AN ABSTRACT OF THE DISSERTATION OF

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Water right marketing and transfers represent a resource reallocation strategy that has received considerable attention in the American West owing to nearly full appropriation of water in the region. Several western states permit transfers between different uses and places of use thus allowing water to move to higher-value economic activities. While facilitating economic development, reallocation can produce adverse economic, sociocultural, and/or environmental third-party effects.

The purpose of this study was to describe transfer characteristics and conformity to a conceptual model, identify spatiotemporal transfer patterns, and determine the degree of association of sociocultural factors with transfer activity in New Mexico's Rio Grande basin (1975-1995). Transfer data from the Office of the State Engineer were merged with 1990 Census data in a geographic information system and stratified into sub-basins. Analytical methods included: comparison of the data with a conceptual model of transfer types, Peuquet's Spatiotemporal Triad

Framework to identify patterns on the landscape, and multivariate statistical modeling techniques to identify significant sociocultural variables.

The research revealed that transfers primarily involve irrigation-to-higher value use shifts as the conceptual model proposed. Market-based transfers are critically important to expanding municipal water supplies in the study area. Transfer activity was responsible for the retirement of 2,096 acres of farmland in the Middle sub-basin, was intensely clustered in the Upper and Middle sub-basins, and particularly so for growing communities within the former. The spatiotemporal pattern of transfer activity in these communities suggests the operation of a distance-decay function related to urban expansion. Multivariate regression modeling showed variables related to rurality, farming, income, race, and development to be significant variables for the study area and Middle sub-basin. Significant variables in the Upper sub-basin were related to recreational residential development. No important associations were found to occur in the Lower sub-basin.

The study suggests that economic, environmental, and socio-cultural third-party effects of transfer activity are more likely to be felt in the more populous and urbanized Middle sub-basin. Water marketing has implications for agricultural production and land retention in this sub-basin. Third-party effects in Upper sub-basin are more likely to be confined to urban places and their immediate hinterlands.

Transfers of Water Rights in New Mexico's Rio Grande Basin: Spatiotemporal and Sociocultural Patterns

By

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APPROVED:

Major Professor, representing Geography

Chair of Department of Geosciences

Dean of Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

David D. Shively, Author

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LIST OF ABBREVIATIONS AND ACRONYMS

ACPPU	Application for Change in Place and/or Purpose of Use
AF (af)	Acre-Feet
AFCU (afcu)	Acre-Feet of Consumptive Use
AMA	Active Management Area
BARA	Bureau of Applied Research in Anthropology (University of Arizona)
BNA	Block Numbering Area (U.S. Bureau of the Census)
BU	Beneficial Use
BUREC	Bureau of Reclamation
CAP	Central Arizona Project
EBID	Elephant Butte Irrigation District (New Mexico)
GIS	Geographic Information System
IBWC/CILA	International Boundary and Water Commision/La Comisión Internacional de Límites y Aguas
IPP	Intermountain Power Project
LRG	Lower Rio Grande (Sub-basin)
MRG	Middle Rio Grande (Sub-basin)
MRGCD	Middle Rio Grande Conservancy District (New Mexico)
MWD	Metropolitan Water District (California)
POD	Point of Diversion
POU	Place of Use

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

SEO	State Engineer Office (New Mexico)
URG	Upper Rio Grande (Sub-basin)
USPLS	U.S. Public Land Survey

CASES CITED

Albuquerque v. *Reynolds*, 71 *N.M.* 368 (1962).

Arizona v. *California*, 373 *U.S.* 546 (1963).

Arizona v. *California*, 460 *U.S.* 605 (1983).

El Paso v. *Reynolds*, Civil No. 80-730-HB, D.N.M. (1983).

Sleeper v. *Ensenada Land & Water Ass'n.*, 107 N.M. 494, 760 P. 2d 787 (Ct. App. 1988).

Sporhase v. *Nebraska* ex rel. *Douglas*, 458 *U.S.* 941 (1982).

Templeton v. *Pecos Valley Artesian Conservancy District*, 65 *N.M.* 59 (1958).

Texas v. *New Mexico*, *U.S.*, No. 65, Original (1975).

United States v. *New Mexico*, 438 *U.S.* 696 (1978).

Winters v. *United States*, 207 *U.S.* 564 (1908).

TRANSFERS OF WATER RIGHTS IN NEW MEXICO'S RIO GRANDE BASIN: SPATIOTEMPORAL AND SOCIOCULTURAL PATTERNS

1. INTRODUCTION

Water marketing, the buying and selling of established rights to water, has received considerable attention as a method by which scarce or limited water resources may be reallocated from lower- to higher-value economic uses, especially in the western United States. As such, the use of a market-mechanism for water resources reallocation represents a strategic response to a number of separate but ultimately interrelated issues or phenomena which have come to bear on the American West (the "West") as a whole, and upon the Southwest in particular. These include: nearly full or complete appropriation of surface and ground water resources, changing attitudes about environmental quality, rapidly increasing population growth and economic development, climate change and drought uncertainty, unresolved claims for federally reserved water rights, and interstate and international sharing of limited water resources.

Water marketing can be conceptualized as a continuum of market-oriented mechanisms which have varying degrees of legal, temporal, and spatial permanence, and can occur alongside non-market transfers. Given the usufruct nature of western water rights, however, and the legal, economic, and institutional principles that have until recently characterized water resources development in the West, the utilization of market principles to effect resource reallocation can be seen as paradoxical from several standpoints. Nonetheless, water marketing represents just one element of an emerging resource management framework that, in addition to economic development, has as its chief concerns: efficiency in water use, flexibility in approach and practice, and environmental quality at all spatial scales. This framework can be seen as representing a departure, or shift, from the dominant management approach that has tended to stress resource appropriation at the expense of the environment and the nation's taxpayers, and instead has as its focus a more comprehensive approach to resource management than the historic institutional mind-set of resource development allowed (Brown and Ingram 1987; U.S. Geological Survey 1996a; Weatherford 1982; Weatherford and Brown 1986). This emergent framework is developing of necessity and in response to diverse social demands and changing preferences for water related goods and services in this vast region.

It is perhaps ironic that market-oriented reallocative mechanisms have raised concerns over issues that they were intended to redress. The increasing emphasis on the reallocation of water, especially that which has previously been used for agricultural purposes, through the market mechanism to higher-value uses has raised questions and concerns within a number of different forums over potential "third-party effects." Third-party effects, or the negative externalities associated with economic activity, can be either economic, social, cultural, and/or environmental in character and can occur at spatial and temporal scales that vary considerably in extent. Underlying the issue of potential third-party effects of water resources reallocation are the issues of equity, especially as related to socioeconomic opportunity, and of landuse change and its implications for the broader cultural landscapes and economic systems in which we function.

1.1 Purpose of the Study

It is with such third-party effects of water marketing and simple one-party transfers of water rights that this study is primarily concerned. Its purpose is to document and describe the characteristics of water right transfers, to identify spatiotemporal patterns of transfer activity on the sociocultural landscape, and to determine the degree to which sociocultural, development, and other factors are associated with transfer activity. The information produced by such an investigation can demonstrate that water right transfers are more or less likely to be associated with geographic areas having an observable set of socioeconomic and/or other conditions, and can identify those areas to which attention should be directed to more closely examine third-party effects.

Given that water marketing and transfer activity occur in a number of western states, that they are highly conditioned by differing state institutions and polices and are thus sensitive to context, and that they assume a variety of forms, an investigation of this nature must by necessity focus on transfer activity within a clearly delineated political and/or water resources management unit (i.e., a particular state and/or subordinate water resources region) in order to control for confounding effects related to context. A narrowing of the spatial scope of such a study further facilitates the identification of the appropriate level of spatial resolution at which the relationships between variables can be meaningfully explored and interpreted.

Specifically, the study examines the spatiotemporal pattern of water right transfers executed within New Mexico's Rio Grande basin during the period 1975-1995 in the context of local and regional patterns of ethnicity, socioeconomic well-being, and regional development. The significance of the market mechanism within the basin's sub-units is also explored through the comparison of market and non-market-based transfers. This study integrates observational data acquired from a comprehensive census of water right transfer applications submitted to the office of the New Mexico State Engineer and census of population data from the U.S. Bureau of the Census into a geographic information system (GIS).

Multivariate statistical analyses utilizing regression and correlation techniques are employed to identify any socioeconomic factors or variables (e.g., population density, rurality, ethnicity, employment, income, poverty, housing and development) that help to explain spatiotemporal variability in transfer activity. Spatial analysis and modeling permit the relationships between variables to be explored objectively and without the bias that might underlie a more descriptive approach to the topic. Furthermore, a properly designed and executed spatial investigation allows for replication and for the communication and comparison of results from similar studies conducted in different locations or regions.

While the inferences that can be drawn from observational and proxy data are necessarily limited, the identification of significant independent factors or variables that are associated with those areas from which water rights have been transferred helps to ascertain the existence and/or relative significance of heretofore hypothetical third-party effects. In many cases, however, third-party effects might be difficult to measure and quantify given their basis in the perceptions of affected groups or parties. It is in such cases that more qualitative and descriptive data and information can prove useful in at least identifying the existence of perceived and perhaps actual impacts, especially those which are sociocultural in nature. It is also conceivable that perceived impacts might be identified simply by omission (i.e., by a lack of water market activity in discrete areas). The study is substantive also in that its findings may be extended, by implication, to other areas of the West that are either utilizing or considering the utilization of the transfer and/or market mechanism to reallocate limited water resources.

By relying upon techniques of spatial analysis, this study is intended to complement related geographic research (and that from other disciplines) in the areas of water resources management and policy, landuse practices and issues, economic development, and culture. The location specific nature of appropriative water rights as defined in the western United States predisposes these for spatial research, and the approach outlined here will represent a unique contribution in geographic water resources research. Lastly, the attention and consideration that are devoted to potential broader implications of water marketing for these topics are intended to facilitate both the communication of this study's results to a broader audience, and the identification of related questions that merit additional research.

1.2 Organization of the Dissertation

In order to better consider water marketing and water resources reallocation in the context of the West, Chapter 2 is devoted to a discussion of issues bearing on water resources management and policy in this region. A review of the relevant literature concerned with third-party effects of water marketing is provided in Chapter 3 of this work; it addresses the research questions posed above, and further narrows the scope of the investigation. Chapter 4 provides a description of the study region including its physical geography, history of water resources development, community values regarding natural resources, and current natural resource management approaches.

The general methods employed in this investigation, and those issues which are related to research design, are discussed in Chapter 5. Chapter 6 is devoted to the presentation of the analyses employed to answer the general and specific research questions, and their results. Lastly, a summary and conclusion provided in Chapter 7 examines the study's results, the inferences that may be based upon them, and their broader implications for water resources, landuse, and economic and social policy in the West.

2. ISSUES AFFECTING WATER RESOURCES MANAGEMENT IN THE WEST

Traditional approaches to water resources management in the West are today being challenged by a host of issues and constraints that concern resource availability, multiple use of natural resources, environmental quality, and even the fate of threatened and endangered species. In exploring these issues and constraints, this chapter places Western water resources reallocation in a broader regional context.

2.1 Constraints on Water Resources Development

There is consensus among water resource managers that the vast majority of the West's surface and ground water resources are fully appropriated. Full appropriation has been a fact of life in the Southwest for decades (Weatherford and Brown 1986), and is now being recognized as an obstacle to continued economic growth and development even in such well-watered regions as the Puget Lowland of Washington state (Rosapepe 1996). Opportunities to expand the resource base through further development of economically and environmentally costly large-scale storage facilities and distribution systems are few owing to a general lack of suitable sites (Reisner 1993; Zeilig 1988) and increasing public concern over environmental quality.

2.1.1 Environmental Constraints

That environmental constraints carry much more weight today than they ever had in the past is evidenced by the failures to obtain authorization and/or funding for the Two Forks Dam project near Denver, Colorado, and the continued and contentious negotiations over the Animas-La Plata inter-basin diversion project in southern Colorado[1] (Clark 1987; Marston 1996). This inability to site and/or fund large projects is also related, in part, to the new-federalist policies promulgated by the Reagan Administrations and their successors which increased the financial burden on the states for such projects, as is the interest in the market as a reallocative institution (Clark 1987; Muckleston 1990).

2.1.2 Population and Development Pressures

The West has experienced considerable growth in population and development over the last several decades, especially within the Sunbelt and Pacific Rim states, and the changes that have already begun to be wrought in its landscapes, cultures, economies, and institutions are significant (Ballard and Gunn 1983; Colby 1988; Cronon et al. 1992; Malone and Etulain 1989; Roberts and Butler 1983). The region is today characterized by post-industrial economic development and activity, urban and suburban expansion, and changing perceptions of the appropriate uses of natural resources. It has become clear that the relentless

[1] The U.S. House of Representatives voted 221-200 to cut funding for this last Colorado Basin project in 1996, but the U.S. Senate later voted to include funding (Marston 1996).

westward (and more recently southward) shift in the United States' geographic center of population that has been observed since the 1790 Census of Population (Bryant 1991) will undoubtedly continue for some time even though migration flows to the region have been shown to be more unstable in recent years than had previously been thought (Manson and Groop 1996). The availability of water in sufficient quantity and quality has been and continues to be seen by many as the factor that is likely to prove limiting to continued growth in the West. These parties predict that future competition for limited water resources will only intensify in the future (Ballard and Gunn 1983; Cobourn et al. 1992; El-Ashry and Gibbons 1986; Getches and Meyers 1986; Kneese and Brown 1981; Thomas 1981).

Energy resources development has been a factor of considerable importance with respect to the growth and economic development of the Sunbelt and West in general, and though its relative significance has declined in recent decades due to the dynamics of the international market for oil, the potential still exists for expansions in domestic energy resources production and exploration/development in the West - particularly in the case of shocks to the international oil market (Kneese and Bonem 1986). While production from oil and coal fields will not likely create large new demands on western water, renewed interest in oil-shale processing and transport via slurry pipelines, coal gasification, and expansion of hydroelectric energy generating capacity can only promote further conflict over water resources (Kneese and Brown 1981).

Competing demands for water in the West can be highly visible and contentious. Examples of note include: standing offers by the City of Albuquerque, New Mexico, to purchase water rights at $1000 per acre-foot for transfer to municipal use (Nunn 1987:193); the public outcry against ultimately approved applications submitted to the New Mexico State Engineer to pump up to 6 million gallons (18.41 acre-feet) per day from a fully appropriated groundwater basin for computer micro-chip production by the Intel Corporation (Selcraig 1994); and the unresolved claims (i.e., applications for transfer) on 200,000 acre-feet (af) of rural Nevada water rights by the Southern Nevada Water Authority, the agency charged with providing water to the booming services-oriented City of Las Vegas (Flora et al. 1992; Christensen 1994). The Authority is now aggressively attempting to capture a larger share of the compact-apportioned Lower Colorado River to meet its future water demands, and in doing so is furthering the cause of flexibility in water resources management in a traditionally inflexible system (Christensen 1994). These examples make clear that the water demands of a still growing and thirsty West will increasingly be met through the retirement and reallocation of existing water rights, and that these demands will not be easily satisfied.

2.1.3 Uncertainty Regarding Climatic Change

As significant as the concerns relating to the availability of water for future growth and development in the West are, they are made more pressing when climate change, drought, and the relationships between the two are considered.

Even under static water-use conditions, climate change that results in long-term negative changes in water yields can produce both domestic and international impacts (political, economic, social, environmental, institutional) that resource managers, planners, and policy makers are forced to address (Changnon 1987; Chen et al. 1983; Clyde 1986; Kneese and Bonem 1986). Such efforts, however, are likely to be hampered by the fact that climate change and impacts research is still in a developmental phase, as is the science of modeling the hydrologic impacts of climate change (Changnon 1987; Commission on Geosciences, Environment, and Resources 1991). Furthermore, prediction of impacts associated with climatically induced hydrologic change is likely to prove equally difficult. The solutions proposed to deal with future uncertainty in climate and water resource availability are essentially the same, however, and entail efficiency in water use, conservation, and flexibility in resources management (Commission on Geosciences, Environment, and Resources 1991).

2.1.4 Federal Reserved Water Rights

The nebulous nature of unclaimed and unquantified "federal reserved water rights" that pertain to lands reserved by the federal government, especially those reserved for the purposes of establishing Indian reservations, has introduced further uncertainty over the availability of water supplies for future growth in the West. The landmark U.S. Supreme Court decision in *Winters* v. *United States* (1908) established that federally created Indian reservations have attached to them "reserved" water rights sufficient in quantity to meet the purposes of their inhabitants, and that these water rights have priorities that date from their establishment (Matthews 1984). Such Winters rights are thus generally senior to other established water rights in the West given that many reservations were established prior to large-scale settlement by Euro-Americans, and they cannot be lost through non-use (i.e., are not subject to the abandonment or forfeiture provisions that apply to other appropriators under most state water codes).

The uncertainty with regard to reserved or Winters rights stems involves the potential magnitude of unclaimed Indian rights. Because the scope of the Winters Doctrine was further clarified by the U.S. Supreme Court in two decisions, *Arizona* v. *California* (1963)[2] and *Arizona* v. *California* (1983), to allot Indian reservations reserved water rights sufficient to serve all of their irrigable lands (Matthews 1984), the magnitude of Indian water right claims can be very large indeed. This fact is particularly troublesome in river basins that have not yet been adjudicated (i.e., scrutinized for the legitimacy of claimed and/or disputed water rights). And it has been noted that even in the case of the Colorado basin where some tribes have traded away future claims on water and/or rights to priority in use in return for federal assistance in reclamation, the actualization of remaining reserved rights could place severe pressures on existing and future non-Indian uses, and ultimately

[2] The main issue dealt with by the court in this case concerned conflicting interpretations of the Boulder Canyon Project Act (1928) and the Colorado River Compact which was, in effect, authorized as a rider to the act. The decision settled the issue of division of the Lower Basin States' apportionment between Arizona and California, and paved the way for congressional approval of the Central Arizona Project (Clark 1987; Hundley 1986).

on other basins as the Southwest grows thirstier (Getches and Meyers 1986; Marston 1996).

The label that has been attached to the outcome of the *Winters* decision, "the Winters Doctrine," indeed signifies the impact of this case for western water law and water resources management in the West. Winters rights differ from other federal reserved water rights, however, with respect to their relative size and the types of uses to which they may be devoted. Though federal reserved water rights can also be asserted and/or established on other federally owned and managed lands (e.g., national forest lands and wilderness areas, national parks, and conceivably land areas managed by the Bureau of Land Management), uncertainties regarding the potential magnitude and applications of such rights were effectively laid to rest by the U.S. Supreme Court in *United States* v. *New Mexico* (1978). The court held in this case that the U.S. Forest Service may not utilize as a precept the Organic Administration Act of 1897 (16 U.S.C. §471, 1974) to assert reserved rights for the maintenance of minimum streamflow levels in the Mimbres River on the Gila National Forest, and that federal agencies are in effect bound by the water laws enacted by the states (Clark 1987; Matthews 1984).

2.1.5 Interstate and International Sharing of Water Resources

Interstate and international sharing of water represents another major issue that bears on the limited water resources of the West. Interstate compact agreements that apportion water between co-basin states have been established in a number of major river basins (e.g., the Upper and Lower Colorado Rivers, the Rio Grande, Pecos, Missouri, and Arkansas-White-Red). While compact agreements have the function of providing stability and certainty with regard to competing claims to shared water, some instability remains as states or other entities either struggle to conform to rules for apportionment, to change these rules, or seek to broaden their interpretation.

Examples of the former are provided by southern California, and by the *Texas* v. *New Mexico* (1975) suit over the terms of the Pecos River Compact (1948). In the case of southern California, the Metropolitan Water District (MWD) serving the large urbanized South Coast basin (which includes the Los Angeles and San Diego Metropolitan Areas) lost a historical source of supply as Arizona asserted its claim on the Central Arizona Project (CAP) water guaranteed to it by the Boulder Canyon Project Act and Colorado River Compact (El-Ashry and Gibbons 1986; Hundley 1986). This loss has been important in the context of water marketing issues in California; the MWD has been forced to look elsewhere for sources of supply.

Texas v. *New Mexico* was concerned with the issue of insufficient delivery of a downstream state's (Texas) share of water, and the manner and amounts to be credited (Bohnhoff 1989; DuMars 1989). The decision requires New Mexico to meet the apportionment requirements of the Pecos River Compact, and to compensate Texas for undelivered water; that the Pecos basin is of yet unadjudicated in New Mexico presents additional difficulties for this state. An example of efforts to change or broaden the scope of existing rules for compact apportionment is provided by the activities of the Southern Nevada Water Authority which were discussed previously.

As important as interstate compacts have been with regard to the sharing of interstate waters, they can be seen as representing barriers to basin-wide efficiency in water use and comprehensiveness in resources planning and management, a further source of uncertainty. This occurs when upstream states seek to fully utilize their "paper rights" in order to preclude the possibility of losing them in the future, because they do not generally contain provisions that deal expressly with the interstate transfer of either established water rights or unallocated waters (El-Ashry and Gibbons 1986), and because compacts are generally limited in scope to specific water-related issues (e.g., apportionment, flood control, pollution control) and are generally not binding on federal agencies and projects functioning within their respective basins (Muckleston 1990). Lastly, compacts may be subservient to other legal arrangements regarding the apportionment of water resources. Such is the case with the Colorado River Compact whose member states must, in effect, adjust apportionments for such diverse things as evaporation losses associated with storage facilities, Indian or Winters claims, reduced flows associated with prolonged drought, and treaty obligations with Mexico.

Apart from the uncertain issue of interstate transfer of compact waters, the issue of interstate transfer of non-compact waters has proven to be quite contentious in itself as states seek to prevent exportation of their water resources.

The issue was definitively settled by the United States Supreme Court in *Sporhase* v. *Nebraska* (1982) in which it held that water is an article of commerce and as such must be managed in accordance with the commerce clause of the U.S. Constitution; states do not have the right to impede interstate commerce (Matthews 1984). As such, any entity may acquire water from a state other than that in which it is to be utilized as long as the appropriate permitting criteria are met. This decision was further refined in *El Paso* v. *Reynolds* (1983) in which a federal district court held that a state (New Mexico) may ban the export of water outside of its boundaries only for the local (and more-or-less immediate) purpose of protecting the public health and safety of its citizens, and that it may not discriminate economically against other states (Clark 1987; Matthews 1984). These rulings can thus, under particular circumstances, have the effect of geographically or spatially increasing the demand for a given state's water resources.

