The Iowa Rivers Information System (IRIS): Progress Report 2003

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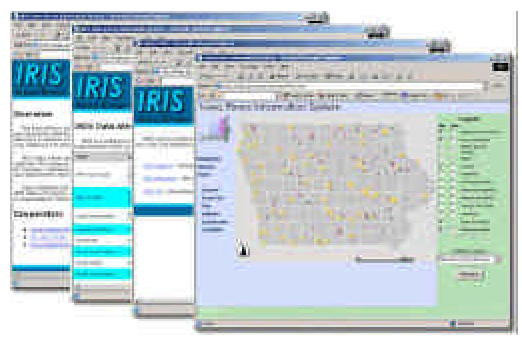
Special points of interest:

- The IRIS web site is at maps.gis.iastate.edu/iris
- Contact Information is on page 10.

Overview

The Iowa Rivers Information System (IRIS) is envisioned as a widely accessible tool for both professionals and the public to obtain information about rivers and streams in Iowa and the diversity of natural resources they support. The ultimate goal is to provide a single entry to the world of information about Iowa rivers and streams. Data and research products are available through IRIS, as well as web links to many other sites containing a wealth of information. IRIS is based on GIS principles and most of the available information is geo-referenced for mapping and spatial analysis. Uses of IRIS are only limited by the imagination. From the fisheries biologist seeking information to evaluate a stream's potential as a smallmouth bass fishery, to the water quality analyst searching for clues to explain differences in stream nutrient levels, to the classroom teacher helping students understand stream ecosystems, IRIS will be an essential tool. The true power of IRIS will be in how it simultaneously provides users with maps to visualize spatial relationships, spatially referenced databases, links to numerous other databases, and tools to work with data from a variety of sources, all linked by their location. All of this is being developed within a state-of-the-art web interface, bringing the power of IRIS to anyone with a computer and internet access.



IRIS features a collection of web pages describing the IRIS program, available data and web mapping interfaces.

The IRIS project consists of two primary areas of focus. Development of the databases and web interface creates the backbone for IRIS. Coordinated investigations complement IRIS by focusing statewide attention to specific data and research needs.

IRIS Development

Data Development

The database created within ArcView 3.2 containing variables describing certain physical features of stream reaches in Iowa is complete with a few exceptions. The database is represented as a series of shapefiles. Each shapefile contains reach line-work for each of the 57 HUC 8 level watersheds for the state. During this last year we added 4 new variables to the previous list; these are gradient, public land, tier/range/section (T/R/S) and 24K USGS topographic quadrangle name. The public land information indicates whether or not the reach flows through public land designated by the Iowa GAP stewardship data. T/R/S and 24K quadrangle name information was obtained from Iowa DNR NRGIS coverages. Gradient was calculated within ArcView using an extension from the ESRI ArcScripts page and a digital elevation model grid. We also added a new table to the collection similar to the GAP land cover percent within 90 meters of a particular reach segment. It shows land cover percent using the National Land Cover Dataset (NLCD) available from the USGS; we added this information because we have reaches that fall outside the Iowa border and the NLCD is a national dataset. The exceptions mentioned previously include 2 watersheds for which gradient has not yet been calculated, and 1 watershed for which GAP land cover percent has not been calculated.

There are a number of data layers that have been identified by the project staff and user input, but have not been incorporated into the IRIS map service; as these data sets become available they will be included. One such data set is the land cover data for the states surrounding Iowa. We will add that information to our database when the GAP land cover data becomes available from adjacent states. The gradient and land cover variables missing for certain watersheds will be calculated.

IRIS Interface and Map Services

The current web interface for IRIS (http//maps.gis.iastate.edu/iris/index.asp) has been built using a variety of server-side technologies including ESRI's ArcIMS and SDE technology.

The IRIS web interface is at maps.gis.iastate.edu/iris/

Use of ArcIMS allows users to access IRIS data through a web interface and also as a set of 'map services' useable by a number of different clients including the ArcGIS suite of mapping tools, ArcView 3.x and ArcExplorer. Both the web interface and the desktop GIS clients use the same web services. Use of server-side scripting technologies such as Java server pages (JSP) can also allow web clients to view ArcIMS map services being served by other ArcIMS map services. We have briefly discussed this possibility with the developers of the IOWATER web service at the Iowa Geologic Survey (IGS). The IRIS project has given the developers a detailed description of the configurations necessary for multiple ArcIMS map services to be displayed in a web client.

