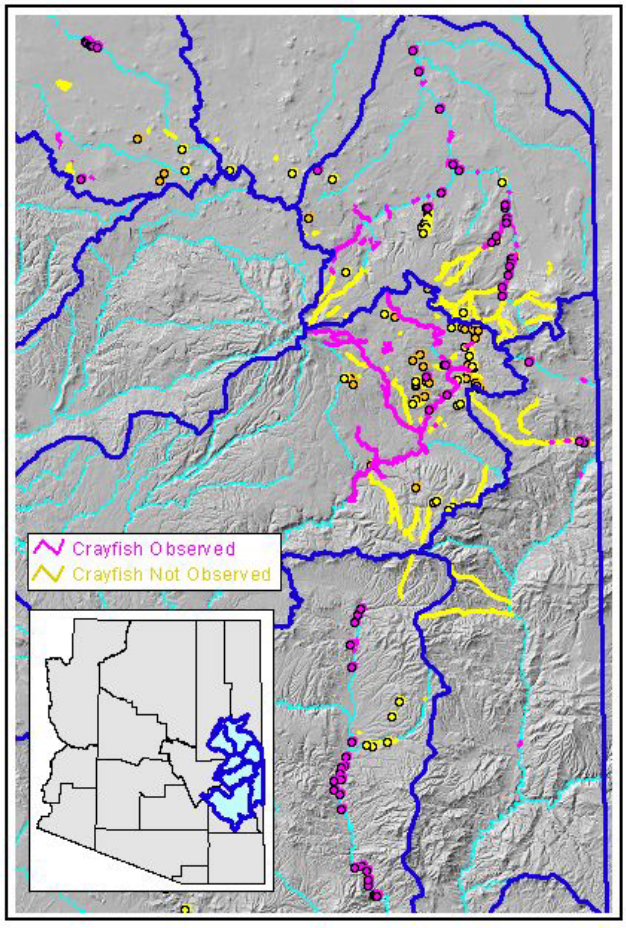
DATABASE DEVELOPMENT AND MAPPING OF CRAYFISH DISTRIBUTION IN THE WHITE MOUNTAINS, ARIZONA

Susan D. Snetsinger
Conservation Biologist/GIS Analyst
Pacific Biodiversity Institute



Pacific Biodiversity Institute
Arizona Branch
1641 E. Del Rio Drive
Tempe, AZ 85282

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PROJECT FUNDING

The Zane Grey Chapter of Trout Unlimited generously provided primary funding for this project. Additional funds were kindly provided by Arizona Flycasters.

EXECUTIVE SUMMARY

Coldwater streams in the White Mountains of Arizona provide important habitat for many native species. However, these species and habitats are being negatively impacted by the presence of exotic crayfish, which prey on native fish as fingerlings and devour stream vegetation, leading to increased sedimentation and lower water quality.

The White Mountains Crayfish Working Group is gathering information on crayfish distribution and methods for controlling this invasive species. The Working Group hired Pacific Biodiversity Institute to compile existing information on crayfish distribution to help identify data gaps and prioritize areas for additional surveys or control efforts. To this end, PBI developed a database, GIS, large-format map, and an internet map site and web page for the group. Although many data gaps exist, the data model and structure are now set up, and it is a simple matter for the Working Group to add to the current database. The Working Group is organizing volunteers to begin conducting surveys in the summer of 2003, and this should lead to substantial increases in the quantity and quality of data present in the database and represented on the Crayfish Distribution Map.

This report presents the Crayfish database, GIS, map, and internet site, providing general information in the body of the report and technical details for database/GIS managers in the Appendices. The database contains 361 records spanning from 1975 to 2002, and is based on data obtained from various programs within the Arizona Game & Fish Department. The GIS contains 32 data layers, documentation on the data layers, a digital map, and ArcView files for displaying the data. The internet site presents an interactive map showing crayfish distribution in the White Mountains. Users can choose which GIS layers to view, and query databases underlying the data themes. The website also has two introductory pages – one page describing the White Mountains Crayfish Working Group and its goals and the other containing instructions for using the map internet site.

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Susan D. Snetsinger

INTRODUCTION

Coldwater streams provide important habitat for many sensitive species in the Southwest. The Nature Conservancy (TNC 1999)[1] identified the White Mountains of Arizona as a critical conservation target, containing some of the best examples of these aquatic habitats. However, the presence of non-native crayfish is becoming an issue of increasing concern in the region. Crayfish are negatively impacting native species and habitats, consuming native fish as fingerlings and devouring stream vegetation.

The White Mountains Crayfish Working Group was established in 2002 to address impacts of crayfish on aquatic species and habitats in the White Mountains. This group is a collaborative effort between biologists, anglers, government agencies, conservation organizations, researchers, and interested individuals to control crayfish and restore aquatic habitat for native species. The group is working to develop a cooperative management plan for crayfish control in the White Mountains, initiate public outreach and education programs on crayfish, and conduct research on crayfish control and native species restoration. Eventually, the group may promote this program as a model for a statewide crayfish control effort.

As a first step, the Working Group contracted Pacific Biodiversity Institute (PBI) to compile existing information on crayfish distribution in the White Mountains. To this end, PBI developed a number of products for the group, including a database of crayfish survey records, a GIS, a large-format map showing crayfish distribution, an internet map site and a web page. These products will help the group raise awareness of the crayfish issue and prioritize areas for conservation and crayfish removal efforts.

This report describes the database, GIS, and internet map site, and the methods used to develop these products. General information is provided in the body of the report, with technical notes in the appendices.

STUDY AREA

The study area includes the Upper Little Colorado, Silver, Little Colorado Headwaters, White, Black, San Francisco, and Upper Gila-San Carlos Reservoir watersheds, as defined by USGS Hydrologic Unit Codes or HUCs (Figure 1). The extent of these

[1] [TNC] The Nature Conservancy. 1999. Ecoregional Conservation Analysis of the Arizona – New Mexico Mountains. The Nature Conservancy. Santa Fe, NM.

watersheds includes lower elevation areas outside of the White Mountains. Although data were compiled for the entire region, the maps and GIS focus on the higher elevation areas (above 5,000 feet), which are of primary interest.

Figure 1. White Mountains study area in relation to Arizona counties. Area of primary interest is contained within the rectangle overlaying the watersheds.

DATABASE

I compiled a relational database of all records where crayfish were observed or not observed, using five sources of data. The database was created in Microsoft Access 2000, and includes 361 records spanning from 1975 to 2002. Many of these records are repeat observations for the same location.

In some cases, repeat observations have differing information about crayfish presence. For example, in one year a location that lists crayfish as present may list crayfish as "not observed" the following year. In these cases, it is highly likely that crayfish were still present but just not observed. I preserved all records for such locations but organized the data in the GIS and final map such that positive findings of crayfish for a location at any point in time always overrode negative findings (this can easily be changed if desired).

