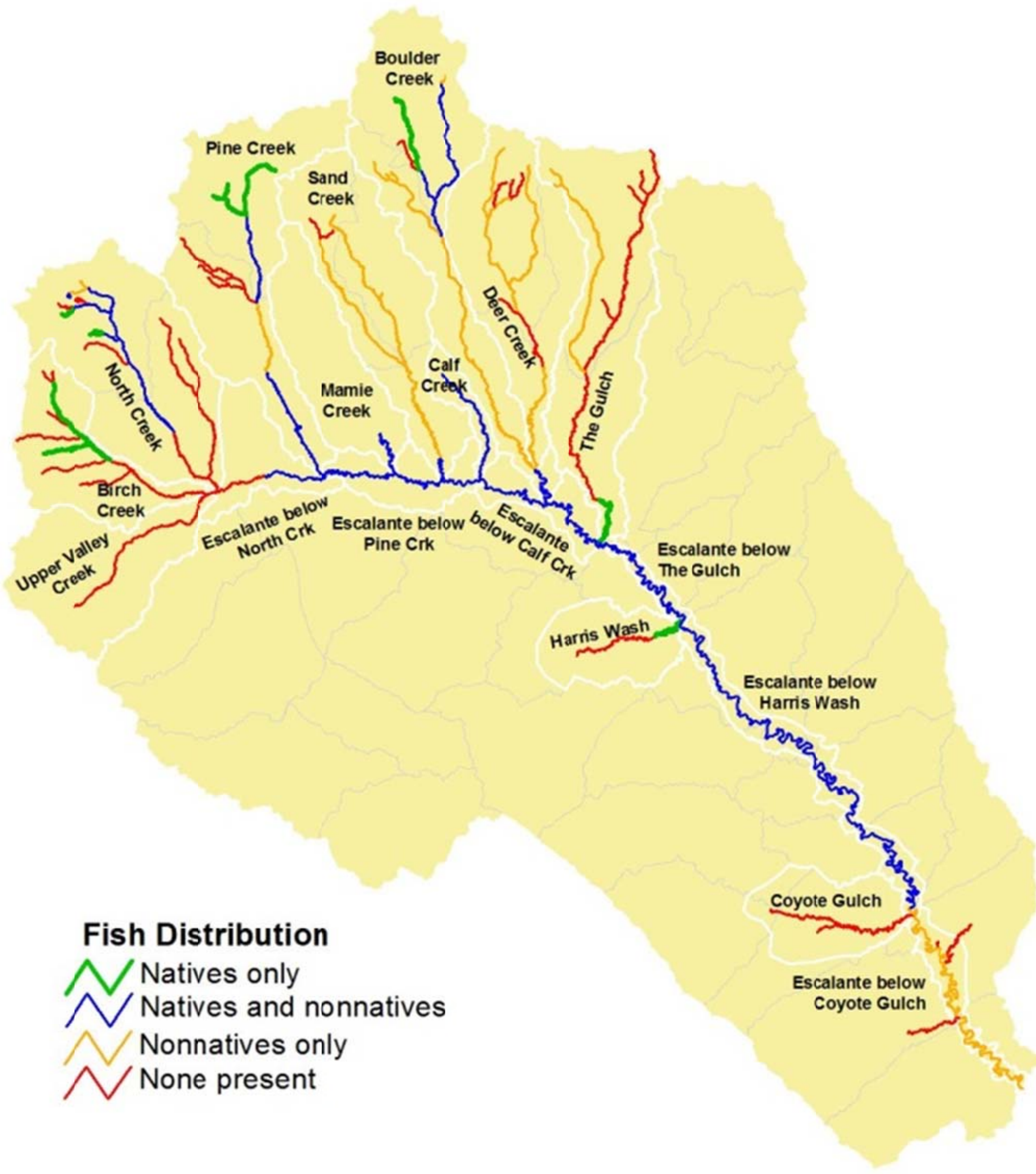


Figure A-1

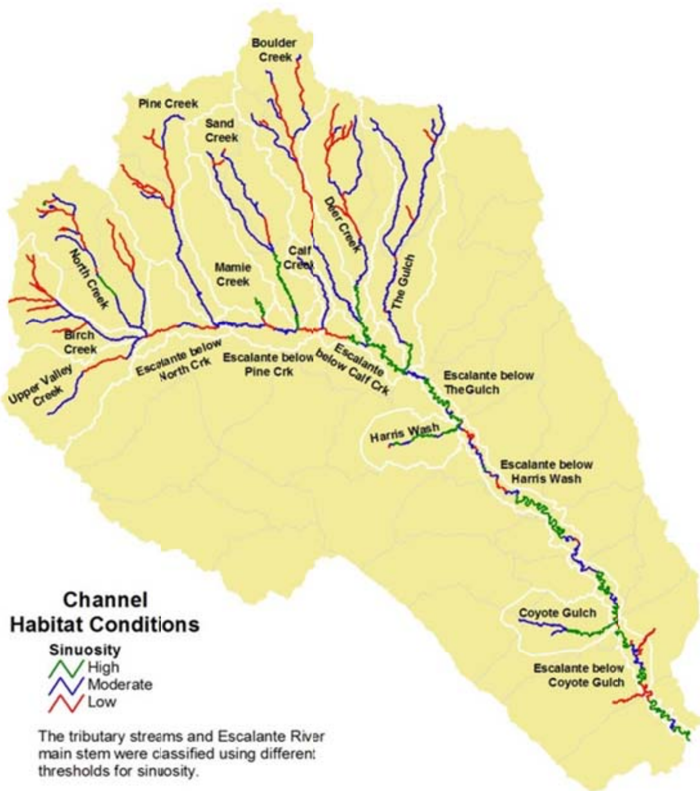
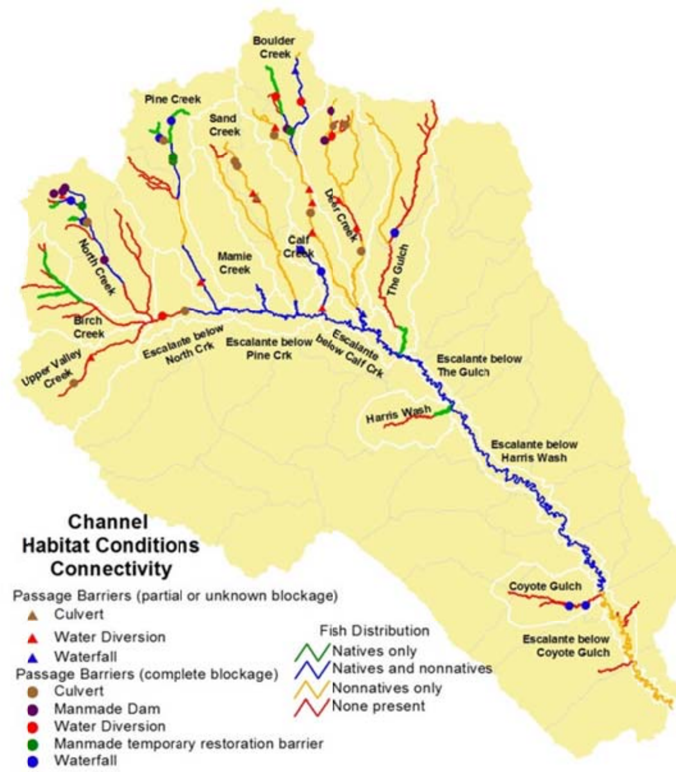