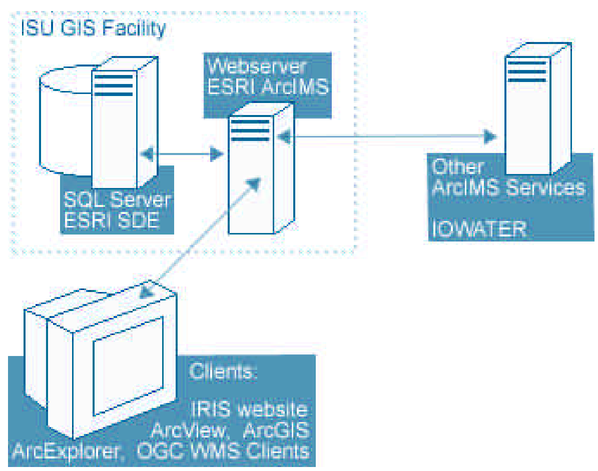
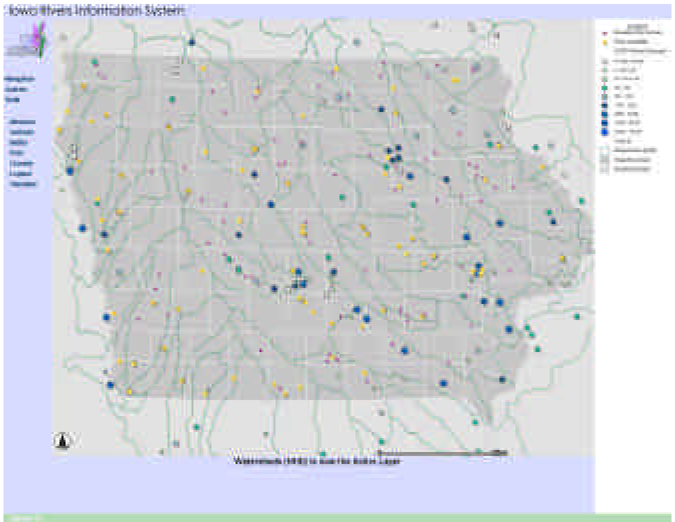


Diagram of IRIS infrastructure

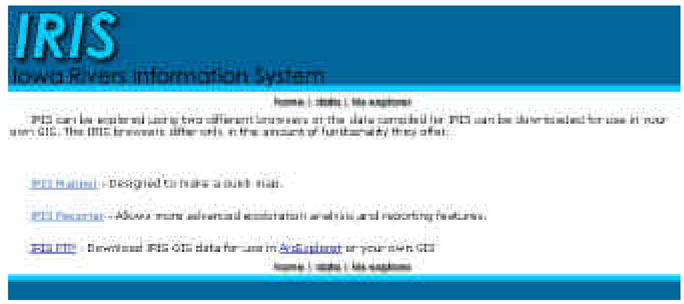
The IRIS website includes introductory material for the IRIS project, information about the IRIS attributes and data layers. Links to the IRIS mapping interfaces and data download via FTP are also included. Currently users are able to view, query and interact with IRIS data through a limited set of traditional GIS tools. Tools include the ability to zoom in and out, find specific reaches and the ability to classify reaches according to IRIS attributes.



Example of an IRIS map.

Additional data layers have been added as they become available and links to metadata or information about the different data layers now exist. Current layers include an NHD reach layer, HUC-8 watersheds, base line fish survey data, flow variability, and various cultural reference layers; for a complete listing see Table 1. An additional layer allowing users to view USGS real time stream gauge information has been added. This data is currently being stored in an ArcSDE data layer. Scripts were written in Python to scrape real-time gauge data from the USGS website every three hours, then update the layer in the SDE database.

Based on user input, a decision was made to create two web-mapping interfaces to access the IRIS data. This decision is based on interface complexity and desired outputs from a potentially wide-range of users. ***IRIS Mapper*** will consist of a set intuitive GIS tools to explore and map a limited set of IRIS data. The interface and available data will target the general public who may have a lesser interest in the more research-oriented datasets collected by IRIS. ***IRIS Reporter*** contains a much more comprehensive set of data from the IRIS data collection. Additionally, the GIS and reporting functionality of this interface will be much more robust than *IRIS Mapper*. GIS functions, beyond zoom and panning functions, will include tools to query, select and classify features with a selected data layer. Reporting functions for the *IRIS Reporter* application will include the ability to select one or a series of NHD reaches and retrieve associated records attached to the NHD reach and attributes from datasets in proximity to the selected NHD reaches. Reports will include map(s) and tabular output with options for HTML or PDF format. Currently the report only allows the printing of a map to both an HTML page and to a PDF (Tools | Print), tabular output of attribute information is being developed.



IRIS Explorer page

Adding additional layers to the existing IRIS map service as they are requested is an easy process. As layers or additional attributes for layers are developed or made accessible they will be added to the IRIS map service. However, modifications to the business logic (programming of the layer interaction and XML communication with the ArcIMS application server) are required with each additional layer added to the web service. These modifications are required to maintain consistent web functionality such as layer classification, querying and labeling. Additionally, many of the reporting tools are in development or need to be developed. The complexity of linking several independent databases to geographic features in a reporting system requires a substantial reworking of the out-of-the-box ESRI ArcIMS web client. Future mapping tools to be developed are the ability to select adjoining reaches up or downstream from a point selected by the user. Advanced reporting options will also be developed. A user will be able to perform a spatial or attribute query, generate a map of the selected features, and output a report that includes the map and attributes of the selected records.