DATA SOURCES

Four data sources came from the Arizona Game and Fish Department (AGFD). These included the Herpetological Database, the Fisheries Database, the General Aquatic Wildlife Study (GAWS) database, and a Crayfish Trapping database maintained by the Snail program. The fifth source was a hand-drawn map compiled by local experts (Arizona Game & Fish Department and TNC personnel) delineating areas where, in their professional opinion, crayfish are thought to exist or be absent. A unique field in the database identifies these "professional opinion" records, so that they can be easily separated from those records based on actual field observation.

DATABASE COMPILATION

I went through a series of steps to compile the Crayfish database from the original AGFD databases. First I eliminated all non-geographically referenced records and records outside of the study area. Next I eliminated all records that did not have clear positive or negative indication of crayfish presence (since the original databases had a variety of purposes, information on crayfish was not always maintained). Those eliminated included Herpetological database records prior to 1992, when a mandatory Crayfish observed/not observed field was added to their data collection protocol (however, for records prior to 1992, if crayfish presence or absence was noted in any comment fields I preserved the record in the final database). I eliminated all Fisheries records without comments regarding crayfish (while the Fisheries database has a "Crayfish" field, it is unclear if and when that field was mandatory). After finalizing which database records to use in the Crayfish database, I converted fields and data formats as necessary, to combine all records into a common database structure.

Database Structure

The Crayfish database is comprised of 5 main tables, related by a common record number. In addition, the database contains 10 supporting tables. The tables are briefly described below.

Main tables

SURVEY – Basic survey identification & location information (1 record per survey)

METHODS – Method used, including type & number of traps (1 record per survey)

HABITAT – Habitat variables (1 record per survey)

CRAYFISH – Crayfish trap data (1 record for each species of crayfish encountered on a survey)

OTHERCAPTURE – Trap data on other species inadvertently captured (1 record for each type of species inadvertently captured during a survey)

Supporting tables

SpeciesGroups – Types of species inadvertently captured (lookup values for the OTHERCAPTURE table)

WaterTypes – Water feature types (lookup values for the HABITAT table)

MethodTypes – Survey method types (lookup values for the METHODS table)

Substrates – Substrate types (lookup values for the HABITAT table)

Reaches – Stream and waterbody reach numbers & names (lookup values for the SURVEY table)

Quads – USGS quad names (lookup values for the SURVEY table)

Organization – Organization information (lookup values for the SURVEY table)

Observers – Observer initials and names (lookup values for the SURVEY table)

CoordSource – Source of geographic coordinates (lookup values for the SURVEY table)

DataSource – Names of organizations supplying data to the database (lookup values for the SURVEY and Organization tables)

The database contains a data entry form that has fields from all of the main tables (Figure 2). Several predefined queries are also contained within the database. These queries are used to create export Dbase files, which are then imported into the GIS and used to display crayfish survey records for points (such as tanks, springs), polygons (lakes, reservoirs, etc.), and lines (streams and rivers) (see Appendix A for greater technical detail regarding data entry fields, queries, and links to the GIS).

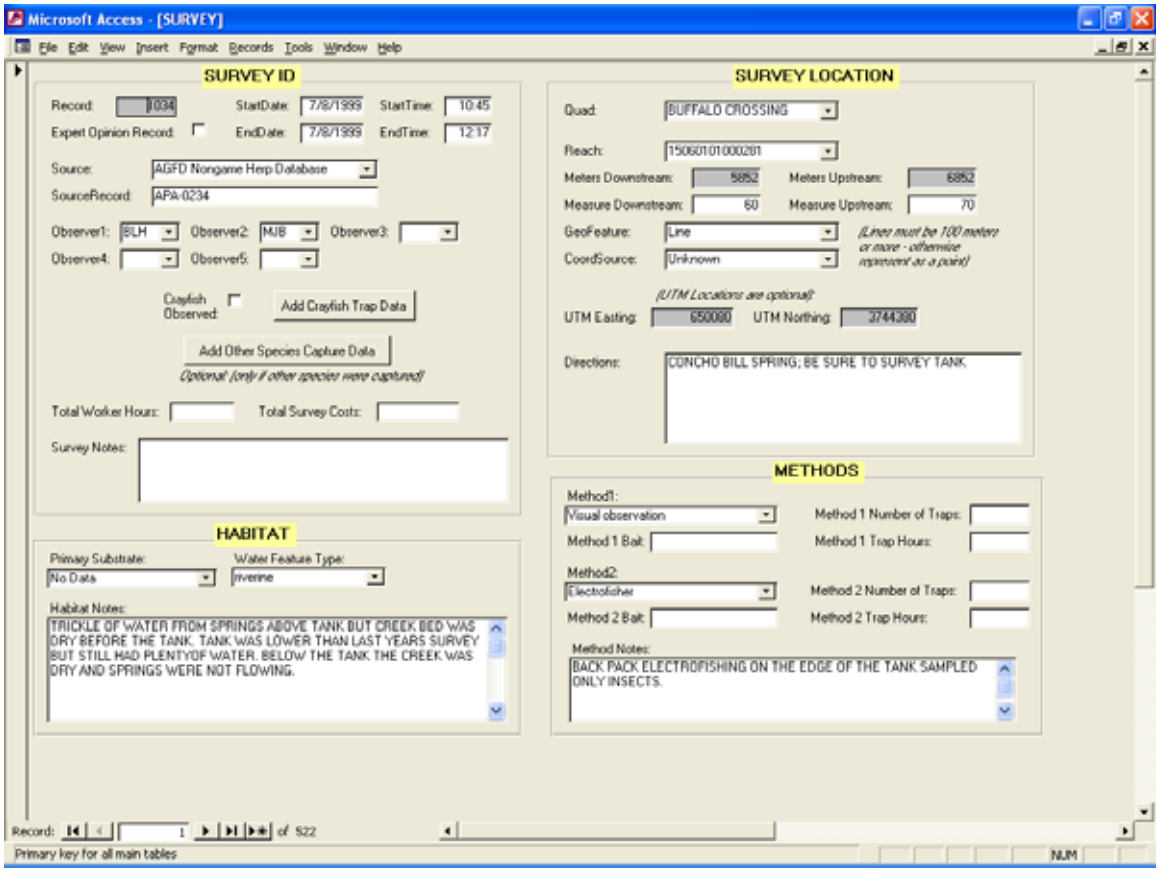

Figure 2. Data entry form in the Crayfish database.

Geographic Referencing of Records

In order to spatially display the Crayfish database records in a GIS, the records need to be geographically referenced. I chose to reference the location of survey records in relation to the National Hydrography Dataset (NHD) GIS layer, using relative position along stream reaches, rather than map coordinates. This type of relative referencing allows database records to be displayed in a GIS with a process called “dynamic segmentation”.

Dynamic segmentation is a highly efficient method for displaying database records in a GIS - rather than creating a new GIS layer or having to edit portions of a GIS layer every time a record is added or revised, dynamic segmentation allows display of attributes within database records on a currently existing, static data layer (such as a hydrography

layer). All editing is done in the database, and the map is simply redisplayed in the GIS according to the new database files.