The United States shares a number of waterways with its sovereign neighbors, and the agreements and treaties reached between these entities over transboundary and international waterways are intended to govern their utilization. Of significance in the West are three major waterways: the Colorado, Columbia, and Rio Grande Rivers. Of the three, the former two are transboundary rivers (i.e., their courses cross established international borders), and the latter represents an international waterway for much of its length.

The United States-Mexico Treaty over the sharing of Colorado River waters (1944)[3] entitles Mexico to 1.5 million acre-feet (maf), and as mentioned previously, this water must be deducted from shares granted by the Colorado River Compact member states to themselves - notwithstanding reduced flows associated with drought. The United States, and the compact states in particular, face additional burdens as they struggle to meet the salinity standards established under Minute 242 of the International Boundary and Water Commission in 1973. Under this agreement, the United States must ensure that the salinity of Colorado River water flowing across the border will average 115 parts per million (ppm), plus or minus 33 ppm, annually in excess of that measured at Imperial Dam, and it must do so at whatever cost. This has caused the United States, more particularly its Bureau of Reclamation, to opt for improved drainage works in the Upper basin and the construction of one of the world's largest desalination plants at Yuma, Arizona (Hundley 1986). The cost of these yet to be completed solutions is enormous, and their mere existence underscores the importance that the West places on its available water resources.

While the sharing of the waters of the upper Rio Grande (i.e., upstream of Mexico) between the United States and Mexico has been governed by the terms of the 1906 Convention allocating 60,000 af of water annually to Mexico's Juárez region (Clark 1987:97), the waters of the middle and lower portions of the basin (Rio Grande/Río Bravo) are shared according to the terms of the 1944 Treaty

[3] This treaty was ratified by U.S. Senate on April 18, 1945, and by the Mexican Senate on September 27, 1945 (Hundley 1986:27-28).

reached between these parties. This bilateral agreement established the International Boundary and Water Commission (IBWC)/La Comisión Internacional de Límites y Aguas (CILA) as the joint international body charged with the monitoring and management of surface waters in these portions of the basin as well as enabling the construction of two international reservoirs (Amistad and Falcon) for water supply storage.

Though the IBWC/CILA was given supreme jurisdiction in order to facilitate the equitable apportionment of the middle and lower Rio Grande/Río Bravo and its tributaries, and the equitable resolution of surface water issues, the treaty did not deal with the apportionment of groundwater from shared aquifers underlying the basin nor with water quality issues. Groundwater mining, water quality problems (particularly salinity and the discharge of untreated Mexican municipal and industrial wastes), and water supply shortages (especially in the twin cities of El Paso/Ciudad Juárez) are all issues that have come to bear on the region and the IBWC/CILA (Eaton and Hurlbut 1992).

The sharing of selected benefits from upstream Canadian storage of the waters of the Columbia River by the United States and Canada is governed by the terms of the Columbia River Treaty of 1961.[4] This sixty year agreement allows for the joint development and management of the basin for flood control and hydroelectric power generation. Because the Columbia's headwaters are located primarily in Canada, the treaty specified that Canada would receive compensation

[4]The treaty was ratified by the U.S. Senate in 1961, and endorsed by the Canadian Parliament in 1964.

for one-half the value of estimated flood damage mitigation benefits accruing to the United States from 8.45 maf of Canadian storage (the Canadian storage totals some 15.5 maf), and for one-half of the additional power generated by downstream U.S. projects. While the flood damage entitlement was payable upon completion of the projects (Duncan Dam was completed in 1967, High Arrow Dam in 1968, and Mica Dam in 1973), a protocol to the treaty specified that the Canadian power entitlement was to be met through an initial thirty-year sale (again payable upon Canadian project completion) and was to be renegotiated thereafter (Swainson 1986).

While the Columbia River Treaty is recognized as a model of international cooperation in resources planning and management (Muckleston 1980; Swainson 1986), uncertainty over the renegotiation of the remaining Canadian power entitlement remains an issue for the United States as does the future entitlement's implications for the Northwest Power Planning Council's salmon recovery program. Furthermore, the hydroelectric power benefits realized by the Pacific Northwest states contributed to a surplus of electric power in the region that began to disappear in the late 1980s as the region grew both economically and in terms of population (Northwest Power Planning Council 1990). The river that had always been seen as a water resources cornucopia both within the region and from without is now revealing that it is not inexhaustible, and that it is perhaps already seriously overtaxed.

2.2 A New Approach In Western Water Policy

As discussed above, water marketing can be viewed as one element of an emergent resources management framework or approach that is focused upon balancing economic development with efficiency in water use, flexibility in approach and practice, and environmental quality. This framework can be conceptualized through the use of a Venn diagram in which its various elements (e.g., conservation, basin planning, instream flow protection, etc.) are created by the overlap of the water resources management sphere with different dimensions (Figure 2.1).

This “new approach,” though it is essentially being developed and adopted in an incremental and haphazard fashion, differs from the old chiefly because of its comprehensive or holistic nature and because of its reliance upon non-structural means to meet management objectives. Whereas water resources management was previously synonymous with structure-based resource development projects that relied upon spatial and temporal alteration of hydrologic systems, the new framework or approach is more concerned with mitigating the third-party effects of such projects and facilitating resource use efficiency, conservation, and reallocation. Outstanding examples of the application of this approach include: the development of "conserve-and-transfer" strategies to facilitate water conservation and reallocation (OWRD 1992; Root 1993), increasing reliance on the market mechanism to facilitate reallocation, the use of a planned restorative flood on the

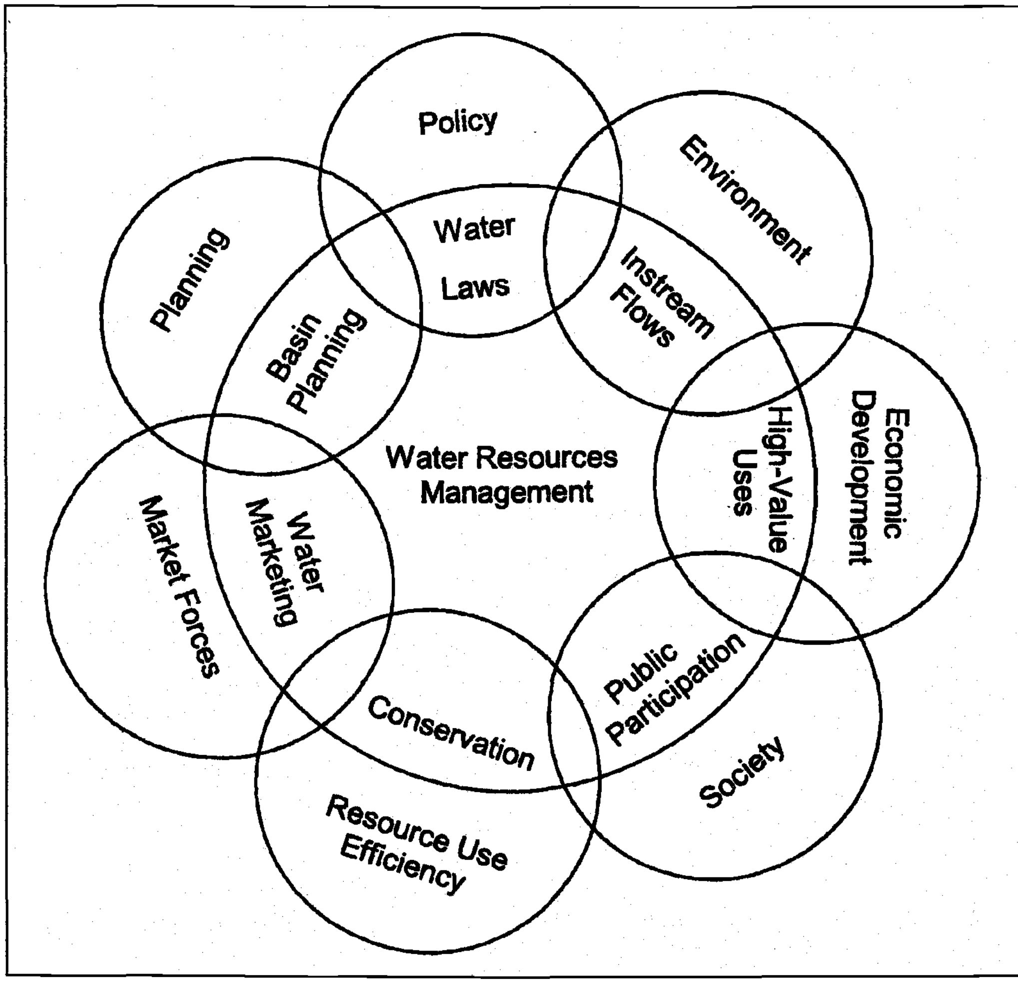

Figure 2.1. The new approach to water resources management.

Colorado River below Glen Canyon Dam for habitat mitigation purposes (Sibley 1996), small dam decommissioning and removal in California (Reisner 1997), the implementation of hydropower management measures including reservoir drawdown and planned releases of stored waters to improve juvenile salmonid survival and migration success in the Columbia River basin (Northwest Power Planning Council 1993), and the establishment of a state water bank in California to facilitate temporary transfers of water during the 1991 drought (California Department of Water Resources 1992).

2.2.1 Water Resources Conservation and Water Marketing

While the new approach is still in its infancy and is not fully defined because of its comprehensive nature and openness to public participation at different levels, two elements in particular - water conservation (i.e., improved efficiency in use) and instream flow values - merit brief discussion because of their relationships with water marketing. Because irrigated agriculture represents the single largest consumptive use of water in the West, it is generally agricultural water rights that are the focus of water reallocation and water marketing proponents. Individual irrigation water rights generally prescribe as much as 3 af of water per acre of irrigated cropland, and when multiplied by the vast acreages of western cropland that is subjected to irrigation, this translates to vast amounts of water devoted to agriculture in the West.

In 1980, approximately 69 percent of the surface and ground water withdrawn in the West[5] was devoted to irrigation (Solley et al. 1983:33); in 1990 this rate had increased to approximately 73.8 percent.[6] Current Western irrigation

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[5] Per capita withdrawals, based on total population in nine western water-resource regions or major drainage basins including: the Missouri, Arkansas-White-Red, Texas-Gulf, Rio Grande, Upper and Lower Colorado, Great Basin, California, and Pacific Northwest Regions as defined by the U.S. Geological Survey (Solley et al. 1983).

[6] Calculation based on figures provided by Solley et al. (1993).

efficiencies approach 53.7 percent (consumption/withdrawal),[7] translating into 90 percent consumptive use by agriculture of total western water consumption. While current irrigation efficiencies are somewhat lower than the 60 percent consumption rate of a decade ago (Mann 1982) owing to improved irrigation technologies and transfers of agricultural water to other uses, the "use it or lose it" tenet of the prior appropriation doctrine which governs water resources allocation in the West still functions as a disincentive to water conservation.

Nonetheless, one important reallocative strategy of the new management approach, the "conserve-and-transfer" principle or strategy, relies on the interaction of water use efficiency with market-based reallocation to provide an incentive for water conservation (Colby 1988; Weatherford 1982). Agriculturalists in particular and other large-scale users of water resources can realize benefits from improvements in irrigation and/or agricultural practices by being given the ability to market conserved water. This strategy can either form the basis of, or interact tangentially with, water right marketing though the latter is generally the rule owing to the greater importance historically attached to the concept of transferability of water rights than to the concept of conservation.

One exception to this rule, however, is presented by the state of Oregon which, though it treats water rights as appurtenant to and non-severable from the properties on which they are exercised (thus rendering them unmarketable), enacted a model water conservation law (ORS 537.455 to 537.500) which allows for the

[7] Calculation based on figures provided by Solley et al. (1993).

severance and transfer between separate parties of 75 percent of waters conserved through approved conservation proposals. Such transfers may be made as conditions of sale or lease, and the balance of conserved water is to be devoted to instream water rights by the Oregon Water Resources Commission (Oregon Water Resources Department 1992).

2.2.2 Water Marketing and Instream Flows

Instream flow values relate to the use of the market mechanism in water resources reallocation because of their qualitative differences from other "higher uses" of water, and because these values have historically not been supported by water law in the West. The maintenance and enhancement of instream flows, or surface waters flowing within the bounds of naturally defined channels, can provide a number of water-related goods and services that are not always easily quantified in economic terms. These goods and services are represented by ecological, recreational and aesthetic values as well as those which are more utilitarian in nature. Water resource managers, while giving implicit consideration to such values as pollution abatement through flow enhancement, have historically been less supportive of the instream flow concept but it is increasingly being recognized as one which is desirable given full appropriation and changing societal preferences (Root 1993).

Today, appropriative water rights may be established to provide for instream flows in Alaska, Arizona, Colorado, Idaho, Nebraska, Nevada, Oregon, South Dakota, Utah, and Wyoming (Dunbar 1983; Reisner and Bates 1990; Root 1993). Such rights are often junior to the majority of other appropriative rights, however, due to the relatively recent emergence of enabling laws and policies and thus do not necessarily guarantee specified minimum flow levels by themselves; such water rights are less reliable due to their lack of seniority. Instream flow water rights may generally be established and exercised by state water resource and/or other natural resources management agencies, and they are generally established from the unappropriated waters of the state rather than from existing water rights through transfers. Alaska and Arizona are the only states that allow private parties to file for instream water rights (Root 1993:63), and the modification of state water codes in the West to allow for the private transfer of existing appropriative surface water rights to instream water rights remains a highly-charged and controversial issue.

2.3 Third-Party Effects of Water Right Transfers

As noted earlier, the transfer of water rights via the market mechanism can produce adverse indirect or third-party effects that can take a variety of forms: economic effects, social and/or cultural effects, and environmental effects (Brown et al. 1982; Brown and Ingram 1987; Folk-Williams et al. 1985; Nunn 1987; Nunn and Ingram 1988). Concerns over third-party effects generally stem from larger issues such as: the preservation of the family farm and agrarian communities and ways of life in the West, the preservation of prime farm land for future food and fiber production, the preservation and maintenance of diverse cultures and institutions, and the protection of terrestrial and aquatic ecosystems and their inherent values to society. While these issues are most certainly and inextricably linked to larger-scale processes such as structural economic and demographic change, the concerns over third-party effects are no less valid. Such concerns have been raised in forums ranging from the community to the superior courts of western states (Brown and Ingram 1987; Nunn and Ingram 1988; Peña 1992).

2.3.1 Economic Third-Party Effects

Barring the effects of structural economic and demographic changes that might otherwise tend to ameliorate or mitigate economic third-party effects of water right marketing, market-based transfers of agricultural water rights to higher-value uses can affect local economies through the retirement of agricultural lands, reductions in property tax revenues due to property devaluation and acquisition of such rights by non-taxable public entities such as municipalities, reductions in farm and agricultural processing employment, and impacts on local businesses that provide essential goods and services to agricultural communities (Nunn 1987; Colby 1992). Such economic effects may also be seen as representing social effects when evaluated for their impacts on social institutions such as families and communities. Similarly, farm-to-farm transfers of water rights might provide another mechanism whereby structural changes in agriculture at the level of the community or region are realized, and perhaps with the undesirable local socioeconomic effects that have been observed in communities where land and capital have been concentrated in the hands of few (Goldschmidt 1978; MacCannell 1986).

2.3.2 Sociocultural Third-Party Effects

These perceived socioeconomic effects of water right marketing can be regarded or interpreted as sociocultural effects in the context of the independent agriculturalist and his/her supporting institutions and community (Flora et al. 1992), and particularly in the context of unique culture groups that have a significant presence in the West. For example, the rural Hispano or Spanish-American[8] communities of the Southwest and the agriculturally-based Mormon communities of the Mormon culture region which centers on Utah's Great Salt Lake Basin have hydraulic legacies with respect to both water and the special institutions that developed to manage the resource. Although the relative political strength of these groups differs within their respective regions, these legacies are very important if not critical to the maintenance of these cultural entities (Brown et al. 1982; Brown and Ingram 1987; Flora et al. 1992; Nunn 1987; Peña 1992).

The importance of such legacies was exemplified by the notorious *Sleeper* case [*Ensenada Land and Water Association et al.* v. *Howard M. Sleeper et al. and*

[8] The term Hispano and Spanish-American are used interchangeably in this work. It is recognized that though both receive common usage by authors dealing with the Spanish-derived ethnic population residing in the Rio Grande basin of Southern Colorado and New Mexico, they have different cultural, social, and political implications and are variously preferred by these people (Lopez 1974; Nostrand 1992; Rosenbaum 1981; Samora 1966; Zeleny 1974).

Steve Reynolds, New Mexico State Engineer, No. RA-84-53 (c); *Sleeper* v. *Ensenada Land and Water Association* (1988)] which served as the theme for John Nichols' (1974) popular fictional work, *The Milagro Beanfield War*. *Sleeper* pitted the residents of a rural Hispano community in northern New Mexico against development interests in a fight over the transfer of water rights for snow-making purposes at a proposed ski area. The transfer, approved by the State Engineer, was later reversed in district court on the grounds that the transfer would be contrary to the public welfare which includes the preservation and maintenance of the cultural identity of the rural Hispano communities of northern New Mexico. Though this case was later reversed by an appeals court on procedural grounds[9], the decision handed down by District Court Judge Encinias and the fact that the case was brought by a rural and ethnic community with few other resources enshrined it as yet another landmark case in western water law.

A more recent example of the successful utilization of the public interest/welfare[10] argument being applied to a similar situation is provided by Rivera (1996) who documented the successful protest of a proposed transfer in New Mexico's Río Pecos basin by traditional Hispano communities of the Nuestra

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[9] Approval was granted prior to the enactment of legislation modifying an existing statute (NM§72-5-23) that served to broaden the standing requirements in water transfer application review proceedings and that broadened the scope of public interest/welfare to include concerns related to culture and community (De Young 1994).

[10] The expression "public interest/welfare" is utilized in the remaining text to account for variable interusage of the two terms in the literature. It is acknowledged that the terms "public interest" and "public welfare" have different legal meaning.

Señora y Sangre de Cristo land grant at Anton Chico. The protestants argued that the transfer of a community resource from the largest functioning grant within the Hispano culture region would represent an irreversible negative impact on the integrity of the grant and its communities because of direct impacts on *acequia* (ditch) management and utilization, and on traditional use of the common lands (*ejido*) of the grant. In this case the State Engineer ultimately rejected the transfer application and required the applicant (the Pecos River Learning Center) to meet its water needs in other ways.

2.3.3 Environmental Third-Party Effects

Environmental third-party effects of water marketing - which can include the fragmentation and abandonment of agricultural lands, the degradation of instream and terrestrial fish and wildlife habitat, and impacts on water quality (Nunn 1987) - can have economic and sociocultural implications as well. In addition to the economic impacts discussed previously, retired agricultural lands may be invaded by nuisance plant species that diminish property values, discourage the development of such lands, and perhaps impose sometimes costly land management problems for neighboring properties (Karpisak 1980; Nunn 1987). Furthermore, water marketing can be seen to represent a specific mechanism or process of landuse change that, when occurring in conjunction with other land development pressures related to local population growth and suburbanization

(Furuseth and Pierce 1982), can facilitate or hasten the permanent loss of important or prime farmland.

Given the potential for water right marketing to impose local, and sometimes more widespread third-party effects on economies, environments, and communities, opposition to water right marketing is sometimes intense and emotionally charged. In response to such concerns as voiced at various levels of society and in different forums, water law in the West is being slowly refined and modified so that they may be accommodated and considered. In what Tarlock (1991:987) has termed "a new riparianism in the West," communities and other concerned entities such as environmental organizations are increasingly attempting to assert control over water management decisions through different means including the courts, the enactment of "area-of-origin" statutes that limit or restrict inter-basin diversions of water, and statutes and/or administrative rules that define scope and standing related to the public interest. Because such statutes and rules generally require that the public interest be considered in reallocation decisions, Tarlock views this trend as a rejection of the tenets of the prior appropriation doctrine and a return to tenets of the riparian doctrine of water use which has its basis in common law. As a final point, it is important to note that third-party effects have always been a latent feature of water resource development activities in the West. The impacts of hydroelectric power system development in the Columbia River basin and of the California State Water Project on salmonids, and the dewatering of western streams for irrigation purposes by agriculturalists, serve as important examples of unintended effects. While it is an understatement to say that these large-scale and long-lived effects are controversial and highly charged issues today, third-party effects related to more local exercises in water resources reallocation can often assume similar proportions in our socially, culturally, and politically more diverse post-industrial West.

3. WATER RIGHT MARKETING AND THIRD-PARTY EFFECTS: A REVIEW OF THE RELEVANT LITERATURE

Functioning markets for water rights have been established in a number of western states (Arizona, California, Colorado, Idaho, New Mexico, Texas, and Utah) and are being viewed by others as a potentially useful resource management tool (Bosch 1991; Gould 1989; Nunn 1987; Nunn and Ingram 1988; Reisner and Bates 1990; Wahl and Osterhoudt 1985; Weatherford 1982; Western Water Policy Review Advisory Commission 1998). This chapter begins with a discussion of the important characteristics of Western water rights that either predispose or preclude them for transfer via the market mechanism, then considers specific mechanisms of exchange. Examples of each mechanism are presented, where possible, and market activity in the West is summarized. Lastly, a review and analysis of investigations that have as their focus third-party effects is undertaken to identify existing gaps in our knowledge concerning these impacts.

3.1 Water Markets: Principles and Practice

The prior appropriation doctrine of water rights administration, which is generally considered to be a unique product of frontier development in the public domain of the nineteenth century West (Dunbar 1983; Matthews 1984; Pisani 1992), is predicated upon the principle of priority of use and breaks with the riparian doctrine in that it permits the diversion and use of water away from waterways and the properties immediately adjoining them. Having thus modified a system of water usage having roots in the common law and which relied upon the principles of "reasonableness of use" and "continuity of flow" (Clark 1965; Matthews 1984), which together ensured that the quantity and quality of surface waters would not be unreasonably diminished thus causing injury to other riparian landowners, the prior appropriation doctrine has created a system of property rights in water that predisposes water to be an article of commerce.

Though the 17 western states[11] of the conterminous United States rely almost exclusively upon the prior appropriation doctrine for water rights administration (Clark 1965; Matthews 1984), it has been variously interpreted and modified by each of them through time. The water codes of the western states are products of geography in that they were influenced by the specifics of settlement and economic development in different regions of the West, the willingness of early state policymakers to examine the emerging programs of their neighbors in the wider region, and early federal laws and institutions that were concerned with settlement in the region. This, together with the specific treatment each accords to water as an item of property, has much to do with their different policies regarding the transferability of water rights.

