Evaluations of Resiliency in California's Wild and Scenic Rivers

CAPSTONE PROJECT AUGUST 2016

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Recommended Course of Action

Our recommended course of action for our sponsor National Park Service (NPS) and Others is to consider using the Nature Conservancy model of North Carolina's Freshwater resilience for determining how the National Wild and Scenic River System contributes to climate resiliency. With a successful attempt of analyzing 11 resilience attributes we are able to propose to our sponsor how to determine climate resiliency.

Introduction:

In the past 50 years, we have learned- all too slowly, I think to prize and protect God's precious gifts. Because we have our own children and grand children we will come to know and come to love the great forest and wild rivers that we have protected and left to them… An unspoiled river is a very rare thing in the Nation today. Dams have harnessed their flow and vitality and too often they have been turned into open sewers by communities and by industries. It makes us all very fearful that all rivers will go this way unless somebody acts now or try to balance our river development.

-President Lyndon B Johnson: October 2, 1968
(signing the Rivers and Scenic Act)

Some of the world's worst impact of climate change is on people and ecosystems, the impacts of climate change becoming increasing apparent across rivers in California. The Wild and Scenic rivers in California have not been spared. Freshwater ecosystems are important for biodiversity and provide essential ecosystem services. With decades of damming, development and diversion has taken a toll on country's rivers. During the 1960's the country began to recognize the damage that was inflicting on the wildlife and landscape. This soon led congress to preserve our waterways, The National Wild Scenic River System was created by congress in 1968 to persevere certain rivers with natural, cultural and recreational values in a free flowing condition for the enjoyment of present and future generations. (National Wild Scenic Rivers System, 2016) All Rivers in the Wild Scenic River System are classified as wild, scenic of recreational. Wild River Areas: Rivers or sections that are free of impoundments and generally inaccessible expect by trail, with watersheds or shorelines essentially primitive and waters that are unpolluted. Scenic River areas: rivers or sections that are free of impoundments with shorelines or watersheds still largely undeveloped but are accessible in places by roads. Recreational River Area: rivers or sections that is accessible by road or railroad that may have some development along their shorelines and may have gone through some diversion in the past. The main goal of each river in NWSRS act is to protecting and enhancing the values that caused it to be designated. As of December 2014, the National rivers System protects 12,709 miles to 208 rivers in 40 states. (NPS, 2016)

WSR of Untied States

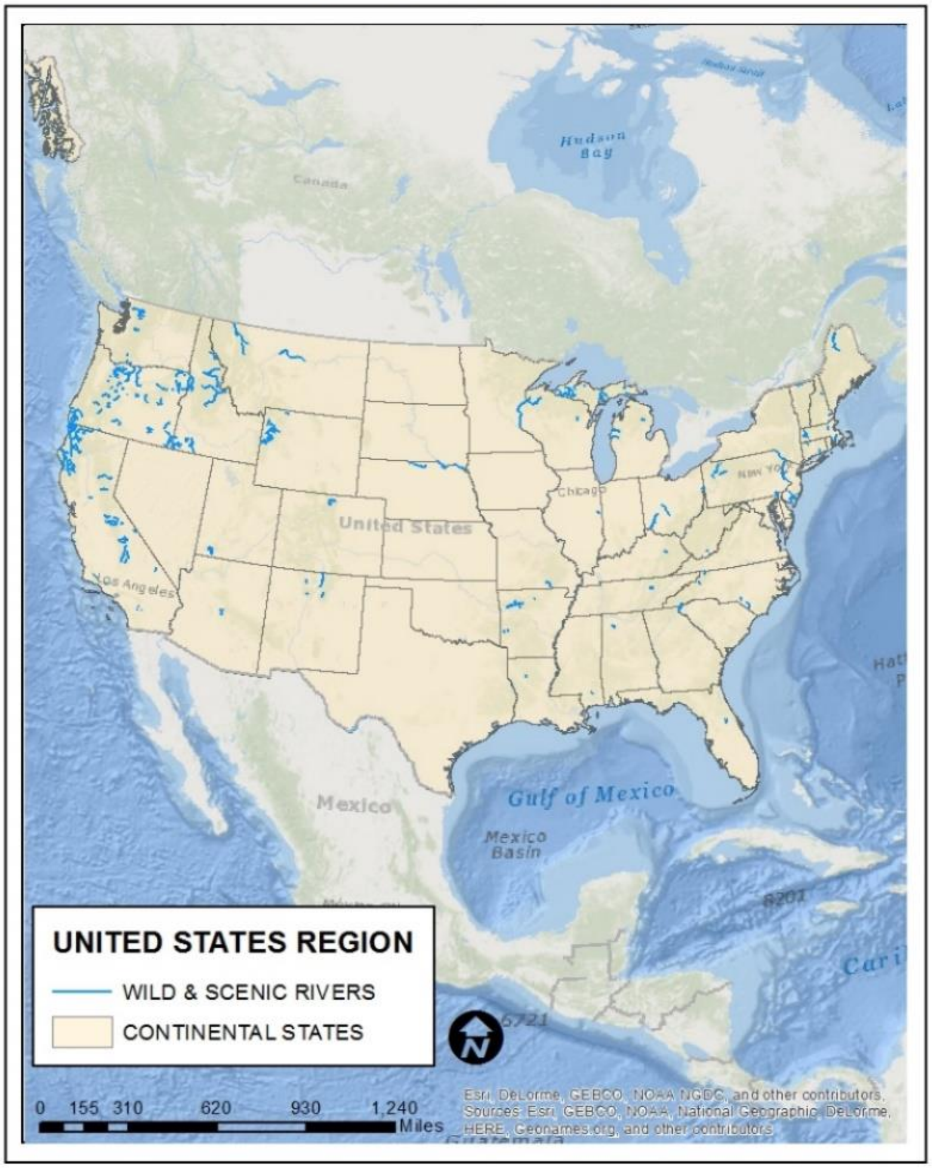

Figure 1: Wild and Scenic Rivers located in the United States

For this project were tasked by the National Park Service to perform an analysis and investigate how the National Wild and Scenic River System in California contributes to climate resiliency. We describe statistical and modeling approaches to demonstrate how resilience can be applied to decision making. Currently, California has 189,454 miles of rivers, 1,999 miles are designated wild and scenic which is considered 1%. (National and Wild Scenic System). The rivers that are included in the system are:

- Armargosa River
- Bautisa Creek
- Big Sur River
- Black Butte
- Cottonwood Creek
- Eel River
- Feather River
- Fuller Miller Creek
- Kern River
- Kings River
- Klamath River
- Lower American River
- Merced River
- North Fork American River
- North Fork San Jacinto
- Palm Canyon Creek
- Piru Creek
- Sespe Creek
- Signoc river
- Smith River
- Trinity River
- Tuolumne River

Figure 2: Wild and Scenic Rivers of California

Ecological resilience has been applied to understanding river and stream systems and is the measure of the amount of change or disruption that is required to transform a system. Ecological resilience as a measure of change or destruction that is required to a system for being maintained by a set of reinforcing processing and structures. (Holling, 1973). Outlined below in Social-Ecological table is displaying how Ecological resilience is displayed in the Wild and Scenic Rivers Systems located in California.

Social-Ecological Systems Table | "Wild & Scenic Rivers of California/Resiliency"				
Spatial & Temporal Scale		**Environmental**	**Economic**	**Social**
Above Focal Scale (+1) Wild & Scenic Rivers in United States		Human population increases the pace of climate and land use changes throughout the nation	Development and ecotourism heavily depends on scenic rivers	Protect the WSR for Public use and enjoyment
Focal Scale (0) Wild And Scenic Rivers of California		Severe droughts shifting percipatation patterns lowering water levels in rivers, leaving polluants less water to dilute	Dams are prone to block fish migration, harms water quality, flood vurnable wildlife habitat Reduce and alter river flows	Strenghen relationships among Federal, State, local resource agencies and stakeholders to facilate the implementation of adaptive river mangement
Embedded Scale (-1) Individual Rivers and Streams located through California		Hotter, drier conditions, less snow accumlation. Imapacts of pollution lowering river flows which causes toxic algae blooms and unheathy river conditions	Water avaliablity wiill decrease CA water mangement system will adapt to extreme scarcity and higher operational cost	Decisions related to land use planning, water protection and flood protection have a profound impact on the community's vurnability

Table 1: Social-Ecological Systems Table for Wild and Scenic Rivers in California

According to the Nature Conservancy, pace of environmental change accelerates due to climate land use changes associated with a growing human population and rising resources use, identifying areas that are likely to be highly resilient to this change will be important. This project will be implemented with scientific studies used and done by The Nature Conservancy (TNC) to determine the resilience of Wild and Scenic Rivers in California. This analysis is based on previous completed projects of North Carolina's Freshwater Resilience Report completed by the TNC in the Northeastern region of the US. According to the Nature Conservancy: North Carolina Freshwater Resilience: resilience ecosystems can be characterized by 12 resilience attributes: Network complexity, length of connected networks, number of gradient classes, number of temperature classes, elevation range, impervious surface index, baseline flow, floodplain naturalness index, adjusted cropland index, cumulative dam storage index, cumulative % water body index, and cumulative water use index.