Figure A-2



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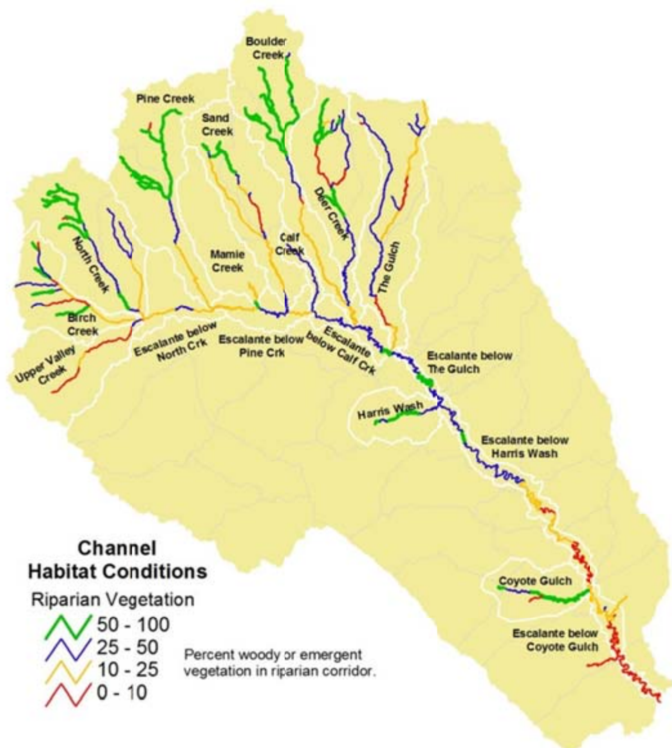


Figure A-4

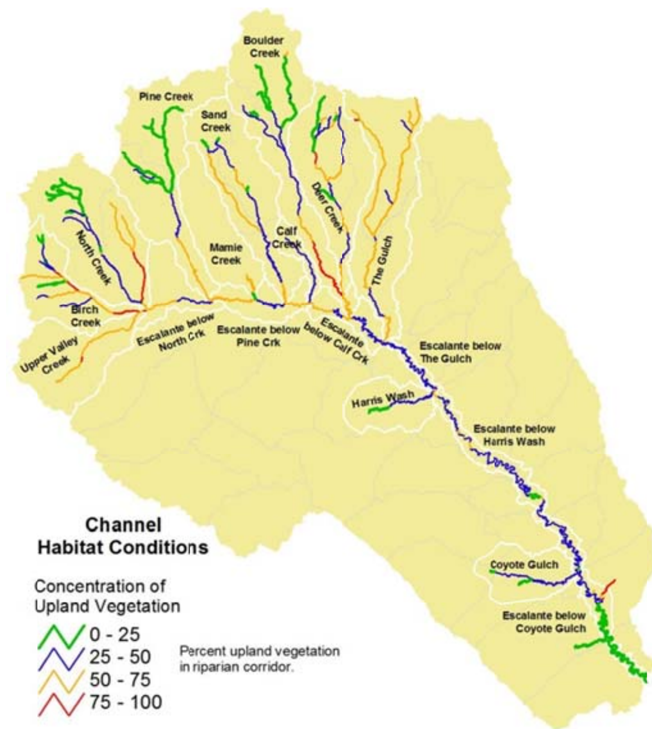
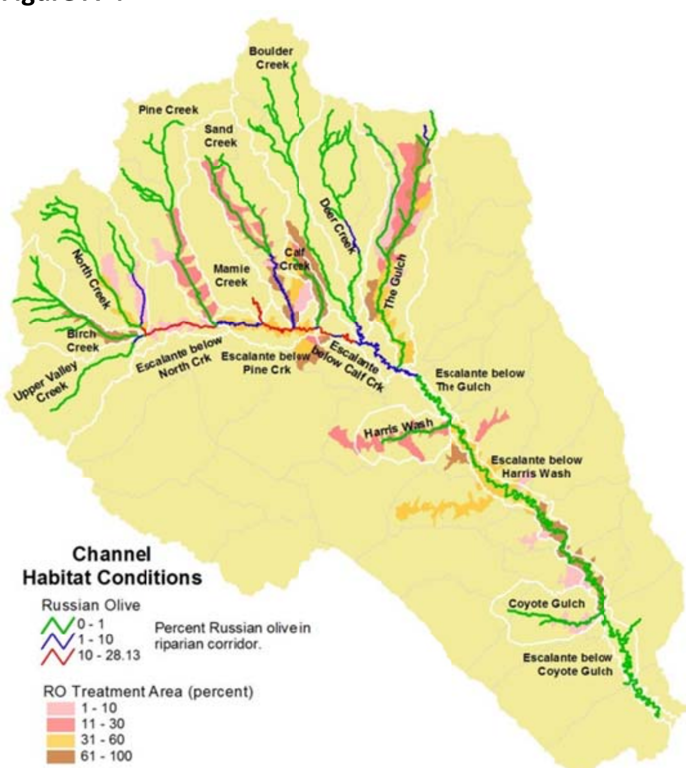