[11] These include: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

3.1.1 Water Code Evolution in the West

The early drafters of state water codes in the West around the turn of the twentieth century had to deal with a number of issues which included: 1) who owns the surface and ground waters; 2) how are water rights to be acquired; 3) how are early riparian and/or vested rights to be treated; 4) how should competing claims to water be settled; and 5) what should be the strength of the ties between water and property? Though it is beyond the scope of this investigation to consider each of these questions in depth, several generalities may be established.

First, the western states were ultimately unanimous in declaring the surface waters flowing across and within their boundaries the property of the public, thus making rights to water usufructory in character[12]. This ensured that the states would have an important role in the development of water resources located within and flowing across their boundaries, and in their management. Groundwater resources have been and remain, however, variously treated as either private or public property (Matthews 1984).

Secondly, the questions concerning the acquisition of water rights and the settlement of competing claims to water (water rights adjudication), including claims based upon vested and/or riparian water rights that were often tied to lands

[12] Water (surface and ground water) is generally held to be a public good in the West, and individuals are granted the right to use water so long as they meet certain criteria. Though some western states have explicitly claimed ownership of the waters flowing within their boundaries, the legitamacy of such claims is questionable given the decision of the U. S. Supreme Court in *Sporhase* v. *Nebraska*. Nevertheless, the right of the states to regulate the use of waters within their boundaries is recognized so long as it is non-discriminatory (Matthews 1984).

settled under one of the various federal land disposal acts, were more deeply concerned with the institutional nature of water rights administration and the protection of individual rights than with procedural matters. The states responded variously by granting the quasi-judicial powers of administration and adjudication to state engineers, water commissions or boards, the courts, or among some combination of these (Dunbar 1983).

And thirdly, the issue of whether or not a water right should be tied to a particular place of use (i.e., should it be treated as an appurtenance) was in turn based upon the issues of vendability, speculation, and on emerging federal reclamation policy which culminated in the 1902 Reclamation Act. Again, various tacks were taken depending upon timing, circumstances, and local politics. Speculation in water resources was generally viewed as non-populist, monopolistic, and as an impediment to orderly and efficient settlement in the region. The experiences of California and Colorado with regard to the activities of ditch companies which vended water for mining and irrigation, respectively, and which wielded considerable local economic and political powers were considered by policymakers in other states (Dunbar 1983).

The potential benefits of federal irrigation projects gave the states an incentive to establish codes providing for water rights administration and adjudication. In addition to the fact that such codes were required as a condition for authorization of early Reclamation Service projects, they were often constructed in such a way that they were compatible with Reclamation policy which was based upon the provisions of the Homestead Act (1862) and which, at least initially, followed the advice of John Wesley Powell that water rights should be appurtenant to the properties on which they are exercised (Dunbar 1983). It is important to note that today while the transferability of individual water rights (either private or public) is governed by state laws, water rights exercised within irrigation districts associated with federal irrigation projects are subject to the rules corresponding to these projects which may differ from those of the states.

The existence of this additional type of institution which can have significant political, economic, and hydrologic clout in many areas of the West, both facilitates and complicates any discussion of water marketing and third-party effects in this region. Discussion is facilitated because in many cases water market activity is significantly more intense within irrigation districts than in the jurisdictions surrounding them, this being a product of different policies concerning the transferability of water rights. On the other hand, discussion is complicated because irrigation districts represent unique institutions which are often locally important as social and/or economic institutions, they have various policies regarding water right transfers that can be at odds with surrounding jurisdictions, and the issue of their members realizing further (and perhaps substantial) financial benefits from the marketing of federally subsidized water rights to non-district entities is a very complex and controversial one (Brown and Ingram 1987; Gould 1989). The discussion that follows will thus focus primarily upon water rights administered by the states and those corresponding to federal irrigation districts will be considered only as necessary given this focus.

3.1.2 Water Rights, Appurtenance, and Severability

Whether or not a state treats water rights as being appurtenant to, and severable from, the properties on which they are exercised has much to do with their transferability and/or marketability. Western prior appropriation surface and ground water rights are generally treated as being appurtenant to their specified places of use. This is primarily a product of early reactions to the Colorado system of prior appropriation which was formalized in 1879 and which recognized the legitimacy of water rights upon the initiation of diversion works rather than upon the filing of a permit application or notice of intent to divert.

The Colorado system as it was initially codified represented the first attempt on the part of any western state or territorial government to formulate a rational and efficient method for the administration of water resources. At that time it did not treat water rights as being appurtenant to the lands on which they were exercised, instead they were attached to the ditches or water bodies from which water was diverted (Dunbar 1983). This facilitated their transferability and marketability for early agriculturalists in the state. Today, however, they are regarded as being appurtenant but severable (Saliba and Bush 1987). Though temporary intrabasin exchanges or loans of water are permitted following notification of the water division engineer for irrigation purposes only (i.e., for the purpose of saving crops or making a more economical use of water) (CRS §37-83-105), permanent water right transfers require the approval of water court judges who hear evidence offered in support of and in opposition to such proposals.[13]

In reacting to the early Colorado system, first Wyoming (with its "Irrigation and Water Rights" statute and constitutional provisions enacted in 1890) and then other western states instead tended to recognize the legitimacy of water rights through the application of water to a beneficial use on a particular piece of property, and that water rights would remain appurtenant to such properties and be non-severable. Additionally, the responsibility of adjudicating Wyoming's water rights was given to a State Engineer, who submitted his findings to a water rights Board of Control which issued water right determinations. Water right holders were granted the right to appeal decisions of the board in district courts (Dunbar 1983). While the water laws of the majority of western states have since been modified to permit the severance of water rights from those properties to which they are appurtenant, Wyoming's water laws still discourage their severance (Dunbar 1983:110; Gould 1989:460) as do those of some other states.

As is indicated in Table 3.1, water rights are treated as being appurtenant and severable in all Western states excepting Idaho, North Dakota, Oregon, and Wyoming, though in some cases with particular restrictions. These restrictions are statutory and can limit the transferability of water rights between different users,

[13] The state is divided into seven administrative water districts, and each is headed by a water judge which is appointed by the state's Supreme Court and who is charged with protecting the interests of other water right holders (Saliba and Bush 1987:121).

places of use, or purposes of use. They are different, however, from restrictions that are issued by state water management entities which are based upon the reduction or prevention of injury to other water rights and appropriators, or to the public interest/welfare. In each of the western states, appropriators must submit proposals for the modification or transfer of water rights to the appropriate management entity which reviews them for injury to other rights before such changes are authorized. In addition to this review, several states have enacted statutes that require state water managers to consider the public interest/welfare in their deliberations of proposed actions.

The relevant water-related statutes of the seventeen western states were consulted in the preparation of Table 3.1, which is described here and in the legend attached to the table.[14] Where no specific statutory language addressed a given category or topic (data field), the code NS (Not Specified) was utilized if the pertinent information was not available from any other source. In the case of the transferability fields (e.g., water rights transferable between different users, uses, places of use...), positive responses Y (Yes) were listed where these are not restricted in some form by statute. The code C (Conditional) was utilized where special restrictions limit transferability in some way; these restrictions are briefly noted in the table. Although agency specific administrative rules generally govern procedure in the case of water right administration, those procedures concerning water right transfers were noted where they are addressed by statute. The codes

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[14] The format of Table 3.1 follows that of Root (1993:63).

Table 3.1. Water right transferability statutes, western states.

1. Agency or Entity Charged with Administration of Water Rights.

2. Source of Affected by Statute(s).
   SW = Surface Waters
   GW = Ground Waters
   BOTH = Surface and Ground Waters

3. Water Right Transfer Statutes.

4. Year Statute Enacted.

5. Water Rights Severable?
   Y = Yes C = Conditional
   N = No NS = Not Specified

6. Water Rights Transferable Between Different Users or Parties?
   Y = Yes C = Conditional
   N = No NS = Not Specified

7. Change in Beneficial Use Allowed?
   Y = Yes C = Conditional
   N = No NS = Not Specified

8. Change in Point of Diversion Allowed?
   Y = Yes C = Conditional
   N = No NS = Not Specified

9. Change in Place of Use Allowed?
   Y = Yes C = Conditional
   N = No NS = Not Specified

10. Date of Priority of Original Water Right Retained?
    Y = Yes C = Conditional
    N = No NS = Not Specified

11. Administrative Procedures
    1 = Agency Notification 5 = Agency Review
    2 = Application 6 = Judicial Review
    3 = Public Notice 7 = Legal Appeal
    4 = Hearing 8 = Legislative Review

12. Proposed Transfer(s) Reviewed for Injury to Other Appropriators?
    Y = Yes C = Conditional
    N = No NS = Not Specified

13. Proposed Transfer(s) Reviewed for Injury to Public Interest/Welfare?
    Y = Yes C = Conditional
    N = No NS = Not Specified

14. Special Restrictions or Conditions Required by Statute(s).

						Transferability					Review			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
State	Agency	Source	Water Right Transfer Statutes	Year	Water Rights Severable	User	Beneficial Use	Point of Diversion	Place of Use	Priority	Administrative Procedure(s)	Injury	Public Interest/Welfare	Special Restrictions
Arizona	Department of Water Resources	BOTH	ARS §45-156, §45-172	1919	Y	Y	C	Y	Y	Y	2,3,4,5,6,7	Y	N	Only to irrig., munic., stock, power, mining, rec., F&W uses.
		GW (AMAs)	ARS §45-463 to §45-478	1980	C	Y	Y	Y	Y	N/A	2,5	N/A	N	Grandfathered GW rights only. Rights may not be conveyed apart from lands to which appurtenant.
California	State Water Resources Control Board	BOTH	CC §1700 to §1707	1943	Y	Y	Y	Y	Y	Y	2,3,4,5,6,7	Y	N	Only appropriative rights established after 1914.
Colorado	Colorado Water Conservation Board/Water Court	SW	CRS §37-83-105	1899	N	Y	N	C	Y	N/A	2, 6	Y	N	Permits only temporary intrabasin exchanges/loans of irrigation water.
		BOTH	N/A - Sources: Dunbar (1983), Vranesh (1987)	1879	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Transfers subject to court approval.
Idaho	Department of Water Resources	BOTH	IC §42-108	1899	C	N	Y	Y	Y	Y	2, 8 (>5,000af)	Y	N	
			§42-2501 to 2504		N	Y	Y	Y	Y	NS	Application to approp. District.	Y	N	For water rights appurtenant to, and transferred between, Carey Act lands only.
Kansas	State Board of Agric., Division of Water Resources	BOTH	KSA §82a-1501 to §82a-1508	1983	Y	Y	Y	N	Y	Y	2, 3, 4, 5, 6, 7	Y	Y	Only for 2,000 af. or more outside 35 mile radius from POD.
Montana	Dept. of Natural Resources, Water Resources Division	BOTH	MCA §85-2-402 to §85-2-403	1973	Y	Y	Y	Y	Y	Y	<4,000af: 2, 5; >4,000af: 2, 5, 8	Y	C	Transfers >4,000 af reviewed for injury to Public Welfare.
Nebraska	Department of Water Resources	BOTH	RSN §46-229.06;	1980	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Implemented through §RSN 46-288 to 46-294. Note: This policy expired December 31, 1996.
		BOTH	RSN §46-288 to 46-294;	1981	Y	Y	C	C	Y	NS	2, 5	Y	N	Intrabasin transfers must use same source of supply and go to same use preference category.
		GW	RSN §46-638 to 46-650	1963	Y	Y	Y	Y	Y	NS	2,3,4,5	NS	Y	For transfer to Municipal and Rural Domestic uses only.
Nevada	State Engineer	BOTH	NSA §533.040 & §533.345	1912*	C	Y	Y	Y	Y	Y	2,5	Y	Y	Beneficial/Economic Practicability, Public Interest. *NSA §533.345 authorized in 1913.
New Mexico	State Engineer	SW	NMSA §72-1-2; §72-5-22 to 24	1907	Y	Y	Y	Y	Y	Y	2,3,4,5,6,7	Y	Y	
		GW	NMSA§72-12-7	1931	Y	Y	Y	Y	Y	Y	2,3,4,5,6,7	Y	Y	
North Dakota	State Engineer	BOTH	NDCC §61-04-15 & §61-04-15.1	1977	C	N	C	Y	Y	Y	2, 5, 6, 7	Y	N	NDCC §61-04-15.1 relies on §61.04.061 for ranking of beneficial uses.
Oklahoma	Water Resources Board	BOTH	OSA §82-105.22 & §82-105.23	1905	C	Y	Y	Y	Y	Y	2	Y	N	Irrigation transfers conditioned by Beneficial/Economic Practicability.
Oregon	Water Resources Department	BOTH	ORS §537.455 to 500	1987	C	Y	Y	Y	C	Y	2, 5-7	Y	Y	Conserved waters. Interbasin transfers subject to review (ORS §537.801 TO 810).
		BOTH	ORS §540.510 to 530	1909	C	N	Y	Y	C	Y	2,3,4,5,6,7	Y	N	Ownership in common of water right & land.
South Dakota	Dept. Water & Nat. Resourses	BOTH	SDCL §46-5-30.3 to §46-5-35	1983	Y	Y	C	Y	Y	Y	1, 2	Y	N	Irrigation transfers conditioned by Beneficial/Economic Practicability; to same use or domestic use.
Texas	Water Commission	SW	TCA §11.084 & §11.085	1911	Y	Y	Y	Y	Y	Y	NS	NS	N	Interbasin transfers subject to Commission approval (TCA §11.085, 1913).
		GW	N/A											
Utah	State Engineer	BOTH	UCA §73-1-10 & §73-1-11	1919	Y	Y	Y	Y	Y	Y	1	NS	N	Note: Conveyances of water rights accomplished by deed.
Washington	Department of Ecology	BOTH	RCW §90.03.380	1917	Y	Y	Y	Y	Y	Y	2, 5	Y	N	
Wyoming	State Engineer													

corresponding to this field were listed in the order in which they occur in relation to one another, though they may not have been listed when redundant. The information summarized in the table is described in more detail below.

Arizona's laws concerning transferability are quite complex owing to the impact of the CAP on the management of groundwater in the southern part of the state. In general, those water rights that are located outside of groundwater Active Management Areas (AMAs) and which do not rely upon Colorado River surface waters may be freely transferred following approval of the Director of the Department of Water Resources (ARS §45-172). Transfers to hydroelectric generation or power production in excess of 25,000 horsepower, however, must be authorized by an act of the Arizona legislature (ARS §45-156).

Groundwater rights within AMAs that are grandfathered (i.e., not based upon Colorado River or CAP waters) are generally appurtenant and severable, but subject to a number of restrictions. Briefly, these include: 1) restrictions concerning the validity of rights based upon their purpose of use at the initiation of an AMA (retired irrigation rights must be supported by development plans for proposed non-irrigation uses as per ARS §45-463); 2) grandfathered irrigation rights in AMAs may be retired and transferred to non-irrigation uses only to lands owned in common by a given party and which are situated within the boundaries of established water service areas corresponding to cities, towns, or private water companies (ARS §45-469 - §45-472); 3) non-irrigation grandfathered rights are appurtenant but more freely transferable outside service area boundaries than grandfathered irrigation rights (ARS §45-473); 4) the payment of appropriate fees when transporting groundwater into an AMA from outside (ARS §45-556); and 5) grandfathered rights transported away from lands retired from irrigation must be maintained in such a way as to keep them free of noxious weeds and blowing dust (ARS §45-546 & ARS §45-558).

California, which has had an exceedingly complex and volatile history with respect to the development of its water laws and customs, has treated the issue of appurtenance variously since the emergence of the appropriation doctrine in its mining camps of the 1850s. Though it is beyond the scope of this investigation to review the judicial and legislative decisions which bear on this issue, the current treatment of surface water right transferability by this state (which still recognizes both riparian and appropriative water rights) may be summed up as follows: 1) only appropriative rights may be transferred from one place of use and/or point of diversion to another, and from one beneficial use to another; 2) appropriative rights established after November, 1914, may be transferred following approval by the California Water Resources Control Board which subjects applications to examinations for potential injury to other similar water rights (CC §1700 - §1707; Saliba and Bush 1987:63); and 3) vested appropriative rights initiated prior to this date may be transferred without board approval, and the burden of proof for potential injury falls on the holder(s) of other similar water rights (Saliba and Bush 1987:66).

With regard to groundwater rights, California has tended to treat these much as riparian surface water rights, subject to the rules of reasonableness in use and continuity of flow. This is, like the riparian doctrine, a legacy of British common law transplanted to this nation during its colonial and early post-colonial periods (Dunbar 1983). Reisner and Bates (1990:104), however, report that those groundwater rights which have been legitimized as appropriative rights through adjudication proceedings may be subjected to transfer.

Idaho, which utilized Wyoming's code as a model for its own (Dunbar 1983:115-119), generally treats water rights as appurtenant and non-severable though they are freely transferable among lands owned in common by a given party (IC §42-108). The state does, however, permit the leasing of water rights among different parties. Temporary leases (i.e., annual) of any perfected water right may be made for the purposes of hydroelectric generation (IC §42-108A and §42-108B), and of water rights pertinent to Carey Act lands for similar application on other such lands (IC §42-2501 to §42-2504). Carey Act water right leases are facilitated through the operation of a State Water Supply Bank which functions on an annual basis to distribute surplus or unused waters to willing buyers (Wahl and Osterhoudt 1985).

Kansas adopted the prior appropriation system for lands in the public domain in 1886, and for all state waters (both surface and ground water) in 1945, thus requiring the conversion of vested riparian rights (Dunbar 1983). Though it treats all water rights as appurtenant and severable (KSA §82a-701), it enacted a

Water Transfer Act in 1983 which specified that transfers of water (i.e., diversion and transportation) may only be effected for quantities of "1,000 af or more per year for beneficial use outside a ten-mile radius from the point of diversion ..." (KSA §82a-1501). The statute was revised in 1995 to allow only transfers of 2,000 af or more outside a radius of 35 miles. It appears that the rationale underlying this unique act has to do with an implicit concern with potential impacts associated with small incremental transfers, especially those involving transfers of irrigation water rights to other higher uses.

The act is notable also in that it permits the state water authority to approve temporary (one year) transfers which may cause injury to other present or future appropriators if it is determined that "an emergency exists which affects the public health, safety or welfare" (KSA §82a-1502), and it requires applicants to adopt and implement water conservation practices that are consistent with guidelines developed by the state water office (KSA §82a-1503). In requiring that "economic, environmental, public health and welfare and other impacts..." be considered in deliberations of proposed transfers, the act implicitly requires the consideration of the public interest/welfare (KSA §82a-1503).

Montana's statutes (MCA §85-2-402 & §85-2-403) governing transferability reflect a proactive and seemingly progressive stance on the part of this state's lawmakers. Though quite complex and seemingly unwieldy by nature of its detail and numerous requirements, and having been considerably revised since its inception in 1973, the primary statute governing transferability (MCA §85-2-

402) addresses changes in appropriation rights and has provisions concerning instream flows, salvaged water and water conservation, water quality, and water leasing. Additionally, the law requires that proposed changes in purpose and/or place of use for diversions equaling or exceeding 4,000 af, or 5.5 cubic feet per second (cfs) of consumptive use, be reviewed by the state legislature which must hold public meetings on such proposals. Proposed interstate transfers of any size must be reviewed for injury to the public welfare as well as to other appropriators and water conservation.

Though this state at one time acted to prevent the transfer of agricultural water rights to energy-related uses (Gould 1989), this law was repealed in 1985 and replaced with laws (MCA §85-2-301 & §85-2-141) which require parties desiring to divert large quantities of unappropriated water for whatever purpose to apply to lease such waters from the state (Reisner and Bates 1990). The law requires that environmental impact statements accompany lease proposals for quantities equal to or exceeding 4,000 af or 5.5 cfs of consumptive use. While these various requirements appear to be progressive in a populist and far-sighted fashion because of the direct involvement of elected officials in reviewing transfer proposals and their details and impacts, it has been suggested that they represent a willingness on the part of the legislature to engage in wholesale marketing of water for economic gain.

Nebraska, which adopted the Wyoming system of water rights administration in 1895, has several explicit laws governing the transferability of its surface and ground waters. A temporary law (RSN §46-229.06) enacted in 1993 and on the books only until December 31, 1996, allowed for the transfer of unused[15] water rights that were appurtenant to certain irrigation district tracts, uncultivable agricultural tracts of less than 20 acres, and lands that had become unsuitable for cultivation or other uses due to having been developed for uses not requiring water. Transfers of such rights were governed by special interbasin and intrabasin statutes (RSN §46-288 to §46-294).

Interbasin transfers of Nebraska surface water rights are reviewed for their compatibility with the public interest; they are permitted only if it is found by the Director of Water Resources that potential economic, environmental, and other impacts will be exceeded by the benefits of such transfers (RSN §46-288 and §46-289). Intrabasin transfers of surface waters are considerably easier to effect, however, with the requirement that proposed transfers be made by application to the Director, that they must utilize the same source of supply, and that they must be of the same water-use preference category (i.e., domestic, agricultural, manufacturing uses) (RSN §46-290 through §46-294).

Transfers of groundwater in Nebraska are governed by the terms of the Municipal and Rural Domestic Groundwater Transfers Permit Act which specifies that applications must indicate the amount of water to be transferred, include maps indicating the location(s) of affected wells and requisite fees. These fees are set at

[15] For a period exceeding three years, and not exceeding ten in the case of irrigation district tracts.

$50.00 for the first 5 million gallons of water per day (mgd) and $20.00 for each additional 5 mgd increment (RSN §46-638 through §46-650).

As should be evident from the discussion of efforts on the part of the Southern Nevada Water Authority to secure an enlarged water supply for the City of Las Vegas, the state of Nevada permits the transfer and marketing of water rights. As specified by statute, however, water rights are appurtenant to their places of use in this state, and they may only be severed and transferred if it becomes "impracticable to use water beneficially or economically" at those places of use (NSA §533.040). Proposed transfers may only be effected through application to the State Engineer who reviews all proposals for injury to other appropriators and to the public interest (NSA §533.345).

