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Data at Risk – Documenting Analysis as well as Data

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Abstract

The spatial and associated data are key components in analysis attempting to balance a reliable water supply and ecosystem restoration. GIS is a major tool in analysis of these issues. GIS data and the processes followed are dependent on conceptual models for these systems and features. Not only is the documentation of data critical, but documentation of the process or analysis used to develop the data is critical for the application and use of the data. The ArcGIS geoprocessor and metadata tools provide opportunities to effectively document the processes followed. It also provides opportunities to effectively model the analysis performed and convey information on the processes and parameters considered. This can assist organizations reviewing the plans.

The digital representation as points, lines, polygons, or raster of real world phenomena is based on conceptual models of the phenomena. Recognizing the underlying conceptual model permits the evaluation of the digital representation in the application and use of the digital data. This is important data quality information for products generated. Where digital data products are under development or preliminary, the conceptual model and processes being followed may be available. Well documented processes permit the use of independent data with additional information. Examples presented are related to water and ecosystem issues on the Pacific west coast of the United States.

Introduction

GIS representations of real world features or phenomena are based on underlying conceptual models. GIS can be described as the digital representation of a conceptual model of real world features or phenomena of interest. The digital representation is often a process that is sequential and iterative as concepts are refined. The process can be as useful for modeling the phenomena as digital products or feature classes generated from GIS analysis.

1. Conceptual model developed
2. Available data collected based on requirements of the conceptual model
3. Extraction or display of information of interest based on the model as a derived product or as a display

4. Refinement of concepts

Where conceptual models are well defined, the resulting GIS representation can be compared with the model for evaluation as to the fitness and use of the GIS data. Documentation of the process provides key information or metadata for any products that are developed. This includes information that supports the proper use and application of the digital data products. The data quality section of the “Content Standards for Digital Geospatial Metadata” (FGDC, 1998) contains some key sections that should be considered in describing the validity and reliability of the digital representation of a conceptual model of the phenomena. These sections include logical consistency, completeness, and lineage as well as statements on the spatial and attribute accuracy.

Conceptual models are often in a state of refinement as processes are better understood or more information is available. The process is often iterative depending on the phenomena of interest. The processes can be modified to reflect changes in the conceptual model as needed. This can lead to refinement of the GIS representation and even changes to the underlying GIS data structure.

The geoprocessing environment of ArcGIS permits the documentation or modeling of processes followed in analysis and development of the digital representation. This information can be shared independently of data products. Documentation of the process and tools used in the process permits others to model the phenomena of interest with available data. It may be possible to share the conceptual model and description of the process followed where the data products are preliminary or considered sensitive. Documentation of the process permits open discussion on the conceptual model and the validity and reliability of representation of the phenomena over the area of interest.

Four examples are provided related to the digital representation of very different conceptual models.

- Drainage impaired lands in the San Joaquin Valley
- Lands being considered for transfer to the states of Oregon and California
- Location of plant species in the Central Valley of California
- Potential habitat restoration areas in the California Delta

