PISCES: a Programmable geographic Information System for Cataloging and Encoding Species observations

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PISCES is a software system developed in Python that uses ArcMap, Arcpy, and Microsoft Access to standardize, store, map, and analyze data on fish species distributions.

Standardization and Storage

PISCES processes spatial and tabular coordinate observations and expert opinions on the location of fish taxa. PISCES standardizes all data to its own database by using Arcpy to join data to USGS 12 digit Hydrologic Unit Codes (HUC 12s).

PISCES process occurrence data in any spatial or tabular format with minimal human input. We add new data to the database by indicating a dataset, a code class, and a species translation table. We can also manually add or correct data in ArcMap 10 by passing selected HUC 12s through our custom Python script tool.

While it handles most data formats with no additional coding, PISCES can be extended with new data processing code via Python classes or function overloading to adapt to small inconsistencies in familiar datasets.

Data Sources

Species occurrence data is the foundation of PISCES. Currently, PISCES includes data from Moyle and Randall 1998, Moyle and Katz 2011 in prep, United States Forest Service field data, and the California Natural Diversity Database.

Data Components

Species Occurrence Data
Standardized data on which species are present in each HUC.

Spatial Attributes
Data for each HUC on key indicators and correlates, such as road density, lake area, dams, stream miles and designations, and more.

Species Attributes
Relevant data about each species - designations, classifications, and traits - that could be important variables for analysis of a HUC or a species.

Mapping Configurations
Stored queries to convert data into rangemaps, run analysis, and generate new ArcGIS data layers.

Reporting

We preloaded PISCES with expert information on the distribution, history, and sensitivities of each native species. We use this data to produce reports on each species, but it is also accessible for use by map producing SQL queries (see below).

Mapping

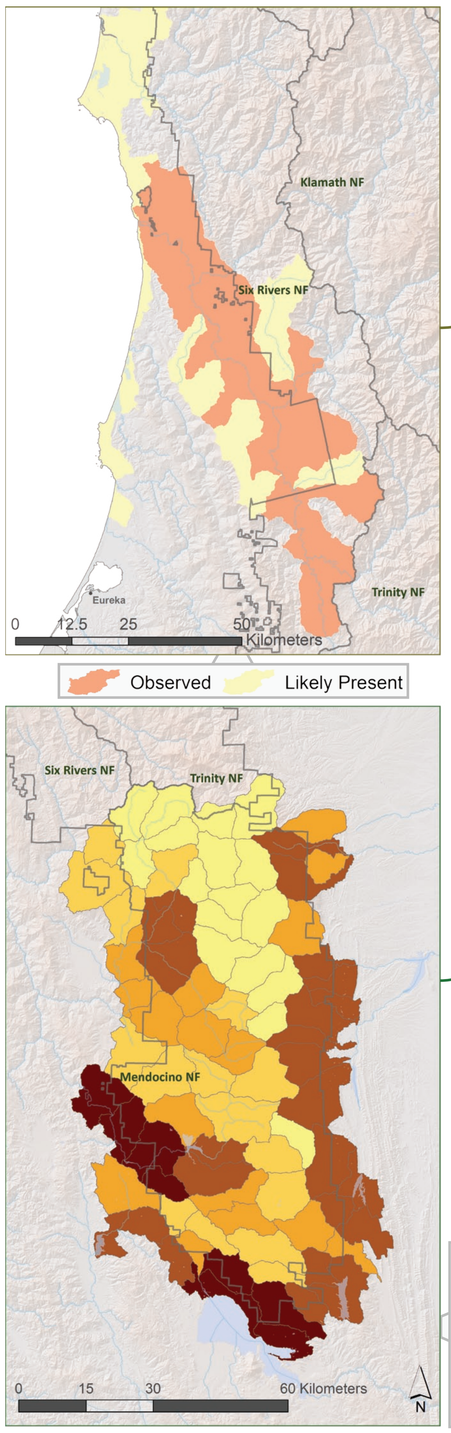
PISCES maps are, at their base, a set of SQL queries that return HUCs to be mapped. These queries are extended to produce sets of maps and process data in four significant ways:

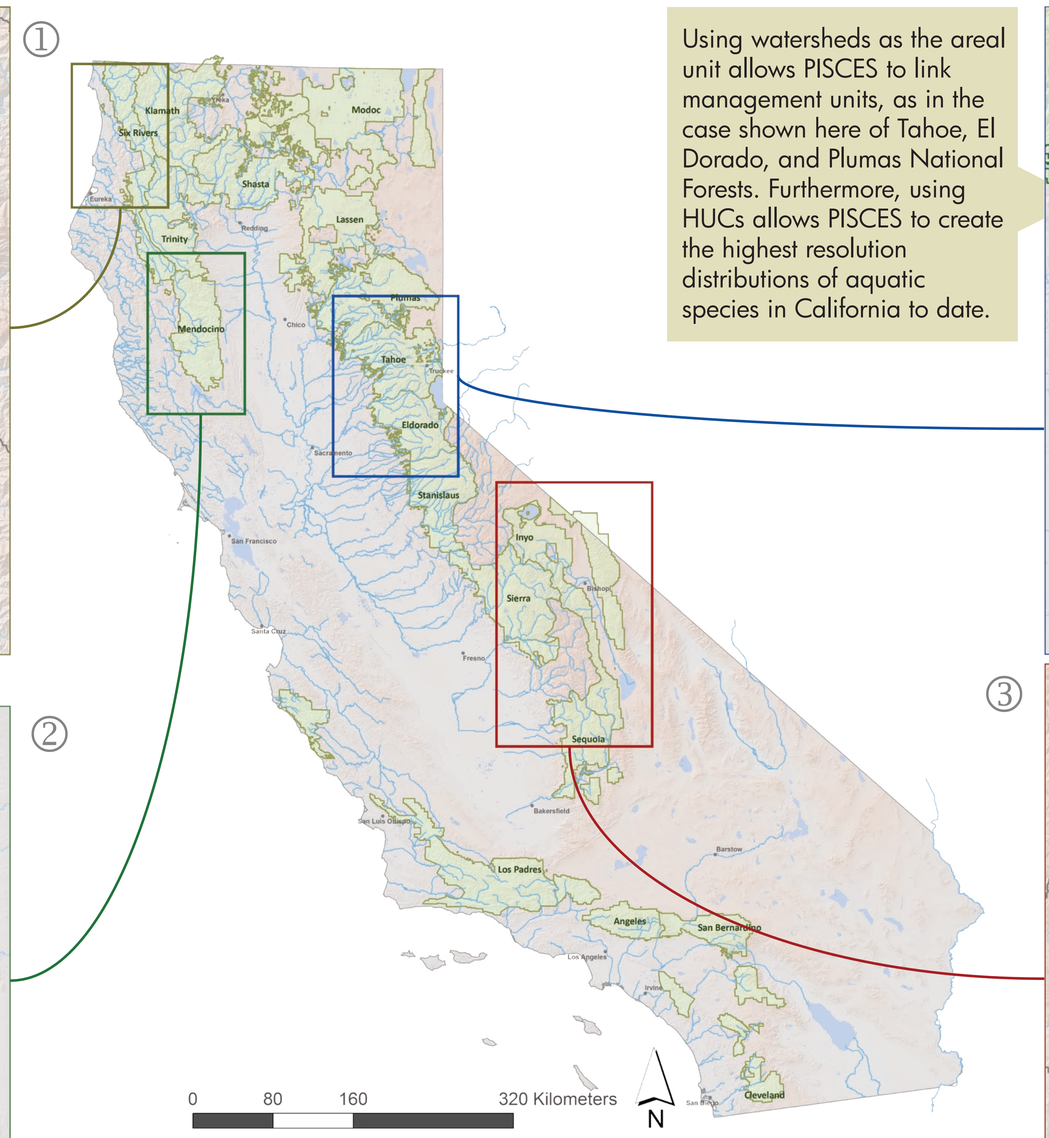
1. Iterators and Data Driven Pages: Map iterators turn the values in a database column into bind variables on a map's SQL queries in order to create sets of maps from a single query. PISCES generates a map for each value in that column.

2. Postprocessing Functions and Queries: After a query's results have been retrieved, postprocessing functions in the form of code or simple SQL queries add additional attributes to each HUC's record. These attributes can then be symbolized or labeled according to a layer file associated with the query.