Records from the original AGFD databases were spatially referenced in a variety of ways – some by UTM coordinates and others according to the Township, Range, Section map grid. Many records also included directions and/or a site name. In a number of cases there was conflicting information about location for a given record. In these situations, I used all available information to make the best judgment I could about the true locations.

I used hydrography and other data layers (e.g. roads) in ArcView GIS, viewed at 1:24,000 scale, to determine the stream or waterbody reach number (from the NHD GIS layer) of the surveys. I also determined starting and stopping points of surveys (if applicable) along a reach, and added this information to the database. Technical notes regarding the geographic referencing of database records are included in Appendix A.

CRAYFISH GIS

The Crayfish GIS is composed of 32 data layers, metadata (i.e. information about the data layers), an ArcView 3.3 project file, and an electronic copy of the final printed large-format map. Ten large-format maps (35 x 55 inches) are included as deliverables for this project, however a simplified 8.5 x 11 version of the map is presented here (Figure 3).

DATA SOURCES

Most of the data were obtained through the Arizona State Land's ALRIS (Arizona Land Resources Information System) program. I used USGS data, accessed via the Arizona Regional Image Archive (http://aria.arizona.edu/), to create a seamless image of USGS 7.5' quads and a continuous 30-meter resolution digital elevation model (DEM) for the study area. The primary hydrography dataset, which is used to link the database and GIS, is the National Hydrography Dataset (NHD). These data were downloaded from the USGS/EPA website (http://nhd.usgs.gov/) and merged for the study area using the USGS/EPA NHD toolkit (available from the same website). Table 1 lists data sources and other basic information for all the data layers.

DATA LAYERS

The data layers are primarily in ArcInfo format (which can be used in ArcView, ArcGIS, ArcInfo, and most other GIS programs). The projection of the data is UTM Zone 12, datum NAD 27, with map units in meters. The scale/resolution of the data varies from 1:24,000 to 1:1,000,000. Basic information on individual data layers (such as scale, source, description, format, etc.) is provided in an Access 2000 database ("CrayfishGISData.mdb"). Detailed information (available for most, but not all layers) is contained in text documents in the "metadata" folder, included with the GIS.

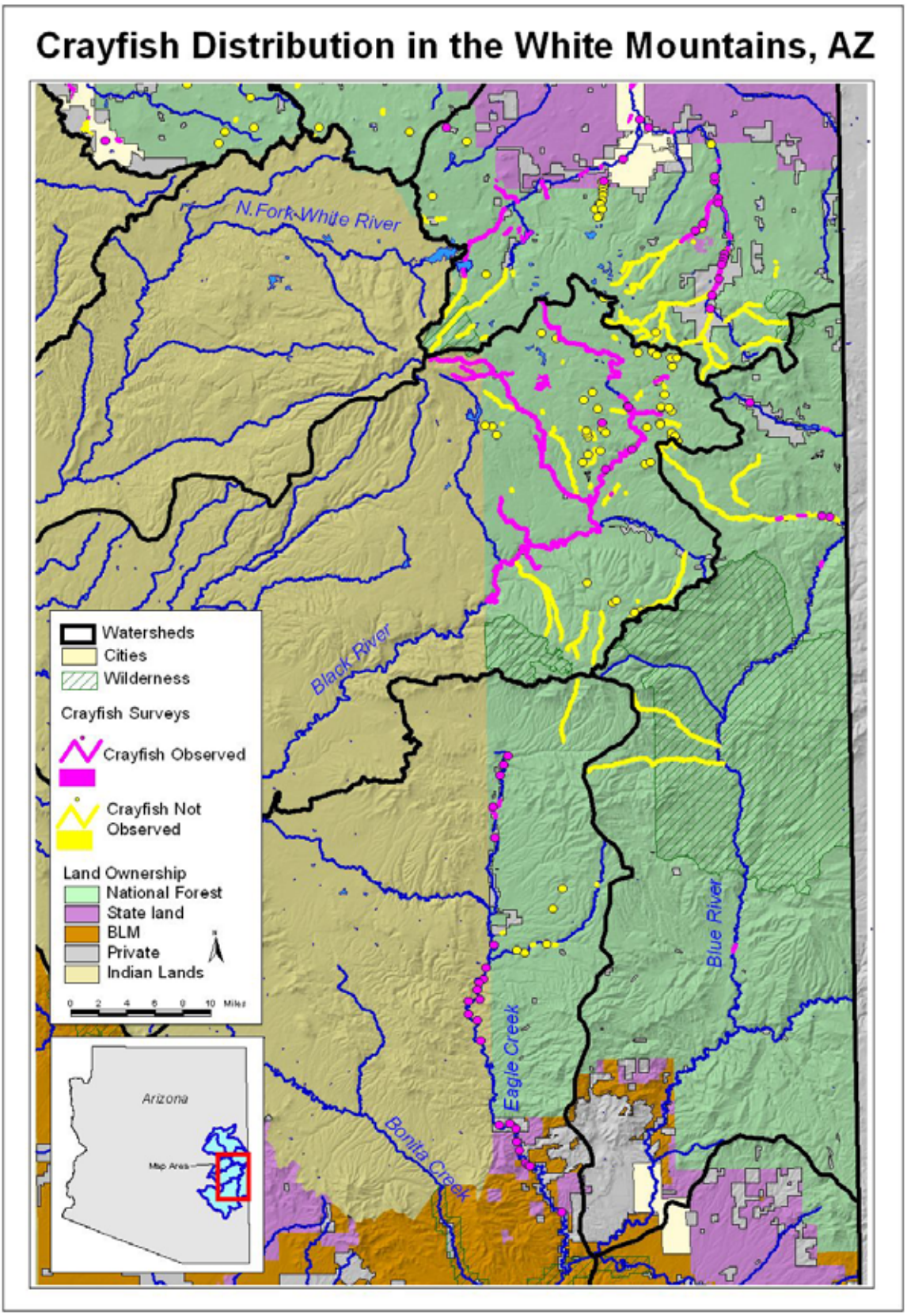

Figure 3. Simplified version of final crayfish distribution map.

Table 1. Data layers contained in the Crayfish GIS.