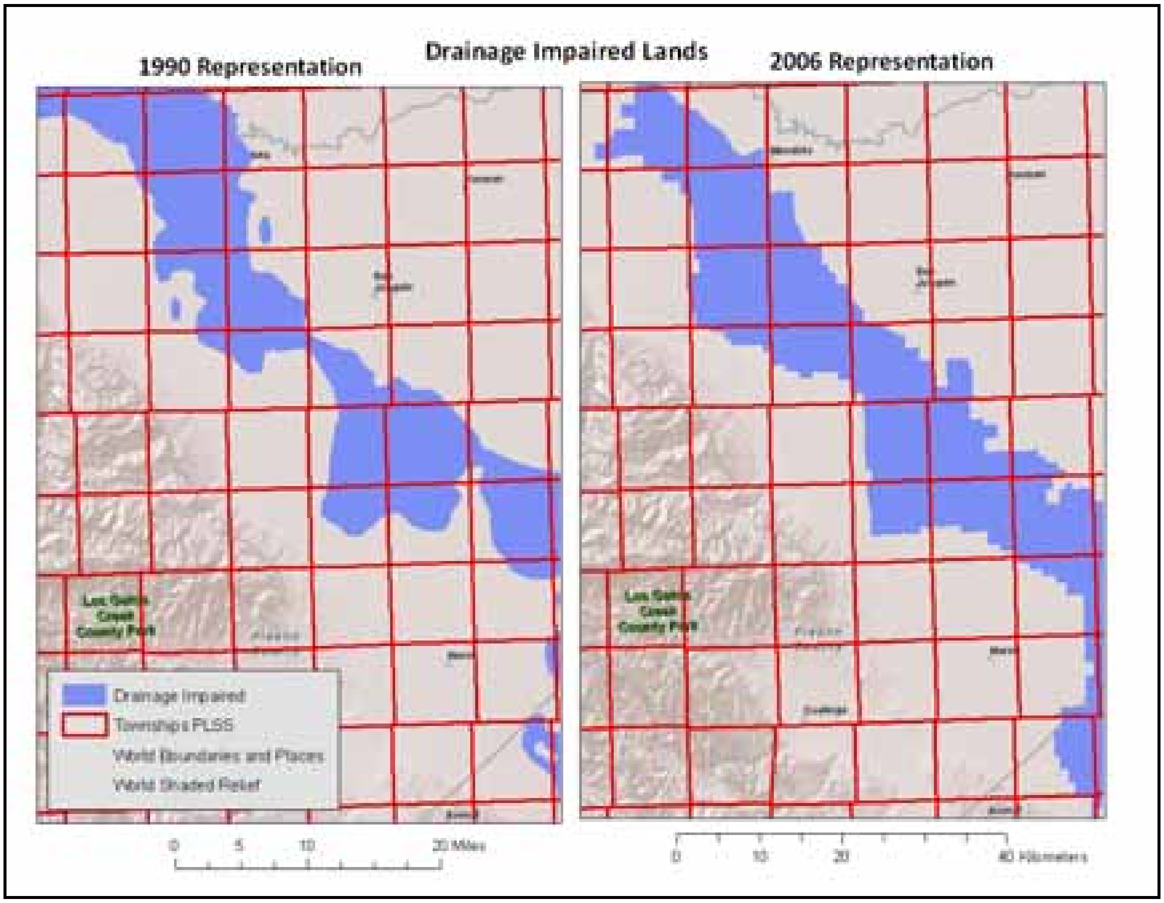
Digital Representation of Drainage Impaired Lands

The first example is the representation of drainage impaired lands on the west side of the San Joaquin Valley, California. This is an area of agricultural land that has not had a drainage outlet since the mid 1980’s. Portions of the western side of this valley have extensive areas of shallow ground-water. Irrigation has raised the ground-water level and increased the salt concentration in the soils and ground-water. This process has led to impairment in crop production. The lands are described as drainage impaired. The conceptual model describes these lands as having the following characteristics:

- Shallow water table of 5 feet or less in April,
- Salinity of groundwater is 12 deciSiemens per meter

- Other general soil characteristics including:
    - High soil salinity
    - Low permeability

This conceptual model is well developed. It has had various representations over time. Figure 1 shows representations of the potential areal extent of drainage impaired lands for a planning horizon of about 50 years. The map on the left represents an estimated extent prepared in 1990. The map on the right represents an estimated extent prepared in about 2005.



