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COMMENTARY

The Role of Geographic Information Systems in American Indian Land and Water Rights Litigation

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INTRODUCTION

The following commentary was written to supply researchers, attorneys, tribal officials, and others involved in American Indian rights protection with information about a tool they can use to their advantage in securing these rights. The commentary promotes the use of geographic information systems (GIS) technology to help resolve American Indian water and land rights litigation.

In a majority of water and land rights litigation cases, the conveyance of jurisdiction hinges upon the delineation and measurement of various spatial features (i.e., trust lands, allotted land parcels, reacquired lands, timber stands, practicably irrigable acreage and arable land). Since such litigation depends on geographic or spatial data, a tool that manages, analyzes, and displays spatial data would clearly be of value. The commentary will discuss how GIS technology is well suited to provide litigation support. In addition, examples will be provided that portray how

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a GIS can be and has been used to resolve legal conflicts over rights to land and water.

GIS V. DBMS

It seems that any time a land boundary or watershed area goes into litigation, appropriate maps delineating the area of interest or conflict are unavailable. In fact, in many cases jurisdictional boundaries are expressed nongraphically. Of course, a nongraphic description of spatial limits is probably not the ideal factual evidence with which to resolve a land dispute. A graphic representation or map is likely to enhance a court's understanding, synthesis, and resolution of a land dispute, simply because it allows the court to visualize the location and extent of the conflict.

While reliance on nongraphic spatial descriptions may be inadequate for resolving spatial conflicts, sole dependence on tabular data from statistical or database management information systems (DBMS) may also be unsuitable. Although tabular data can provide support for testimony, it cannot be a substitute for boundaries drawn between spatial features. In addition, since statistical and DBMS do not utilize the geographic coordinates of spatial locations, they cannot perform any analysis that is spatial in nature.[1]

For example, once the proper data is collected and keypunched into a statistical or database management system, that system can provide information on the number of practicably irrigable acreage on Indian-owned and non-Indian-owned allotted lands. Note, however, that the DBMS does not have the ability to derive any of this information; instead it has to be obtained from another source and entered into the system. Therefore, if we wanted to know where the non-Indian-owned allotted lands were in relation to Indian-owned allotted lands, the tabular database in the DBMS could not provide an answer. The tabular database cannot respond to such a query, because it is unable to manipulate the geographic coordinates of locations.[2] It should be clear, then, that what is needed is a system that combines graphic geographic data with tabular or attribute data about the geographic data.

GEOGRAPHIC INFORMATION SYSTEMS

Such automated systems are referred to as geographic information systems. A geograph information system can be referred to generically as a "computerized system designed to store, manipulate, analyze, and display large volumes of spatial data."[3] Input to a GIS requires automated spatial data that (a) has spatial structure or topology, (b) is referenced to a common geographic coordinate system, and (c) has a tabular attribute structure associated with each graphic feature. GIS analysis and display functions include display of graphic features; association of attribute data with point, polygon, and line features; calculation of area; joining of two or more data layers; thematic representation of data; and areal classification, to name a few. Layers of spatially distributed data that may be included in a GIS database are floodplains, wetlands, soils, animal species habitats, land cover, administrative units, land ownership parcels, utility lines, and sewer lines.

Persons involved in American Indian land claims litigation should be aware of cadastral information systems, also known as Land Information Systems (LIS). Although land parcel maps might be considered part of a layer in a GIS, they are the primary layer in cadastral or land record systems. Cadastral refers to the official recording of land boundaries. As long as they are updated, cadastral maps serve as the official "legal documents describing parcel boundaries."[4] These maps of land ownership can be used to delineate current rights and boundaries, determine real estate value, record land use and development, provide data for planning and managing services and protecting customary and communal rights to land.[5] With an automated GIS, including as its layers cadastral and natural resources information, it is possible to combine seemingly disparate or limited spatial data automatically to produce a representation of spatial data that could be presented in court to enhance testimony graphically in land boundary disputes.

