Lower Colorado River Basin
Aquatic Gap Analysis Project

Progress Report

In partial fulfillment of the obligations for
Research Work Order 50: Development of Conservation Priorities to Protect Biodiversity of Fishes in the Lower Colorado River Basin

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Introduction

The Lower Colorado River Basin (LCRB) has one of the most imperiled fish faunas in the nation and information is needed to develop conservation strategies for the aquatic biota in this regions. Although researchers have suggested that full recovery of native fish communities in the Lower Colorado River Basin is not feasible due to political, societal, and economic reasons, the development of criteria for conservation will aid in any future considerations to protect aquatic species in the basin. Native fishes in the Colorado River Basin have been adversely impacted by modifications in fish communities, hydrology, and river morphology. Reports of introduced species occurred as early as the 1870's and the number of introduced species is now over twice that of native species (Young et al. 2001). Of the 31 fish species native to the Lower Colorado River Basin, 17 are listed as Threatened or Endangered under the Federal Endangered Species Act. In addition to detrimental impacts of introduced species, the Lower Colorado River system provides irrigation water for about 4 million acres of agriculture fields and is a water source for 30 million people in the United States and Mexico (Mueller and Marsh 2002). Historically, Colorado River floods carried nutrients to the lower basin and created productive, vegetated floodplains which were used by the local fish fauna (Ohmart et al. 1988). Today water diversions remove all water from reaches of the Lower Salt, Gila, and Colorado rivers and most historic wetlands in the Colorado River Delta; whereas other reaches have been inundated by reservoirs (Mueller and Marsh 2002). The morphology of the basin system has been highly altered by the 20 major dams and extensive system of canals and channelization projects (Mueller and Marsh 2002). These water diversion projects, coupled with increases in non-native fish abundance, have severely impacted the native aquatic fauna and substantially reduced native fish diversity.

Non-native introductions have substantially changed the native fish fauna in the LCRB. To date, over 90 species have been introduced (Rinne and Janisch 1995) though intentional and unintentional introductions. These introductions are considered one of the primary causes for the decline of native fishes in the region. Identifying the areas that have the highest loss of native fish diversity (or highest increase in non-native fish diversity) can help identify areas that resource managers may focus on for conservation. In addition, developing models of invasion rates of non-native fishes can help resource managers predict areas that have a high likelihood of colonization in the future (Wikle 2003; Marchetti et al. 2004).

Anthropogenic impacts are also a major cause of declines in habitat and native fishes. Not including non-native fish introductions, this may include modification of flows though impoundment, irrigation, or habitat modification, as well as urbanization and other development that include construction of roads, bridges, or mining operations. Other studies have indicated that these anthropogenic influences have altered fish community composition and reduced or eliminated native species (Baker et al. 2005; Oakes et al. 2005). The Lower Colorado River Basin is infamous for being a highly altered system in regards to flow and temperature modifications, irrigation, land use, and non-native fish invasions. Therefore, the LCRB provides an appropriate model to determine the effects of landscape-level factors and non-native fishes on the native fish diversity within the basin.

Statistical models are often used to link metrics for individual species and species assemblages to habitat characteristics at various landscape scales (e.g., Baker et al. 2005; McKenna 2005; Oakes et al. 2005). The most common models are artificial neural networks, classification-regression trees, logistic regression, and linear regression. In general, these models perform similarly and conclusions drawn from one model are typically similar to other models. However, the evaluation of these models have primarily come from predicting fish distributions in regions (Baker et al. 2005; Oakes et al. 2005) which have a substantially different fish assemblages, land use, geology, geography, and hydrology when compared to the LCRB. Therefore, it is unclear if the environmental variables that provided the strongest predictive influence in these systems will also drive the predictive models for the LCRB.

Stream habitat classification is inherently hierarchal and classifying habitat at one scale is strongly related to habitat classification at another scale (Frissel et al. 1986; Gido et al. 2006). Defining the appropriate scale at which to define habitat classification and protect biodiversity is necessary so resource managers can make informed decisions on conservation efforts (MacNally et al. 2002). One of the goals of the GAP program is to develop a coarse-filter approach to identify conservation areas, and other efforts have used the same premise to define an ecological classification system to protect aquatic biodiversity (Sowa et al. 2004; Higgins et al. 2005). A framework including Aquatic Subregions (or Aquatic Zoogeographic Unit; Higgins et al. 2005), Ecological Drainage Units (EDU), and Aquatic Ecological Systems (AES) has been accepted by conservation organizations and has shown promise in providing a framework for conservation of biodiversity (Sowa et al. 2004; Higgins et al. 2005).