Name	*Description*	*Source*	*Scale*	*Type*	*Date*
Boundaries					
clipcov	Rectangular boundary of White Mtns. Study Area	PBI	1:100,000	Polygon	2002
Elevation					
dem30	30 meter resolution Digital Elevation Model	PBI	30 meter	Grid	variable
dem90	90 meter Digital Elevation Model	ALRIS	90 meter	Grid	1979-present
dem90ft	90 meter resolution Digital Elevation Model, with elevation in feet	PBI	90 meter	Grid	1979-present
contour100	100 ft. elevation contours.	PBI	90 meter	Line	1979-present
Hydrography					
hydro	Perennial rivers & streams	ALRIS	1:100,000	Line	unknown
nhd	National Hydrography dataset - lines & polygons	USGS	1:100,000	Other	variable
nhdduu	National Hydrography dataset - digital updates	USGS	1:100,000	Other	variable
nhdpt	National Hydrography dataset - points	USGS	1:100,000	Point	variable
Map grids					
trs	Public Land Survey System grid. Township, Range, Section.	ALRIS	1:100,000	Polygon	1988
Own/Admin					
own_g	Land ownership as a grid	PBI	1:100,000	Grid	1988
own	Land ownership	ALRIS	1:100,000	Polygon	1988
county	County boundaries	ALRIS	1:100,000	Polygon	1988
wilderness	Wilderness areas	ALRIS	Variable	Polygon	1990
Places					
annocov	Annotation/text of geographic names	ALRIS	Unknown	Annotation	unknown
towns	Cities, towns, and villages.	ALRIS	1:1,000,000	Point	1997
cities	Cities	ALRIS	1:24,000	Polygon	2002
Quads					
crayfishdrgs.sid	Seamless USGS 7.5' quads (compressed image-large file size)	PBI	1:24,000	Image	variable
crayfishdrgs2.sid	Seamless USGS 7.5' quads (compressed image-medium file size)	PBI	1:24,000	Image	variable
quadgrid	USGS 7.5 minute quad boundaries	ALRIS	1:100,000	Polygon	unknown
Topography					
slpdeg	Degree of slope	PBI	30 meter	Grid	variable
hilshd30.tif	Shaded relief - 30 meter resolution	PBI	30 meter	Image	variable
hilshd30	Shaded relief - 30 meter resolution	PBI	30 meter	Grid	variable
hilshd90	Shaded relief - 90 meter resolution	PBI	90 meter	Grid	variable
Transportation					
trans	Transportation data - roads, streets, etc.	ALRIS	1:100,000	Line	
trails	Roads & trails	ALRIS	Unknown	Line	unknown
Vegetation					
blp80	Digitized map: David E. Brown & Charles H. Lowe 'Biotic Communities of the Southwest' (August 1980).	ALRIS	1:1,000,000	Polygon	1993
Watersheds					
hucs	Watersheds - USGS Hydrologic Units Codes	ALRIS	1:250,000	Polygon	unknown
Wildlife					
ptnorch.dbf	Crayfish point survey data for sites not linked to GIS hydro data	PBI	Unknown	Database	1975-present
line.dbf	Crayfish line survey data.	PBI	Unknown	Database	1975-present
point.dbf	Crayfish point survey data.	PBI	Unknown	Database	1975-present
poly.dbf	Crayfish polygon survey data	PBI	Unknown	Database	1975-present

INTERNET MAP SITE AND WEB PAGE

I developed a map-based website for the White Mountains Crayfish Working Group to allow users to view and query the Crayfish GIS and database. The map website was developed using ESRI's ArcIMS 4.0 software. I also developed two simple, introductory pages to the map website, which are shown in Appendix B. The first web page describes the White Mountains Crayfish Working Group and its goals. The second page provides detailed information on how to use the map website. The website is temporarily being hosted by Pacific Biodiversity Institute (from April to September 2003) and is accessible at http://www.wildinfonet.org/crayfish .

The 23 layers available through the map website are a subset of the original 32 layers of the Crayfish GIS. The website refers to copies of the original data, which have been converted to shapefile format, edited and simplified for display purposes (Appendix C provides more information on these data). Many of the layers have been assigned a predefined scale range at which they can be viewed. Some of the layers have labels, which also appear only at suitable scales. The map website data layers and their scale ranges are listed in Table 2. Screenshots of the map website at 3 different scales, illustrating different base data layers and map features, are provided as Figures 4-6.

Table 2. Data layers available on the map website, with scale ranges and label fields.

Internet Map Layer Name	Minimum scale	Maximum scale	Label Field
Watersheds	1:500,000	-	Name
Point Survey-Crayfish Observed	-	-	-
Point Survey-Crayfish Not Observed	-	-	-
Point Survey (Not on Reach)-Crayfish Not Observed	-	-	-
Line Survey-Crayfish Observed	-	-	-
Line Survey-Crayfish Not Observed	-	-	-
Waterbody Crayfish Survey	-	-	-
Waterbody Crayfish Survey	-	-	-
Trails	1:24,000	1:500,000	-
Major Roads	1:24,000	1:1,000,000	Fname
Minor Roads	1:24,000	1:500,000	Fname
Waterbody Reaches	-	-	Name
Major Rivers & Streams	1:24,000	-	Name
Stream Reaches	-	1:750,000	Name
Quads	-	-	-
Township, Range, Section	-	-	-
Counties	1:24,000	-	-
Wilderness	-	-	-
Cities	1:24,000	-	-
Land Ownership	1:24,000	-	-
Biotic Communities	1:24,000	-	-
Shaded Relief	1:24,000	-	-
USGS Quads	-	1:24,000	-

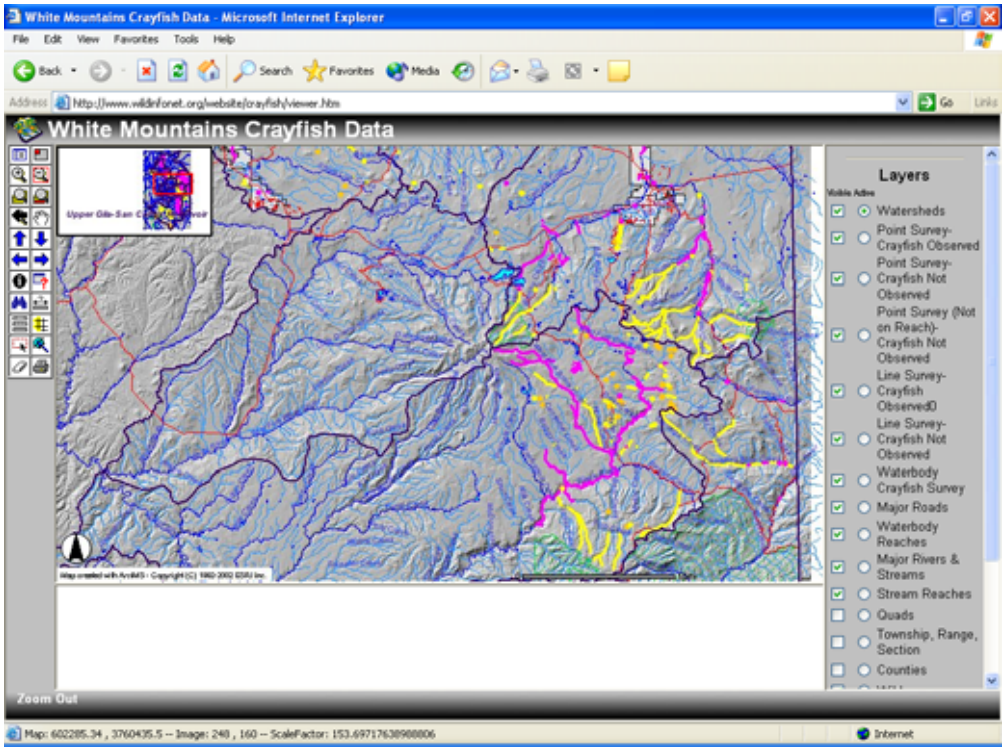

Figure 4. Map website with relief background, overview map in upper left corner, and layer list on right.