Figure A-5



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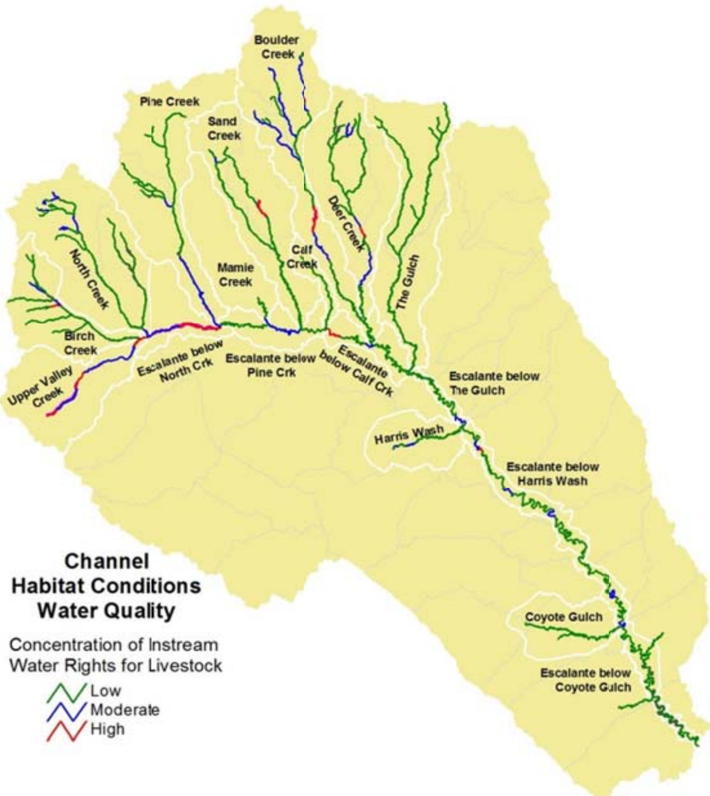
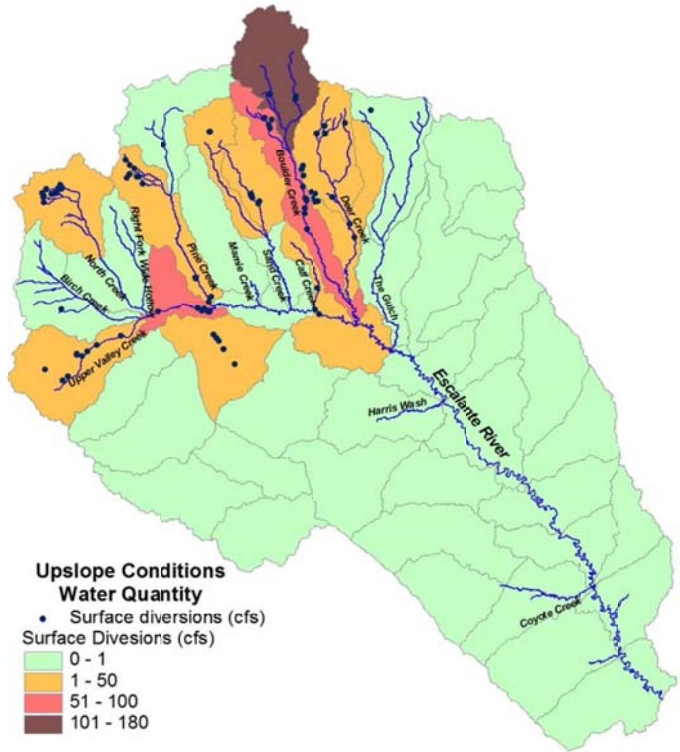


Figure A-7

Figure A-8



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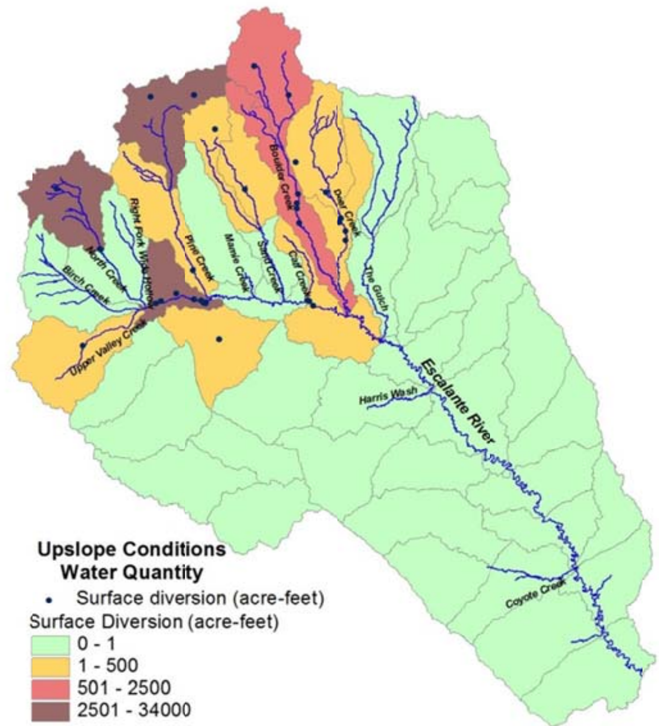

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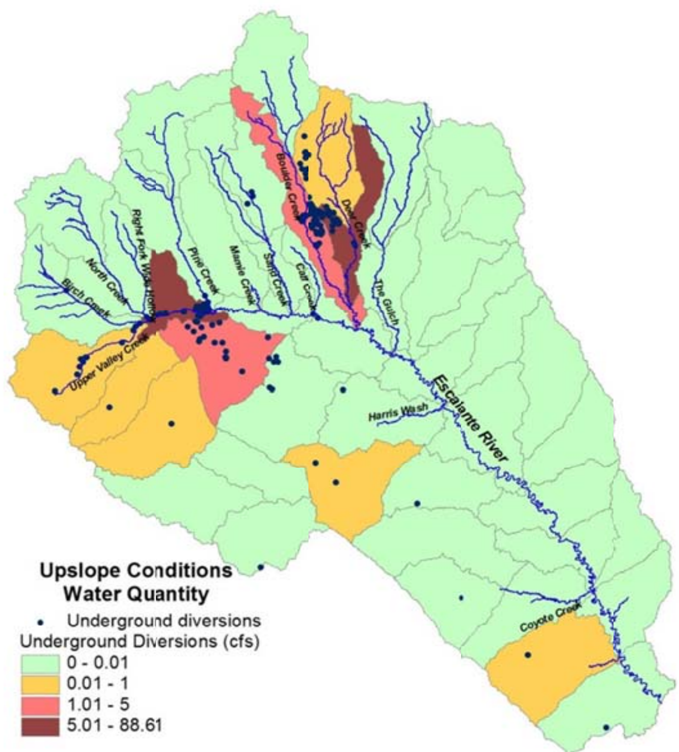