Progress to date

Objectives

1. Determine the rate of change in native and non-native fishes within the Lower Colorado River basin. <u>STATUS: ongoing</u>
2. Identify landscape-level habitat metrics associated with native fish presence in the Lower Colorado River basin. <u>STATUS: ongoing</u>
3. Develop a classification hierarchy for aquatic habitats to provide an ecological basis for determining conservation areas. <u>STATUS: complete</u>
4. Incorporate species, environmental, and threat data in the selection of conservation areas. STATUS: <u>ongoing</u>

Data Collection

Species Data

Fish location data were gathered from several state and federal agencies, universities, and museums. Fish records with complete collection information (point location, species name, site description, and year collected) were checked for accuracy and then entered into a Microsoft Access database. When possible, records with discrepancies were corrected through consultation with the organization/individual that originally provided the record. To date, we have over 1,500,000 individual records in the database encompassing 173 species that have been documented but not all introduced fishes are established in the Lower Colorado Basin (Appendix A). The distribution of records between native and non-native species is nearly even. Although the data range from early 1900's to present, about half of the records were obtained from 1980–present. Supplementary data regarding fish measurements, sampling effort, sampling methods, and site descriptors were included in the database when available. The data source for each record was included for validation of the dataset.

We explored the possibility of including crayfish and mussels in our assessment but found very little available or current information for either invertebrate. At this time, we do not plan on modeling distributions of these taxa.

Habitat and Supplementary Data

Landscape-level habitat data were obtained from several sources (Table 1). These have been attributed to stream segment, catchment, Aquatic Ecological System, and the upstream watershed for each level of aquatic system (these aquatic system designations are described in detail in the next section**)**. Most of these datasets were described in detail in our annual report for 2005 (available at http://www.lcrgap.org/documents/2005_1_year_report.pdf).

Table 1. Habitat and supplementary data used for the Lower Colorado River Aquatic GAP.

Data Type	Source
Aerial imagery (DOQQ)	USGS, Arizona Regional Image Archive
Canals	USGS, National Hydrography dataset
Dams/Reservoirs	US Army Corp of Engineers, National Inventory of Dams
Diversions	California State Water Resources Control Board, Nevada Division of Water Resources, Utah Division of Water Rights, Arizona Department of Water Resources, New Mexico Office of the State Engineer
Elevation	National Elevation Data and Shuttle Radar Topography Mission
Geology	Southwest Regional Gap Analysis Project (SW REGAP) and California Geological Survey (Saucedo et al. 2000)
Hydrologic Units	USGS
Impaired stream classification (303d, 305b)	Environmental Protection Agency, Water Quality Standards Database
Landcover	National Landcover Dataset 2000
Landform	Derived from National Elevation Data
Mines	USGS, Mineral Resources
Point sources of pollution	Environmental Protection Agency , NPDES
Railroads	US Census Bureau, Tiger files
Roads	US Census Bureau, Tiger files
Soils	USDA, Digital General Soil Map of U.S.
Stream network	USGS, National Hydrography dataset
Stewardship	Southwest Regional Gap Analysis Project (SW REGAP) and California GAP
Superfund/Toxic	Environmental Protection Agency
USGS Gage stations	USGS, Water Resources
Water quality	Environmental Protection Agency

Hierarchical Divisions

The primary purpose for creating hierarchical divisions for riverine ecosystems is to provide an ecologically meaningful framework to summarize ecological and anthropogenic information and to create spatially explicit boundaries for conservation planning. Several widely used divisions have been created for terrestrial systems (Bailey 1976; Omernik 1987; Dinerstein et al. 1995) but these have been deemed inadequate to capture the diversity of freshwater systems (Abell et al. 2000). Maxwell et al. (1995) developed a nested hierarchy specifically for freshwater systems (Subzone down to subwatershed). Based on more recent classification efforts for freshwater systems (Higgins et al. 2005; Sowa 2007), we are using the nested hierarchy depicted in Fig. 1 and described in more detail in the following paragraphs.

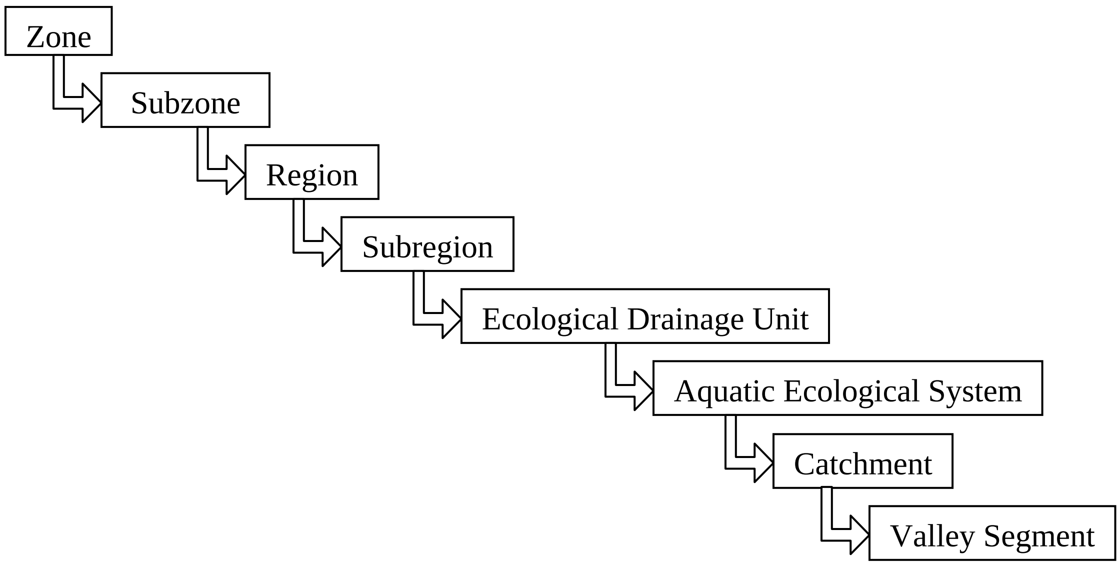

Fig. 1. Schematic of the nested, hierarchical divisions used to assess patterns of ecosystem variation across landscape scales.