The Northeastern Case study was conducted and developed by a region wide analysis of the freshwater stream networks. It estimates the capacity for each network to maintain the diversity and function under climatic and environmental change based on the evaluation of seven characteristics. The results provide information for making and prioritization decisions about freshwater conservation that will produce outcomes. By comparing the stream networks identified by the analysis being above-average in relative resilience. The TNC believes that the results of this analysis can help conservation effort towards streams networks that are likely to remain complex, adaptable, and diverse systems with environmental changes (TNC, 2013) Map below, shows the TNC portfolio rivers grouped by their rank categories for freshwater resilience. Portfolio rivers were identified as the best example of various river types in the region. Majority of the rives ranked as Highest or High Relative Resilience based on their resilience characteristics.

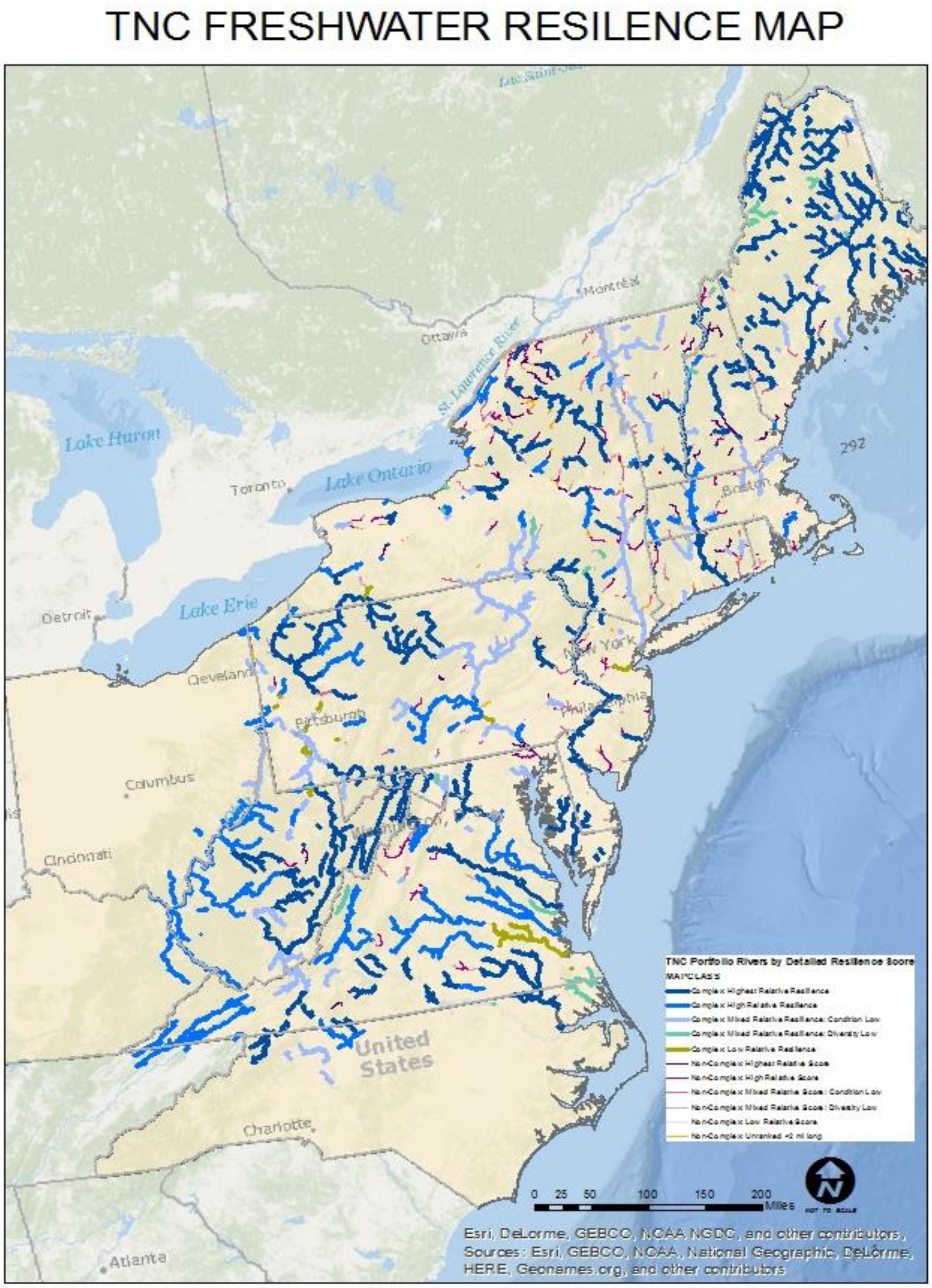

Figure 3: TNC Freshwater Resilience map

In this project we aim to quantify each of these factors from stream networks from the National Hydrology Dataset of California (NHDPLUS Version2, Horizons System) we developed an assessment of resilience across California's Wild and Scenic river systems to determine the highest resilience. This analysis can be used as a tool for the National Park Service to determine how the National and Wild Scenic Rivers contribute to climate resiliency.

Design & Methods

In creating the units of analysis a Functionally Connected Network (FNC) was developed within ArcGIS for the study. The FCN is based on river flow and examined how the rivers in California are connected through flow which takes into account both distance and terrain. To farther break down the elements, dams were added to the map and acted as break within the FCNs since these significantly disrupt natural flow. The units used for study included only the FCN segments which contained Wild and Scenic Rivers in California.

To create the FCN networks, NHDPlus version 2 stream networks were used. Since California was selected as the study area, Vector Processing Unit (VPU) 18 contained the relevant information. To set up the FCN based on river flow instructions are outlined in Exercises 0, 1, 2, 3, 4 and 5. The direction as follows: (Source, NHD)

Exercise # 0:NHDPlusV2.1 Toolbox Installation to Arc Toolbox

Downloaded NHDPlusV2.1 Toolbox from the NHDPlusV2 tools page
http://www.horizon-systems.com/NHDPlus/NHDPlusV2_tools.php.
Unzip the install package. Create an \NHDPlusV21Tools folder. Create an \NHDPlusV21Toolbox folder.
Place the .tbx and .py files in the \NHDPlusV21Tools\NHDPlusV21Toolbox\ folder.
Open ArcCatalog and ArcToolbox. Right click on "ArcToolbox" at the top of the toolbox menu and select "Add Toolbox". Navigate to the \NHDPlusV21Tools folder and select the .tbx, then click "Open". The NHDPlusV2.1 Toolbox should appears in the list of toolboxes.

Exercise # 1: SETTING UP THE NHDPlus DATA:
Part 1—Build Indexes and Raster Pyramids
1. Start ArcCatalog.
2. Using ArcCatalog, navigate to the location in which you unpacked the NHDPlus V2.1 Toolbox in Exercise 0, or by following the User Guide section on Installing NHDPlus V2 Data. Double-click on the "1. Prep NHDPlus V2.1 Data" tool, and use the browse tool to navigate to the top-level folder in which you have unpacked whatever NHDPlus V2.1 data you wish to use.