A definition of geographic information systems also must dispel the misconception that a GIS is just a computer system for making maps.[6] Obviously, an automated spatial database can be created to produce maps for use in court to help make a decision in litigation. However, the true power of using a GIS to create an automated spatial database is in the ability of the GIS to perform spatial operations or queries on the spatial data. For example, new spatial data layers can be derived by overlaying existing data layers; statistics about an area of interest can be produced; areas can be quantified; an inventory of locations can be performed; features or areas of interest can be pinpointed; a determination can be made of changes over time; and spatial patterning can be identified. Once the spatial operations are completed, maps and statistics can then be used to show the results.

GIS APPLICATIONS

Illustration of the role a GIS can play in American Indian land and water claims litigation can be accomplished best by describing how a GIS can provide the spatial data required to support testimony. The topics covered in this litigation that require spatial data are too numerous to include here, so discussion will be limited to the following topics:

1. Identification of change in land status
2. Resource or land inventories
3. Land valuation for land restoration and reacquisition.

Obviously, most of the spatial data required to respond to these topics is nonexistent and must be derived through the spatial modeling and spatial query abilities of the GIS.

1. *Change in Land Status*

In 1987, in land litigation between Zuni Pueblo and the United States, the author (employed by Environmental Systems Research Institute in Redlands, California) used a GIS to develop an automated spatial database identifying lands taken from the Zuni tribe. The objective of the attorneys representing the Zuni tribe was to calculate, as accurately as possible, the total acreage of the Zuni Aboriginal Area and six zones (takings), in which land was taken from the Zuni tribe between 1846 and 1939.

The extent of the taking boundaries came from the *Zuni Tribe of New Mexico v. United States Claims Court,* Docket 161-79L, decision of 27 May 1987. These nongraphic descriptions of the taking boundaries were delineated on United States Geological

Survey (USGS) 1:250,000 scale topographic maps. Next, the legally surveyed boundaries of Zuni trust lands were added to the maps. Finally, the boundary lines of the taking and trust lands were digitized into the GIS, where the area for the individual takings and trust lands could be automatically calculated and chronological maps delineating the taking and trust lands could be produced (see figure 1).

The result of entering the taking boundary lines as a layer in the GIS was that an additional 255,266 acres were identified in the Zuni Aboriginal Area over what the Zuni had originally identified. (Note that trust lands were not included in this summation.) Such a difference is significant when compensation for the takings is a monetary value paid for each acre.

The GIS was used to develop an inventory of Zuni land taken from them between 1846 and 1939. The display and query abilities of the GIS allowed the attorneys to visualize and quantify how the Zuni sovereign area had changed over time. Obviously, this example made only minimal use of the abilities of the GIS. However, the taking boundaries will continue to be utilized to establish monetary values for different types of land (i.e., timber and rangeland) within each of the chronological taking zones.

2. *Resource or Land Inventories*

In 1988, the author developed another automated spatial database that inventoried Zuni agricultural fields. The database was used to support the Zuni tribe in land damages litigation against the United States.

The Zuni agricultural field database was developed over the area of eight 1:24,000 scale USGS topographic map quadrangles on the Zuni Reservation. The data layers included lakes and reservoirs, streams, elevation contours, historic and current Zuni agricultural fields, and Zuni irrigation units.

Between 1911 and 1988, the locations of Zuni agricultural fields and irrigation units were photointerpreted from historical aerial photographs, interpreted from General Land Office surveys, and identified during a survey conducted by the Zuni Archaeology Program. Once the agricultural fields and irrigation unit locations were drafted as a manuscript map, they were automated as a single layer into the GIS. The spatial data manipulation abilities of the GIS were used to extract the agricultural fields for 1911–12,