Zone

Darlington (1957) grouped Earth into six zoogeographic zones: the Nearctic – North America, Neotropical – south and Central America, African – Africa, Oriental – India, southeast Asia, Macronesia, Palaearctic – Eurasia north of the Oriental zone, and Australian – Australia, New Zealand, New Guniea. The Lower Colorado River Basin lies within the Nearctic Zone (Fig. 2).

Subzone, Region, and Subregions

Maxwell et al. (1995) developed seven hierarchical levels for the Nearctic zone based on zoogeography of native fishes and freshwater mussels. The upper three levels are subzone, region, and subregion. The Lower Colorado falls entirely within the Pacific Subzone and the Colorado Region (Fig 2). The Colorado Region was further subdivided into five subregions: Little Colorado, Vegas-Virgin, Gila, Upper Colorado, and Lower Colorado with the purpose to capture the taxonomic groups formed through past geomorphic changes. Abell et al. (2000) reduced these to three subregions (Colorado, Gila, and Vegas-Virgin) based on reviews by biodiversity experts who examined patterns across a wider range of aquatic taxa (Fig.2). We kept the subzone and region delineations of Maxwell et al. (1995) and the revised boundaries for the subregion that incorporated biodiversity patterns of additional taxa (Abell et al. 2000).

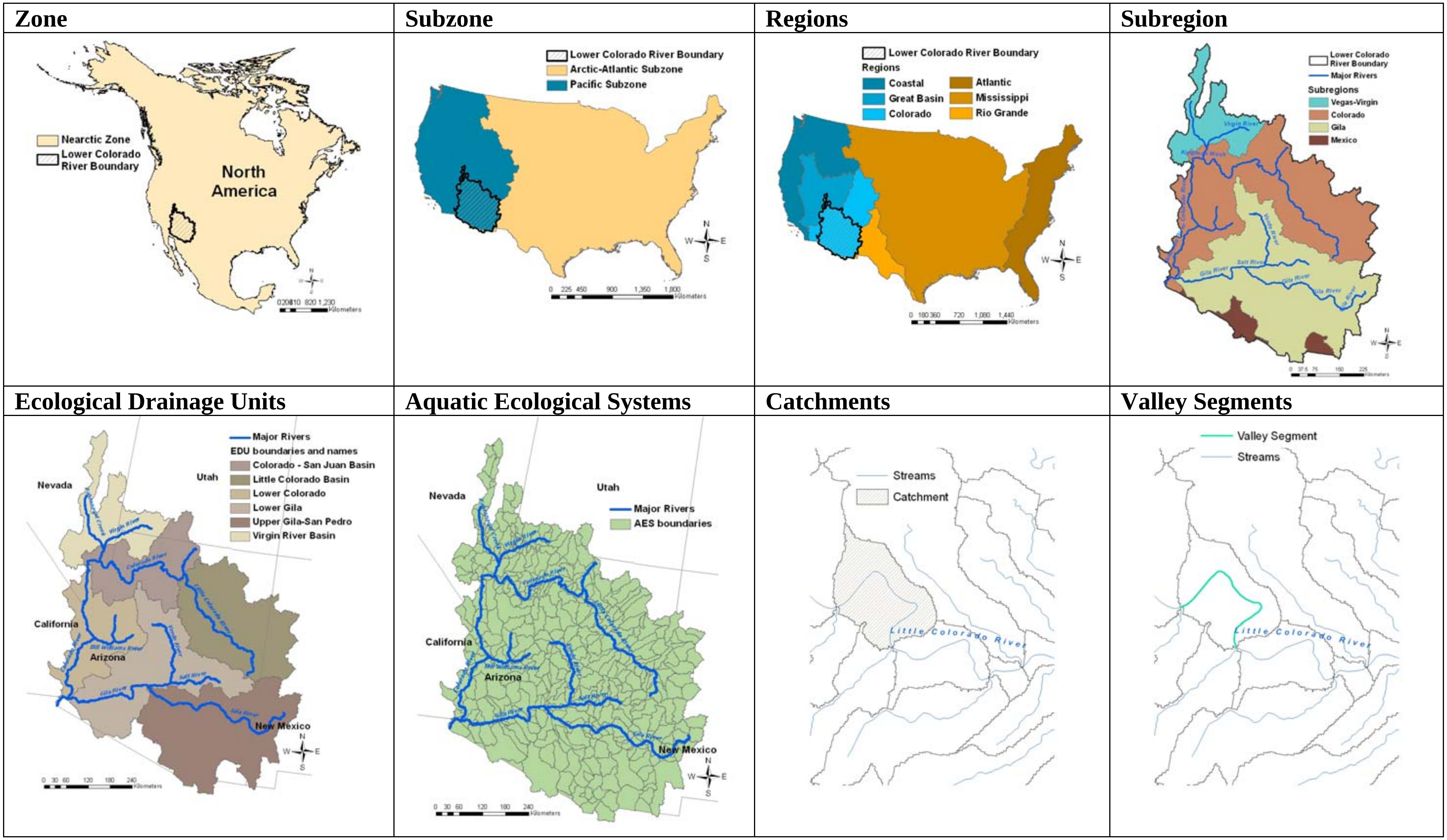

Fig. 2. Nested hierarchical divisions for the Lower Colorado River Basin.