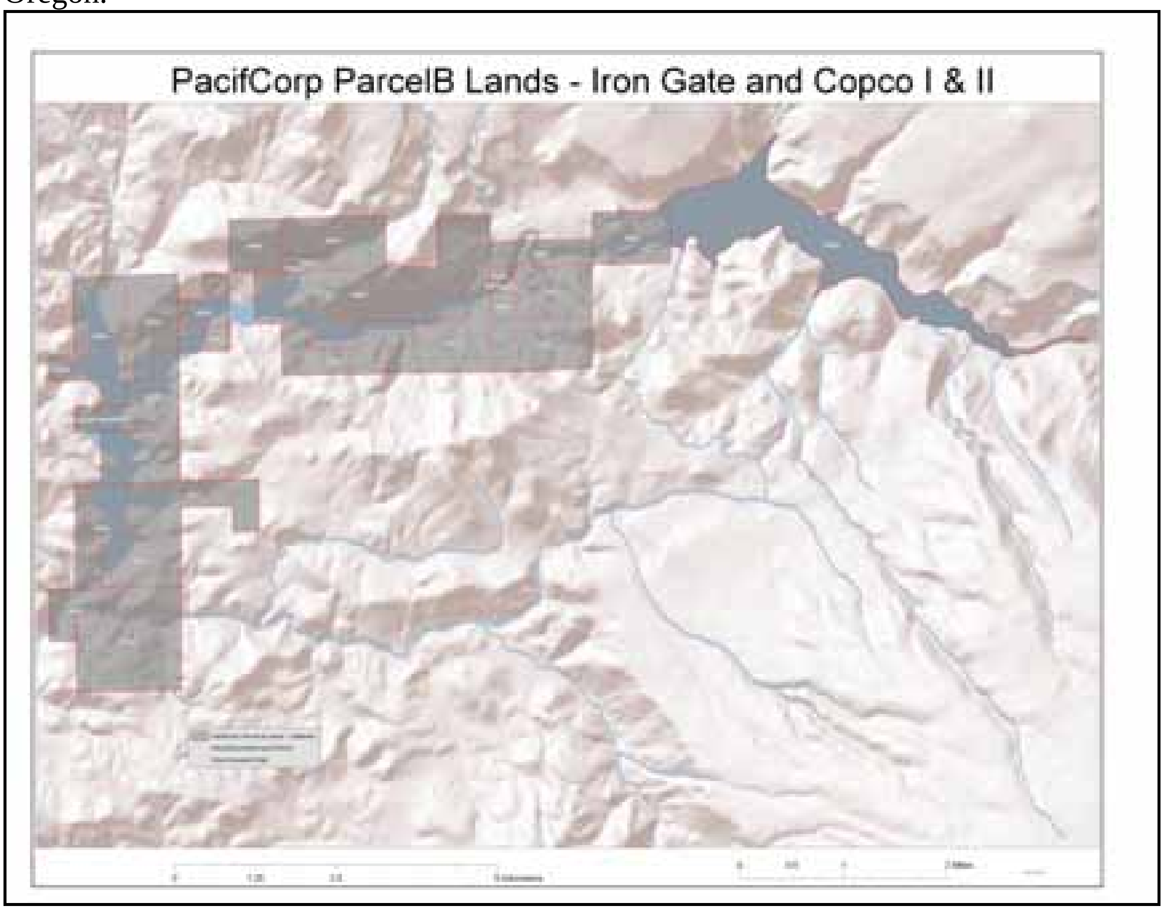
Both are attempts to reflect the characteristics identified in the conceptual model. The planning horizons for these maps are 2040 for the first map and 2050 for the second. The conceptual model over this time period has been modified but the main change has been the increased availability of soil information for the area and continued monitoring of ground-water levels and salinity.

The map shown for 2005 implies far more regular boundaries than what you would expect for natural features as described in the conceptual model. Metadata for the 2005 is not available to identify what digital data was used to develop this dataset or how it was processed. There is no lineage or processing history. The digital representation and the underlying data raises questions which can not be addressed due to the lack of adequate metadata. The data is at risk. It represents many of the risks that all of us face related to our digital representations of real world features.

Digital Representation of Potential Land Transfer

In February 2010, the Klamath Hydroelectric Agreement was signed by a variety of parties concerning the removal of four dams on the Klamath River. Under this agreement, the Secretary of the Interior is to make a determination as to whether removal of these dams to achieve a free flowing river and permit full volitional passage of fish is in the public interest. Among the many requirements under this agreement is the transfer of lands associated with these four dams and the areas currently inundated by these dams from PacifiCorp to the states of Oregon or California. PacifiCorp is the current dam owner.

This is a case of a very simple conceptual model. Figure 2 shows a portion of these lands referred to as Parcel B lands. This figure shows Parcel B lands in California associated with three of these dams. It includes lands that are currently inundated as well as lands adjacent to the dams or reservoir areas. There are additional Parcel B lands associated with J.C. Boyle Dam in
Oregon.