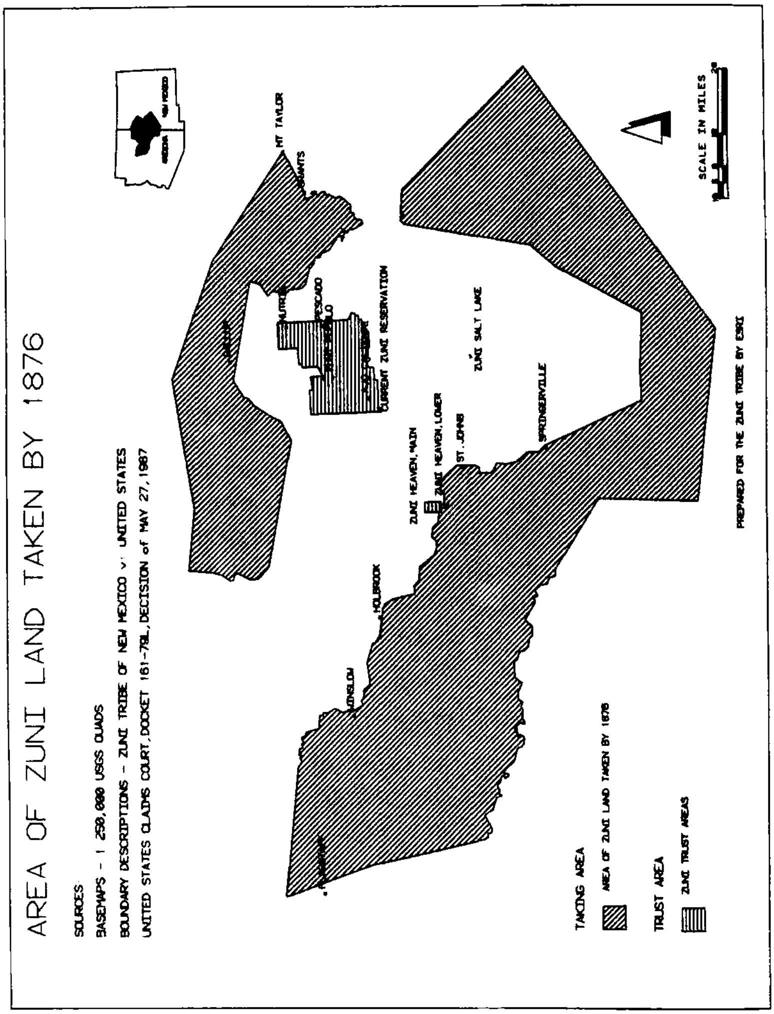

FIGURE 1. The extent of Zuni lands taken by 1876. Map prepared by Environmental Systems Research Institute for the Zuni tribe.

1934, 1954, 1968, and 1987–88 from the agricultural field layer. The fields for each date were plotted as maps, and area calculation reports were generated for each field number by date.

The agricultural field, elevation contours, and hydrology layers were used to illustrate quantitatively the loss of agricultural land due to erosion on the Zuni Indian Reservation between 1911 and 1988. The map plots were used to support testimony before a congressional hearing.

It should be noted that it is expensive to develop specialized automated spatial databases such as the Zuni agricultural field database. In fact, it would not have been appropriate to develop the Zuni agricultural field database if it would have been used only once to illustrate the extent of agricultural land loss. Fortunately, there are many future uses for the database. The most immediate use will be with the elevation, hydrologic, and agricultural field data layers in an effort to monitor and rehabilitate the reservation's eroded agricultural lands.[7] The yet-to-be developed model for sustainable development is made possible by a legislative settlement that resulted in the Zuni Land Conservation Act of 1990.

Another area of American Indian land and water rights litigation, in which GIS technology has not yet been implemented, is water rights litigation. In previous Indian water rights adjudication cases (e.g., *Wind River Indian Reservation v. the state of Wyoming*), aerial photos were used to identify and inventory lands where irrigation was practical and practiced. The acreage of irrigated lands (measured manually from aerial photos with a planimeter) was used to help establish a measure of the reservation's water rights. A review of the historic serial photos was used to supplement the most current aerial photos in an effort to identify whether acreage is capable of being irrigated.

In many water rights adjudication cases, hundreds of aerial photos have to be photointerpreted. While this may not be so difficult, the task of keeping track of irrigated agricultural fields shown in hundreds of aerial photos is indeed overwhelming. Such a project might be manageable if the irrigated fields were mapped and entered into a GIS.

In some cases, it may be necessary to review aerial photos from different dates to help determine water requirements. The fields delineated on these aerial photos would be inserted in the GIS as additional layers, according to the photo dates. The cartographic modeling and spatial query abilities of the GIS can then be used to determine the difference in irrigation practices between time frames. Such an operation would be difficult to carry out without a GIS.