Part 2—Relates and Joins
1. Close ArcCatalog, open ArcMap.
2. Using ArcMap, build relates between Feature Classes
a. Go to File, Add Data. In the Add Data dialog box, navigate to the
\NHDPlus06\NHDSnapshot\Hydrography directory and select NHDFlowline.shp. Click
b. This step adds a relate between NHDFlowline.shp and NHDWaterbody.shp. Right-click on NHDFlowline in the Layer list, go to Joins and Relates, Relate
In the Relate dialog box, Use the pulldown list in item 1, select WBAREACOMI. ii. Using the icon in item 2, navigate to NHDWaterbody.shp. iii. Use the pulldown list in item 3 and select COMID. iv. In item 4, enter the name of the relate Flowline Waterbody. Click OK.

c. To use the relate, open the attribute table for the NHDFlowline feature class. Select one or more NHDflowline features that should have a relationship with a NHDWaterbody polygon (e.g. artificial paths passing through water bodies.) From the Table Options menu, choose Related Tables>Flowline_Waterbody. The NHDWaterbody feature class will be added to the map, and its table will be opened, with the water bodies related to the selected NHDFlowlines selected and highlighted.
d. Following the directions in steps 2a and b, additional relates between feature classes may be added according to the information in Table 1. Remember that the feature class listed in the "From Feature Class" column of Table 4, must be added to the map before building a relate from it. With the exception of grids, the feature class listed in the "To Feature Class" column need not be added to the map prior building a relate to it. Additional relates other than those shown are possible
e. Following the directions above, you may build additional relates between feature classes and attribute tables according to the information in Table 5. Remember that the feature class listed in the "From Feature Class" column of Table 2, must be added to the map before the relate can be built from it. The table listed in the "To Attribute Table" column need not be added to the map to build a relate to it.
f. Build a join between NHDFlowline.shp and PlusFlowlineVAA.dbf. Right-click on NHDFlowline in the Layer list, go to Joins and Relates, Joins. In the Join Data dialog box,
i. Use the pulldown list in item 1, select ComID. ii. Using the icon in item 2, navigate to the PlusFlowlineVAA.dbf file in \NHDPlus06\NHDPlusAttributes. iii. Use the pulldown list in item 3 and select COMID.

Exercise 2 — Linking Data to the NHD –
Within this document, the term NHDPlus is used when referring to NHDPlus Version 2.1 (unless otherwise noted).
The NHDSnapshot component of NHDPlus contains a linear referencing system in NHDFlowline.shp. The route identifier is NHDFlowline.Reachcode and the route measures are stored as m-values with the coordinates.1. Using ArcCatalog, create a new point shapefile. a. Right-click on the NHDPlusMS\NHDPlus06 folder, go to New, Shapefile. In the Create New Shapefile dialog, i. Give the shapefile a Name of PointsOfInterest. ii. Use the Feature Type pull down to select Point. iii. Click Edit to create a Spatial Reference for the shapefile.

iv. In the Spatial Reference Properties window, click Import from the Add Coordinate System pull-down menu v. In the Browse For Datasets or Coordinate Systems window, browse to the NHDPlusMS\NHDPlus06\NHDSnapshot\Hydrography folder and select NHDFlowline.shp. Click import. vii. The Create New Shapefile dialog is now complete.

Exercise #3:
Within this document, the term NHDPlus is used when referring to NHDPlus Version 2.1 (Using ArcCatalog we begin by creating a new personal geodatabase and a geometric network from the NHDFlowlines:
1. Start ArcCatalog.
2. Right-click on the \NHDPlus06 folder, go to New, File Geodatabase. The database will be added to the left and right windows. Rename the database to NHDPlusFGDB.
3. Right-click on NHDPlusFGDB in the left window, go to New, Feature Dataset. In the New Feature Dataset dialog, Name the feature dataset Hydrography.

4. Click Next.
5. The next screen prompts you to choose a coordinate system.
The new feature dataset called Hydrography is now created and appears in the left window of ArcCatalog under the NHDPlusFGDB personal geodatabase.
6. Next we add the data to the geodatabase. Right-click on the Hydrography feature dataset in the left window. Go to Import, Feature Class (single). In the Feature Class to Feature Class dialog.
7. Use the Folder button to browse to \NHDPlus06\NHDSnapshot\Hydrography and select NHDFlowline.shp for Input Features
8 Leave Output Location as: …\NHDPlus06\NHDPlusFGDB.mdb\Hydrography
9.. Enter NHD_KnownFlow in Output Feature Class
10.Use the SQL button to build an Expression as shown below. This expression extracts from all the NHDFlowlines, only those with known flow direction. The expression should read: "FLOWDIR" = 'With Digitized' Note the single quotes around the 'With Digitized'. Click on Get Unique Values in order to select 'With Digitized'. Click OK.
11.Returning to the Feature Class to Feature Class dialog, scroll down in the Field Map box and right click ENABLED and select properties. Change the name to ENABLED_CHAR. Click OK.
12. Leave the remaining items in the dialog at their default values and click OK.
13. Click OK back in the Feature Class to Feature Class dialog box.
14. The import Feature Class to Feature Class operation will execute. Wait until the import is complete. Then click "close".
15.The new feature class called NHD_KnownFlow is now created and appears in the left window of ArcCatalog under the Hydrography feature dataset
16.Right-click on the Hydrography feature dataset in the left window. Go to New, Geometric Network. Proceed through the Build Geographic Network Wizard, taking all the defaults. The geometric network called hydrography_net will be created.

Exercise 4:Navigating NHD with NHDPlus Flow Table and the NHDPlus Value Added Attributes
Within this document, the term NHDPlus is used when referring to NHDPlus Version 2.1 (unless otherwise noted).
1. Navigating NHD with NHDPlus Flow Table
a. Start ArcMap.
b. Confirm that the NHDPlus V2 Flow Navigation Toolbar is present in ArcMap. It consists of a set of 4 green arrows. If the toolbar is not present, see Exercise 0 for installation instructions.
c. Use the File, Add Data menu. In the Add Data dialog, navigate to the NHDPlusMS\NHDPlus06\NHDSnapshot\Hydrography folder and select NHDFlowline.shp.
d.The Flow Table Navigator does not have a distance option and navigates whole flowlines. The results are displayed as a selected set of NHDFlowlines.

Exercise 5 – NHDPlus Network Analysis
1. Start ArcMap.
2. Using ArcMap,
a. Use the File, Add Data menu. In the Add Data dialog, navigate to the \NHDPlusMS\NHDPlus06\NHDPlusSnapshot\Hydrography folder (see Exercise 0 and the NHDPlusV2 User Guide for access to this data), select NHDFlowline.shp
b. Load the Discharge Point events (see Exercise 0 for access to this data) into the map. These events represent locations where something is being discharged into a surface water feature. Double click on Make Route Event Layer tool in the ArcToolbox. In the dialog:

i. Use the Input Route Features pull down to select the NHD route feature class which is NHDFlowline
ii. Use the Route Identifier Field to select the NHD route identifier which is ReachCode.
iii. Use the Input Event Table Folder button to browse to the \NHDPlus06 folder and select Discharge_Points.dbf.
iv. Use the Route Identifier Field pull down to select RCH_CODE as the route identifier in the event table.
v. Use the Event Type pull down to select Point.
vi. Use the Measure Field pull down to select P_Meas.
vii. Use the Offset Field pull down to select EOFFSET
viii. Leave the remaining items at their default values.
ix. Click OK.

These exercises describe the necessary steps to load proper geometry and allow ArcGIS to process and create a stream network. Exercise 4 explains navigation of the flow using proper tools and exercise 5 details the steps for analysis of the network. (NHDPLUSV2 Documentation, Exercises) Figure???