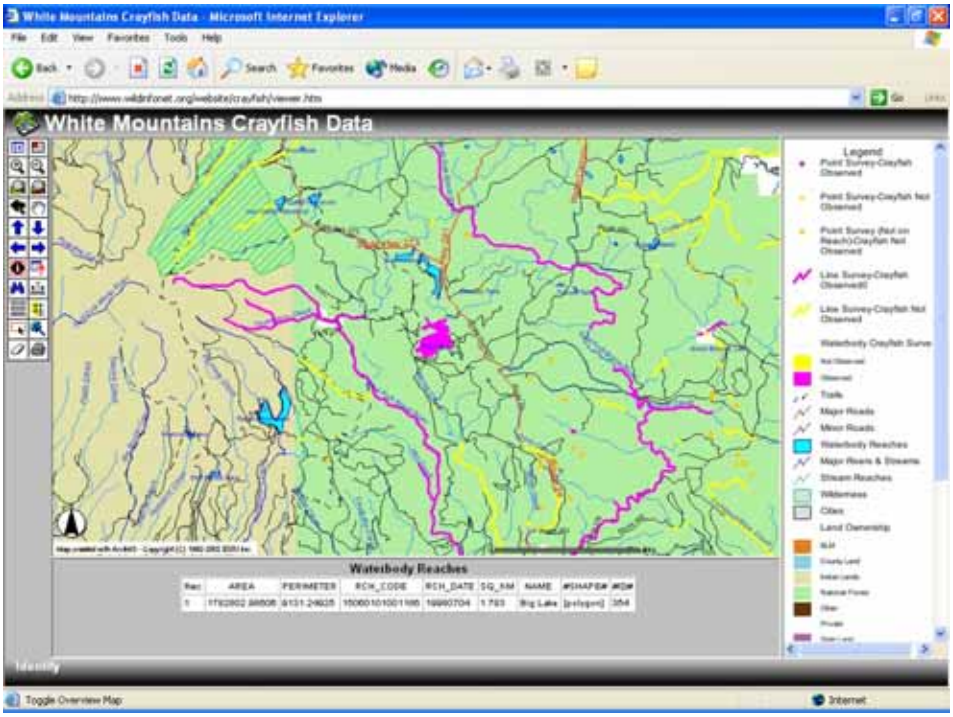

Figure 5. Map website with ownership background and map legend on right. Results of using the Identify tool ℹ to query the "Waterbody Reaches" layer for Big Lake (in center) are shown below the map.

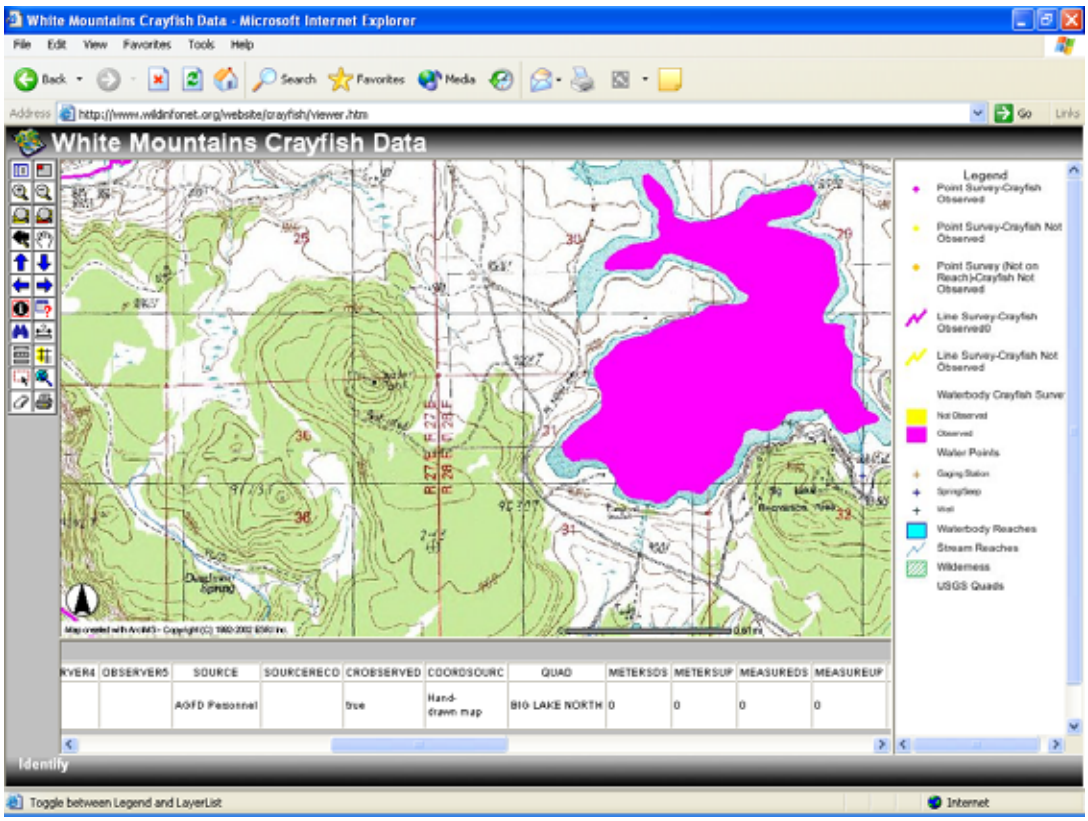

Figure 6. Map website with USGS quads as background and map legend on right. Results of using the Identify tool ❶ to query the "Waterbody Crayfish Survey" layer for Big Lake are shown below the map (records in this layer come from the original Crayfish database).

DISCUSSION

The products developed by Pacific Biodiversity Institute and described in this report (the database, GIS, map, internet map site and web pages) are a significant preliminary step in understanding the distribution and potential impacts of crayfish in the White Mountains. However, all of these products should be considered works in progress, and will be most useful if they continue to be updated as new information becomes available. Currently, the map and database only contain information on crayfish observations that happened to be collected by Arizona Game & Fish Department personnel as they were working on other projects. The Crayfish Working Group is beginning to organize volunteers to check existing records and survey new areas for crayfish; this will provide significant improvements in the geographic extent and quality of the data.

As the quantity and quality of data increase, the database and map-based products will serve as valuable tools in prioritizing aquatic habitats for conservation and crayfish control efforts. Eventually, the White Mountains Crayfish database, GIS, and internet site could serve as models for a statewide information network on crayfish, fostering cooperation, efficiency, and greater success in controlling the impacts of crayfish on Arizona's native species and habitats.