IRIS Data Accessibility

Data within the IRIS Explorer interface will be placed into general subject groups, and will be displayed within the map table of contents within these groups. A listing of planned data, associated grouping, and availability is listed in the Table 1. Bold items are currently available for use within the IRIS web interface and map services. The section labeled 'DATA ACCESSIBILITY' summarizes how the user will be presented data within the *IRIS Reporter* web interface. As mentioned previously, the nature of ArcIMS web services makes all data layers presented in a web service accessible to a variety of ESRI desktop clients including ArcGIS, ArcView, and ArcExplorer. In addition, our servers are using the ArcIMS WMS (web mapping service) connector, so these same map services can potentially be used in a number of other non-ESRI clients having the ability to use services compliant with Open GIS Consortium (OGC) WMS standards.

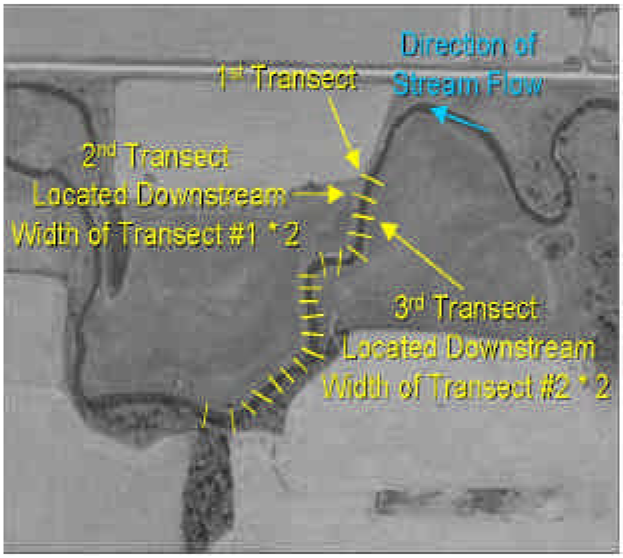
Table 1. Information currently planned for inclusion in IRIS. Items in bold type are available as of June, 2003. More data layers will be added based on suggestions from users. Contact IRIS (see page 10) if you have suggestions.

GROUP	DATA LAYER OR DESCRIPTION OF SCALE DEPENDENT LAYERS	SCALE DEPENDENT LAYER	DATA ACCESSIBILITY MAP	REPORT	FTP
Biological	**Baseline fish survey**		X	X	X
	Contemporary fish survey		X	X	X
	Water Quality Bureau fish survey		X	X	
	Historical Fish Community Surveys		X	X	X
Water Quality	Impaired waters		X	X	
	Fish kills		X	X	
	Animal Confinement		X	X	
	IOWATER		X	X	
	EPA Toxic Release Inventory (TRI)		X	X	
	STORET		X	X	
Physical	**Flow variability**		X	X	X
	USGS Stream Gauges		X	X	
	Dams		X		
	Habitat Survey		X		
	Soils	**STATSGO**	X		
		ISPAID	X		
Reference	**NHD Baselayer** (Preliminary)		X	X	X
	County Boundary		X		
	Roads and Highways		X		
	Waterbodies (NHD)		X		
	Watersheds	**HUC-8**	X	X	
		HUC-11	X	X	
		HUC-14	X	X	
	Landform Regions		X	X	
	Eco-Regions (Omernick)		X	X	
	Iowa and bordering states boundaries		X		
	Land cover		X		
	B&W Orthophotos		X		
	Color Infrared Orthophotos		X		
	DRGs (Topographic maps)	1:250K	X		
		1:100K	X		
		1:24k	X		
Cultural	Recreation areas		X		
	Stewardship		X	X	

Coordinated Investigations

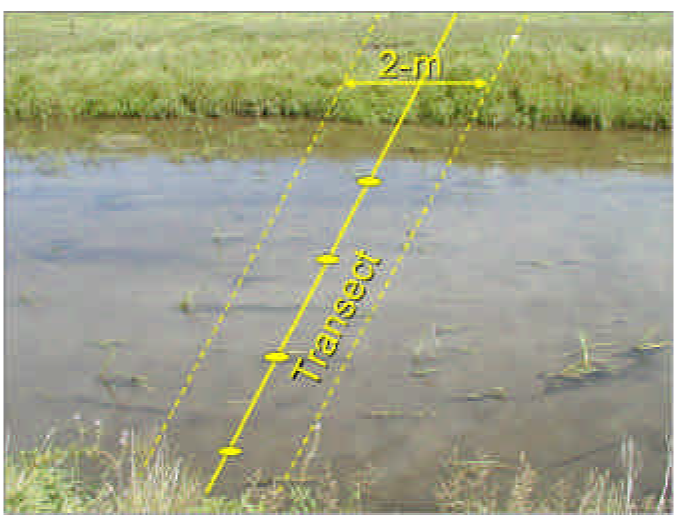
In-Stream and Riparian Habitat

Since 1995, habitat has been surveyed at 74 locations in Iowa streams to determine the quantity and quality of habitat types found in Iowa and how they vary throughout the state.