FLOWLINES OF CALIFORNIA

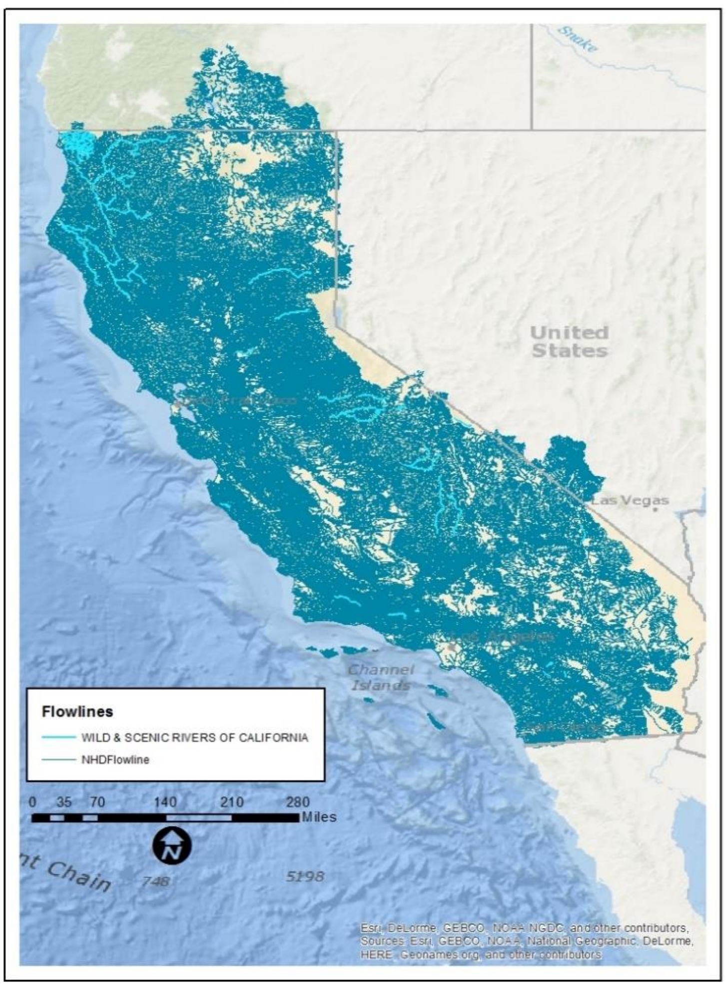

Figure 4: California Flowlines

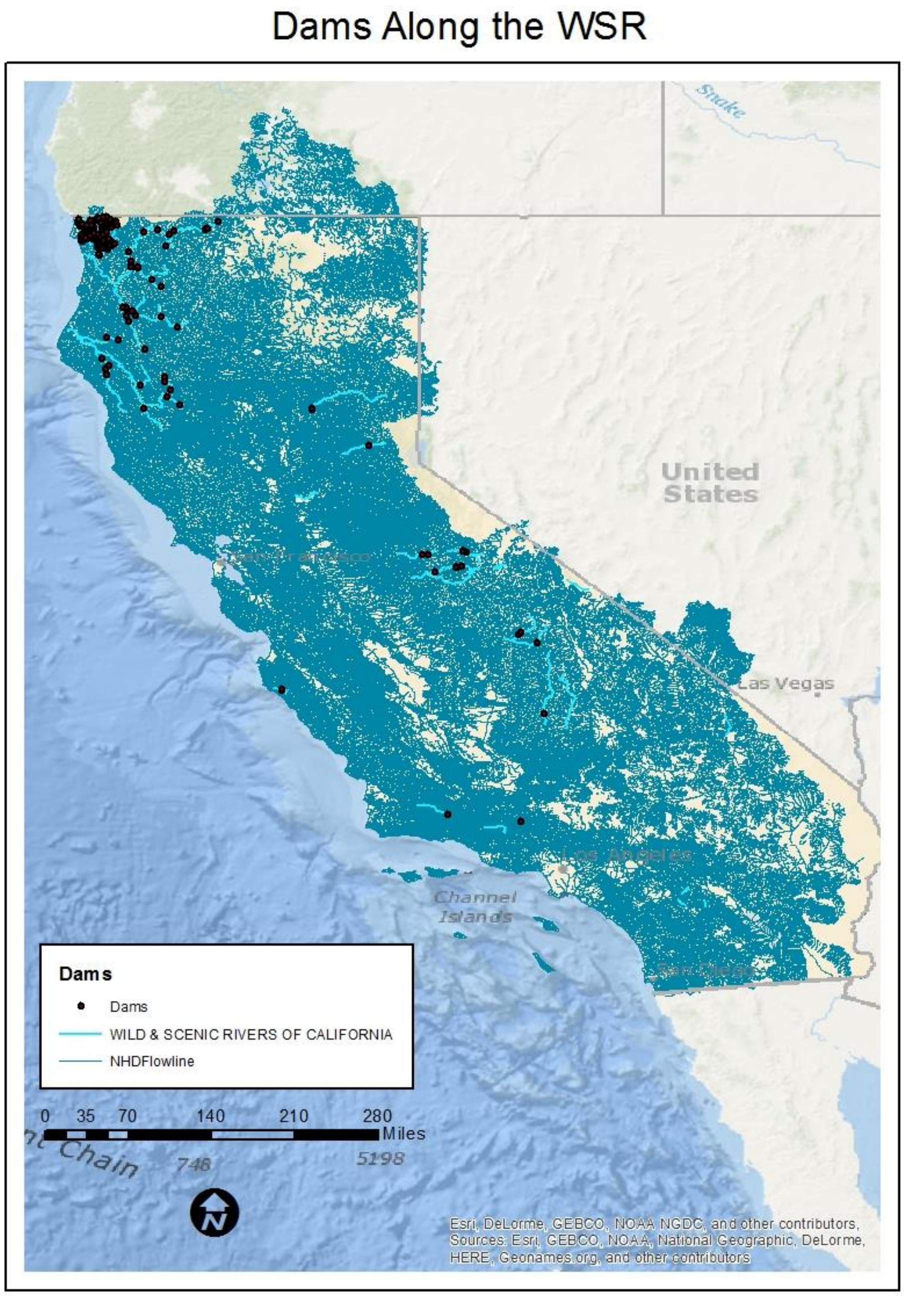

Figure 5: Dams along Wild and Scenic Rivers

The dam information database provided by the NPS RTCA (2012NationalAnt_NABD_2012.zip) showed the known dam locations. These dams were added to the FCN as barriers in the Utility Network Analysis

tool. Next, points were placed on the barriers and the trace upstream function showed how the river was connected with the barriers added. Figure?
Based off this analysis 17 Units of Analysis contained sections of WSRs. These 17 sections became the units of analysis for the rest of the project.

Assessment:

The approach we used for examination was based on TNC methodology used for examination of rivers (The Nature Conservancy: North Carolina's Freshwater Resilience). In our analysis we looked at the goals of the attributes described in TNC publications and made alterations as necessary to better assess rivers in California with a preference towards elements which caused river segments to gain WSR status. These elements are outlined in Table1: as well as the folder locations, columns and procedures for each category. (Number 6 was not used in our analysis)

No.	Characteristics Leading to Resilience	Resilience Attribute	Spirit of the Attribute
1	Linear connectivity	Network complexity	The **higher** the number of stream size classes, the more resilient
2	Length of Connected Network	Length in Kilometers	The **longer** the stream, the more resilient
3	Number of Gradient Classes	Gradient of Stream	The **higher** the gradient, the more resilient
4	Elevation Range	Highest Elevation-Lowest Elevation	The **greater** the elevation change, the more resilient
5	Number of Temperature Classes	Warmest to Coolest Stream temperatures	The **greater** the temperature span, the more resilient
6	Baseflow Index	Baseflow Index(%baseflow in class)+N	The **higher** the baseflow index, the more resilient
7	Impervious Surface Index	Percent Developed Imperviousness	The **higher** the impervious serface index, the more resilient
8	Floodplain Naturalness Index	Amount Developed	The **lower** the developed land, the more resilient
9	Adjusted Cropland Index	Percent of cropland in a catchment	The **higher** the index, the more resilient
10	Cumulative Dam Storage Index	Amount of flow alterations from dams	The **lower** the flow alterations, the more resilient
11	Cumulative Percent Waterbody Index	Amount of non natural waterbodies	The **greater** the flow, the more resilient
12	Cumulative Wateruse Index	Percent of mean annual network flow	The **greater** the velocity, the more resilient

Table: 2

Network Complexity:

Network Complexity refers to the variety of different sized streams and rivers that are contained in a network. Stream size a networks complexity are critical factors, this methodology was based on TNC description and deals with the square miles covered by waterway units. The size classes are described in Table 3.

Table: 3 River and Stream Classification

Size Classes	Type	Size
1a	Headwaters	0 <3.861 sq. mi
1b	Creeks	>=3.861 <38.61 sq. mi
2	Small Rivers	>=38.61 <200 sq. mi
3a	Medium Tributary Rivers	>=200 <1000 sq. mi
3b	Medium Mainstem Rivers	>=1000<3861 sq. mi

4 and 5	Large and Great Rivers	>= 3861 sq. mi

Source: TNC: North Carolina Freshwater Resilience

Length of Connected Networks:

The length of connected networks is simply the total length in Kilometers of each river segment. For this category the sum of each river segment in the units of analysis produced the final results. The linear length of the unit of analysis is important since it enables water flow, sediment and nutrient natural regimes, and species relocation. This category starts at the headwaters and ends at either a dam or where the river naturally stops flowing, such as the ocean or lake area.

Number of Gradient Classes:

The Number of Gradient Classes, the elevation slope database file was joined with the units of analysis through COMID. Unlike the TCN methodology, we believed a more accurate measure of gradient classes was to measure the difference between the highest and lowest gradient. The reasoning behind this was a lack of variation in the number of gradient classes for the units of analysis would have made this category moot. Since gradient variation is a factor in shaping biodiversity, the slope change was used to examine variations in this category.