APPENDIX A. TECHNICAL NOTES REGARDING GEOGRAPHIC REFERENCING AND DISPLAY OF DATABASE RECORDS

Determination of Hydrography Layer for Use in Geographic Referencing

I evaluated several hydrography GIS layers (USFS, ALRIS, and AGFD layers) and found the USGS National Hydrography Dataset (NHD) to be most useful for this project. First, NHD has full, consistent coverage for the entire state (and nation), so this database/GIS model for the White Mountains can easily be expanded to other areas in the future. Second, it also has routed stream networks, which are necessary for most types of hydrologic modeling. Third, although the data scale is 1:100,000, it is designed to incorporate finer scale data as they become available (for example, the U.S. Forest Service is currently developing 1:24,000 hydrography data for the White Mountains area, which they are planning to attribute with NHD reach numbers). Fourth, the NHD is the standard towards which agencies are moving (ALRIS and Forest Service). Fifth, the USGS/EPS are continuing to develop tools to help simplify display and analysis of these data. Last and most importantly, the NHD contains unique identifiers ("reach numbers") for all linear and polygon hydrographic features, which can be used to link the database records to individual stream reaches or waterbodies via dynamic segmentation.

Determination of Geographic Feature Type

Points - All records that had a length less than 100 meters (since it would be hard to see a line shorter than 100 m. on the map, when viewed at scales most relevant to this project), or had no length listed were assigned "Point" as geographic feature type within the Crayfish database. If a record referred to a water body (and thus normally would be classified as a Polygon), but that water body was not included in the NHD layer (in almost all cases these unmapped water bodies were tanks), it was classified as a Point, and appears as such on the final map. There is no way to portray these records as polygons without editing the GIS data to add each one in separately.

Lines - Records that identified survey lengths greater than or equal to 100 meters were assigned "Line" as geographic feature type within the Crayfish database. Often "Line" records only had a single UTM location. If I could not decipher from the "Directions" and other information in the record where the start and stop points were, I considered the UTM location to be the midpoint of the line survey (the AGFD database managers informed me that single UTM locations were not recorded consistently as either the upstream or downstream point of the survey).

Polygons - Records that referred to water bodies (such as ponds, lakes, reservoirs, etc.) that were present on the National Hydrography Dataset (NHD) GIS layer ("region.rch"), were assigned "Polygon" as geographic feature type within the Crayfish database. If the record referenced only a particular point or area within a water body (e.g. the north end of Blue Lake), that record was still assigned to the entire water body (this makes things much simpler from a GIS perspective. It also makes sense from a real

world perspective in that once crayfish have invaded a portion of water body, they are likely to quickly spread to the entire water body).

Entering Location Information in the Database

Dynamic Segmentation - General Information

Dynamic segmentation requires two pieces of information in order to display features (in this case, crayfish surveys) along a route (i.e. stream). The first is the geographic link that ties the database record to a particular route (in this project the link is created using the "reach" field in the database record and "rch_code" in the NHD GIS layer). The second is more detailed information about which portion of the route the database record pertains to. For example, the record may refer to a single point along the route, a small portion of the route, or the entire route. Most dynamic segmentation processes use "measures" to refer to locations along a route. In most cases, measures range from 0 (at the furthest downstream point of the route) to 100 (at the furthest upstream point). Line survey records must have 2 measures to designate the upstream and downstream points of the survey. Point survey records contain a single measure. For example, if Route (i.e. Stream Reach) #15021001 is 1200 meters long, and a database record for a stream survey pertains to the lower half of that stream reach, the downstream measure reference would be 0, and the upstream measure reference would be 50 (**not** 0 to 600, since this refers to the length in meters, not "measures").

Identifying Survey Location Along a Route

The simplest way to determine the measure values for a survey location is in a GIS. Customized tools have been developed for both ArcView and ArcGIS that allow the user to click on a location along a route and have either the "measure", or the relative distance along the route in meters, displayed for that location. Relative location can be reported in either the map units (meters, for this project) or in "measures", and the user must be conscious of which type of unit is being displayed in the GIS. (If the highest value for the most upstream point of all routes is 100, then "measures" are being reported). For ArcView users a "routetool.avx" extension, which reports locations in "measures", can be downloaded from the ESRI website or copied from the Crayfish GIS CD that accompanies this report. For ArcGIS users, a similar tool is available either directly through the software program or through a sample in the ArcObjects Developers Kit, depending on the software version. A copy of the IdentifyMS tool, which can be used in ArcGIS 8.2 is included on the CD. The ArcGIS tools, depending on which ones are used, may report distances in "meters".

Meters vs. Measures Database Fields

The Crayfish database contains 2 pairs of location fields so that relative location along a route can be entered using either "measures" or "meters". The Enter Data Form contains "Measure Downstream" and "Measure Upstream" fields. I expect that data will typically

be entered using these fields. However, “Meters Downstream” and “Meters Upstream” also occur on the form. Though they are grayed, data can be entered in these boxes if location is reported as meters. If meter data is entered, the query “Update Stream Measures using Meters” (contained in the database) should be run after the data entry session. This query uses the meter data to automatically update the “measures” fields, which are necessary to display the data using dynamic segmentation.

For point surveys, location should be entered in the Downstream field, since there is only a single location. The Upstream field should be left blank. For line surveys, both the Downstream and Upstream fields must be filled in (whether using “measures” or meters).

Display of Database Records

The Crayfish database contains four queries that are used to create export Dbase files. The queries contain data from the 3 primary tables – Survey, Methods, and Habitat. Trapping data from the Crayfish and OtherCapture tables are not included as these records are linked to the Survey table using a 1 to many, rather than 1 to 1 relationship. The export files are then imported to the GIS and used to spatially display the database records.

Three of the queries select records by geographic feature type. These are the Point Records, Line Records, and Polygon Records queries. The fourth query, Point Records Without Reach #’s, selects all point records which, when examined, were found **not** to occur along stream reaches as mapped in the NHD.

Point Records – Records from this query can be displayed using dynamic segmentation with the NHD “route.rch” layer. Use “rch_code” in the NHD layer and “reach” in the point table to create the geographic link. “Measureds” identifies location along the route.

Line Records - Records from this query can be displayed using dynamic segmentation with the NHD “route.rch” layer. Use “rch_code” in the NHD layer and “reach” in the line table to create the geographic link. “Measureds” and “Measureup” identify the start and end locations along the route.

Polygon Records – Since dynamic segmentation can only be used for route-referenced data (i.e. points and lines), these records must be displayed using a different method. Records from this query can be displayed by joining the polygon table to the table of the NHD “region.rch” layer. Use “rch_code” in the NHD layer and “reach” in the polygon table as the join fields. Then, define the region.rch layer with the joined table to include only those records where the record number (“record” from the crayfish database) is >=1. This will display just the water bodies with crayfish survey information.

Point Records Without Reach – These records cannot be displayed using dynamic segmentation since there is no reach number. Rather, all these records contain UTM coordinates. The table should be added to the GIS as an “event theme” using the map coordinates.