Example layout of sampling transects.

This work will help us understand relationships between in-stream habitat, stream banks, fish communities, land use and other stream features. In-stream habitat characteristics surveyed include depth, width, current velocity, fish cover and substrate composition.

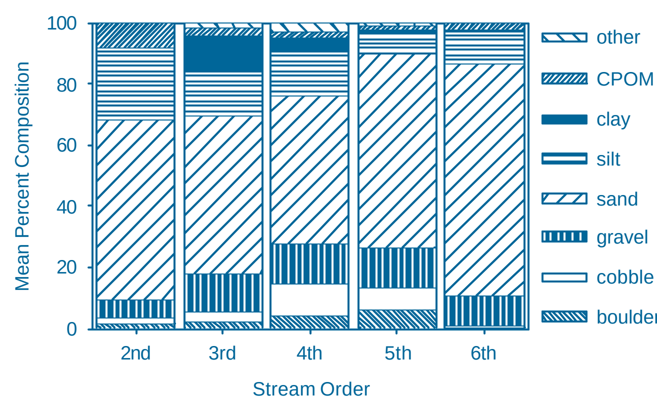


Example transect for sampling in-stream habitat.

Stream bank features surveyed include height, slope and vegetation covering banks. In-stream and bank features are measured or visually estimated. Data have been entered into a database where it can be summarized and examined.

Example transect for sampling riparian habitat.

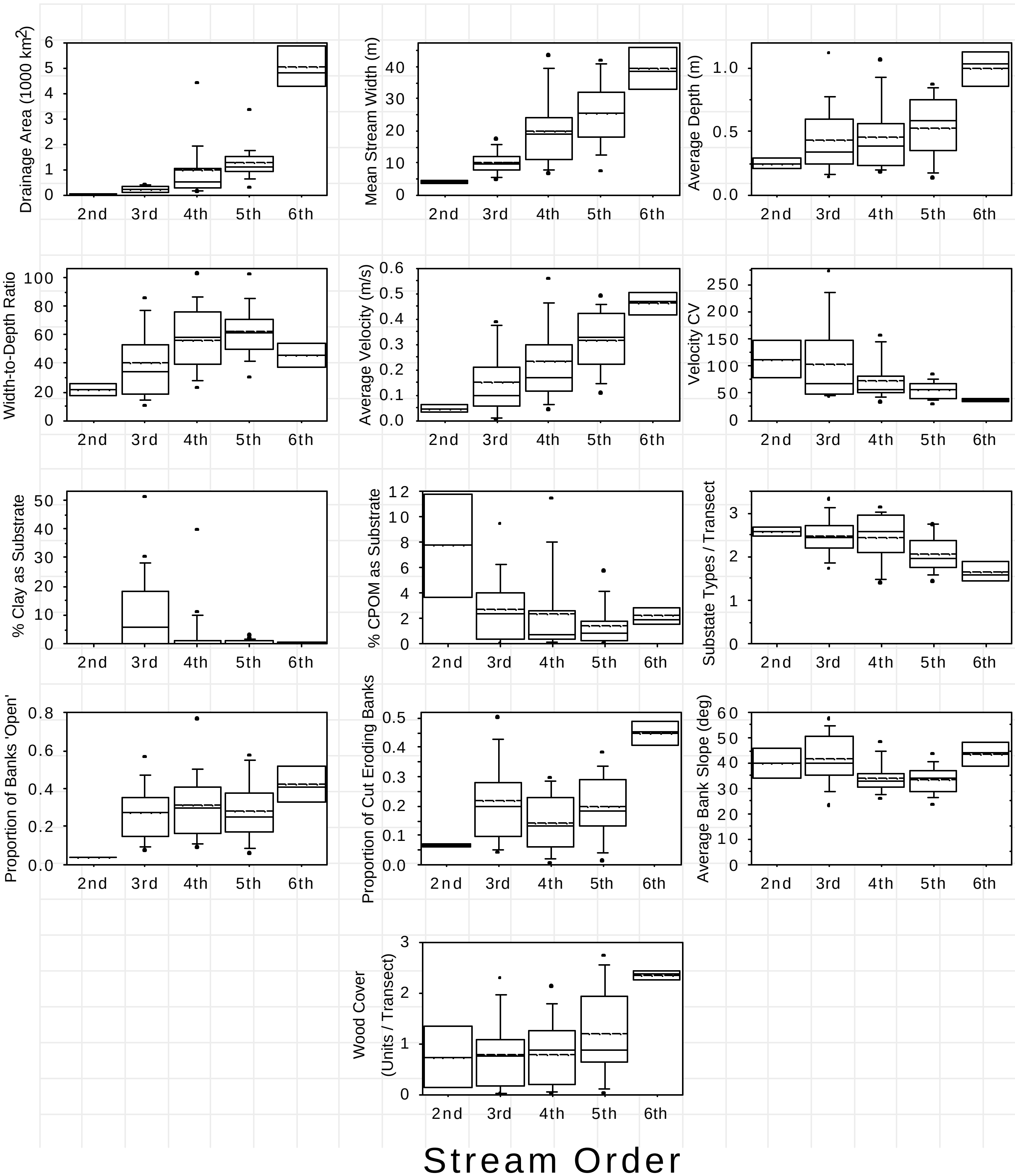
An analysis of stream habitat data from 58 locations on 46 streams collected between 1995 and 2001 has been completed. A variety of statistical techniques were used to analyze 36 stream habitat variables. The following is a subset of findings. Compared with other midwestern states, Iowa streams have more sand and less gravel, cobble and boulders.