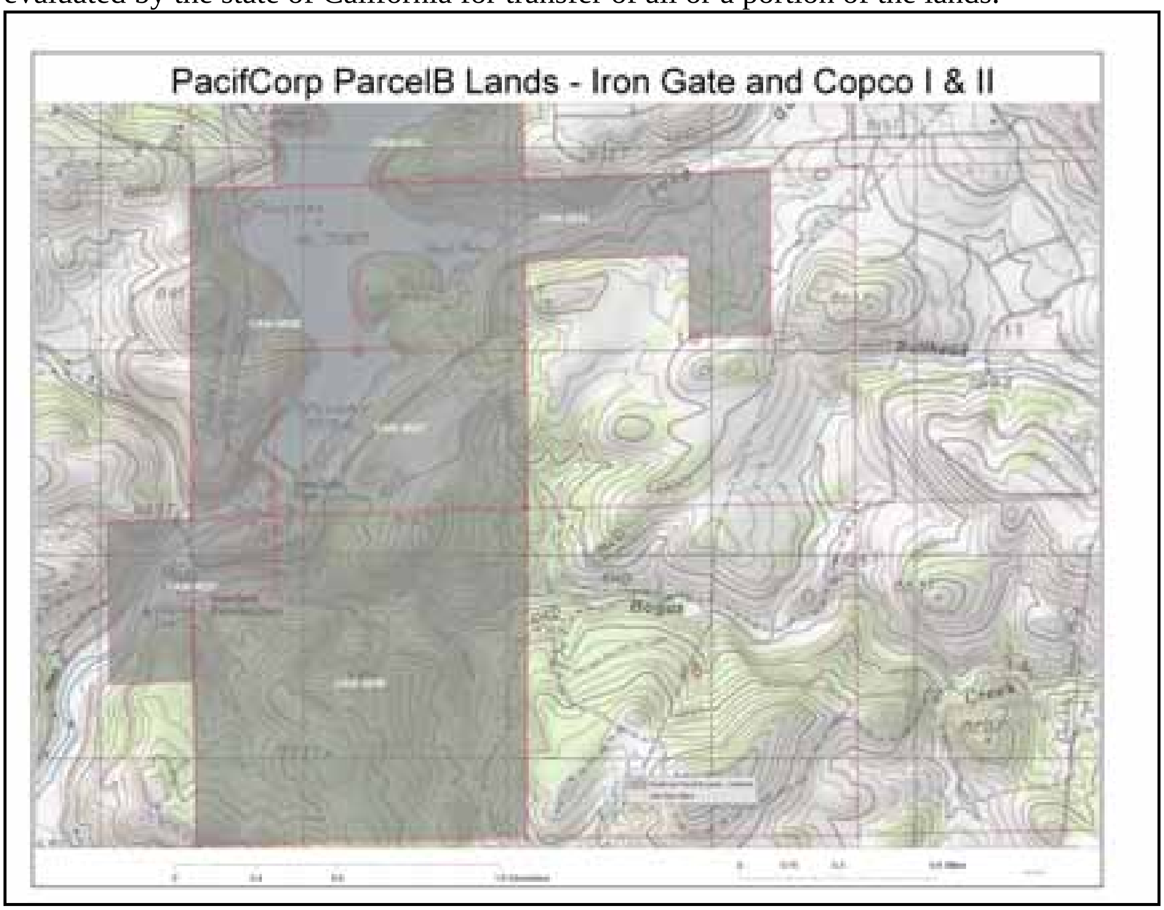


The basic concept and the representation of these lands can be expected to change based on the language in the agreement and input from the respective states.

> "…PacifiCorp lands… identified as Parcel B shall be transferred to the State of Oregon or the State of California, as applicable, or to a designated third party…. These transferred lands shall thereafter be managed for public interest purposes such as fish and wildlife habitat restoration and enhancement, public education, and public recreational access. Each State shall undertake inspection…of Parcel B lands...Following such evaluation, the State of Oregon and the State of California may…, elect not to accept the transfer of all or any portion of Parcel B…lands; provided….transfer…will not achieve the intent…"

Both states are expected to evaluate the lands to identify which portions of these lands meet their own criteria for public interest and long term management. The basic conceptual model can be expected to undergo revision as the states identify characteristics that are important to them. It is work in progress with refinement of the digital representation based on characteristics identified by the respective states. Documentation of changes in the overall conceptual model should assist in documenting the GIS feature classes for these parcel B lands.

Figure 3 is an enlarged portion of lands in the vicinity of Iron Gate Dam that will be evaluated by the state of California for transfer of all or a portion of the lands.