Ecological Drainage Units

The purpose of delineating an Ecological Drainage Unit (EDU) is to distinguish unique zoogeographic subunits within subregions. The biotic assemblages within the zoogeographic subunits typically have similar foraging and reproductive strategies, and physiological tolerances (Sowa 2005). The EDUs are generally groupings of existing 8-digit hydrologic unit codes (HUC) which is a watershed boundary system developed by US Geological Survey. The Nature Conservancy recently defined EDU boundaries for the Colorado River and are in the process of completing an EDU data layer for the entire United States. We regrouped the 8-digit HUCS for the Virgin River and the Colorado – San Juan because one of the Virgin River HUCs (15010009) had been incorrectly grouped into the Colorado – San Juan Basin (Fig. 3). This edit was made after consultation with Craig Walker, Supervisory Biologist, Utah Division of Wildlife.

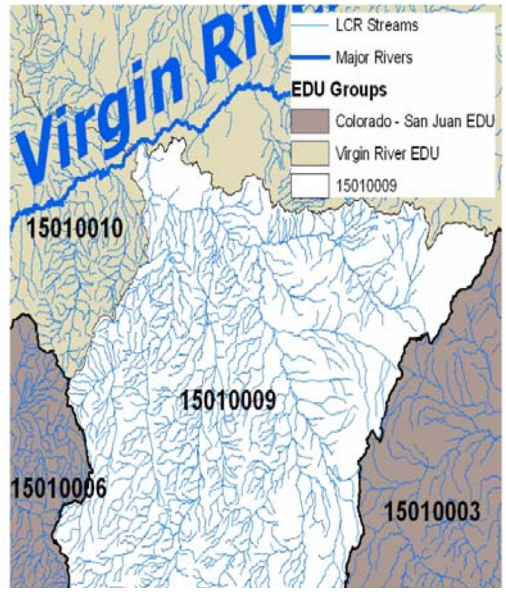

Fig. 3. The original Ecological Drainage Unit (EDU) dataset created by The Nature Conservancy included one Virgin River watershed (15010009) that was incorrectly grouped in with the Colorado – San Juan EDU. After consultation with regional fisheries biologists, we reassigned this watershed to the Virgin River EDU.

Aquatic Ecological Systems

The purpose of delineating Aquatic Ecological Systems (AES) is to derive watershed boundaries that reflect distinct biological communities and provide a base layer that could be used to delineate conservation priorities. The boundaries are kept fairly large (e.g. 200 – 1,600 km^2) to encompass potential movement patterns of fishes, represent habitat heterogeneity at broad scale, and maintain practical units for conservation management and planning (Maxwell et al. 1995; Sowa et al. 2005).

Several methods have been used to derive naturally distinct spatial units such as AES: 1) a top-down approach where the boundaries are set *a priori* based on knowledge of variables such as stream size and expert opinion of a system or by using large-scale landscape variables, 2) a bottom-up approach that conducts multivariate or clustering analyses of empirical data (i.e. water chemistry, flow regime, temperature, connectivity), and 3) a tiered approach that typically begins with top-down and modifies the boundaries based on additional landscape data and expert opinion (Seelbach et al. 1997; Hawkins et al. 2000; Higgins et al. 2005; Eros 2007; Sowa et al. 2007). The bottom-up approach generally is considered the most rigorous but requires fine-scale data sets (Higgins et al. 2005; Stagliano 2005). Hawkins et al. (2000) reviewed the efficacy of the various classifications and recommended using a combination of reach-level and large-scale landscape features (tiered approach).

Therefore, we used the tiered approach to develop AES boundaries for the Lower Colorado River Basin. The metrics we selected were landscape and reach-level features that have been linked to biodiversity of freshwater taxa (Seelbach et al. 1997; Allan 2004; Sowa et al. 2007).

The primary metrics assigned to each stream segment (defined as a confluence to confluence section) were 1) dominant landform (e.g. canyon, plains) transected by the stream segment, 2) occurrence within a subregion, 3) Shreve link value, and 4) magnitude of change in Shreve link value from one stream segment to another. These criteria or similar substitutes (e.g. Stahler Order) have been used successfully in other studies with similar goals (Seelbach et al. 1997; Sowa et al. 2005).

The dominant landform for each stream segment was determined using a Topographic Position Index (TPI) developed by Weiss (2001). Indices are calculated using two scales of moving windows (neighborhoods) to determine the relative change in elevation and overlaid with a slope data layer to derive landform types. We used an ArcView 3.X tool created by Jenness (2006) that calculates the TPI based a user-selected input values. The size of the windows and criteria to designate land form are determined by the user (see Jenness (2006) for further details). After several trials, we found that circular neighborhood sizes of 2000 m and 500 m adequately identified narrow slot canyons and wider valleys by comparing the results to known geologic features. We used one of the default landform classifications developed by Weiss (2001) which resulted in nine landform types (Table 2).