Figure A-11

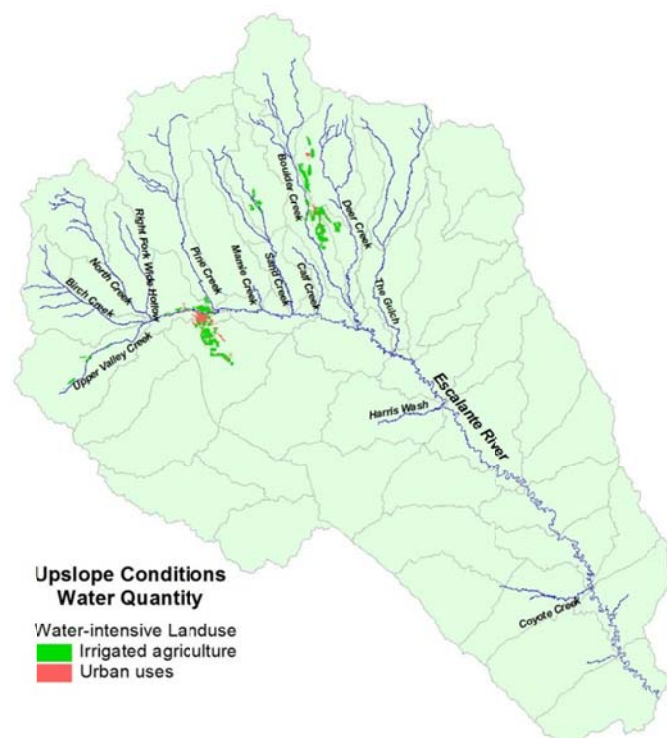


Figure A-12

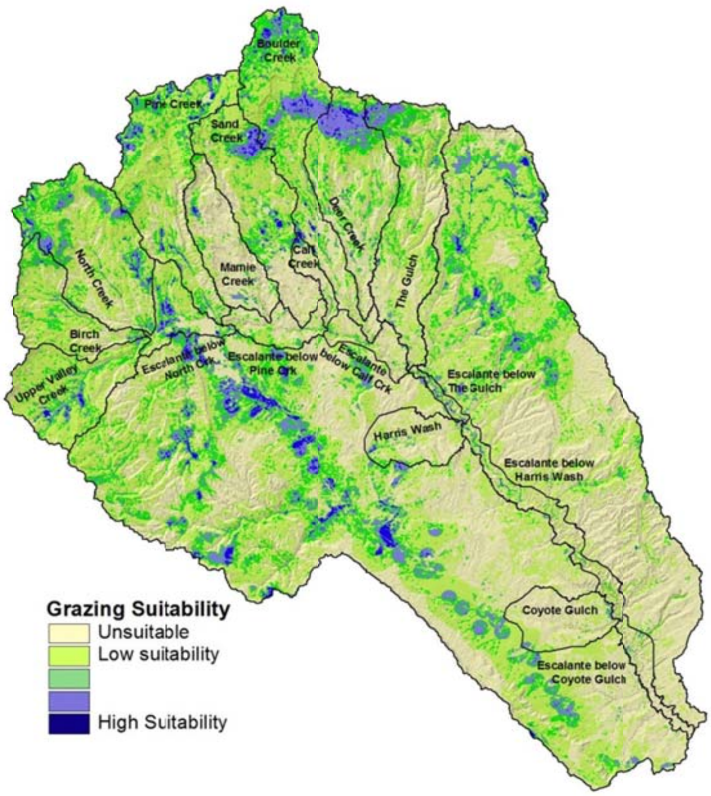


Figure A-13

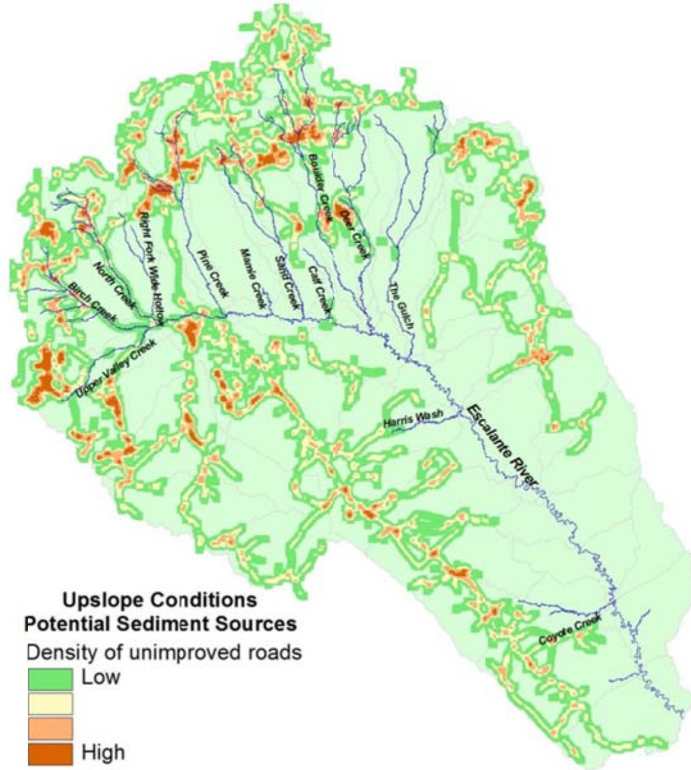


Figure A-14

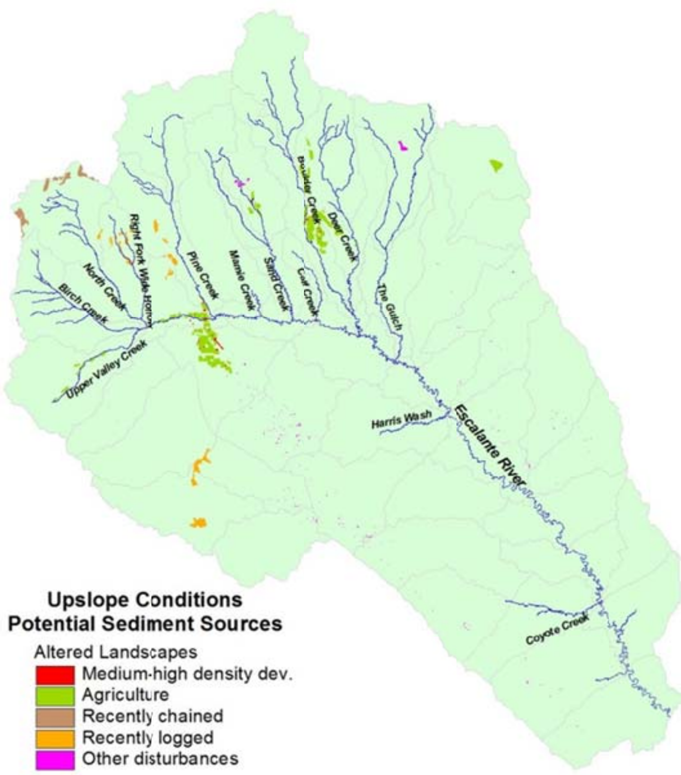


Figure A-15

Appendix B: Historical Aerial Imagery

The digital scans of 10 historical aerial photos from 1951 (three photos) and 1960 (eight photos) were obtained from US Department of Agriculture and georeferenced to support comparisons with current stream channel