New Mexico's water code has treated water rights as appurtenant and severable since its establishment in 1907 (NMSA §72-5-22 through §75-2-24). Any application for change of place or purpose of use (ACPPU), and/or point of diversion, for both surface and ground waters must be reviewed for injury to other appropriators and for injury to the public interest/welfare (Brown and Ingram 1987; Clark 1987; Nunn 1990; De Young 1994). Furthermore, because adjudications of some New Mexico river basins are ongoing, proposed water right transfers from such basins are subjected to individual examination and determination of validity at the time application for transfer is received by the State Engineer, thus removing a potential obstacle to the transferability of water rights in this state (Nunn 1990).

New Mexico, like Colorado, is noteworthy among western states in that it recognizes the hydrologic linkage or connectivity between surface and ground waters. Whereas Colorado distinguishes between tributary and non-tributary groundwater, and treats the latter as subject to the doctrine of reasonable use as is done in unadjudicated groundwater basins in California[16], New Mexico has followed its own *Templeton* doctrine (based on *Templeton* v. *Pecos Valley Artesian Conservancy District* 1958) which regards all the waters of a basin, whether surface or ground water, as "one and the same" (Clark 1987:310). Tested in the courts (*Albuquerque* v. *Reynolds,* 1962) and only recently subject to reappraisal given ongoing investigations by the U. S. Geological Survey of the strength of such a linkage in the case of the Rio Grande,[17] the doctrine has greatly facilitated the transferability and marketability of water rights in this state by allowing parties to retire surface water rights and in effect convert them to ground water rights.

As was mentioned above, North Dakota is one of three states that does not permit the transfer of water rights between separate parties. It does permit the transfer of existing water rights from one place of use to another, provided they are both either owned or leased by the same party, and allows for the assignment of rights (NDCC §61-04-15). Also, water right holders may apply to change points of

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[16] Vranesh (1987, 232) notes that "[t]here is a rebuttable presumption that all water is tributary to some natural stream."

[17] Specifically, the linkage between the river and the Santa Fe Group aquifer system is being investigated (McAda 1996; U.S.Geological Survey 1997).

diversion, and purpose of use if the new use is of a superior type[18] than before (NDCC §61-04-06.1 and §61-04-15.1). Gould (1989) noted that this last requirement was designed to prevent the conveyance of agricultural water rights to energy-related uses as had occurred in Montana in 1979.

Oklahoma's laws governing transferability are similar to those of Nevada in that waters utilized for irrigation or other purposes may, if those uses become "beneficially or economically impracticable," be severed from their places of use and made appurtenant to other lands by transfer (OSA §105.22 and §105.23). Transfers can include changes in point of diversion and/or purpose of use.

Oregon treats water rights as appurtenant and non-severable excepting those which are modified by approved conservation plans (ORS §537.455 - §540.500). The Oregon Water Code of 1909 allows full transfers of surface or ground water rights only among properties owned in common by the same appropriator and only following application to, and approval of, the state's Water Resources Commission (ORS §540.510 - §540.530). This historic treatment of water rights as non-severable items of property had precluded the emergence of a water right market in this state until the passage of the conservation law; an active market for conservation program water rights, however, has yet to develop in this state. Since its passage in 1987, the law has facilitated only one approved transfer for 0.1 cfs

[18] The ranking of beneficial uses, from highest to lowest, is domestic, municipal, livestock, irrigation, industrial, fish and wildlife and other recreational uses.

which was devoted to instream flows. Two pending applications for a total of 1.14 cfs propose to devote 85 percent of conserved waters to offstream uses.[19]

South Dakota's laws permit the sale, lease, grant, conveyance, or other transfer of water rights upon application to and approval of the Chief Engineer of the Department of Water and Natural Resources. Following amendment of the subject water right permit, the water right may be assigned to its new owner (SDCL §46-5-30.3 through §46-5-35). Water rights utilized for irrigation purposes are subject to additional restrictions, however, including those which duplicate language also found within the Nevada and Oklahoma statutes concerning beneficial and/or economic practicability of use (SDCL §46-5-34), prevent the change in purpose of use unless to domestic and public-related domestic uses (SDCL §46-5-34.1), and require the acquisition of a soil-water compatibility permit for the proposed move-to lands (SDCL §46-5-35).

Texas, having a long and complex history of water law evolution much like California and for many of the same reasons, followed the lead of Oregon and other states in merging vested surface water and riparian rights into an appropriation system based on permits (Chang and Griffin 1992).[20] Surface water rights are readily transferable, however, interbasin transfers are subject to approval by the Texas Water Commission which evaluates such proposals for injury to other rights

[19] Source: Personal communication (January 29, 1998) with Michael McCord, Oregon Water Resources Department.

[20] California treats vested and riparian rights separately and differently than appropriative rights established through the permit process.

(TCA §11.085). Groundwater in Texas, however, remains subject to the English rule of absolute ownership in property, though several underground water conservation districts have been created to facilitate the conservation and continued exploitation of the High Plains aquifers underlying the Panhandle region of this state (Dunbar 1983). Given its private property nature, Texas groundwater is treated as a freely developable and marketable commodity (Chang and Griffin 1992), except in the underground water conservation districts where resource development is limited by well spacing rules administered by the districts' county committees (Emel and Roberts 1995).

Utah, which initially developed a system of water rights administration that relied upon the supervision of the Church of Latter Day Saints, had to mold this institution into an appropriative system in order to qualify for early reclamation projects. After experimenting with the Colorado system, in 1903 it adopted the Wyoming system of water rights administration and the Colorado system of water rights adjudication (i.e., primarily through the courts). The adjudication of customary rights established under the Mormon system of water rights administration proved to be a daunting task, however, because the lack of funding for adjudication proceedings and the unwillingness of irrigators to shoulder the costs themselves delayed adjudication. The state eventually settled on the Oregon system which at that time relied upon the findings of the State Engineer as submitted to district courts[21] (Dunbar 1983).

[21] This system is unchanged today. However, findings of fact in regard to water rights adjudications are conducted and submitted by the Director of the Oregon

Today, the state of Utah treats appropriative surface and ground water rights as appurtenant but severable and transferable by deed as is done for real estate (UCA §73-1-10 & §73-1-11). Water rights that take the form of shares of stock in incorporated mutual irrigation companies are not treated as appurtenant to the lands of irrigators but rather to the service areas corresponding to these companies.[22] Transfer activity within such areas can be intense, especially in the Bonneville or Great Salt Lake Basin (an administrative sub-basin of Utah's Great Basin which also includes the Sevier River and Bear basins) which represents the most populous area of the state (Brown et al. 1982; Reisner and Bates 1990; Saliba and Bush 1987).

Though the State of Washington's water code was heavily influenced by that of Oregon which does not permit the transfer of water rights between different users and uses, its statutes treat water rights as appurtenant and permit their severance and transfer (RCW §90.03.380). Because of this stance concerning severability, the Washington code enacted in 1917 was also substantively different from a model code whose development was commissioned from outside the state's legislature. This code, the "Bien code," was drafted by Morris Bien who served as legal advisor to the first chief engineer of the Reclamation Service (Frederick Newell) and who followed the Reclamation policy of making water rights explicitly

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Water Resources Department working under the Oregon Water Resources Commission.

[22] Mutual irrigation company water rights are transferrable outside the service areas of these entities upon application to and approval of the Utah State Engineer who submits such proposals to administrative hearings (Saliba and Bush 1987).

appurtenant and implicitly non-severable. Though never enacted by Washington, the Bien code was used as a model by a number of other Western states.[23]

3.1.3 Mechanisms of Exchange

Water market transfers represent negotiated transactions between parties who hold water rights (i.e., sellers) and bargaining partners who seek to acquire water rights. In the context of an existing market, the holder of a water right can be seen as operating in a "world sphere" comprised of social, economic, cultural, and physical dimensions that interact so as to influence attitudes and decisions about whether or not to participate in a market (Figure 3.1). This entity or individual may act upon changing economic information or production potentials, perceived changes in climate, and/or community attitudes about the acceptability of participating in markets. They may act to pursue a market transaction, or to change the use or place of use of their water right such that they operate under a new "world sphere." This transfer is not necessarily a one-way action because it may be reversible due to a failed enterprise or other factor.

Once a decision to participate in the market is made the holder must identify a bargaining partner, and in negotiating a transaction the parties are constrained by dimensions of the institutional environment governing the state or place in which

[23] Though each permits the severance of appurtenant rights, the states of New Mexico, North Dakota, Oklahoma, and South Dakota all adopted variants of the Bien code (Dunbar 1983).

they operate. These include laws, broader-based community attitudes, case history, and transactions costs related to market function. Ultimately, a decision to sell or retain the water right is made. If sold, the "water right buyer" shown in Figure 3.1 becomes the new "water right holder" and operates under a particular world sphere that is probably different from that which influenced the previous holder of the right.

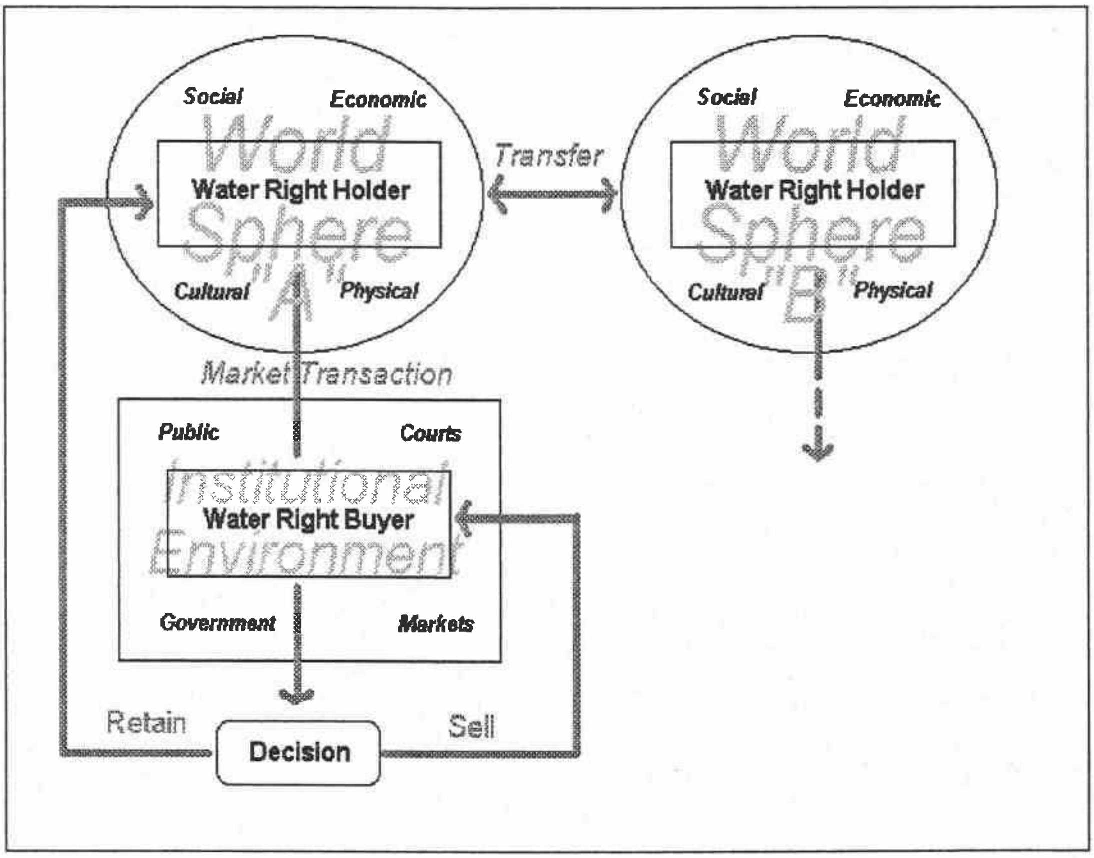

Figure 3.1. Conceptual model of a water right transfer.

Though in a strict sense water right marketing might be said to involve the permanent conveyance of water rights as articles of property between separate parties, it generally is treated in a broader fashion in the literature as a host of different transaction arrangements through which willing sellers and buyers can interact. Transaction arrangements are market-oriented mechanisms, ranging from negotiated adjustments in water use to absolute sales of water rights, which can be conceptually placed along a continuum of transfer mechanisms which have varying degrees of legal, temporal, and spatial permanence and complexity (Figure 3.2). The lending of water rights, as is practiced in Colorado, represents the mechanism with the least degree of legal, temporal, and/or spatial permanence. Colorado law specifies that only irrigation water rights may be loaned for the purpose of saving crops or making a more economical use of water, that both parties involved in the transaction must hold irrigation rights in the same stream or ditch, and that such loans are to be temporary and should not be construed as permanently modifying existing rights (CRS §37-83-105; Vranesh 1987).

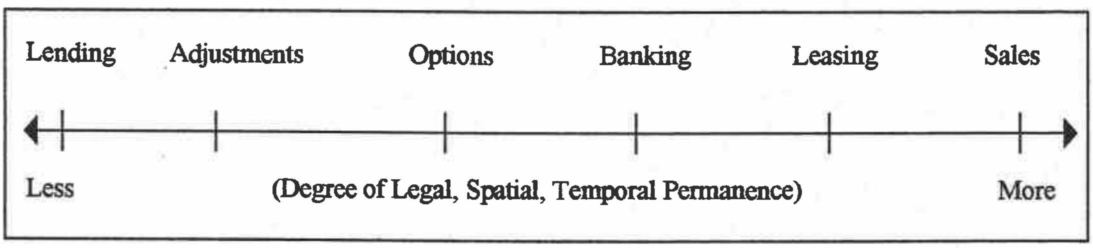

Figure 3.2. Continuum of water right transfer mechanisms.

Negotiated water right adjustments are agreements which allow one party to the transaction (the buyer) access to water that would be difficult to obtain through other transfer mechanisms. The sellers are compensated in return for their agreement to adjust their use of water in some respect, thus such transactions need not involve a physical transfer of water rights (Bush 1988; Saliba and Bush 1987). An example of a negotiated adjustment is presented by an agreement effected on New Mexico's Rio Chama (a tributary of the Upper Rio Grande) to bolster instream flows on summer weekends for recreational boating purposes. The owners of the waters in question incur no costs in implementing this agreement because they are able to capture the supplementary releases in a downstream reservoir (De Young 1994).

Water right options represent legal options to lease or purchase water rights, or portions of, from a seller at some point in time under specified conditions concerning price, quantity, and delivery (Saliba and Bush 1987). They provide buyers with certainty regarding potential supplementary water supplies, but differ from standard lease and sale agreements because they need not ever be implemented. Similarly, options differ from other transfer mechanisms because, until they are exercised, they exist on paper only.

Water banking entails the creation of exchange pools or water right clearinghouses, through which water right holders make available all or some portion of their water rights for temporary transfer to other users and/or uses. As such, water banks allow for the leasing or renting of water rights to supply or supplement a given party's water requirements. While some water banks develop in response to anticipated drought, and are thus temporary, seasonal, and even experimental in character, others may function as more permanent institutions that facilitate transfers each growing season when irrigation and other demands for water are generally highest (Wahl and Osterhoudt 1985). Water banks generally require that some entity manage transactions for the participants, and transactions costs which can represent formidable barriers to the transfer of water rights are thus kept low.

A number of examples of water banks are found in the West. California's Federal Water Bank, which functioned during the 1976-77 drought, and its 1991 Drought Water Bank represent examples of the more temporary type of exchange. These were experimental projects designed to reduce drought impacts especially on higher-value agricultural (e.g., maintenance of orchards and livestock) and municipal uses, and just as importantly to identify constraints and/or impacts that might affect the success of future endeavors.

While both of these operations required joint federal and state cooperation, especially with regard to water resources infrastructure such as storage and transport systems, the Federal Bank was primarily a federally managed bank whereas the 1991 Bank was administered by the California Department of Water Resources (California Department of Water Resources 1992; Wahl and Osterhoudt 1985). Both banks functioned through the purchase and resale of state and federal project water (i.e., surface irrigation waters); the Federal Bank sold 42,544 of 46,438 af (Wahl and Osterhoudt 1985:117), and the 1991 Bank roughly 555,000 of 820,000 af (Coppock and Kreith 1993:6). Southern California's MWD alone acquired 215,000 af of supply from the 1991 Bank.

By comparison, Idaho's State Water Supply Bank is a continuously functioning entity (Brown 1999; Wahl and Osterhoudt 1985) which has roots in water rental arrangements that occurred in the 1930s.[24] Though it undoubtedly serves to alleviate water shortages experienced during drought conditions, as the banks in California have done, it also has the function of moving water to higher-value uses on an annual basis. Transfers, termed leases by the bank, are restricted to a duration of only one year and users requiring more water than they possessed rights to renegotiate for it each year. Prices are fixed annually and are based on operator costs. These were quite were quite low in the early 1980s, ranging from $0.64 in 1980 to $2.50 per acre-foot in 1984 (Wahl and Osterhoudt 1985:120).

A water-exchange pool operated and administered by the Arvin-Edison Water Storage District in California's eastern San Joaquin Valley offers an example of a water bank that was more restricted than those already discussed. At least prior to 1985, the district had operated the exchange annually for the purpose of making more efficient use of its irrigation waters, and exchanges were limited to district contractors and to within its boundaries; this exchange thus did not permit water to be applied to higher-value uses as others generally do. Prices were based on normal water delivery rates set by the district (Wahl and Osterhoudt 1985).

Although water bank transactions are sometimes termed leasing arrangements in the literature, they can be distinguished from isolated water right leasing arrangements that are generally negotiated between two parties on an

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[24] The bank had operates only within the boundaries of Water District No. 1 on the upper Snake River.

individual or case-by-case basis and which operate for longer periods of time. Isolated water right leasing arrangements thus function in much the same way as absolute water right sales except that their longevity is fixed by contractual agreement, and the water rights of concern revert to the lessor upon contract termination.

Water right leasing arrangements are generally subject to the same laws that govern the sale of water rights and can thus occur in those states whose water codes either implicitly or explicitly encourage water right marketing. In noting, however, that those states (California, New Mexico, Utah, Washington, and Wyoming) which enable water leasing have generally inadequate statutes, Gould (1989) points to the fact that most statutes address temporary and isolated water needs and do not well accommodate intermittent or more recurring water shortage situations. In a similar vein, Bush (1988:35) observed that the legal and technical aspects and costs of evaluating lease proposals for injury to third parties (i.e., other appropriators or the public interest/welfare) make these temporary transfers "too troublesome to attempt."

In spite of these points it is clear that temporary transfers can serve well particularly in special situations such as have been experienced by Utah. This state presents two rather unique examples of water markets that have relied primarily upon leasing arrangements. In response to different stimuli separate markets have developed in the Sevier River and Bonneville basins. The Sevier River basin market was largely influenced by the establishment of the Intermountain Power

Project (IPP) coal-fired electric generating facility within its boundaries. In 1982 the IPP purchased 45,000 af of water rights (88 percent of which was represented by mutual irrigation company shares) at a price of $1,750 per acre-foot to secure its water needs (Wahl and Osterhoudt 1985:115); the average price for company water preceding and following this purchase was about $350 per af (Saliba and Bush 1987:167). Because the IPP's generating capacity was scaled back following the purchase of these rights and it plans on retaining the 25,000 af of excess unneeded water for purpose of future expansion, the project had become by 1987 the sub-basin's largest renter of non-company water (Saliba and Bush 1987:169-170).

In contrast to this example, the Bonneville basin water market developed largely in response to increased urban demands for water and in anticipation of the delivery of its Colorado River allocation via the Central Utah Project. This market relies primarily upon short-term leasing of private water rights and also those which are represented by mutual irrigation company stock (Brown et al. 1982). Water leases therefore represent an important tool for interim water resources reallocation in this sub-basin.

The absolute sale of water rights in a market setting involves the negotiation of isolated transactions between willing sellers and buyers such that established rights may be transferred in return for monetary or other compensation. Such transactions generally result in a physical or spatial transfer of the point of diversion (POD), the point at which the water is withdrawn from either surface or ground water sources, and of the place at which the water right is exercised (i.e., place of use or POU). Additionally, water market transactions offer an important means by which water may be shifted to higher-value economic uses because they permit the purpose of use or beneficial use (BU) of the affected water rights to be changed.

Because these criteria may also be seen to apply to more temporary market-based transfers, it is important to note that sales of water rights are generally construed as being legally, spatially, and temporally permanent. Saliba and Bush (1987:46) define market-based sales of water rights in the following fashion: "[s]ales of water rights involve the transfer of title including all benefits, costs, obligations, and risks associated with that right. Most transferable water rights are perpetual, so a sale implies the permanent transfer of all legal claims existing under the right." Thus, for the purposes of this study water marketing is operationally defined as the negotiation and conclusion of isolated transactions involving the permanent transfer of water rights between separate parties or entities within an intrastate setting.

3.1.4 Water Market Examples

As should be clear from the discussion of appurtenancy and severability, each of the fifteen Western states excepting North Dakota and Wyoming allow water rights to be bought and sold in one manner or another. And while it is beyond the scope of this discussion to present examples of market-based sales in each of these states, several examples of those regions which utilize market-based sales of water rights to facilitate rural-to-urban transfers have been drawn from the literature.

Market-based transfers of primarily agricultural water rights have been important to the continued growth of the Phoenix and Tucson Metropolitan Areas of southern Arizona since passage of the Groundwater Management Act in 1980. Enacted with the primary objective of curbing groundwater overdraft in this portion of the state, the act enabled the establishment of a state Department of Water Resources, the establishment of the region's four groundwater active management areas (AMAs), and quantification and legitimization of groundwater rights within and outside of the AMAs. The act also established the parameters under which transfers of groundwater may be effected within the region.

Relying primarily upon the availability of Grandfathered Type I and II groundwater rights for transfer to other uses within the boundaries of the AMAs, the cities of Mesa, Phoenix, Scottsdale, and Tucson had by 1986 together acquired water rights in excess of 128,500 af (Table 3.2). These acquisitions reflect

Table 3.2. Water right transfers from selected Arizona cities as of 1986. (Source: Saliba and Bush 1987:102-106)

	Water Rights Type	Amount (af)	Prices Paid (Per af)
Mesa	GW - Grandfathered	30,000	$1,000 (Average)
Phoenix	GW - Grandfathered	30,000	$1,000
Scottsdale	Surface Water	13,500	$1,300
Tucson	GW - Grandfathered	55,000	$400 to $900

purchases of land with appurtenant water rights, and because the cities are required by state law to manage these lands following the retirement of their water rights to prevent the growth of noxious weeds and blowing dust they will have to spend additional funds to accomplish this.