It is expected that there will be a long term interest by the two states in the restoration and management of the lands currently inundated by the reservoirs or immediately adjacent to the Klamath River. Criteria for other lands will be defined by the respective state.

Digital Representation of Plant Species

Reclamation has been collecting digital data related to several invasive plant species in riparian vegetation communities. Depending on who is collecting the location of these species and the intent or application of data, several schema have been used. The plant locations have been represented as points, lines, and polygons. For each of these data types, similar information has collected. The use of this information has been limited to general location of particular species because of the use of different feature types and the lack of a clear conceptual model.

Digital Representation of Potential Habitat Restoration Areas

The Delta Vision Strategic Plan identifies the following targets for habitat restoration.

- Inter-tidal Marsh - 12,000 hectares (30,000 acres) by 2040
- Tidal open water - 18,000 hectares (45,000 acres) by 2040
- Increased inundation of flood plains to restore their function as an interconnected system with wetland and aquatic habitats

The plan provides key criteria for identifying potential areas for restoration of these habitats (Delta Vision Strategic Plan, 2008). Tidal marsh should be within the current range of tides. The topography should accommodate changes in the tidal range due to sea level rise. The topography should be varied enough to include flood plain habitat and uplands as a complex and interconnected system. The area should be large enough to permit the development of dendritic drainage patterns or networks within the wetland areas. Besides providing for a complex set of habitats of wetland, floodplain, and upland, the system needs to connect to open water. This would provide opportunity for organisms to migrate between habitats on a daily, seasonal, and annual basis.

Supporting studies for the Delta Vision process by Stuart Siegel examines the issue of potential wetland restoration areas considering potential sea level rise and tidal range. In this examination, Siegel recognizes that portions of the Delta would experience different ranges of water elevations from sea level rise and tidal influence (Siegel, 2007).

Figure 4 is the table prepared by Siegel showing his expected variations in tidal range and potential area for habitat restoration for major segments of the Delta.

Total Area Potentially Available to Reach Ecosystem Targets, by Subregion, Delta and Suisun

This table shows the total acreage of lands potentially available for ecosystem purposes in the Delta and Suisun Marsh by elevation (Criterion 1). It extends outward to the boundary of the legal Delta and Suisun Marsh and excludes the deeply subsided interior Delta and all urban areas. Not all such land can or should actually be used for restoration.

Elevation Category	Restoration Location, Groupings Based on Landform Divisions													Total Acreage
	1. Suisun Marsh	2. Suisun-Cache Corridor	3. Cache Slough	4. Prospect	5. Yolo Bypass	6. Netherlands	7. East Delta, North	8. Sutter Island	9. Mokelumne/Cosumnes	10. East Delta, South	11. South Delta	12. Southwest Delta	13. Dutch Slough	
Elevation Range (ft NAVD88) Used in Analysis														
Upland (area above SLRA to Legal Delta boundary)	12+	12+	12+								10.5+	11+		
Sea Level Rise Accommodation (0 to 5 feet > MHHW)	7 to 12	7 to 12	7 to 12								5.5 to 10.5	6 to 11		
Intertidal (MLLW – MHHW)	1 to 7		3 to 7								2 to 5.5	2 to 6		
Shallow Subtidal (0 to 3 feet < MLLW)[a]	-2 to 1		0 to 3								-1 to 2	-1 to 2		
Intermediate Subtidal (3 to 6 feet < MLLW)[a]	-5 to -2		-3 to 0								-4 to -1	-4 to -1		
Deep Subtidal (deeper than 6 feet < MLLW)[a]	< -5		< -3								< -4	< -4		
Area Available to Reach Ecosystem Targets (acres)[b, c, d]														
Upland Area	19,705	TBD	31,619	53	29,512	12,017	4,438	150	5,425	1,690	85,255	3,402	39	193,306
Sea Level Rise Accommodation Area	8,482	TBD	9,717	110	16,234	10,371	10,678	550	4,905	7,227	23,351	2,451	242	94,318
Tidal Portion														
Intertidal	42,802	0	9,491	1,653	5,454	14,503	6,906	440	4,066	5,531	16,694	2,594	241	110,275
Shallow Subtidal	10,826	0	2,704	59	593	13,391	2,782	585	3,718	4,471	13,592	1,775	342	54,838
Intermediate Subtidal	491	0	1,930	20	1,625	935	2,860	862	1,492	5,737	10,047	1,576	234	27,809
Deep Subtidal	0	0	78	0	1,511	18	2,704	11	52	1,093	5,872	1,186	107	12,632
Total Area, Tidal Portion Detail	54,119	0	14,203	1,632	9,183	28,847	15,252	1,898	9,328	16,832	46,205	7,131	924	205,554
Total Area (Upland, SLR, Tidal)	82,307	0	55,537	1,793	54,929	51,235	30,368	2,599	19,658	25,749	154,811	12,984	1,205	493,175