Substrate composition of habitat stations grouped by order in Iowa streams.

Streams with trees shading the stream channel tended to have more types and abundances of fish cover than streams without shading trees. The habitat of all large streams was very similar, while habitat in small streams was highly variable. Large streams tended to have wood rather than rocky fish cover, eroding cut banks and fewer types of substrate than smaller streams.

The study inventoried the types and abundances of stream habitat features found in Iowa streams and revealed groupings of habitat characteristics, variation of habitat with stream size and relationships with bank characteristics.

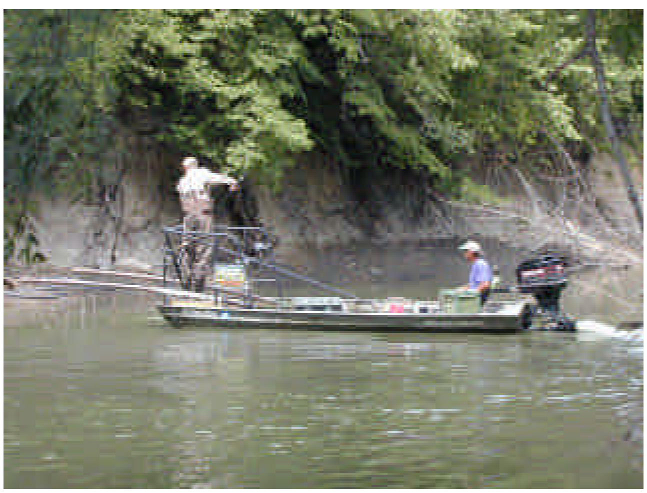


Habitat variables with significant differences among stream orders. Boxes encompass interquartile ranges; solid lines within boxes represent medians; dashed lines within boxes represent means; vertical lines above and below boxes extend to the 95th and 5th percentiles, respectively, and dots indicate values beyond the 95th and 5th percentiles.

Stream Fish Communities and Habitat

The ultimate goal of this study is to identify specific habitat needs of fish communities and use this information to guide future management efforts. Since 1995, habitat and fish communities have been surveyed from 56 locations. Fish communities were sampled using backpack, barge or boat electrofishing gear depending on stream size.

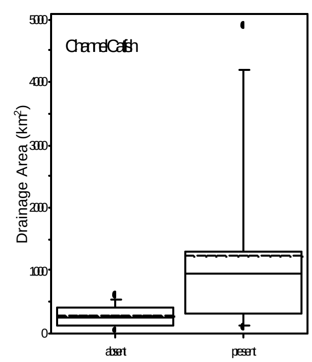
Barge electrofishing a wadeable stream.



Boat-electrofishing a non-wadeable stream.

The length and weight of each game fish was recorded. Non-game fish were counted and a single weight was recorded for all individuals of a species.

An analysis of stream habitat and fish community data from 37 locations on 32 streams collected between 1995 and 2001 is nearing completion. A total of 73 species were sampled. An average of 22 species and 950 individuals were collected per sample. Species composition, individual species abundances and trophic feeding guilds were compared to 36 habitat variables. Creek chubs and sand shiners typified small stream fish communities; large streams typically contained walleye, common carp and freshwater drum. Trophic structures of stream fish communities tended to be dominated by invertivores and omnivores. The following characteristics distinguished where channel catfish were present relative to streams they were absent from: larger drainage area, higher amounts of wood and rock fish cover, higher current velocity and higher amount of trees shading the stream.