Another important component of a GIS in water rights adjudication would be the addition of a land ownership parcel layer. Once the irrigated lands were overlaid with the land ownership parcels, it would be possible to identify the owners of the irrigated lands and to distinguish between Indian-owned and non-Indian-owned allotted lands that are being irrigated.

The advantage of using the GIS to organize the irrigated field data is that in water rights adjudication cases, it is probable that the database will be used over a long period of time and accessed by many parties.[8] Note that the *Wind River Reservation v. the state of Wyoming* water rights adjudication case lasted for twelve years.[9] A well-organized automated spatial database containing irrigation lands would be almost invaluable in terms of providing rapid access to data and permitting easy on-line updates.

Because of the expense that is incurred in creating such a database, development of a one-use-only database should be avoided. Attention should be given to designing databases that will be useful beyond the scope of litigation. Once litigation is completed, the automated database (e.g., irrigated lands and land ownership parcels) should be turned over to the tribe to be used for their own purposes.

3. *Land Valuation for Land Restoration and Reacquisition*

The Role of a GIS in Land Valuation

None of the land claims cases heard between 1946 and 1976 by the Indian Claims Commission (ICC) restored land to a tribe. This issue has not gone completely unnoticed, particularly by the tribes, who would have preferred and are still seeking land restoration. For example, Sioux claims that were filed in 1923 and have not yet been settled seek restoration of the Black Hills.

Since many reservations are tracts of land "within a vast zone of public domain that continues to support grazing, lumbering, mining, farming, and recreation,"[10] any restoration of land would have to come from the public domain as well as from private properties. Any change in the status of public domain or private property requires detailed and costly evaluation and impact assessment studies. The same process would have to be undertaken if a tribe such as the Zuni were seeking compensation for taken lands.

The assessment process, also known as land valuation, could be performed with the help of a digital spatial database in a GIS. The database could consist of (1) graphic files representing the locations of integral resources and (2) linked tabular files containing statistical information on resource types. The result would be graphic and tabular data files that are capable of being queried to resolve litigation.

The valuation database might include land cover/land use (e.g., forest characteristics and their potential, rangeland characteristics and their potential, agricultural lands and their potential), locations of mineral deposits, land ownership boundaries, and jurisdictional zones. The tabular files associated with the spatial data would have to include parcel ownership, prior parcel ownership, mineral rights, population density, and finally the most complex variable, an actual or derived monetary value assigned to each land cover/land use.

It is in the derivation of monetary value for land cover/land use that a GIS would truly be invaluable, because monetary value often depends on the co-occurrence of two or more variables (e.g., agricultural land within a certain range of slope), the distance from one resource to another, or the distance from a resource to a feature (e.g., the proximity of prime timber stands to a railroad or a sawmill). It would seem difficult to assign equitable monetary values to types of resources without taking into consideration the spatial relationship of one resource to another. Therefore, derivation of spatial information, essential for determining monetary values of resources in the valuation process, can best be accomplished within the framework of a GIS, where spatial operations such as overlaying one layer with another to determine proximity are possible.

The Role of a GIS in Land Restoration Litigation

The specialized database developed during the land valuation process can also be used to the advantage of both the plaintiff and the defendant during litigation. Basically, the role of the GIS is to provide an unbiased spatial database that can be queried by both parties. For example, a plaintiff tribe might be able to demonstrate how an addition of prime grazing land could augment the tribe's economy. Supporting arguments could be made by overlaying the boundary of the land in question with rangeland productivity zones. Using the attribute files in the GIS, the tribe could calculate the number of acres in each productivity zone and then could estimate the number of cattle the acreage would support. On the other hand, a state or federal agency might be able to provide, for its defense, the number of acres of prime grazing land that would be removed, along with an estimate of lost income from leasing. The defendant might also wish to use the GIS to calculate the amount and value of agricultural land that would be removed by land restoration to a tribe, as well as to calculate the number of persons who would have to relocate (figures 2 and 3). Various pieces or combinations of the data could be used to make projections about the effect of land restoration on local economies and real estate. Clearly, the capability to provide such information as testimony during litigation increases the ability of the court to make its decision. Thus, a GIS is performing its intended function, which is to support decision making.