Purchases of water rights have been equally important to creating and maintaining high rates of growth and development in Colorado's Front Range since the 1960s. Rice and MacDonnell (1993:3) report that transfers of South Park (a montane valley containing the headwaters of the South Platte River) agricultural water rights by the Front Range municipalities of Aurora, Denver, and Thornton have been responsible for the reduction in irrigated agriculture from 35,000 to less than 4,000 acres over the period 1969 to 1991. Similarly, owing to their control of a majority of shares in the Colorado Canal which supplies irrigation waters to Crowley County from the Arkansas River, the cities of Aurora and Colorado Springs have been in large part responsible for the reduction in irrigated acreage within the county from 68,000 to 4,000 acres (Rice and MacDonnell 1993:4). Given diversion rates of two-to-three af per acre, these transfers can be seen as involving vast quantities of water.

Brown et al. (1982) have reported on other rural-to-urban transfers in the Colorado Front Range that assume equal proportions to those presented by Rice and MacConnell. Between the years 1957 and 1978 Front Range municipalities expanded their share of Colorado-Big Thompson (CBT) Project (the U.S. Bureau of Reclamation interbasin diversion implemented as part of the Colorado River

Compact) waters from 15 to 34 percent (1982:234). These authors cite a study (Brown et al. 1982:234) conducted by the Colorado Department of Agriculture which estimated the retirement of irrigated lands in Denver Metropolitan Area counties owing to the CBT and other transfers at 55,000 acres from 1959 to 1974.

Wahl and Osterhoudt (1985) have noted that agricultural to urban transfers occur with little friction in the Northern Colorado Water Conservancy District that is served by the CBT. This they attribute to several factors. First, CBT water is easily marketable within the district because it serves the function of a supplementary supply. Secondly, the fact the urban corridor is located upstream of the majority of the district's agricultural lands, and that municipal and industrial uses are typically low consumptive uses, means that agriculturalists can and do utilize return flows for irrigation purposes.

In New Mexico, market-based transfers (especially permanent transfers) have been an important means by which various water users, municipalities, and other water suppliers have been able to capture additional water supplies in the state's many fully appropriated river basins. Nunn (1990) conducted a survey of transfer applications processed by the State Engineer's Office (SEO) during the period 1975-1987. She found that 1,309 transfers involving changes in place and/or purpose of use, excluding one-party agricultural shifts in POU, had occurred in the state during this period. Their spatial frequency subdivided by water region is summarized in Table 3.3.[25]

[25] Because stream and groundwater basins do not necessarily coincide exactly, and because of legal and administrative considerations, Nunn combined these into

Table 3.3. Frequency of water right transfers in New Mexico by water region. (Source: Nunn 1990:99)

Water Region	Number of Transfers
Bluewater	36
Canadian (Arkansas)	32
Gila-San Francisco	284
Lower Rio Grande	15
Middle Rio Grande	168
Upper Rio Grande	99
San Juan	145
Pecos River Valley	239
Central Groundwater	48
Southwest Groundwater	4
Southcentral Groundwater	151
Southeast Groundwater	88

Though the total volume of water represented by these transfers was not reported, the quantities corresponding to several basins were documented. Expressed in terms of the amount of water consumed (acre feet of consumptive use or afcu) at the move-to location instead of quantities of water diverted, these volumes were as follows: 42,069 afcu in the Rio Grande basin, 3,157 afcu in the San Juan basin, 22,510 afcu in the Pecos basin, and 4,665 afcu in the Gila-San Francisco basin. Furthermore, while this study did not reveal the proportion of market- to non-market-based transfers, it did attempt to characterize transfer types with respect to changes in general BU categories (i.e., agricultural vs. non-agricultural). The results showed that while a considerable amount of water (26.3

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inclusive water regions. Surface and ground water basins delineated by the New Mexico State Engineer may differ somewhat from this scheme.

percent) was transferred from one agricultural use or user to another, the majority of water being transferred was devoted to non-agricultural uses (Table 3.4).

Table 3.4. Water right transfers and changes in use, New Mexico, 1975-1987. (Source: Nunn 1990:99)

Change in Use	Percent of All Water
Agriculture to Agriculture	26.3
Agriculture to Ag. & NonAg.	2.6
Agriculture to Non-agriculture	29.4
Non-agriculture to Agriculture	3.9
Non-agriculture to Non-agriculture	37.9

The Gila-San Francisco basin is notable because of the large number of transfers occurring within it during Nunn's study period, and because of the relatively small amount of water involved. Because this basin is shared with Arizona and is tributary to the Colorado River, appropriations of its waters in New Mexico were fixed at 31,000 afcu by the U.S. Supreme Court in *Arizona* v. *California* (1963); the court also closed the basin to interbasin diversions and ordered it to be adjudicated by the State Engineer (Bush and Saliba 1987). The restriction on appropriation, and more stringent requirements concerning the appropriation of water for domestic and landscaping purposes, had the effect of creating an artificial, administrative, and psychological scarcity of water and prompted the development of an active water market within the basin (Brown et al. 1982; Nunn 1990). In addition to a large amount of non-market transfer activity, water right options, lease agreements, and absolute sales of water rights have been employed within the basin. Prices have ranged from as little as $3.50 per af in the case of a municipal lease of groundwater pumping rights to as much as $6,600 per af for transfer options for mining uses (Saliba and Bush 1987).

Texas contains an active water market in its rapidly growing Lower Rio Grande Valley[26] adjacent to the Gulf of Mexico. Chang and Griffin (1992:885) report 152 separate transactions, including lease agreements and water right amendments (permanent transfers), totaling some 79,650 af of surface water having occurred during the period 1970-1990. Agricultural-to-municipal transfers accounted for approximately 94.12 percent of this amount, and 99 percent represented agricultural to non-agricultural changes of use. The cities of Brownsville, Harlingen, and McAllen are all active water traders, and though each acquires water rights through permanent sales, they rely more heavily on lease arrangements for temporary and even permanent transfers (Schoolmaster 1991).

One final type of market transaction that is considered is the "special purpose transfer." Special purpose transfers, however effected, can be characterized as those transfer arrangements that serve to move typically large quantities of water to a single large user. Transfers may consist of a single large

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[26] For administrative purposes, the Lower Rio Grande Valley encompasses the lower reach of the Rio Grande from the Gulf to International Falcon Reservoir, and the middle reach which extends upstream to Amistad Reservoir.

transaction, or a package of smaller ones such as in the case of the Intermountain Power Project. In addition to the IPP transfer which has already been discussed, examples of special purpose transfers in the West include: the 1972 Utah Power and Light Company/Emery Water Conservancy District transaction for 6,000 af; the Casper-Alcova Irrigation District/Casper, Wyoming, transaction for some 7,000 af ; and the Imperial Irrigation District/Metropolitan Water District of Southern California (MWD) negotiations for the transfer of conserved irrigation waters Wahl and Osterhoudt (1985).

The MWD transfer arrangement was formalized in December of 1989 and will transfer 106,110 af per year for a period of 35 years to the MWD at a total cost of $222 million (Rosen 1992).[27] Both it and the Casper transaction serve as excellent examples of the conserve-and-transfer strategy (Weatherford 1982) because they are characterized by municipal water suppliers realizing expanded water supplies through the improvement in efficiency of irrigation works such as canals and delivery systems.

3.2 Third-Party Effects Associated With Water Marketing

The literature devoted to third-party effects related to water marketing in the West, though it is often overlapping in terms of content, can be conveniently grouped into three topical areas: economic impacts, sociocultural impacts, and

[27] Rosen (1992:4) notes that the "effective price to [MWD] will be about $100 per acre-foot per year."

environmental impacts. The majority of the work in this general subject area has been largely speculative because of a focus on market activity and/or potential or expected impacts – quantitative studies on actual impacts have been fewer. Attention will be focused on the latter in the remainder of this chapter.

Before this is done, however, it is perhaps important to consider the conversion of water rights in a different but still intimately related context: that of landuse change. The statistics pertaining to relative amounts of water and land involved in water market transactions in the previous discussion of mechanisms of exchange show that a number of western states have seen the conversion of agricultural water rights to other often non-agricultural uses. Water marketing therefore represents a force that comes to bear on the significance and structure of agriculture in the West, and upon the region's landscapes. And while this force is just one of many internal and external forces of agricultural change that interact in many and complex ways (Bryant 1992), it is nonetheless surprising that it has received very scant attention, if any, in the literature devoted to processes of landuse change and control (Bogue 1956; Clawson 1971; Dideriksen et al. 1977; Furuseth and Pierce 1982; Greene and Harlin 1995; Jackson 1981; Lamb 1975; Platt and Macinko 1983; Plaut 1976; Schnepf 1979).

Studies of landuse change at the rural-urban fringe have typically focused on the dynamics of land markets, the impact of improving transportation systems, and other metropolitan forces. Theoretical and empirical modeling of landuse change has generally employed population density and distance decay parameters to describe the dynamics of land conversion. These density-distance decay models, and others that employ additional parameters representing landuse planning impacts on the conversion process or the relative sizes of the urban places under consideration, all treat land availability as the factor which serves to limit urban growth and do not consider other important factors such as regional economic development or water availability (Furuseth and Pierce 1982). Similarly, work in rural sociology and agricultural geography devoted to the issue of agricultural landuse has tended to focus more on large-scale forces (i.e., technological change, farm capitalization, and land rent) that can influence farm structure and labor (Albrecht and Murdock 1990; Bowler 1992; Buttel and Newby 1980; Ilbery 1985; Lobao 1990; Molnar 1986) than upon more local factors of production.

The inattention paid to water availability as a constraint on urban/suburban land conversion, or to water transfers as a factor that promotes agricultural land conversion at the urban fringe or elsewhere, is probably a product of timing and scale. The period of peak interest in landuse conversion studies seems to have come at least a decade in advance of that corresponding to third-party effects of water marketing. Also, water availability varies locally and regionally and its impact on agriculture and other landuse concerns is difficult to assess and synthesize across broader landscapes. It is also related to the fact that the relationship between water and land in the realm of agriculture is a complex one with advances in pumping and irrigation technologies and the utilization of new supplies of water tending to offset losses of cultivable lands (Greene and Harlin

1995). Nonetheless, with full appropriation of fresh surface and ground water resources a strong probability facing those areas of the West which have not yet reached this stage, it will be difficult to offset continued losses of prime farmlands with further expansions of the agricultural land base.

3.2.1 Economic Impacts

Probably more has been written about the potential economic impacts related to water marketing in the West than about other third-party effects. These impacts can include those exerted on the tax bases of the exporting region (or area of origin), the retirement of agricultural lands, reductions in farm and agricultural processing employment, and impacts on local businesses that provide essential goods and services to agricultural communities (Colby 1992; Nunn 1987). The majority of authors have addressed the more general potential economic impacts that *can* occur given the various concepts and vagaries of western water law; fewer have devoted their research to the identification and characterization of real or perceived impacts.

The most recent example of the latter is a case study by Howitt (1993) which documented direct and third-party economic effects of water transfers made through California's 1991 Drought Water Bank within Yolo and Solano Counties of the Central Valley. The Bank purchased irrigation water from farmers in these and other northern California counties, and in turn marketed this to higher-value uses elsewhere within reach of the State Water Project after return flow and other requirements had been satisfied. The two counties supplied some 196,252 af of water to the 1991 Bank (approximately one fourth of the total), and purchased 211,309 af, thus together they were net importers of water (Coppock and Kreith 1993:11). Additionally, a pool of some 15,000 af of water was made available for intra-county transfers through the Solano County Emergency Water Pool administered by the County Water Agency.

While statewide fallowing contracts involving the resting of lands irrigated with surface waters represented approximately 51 percent of the Bank's total supply (with storage water and groundwater exchanges or substitutions representing 17 and 32 percent, respectively), the corresponding proportion of fallowing contracts in the two counties was closer to 75 percent (followed by groundwater exchanges with 20 to 25 percent) (Coppock and Kreith 1993:11). The Solano Pool relied entirely upon fallowing contracts.

Aside from the Solano Pool contracts which were clustered in the north-central portion of Solano County, the areas affected by transfers were spatially restricted to a zone of approximately 15 by 35 miles adjacent to the City of Sacramento and the Sacramento River, which forms the eastern boundary of both counties. This owes to the dependence of the Bank on state and federal project waters. Groundwater exchanges were limited to Yolo county.

Howitt's study utilized survey data and farm production and county input-output models to quantify and model impacts of transfer activity on individual farms and on county employment and income - particularly that related to agricultural employment (farm and non-farm), production, and related industries within the two counties. Potential impacts resulting from two alternative future policy paths were also modeled. These policy paths were represented by two scenarios: a "restricted market scenario" in which the market restricted to 15 percent of available surface waters within agricultural production subregions delineated for each county, and a free market scenario in which all agricultural lands but those contributing to grain production for waterfowl feeding were included.

The modeling results and farmer survey data both indicated that net farm profits increased as a result of participation in the programs, leading Howitt to conclude that "[a]lmost all farmers in Solano and Yolo Counties who sold water were financially better off as a result of the 1991 water transfers..." With respect to third-party effects visited upon other agriculturalists, the survey data indicated that "[e]xcept for impacts on groundwater...other farmers were not hurt" (1993:42). Agriculturally related income in the counties suffered losses of 3.5 to 5 percent of total, though agribusiness generally felt that it had not been much affected with respect to both sales and income. Though Howitt observed that the economic third-party effects of the program were relatively small, he did note (and without explanation) that they "were excessively concentrated in particular geographical areas" (1993:42). These areas were almost certainly those corresponding to those in which transfers were clustered. Lastly, the modeling of future policy alternatives revealed that "completely free sales...could lead to substantial third-party costs, both in jobs and in income" (1993:42).

Howitt's study is instructive in that the more immediate direct and indirect (i.e., third-party) effects related to the implementation of a statewide water reallocation strategy are revealed. While the effects were minimal, the results are best considered in the context of the temporary nature of the program - minimal effects could become significant given repeated operation of the same or a similar program should water availability conditions warrant. And the implications for permanent transfers in this or a similar setting are perhaps more significant yet. Lastly, while the study documented the spatial extent of transfer contracts established in sub-county level agricultural production regions, the data were not related to any geographic factors or any inherent characteristics of water rights.

As a part of their larger study documenting water market activity in Texas' Lower Rio Grande Valley, Chang and Griffin (1992) conducted a limited cost-benefit analysis of agricultural-to-municipal transactions to determine the magnitude of direct impacts on farmers and the extent to which they were offset by municipal gains. A representative sample of eight transactions (absolute sales as opposed to leases) involving surface irrigation waters occurring during the period 1981-1985 were selected for this analysis. The agricultural value of irrigation water as applied to cotton (the predominant crop in the area) was compared with the net present value of that water as an urban supply increment. This latter value was calculated as a consumer surplus measure that is sensitive to population growth and demand elasticity, and the data utilized to derive these statistics came from a comprehensive community water demand and allocation study conducted for some 221 Texas communities.

The results of the analyses indicated that while agricultural costs ranged from $249 to $1,894 per 1000 cubic meters (approximately 0.82 af) of transferred water for the eight different transactions, municipal benefits ranged from $5,000 to $17,000 for the same quantities. Selling prices and transactions costs aside, the authors note that municipal benefits clearly outweigh agricultural opportunity costs especially given that some of the involved water rights were underutilized and even in danger of being canceled (Chang and Griffin 1992:889).

While this study lends credibility to the assertion that water generates higher returns when it is allocated to higher uses, third-party effects of any nature were virtually ignored by these authors who instead implicitly assumed that these would be largely absent. This is due to the correlative nature of water rights (i.e., lack of a system of seniority) in their study area and to the fact that half of the water rights examined in this portion of their study had already been disassociated with agricultural activity. Their overall findings regarding the high frequency of transfer activity in a region whose primary mode of economic production is related to agriculture, however, suggest that economic impacts of water marketing in the Lower Rio Grande basin of Texas might indeed be significant. Consideration of actual farm production and economic data for the larger set of transfer data, and of the economic dynamics of cotton and other crop production systems in the study area, would begin to reveal the extent and significance of these impacts.

3.2.2 Environmental Impacts

Third-party effects or impacts that are environmental in nature might include hydrologic effects, effects on aquatic and/or wetland ecosystems, and the loss or conversion of agricultural lands which may either be abandoned and left fallow in arid and semi-arid environments thus potentially generating additional economic impacts or which are converted to non-agricultural uses (Nunn 1987; Root 1993). To date, studies of environmental impacts have focused on the latter type of these impacts and include those of Karpisak (1980), the 1991 Drought Water Bank study (documented by McBean 1993), and Census of Agriculture reports prepared by the Colorado Department of Agriculture (U.S. Department of Commerce 1959-1974) [Brown et al. 1982].

In a study focused on patterns and trends in ecological succession on irrigated agricultural lands abandoned because of economic factors and also through urban purchases of water by the City of Tucson, Arizona, Karpicsak (1980) found that such lands are quickly colonized by native and introduced noxious plant species. Using airphoto analysis and field survey techniques, he found that *Salsola kali* (Russian Thistle or tumbleweed) generally becomes dominant on newly abandoned lands to the exclusion of other species, and is gradually replaced after several years by other weed and grass species. Bulk soil densities and soil surface crust strength on these lands were also found to increase over time.

It has been inferred from Karpicsak's findings that during the first 2-3 years following abandonment conditions are such that abandoned farm lands in this desert environment have the potential to generate third-party economic impacts on adjacent landowners and generally depress real estate values because of problems associated with blowing dust and tumbleweed (Meitl et al. 1983; Nunn 1987). Inferences aside, this study's results and the general perception of a nuisance problem were responsible to some extent for the development of statutes requiring the maintenance of abandoned agricultural lands in south-central Arizona. The relative significance of such impacts, however, must be compared to similar conditions that are generated from lands which are either in a more natural state or which have been subjected to disturbance of some sort.

The 1991 Drought Water Bank transfers had the effect of idling significant amounts of irrigated farmland. The decreases in irrigated acreage were within the range of annual average variation for Yolo County, but outside the normal range for Solano County (McBean 1993). While the transfers were of a temporary nature, it is not unlikely that third-party environmental impacts occurred though these were not addressed by the Drought Water Bank Study. Again it must be stressed that the results of this study might be expected to differ considerably from those of a longer-term study conducted in a region in which water marketing is an established reallocation policy.

The Colorado Census of Agriculture reports documented changes in various agricultural land uses including irrigated and non-irrigated agriculture. These censuses estimated that during the period 1959-1974, some 55,000 acres of irrigated farmland were converted to other uses in the Denver Metropolitan region, though this reduction in irrigated acreage was offset by gains in the plains counties situated in the South Platte River basin and adjoining areas made possible in part by increased use of the Ogllala aquifer underlying this region. Such information, while useful for many purposes, sheds little light on the sub-county fragmentation of agricultural lands given the fact that data are aggregated at the county level and represent unvalidated estimates. Similarly, it provides little information on specific impacts that might be associated with farm land idling and conversion in this area.

3.2.3 Sociocultural Impacts

Sociocultural impacts resulting from water right transfers, though they are often intimately linked to economic impacts, are more difficult to define, measure, and quantify. This is because they can involve diverse social institutions, ranging from the family to a collective regional identity, and the values implicit within. Accordingly, perceived sociocultural impacts often engender considerably more controversy and opposition than do perceived economic impacts. *Sleeper* serves as a good example of this phenomenon, as does the example provided by Rivera (1996).

Studies that have focused on actual and perceived sociocultural impacts include those conducted by Brown and Ingram (1987), the Bureau of applied Research in Anthropology (1984), and Vandemoer and Peters (1984).[28] Using the results of a non-randomized but highly structured survey of 98 leaders of rural and agricultural Hispano communities of five northern New Mexico Counties in the Upper Rio Grande basin, Brown and Ingram (1987) found that 79 percent of the respondents felt that the members of their communities were opposed to water right sales because they would erode the social fabric maintaining these communities. Furthermore, they found that the residents of such communities generally lack the information required to effectively participate in decision-making forums.

The studies conducted by the Bureau of Applied Research in Anthropology [BARA] (1984) and Vandemoer and Peters (1984) were surveys of Tohono O'odham preference regarding water and landuse/development issues on reservation lands in southern Arizona. The BARA study employed stratified random sampling to identify 147 individuals which were then interviewed by trained Tohono O'odham interviewers, whereas the other utilized a more unconventional method which entailed the administration of an open-ended questionnaire to participants in tribal council meetings; the responses were those of the council. The results of these surveys were generally in agreement and indicate

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[28] The studies conducted by the Bureau of Applied Research in Anthropology (i.e., *Socio-Cultural Impact Assessment of the San Xavier Planned Community.* Tucson: University of Arizona. 1984.) and Vandemoer and Peters (i.e., Vandemoer, C., and Peters, R. 1984. *Indigenous Response to Water in an Arid Environment: A Papago Case Study.* Tucson: John Muir Institute for Environmental Studies.) are summarized in Brown and Ingram (1987).

that more traditional Tohono O'odham have stronger attachments to their people's land and water than do those who have more contact with the dominant Euro-American society. Of special interest is the relatively strong support expressed for the expansion of agriculture on tribal lands (Brown and Ingram 1987). The findings of Brown and Ingram regarding participation in decision-making were mirrored by those of BARA. Regardless of their methodologies, these examples demonstrate that water and land resources embody deep cultural values among groups that have long histories in the southwest. Similar results might be expected from other culture groups and sub-cultures that are either indigenous, rural, marginalized, and/or agriculturally oriented.

3.3 Discussion

This review of the relevant literature shows that there are significant differences in state policy that affect the transferability and marketability of water rights in the West. A broad range of transfer mechanisms are utilized to effect transfers in western states, however, the specific mechanisms and the conditions that are often imposed upon transfers are highly context specific. This certainly has an influence on relative market activity in the states, and upon the potential for the generation of third-party impacts.

The literature shows that water right transfers and marketing clearly has the potential to generate a host of third-party impacts which are often related to one another. And while the majority of authors writing about third-party impacts have chosen to deal with them as issues for discussion rather than areas for investigation, their work should be lauded for its breadth, scope, and intent. However, their work must be seen as being more hypothetical and conjectural given that it is not well supported by substantive research into the nature, extent, and pervasiveness of third-party impacts.