Drainage areas of sites with and without channel catfish. Boxes encompass interquartile ranges; solid lines within boxes represent medians; dashed lines within boxes represent means; vertical lines above and below boxes extend to the 95th and 5th percentiles, respectively, and dots indicate values beyond the 95th and 5th percentiles.

This study compliments a prior analysis of the habitat data and gives biological relevance to the quantity, quality and variation of habitats in Iowa streams

Hydrological Conditions in Iowa Streams

Hydrological (flow) conditions are major environmental characteristics of streams. The magnitude of flow is a measure of stream size, which has a dominating effect on streams and how they are managed and used. Beyond flow magnitude, many other characteristics of flow also have important effects on stream ecosystems. Variation in flow, timing and seasonal predictability of high and low flows, and the rate of change in flow are also important determinants of a stream's overall flow regime. We adopted a methodology pioneered by Leroy Poff to characterize hydrological conditions in Iowa streams and compare them to streams nationwide.

We obtained hydrological information from United States Geological Survey (USGS) gauge stations. Two different hydrological databases were used. One, called Daily Values, yielded daily flow information (mean, min. max.), while the other, Peak Values, provided annual peak discharge values, the stage at peaks, and partial peak discharge values.

A digital GIS coverage of the gauge station locations was obtained from the Iowa DNR. Using methods developed by

Leroy Poff, we created new hydrological variables using mean daily discharge and partial peak data. Data from the entire period of record of 71 individual USGS gauge stations were used to create 12 descriptors of magnitude, variability, and predictability of flow for Iowa streams. The descriptors were: catchment area (area), mean daily discharge (qmean), mean annual runoff (mar) - calculated as mean daily discharge/catchment area, predictability of daily flow (daypred), variation of mean daily flow (daycv), average duration of flooding (avedur), predictability of flooding (fldpred), frequency of flood events (fldfreq), period of year when floods failed to occur (fldfree), predictability of low flow events (lowpred), period of year when low flow events failed to occur (lowfree), and mean number of days per year where no flow was detectable by the gauge (zeroday).

Using information from a similar analysis by Leroy Poff for streams throughout the entire United States, we compared hydrological regimes in Iowa streams with two groups of streams across the country. The first group included all 816 of the streams in Poff 's national database. The second group was a subset of the first group containing only those streams matching the qualitative stream types found in Iowa.

Comparisons of hydrological conditions in Iowa streams to two groups of streams across the USA revealed some interesting differences. Mean annual runoff (mar) values for Iowa streams tended to be lower than those from both the total (US-A) and restricted (US-R) nation-wide groups of streams, with the range for Iowa streams being much narrower. This variable indicates that Iowa streams have relatively low discharges for their catchment area when compared to other streams in the US. Variation in daily flow (daycv), duration of flood events (avedur), and predictability of flood events (fldpred) for Iowa streams were similar to both the total and restricted US stream groups. In contrast, predictability of daily flow (daypred), frequency of flooding events (fldfreq), predictability of low flow events (lowpred), and period of year were low flow events are absent (lowfree) values for Iowa streams were different from both of the US stream groups.

Hydrologically, most of Iowa's perennial streams appear to match two categories from Poff's nationwide classification system: perennial runoff and perennial flashy. None of the Iowa streams matched the mesic groundwater, winter rain, snow and rain, or snow melt categories. Of the intermittent Iowa streams, one would be classified as harsh intermittent (greater than 100 days of zeroflow average per year), while the other streams fit into the intermittent runoff or intermittent flashy categories. Considering the continental climate and predominance of agriculture in Iowa, the hydrological classification of streams into these categories seems reasonable. Extensive row cropping, which causes soil compaction, would be expected to increase overland runoff and decrease infiltration and groundwater flow. Drainage tiling and channelization, both common hydrological alterations in Iowa, further accelerate the flow of water off the land, causing a more "flashy" hydrograph than in catchments lacking these drainage "improvements".

Variation in daily flow tended to be comparable or perhaps slightly greater in Iowa streams than in either the "US-all" or "US-restricted" groups. Predictability of flooding in Iowa streams was similar to US streams, indicating that even though variation in daily flow may be relatively high, flooding in Iowa streams is, on average, no less predictable than in streams across the US. Frequency of flooding and duration of floods tended to be greater in Iowa streams than either of the US groups. These relatively frequent flooding events, occurring for somewhat longer periods but with comparable predictability to streams nation-wide, may be beneficial to some members of the fish community. Flooding is known to enhance the nutrient base, create additional breeding habitat, and provide important nursery areas, especially for smaller fish species and young-of-year.