Table 4: Number of Gradient Classes:

Gradient Classes		
1.	Very Low Gradient	<0.02%
2.	Low Gradient	>=.02 <.1%
3.	Moderate- Low Gradient	>=.01 <.5%
4	Moderate-High Gradient	>=.02 <2%
5.	High-Gradient	>=.2<.5%
6.	Very High Gradient	>= <.5%

Source: TNC: North Carolina Freshwater Resilience

Elevation Range:

For each FCN the lowest elevation was subtracted from the highest elevation. Smooth Elevation was used since it reduces the inaccuracies and errors which are initially contributed when translating real world terrain on a map. Elevation range helps with habitat development and greater elevation range is preferable.

Temperature Classes:

Temperature classes, we deviated from the methodology of TNC while still keeping the spirit and meaning of the attribute. The reason for transition has to do with TNC's use of the Northeast Aquatic Habitat Classification system which assigned water temperature categories based off their proportion of

cold water to warm water species of stream fish. This measurement seemed inaccurate for California since species differences, as well as climate categories would limit the amount of variation in a metric designed for a different climate type.
Ultimately, a difference of low to high average temperature was used as the measurement for this metric.

Impervious Surface Index:

For land cover analysis, we used classifications of US land from NLDC2012 included with the NHDPlus2 data. Descriptions can be found through the USGS (http://www.mrlc.gov/nlcd06_leg.php)

Table 5: USGS Classification Table:

<table>
<tr><th>NLCD Number</th><th>Type of Land</th><th>Classification</th></tr>
<tr><td>21</td><td>Developed Open Space</td><td rowspan="2">Low Development</td></tr>
<tr><td>22</td><td>Developed, Low Intensity</td></tr>
<tr><td>23</td><td>Developed, Medium Intensity</td><td>Medium Development*</td></tr>
<tr><td>24</td><td>Developed, High Intensity</td><td>High Development</td></tr>
<tr><td>81</td><td>Pasture/Hay</td><td rowspan="2">Agriculture</td></tr>
<tr><td>82</td><td>Cultivated Crops</td></tr>
<tr><td>31</td><td>Barren Land (Rock/Sand/Clay)</td><td rowspan="11">Natural</td></tr>
<tr><td>41</td><td>Deciduous Forest</td></tr>
<tr><td>42</td><td>Evergreen Forest</td></tr>
<tr><td>43</td><td>Mixed Forest</td></tr>
<tr><td>51</td><td>Dwarf Scrub</td></tr>
<tr><td>52</td><td>Shrub/Scrub</td></tr>
<tr><td>71</td><td>Grassland/Herbaceous</td></tr>
<tr><td>72</td><td>Sedge/Herbaceous</td></tr>
<tr><td>74</td><td>Moss</td></tr>
<tr><td>90</td><td>Woody Wetlands</td></tr>
<tr><td>95</td><td>Emergent Herbaceous Wetlands</td></tr>
<tr><td colspan="3">*For Floodplain Naturalness Index, medium developed areas were classified as High Development</td></tr>
</table>

Impervious surface index is a measure of the development around a waterway which contributes to the ability of the environment to absorb overflow of water. The more developed the segment, the more impervious and the less resilient. For this section, TNC methodology was slightly changed since the classes of impervious surface in our data was not sufficiently outlined to replicate. Instead we used the formula

3*%High Development + 2*%Medium Development + 1*%Low Development and Agriculture + 0*%Natural Land

Table 6: Gradient Class of Impervious Surface:

Gradient Classes
Class 1: 0 to <= .05% impervious surface
Class 2: .05% to <=2%

Class 3: 2% to <= 10%
Class 4: >10%

Source: TNC: North Carolina Freshwater Resilience

Floodplain Naturalness Index:

The floodplain naturalness measures the surrounding areas impact on the waterway. This differs from impervious surface, since impervious surface deals with the way the environment absorbs excess water and alters a flooding event, while floodplain naturalness examines how the environment contributes to the river environment. The greater the development and agriculture, the more unnatural runoff causing environmental alterations. For this metric, TNC methodology was used. The formula used was

(1 * % high intensity developed) + (0.75 * % low intensity developed) + (0.25 * % agriculture.) + (0 * % natural)

Adjusted Cropland Index:

For adjusted cropland index, a measure percent cropland was used. This metric simply measured category 80 and 81 of land use and divided them by the total land cover. This methodology deviated from TNC description due to lack of time and personnel. TNC methodology requires rather intense calculations which we were not capable of during with such a small staff in such limited time. While the methodology differs, the cropland percentage metric still captures the impact of cropland on buffering from non-source pollution contributions.

Table 7: Adjusted Cropland Index:

Gradient Classes
Class 1: <2%
Class 2: 2-9%
Class 3: 10-49%
Class 4: >50%

Source: TNC: North Carolina Freshwater Resilience

Cumulative Dam Storage Index:

The impact of barriers on the waterway is important because they alter the natural state of the river, causing severe ramifications to resilience. For this metric, we deviated from TNC methodology in that we took a count of the number of barriers in each river segment. The measurement was ultimately a summation of non-natural barriers. TNC based their analysis off experts in their regions so this metric was altered to represent WSR values. Any unnatural barrier changes the wild and scenic nature of a river by definition, so we felt this was an accurate measurement for our purposes.

Table 8: Cumulative Dam Storage:

Dam Storage
1.Very Low: <2%
2. Low: 2-9%
3.Moderate: 10-30%
4.High: 30-50%
5. Severe: 50%+

Source: TNC: North Carolina Freshwater Resilience

Cumulative Water Use Index:

This metric was altered as well, since TNC used specific regional measurements. This metric was designed to examine the free flowing characteristics of a waterbody environment. As such, we examined mean annual velocity, since that would tell us the nature of the flow of the waterway. This proxy measurement examines the annual velocity of the river segment and helps determine alterations in use, since greater use of water leads to lower velocity

Table 9: Cumulative Water Use table:

Classes
Class 1: 0% land covered by water bodies
Class 2: 0-2% land covered by water bodies
Class 3: 2%-5% land covered by water bodies
Class 4: >5% land covered by water bodies

Cumulative Percent Waterbody Index:

This metric examines the amount of water contained or moving through an area. Since TNC used consultants who are experts in their region of interest to develop their metric, it was not useful for our project. TNC focused on dam storage while we decided to look at the mean annual flow since ideally water moves through WSRs. As such we examined the Mean Annual Flow to determine how altered the flow of our units of analysis were from their natural state. The higher the flow alteration, the less resilient the river since it cannot naturally restore itself.

All of these attributes will help us to help us identify the most resilient stream networks in California.

Results:

Our results from the resilience attributes: (See Appendix A). After the Resilience attributes were calculated and categorized, a statistical analysis of Z- score was completed. Z-scores are expressed in terms of standard deviations from their means. These z-scores have a distribution with a mean of 0 and a standard deviation of 1. The Z-score for the attributes was calculated by the table below.

The formula for calculating the standard score is given below:

Calculating the Standard Score (Z-Score)

Standard Score, $z = \frac{X - \mu}{\sigma}$

TERMS:
μ = mean (pronounced 'mu')
X = score
σ = standard deviation (pronounced 'sigma')

Source: Global Edge

The final z-scores are shown in the table below.
Table 10:

Section	Z-Scores
A1	-0.500768201
A2	-0.129859837
A3	0.038700589
A4	-0.245030428
B	0.071983719
C	0.414205189
D1	-0.270191029
D2	0.480950052
D3	1.137881597
E	-0.492895302
F	0.037475941
G	0.252586785
H	0.140351853
I	-0.159126803
J	-0.446405193
K	-0.567342089
L	0.518526528
M	0.072063506
N	-0.165110583
O	0.269789231
P	-0.477088522
Q	0.019302996

Table

Of the final z scores, the following data is of note

- 6 rivers fell in the bottom quarter
- 4 rivers fell into the second quarter
- 6 rivers fell into the third quarter
- 6 rivers fell in the top quarter
- Unit K is the lowest scoring section, The Tuolumne River
- Unit D3 is the highest scoring section, The Klamath River

When mapped the results the following is shown:

Figure 6: River Resiliency

River Guide to classify WSR.