A GIS containing a spatial database, accessible to both the plaintiff and the defendant, can play a critical role in land claims and land restoration negotiations. An upcoming land claims case in which such a spatial database would be useful involves the Oneida Indian Nation and the state of New York. The Oneida Nation, composed of three tribes—the Oneida tribe of Wisconsin, the Oneida tribe of New York, and the Oneida of the Thames band—is claiming "title to and the right to possess approximately six million acres of land in central New York."[11] The area being claimed covers approximately a fifty-mile-wide strip of the state, stretching from Canada to Pennsylvania. The claim is the result of the Oneida Nation's sale of land to New York in 1785 and 1788, prior to the implementation of the United States Constitution, while the Articles of Confederation were in effect.

The Oneida contend that a settlement of their claim should give them possession of the land, fair rental value and interest for the period of dispossession, and claim to the tolls collected by the New York State Thruway.[12] In 1978, the New York Oneida filed suit (78-CV-104) against the state of New York, the State Thruway Authority, and other state agencies. In 1979, the Thames

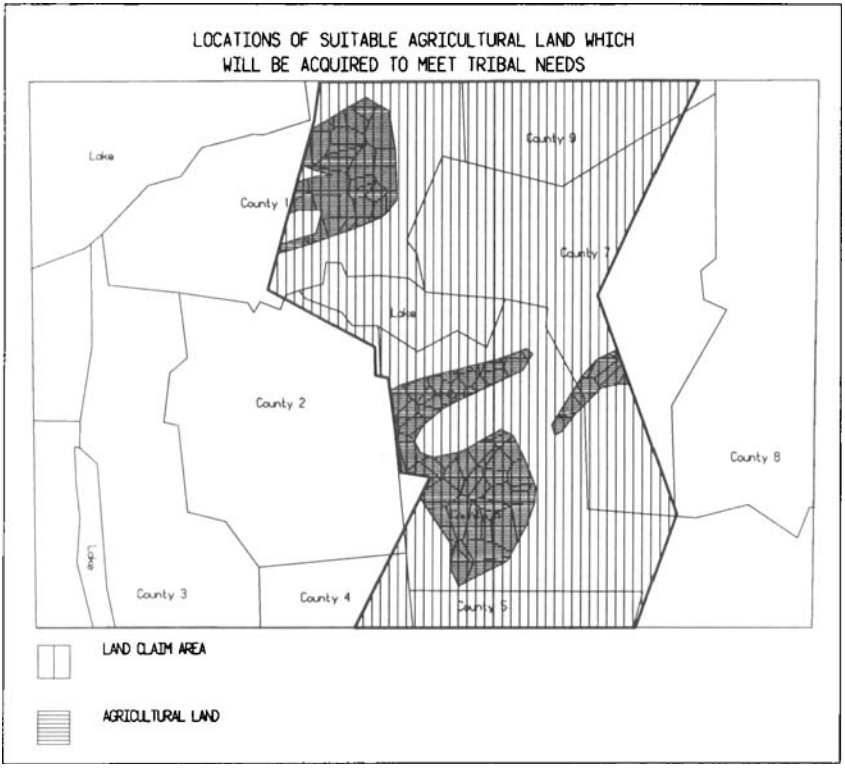

FIGURE 2. The darkly shaded areas identify suitable agricultural lands meeting specific criteria within a land claim area.

band of Oneida and the Wisconsin band of Oneida filed suit (79-CV-798) against the state of New York, state agencies, counties and municipalities, and individual land owners within the claim area. It was estimated by the court that approximately 60,000 individuals, businesses, and government entities comprise the defendant class.