Table 2. Mean Shreve link by landform for each subregion.

	Subregion		
Landform	Virgin	Colorado	Gila
Plains	66	425	221
U-shaped valleys	100	486	229
Open slopes	10	7	6
Midslope drainage, shallow valleys	19	16	3
Canyon, deeply incised streams	74	563	88
Upland drainages, headwaters	1*	1	1
Upper slopes, mesas	1	1	1
Midslope ridges, small hills in plains	1*	1*	1*
Mountain tops, high ridges		1*	1*

* less than 5 stream segments fell into these categories

We followed the recommendations of Sowa et al. (2007) to develop AES separately for subregions because the relative size of streams may vary between subregions and to create AES only for larger drainages (Table 2). This meant that we grouped streams and catchments by the three subregions (Vegas-Virgin, Colorado, and Gila) comprising the Lower Colorado River Basin. Stream segments with Shreve link values that fell in the lower 10^{th} quantile for each subregion were excluded from the AES dataset to prevent the creation of AES for small drainages.

Magnitude of Shreve link change was calculated as the proportional difference from an upstream segment to a downstream segment. This identified confluences where a small river flowed into a much larger river which can indicate a change in biotic community (Seelbach et al. 1997).
We developed the boundaries for the AES in two stages. First we restricted the initial AES boundary delineation to streams using two criteria: 1) Shreve Link value fell in the upper 10% of values for each landform type by subregion and 2) magnitude change in Shreve link was at least

80% (Fig. 4a and b). In the second stage, the AES boundaries were further subdivided when visual inspection revealed changes in dominant landform and gradient which have been shown to reflect biodiversity across several aquatic taxa (Seelbach et al. 1997; Eros 2007; Fig. 4c and d).