Of the comparatively fewer studies that have dealt with this subject matter, few have been either comprehensive with regard to design or longitudinal in nature. Those seeking to answer specific questions related to third-party impacts were very narrowly focused and have little applicability outside of the specific context in which they were conducted. Those employing more of a longitudinal approach either did not consider spatial patterns of such impacts or were not comprehensive with regard to the identification, classification, and quantification of impacts. Furthermore, none of the studies, excepting the 1991 Drought Water Bank Study, have focused on landuse impacts occurring at the local or sub-county level.

Research focusing on geographic and other factors that influence water marketing activity, and on spatial and temporal patterns of landuse change associated with water right transfers is clearly warranted. Such research should be conducted across a continuum of spatial scales from the agricultural field to the whole basin in order to identify any patterns associated with transfers and their potential impacts.

4. THE STUDY REGION

New Mexico's Rio Grande basin has been selected as a study area for the following reasons. First, Nunn's (1990) study and the work of Saliba and Bush (1987) show that a relatively large amount of water market activity involving permanent transfers of water rights between separate parties has occurred here. This is due to a state of full appropriation of the surface water resources of the basin (De Young 1994), to the state of effective full appropriation of the basin's groundwater resources (i.e., withdrawals equal or exceed recharge), and to the rapid rates of growth and development that certain portions of the basin are experiencing. Second, a significant portion of the basin is ethnically quite diverse with Anglo-American, Hispano, and Native American groups predominating. Each of these groups experiences different sociocultural dynamics and has different perceptions regarding the economic, aesthetic, and cultural values of water. And while overt conflict between these groups over proposed water right transfers has been limited to several particular cases, it is certainly more pervasive and intense than appears on the surface. Third, this state's centralized system of water right administration, which vests the SEO with authority to authorize and approve appropriations and transfers of water, facilitates a review of transfers. And lastly, the context specific nature of water markets in the West suggests that the isolation of this specific basin as a case study will allow the identification of factors that are associated with market activity.

A number of other states or portions of such might have been selected as candidates for study given their reliance on water marketing as a reallocative mechanism. Arizona was considered for study particularly given its high level of water market activity and the presence of different and sometimes competing cultural groups, however, this state's market and water code have been greatly influenced by the introduction of the CAP waters. Colorado was also considered for the same reasons, however, its reliance on district water courts as decision forums for water resources administration would vastly complicate such a task. The markets of other places are limited in one or more aspects including: levels of market activity, devotion to special purposes, and their often temporary nature. New Mexico has clearly emerged as the top candidate for a study focused on spatial and temporal patterns of water right transfers, and the factors associated with them.

4.1 Physical Geography

Though it heads in southern Colorado's Hinsdale County, the Upper Rio Grande (i.e., the portion of the river upstream of the United States' border with Mexico) is largely confined to central New Mexico (Figure 4.1). Within this state, the river flows through two distinct physical/cultural regions historically delineated by the early Spanish colonists: the Rio Arriba or Upper River, and the Rio Abajo or Lower River. The Rio Arriba is comprised approximately of Taos, Rio Arriba, Los Alamos, and Santa Fe Counties, and meets with the Rio Abajo at La Bajada ("the descent") near Santa Fe (Pearce 1965:80). Carlson (1990:4) alternatively defines the Rio Arriba as extending to present day Albuquerque, however, Pearce's definition is utilized here because it is more accurate topographically and for reasons having to do with the administration of water rights within the basin. Because it heads in Colorado, the river is exotic to New Mexico and receives water from several important tributaries in northern New Mexico's Rio Arriba including: the Red River, the Rio Pueblo de Taos, Rio Chama, Rio Santa Cruz, and Rio Pojoaque (i.e., the Nambe/Pojoaque/Tesuque basin). One additional tributary of significance, the Jemez River, contributes to the river in the Rio Abajo just north of the city of Albuquerque but is split between the two sub-regions. The river and these tributaries all drain from the slopes of the San Juan and Sangre de Cristo Ranges which are the southern-most extensions of the Rocky Mountain Physiographic region or province (Dick-Peddie 1993).

Much of the length of the Rio Grande and its New Mexico tributaries actually flow through and/or across the Lower Basin and Range physiographic region of the American Southwest. Within the Rio Arriba, the river itself is largely confined to inaccessible gorges (including the "Taos Box" and Otowi Gorge) carved from volcanic and sedimentary deposits which underlie the plateaus bounded on the east and west by the San Juan and Sangre de Cristo Ranges. Owing to this topography, it is along the tributaries and at the confluence of the Rio Grande and Rio Chama that earliest human use of the river occurred with the establishment of the Native American Pueblos. Early settlement and utilization of the river occurred again where the river emerges into the Rio Abajo at La Bajada.

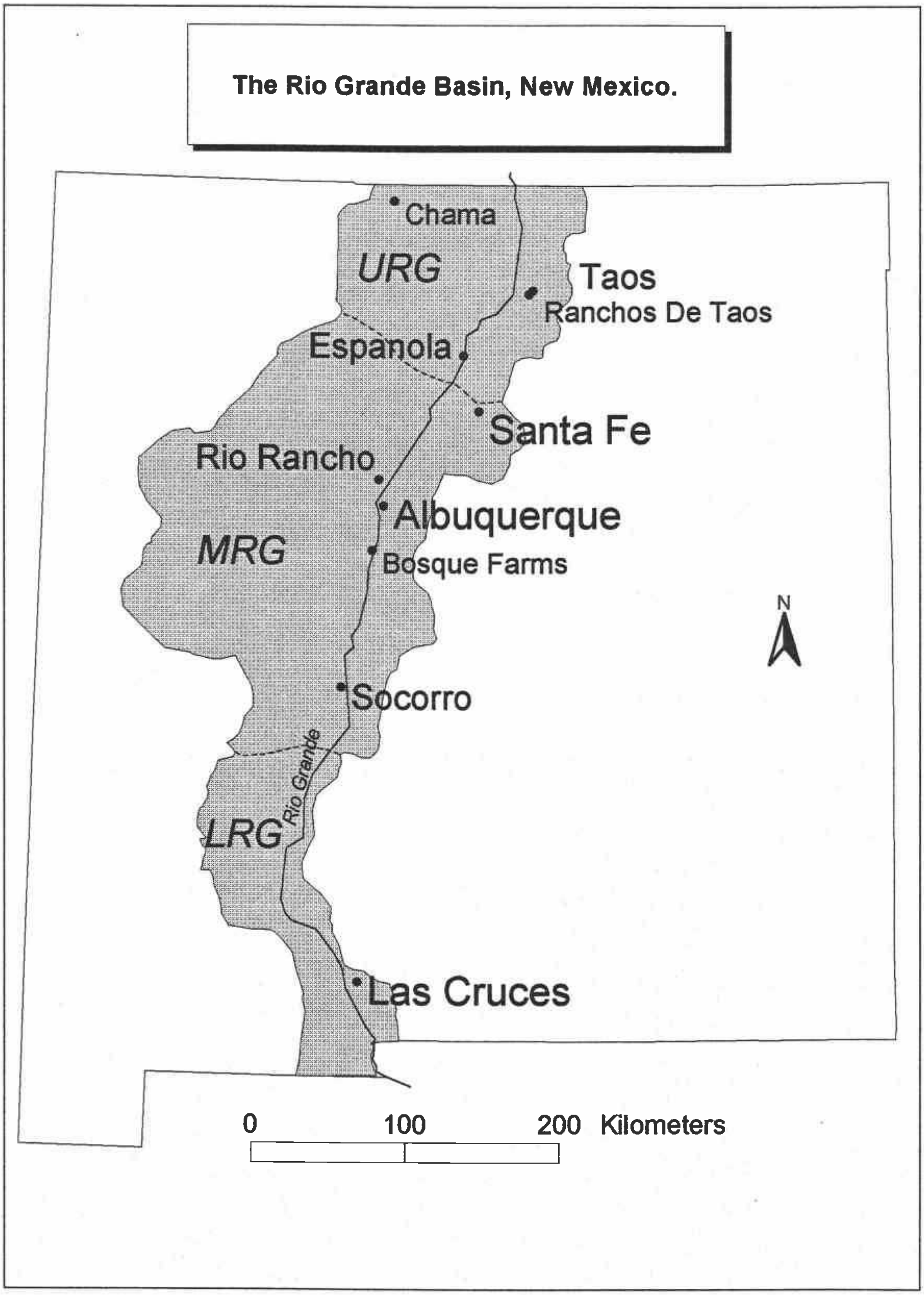

Figure 4.1. The study area: New Mexico's Rio Grande basin.

These Pueblos were situated within the Rio Grande Rift as far south as Isleta to the south of Albuquerque (this area corresponding roughly to the Rio Abajo).

The hydrographic arrangement of the river and its tributaries has much to do with the arid and semiarid climates associated with the non-montane portions of the basin. Climate station data (1961-1990) for representative stations within the study area show the influence of latitude and elevation. Köppen climate classifications for these stations are as follows: the Village of Chama along the upper reaches of the Rio Chama is humid continental with no dry season, Santa Fe has a mid-latitude cold steppe climate, Albuquerque has a mid-latitude hot steppe climate, and El Paso at the southern end of the study area has a subtropical desert climate type. Except for the classification corresponding to Chama, these are generally in agreement with Trewartha's (1957) map of climatic regions of the world.

The climate data show that, except for Chama which receives relatively even amounts of precipitation year round, the bulk of precipitation in the study area occurs during the summer months when air masses originating in the Gulf of Mexico penetrate into the region and deliver their moisture during often intense rainfall events. Notwithstanding this Gulf influence, Thornthwaite water balances calculated for both Santa Fe and Chama (Figures 4.2 and 4.3) show marked water deficits which correspond to the growing season - a fact not lost on the original nor subsequent settlers of the basin.

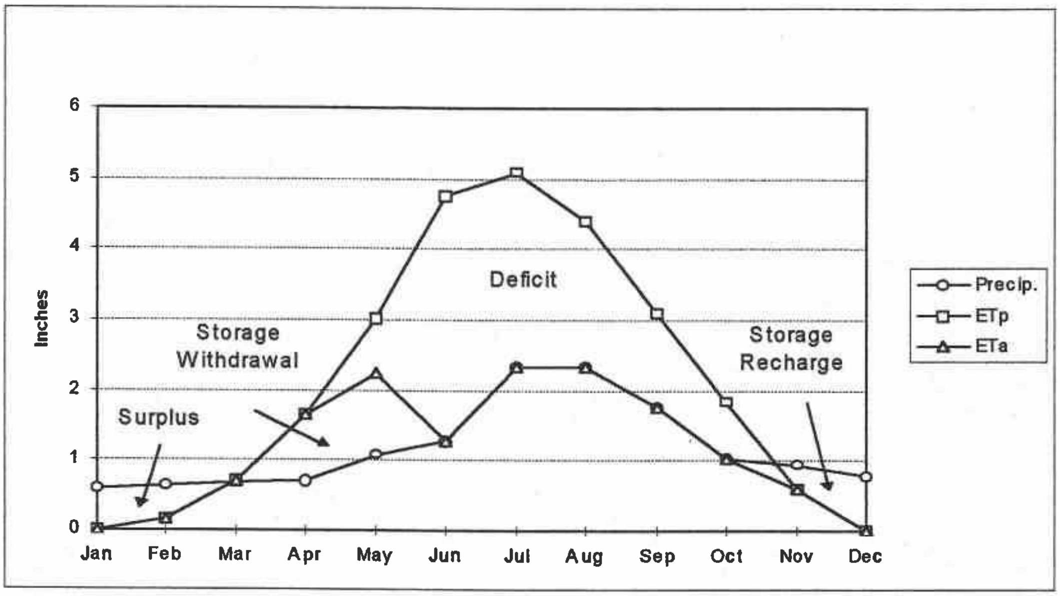

Figure 4.2. Thornthwaite water balance for Santa Fe, New Mexico (1961-90 data).

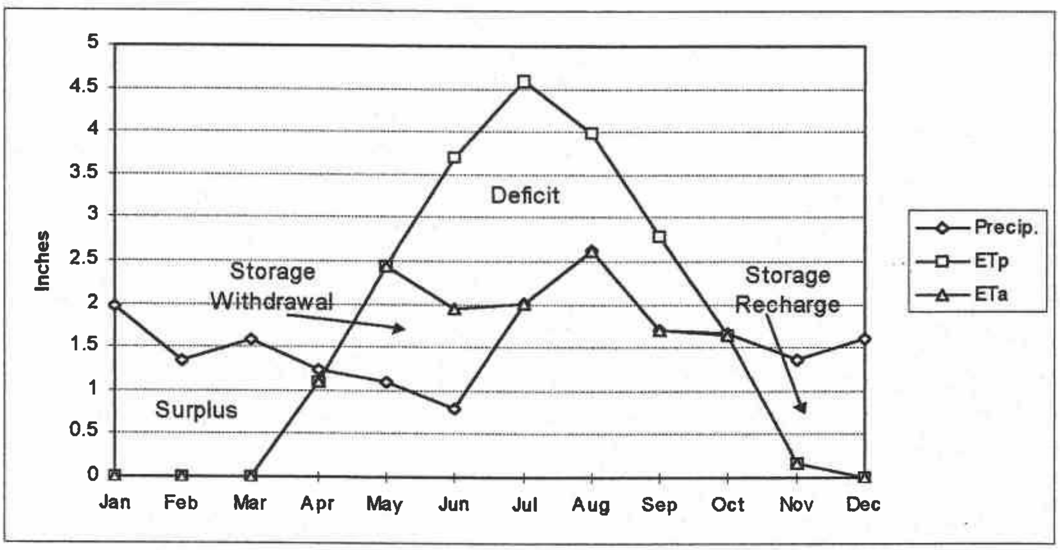

Figure 4.3. Thornthwaite water balance for Chama, New Mexico (1961-90 data).

Table 4.1. Vegetation types occurring in the Rio Grande basin. (Source: Dick-Peddie 1993)

Vegetation Type (In Approximate Order of Dominance)
Desert Grassland
Plains-Mesa Sand Scrub
Chihuahuan Desert Scrub
Great Basin Desert Scrub
Juniper Savanna (ecotone)
Coniferous and Mixed Woodland
Montane Coniferous Forest
Subalpine Coniferous Forest
Plains-Mesa Grassland
Montane Grassland
Montane Scrub
Closed Basin Scrub
Alpine Tundra
Riparian Vegetation (unmapped)

Patterns of natural vegetation in the basin are determined by variations in physiography and climate. Each of the major vegetation types occurring in New Mexico as identified by Dick-Peddie (1993) and listed in Table 4.1 occurs to some extent within the basin, though the desert scrub and grassland types predominate. Today's pattern of vegetation in the basin is probably not much different than that which existed at the time of Spanish settlement in the region in 1598 except for a marked reduction in the occurrence of the more economically valuable vegetation. In reviewing historic vegetation change in the state, Dick-Peddie (1993:20) observed that it is the grassland, forest, and riparian vegetation types whose occurrence have been most affected by the action of humans.

The vegetation type of perhaps the greatest significance in the study area is the Rio Grande Bosque, or the Cottonwood riparian gallery forest, that lines the river where it is unconfined by canyon or gorge walls. Often representing the most easily accessible source of wood for construction, fuel, and other purposes, this linear forest was heavily utilized by Spanish and Mexican colonists, and later by American settlers. It was most heavily impacted, however, by the regulation of the flows of the Rio Grande and Rio Chama, and by drainage and clearance activities related to the expansion of agriculture in the middle portion of the basin between Cochiti and Elephant Butte Reservoirs (Dick-Peddie 1993; DuMars and Nunn 1993; Scurlock 1988). Flow regulation has limited the reproductive success of the historic climax species, the Fremont Cottonwood (*Populus fremontii*), and allowed succession by two highly competitive introduced shrub-trees, the Salt Cedar (*Tamarix* spp.) and the Russian Olive (*Elaeagnus angustifolia*) (Dick-Peddie 1993:151). These conditions have had similarly negative repercussions for other selective and sensitive plant and animal species within the basin (McDaniel 1996; Western Network 1995).

4.2 Human Geography

The cultural landscape of New Mexico's Rio Grande basin is one of sequent occupance. Though human tenure in the study region dates to pre-Pueblo times (circa 1300 AD), it was the advent of Pueblo society which brought a hydraulic legacy to the area. Most probably representing a fusion of local and Anasazi cultures, the Rio Grande Pueblo peoples were well established agriculturalists by the time of the Coronado expedition of 1540-1542. Clark (1987) observes that though the Coronado party noted the mix of crops cultivated by the Pueblo peoples they came into contact with (maize, beans, melons and squashes), it was not until the Espejo expedition came into the area some forty years later that the practice of canal/ditch irrigation by the Pueblos was first documented. Also documented by both expeditions was the extreme reverence in which water was held by these people as a basic element of life.

The first and second Spanish colonizations in the Rio Grande basin[29] brought Spanish-Moorish customs and attitudes regarding the utilization of water for agriculture and settlement in semi-arid environments, and these were in essence very similar to those of the Pueblos already residing there. Though dependent upon an immense body of law which governed the settlement and administration of Spanish colonies in the New World, Spanish customs regarding water use in the New Mexico colony essentially treated water and diversion works as community property much like the ejidos which made up the majority of the grants or *mercedes* issued by the crown and its representatives (Clark 1987; Ebright 1987; Van Ness 1987). The same was true, to some extent, for diversion works such as the *acequia madres* (main or mother ditches) and other major community canals which supplied water to smaller acequias for irrigation and other purposes.

Though the details, specifics, and actual practices of the establishment and settlement of the mercedes differed from place to place within New Mexico, two characteristic patterns of Spanish settlement became established (Ebright 1987;

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[29] The first occupation began in 1598 and was terminated in 1680 by the Pueblo Revolt. The second occupation began about 1690.

Nostrand 1987). The first and most spatially dominant is that of the *rancho*, a settlement consisting of dispersed homesites and irrigable tracts (*suertes*) generally situated along natural waterways and acequias. The settlements at Santa Fe, Ranchos de Albuquerque, and Ranchos de Taos are all based on this model. The other type, the *plaza*-based settlement consisting of a large rectangular plaza of adjoining apartments lacking windows to the outside, was considerably more centralized and defensible and came into favor following the Pueblo Revolt. Two existing and functioning examples of plaza communities in the Rio Arriba include Chimayó and Truchas.

Whichever the type, colonial Hispano settlements situated in the study area generally shared aspects of situation and spatial arrangement (Carlson 1990). Like the antecedent Native American Pueblos, they were situated along floodplains or bottomlands of the Rio Grande and its tributaries to take advantage of alluvial soils and surface water for crop production. This practice was later followed by Hispano settlers in the public domain lands of the Rio Abajo following the Treaty of Guadalupe Hidalgo (Wilson 1988). The suertes corresponding to the various settlements also had a characteristic long-lot configuration primarily to ensure access to the acequias providing water for irrigation. This pattern of landuse is still very much in evidence in the study area, as is demonstrated by Figure 4.4.

Even following the Treaty of Guadalupe Hidalgo (1848), the settlement of Anglo-Americans, the subsequent expropriation of the ejidos and other private lands corresponding to the mercedes, and the coming of post-industrial society, the

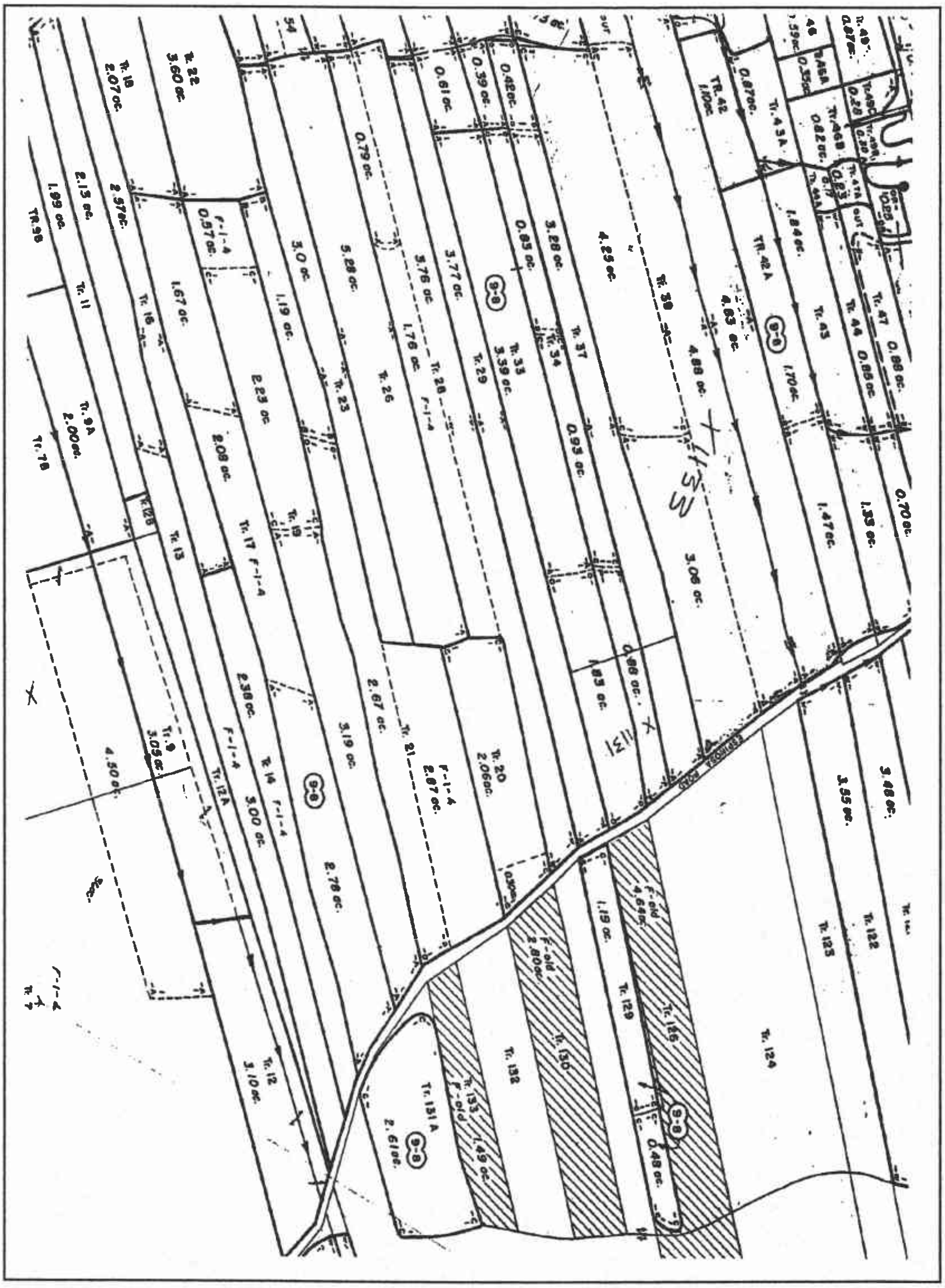


Figure 4.4. Long-lots or suertes. (Source: Rio Grande del Rancho Hydrographic Survey Sheet 1.9, New Mexico SEO.)

community acequia systems of New Mexico's Hispano settlements remain important symbols of community to their residents (Brown and Ingram 1987; Clark 1964; Rodríguez 1987). Though the administration of their waters ostensibly falls under the purview of the Office of the State Engineer, legislation enacted in 1903 led to the establishment of two different models of acequia administration. One relies on the traditional role of the *Majordomo* or ditch administrator, and another more modern model relies on corporatization of the ditches and their administration by Ditch Commissioners (Clark 1987).