The intent of the Oneida land claims is that

1. settlement would provide for a substantial land base in New York State;

2. for each acre that is not restored, the Oneida will be compensated based on full market value, as well as rental fees from those occupying the land.[13]

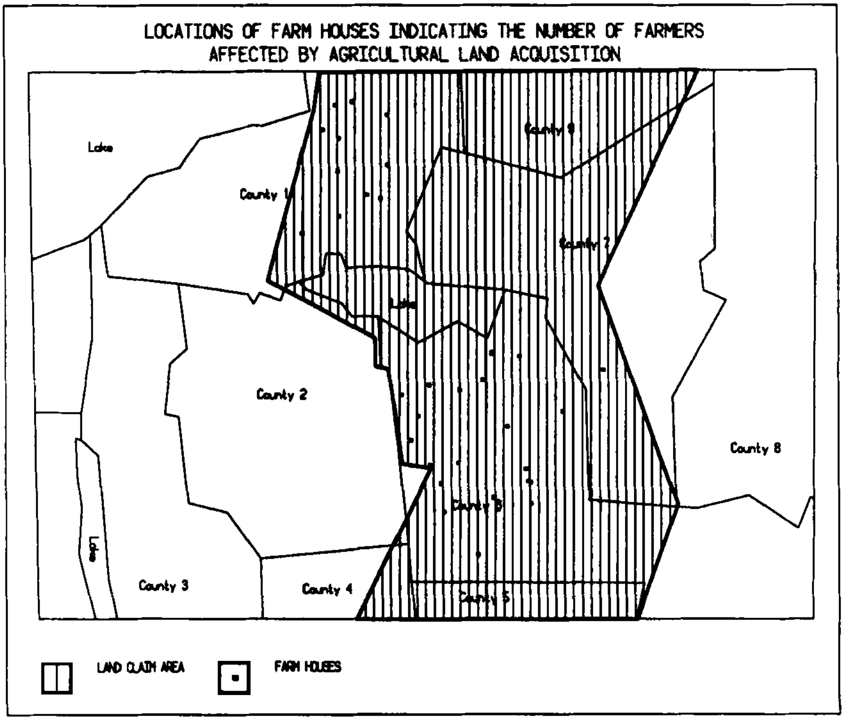

FIGURE 3. Plotting the locations of farmsteads is one way of graphically identifying the number of farmers within a claim area.

Quite obviously a real need exists for a spatial database. Such a database should contain the following layers: an accurately delineated boundary of the claim area, a soils layer, a hydrology layer, a land ownership layer, a wetlands layer, a land cover/land use layer (including agricultural lands and timber stands), census tracts, a layer identifying the locations of municipalities and settlements, and a layer identifying wildlife ranges. Most importantly, the land cover/land use layers should contain a monetary value attribute for each type of land in the layer. The monetary values may be available from existing records; however, it is more likely that the monetary value will have to be derived with the help of the spatial operations available in the GIS.

Used alone or in combination, the data layers could accurately delineate the area in question, estimate the exact number of acres, describe and quantify natural resources, and identify the number of people and municipalities within that area. Of course, as has been stressed throughout this commentary, the information could be formatted or generated to solve problems or answer questions during litigation. For example, a simple thematic map of the prime timber stands in the claim area might help support a decision by either the plaintiff or the defendant. As it stands now, no one knows the distribution, quantity, or value of any resource (much less prime timber stands) in the claim area, so testimony delineating and identifying resources would only be judgmental. However, if a specialized spatial database were developed and installed in a GIS, the database could effectively support testimony documenting the area in question. Besides being instrumental in litigation, the database developed for the land claims would be beneficial in resolving future conflict if a decision were made in favor of the Oneida.

So that both the defendant and the plaintiff will be prepared for any outcome, a spatial database documenting the area in question must be developed. In one scenario, the defendants may want to negotiate for alternatives to relocation, such as a monetary settlement or a transfer of land that would not require relocation of people. Of course, prior to this avenue, a detailed inventory of existing land and its status would have to be conducted. As can be seen, a real need exists for identifying and delineating the types and percentages of land in the claim area. The Oneida would also have to know what types and quantities of land are within the claim area. In fact, the Oneida leaders already have polled their members as to what types of land the nation should acquire (i.e., agricultural, commercial, or forest) if it were to win the case and were given the opportunity to establish a large land base in New York State. Obviously, a specialized spatial database can be well utilized in the Oneida planning efforts.