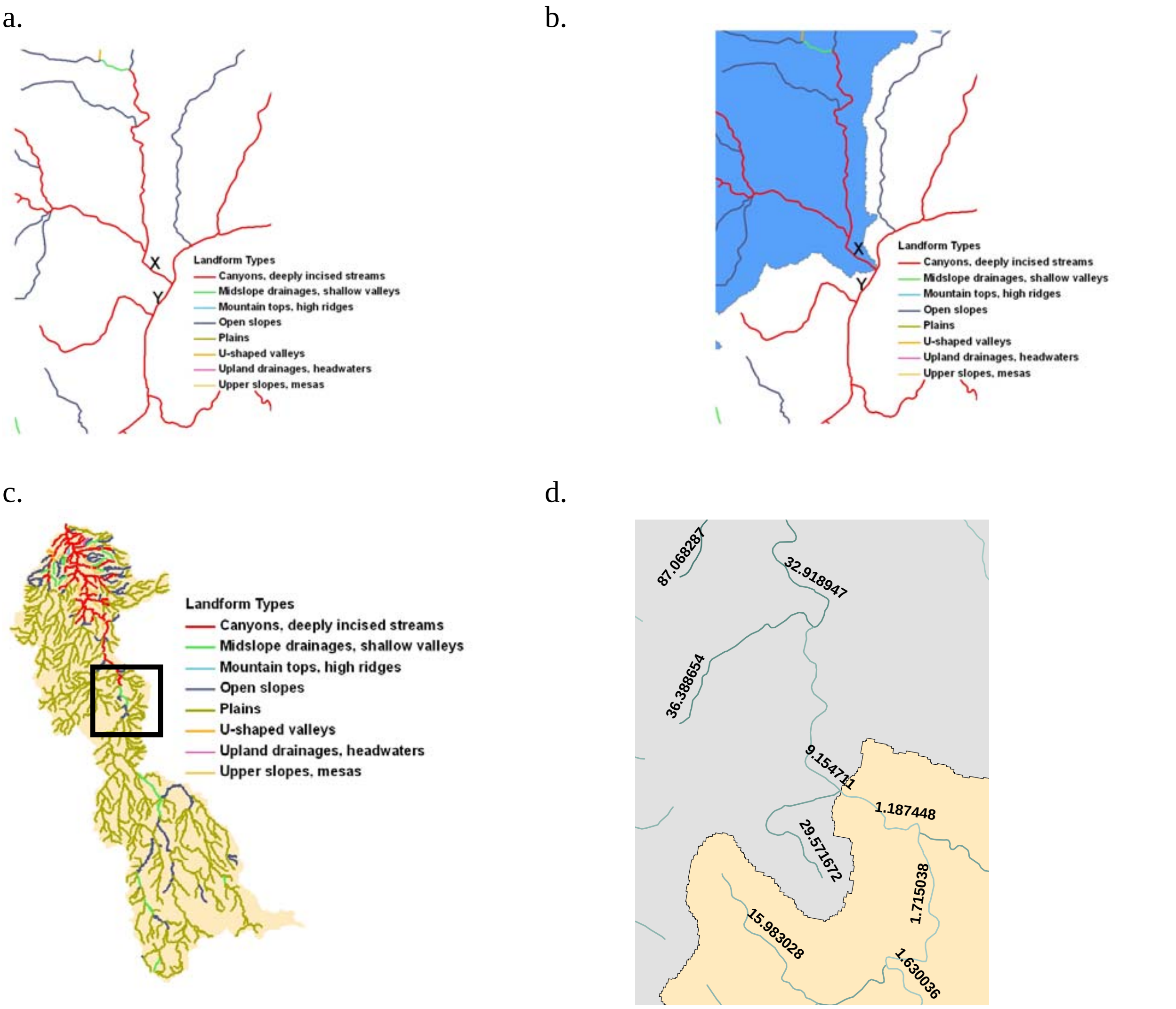

Fig. 4. Examples depicting process used to designate individual AES. In figure 4a the Shreve link value for stream segment X fell in the upper 10% of values for canyons in the Colorado subregion and the magnitude of change in Shreve link values between stream segment X and Y was greater than 80% so the confluence of these two stream segments was used as the starting point for an AES as shown by the blue shaded area in figure 4b. Figure 4c depicts an example of an AES where the landform type changes from predominantly plains (shown in yellow) to predominantly canyons (shown in red) with a greater prevalence of open slopes, u-shaped valleys, and midslope drainages. This also would have been looked at more closely using information on gradient such as shown in figure 4d to further justify dividing the watershed into two AES. Note that the main drainage line changes from a gradient of 1 – 2 m/km to 8-32 m/km. This AES would be divided based on this information.

Catchments
Catchments were derived for each valley segment using a flow direction data layer derived from the National Elevation Dataset using the ArcHydro toolset available for ArcGIS. The catchment boundaries represent the area of land contributing directly to a single valley segment; not the upstream area.

Valley Segments
The base layer for all analyses was derived from the USGS National Hydrography Dataset (NHD) stream layer. This data set was error-checked and rectified using orthophotos from the years 2000-2002 and the National Elevation Dataset (NED). Disconnected streams were visually examined using orthophotos to look for evidence of connectivity to the primary stream network. Because dry stream beds are often used as offroad trails in the southwest, the pathway of apparent connection was further examined using the NED to confirm that it indeed traveled downhill. Based on these criteria, valley segments (confluence to confluence stream segment) were created for the LCRB.

We utilized the RivEx tool (available from http://www.rivex.co.uk/) to further clean the basal stream layer. Additional edits included the removal of pseudo nodes, snapping streams that were disconnected at confluences, dissolving multisegment stream segments, correcting flow direction, fixing multipart lines, and correcting intersection lines. This cleaning of the stream network allowed us to derive upstream and downstream information.

Literature Collection

In July 2005, we posted an online literature database for research related to the Lower Colorado River Basin that is searchable by author, title, year, and keywords. This database was compiled initially from an existing database of pre-2000 literature created by Carol Pacey and Paul Marsh (Arizona State University) in cooperation with Gordon Muller (USGS), a reference list for the Upper Colorado River Basin produced by US Fish and Wildlife Service, and a list of reports provided by Arizona Game and Fish Department. Additional references have been incorporated (including all past Desert Fishes Council Proceedings) to result in a current list of over 2,200 records and we are continually receiving new material. Approximately 550 of these references have been collected in or converted to an electronic format. Documents that are not copyrighted (primarily grey literature) will be available to download. The database is accessible to the public from the Lower Colorado River Aquatic GAP website (http://www.lcrgap.org/search.htm). Response to the initial release of this database has been positive. Additional documents are being collected from online websites and through contacts with the cooperating agencies and organizations for inclusion in the literature database. This has been an ongoing project.

Webpage Development
A webpage for the project was developed to facilitate the dissemination of project updates and products (www.lcrgap.org). When the website went online, 135 cooperators interested parties were notified of the web address. The webpage has a current status page (http://www.lcrgap.org/current_status.htm) that lists activities/updates by quarter for the project.

The webpage is our primary source of communication with our stakeholder and has information on:

Current status of the project
Overview of principal investigators
Bibliography and searchable database
Workshop and meeting minutes, handouts and notes
Presentations related to the GAP project
Progress reports on the project
Project partners
Useful links related to the project and associated data

Future Tasks

Model Development

Over the next few months we will develop predictive distribution models for both native and non-native fishes using the artificial neural network method. These will be overlaid with AES classes, threats, and protection status (as defined by the terrestrial SW ReGAP and California GAP projects) to provide a preliminary assessment of aquatic community status in the LCRB. This information will be provided to stakeholders for use in conservation planning efforts.

Timeline and products

2008

Jan – Jun	Continue development of predictive models; error check model outcomes by expert review; begin to develop human stressor index; present information to stakeholders at national, regional, and local meetings; turn in progress report.
Jul – Dec	Develop human stressor indices; present information to stakeholders at national, regional, and local meetings.

2009

Jan – Jun	Complete modeling; develop conservation priorities; write manuscripts to peer-reviewed journals; complete final report.

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Appendix A: List of fish species and the number of individual records for each acquired for the Lower Colorado River Basin Gap Analysis Project as of August 2005.