Unit	RIVER_ID	River Name	Notes
Too Small	208	River Styx, Oregon Wild and Scenic River	Includes WSR
J,K,I	53	Tuolumne, California Wild and Scenic River	Includes WSR
H	62	Merced, California Wild and Scenic River	Includes WSR
G	63	Kings, California Wild and Scenic River	Includes WSR
F	64	Kern, California Wild and Scenic River	Includes WSR
D1	SD10	Smith, California Wild and Scenic River	Includes WSR
D3	SD11	Trinity, California Wild and Scenic River	Includes WSR
C	SD7	Lower American, California Wild and Scenic River	Includes WSR
D2	SD8	Eel, California Wild and Scenic River	Includes WSR
D3	SD9	Klamath, California Wild and Scenic River	Includes WSR
A 1, 2, 3	64	Kern, California Wild and Scenic River	Flow Extension
B	64	Kern, California Wild and Scenic River	Flow Extension
E	SD8	Eel, California Wild and Scenic River	Flow Extension
L	SD9	Klamath, California Wild and Scenic River	Flow Extension
M	SD7	Lower American, California Wild and Scenic River	Flow Extension
N	64	Kern, California Wild and Scenic River	Flow Extension
O	64	Kern, California Wild and Scenic River	Flow Extension
P	53,62	Tuolumne, California Wild and Scenic River	Flow Extension
Q	SD7	Lower American, California Wild and Scenic River	Flow Extension

Table 11: River Unit Guide

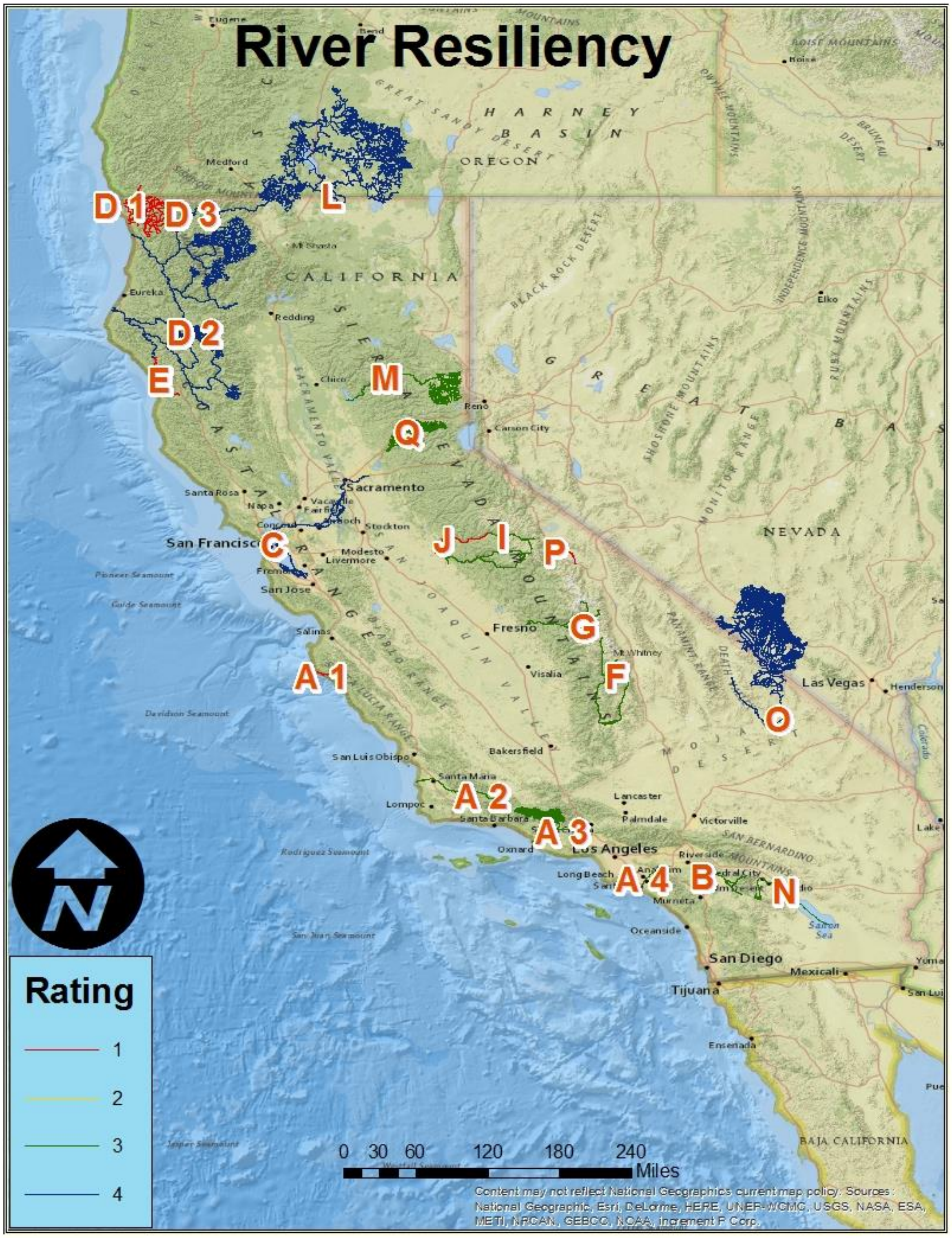

Figure 7: Scoring Methods

These results are of our scoring method. Alternate scoring methods should include similar results.

Discussion

Our methodology, like TNC's methodology for the northeast and southeast regions of the United States provides a possible metric to examine resiliency. We developed analysis of the WSR thought the 11 attributes provided by the TNC. Resiliency itself is a broad and wide ranging term and a full measure is one which includes a myriad of measurements. Due to time and personal limitations only selected concepts of resiliency are used any model.

While TNC methodology explores some aspects of resiliency in depth, it neglects others. One aspect of resiliency is stewardship by local parties. Local parties can help restore and preserve resiliency to an environment. If funding were allotted to restoration and preservation of WSR, local stewardship information is highly recommended. This information will help determine the extent of fiscal resource expenditure verses the amount of volunteer work.

Other aspects of resiliency not addressed are the cultural, historic, recreational, and scenic values necessary which define the remarkability of WSRs. Measures for the scenic nature of the river within a quarter mile are recommended. This could include factors like development and skyline interruption by city environments. A measure of the recreational capacity could include kayak and rafting information as well as restrictions on human interaction with the water through possible contamination of fish. Historic aspects, while difficult to define and create a metric, are needed to fulfill this remarkable aspect. Additionally, cultural factors, such as Native American heritage and local ownership of are necessary.

Finally, other ecological values could prove helpful in examination of resiliency. An extensive list of recovery indicators provided by the EPA discusses base, ecological, stressors, and social aspects needed to understand recovery potential of waterways (https://www.epa.gov/rps/overview-selecting-and-using-recovery-potential-indicators). These factors, with some modification, can provide important insight into resiliency. Additionally, factors included by the EPA include Corridor stability, biotic community integrity, pollutant loading, future land use trajectory, and human health factors.

Business Case and Implementation Plan

The TNC North Carolina Freshwater Resilience Case Study example is an effective way of determining for understanding resilient WSR'S in the state of California. For any future implementation of measures of resiliency, a clear definition of factors considered resilient needs to reflect the organizational goals of NPS or the sponsor organization. Though the agreed upon method showed some aspects of resiliency, it did not measure all the outstanding remarkable values required to designate a segment of river as wild and scenic. We believe it is necessary to add measures of scenic, recreational, historic, and cultural values to fully align our concepts with the needs, wants, and desires of the NPS WSR program.

In order to successfully implement the methodology in a business case, one must:

1. Examine and determine which categories of resilience are relevant
2. Determine the best metric for measurement of these categories
3. Create the data for analysis
4. Equalize the data results mathematically for ranking
5. Rank the variables
6. Compare and display the results

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Appendix:

Appendix I:

Landcover Attributes:

LandCover	24	23	22	21	82	81	31	41	42	43	51	52	71	72	74	90	95	Total
A1	0	0	0.9207	23.8572	0.2583	0.0612	4.0248	0.4428	1313.732	326.6982	0	994.1526	0	0	0	3.771	0.0045	2667.923
A2	10.9395	237.1068	362.6694	4618.451	7490.749	2458.717	5697.319	2.43	32537.16	30018.2	0	166041.1	39714.1	0	0	852.2811	891.1863	290932.4
A3	342.5418	4597.494	5397.811	14993.36	5519.426	1344.76	3229.672	26.2791	45323.19	33936.32	0	192050.7	37520.7	0	0	1163.496	625.3236	346071.1
A4	1916.57	19220.5	18926.69	19865.5	4896.882	2824.649	1457.42	10.6524	17560.62	2440.859	0	52930.3	23542.17	0	0	980.9127	281.7486	164938.9
B	0	0	936.9243	2521.083	1487.974	556.488	163.5237	0	4740.053	579.3561	0	14867.67	4797.628	0	0	34.5528	132.912	30818.16
C	17447.92	73482.68	72336.78	181596.8	838287.2	150702.6	101625.8	127104.6	2679392	97094.93	0	1380883	1198495	0	0	21896.1	64706	7005052
D1	1.6029	10.161	68.8914	1480.992	5.6889	6.1731	76.653	654.8832	39839.75	3044.738	0	8767.855	361.2375	0	0	11.6505	2.5236	54332.8
D3	1925.835	6675.779	22291.61	121980.3	282067.3	144974.6	53149.8	45102.6	3800447	88074.96	0	1714866	723824.2	0	0	10293.95	160885.8	7176560
E	0.5841	14.6187	37.8252	1755.031	12.006	33.9894	63.0477	1292.377	24183.92	1276.922	0	4137.472	2086.949	0	0	69.4638	4.9392	34969.15
F	0.324	5.5134	72.0288	379.8099	0	133.6536	48074.71	360.558	163018.1	59.3712	0	171923.3	21818.9	0	0	70.1496	1726.292	407642.8
G	30.087	5.6565	18.5337	372.4587	2.8341	0	53967.83	512.7381	82118.64	204.7563	0	55047.64	10757.58	0	0	25.02	264.1455	203327.9
H	2.16	25.3269	57.0285	1023.116	1.62	0	17640.42	673.4268	93184.48	878.6484	0	48813.8	6998.293	0	0	0	399.1212	169697.4
I	0	0.639	0.5967	53.8218	0	0	7125.555	2.4867	11505.78	0.7092	0	8810.267	1712.425	0	0	0.1044	362.0007	29574.39
J	21.3696	48.7935	195.3216	868.7448	17.1378	0	20005.21	1372.103	62462.96	344.2221	0	42892.9	7589.097	0	0	2.3859	576.0036	136396.2
K	0	0.135	0.0702	6.993	0	0	1798.775	1.7055	2593.134	0.0576	0	2401.174	58.0158	0	0	0.0756	63.945	6924.081
L	368.766	1071.55	3543.25	13524.84	73268.78	42169.9	10020.05	219.1698	924735.9	168.3027	0	498745.9	303770.7	0	0	1897.366	79512.07	1953017
M	43.4925	154.5093	1170.842	4740.095	1043.471	5696.147	14.43845	628.5465	186564.4	628.8246	0	138630.9	48528.33	0	0	3.4578	6635.747	394483.2
N	892.2987	6325.835	5867.844	4019.731	4088.928	2090.871	17631.59	26.8416	10109.45	1417.529	0	80730.02	12424.32	0	0	181.7091	183.375	145990.4
O	28.9251	616.6818	6880.878	3754.993	0	514.0809	115262.6	29.4642	35592.7	99.0747	0	2117855	24267.52	0	0	1675.277	156.7107	2306734
P	21.456	102.2184	193.6305	127.3077	0	18.3375	1638.294	19.1556	10437.96	7.9182	0	13030.44	200.2157	0	0	144.1494	146.0844	26087.17
Q	4.9779	61.1091	140.8752	502.92	0	0	170.3835	627.2973	30996.77	1736.76	0	11623.06	697.5486	0	0	2.2266	14.7771	46578.7

LandCover	High Development	Medium	Low	Open	Agriculture	Natural	Flood Hi	Flood Lo	Flood AG	Flood Nat
A1	0	0	0.9207	23.8572	0.3195	2642.826	0	24.7779	0.3195	2642.826
A2	10.9395	237.1068	362.6694	4618.451	9949.4658	275753.8	248.0463	4981.12	9949.466	275753.8
A3	342.5418	4597.494	5397.811	14993.36	6864.1857	313875.7	4940.036	20391.17	6864.186	313875.7
A4	1457.4195	19220.5	18926.69	19865.5	7721.5311	99204.68	20677.92	38792.19	7721.531	99204.68
B	0	0	936.9243	2521.083	2044.4616	25315.69	0	3458.007	2044.462	25315.69
C	17447.922	73482.68	72336.78	181596.8	988989.8013	5671198	90930.6	253933.6	988989.8	5671198
D1	1.6029	10.161	68.8914	1480.992	11.862	52759.29	11.7639	1549.884	11.862	52759.29
D3	1925.8353	6675.779	22291.61	121980.3	427041.927	6596644	8601.614	144271.9	427041.9	6596644
E	0.5841	14.6187	37.8252	1755.031	45.9954	33115.09	15.2028	1792.856	45.9954	33115.09
F	0.324	5.5134	72.0288	379.8099	133.6536	407051.4	5.8374	451.8387	133.6536	407051.4
G	30.087	5.6565	18.5337	372.4587	2.8341	202898.3	35.7435	390.9924	2.8341	202898.3
H	2.16	25.3269	57.0285	1023.116	1.62	168588.2	27.4869	1080.144	1.62	168588.2
I	0	0.639	0.5967	53.8218	0	29519.33	0.639	54.4185	0	29519.33
J	21.3696	48.7935	195.3216	868.7448	17.1378	135244.9	70.1631	1064.066	17.1378	135244.9
K	0	0.135	0.0702	6.993	0	6916.883	0.135	7.0632	0	6916.883
L	368.766	1071.55	3543.25	13524.84	115438.6719	1819069	1440.316	17068.09	115438.7	1819069
M	43.4925	154.5093	1170.842	4740.095	6739.6176	381634.6	198.0018	5910.937	6739.618	381634.6
N	892.2987	6325.835	5867.844	4019.731	6179.7987	122704.8	7218.134	9887.576	6179.799	122704.8
O	28.9251	616.6818	6880.878	3754.993	514.0809	2294939	645.6069	10635.87	514.0809	2294939
P	21.456	102.2184	193.6305	127.3077	18.3375	25624.22	123.6744	320.9382	18.3375	25624.22
Q	4.9779	61.1091	140.8752	502.92	0	45868.82	66.087	643.7952	0	45868.82

LandCover	Percent Hi	Percent Lo	Percent AG	Percent Nat	Naturalness	Percent Hi	Percent Med	Percent Low	Percent None	Impervious Surface
A1	0	0.0092873	0.00011976	0.99059291	0.006995442	0	0	0.009287337	0.990712663	0.009287337
A2	0.000853	0.0171212	0.03419855	0.94782764	0.022243148	0.0008526	0.000814989	0.017121227	0.982026182	0.021308978
A3	0.014275	0.0589219	0.01983461	0.90696885	0.063424715	0.0142746	0.013284827	0.058921911	0.92680346	0.12831545
A4	0.125367	0.2351912	0.04681449	0.60146322	0.313464214	0.1253672	0.116531037	0.235191248	0.648277715	0.844354786
B	0	0.1122068	0.0663395	0.82145371	0.100739966	0	0	0.112206786	0.887793214	0.112206786
C	0.012981	0.0362501	0.14118237	0.80958684	0.07546386	0.0129807	0.010489955	0.036250065	0.950769217	0.096172129
D1	0.000217	0.0285257	0.00021832	0.97103942	0.021665406	0.0002165	0.000187014	0.028525747	0.971257738	0.029549322
D3	0.001199	0.0201032	0.0595051	0.91919311	0.031152259	0.0011986	0.00093022	0.020103217	0.978698212	0.025559369
E	0.000435	0.0512696	0.00131531	0.94698029	0.039215812	0.0004347	0.000418046	0.051269646	0.948295605	0.053409984
F	1.43E-05	0.0011084	0.00032787	0.99854939	0.000927601	1.432E-05	1.35251E-05	0.001108418	0.998877262	0.001178428
G	0.000176	0.001923	1.3939E-05	0.9978873	0.001621501	0.0001758	2.78196E-05	0.001922965	0.997901243	0.002505981
H	0.000162	0.0063651	9.5464E-06	0.99346336	0.0049382	0.000162	0.000149247	0.006365117	0.993472908	0.007149539
I	2.16E-05	0.0018401	0	0.99813834	0.001401648	2.161E-05	2.16065E-05	0.001840055	0.998138338	0.001948088
J	0.000514	0.0078013	0.00012565	0.99155866	0.006396784	0.0005144	0.000357733	0.007801288	0.991684306	0.010059974
K	1.95E-05	0.0010201	0	0.99896041	0.000784566	1.95E-05	1.94972E-05	0.001020092	0.998960411	0.001117578
L	0.000737	0.0087393	0.05910788	0.93141529	0.022068964	0.0007375	0.000548664	0.008739348	0.99052317	0.012049124
M	0.000502	0.014984	0.01708468	0.96742939	0.0160111	0.0005019	0.000391675	0.014984004	0.984514069	0.017273136
N	0.049443	0.0677276	0.04233019	0.84049968	0.110820784	0.0494425	0.043330503	0.067727595	0.882829863	0.302716226
O	0.00028	0.0046108	0.00022286	0.99488647	0.003793688	0.0002799	0.00026734	0.004610792	0.995109329	0.005985109
P	0.004741	0.0123025	0.00070293	0.98225373	0.014143443	0.0047408	0.00391834	0.01230253	0.982956657	0.034361648
Q	0.001419	0.0138217	0	0.98475951	0.011785074	0.0014188	0.001311954	0.013821666	0.98475951	0.020702047