Land Reacquisition

Tribes that supplement their land base through land purchase must also go through a land evaluation and impact assessment process. For example, the ninety-nine-year leases that the Seneca Nation holds over the city of Salamanca, New York will expire shortly. There are bills before Congress that would pay the

Seneca $35 million in exchange for renewing the leases. The private land owners are afraid the Seneca will acquire additional lands with the money, thus depriving the local governments of the tax revenues for those lands. In this case, a GIS with a cadastral layer containing property tax information would be invaluable to the local governments in negotiating this conflict with the Seneca.

The same GIS should include as a layer the aboriginal boundary of the Seneca Nation, because the bill in Congress specifies that the tribe can purchase land only within the bounds of its aboriginal territory. Additional data layers containing agricultural, forested, and wetlands locations within the bounds of the Seneca aboriginal territory would greatly help the Seneca in their land selection process.

PROBLEMS FACING THE IMPLEMENTATION OF A GIS IN LAND AND WATER RIGHTS LITIGATION

After careful consideration of this commentary, the reader should understand that the availability of spatial data in land claims areas is limited. Basically, the problem is that there are no existing or continuous data for most resources across claim areas. The problem of not having existing or continuous data is significant, and it has to do with the expense incurred to develop a new, continuous database.

At the present time, costs are high for developing any of the databases described in the commentary. This discussion is not intended to deter the reader, only to make the reader aware of the expense. Where budget constraints preclude the implementation of a GIS in land and water rights litigation, other tools may be sought for completing the same tasks.

CONCLUSION

This commentary is intended primarily to inform attorneys and others involved in American Indian land and water rights litigation about the uses of geographic information systems to support testimony in litigation. It should be apparent from the examples that the ability of the GIS to store and manipulate spatial data is unsurpassed. If designed and implemented properly, the GIS can provide accurate spatial data that avoid approximations and inaccuracies. Such data permit more qualified and precise testimony, which, ultimately, will enhance the decision-making abilities of the court.

Although this commentary concentrates on the use of a GIS in litigation, a GIS can also play a role in the decision-making process in negotiations. For example, the Wisconsin Chippewa tribe, wishing to exercise its treaty rights on ceded lands, has met with opposition from the state of Wisconsin. Recently, attempts to resolve these conflicts in litigation have failed, and they will have to be resolved through negotiation. In this situation it is necessary to develop appropriate automated spatial data inventories of natural resources that are guaranteed by Chippewa treaties. The unique analytical abilities of the GIS can be used here to model the effects of utilization of off-reservation resources by the Chippewa. The inventory data and models can then be employed by both sides to make well-informed decisions in a negotiated settlement. In any case, whether it is used in litigation or negotiation, a GIS is a tool that can serve the best interests of the tribes whose rights are being represented and protected.

Besides being a useful tool for the protection of resources, the GIS is also helpful in the management of tribal resources. In order to aid in protecting and managing resources successfully, a GIS must go through an evolutionary process.[14] In the upcoming Oneida litigation, for example, a GIS will first be used to inventory resources in the land claims area. Second, after the inventory is completed, the GIS will be used in analyzing the inventory data in order to derive new information in support of litigation (e.g., the most suitable agricultural lands will be identified using the spatial overlay abilities of the GIS). Third, upon the completion of litigation, the GIS will be used to manage the newly acquired land or resources. It is important to note that the GIS can progress through this evolution only if it is based on a solid conceptual and database design.

It is important that the spatial databases developed for litigation continue to be of use to tribes after litigation. If fact, the primary role of the GIS should be for resource management decision-making purposes. Ideally, automated natural resource data already should exist in a format that can readily support litigation. However, it is unlikely that this would often be the case. In most instances, the need for spatial data to support litigation is the catalyst for developing an automated spatial database.

When money is spent to hire GIS experts and develop spatial data to support litigation, the GIS should not be designed nor data collected or compiled without input from tribal resource managers. These managers should be able to ensure that the data can be used for other purposes related to managing tribal resources. Although the tribal resource managers may not at first understand the abilities of a GIS, GIS experts can interact with and educate them in developing a practical database that can be used to manage resources and solve problems.[15]

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