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Acipenser transmontanus	white sturgeon	introduced	1						
Agosia chrysogaster	longfin dace	native	159832						
Ambloplites rupestris	rock bass	introduced	127						
Ameca splendens	butterfly splitfin	introduced	1						
Ameiurus catus	white catfish	introduced	1						
Ameiurus melas	black bullhead	introduced	5095						
Ameiurus natalis	yellow bullhead	introduced	3362						
Ameiurus nebulosus	brown bullhead	introduced	11						
Anguilla rostrata	American eel	introduced	1						
Archocentrus nigrofasciatus	convict cichlid	introduced	77						
Campostoma anomalum	central stoneroller	introduced	2						
Campostoma ornatum	Mexican stoneroller	native	225		WSC				
Carassius auratus	goldfish	introduced	235						
Catostomus ardens	Utah sucker	uncertain	4						
Catostomus clarkia clarkii	desert sucker	native	957						
Catostomus clarkii	desert sucker	native	52439						WSC
Catostomus clarkii intermedius	White River desert sucker	native	24				SENS		
Catostomus clarkii utahensis	Virgin River desert sucker	native	51						
Catostomus discobolus	bluehead sucker	native	43190			E			
Catostomus discobolus yarrowi	Zuni bluehead sucker	native	132	C	WSC		E		
Catostomus insignis	Sonoran sucker	native	34018						
Catostomus latipinnis	flannelmouth sucker	native	38178			E			
Catostomus platyrhynchus	mountain sucker	native	25						
Catostomus plebeius	Rio Grande sucker	introduced	10						
Catostomus sp.	Little Colorado sucker	native	3578		WSC				

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Chaenobryttus gulosus	warmouth	introduced	77						
Clarias batrachus	walking catfish	introduced	2						
Cottus bairdii	mottled sculpin	introduced	1						
Crenichthys baileyi	White River springfish	native	314						
Crenichthys baileyi albivallis	Preston White River springfish	native	38					SENS	
Crenichthys baileyi baileyi	White River springfish	native	17	E				SENS	
Crenichthys baileyi grandis	Hiko White River springfish	native	59	E				SENS	
Crenichthys baileyi moapae	Moapa White River springfish	native	71					SENS	
Crenichthys baileyi thermophilus	Moormon White River springfish	native	56					SENS	
Ctenopharyngodon idella	grass carp	introduced	32						
Cyprinella formosa	beautiful shiner	native	87	T	WSC				
Cyprinella lutrensis	red shiner	introduced	193046						
Cyprinella venusta	blacktail shiner	introduced	2						
Cyprinodon arcuatus	Monkey Spring pupfish	native	24						
Cyprinodon eremus	Quitoboquito pupfish	native	132						
Cyprinodon macularius	desert pupfish	native	2301	E	WSC				
Cyprinodon nevadensis amargosae	Amargosa River pupfish	native	3						
Cyprinus carpio	common carp	introduced	29223						
Danio malabaricus	Malabar danio	introduced	1						
Dorosoma petenense	threadfin shad	introduced	5320						
Elops affinis	machete	native	20						
Empetrichthys latos	Pahrump poolfish		2					SENS	
Esox lucius	northern pike	introduced	391						

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Fundulus zebrinus	plains killifish	introduced	3272						
Gambusia affinis	mosquitofish	introduced	57175						
Gila atraria	Utah chub	introduced	5						
Gila bicolor mohavensis	Mohave tui chub	native	4	E					
Gila cypha	humpback chub	native	109478	E	WSC	E			
Gila ditaenia	Sonora chub	native	6867		WSC				
Gila elegans	bonytail chub	native	332	E	WSC	E		SENS	
Gila intermedia	Gila chub	native	7040	PE	WSC		E		
Gila nigra	headwater chub	native	123						
Gila nigrescens	Chihuahua chub	native	1	T		E			
Gila orcuttii	arroyo chub	introduced	1						
Gila purpurea	Yaqui chub	native	1790	E	WSC				
Gila robusta	roundtail chub	native	11248		WSC	E	E		
Gila robusta jordani	Pahranagat roundtail chub	native	12	E				SENS	
Gila robusta robusta	roundtail chub	native	635						
Gila seminuda	Virgin River chub	native	122	E	WSC			SENS	
Gila seminuda moapa	Virgin River chub subspecies	native	1						
Helostoma temminkii	kissing gouramis	introduced	2						
Herichthys cyanoguttatum	Rio Grande cichlid	introduced	1						
Heros severus	banded cichlid	introduced	7						
Hybopsis gracilis	bigeye chubs	introduced	1						
Hypophthalmichthys molitrix	silver carp	introduced	2						
Ictalurus lupus	headwater catfish	introduced	3						
Ictalurus pricei	Yaqui catfish	native	5	T	WSC				
Ictalurus punctatus	channel catfish	introduced	19644						
Ictiobus bubalus	smallmouth buffalo	introduced	20						
Ictiobus cyprinellus	bigmouth buffalo	introduced	99						
Lavinia exilicauda	hitch	introduced	2						
Lepidomeda albivallis	White River spinedace	native	71	E				SENS	