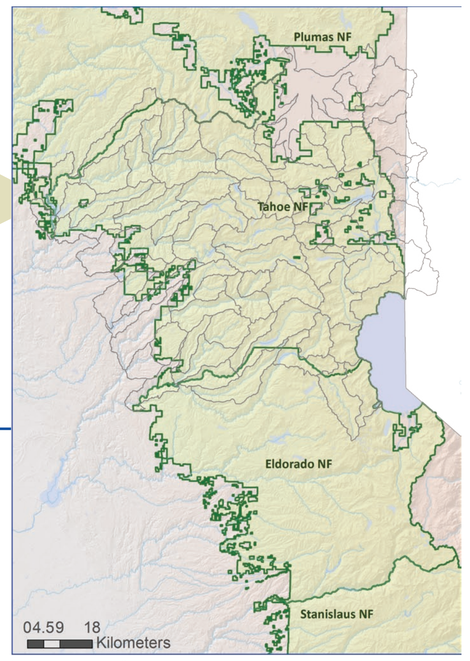
3. Base MXDs: PISCES adds generated data layers to a specified .mxd file at a known level in the Table of Contents. We use different mxd files in order to symbolize or highlight specific layers, provide extra data, or enable ArcGIS' Data Driven Pages.

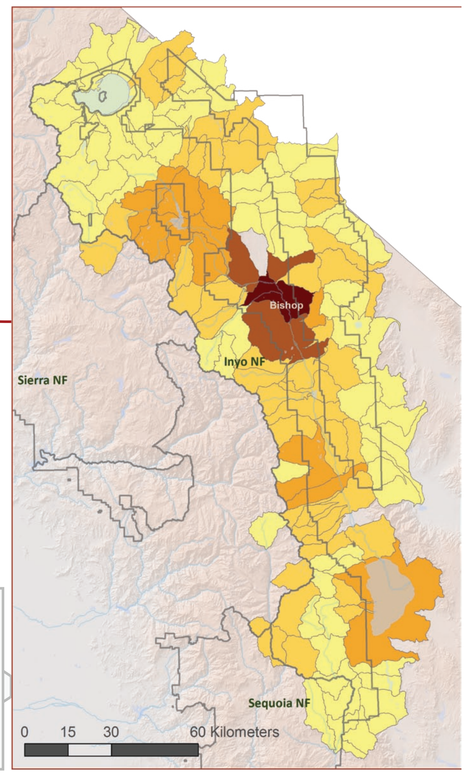
4. Layers: Each generated layer can specify a .lyr file to copy symbology from. Combined with data added via a callback function, we can automatically generate and symbolize all of the maps on this poster and many more.

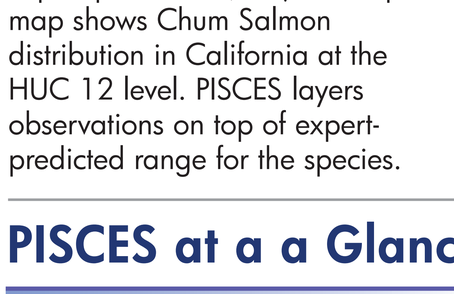




Using watersheds as the areal unit allows PISCES to link management units, as in the case shown here of Tahoe, El Dorado, and Plumas National Forests. Furthermore, using HUCs allows PISCES to create the highest resolution distributions of aquatic species in California to date.







Number of Native Species
1 - 2
3 - 4
5 - 6
7 - 8
9 - 11

Number of Sensitive Native Species
0
1
2
3
4

Range Mapping ①

PISCES was designed to create species rangemaps from presence data from varying sources and of varying quality (observations, expert predictions, etc). The top map shows Chum Salmon distribution in California at the HUC 12 level. PISCES layers observations on top of expert-predicted range for the species.

Diversity/Richness ②

We configured PISCES to provide a count of species per HUC, giving us a quick measure of fish diversity. At bottom left is a species richness map of Mendocino National Forest showing HUC 12s, where deeper orange indicates more species. When mapped statewide, richness maps illuminate both data gaps and hotspots of fish diversity.