conditions. Figure 1 below shows the coverage provided by the images along the main stem Escalante River. Figures B-2, B-3, and B-4 provide a comparison of some of the historical images to the 2011 NAIP imagery. The current stream channel alignment as digitized from the 2011 NAIP imagery is shown on each image to facilitate assessment of changes in the stream channel alignment and riparian vegetation.

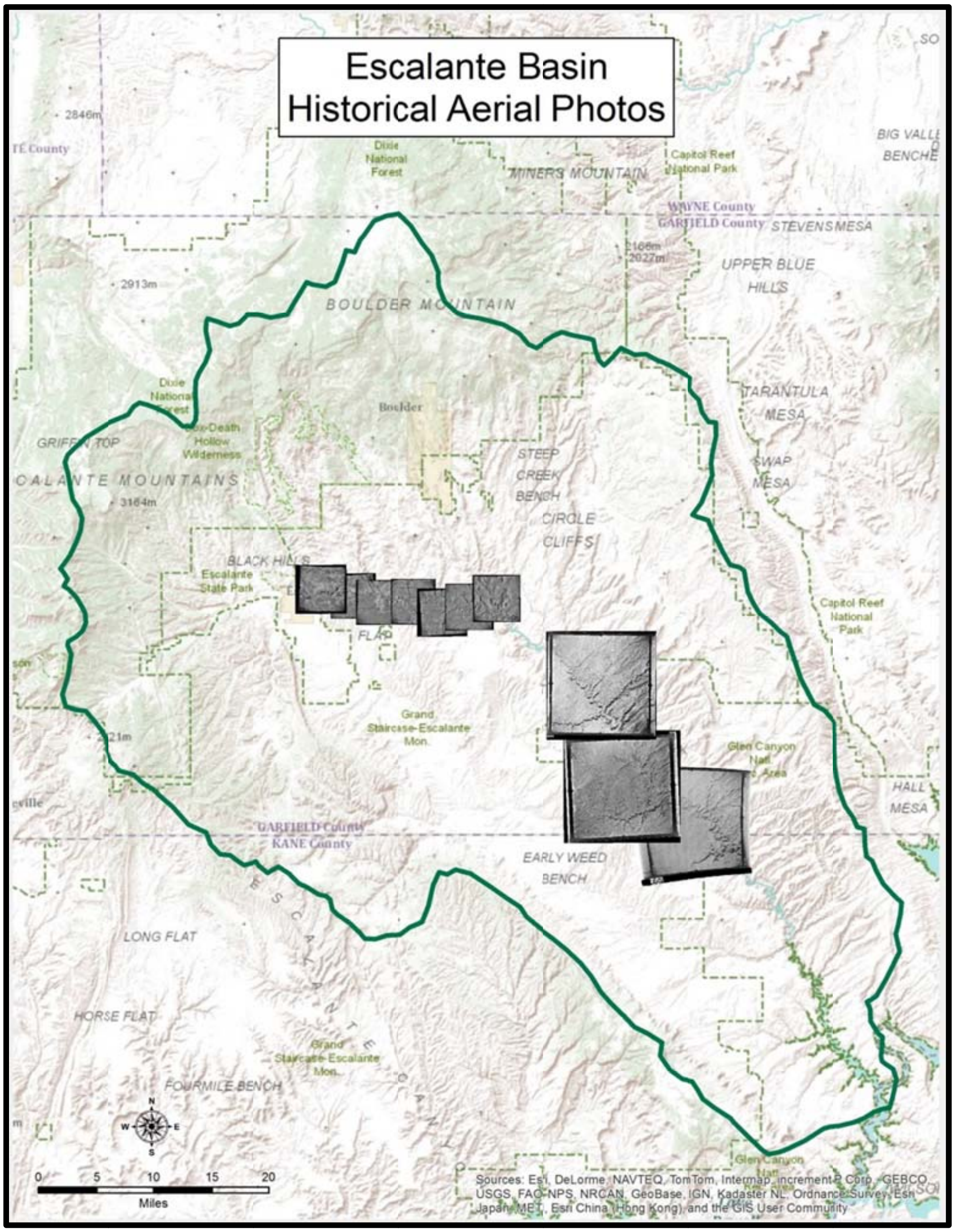
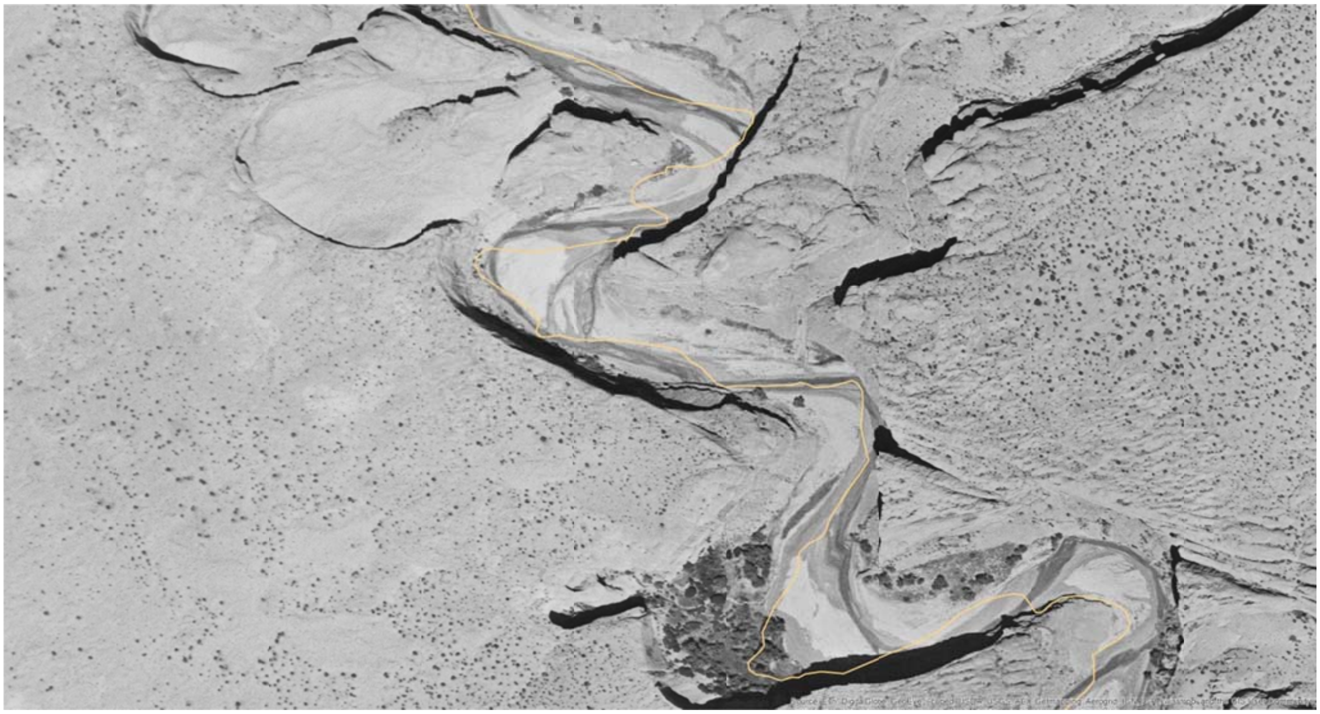