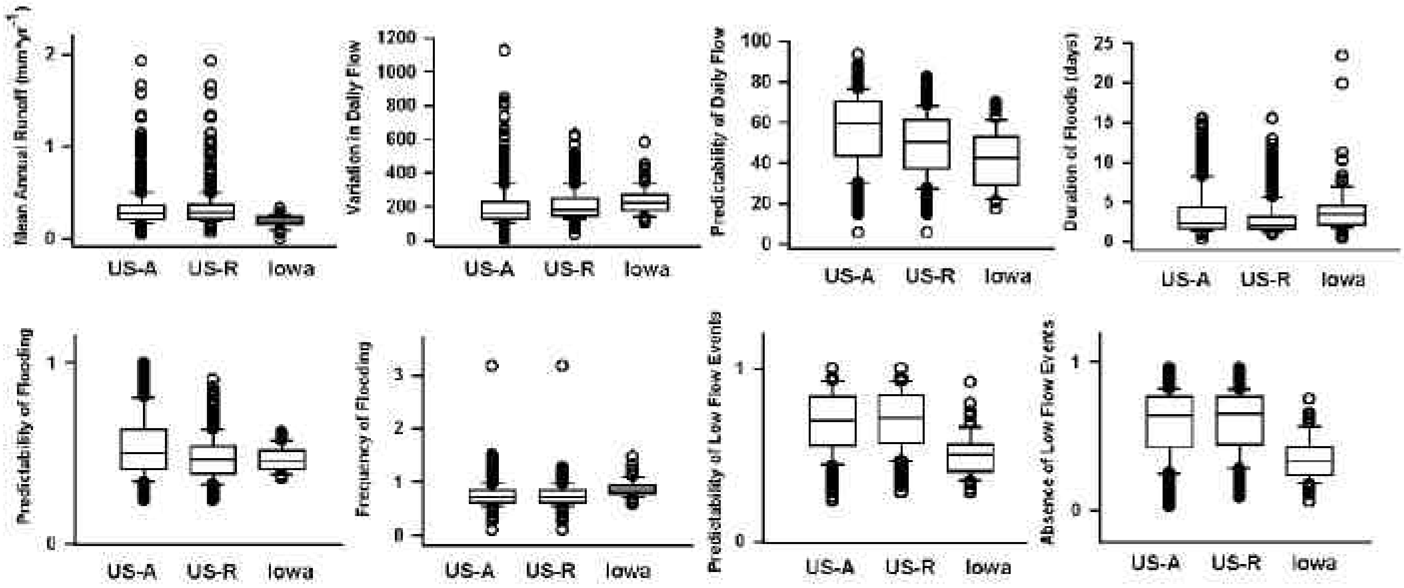
Predictability and absence of low flow events were both much lower in most Iowa streams than in the nation-wide groups, suggesting a relatively harsh environment for fishes and other aquatic biota in Iowa streams. Low water conditions can be detrimental to fish populations in many ways, including extreme temperature and oxygen conditions, increased risk of predation by terrestrial predators, and increased competition as fish are crowded together in pools during times of low flow. Predation by piscivorous fish also increases under these conditions.

Fish Communities and Availability of Deep-Water Habitat

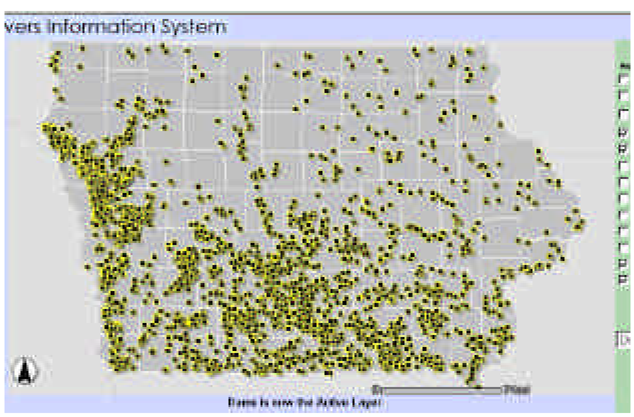
One of the most important physical habitat characteristics for game fish in streams may be the availability of deep-water habitat. Stream anglers know the value of deep pools for harboring quality game fish. Likewise, there is evidence from research that availability of deep pools has a positive effect on game fish abundance and biotic integrity as reflected in natural fish communities. Agricultural practices, which affect more than 90% of the Iowa landscape, are known to reduce the depths of pools by sedimentation. Because of this, deep-water habitat in Iowa streams is believed to be limited.

In unaltered streams, if deep water is not available nearby, fish can move downstream to find suitable deep water during winter or periods of drought. However, with dams now blocking fish movements on most streams in Iowa, moving downstream to a larger river is frequently difficult if not impossible.

Channel catfish and smallmouth bass are among the most commonly sought game fish in Iowa streams. Anglers seek pools when fishing for these species, and both have been documented to prefer overwintering in pools greater than 10 ft deep. These species also demonstrate homing tendencies, suggesting that both species will return to the same habitat locations if that habitat resource is critical for survival. In a



Hydrological comparisons of Iowa streams with streams from across the United States. Boxes encompass interquartile ranges; solid lines within boxes represent medians; dashed lines within boxes represent means; vertical lines above and below boxes extend to the 95th and 5th percentiles, respectively, and dots indicate values beyond the 95th and 5th percentiles.