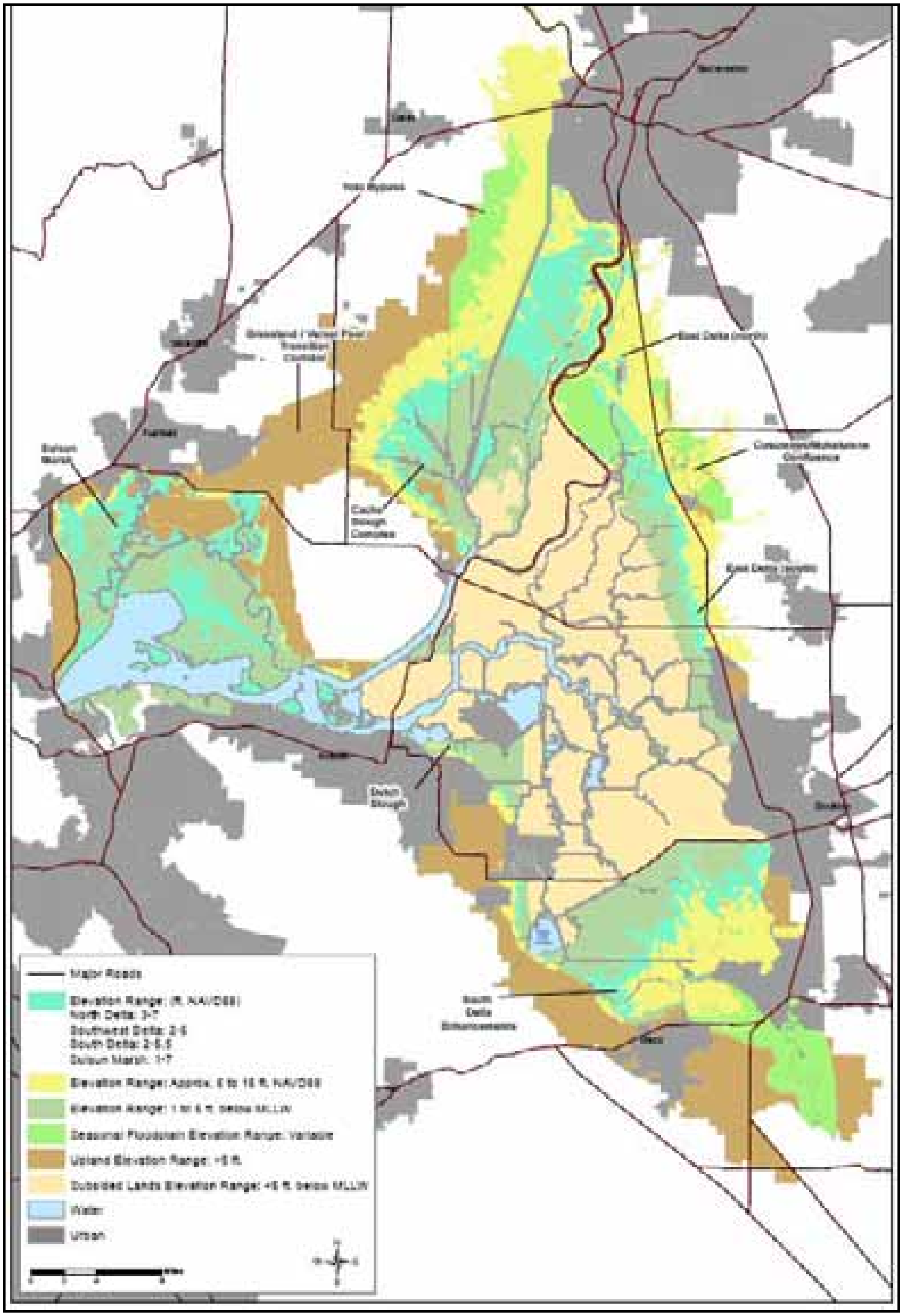
Prepared for Delta Vision by Stuart Siegel (WWR) with data from Dave Hansen (USBR), 8.20.08 • Taisa edits • Siegel edits 9.2.08.