Figure B-1: Coverage of historical aerial photography.

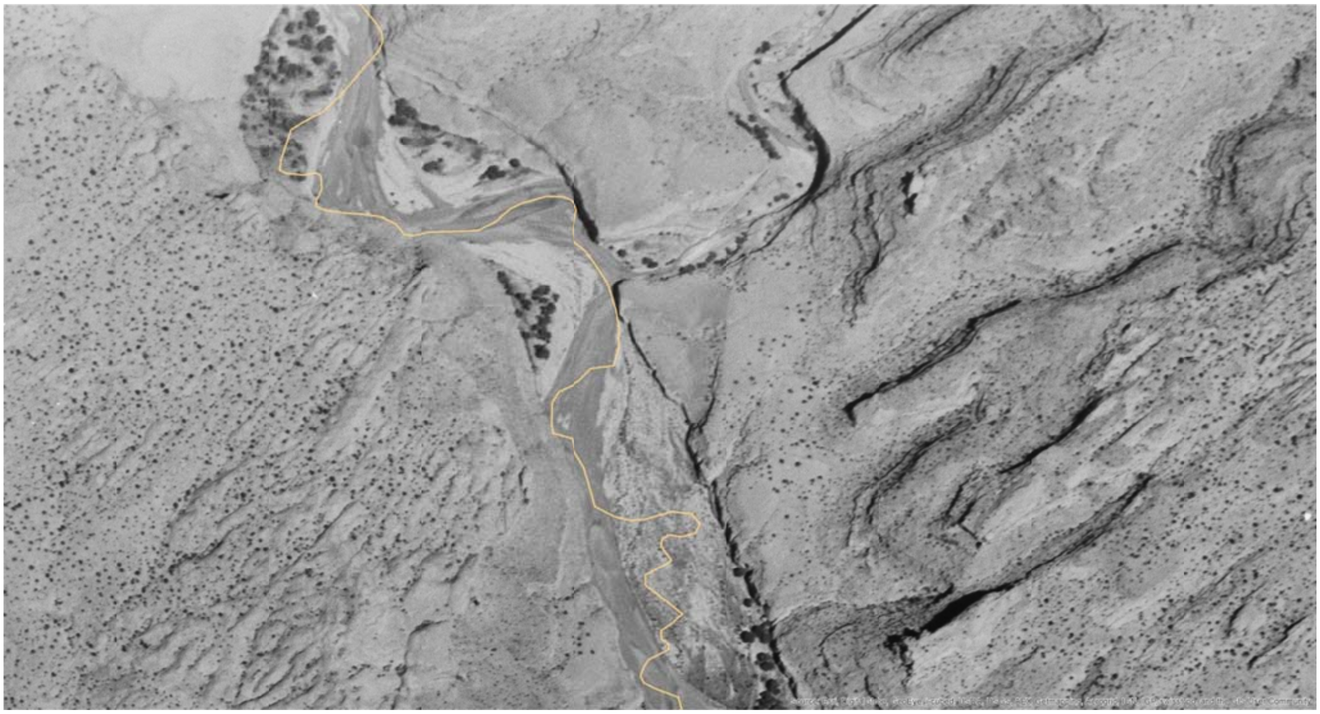
1951



2011

Figure B-2. Reduced braiding and increased upland and woody riparian vegetation from 1951 to 2011 is evident in this stream reach between The Gulch and Harris Wash.