Appendix II:

Sq miles & Sq KM attributes:

	KM	MI	Size Class	Metric
A	3142.2465	1213.227658	3a	4
A1	2567.9754	991.5004379	3a	4
A2	291063.322	112380.1307	3a	4
A3	347929.833	134336.4043	3a	4
A4	167994.746	64863.10746	3a	4
B	32001.0183	12355.65717	5	6
C	7105545.89	2743465.48	5	6
D2	10324411.3	3986275.87	5	6
1D	54359.8074	20988.43036	5	6
2D	2918317.55	1126768.241	5	6
3D	7336695.55	2832712.824	5	6
E	35076.3849	13543.06236	5	6
F	409011.407	157920.1223	5	6
G	205378.817	79297.17216	5	6
H	170544.471	65847.56146	5	6
I	29913.5394	11549.67739	5	6
J	138467.377	53462.53116	5	6
K	7328.3148	2829.477001	3b	5
L	2002054.99	772997.4339	5	6
M	398522.768	153870.4376	5	6
N	155481.056	60031.54672	5	6
O	2308515.96	891322.6298	5	6
P	27063.5724	10449.29943	5	6
Q	46749.3048	18050.00008	5	6

Appendix III: Gradient Flow:

	High	Low	
A1	0.130929	0.000001	0.130928
A2	0.355825	0.000001	0.355824
A3	0.55863	0.000001	0.558629
A4	0.017133	0.000001	0.017132
B	0.2832	0.000001	0.283199
C	0.00821	0.000001	0.008209
D2	1.3064	0.000001	1.306399
D1	0.65	0.000001	0.649999
D2	0.332236	0.000001	0.332235
D3	1.3064	0.000001	1.306399
E	0.0275	0.000001	0.027499
F	0.21115	0.000001	0.211149
G	0.43435	0.000001	0.434349
H	0.468431	0.000001	0.46843
I	0.4663	0.000001	0.466299
J	0.03063	0.000001	0.030629
K	0.038956	0.000001	0.038955
L	0.9415	0.000001	0.941499
M	0.35863	0.000001	0.358629
N	0.17505	0.000001	0.175049
O	0.2871	0.000001	0.287099
P	0.19025	0.000001	0.190249
Q	0.57609	0.000001	0.576089

Appendix IV:
Elevation Attributes:

	MAXELEVRAW	MINELEVRAW	MAXELEVSMO	MINELEVSMOTH	Change	In Meters
A1			108000	104	107896	1078.96
A2			160254	244	160010	1600.1
			209444	158	209286	2092.86
			13791	219	13572	135.72
B	297313	42002	297313	42198	255115	2551.15
C	290	-393	3368	-364	3732	37.32

D2	227426	-5	227426	-5	227431	2274.31
D1			160734	344	160390	1603.9
D2			198128	0	198128	1981.28
D3			227426	156	227270	2272.7
E	69419	11102	69419	11127	58292	582.92
F	372756	76159	372756	77453	295303	2953.03
G	364078	27827	364078	27827	336251	3362.51
H	350214	23672	350214	23672	326542	3265.42
I	336921	114407	336921	114407	222514	2225.14
J		23058	65876	23058	42818	428.18
K		65756	114407	65876	48531	485.31
L			231934	75657	156277	1562.77
M			242550	26211	216339	2163.39
N			179132	-7099	186231	1862.31
O			229510	-8450	237960	2379.6
P			320634	206330	114304	1143.04
Q			255658	21354	234304	2343.04

Appendix V: Barriers:

ds69 intersect	300m tolerance	point return
A	986	
B	0	
C	993	
D2	3805	
E	73	
F	3	
G	9	
H	0	
I	62	
J	1	
K	4	
L	8	
M	12	
N	2	
O	0	
P	1	
Q	23	

Appendix VI:

Flow Attributes:

MAFLOWV	Flow High	Flow Low		MAVELV	Vel High	Vel Low	
A1	75.08579	12.7359	62.34989		1.93557	0.6249	1.31067
A2	448.7009	10.67962	438.0213		2.86066	0.70897	2.15169
A3	456.4693	2.06024	454.4091		2.84912	0.54362	2.3055
A4	551.1772	525.0169	26.16026		2.77865	1.06447	1.71418
B	111.514	2.2453	109.2687		2.26	0.5605	1.6995
C	4127.73	0.7278	4127.002		2.8466	0.4941	2.3525
D1	6178.051	43.02087	6135.03		2.70477	0.64307	2.0617
D3	7867.614	3.31591	7864.298		3.75143	0.57274	3.17869
E	1682.694	51.125	1631.569		2.404	0.73411	1.66989
F	1037.677	2.1558	1035.521		2.905	0.5246	2.3804
G	2368.48	45.2102	2323.27		4.23	0.9109	3.3191
H	1496.414	25.813	1470.601		3.2054	0.73507	2.47033
I	1347.441	35.6436	1311.798		2.93286	0.89312	2.03974
J	2629.825	1972.842	656.9829		3.0916	1.0801	2.0115
K	1352.733	1348.893	3.8405		2.72352	0.95496	1.76856
L	1572.403	0.0004	1572.403		2.4295	0.437	1.9925
M	2551.78	2.376	2549.404		3.1471	0.5136	2.6335
N	117.4487	2.5496	114.8991		1.90663	0.5957	1.31093
O	68.6596	0.0001	68.6595		2.3921	0.4762	1.9159
P	261.6847	1.6936	259.9911		1.8344	0.5566	1.2778
Q	1038.906	14.1806	1024.725		2.4633	0.5796	1.8837

Appendix VII

Temperature Attributes:

TempVC		High	Low	
A		1603.148	1013.42	589.7282
A1		1459.42	0.785607	1458.634
A2		1574.404	0.002319	1574.401
A3		1673.552	0.001609	1673.55
A4		1590.964	0.0025	1590.961
B		1625.725	459.087	1166.638
C		1566	1129.706	436.2945

D2		1564.447	450.309	1114.138
D1		1220.599	884.395	336.204
D2		1405.48	0.029	1405.451
D3		1411.18	0	1411.18
E		1290.45	1229.298	61.15228
F		942.7873	-114.917	1057.704
G		657.2525	-150.075	807.3274
H		1022.299	7.3371	1014.962
I		375.9365	86.6644	289.2721
J		878.7302	497.2077	381.5225
K		423.8785	386.2694	37.6091
L		1016.41	315.247	701.1629
M		925.3961	546.346	379.0501
N		1956.262	1272.46	683.8025
O		1853.49	860.3649	993.125
P		595.0782	346.7319	248.3463
Q		1514.937	493.85	1021.087

Appendix VII:

County Attribues:

Sector	Alameda	Butte	Contra Costa	Del Norte	Fresno	Glenn	Humboldt	Imperial	Inyo	Kern	Lake	Lassen	Madera
A													
B													
C	254.89		302.73										
D2				13.67		606.63	113.98				50.85		
E							113.98						
F										2159.89			
G					2813.24								
H													748.71
I													
J													
K													
L													
M		715.33										202.61	
N								1169.24					
O									111.57				
P													
Q													

Sector	Mariposa	Mendocino	Modoc	Mono	Monterey	Orange	Placer	Plumas	Riverside	Sacramento	San Bernardino	San Joaquin
A					545.54	765.39			1099.26			
B									1099.26			
C										681.06		1753.37
D2		81.53										
E		81.53										
F												
G												
H	5.32											
I												
J												
K												
L			261.53									
M								118.73				
N									1099.26			
O											659.42	
P				229.71								
Q							191.22					

Sector	San Luis Obispo	San Mateo	Santa Barbara	Santa Clara	Sierra	Siskiyou	Solano	Trinity	Tulare	Tuolumne	Ventura	Yolo	TOTAL
A	2579.14		264.25								719.48		5973.06
B													1099.26
C		93.08		298.22			452.77					780.74	4616.86
D2						411.07		22.53					1300.26
E													195.51
F									2600.28				4760.17
G													2813.24
H													754.03
I										35.75			35.75
J										35.75			35.75
K										35.75			35.75
L						411.07							672.6
M					39.03								1075.7
N													2268.5
O													770.99
P													229.71
Q													191.22