CRAYFISH CONTROL AND MANAGEMENT IN ARIZONA'S WHITE MOUNTAINS

A COLLABORATIVE EFFORT TO RESTORE NATIVE SPECIES

ENTER INTERACTIVE MAP SITE:
http://www.wildinfonet.org/website/crayfish

VIEW TIPS FOR USING MAPSITE: maptips.htm

Background

Coldwater aquatic streams in the arid southwestern U.S. are rare, yet are the lifeblood for many wildlife and fish species. Streams in the southwest are best represented in the White Mountains of Arizona, home to the headwaters of three major southwest rivers-the Salt, the San Francisco/Gila, and the Little Colorado. However, these streams have been severely impacted by the introduction of crayfish. Crayfish, an invasive species not native to Arizona, has been shown to impact native species as well as their aquatic habitats - preying on native fish as fingerlings, devouring insects and amphibians, consuming stream vegetation, degrading water quality, and increasing sediment in streams.

White Mountains Crayfish Working Group

Biologists, anglers, and others have joined together and committed to improve our streams and native aquatic fish and wildlife by combining our efforts to control crayfish and restore streams through an innovative collaboration of government agencies, conservation organizations, researchers, and interested individuals. Called the White Mountains Crayfish Working Group, we intend to develop a cooperative management strategy for controlling crayfish populations across the White Mountains and to implement this plan through long-term partnerships. We believe our effort will result in improved aquatic habitat for native species populations, such as the threatened Apache Trout, loachminnow, Chiricahua leopard frog, and many others. This effort will be a model for other states to follow to manage crayfish and other non-native species.

This web site is a product of this partnership. The Zane Grey Chapter of Trout Unlimited provided seed money to the White Mountains Crayfish Working Group to develop a GIS map and database, which you can access at the top of this page. The intent is to provide a tool for our volunteer conservation organizations to access this information, download

data collection forms, and immediately upload information on new locations of crayfish. The Group thanks Zane Grey and the Pacific Biodiversity Institute for creating and housing this information. This effort is just one of a series of activities the Crayfish Working Group will undertake to help restore Arizona's native aquatic wildlife!

Strategies of the White Mountains Crayfish Working Group

- Create crayfish distribution/spatial database and other technological products, such as a worldwide web site which displays this data as well as information about this effort.
- Develop a crayfish control plan which prioritizes control and management areas, and includes native species reintroductions and habitat restoration.
- Use volunteers and funding partners to conduct crayfish control and habitat restoration activities.
- Initiate innovative public outreach and education programs.
- Pursue funding for, and implement, active native species and habitat restoration.
- Research and use most effective crayfish control methods.
- Monitor our results of crayfish control and native species restoration.
- Elevate collaboration to a state-wide effort of crayfish control and native habitat/species restoration.

White Mountains Crayfish Working Group Members

U.S. Forest Service U.S. Fish and Wildlife Service U.S. Bureau of Reclamation
AZ Game and Fish Department White Mountain Apache Tribe
The Nature Conservancy Zane Grey Trout Unlimited Arizona Flycasters
White Mountain Flyfishing Club Pacific Biodiversity Institute
Univ. of Arizona White Mountain Conservation League Federation of Fly Fishers
Old Pueblo Trout Unlimited Jim Walters Dr. Joe Bagnara

Funding Contributers

Zane Grey Trout Unlimited Arizona Flycasters National Wildlife Federation
Defenders of Wildlife Federation of Fly Fishers

TIPS FOR USING THE INTERACTIVE MAP SITE

ENTER INTERACTIVE MAP SITE:
http://www.wildinfonet.org/crayfish/

Starting Up:

If you are new to using interactive maps, you may want to print this page from your browser, for a reference while you are exploring the White Mountains Crayfish Map Site and its capabilities.

The Map Site has 3 main components.

- The main **Map Viewing Area** in the center of the screen**.** This shows a relief map of the White Mountains Area, the Watersheds containing crayfish data, Rivers, and sites where crayfish have been Observed (Pink) or Not Observed (Yellow), cities, and wilderness areas, when the map site first starts up. As you **Zoom In** to look at greater detail of the map, more layers will appear on the map (e.g. Roads, Streams, etc.). When you reach a scale of 1:24,000, the base map changes to a USGS Quad map. You control which layers draw on the map by using the Layer list/Legend (see below).
- **Layer list/Legend**. You use the **Toggle Between Legend & Layer List tool** (described below) to change from a Layer list, which shows a list of the data layers in the map, with options to draw them on the map or make them *"Active"* (for explanations of how and why to do this, see ***TIP ("Making layers Active")*** below), and a Legend, which allows you to see how each of the layer's are displayed (e.g. Crayfish Line Surveys where crayfish were observed are shown as pink lines). In the Layer list, click the Visible check box next to a layer name to draw it on the map, or check it off to remove it from the map.

> ***TIP (Making layers "Visible"):*** When you draw a layer on the map by checking its Visible checkbox, note that the layer draws on the map in the order in which it is listed in the Layer list (you cannot change this order). The first layer drawn is the bottom-most layer marked Visible in the list, then the next layer drawn is the Visible layer listed above that, and so on. This means, for example, that if you make "Biotic Communities, which is listed near bottom of the Layer list visible, then make "Land Ownership", which is listed just above it, visible, you will not be able to see the Biotic Communities because the Land Ownership will draw on top of the Biotic Communities.

TIP ("Map Base Layers"): There are 3 base layers which can be used for the map, at most scales. These are: Land Ownership, Biotic Communities, and Shaded Relief. Due to the issue raised in the above ***TIP***, it is recommended that you only have one of these base layers marked Visible at a time. Another base layer, USGS Quads, automatically appears at map scales of 1:24,000 or finer - the other base layers are NOT available at these scales.

TIP (Making layers "Active"): Many of the Map tools on the toolbar require that a layer be made *Active*, in order to use them. For example, if you want to identify all the information in the underlying database about a particular Crayfish Line Survey where crayfish were observed, you must make the "Line Survey-Crayfish Observed" layer *Active*, then use the Identify tool to click on the particular line survey of interest. Or, to identify the "Reach" number of a particular stream, make the "Stream Reaches" layer *Active*, then click on the stream reach of interest. (see below for more information on how to use Identify, and other tools). *To make a layer Active, click in the Active option circle next to the layer's name. Only one layer can be Active at a time.*

Toolbar. This contains many tools which can allow you to view the map, query the underlying database, etc., in ways that you specify.

Map Toolbar: The toolbar is located on the upper left side of the screen. To see what a tool does, pause the mouse pointer over the tool. Below is a brief explanation of the tools on the toolbar, from left to right, top to bottom:

1. **Toggle Between Legend & Layer List:** Click this button to view either the Layer list, where you can click the visibility of layers on and off and determine the active layer, or the Legend list, where you can see the legend for each of the visible layers.
2. **Toggle Overview Map:** Click button to either show or remove Overview map in the upper left corner of the Main map.
3. **Zoom In and Zoom Out** (2 tools): Click or draw a box to zoom in or out.
4. **Zoom to Full Extent:** Click to zoom out to the geographic extent of all data layers in the map.
5. **Zoom to Active Layer:** Click to zoom out to the geographic extent of just the layer that is designated *Active* in the layer list.
6. **Back to Last Extent:** Click to go back to the last extent.