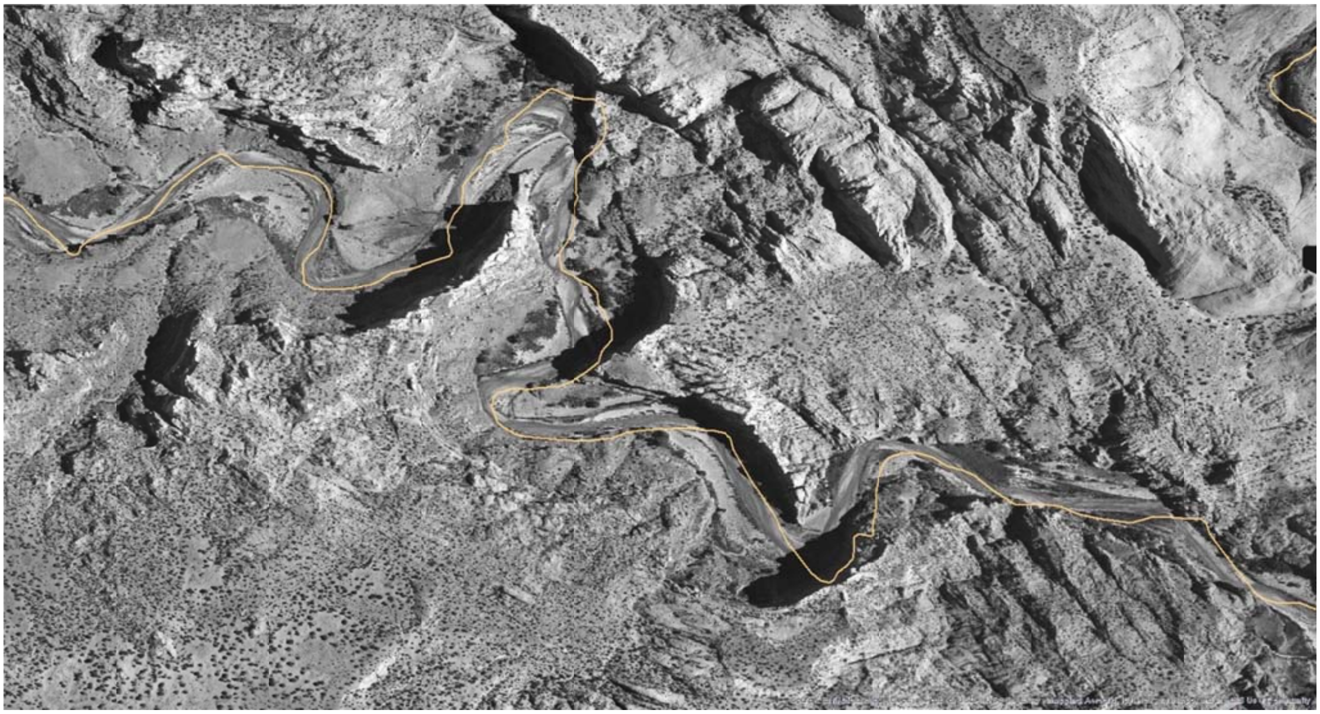
1951



2011

Figure B-3. Reduced braiding, change in channel alignment and increased upland and woody riparian vegetation is evident between 1951 and 2011 in this stream reach below Harris Wash.

1960



2011

Figure B-4. Some changes in channel alignment are evident between 1960 and 2011 as well as an increase in upland and woody riparian vegetation and Russian Olive (light green) in this stream reach between Calf Creek and Deer Creek.

Appendix C: Tables

Table 1

Analysis Units	Conservation Opportunities	Limiting Factors						
Tributaries	Target Fishery	Non-native fish	Channel Habitat Conditions				Upslope Conditions	
			Water Quality	Riparian Vegetation	Sinuosity	Barriers	Water Quantity	Sedimentation Risk
Upper Valley Creek	None present	None present	2014 water quality impaired DO/temp; mod to high concentration of instream livestock water rights	High encroachment of upland vegetation; limited riparian vegetation	Low in middle reaches		9.4 cfs allocated, primarily through surface diversions	High risk from roads and grazing
Birch Creek	CRCT at high density; genetics unaltered and unknown	None present	2014 water quality impaired temp	Mod – high upland encroachment; limited riparian vegetation.	Low in tributaries		0.1 cfs surface diversion	Moderate risk from roads
North Creek	CRCT at low density; Genetics unaltered and unknown	Rainbow and brook trout	2014 water quality impaired DO/temp	Mod upland vegetation in North Creek; high upland vegetation in Right Fork Wide Hollow and some RO present	Low in upper tributaries	4 dams and 1 culvert – complete blockage	37.4 cfs allocated in upper North Crk, primarily in reservoir storage (24,445 acre-ft)	Mod- high risk from roads and grazing
Pine Creek	CRCT at high density in upper reaches; genetically unaltered; BHS upstream from Escalante confluence	Brown trout in Pine Creek	Moderate intensity instream livestock water rights in lower reaches	Mod upland vegetation in lower reaches	Low in upper reaches and tributaries	2 culverts in upper reaches – complete blockage	3.6 cfs in small reservoir in Upper Pine Crk; 26.6 cfs primarily in diversions in lower Pine Crk	High from grazing in upper drainage and roads and some logging in the middle regions
Mamie Creek	BHS in lower reach	Brown trout in lower reach		Russian Olive and upland vegetation			0 cfs allocated	Low risk
Sand Creek	BHS and FMS in lower reach	Brown trout present throughout most of drainage and brook trout in upper reaches		Mod encroachment of upland vegetation and Russian Olive present below confluence with Sweetwater Creek		2 culverts complete blockage; 1 culvert and 2 diversions in Sweetwater Creek partial blockage	12 cfs diverted in Upper Sand and 24 cfs diverted in Sweetwater	High sediment risk from roads and grazing
Calf Creek	BHS, FMS, and RTC	Brown trout present at high density		Low - mod upland vegetation		1 diversion - partial blockage near confluence with Escalante	0.72 cfs diverted	Low risk
Boulder Creek	CRCT mod-high densities in upper reaches, some unaltered and some suspected hybridized; BHS, FMS, and RTC below Deer Creek confluence	Rainbow, brook and/or brown trout present throughout system with exception of upper reaches of West Fork Boulder Creek	Moderate intensity instream livestock water rights in middle reaches and upper tribs;	Mod – high upland vegetation in mid to lower reaches; RO below Deer Creek confluence	Low in middle to upper reaches and tributaries	Middle reach: 1 culvert – complete blockage; 2 diversions partial blockage; Upper tribs: 1 dam, 2 culverts, 2 diversions complete blockage	179 cfs diverted and 1350 acre-ft in storage in Upper Boulder Crk; 98 cfs diverted and 628 acre-ft in storage in Lower Boulder drainage	High risk from roads and grazing and agriculture
Deer Creek	No natives present – could be managed for wild trout fishery with brown and brook trout present	N/A	Moderate intensity instream livestock water rights in middle reaches and upper tributary	Low – mod upland vegetation	Low in middle reach and upper tributaries	2 dams and 1 diversion – complete blockage; 3 diversions and 3 culverts – partial blockage	25.5 cfs diverted and 315 acre-ft storage in Upper Deer Crk; 5.6 cfs diverted and 345 acre –ft storage in Lower Deer Crk	Mod-high in headwaters from grazing; high in mid-reaches from roads
The Gulch	FMS present in lower reach; brook trout in Steep Creek could be wild trout fishery	N/A		High upland vegetation with limited riparian, particularly in The Gulch; Steep Creek has better riparian cover			0.65 cfs diverted in Upper Gulch	Low risk
Harris Wash	FMS present in lower reach	None present					0 cfs allocated	Low risk
Coyote Gulch	None present	None present		Some upland vegetation; has been treated for Russian olive eradication			0 cfs allocated	Low risk