Notes:
[a] All subtidal areas exclude existing tidal waterways; restoration opportunity areas already exclude the "deep Delta" or deeply subsided islands.
[b] From USBR GIS analysis August 2008.
[c] All results based on DWR 2007 LiDAR 2m grid except for southeastern side of South Delta and far northern end of Yolo Bypass derived from 10m USGS DEM.
[d] Based on current sea level heights.

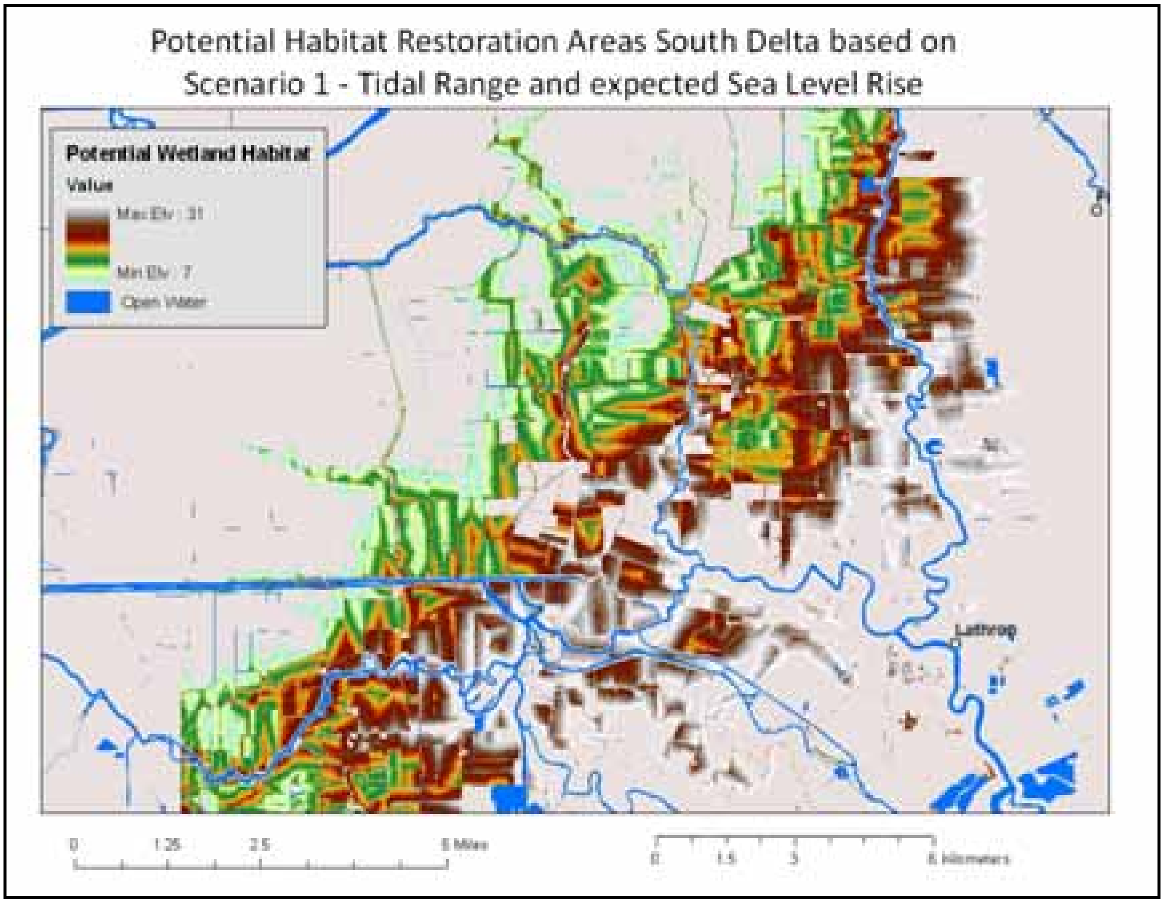
Of interest in identifying opportunities for aquatic and wetland restoration is recognizing areas in or adjacent to the Delta that will accommodate variations in sea level rise and tidal fluctuations.