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Lepidomeda altivelis	Pahranagat spinedace	native	4						
Lepidomeda mollispinis	Virgin River spinedace	native	667		WSC			SENS	
Lepidomeda vittata	Little Colorado spinedace	native	3665	T	WSC				
Lepomis cyanellus	green sunfish	introduced	26933						
Lepomis gibbosus	pumpkinseed	introduced	1						
Lepomis macrochirus	bluegill	introduced	6196						
Lepomis microlophus	redear sunfish	introduced	328						
Meda fulgida	spikedace	native	18608	T	WSC		T		
Melanochromis auratus	golden mbuna	introduced	1						
Melanochromis johanni	blue mbuna	introduced	1						
Metriaclima zebra	zebra mbuna	introduced	1						
Micropterus dolomieu	smallmouth bass	introduced	4833						
Micropterus punctatus	spotted bass	introduced	10						
Micropterus salmoides	largemouth bass	introduced	15545						
Moapa coriacea	Moapa dace	native	102	E				SENS	
Morone chrysops	white bass	introduced	26						
Morone mississippiensis	yellow bass	introduced	319						
Morone saxatilis	striped bass	introduced	374						
Moxostoma erythrurum	golden redhorse	introduced	1						
Mugil cephalus	striped mullet	native	10						
Notemigonus crysoleucas	golden shiner	introduced	1624						
Notropis stramineus	sand shiner	introduced	1						
Oncorhynchus clarkii	cutthroat trout	introduced	571						
Oncorhynchus clarkii clarkii	coastal cutthroat trout	introduced	1						
Oncorhynchus gilae	Gila trout	native	3002	E	WSC		T		
Oncorhynchus gilae apache	Apache trout	native	2923	T	WSC		T		
Oncorhynchus kisutch	Coho salmon	introduced	16						
Oncorhynchus mykiss	rainbow trout	introduced	162409						
Oncorhynchus mykiss gairdnerii	Columbia River redband trout	introduced	46					SENS	

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Oncorhynchus mykiss irideus	coastal rainbow trout	introduced	2						
Oncorhynchus nerka	sockeye salmon	introduced	20						
Oreochromis aureus	blue tilapia	introduced	77						
Oreochromis mossambicus	Mozambique tilapia	introduced	62						
Orthodon microlepidotus	Sacramento blackfish	introduced	1						
Parachromis managuensis	Jaguar cichlid	introduced	1						
Perca flavescens	yellow perch	introduced	258						
Pimephales notatus	bluntnose minnow	introduced	1						
Pimephales promelas	fathead minnow	introduced	102668						
Plagopterus argentissimus	woundfin	native	89	E	WSC			SENS	
Poecilia latipinna	sailfin molly	introduced	3338						
Poecilia mexicana	shortfin molly	introduced	209						
Poecilia reticulata	guppy	introduced	1351						
Poeciliopsis occidentalis	Gila topminnow	native	5964						
Poeciliopsis occidentalis occidentalis	Gila topminnow	native	79627	E	WSC		T		
Poeciliopsis occidentalis sonoriensis	Yaqui topminnow	native	271	E	WSC				
Polyodon spathula	paddlefish	introduced	2						
Pomoxis annularis	white crappie	introduced	20						
Pomoxis nigromaculatus	black crappie	introduced	2016						
Ptychocheilus lucius	Colorado pikeminnow	native	3770	E	WSC	E	E		
Pylodictis olivaris	flathead catfish	introduced	3649						
Rhinichthys cobitis	loach minnow	native	9575	T	WSC		T		
Rhinichthys deaconi	Las Vegas dace	native	4						
Rhinichthys osculus	speckled dace	native	174247						
Rhinichthys osculus moapae	Moapa speckled dace	native	18					SENS	
Rhinichthys osculus preston	Preston speckled dace	native	43						
Rhinichthys osculus robustus	Lahonton speckled dace	native	1						
Rhinichthys osculus velifer	Pahranagat speckled dace	native	37					SENS	

				Species Status Rank*					
Scientific Name	Common Name	Nativity	# of Records	Federal	Arizona	Navajo Nation	New Mexico	Nevada	Utah
Rhinichthys osculus yarrowi	Colorado River speckled dace	native	43						
Salmo trutta	brown trout	introduced	12981						
Salvelinus fontinalis	brook trout	introduced	6169						
Salvelinus namaycush	lake trout	introduced	1						
Sander vitreus	walleye	introduced	958						
Snyderichthys copei	leatherside chub	native	1						WSC
Thymallus arcticus	Arctic grayling	introduced	1409						
Tilapia mariae	spotted tilapia	introduced	1						
Tilapia mossambica	Mozambique tilapia	introduced	1						
Tilapia rendalli	redbreast tilapia	introduced	1						
Tilapia zilli	redbelly tilapia	introduced	44						
Xiphophorus maculatus	southern platyfish	introduced	6						
Xyrauchen texanus	razorback sucker	native	9872	E	WSC	E		SENS	

*Federal: these species are listed under the Endangered Species Act as either Endangered (E), Threatened (T), Proposed Endangered (PE), Candidate (C)

Arizona: Wildlife of Special Concern (WSC)
Navajo Nation: Endangered (E)
New Mexico: Endangered (E) or Threatened (T)
Nevada: Sensitive species (SENS); Species protected under NRS 501
Utah: Wildlife of Special Concern (WSC)