Analysis Units	Conservation Opportunities	Limiting Factors						
			Channel Habitat Conditions				Upslope Conditions	
Tributaries	**Target Fishery**	**Non-native fish**	**Water Quality**	**Riparian Vegetation**	**Sinuosity**	**Barriers**	**Water Quantity**	**Sedimentation Risk**
Escalante River								
Below North Creek	BHS in downstream reach below culvert barrier	Brown trout present in same reach	Mod to high livestock	Significant Russian Olive, mod upland	Low	1 culvert and 1 diversion – complete blockage	54.7 cfs diverted; 33,192 acre-ft in storage; 190 cfs pumped	High risk due to agriculture, roads, and grazing
Below Pine Creek	RTC, BHS, FMS full extent	Brown trout, red shiner in full extent	Mod livestock between Mamie and Sand Creeks	Significant Russian Olive, particularly below Mamie Creek; high upland above Mamie Creek	Low below Sand Creek.		0 cfs allocated	Low risk
Below Calf Creek	RTC, BHS, FMS full extent	Brown trout, red shiner, channel catfish in full extent	High just below Calf Creek	Mod RO and upland	Low between Calf and Deer Creek		0.6 cfs allocated	Low risk
Below The Gulch	RTC, BHS, FMS full extent	Brown trout just below confluence, redside shiner, channel catfish full extent		RO present in reach immediately below The Gulch; low-mod upland vegetation			0 cfs allocated	Low risk
Below Harris Wash	FMS full extent, RTC upstream reaches	Redside shiner and channel catfish full extent		Low-mod upland vegetation; poor riparian cover in lower reaches	Low in reaches immediately below Harris Wash		0 cfs allocated	Low risk
Below Coyote Gulch	None present	Redside shiner and channel catfish full extent	Lower end gets into backwaters of Lake Powell				0 cfs allocated	Low risk

Table 2

Restoration Complex	Limiting Factors	Conservation Objectives	Strategies
Tributaries			
Upper Valley Creek	• High sediment loads from land management and geologic formations • Habitat fragmentation	Evaluate fine sediment sources to determine the practicality of reducing sediment loading into the upper Escalante River.	• Fine sediment sourcing analysis • Determine ecological significance of barriers
Birch Creek	• Fine Sediment from land management and geological formations • Water temperatures • Limited riparian veg.	Expand native CRCT population	• Riparian restoration • Russian Olive removal
North Creek	• Habitat fragmentation • Sedimentation from roads • Upland veg. encroachment; Russian Olive • Non-natives trout	Protect existing CRCT populations; expand downstream where feasible; reduce fragmentation and improve habitat	• Nonnative trout removal • Restoration barrier construction • Barrier removal • Riparian restoration • Russian Olive removal
Pine Creek	• Livestock use • Upland veg, encroachment in lower Pine Creek • Non-native trout • Habitat fragmentation in headwaters • Potential stream dewatering	Protect and expand CRCT and BHS populations	• Grazing management • CRCT population in headwaters • Restoration barrier construction to protect expanded population • Barrier removal in to reconnect CRCT • Floodplain and channel restoration in lower Pine Creek • Protect existing BHS population • Improve irrigation efficiency to restore instream flows
Mamie Creek	• Non-natives • Upland veg. encroachment; Russian Olive	Protect BHS populations and improve habitat	• Non-native trout removal • RO removal
Sand Creek	• Non-natives • Fish passage/habitat. fragmentation • Sedimentation • Dewatering	Reconnect habitat for BHS and FMS; improve WQ	• Barrier construction/non-native trout removal • Culvert/dam removal or fish passage retrofit

Restoration Complex	Limiting Factors	Conservation Objectives	Strategies
Tributaries			
			• Grazing management • Improve irrigation efficiency to restore instream flows
Calf Creek	• Non-natives	Protect and enhance BHS, FMS and RTC populations	• Removal near mouth • CRCT reintroduction between falls
Boulder Creek	• Non-natives • Livestock • Upland veg encroachment; RO • Dewatering	Protect and expand CRCT, BHS, FMS and RTC populations; improve habitat and WQ	• Non-native trout removal • Irrigation efficieny improvements • Fish passage restoration (strategic) • Riparian restoration
Deer Creek	• Habitat. Fragmentation • Dewatering • Livestock management	Enhance wild trout fishery	• Irrigation efficieny improvements • Grazing management • Fish passage restoration
The Gulch	• Upland veg. encroachment	Protect FMS populations; enhance wild trout fishery	• Riparian restoration
Harris Wash	N/A	Protect FMS populations and habitat	• Monitoring
Coyote Gulch	N/A	Evaluate watershed for capacity to hold fish populations	• Monitoring
Escalante River			
Below North Creek	• Sedimentation • Dewatering • Livestock management • Russian olive • Habitat fragmentation	Protect BHS population; improve habitat, Water Quality and enhance stream flows	• Grazing management • Fish passage (strategic) • Russian Olive removal and riparian restoration • Irrigation efficiency improvement and instream flow protection
Below Pine Creek	• Dewatering • Russian Olive • Habitat Quality	Improve habitat for BHS, FMS and RTC by restoring habitat complexity through flow and riparian habitat restoration	• Russian Olive removal and riparian restoration • Upstream irrigation efficiency improvement and instream flow protection
Below Calf Creek	• Russian Olive • Habitat Quality	Improve habitat for BHS, FMS and RTC by restoring	• Russian Olive removal and riparian

Restoration Complex	Limiting Factors	Conservation Objectives	Strategies
Tributaries			
		habitat complexity through riparian habitat restoration	restoration
Below The Gulch	• Russian Olive • Nonnative Warmwater Species	Improve habitat for BHS, FMS and RTC by restoring habitat complexity through riparian habitat restoration and build population resiliency into BHS, FMS and RTC populations upstream	• Russian Olive removal and riparian restoration
Below Harris Wash	• Russian Olive • Nonnative Warmwater Species	Improve habitat for BHS, FMS and RTC by restoring habitat complexity through riparian habitat restoration and build population resiliency into BHS, FMS and RTC populations upstream	• Russian Olive removal and riparian restoration
Below Coyote Gulch	• Russian Olive • Nonnative Warmwater Species	Improve habitat for BHS, FMS and RTC by restoring habitat complexity through riparian habitat restoration and build population resiliency into BHS, FMS and RTC populations upstream	• Russian Olive removal and riparian restoration