Locations of dams on Iowa rivers and streams

15-mile section of the Wapsipinicon River, nearly all channel catfish and walleye radio-tagged as part of a telemetry study migrated yearly to the same overwintering location. The overwintering habitat was a man-made sand-extraction pit over 20 ft deep, which is believed to be the deepest area in this river segment. Radio-tagged smallmouth bass were also found utilizing the sand pit as well as another large natural pool roughly10 ft deep. Downstream migration from this river segment is prevented by a dam. In contrast, nearly all radio-tagged channel catfish and walleye in the Turkey River migrated over 25 miles downstream to overwintering locations in the Mississippi River. The Turkey River segment is believed to lack deep-water areas like the sand-extraction pit in Wapsipincon River.

Channel catfish and smallmouth bass populations are known to vary significantly among river segments, as do fish communities as a whole. We hypothesize that availability of deep-water habitat, either locally in the form of deep pools or via unblocked downstream migration, may explain some of these differences. In order to evaluate this hypothesis we are launching a new study in 2003 to examine relationships of fish communities and populations of channel catfish and smallmouth bass with availability of deep-water habitat in three eastern Iowa rivers.

During the summer of 2003, the longitudinal profile of maximum stream depth will be determined. A boat-mounted GPS/depth-finder will be used to record the maximum depths occurring along the entire length of each stream reach. The stream depths will then be adjusted to the mean daily stream depth as determined by the USGS gauging stations on the rivers. The resulting series of geo-referenced adjusted maximum stream depths will then be used to construct a longitudinal depth profile, which can be overlayed on other spatial representations of the study streams. These profiles will be analyzed to provide information on the availability of habitat in each stream of certain depths. The resulting measures of deep-water habitat availability will be compared with fish community and gamefish population data.

Fish communities will be sampled during summer of 2003 and 2004 according to existing Iowa DNR protocol via boat electro-shocking. This is being done so that the collected data can be compared with previously collected fish data from ongoing studies of Iowa stream fish communities. Within each stream reach, fish will be sampled at 2-3 sites. The identity, capture location, length, and the presence of externally visible disease or lesions will be recorded for all fish. In addition, scales and pectoral spines from every captured channel catfish and smallmouth bass will be collected along with wet weight. These data will then be used to calculate the characteristics of interest for the fish communities and gamefish populations. To test the hypothesis that access to quality deep-water habitat affects the stream fish community, we will examine differences in species richness (the number of different species), tropic guild proportions, Index of Biotic Integrity (IBI), and catch-per-unit effort (CPUE, total number of fish captured per time effort) among stream reaches within rivers and among rivers. We will then relate these differences to differences in availability of deep-water habitat among reaches.

Using scales, pectoral spines and otoliths, we will estimate age and growth of channel catfish and smallmouth bass. The age estimates will be use to construct the population age structure, and the growth estimates will be pooled to calculate the mean population growth rate for each age class. Channel catfish and smallmouth bass age structure and growth rate differences will be compared among stream reaches within rivers and among rivers to test the hypothesis that access to quality deep-water habitat affects population growth rates and population age structure.

Land Use Relationships with Flow Regime, Habitat and Fish Communities in Iowa Streams

As part of the IRIS project, coordinated investigations of flow regimes, in-stream and riparian habitat, and fish communities have been undertaken with the eventual goal of integration with landscape-scale data. The recently completed Iowa Gap Analysis Project has produced state-of-the-art land use designations at a high level of spatial resolution. We are now in a position to address one of the fundamental goals of IRIS – to analyze patterns of stream characteristics measured at local scales with landscape-scale attributes of the surrounding drainage basins.

The goal of this future project is to explore relationships of land use with flow regime, in-stream and riparian habitat, and fish communities in Iowa streams. Specific objectives include (1) Defining land use in the entire drainage basins and riparian corridors for all stream locations with data on flow regime, in-stream and riparian habitat, and fish communities, (2) Examining simple, univariate relationships of land use with flow regime, in-stream and riparian habitat, and fish communities, (3) Examining complex, multivariate relationships of land use with flow regime, in-stream and riparian habitat, and fish communities, and (4) Evaluating the relative influence of basin-wide vs. riparian corridor land use on flow regime, in-stream and riparian habitat, and fish communities.

For More Information:

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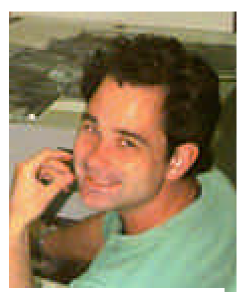

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