Sensitive Species by HUC ③

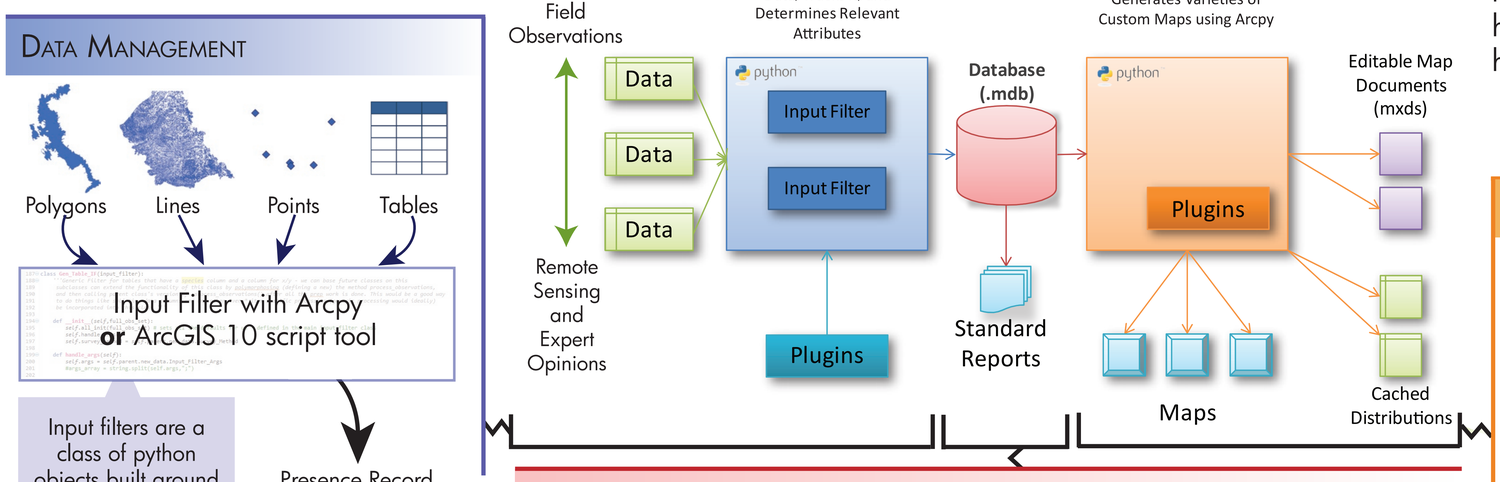
PISCES stores auxiliary information about each species and each HUC, allowing for map generation that relates any number of environmental, human, or ecological variables. Results can be displayed as a map, or in tabular form as simple SQL queries, allowing us to rapidly answer complex questions in map form.

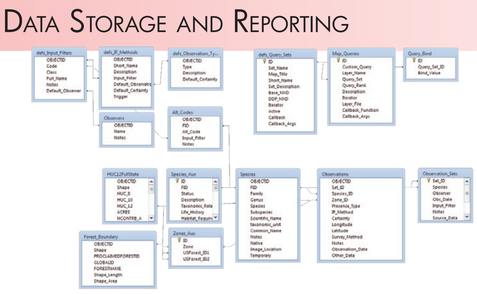
Other

PISCES provides answers to questions in the form of maps and data tables. PISCES can answer most questions in the scope of its data with SQL statements or with a Python extension.

Future maps from PISCES will include better measures of diversity, species-specific habitat suitability modeling, and analysis of species distributional shifts due to interactions of climate effects, habitat characteristics and life history traits.

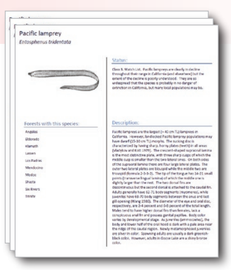
PISCES at a a Glance





Data Storage and Reporting

We use a Personal Geodatabase for all primary data storage in order to link Microsoft Access data tables that store observations and other data to critical feature classes using only SQL. Access provides an interface for joined queries and analysis.



Reports generated in Access include species status, presence on national forests, a picture, and other relevant information.

Mapping and Analysis

SQL Query
Select HUC12 as Zone_ID from ...

.mxd

Arcpy

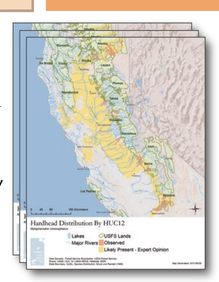
Species Bind Variables
CMC01,SOM09,CSB04...

Multiple Layers and MXDs

Postprocessing Plugin using Arcpy

Plugins can execute on every layer and can modify already selected HUCs, add attributes, remove items, and do other tasks requiring more than SQL.

Arcpy.mapping



Maps for each taxa with multiple, flexible layers generated by PISCES using arcpy.

Metadata

Map Projection: NAD 1983 California Teale Albers
Software: ArcGIS 10 SP2; Arcpy on Python 2.6 with PyODBC; Windows 7 x64 and Windows Server 2008; Microsoft Access 2010
Poster Software: ArcMap 10 SP2, Adobe Illustrator CS2, and Microsoft Powerpoint 2010
Data Sources: Hillshade generated from USGS 30m DEM; rivers and lakes from USGS and BLM CASO; Forest Service boundaries from United States Forest Service; Species presence data from Moyle and Randall 1998, Moyle and Katz 2011, United States Forest Service, CNDDB.
Date: June 22, 2011

Funding Agency: United States Department of Agriculture - Forest Service - Region 5

Website: http://watershed.ucdavis.edu | **Twitter:** @UCDavisWater