The topographic and climatic constraints on extensive agricultural development in the Rio Arriba predisposed this region to be one whose agriculture is dominated by smaller-scale agricultural systems. Using indices and data for 1969-1982 to characterize agricultural systems at the county level for the contiguous United States, Lobao (1990:98) has shown that the Rio Arriba is dominated by smaller family farms as opposed to larger family or industrialized farming operations. Also, owing to a number of factors which include relatively small agricultural tracts and individual land holdings, farming in this region is generally a part-time endeavor (Brown and Ingram 1987:53). The more agriculturally friendly Rio Abajo (i.e., favorable topography, climate, soils, land divisions), however, tends more toward larger-family farming. The southernmost portion of the study area, centered on Las Cruces and including Sierra and Dona Ana Counties, is characterized by more industrialized agriculture (Lobao 1990).

Though the human geography of the Rio Arriba is clearly a rich one owing to the presence of two culture groups with relatively long tenures in the region which is strongly expressed through the cultural landscape, many of the region's inhabitants experience rates of economic poverty and deprivation that are

Table 4.2. County-level socioeconomic statistics for study area. (Source: School District Data Book 1998)

County	Percent Urban	Percent White	Percent Hispanic[1]	Percent Native Amer.[2]	Median Hsehold Income	Percent in Poverty[3]	Percent Children in Pov.
Los Alamos	97.22	85.87	10.67	0.85	54,801	2.39	3.10
Rio Arriba	24.27	12.98	72.36	14.17	18,373	27.27	33.20
Santa Fe	72.01	47.34	49.19	2.21	29,403	12.70	15.98
Taos	17.58	26.82	65.71	6.67	16,966	27.40	33.07
Bern-alillo	95.60	55.96	36.86	2.96	27,382	14.33	19.78
Sandoval	72.66	51.18	27.63	19.28	28,950	15.56	19.88
Valencia	67.52	45.46	50.16	3.04	24,312	18.32	24.93
Dona Ana	73.95	40.61	56.32	0.61	21,856	25.59	35.10
Sierra	62.39	74.99	23.89	0.81	15,612	18.99	26.02
Soccoro	55.10	39.54	48.65	9.29	19,165	29.00	34.68
New Mexico	72.92	50.55	38.06	8.49	24,087	20.19	27.17
USA	75.21	75.76	8.81	0.75	30,056	12.76	17.84

[1]For the United States, this racial category can include persons with cultural heritage different than that which predominates in the study area.
[2]For the United States, this category includes persons who are either Eskimo (Inuit) or Aleut.
[3]The poverty threshold level for a family of four in 1989 was $12,674. This level is not adjusted for regional, state, and/or local variability in cost of living.

unequalled elsewhere in the state and in the majority of the West. Brown and Ingram (1987) have noted that it is especially the Hispano population within this region that experiences lower income levels and higher rates of poverty. Table 4.2 presents socioeconomic data for New Mexico counties falling within the study area that are derived from the 1990 Census of Population and Housing and the School District Special Tabulation (Bureau of the Census 1998a). The county data are grouped into the two historic subregions (the Rio Arriba and Rio Abajo) and an additonal sub-region (the Lower Rio Grande basin extending from Elephant Butte Reservoir to El Paso) of the larger study area, and statistics corresponding to the State of New Mexico and the United States are included for the sake of comparison.

Notwithstanding potential inaccuracies due to overgeneralization and the occurrence of an extreme outlier (i.e., Los Alamos County whose socioeconomic situation is largely determined by federal research and development spending at the Los Alamos National Laboratory) the data suggest fairly strong correlations between Percent Hispanic, Percent Urban, and Percent in Poverty for both the Rio Arriba and Lower basin areas. Brown and Ingram's assertion that the more rural Hispano counties of New Mexico's portion of the basin tend toward greater poverty than other areas does indeed seem to be a valid one, and one that can certainly be extended to the Lower basin counties as well.

Though the socioeconomic situation of the more rural Hispano counties has numerous causes and far-reaching implications, it is of more immediate significance to this study with regard to the issue of third-party effects of water right transfers and the expropriation of cultural and economic resources. Indeed, this is the basic issue which underlies *Sleeper* and the other legal cases and transfer protests discussed previously. It also has some methodological implications, namely that the identification and measurement of sociocultural third-party effects of water right transfers visited upon an already impoverished and/or disadvantaged population presents a dilemma which is like that of the horse and the cart. In the first place, it is difficult to measure such effects without detailed survey data corresponding to a very specific population. Secondly, assuming that such data can be collected, can such effects be differentiated from other larger-scale structural effects of economic development in the region and nation? And lastly, what is the level at which this particular population is subjected to the effects of water marketing? It may be that the population and/or its spatial territory is either disproportionately targeted or avoided by those seeking to acquire new rights to water.

Physiographic differences and differences in the structure of agriculture in these portions of the study region have consequences for cropping patterns. Whereas historically a relatively wide mix of crop types characterized the mountain valleys of the Rio Arriba because of the subsistence nature of agriculture (Weigle 1975), today it is alfalfa, hay, irrigated pasture, and orchard crops that predominate. Dominant crop types in the Rio Abajo include these and vegetable (especially green chile) crops. The southernmost portion of the basin downstream from Elephant Butte Dam and Reservoir corresponds spatially with the Elephant Butte Irrigation District (EBID) and is New Mexico's most important agricultural area.

In 1985 this region produced 70 percent of the state's high-value crops which included alfalfa, pecans, cotton, chile, lettuce, onions, and wheat (Lansford 1989:54).

The ranchos, plazas, acequias, and suertes of colonial New Mexico have, except where they remain spatially isolated by nature of their location within the basin, been largely incorporated into the larger post-industrial American cultural landscape that today is dominated by the modern American urban system. Beginning in the 1940s and continuing to the present, portions of the study area have experienced considerable population growth and development with the entrenchment of military, amenity, and information-based economic activities. This is illustrated for the City of Albuquerque in Figure 4.5. McAda (1996:3) reports that groundwater withdrawals by the City of Albuquerque "increased from about 2,000 [af] in 1933 . . . to about 59,000 [af] in 1970, and to about 123,000 [af] in 1994." This demand, and that of other water users in the Rio Grande basin, together with full appropriation of surface water supplies and a unique body of water law has led to the establishment of an active water rights market within the study area.

Population growth and development in the basin translates into increased water use for a number of non-agricultural purposes. Sub-basin water consumption patterns for 1985 and 1990 are shown in Figures 4.6a-f.

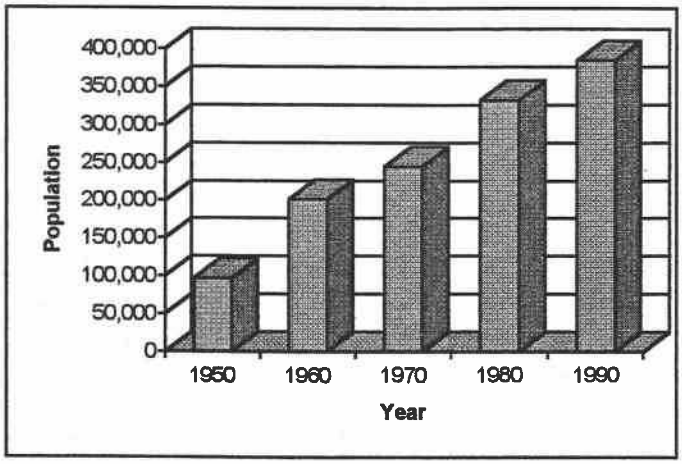
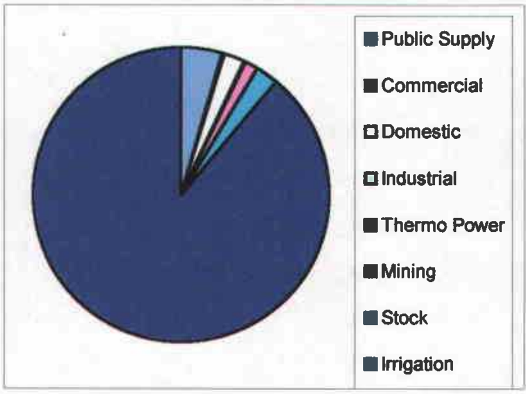
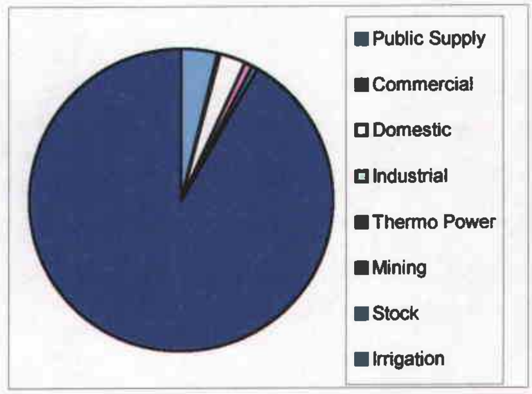


Figure 4.5. City of Albuquerque population, 1950-1990.
(Source: U.S. Bureau of the Census.)

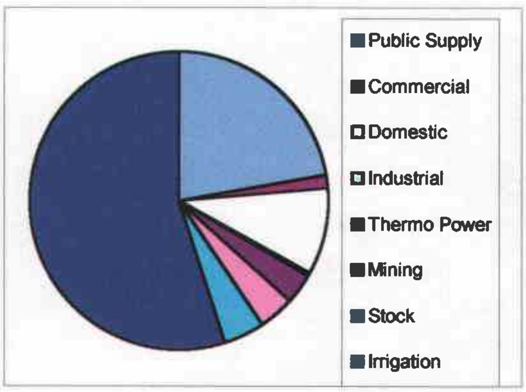
The sub-basins correspond to the delineation presented above in the context of socioeconomic conditions in the study area, and are described more fully in Section 4.3.2. Through the public supply and irrigation categories of water consumption, these figures show different levels of relative development of each of the sub-basins. The Middle Rio Grande sub-basin clearly has the greatest proportion of total water use allocated to public supply (i.e., municipal use), and though the relative proportion of water devoted to this use diminishes from 1985 to 1990, the actual amount increased from 106.67 to 114.78 mgd during this period. The data from which the charts are derived actually show significantly large increases in irrigation from 1985 to 1990, perhaps an effect of economic recovery in this region following the national economic recession of the early and middle 1980s.



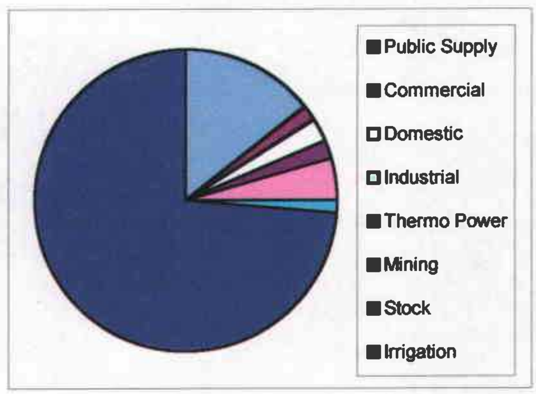
a. Upper Rio Grande sub-basin, 1985.



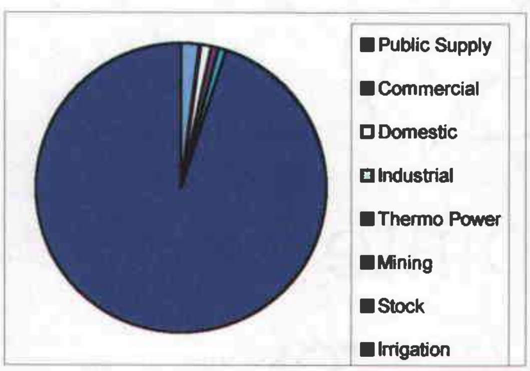
b. Upper Rio Grande sub-basin, 1990.



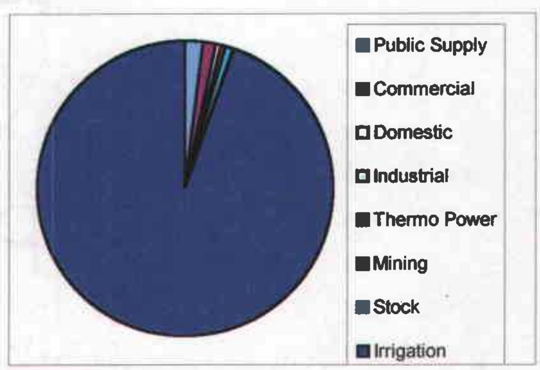
c. Middle Rio Grande sub-basin, 1985.



d. Middle Rio Grande sub-basin, 1990.



e. Lower Rio Grande sub-basin, 1985.



f. Lower Rio Grande sub-basin, 1990.

Figures 4.6a-f. Water consumption in the Rio Grande sub-basins, 1985 and 1990. (Source: U.S. Geological Survey 1996b)

4.3 Water Resources Management

Water resources management in the study area is affected by a number of factors and players which include: interstate and international sharing of water, special projects and districts related to irrigation and/or flood control, federal reserved water rights, and state water institutions and policies. Though these factors and players interact with each other in many and complex ways to provide the mix of water related goods and services enjoyed by the basin's residents, they ultimately have separate missions and agendas which often places them at odds with one another.

4.3.1 Water Institutions

New Mexico follows the prior appropriation doctrine of water rights administration and, aside from the activities of the state's Interstate Stream Commission, which has authority to administer interstate stream compacts and to engage in water resources research and planning activities, the SEO has ultimate responsibility for water rights administration within the state.[30] Additional responsibilities include water resource investigations, dam safety, hydrographic surveys for water rights adjudication, flood mitigation, water well drilling permit administration, and rehabilitation of diversion dams and ditches. The State Engineer also serves as a member of the Rio Grande Compact Commission, and

[30] The activities of the previously mentioned acequia organizations and those of other entities entitled to the use of the public waters of the state must conform to state laws and policies unless otherwise specified.

receives assistance from the Interstate Stream Commission Staff in this task[31] (New Mexico State Engineer Office 1994).

The responsibilities of the SEO pertain only to state waters, however, which do not include state and federal project waters within the basin such as those corresponding to the Middle Rio Grande Conservancy District (MRGCD) and the EBID. These waters are managed by the MRGCD and the U.S. Bureau of Reclamation (BUREC), though the U.S. Army Corps of Engineers (the "Corps") plays a role in flood control in the basin. Coordination of flows for project administration and delivery of water to Mexico as per the terms of the 1906 Convention is primarily the responsibility of the BUREC and is accomplished at Elephant Butte Reservoir (Clark 1987; Eaton and Hurlbut 1992).

The MRGCD represents a unique and important water management institution in the basin and in the broader region. Enabled by New Mexico's 1923 Conservancy Act, the District was established two years later by District Court order for the purpose of engaging in drainage, flood control, and irrigation activities in the middle portion of the basin from Cochiti Reservoir to Bosque del Apache Wildlife Refuge just upstream of Elephant Butte Reservoir. The District's average width is probably less than five miles for its entire length of some 150 miles. A state organization headed by a Board of Directors and Chief Engineer, its

[31] The Rio Grande Compact for the interstate apportionment of the waters of the Rio Grande between Colorado, New Mexico, and Texas was approved by the U.S. Congress in 1939.

operations involve assistance from both the BUREC and the Corps (DuMars and Nunn 1993).

Given its mission, location, and inclusion of the Albuquerque Metropolitan Area, the MRGCD is a major player in the water politics of the basin. Its mission today remains unchanged - drainage, flood control, and irrigation - and to ensure its own survival it is firmly committed to the preservation of its water rights. The exercising of irrigation water rights provides financial assessments to the District's coffers, and the maintenance of these rights and irrigation lands will ensure its long-term survival.

The District holds several types of water rights: perfected state surface water rights (permit No. 0620) existing within the District's boundaries at the time of its creation and which were pooled under an application for a change of point of diversion for the 80,785 acres of corresponding land; permitted state surface rights (permit No. 1690) acquired by the District itself for the irrigation of some 42,482 acres of land; Tribal water rights, not all of which are exercised, for the irrigation of 8,847 acres; and unquantified permitted and non-permitted groundwater rights corresponding to the district and its members; and San Juan/Chama rights[32] for 20,900 afcu of BUREC contract water (DuMars and Nunn 1993:48-50). The

[32] This interbasin diversion represents a portion of New Mexico's share of the apportionment of the Upper Colorado River guaranteed to it by that compact. San Juan/Chama Project water is being utilized to offset new groundwater diversions, especially by municipalities, primarily within the Middle Rio Grande sub-basin (Chavez 1995).

District, like the SEO, must administer its water rights under the parameters of the Rio Grande Compact and the 1906 Convention.

4.3.2 Water Rights Administration

The administration of state water rights in the study area is affected by a number of factors. Chief among these is the state Groundwater Law of 1931 which applied the prior appropriation doctrine to definable underground water basins (declared basins), and the previously mentioned *Templeton* doctrine which recognizes the hydrologic linkage between surface and ground waters (Clark 1987). These laws, together with the ability to close fully appropriated surface and ground water sources from further appropriation, gives the State Engineer broad administrative powers and has led to the interchangability of surface and ground water rights which has greatly facilitated water marketing.

The Rio Grande Surface Water Basin (Figures 4.1 and 4.7) is underlain by the Rio Grande and Lower Rio Grande Declared Underground Water Basins (Figure 4.8). This, plus the administrative division of the surface basin into two sections at the Otowi Bridge gauging station,[33] has created three administrative sub-basins within the larger basin: The Upper Rio Grande (URG) sub-basin extending from the Colorado-New Mexico border to Otowi, the Middle Rio Grande (MRG) sub-basin extending from Otowi to Elephant Butte Dam, and the Lower Rio

[33] Rio Grande flow measurements made at this point are utilized to determine New Mexico's delivery schedule of Rio Grande waters to Texas under terms of the 1938 Rio Grande Compact (Clark 1987; Nunn 1990).

Grande (LRG) sub-basin which extends from Elephant Butte Dam to the New Mexico-Texas border (see Figure 4.1). Water rights within each sub-basin are administered by a different district office of the State Engineer. The main Santa Fe Office administers the Upper sub-basin, the Albuquerque District Office administers the Middle sub-basin, and the Las Cruces District Office the Lower sub-basin. Centralized water right files and records are maintained at the Santa Fe Office.

Owing to location and proximity to different centers of population and commerce, each of the three sub-basins has a different character. The URG sub-basin is roughly coincident with the Rio Arriba (excluding Santa Fe)and includes historic Hispano settlements such as Chama, Chimayó, Española, and Taos, as well as a number of Tewa Pueblos which are culturally distinct from those situated downstream. The Middle sub-basin includes the Albuquerque Metropolitan Area and the growing City of Santa Fe which is the state capital, cultural center, and an internationally important tourism destination. It also fully contains the MRGCD and the Albuquerque Groundwater basin which is a constituent of the larger declared Rio Grande Underground Water Basin. Owing to its lower population density and containment of the EBID, the Lower sub-basin has a distinctly agricultural character and counts the City of Las Cruces as its primary urban place.

Because the surface waters of each of the three sub-basins are effectively fully appropriated, only applications to appropriate groundwater are considered by SEO. In keeping with the practice of offsetting new and/or enlarged groundwater appropriations with retirements of surface water rights established under the *Templeton* Doctrine and tested in *Albuquerque* v. *Reynolds,* applicants must agree to acquire and retire surface water rights whose consumptive use matches the proposed diversion(s) as a condition of approval of their permit application(s). Such retirements are based upon state recognition of the hydrologic linkage between surface and ground waters, and though *Templeton* was concerned with waters in the Pecos River basin of eastern New Mexico, these de facto transfers of water rights have largely been restricted to the MRG sub-basin.

As previously discussed, actual transfer applications (ACPPUs) are reviewed for potential injury to other appropriators and/or to the public interest/welfare. Beginning with the application to increase an appropriation of groundwater for municipal supply that was the subject of *Albuquerque* v. *Reynolds* (1962), the practice of requiring the retirement of surface water rights to offset groundwater appropriations led to the establishment of an abbreviated administrative procedure for water right transfers that was not subjected to the same degree of oversight and scrutiny as actual or legislatively mandated transfer applications.