This is a topic where the conceptual model is well developed but characteristics considered of importance are under continual discussion. This includes elevations of interest for particular habitat types, variations in tidal range for any particular area and estimates concerning sea level rise. The conceptual model and various digital products representing analysis of potential habitat areas frequently change particularly in the planning stage. The release of preliminary data products from analysis of potential habitat areas is often limited. Figure 5 is one such interpretation for the Delta.

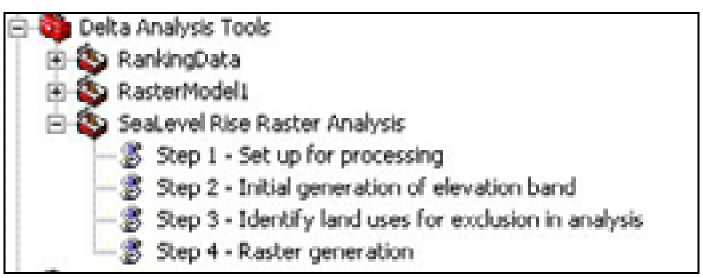
The area has a rich collection of data. Most GIS information is available via the California Spatial Library or California Digital Atlas (http://atlas.resources.ca.gov) or other publicly accessible sites. This data and the description of the conceptual model can yield other but similar results from GIS analysis depending on which factors are considered as important for a particular area.



Geoprocessing tools and scripting can assist in providing investigators concerned with Delta issues a variety of options for sharing interpretations of conceptual models. This can assist in further discussions independent of the active planning process. Figure 6 shows another variation on evaluating potential habitat restoration areas for a portion of the Delta using geoprocessing in ArcGIS.



Geoprocessing tools and scripting permit the sharing of models based on the underlying conceptual model on potential habitat areas. Figure 6 shows a geoprocessing toolbos or model for identifying potential wetland habitat restoration areas for the Delta.



This permits the independent development of digital products where preliminary data products may be restricted for release. This can help to focus discussion on the process followed to represent the model for particular areas. This can assist in identifying what GIS analysis steps are appropriate for potential habitat development for systems as complex as the California Delta.

Summary

Almost any digital geospatial dataset has an underlying conceptual model. Depending on how well the conceptual model is expressed can affect both the GIS representation of the features or characteristics of interest as well as the evaluation of the GIS data against the model. This is valuable data quality information when evaluating a digital dataset for fitness of use and application such as the completeness in the representation of the features and the validity of that representation over the entire area of interest. This is key information or metadata as described in the FGDC metadata content standards.

Conceptual models will undergo refinement or change often in an iterative manner. The representation of lands that will at some point be transferred from PacifiCorp to the states of Oregon and California can be expected to change depending on the evaluation of those lands by the respective states. This is a refinement of both the digital representation and the underlying conceptual model based on the interests of the states.

As a conceptual model evolves the type of spatial representation (point, line, polygon, and raster) may change. Information being captured for elderberry and related species has been captured as points, lines, and polygons. Attribute information is similar for these separate data types. The conceptual model will be revised based on the characteristics of interest for the investigators. This may lead to representation of the location of these species as one data type or multiple data types depending on the expected use and application of the data.

The development of geoprocessing tools and the return of scripting languages permit the documentation and sharing of data models. This can be very useful where the conceptual model is actively being revised or where the resulting digital products (datasets or display products) are preliminary or considered to be sensitive. The conceptual model or variations can be shared along with the geoprocessing methodology for independent analysis or review. This is illustrated in the conceptual model for identifying potential restoration areas of interconnected aquatic and terrestrial habitats within the California Delta. While surface elevation is recognized as a key underlying characteristic for identifying potential restoration areas for different habitat types, the complexity of tidal patterns and surface flows require adjustments for different areas. This is compounded when considering the effect of sea level rise in the system. A geoprocessing model permits the modification of parameters for different areas as needed for evaluation with other scenarios.

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