7. **Pan:** Click and drag the mouse pointer on an area on the map to pan to a different part of the map.
8. **Pan to North, South, East, or West** (4 separate tools): Use these tools to pan in only 1 direction on the map.
9. **Identify:** Make the layer of interest *Active* (by clicking in the option circle next to the layer's name) in the Layer list (if necessary, use the **Toggle Between Legend & Layer List tool**, described above, to get to the Layer List from the Legend). Point to a feature and click. The attribute information for the feature is shown below the map display area. If no attribute information appears, zoom in closer and make sure that you actually clicked on the feature of interest (and that it is *Active* in the layer list!).
10. **Query:** This tool allows you to find features matching a query expression. Make the layer of interest *Active* (by clicking in the option circle next to the layer's name) in the Layer list (if necessary, use the **Toggle Between Legend & Layer List tool**, described above, to get to the Layer List from the Legend). Click the Query button, then build an expression using the tools that appear below the map display area. Choose the Field and Operator, then type in a value in the Value text box, or click Get Samples and click one of the sample values that appears. Click Add to Query. When you are done building your query, click Execute. A list of features matching the query appears and the features are highlighted on the map. Click a record number in the Rec column to zoom to a particular feature, or scroll down and click Zoom to these records to zoom to all of the features returned by your search.
11. **Find:** Make the layer of interest *Active* (by clicking in the option circle next to the layer's name) in the Layer list (if necessary, use the **Toggle Between Legend & Layer List tool**, described above, to get to the Layer List from the Legend). Click the Find tool, and type in a string to search for (do not use quotes). A list of features with an attribute value matching the string you types appears in panel below the map. The features are also highlighted on the map. Click a record number in the Rec column to zoom to a particular feature, or scroll down and click Zoom to these records to zoom to all of the features returned by your search. NOTE: The Find tool is case sensitive, and searches only for strings. If you are looking for a numeric value, use the **Query tool**. You can enter all or part of a word (or words) for which to search.
12. **Measure:** Use to measure distances on the map (they appear in the Display units - see See Units tool below). Click the starting point on your map with the tool, then click to add more points, creating a line. The distance for each line segment and for the Total line distance appears above the map. Double-click to end the line and the Clear Selection tool on the toolbar to remove the measure line on the map.
13. **Set Units:** Click the tool to choose the units that are used to display distance on the map (when you first load the map, the units are set to Miles).
14. **Buffer:** Used to create a buffer of a specified distance around the selected features of a layer. The buffer can be used to select the features of another layer that intersect it or are contained within it. Before clicking the Buffer tool you must select the features to be buffered. Features can be selected using one of the

following tools: Find, Query, Select by Rectangle, or Select by Line/Polygon. Click the buffer tool, and the buffer panel appears below the map. Choose a layer and a buffer distance, and select Display Attributes if you want to see these. Click Create Buffer. A buffer appears around the selected features. Features from the selected layer that fall within the buffer are highlighted in red.

15. **Select by Rectangle or Line/Polygon (2 separate tools):** Use these tools to select features by drawing a line, polygon, or rectangle on the map. All features from the *Active* layer (to make a layer *Active*, click in the option circle next to the layer's name, in the Layer list - if necessary, use the **Toggle Between Legend & Layer List tool**, described above, to get to the Layer List from the Legend) that are contained within or intersected by graphic are selected. To clear selection, use the **Clear Selection tool**.
16. **Clear Selection:** Click to clear the selected features.
17. **Print:** Click to print the map. Type a title for map, when prompted.

APPENDIX C. DOCUMENTATION OF INTERNET MAP SITE DATA LAYERS

Map Website Name (alias)	Minimum scale	Maximum scale	Label Field	Map Website Data Layer	Original GIS Layer	Data Processing Notes (converting from original GIS layer to map website layer)
Watersheds	1:500,000	-	Name	hucs.shp	hucs	Attribute table was simplified.
Point Survey-Crayfish Observed	-	-	-	pointobs.shp	point	Contains only records where "CrObserved = true".
Point Survey-Crayfish Not Observed	-	-	-	pointnoobs.shp	point	Contains only records where "CrObserved = false".
Point Survey (Not on Reach)-Crayfish Not Observed	-	-	-	ptnorch.shp	ptnorch	Contains all original records. Didn't have to split into "true" and "false" sets, since all records are "false".
Line Survey-Crayfish Observed	-	-	-	lineobs.shp	line	Contains only records where "CrObserved = true".
Line Survey-Crayfish Not Observed	-	-	-	linenoobs.shp	line	Contains only records where "CrObserved = false".
Waterbody Crayfish Survey	-	-	-	poly.shp	poly	Contains all original records. Didn't have to split into two data sets, since no overlap exists between CrObserved "false" and "true" records, for same feature. Displays correctly as 1 layer.
Trails	1:24,000	1:500,000	-	trails.shp	trails	Contains Class 5 features only. Attribute table was simplified.
Major Roads	1:24,000	1:1,000,000	Fname	majroads.shp	trans	Contains Class 1, 2, & 3 features only. Attribute table was simplified.
Minor Roads	1:24,000	1:500,000	Fname	minroads.shp	trans	Contains Class 4 features only. Attribute table was simplified.
Waterbody Reaches	-	-	Name	waterbody.shp	nhd	Contains all features from region.rch of the nhd coverage; simplified attribute table.
Major Rivers & Streams	1:24,000	-	Name	majriver.shp	hydro	Contains features where Co (i.e. cartographic order) = 1, 2 & 3 and DatName <> shore, shore-in & null. Attribute table was simplified.
Stream Reaches	-	1:750,000	Name	streams.shp	nhd	Contains all features from route.rch of the nhd coverage. Attribute table was simplified.
Quads	-	-	-	quadgrid.shp	quadgrid	Attribute table was simplified.
Township, Range, Section	-	-	-	trs.shp	trs	Attribute table was simplified.
Counties	1:24,000	-	-	county.shp	county	Attribute table was simplified.
Wilderness	-	-	-	wilderness.shp	wilderness	Attribute table was simplified.
Cities	1:24,000	-	-	cities.shp	cities	Attribute table was simplified.
Land Ownership	1:24,000	-	-	own.shp	own	Attribute table was simplified.
Biotic Communities	1:24,000	-	-	blp80.shp	blp80	Attribute table was simplified.
Shaded Relief	1:24,000	-	-	hilshd30.tif	hilshd30	Converted from grid to tif image.
USGS Quads	-	1:24,000	-	crayfishdrgs.sid	crayfishdrgs.sid	-