Termed "dedications" and distinguishable from regular ACPPUs by nature of the absence of public notice and opportunity for protest, these abbreviated transfers (which were utilized only in the MRG sub-basin to meet conditions imposed by the SEO on municipal water right permits and others that are open-ended in that groundwater pumping requirements can be enlarged as deemed

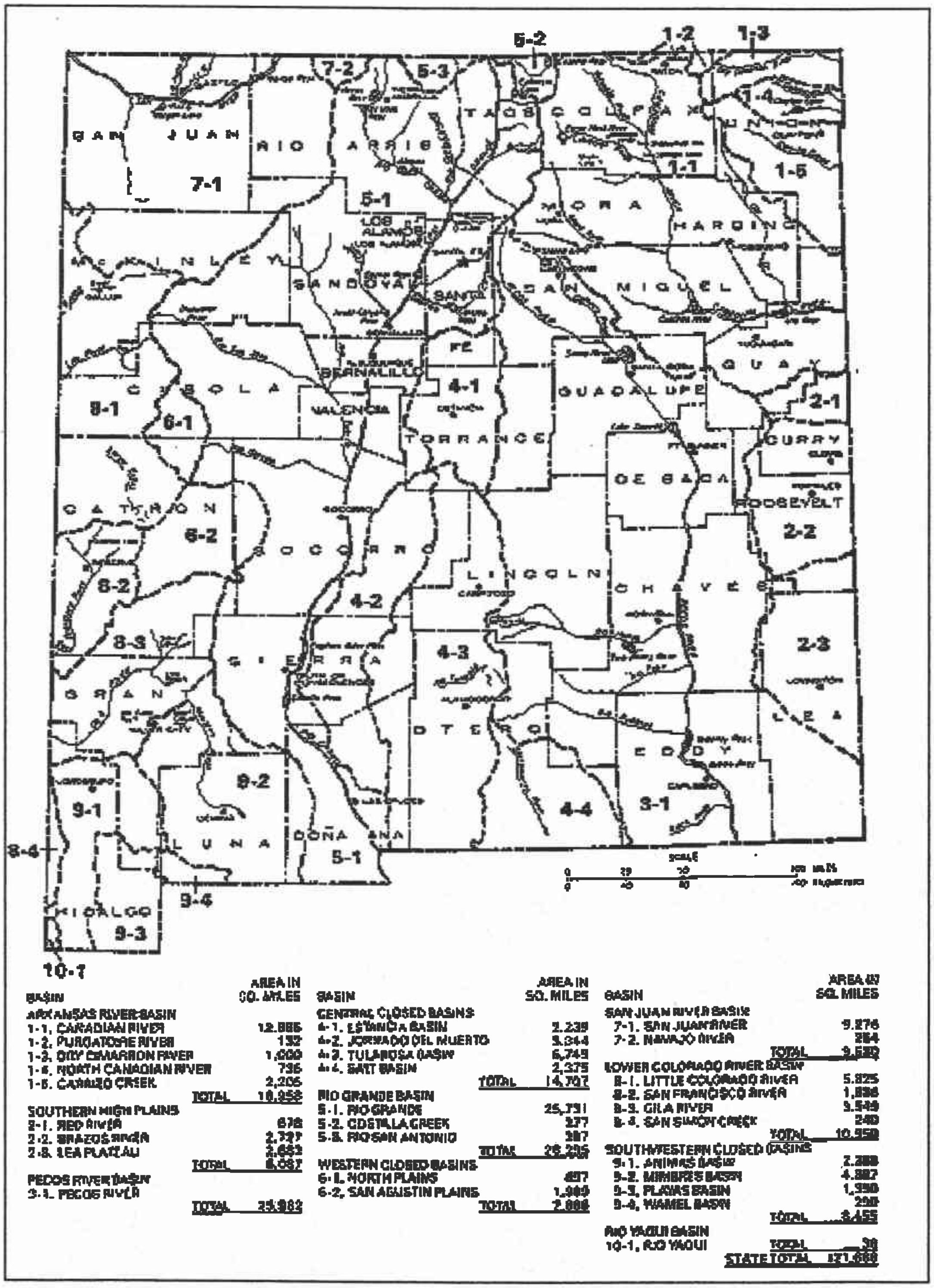
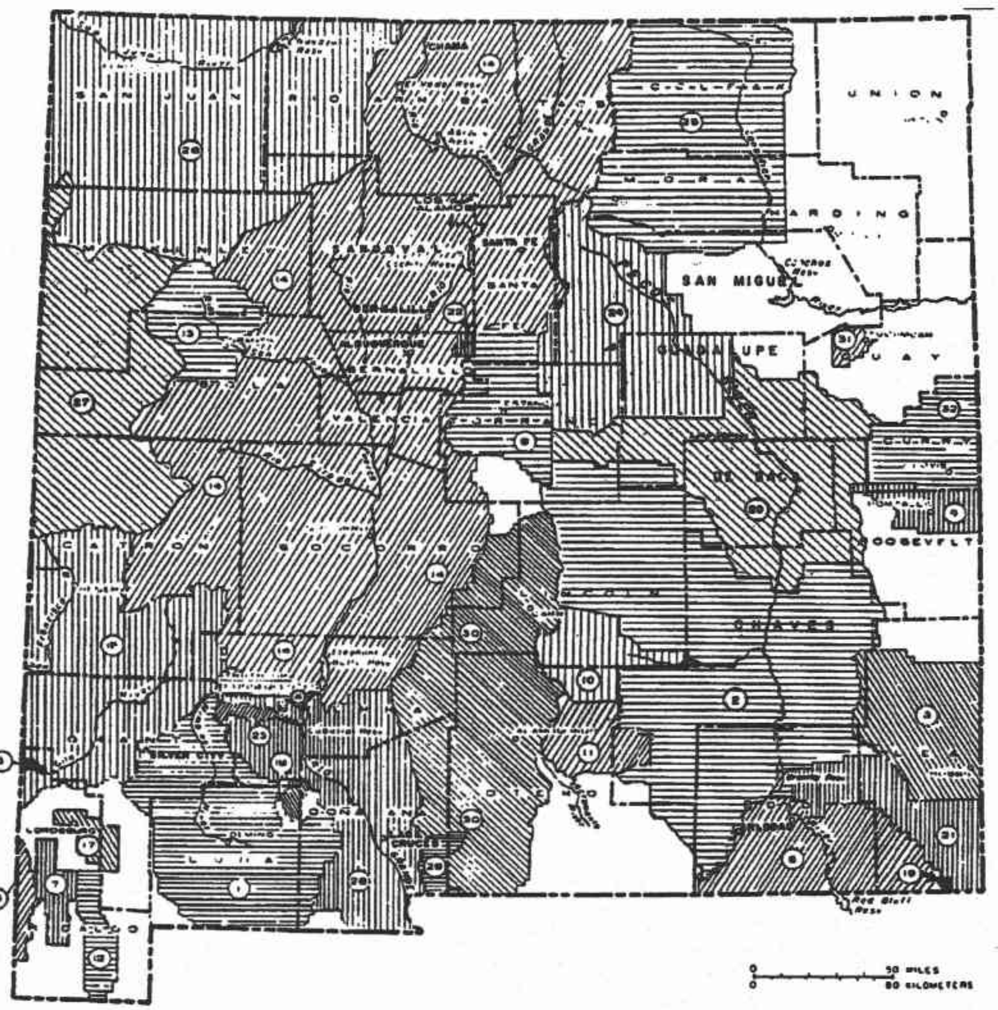


Figure 4.7. Surface water basins in New Mexico. (Source: New Mexico SEO *1994 Annual Report*, p. 16.)



BASIN	AREA IN SQUARE MI.	BASIN	AREA IN SQUARE MI.
1. MIMBRES VALLEY	4,279	17. LORDSBURG VALLEY	329
2. ROSWELL	10,779	18. NUTT-HOCKETT	133
3. LEA COUNTY	2,180	19. JAL	15
4. HOT SPRINGS	284	20. FORT SUMNER	4,924
5. VIRDEN VALLEY	19	21. CAPITAN	1,550
6. CARLSBAD	2,347	22. SANDIA	73
7. ANIMAS	426	23. LAS ANIMAS CREEK	131
8. ESTANCIA	2,005	24. UPPER PECOS	3,842
9. PORTALES	628	25. CANADIAN RIVER	5,825
10. HONDO	1,101	26. SAN JUAN	9,727
11. PENASCO	903	27. GALLUP	5,424
12. PLAYAS VALLEY	515	28. LOWER RIO GRANDE	3,858
13. BLUEWATER	1,318	29. HUECO	255
14. RIO GRANDE	26,209	30. TULAROSA	6,070
15. GILA—SAN FRANCISCO	5,659	31. TUCUMCARI	177
16. SAN SIMON	263	32. CURRY COUNTY	1,350
			102,597

Figure 4.8. Groundwater basins in New Mexico declared by State Engineer as of June 30, 1994.(Source: New Mexico SEO *1994 Annual Report*, p. 19.)

necessary) were found to be "unlawful as practiced in the past" by the Attorney General of New Mexico (i.e., Udall 1994:2). Following a moratorium imposed on the granting of permits to appropriate the groundwaters of the MRG sub-basin and the consideration of administrative procedures that would permit the phased retirement of surface water rights and still meet statutory requirements (Hernandez 1995), the Office of the State Engineer has since developed a set of proposed rules for the sub-basin. These rules specify that, in order to be authorized, any new application to appropriate the underground waters of the MRG sub-basin must demonstrate that pumping requirements (and/or enlargements of) can be met through the retirement of surface water rights that have been already been acquired but not yet dedicated (Office of the State Engineer 1999).

5. METHODS

The selection of New Mexico's Rio Grande basin as a study area is intended to facilitate the investigation of spatiotemporal and sociocultural patterns of water right marketing in a regional context. This study area meets a number of important design criteria including its limited water resources base, rapid growth of urban places, active market for water rights, and considerable sociocultural diversity within its population. Given that all of these criteria are met by the study area, it can be seen to stand apart from other regions within the state of New Mexico (and from the West as a whole) while still retaining elements which can be found in other places. The study makes use of existing data concerning water right transfer activity and descriptors of sociocultural diversity within the study area to investigate spatiotemporal patterns so that inferences about potential third-party effects might be tendered. The methodology employed in this study (including sources of data, data management, and data analysis) is graphically depicted in the flow diagram (Figure 5.1) shown below, and is explained in greater detail in the sections which follow.

5.1 Research Design

Because of its focus on water market activity occurring during a particular period in time, this study is observational in its design. It is comprehensive and multi-faceted, however, with respect to the collection, integration, and analysis of transfer and other data describing spatiotemporal and sociocultural patterns. The

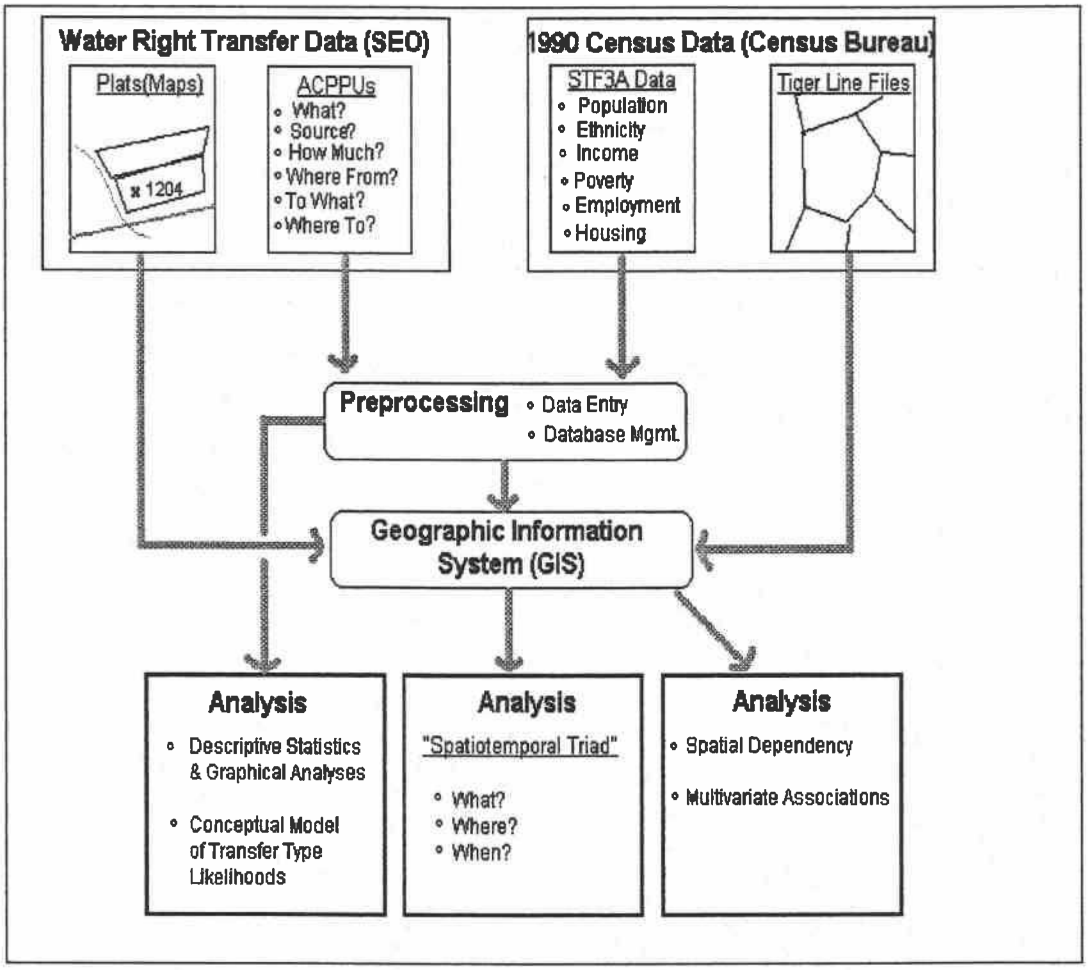


Figure 5.1. Flow diagram showing study methodology including sources of data, data processing, and analyses.

investigation of pattern in connection with water marketing, including inherent spatial and temporal patterns of water right transfer activity as well as related sociocultural patterns, requires the consideration and integration of several different types of data. Water right transfer data that are both geographic and quantitative in character constitute the primary dataset. Continuous sociocultural data at the interval or ratio level that are also geographic or spatial in character are required for multivariate analysis and modeling purposes, and these are spatially linked with the water transfer data. This general task is accomplished through the use of a GIS which is utilized to input, manage, and integrate different types of spatial data and their quantitative and qualitative attributes. The resulting spatially-linked dataset is then subjected to spatial and statistical analyses using appropriate statistical computing software.

Because of the difficulty in designing an experimental study that could offer strong inferences concerning sociocultural change associated with water marketing activity, multivariate analyses of water right transfer data against observable sociocultural parameters is utilized to address the issue of third-party effects by way of proxy. While the optimal inferential study would employ a longitudinal experimental design in which water right transferors (i.e., water market participants and parties engaging in one-party transfers) and local regions served as subjects, the observational design employed here is considerably more limited with respect to the scope of inference which is permitted by the data. This is especially true with respect to the ability to distinguish third-party effects of water marketing from local and regional sociocultural and economic change associated with larger-scale structural economic and agricultural change. Such structural change certainly represents an area of study unto itself and likely varies as a function of spatial scale, the scope of investigation, and of the parameters considered. Nonetheless, this study's results will represent an important first step in the critical evaluation of the strength of third-party effects associated with water marketing in the study region.

The analytical techniques to be utilized include: the interpretation of simple descriptive statistics and graphical characterizations of the data; the fitting of certain qualitative variables to a conceptual model which considers the relative likelihood of occurrence of transfers from one beneficial use (BU) to another; map-based interpretation of spatiotemporal patterns of transfer activity utilizing certain qualitative variables and a conceptual framework developed by Peuquet (1994); and both standard and spatial multivariate statistical analytical techniques (i.e., correlation, regression, and analysis of variance modeling). It is anticipated that the use of a variety of interpretive and analytical techniques will help to develop a multifaceted characterization of transfer activity occurring within the study area and its sub-basins – one which can be viewed both from the context of relationships existing within the data and from the context of this dynamic region.

Data exploration and characterization through simple descriptive statistics and graphical analyses conducted for various spatially and temporally stratified subsets of the water right transfer database allow for the investigation of relationships between more qualitative variables. Some examples of specific questions that can be addressed through such techniques include: from which BUs are water rights being transferred and to which are they being moved; what is the proportion of market vs. non-market transfers; what is the proportion (and relative importance) of water right dedications as compared with transfers effected through

ACPPUs; and what is the distribution of transfer activity throughout the study period?

Being linked to the concepts of supply and demand, trade and transactions costs, the adding of value through manufacture or other economic activity, and the general concept of capital, the principle of the movement of a resource from lower- to higher-value economic activities underpins the entire concept of a functioning market for water rights. These principles are implicitly considered within the conceptual model of water right transfer types which shows the likelihood of transfers of water from one BU to another (Figure 5.2).

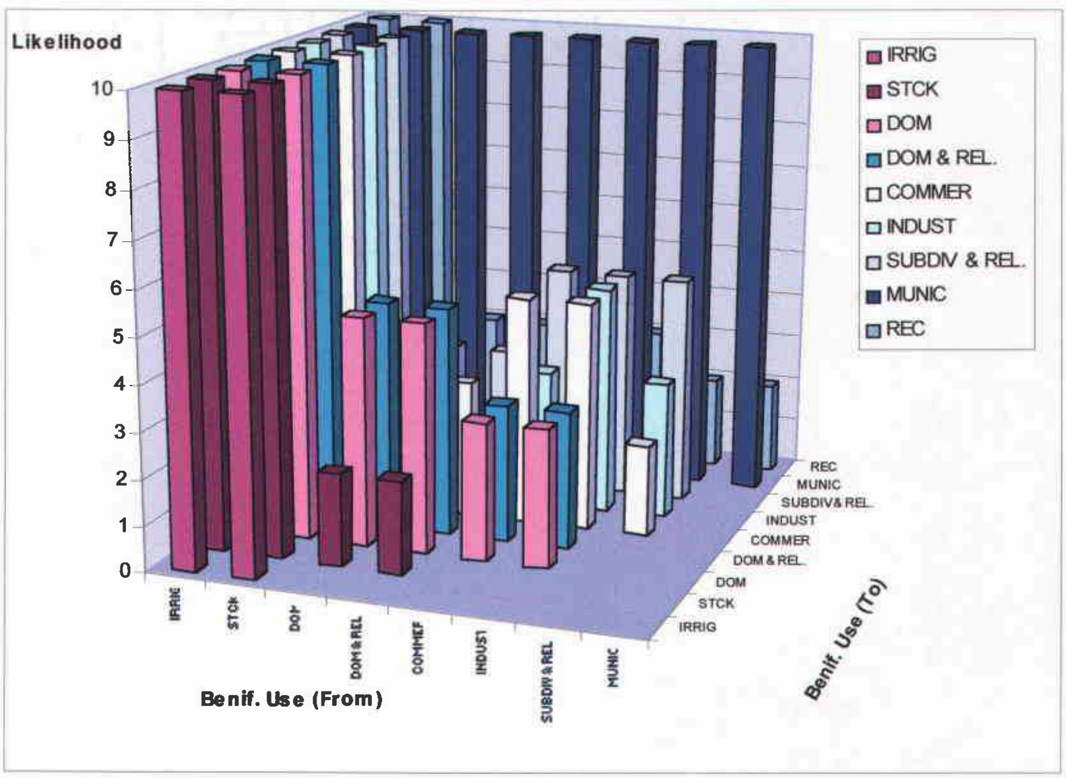


Figure 5.2. Conceptual model of water right transfer types showing likelihood of transfer.

The conceptual model is a three-dimensional graphical diagram that utilizes stepped surfaces or columns to depict the likelihood of a transfer from one BU to another as a hypothetical and intuitive ranking along a relative scale. Transfer likelihood is based upon the relative economic value of water in such an activity, and the physical and institutional ease in effecting a transfer between uses. For example, water utilized for irrigation purposes generally yields lower economic returns than water devoted to municipal uses which include domestic, commercial, and industrial activities which are not self-supplied.

Another factor considered in ranking transfer likelihoods is the likelihood of reversing the direction of the transfer for any given reason. For instance, it would appear to be highly unlikely for a party holding a water right devoted to instream recreational uses to be willing to transfer this right to other (probably offstream) uses. Similarly, it would be highly unlikely for a water right devoted to subdivision and related uses to be severed from such a use and transferred to a different use, unless water service could be supplied through some other means such as municipal supply. This model is analogous to a trend surface diagram that would use a three dimensional surface to approximate the likelihoods if the axes were continuous rather than categorical. In addition to ranking the relative likelihood of a transfer being effected between two different BUs, the position of the BU categories along the abscissa and ordinate axes within the model is dependent upon their relative economic rankings.

Because it is based on ranked likelihoods (ranging from zero to ten) for different categorical transfer types, the conceptual model presented in Figure 5.2 differs somewhat from a hypothetical trend surface that might be used to model transfer likelihood. Such a model would contain a linear or quadratic surface showing high elevation around the walls of the diagram (a ridge), and this surface would diminish more-or-less evenly in elevation to approach zero elevation at the front corner of the diagram (i.e., the origin). The stepped surfaces of Figure 5.2 conform roughly to this hypothetical trend surface in that irrigation and stock related BUs have the highest likelihood of transferability, and municipal usage the highest relative likelihood of receiving water rights. The transferability of irrigation and stock related water rights relates in part to their more transient nature (both seasonally and annually) which is based on the seasonality of irrigation and stock watering activities and the operational decisions of agriculturalists and ranchers. The high likelihood of water right transfers to municipal uses is due primarily to the high demand for water rights exhibited by municipalities in the study area and the West in general.

Map-based interpretation of the features and/or relationships of interest is an essential activity in any geographic study of observable phenomena. Map symbolization is employed here to depict the distribution or arrangement of POUs corresponding to mappable transfers. Simple patterns in the data are also explored utilizing nearest neighbor point pattern analysis to gain an initial understanding of the processes at work, the relationships between data points, and the appropriateness of different statistical analyses.

This procedure allows the characterization of pattern corresponding to an array of points as either clustered, random, or regular, is computationally simple and easily performed in the GIS environment. It relies on the measurement of nearest-neighbor distances between points, and the comparison of these distances with calculated and expected mean distances thus allowing tests of significance to be performed on the results, yielding a nearest neighbor statistic, *R*, which varies from a value of 0 (indicating intense clustering of points) to the value 2 (i.e., a regular arrangement). A value of 1 indicates a random pattern in the points under consideration. The specific formulae involved in the calculation of *R* follow:

1) sum the nearest neighbor distances (d_i) for all sample points (i) in area of concern

$$\sum_{i=1}^{n} d_i \ ;$$

2) obtain the mean nearest neighbor distance

$$\bar{d} = \sum_{i=1}^{n} d_i / n \ ;$$

3) compare this value to the expected value of the average nearest neighbor distance $E(d_i)$, where A = area and N = number of points,

$$E(d_i) = 0.5\,(A / N)^{1/2} \ ;$$

4) and compare these values using a normally distributed z statistic

$$z = [\bar{d} - E(d_i)] / [\mathrm{var}\,(\bar{d})]^{1/2} \ ,$$

where: $\mathrm{var}\,(\bar{d}) = 0.0683A/N^2$. (Boots and Getis 1988: 36-37)

Aside from the use of spatial nearest neighbor analysis to describe general patterns in the location of transfer POUs, and the use of symbolization to characterize different transfer types occurring in the study area, other common analytical approaches and cartographic techniques (i.e., interpolation, mapping of statistical measures and products) are not employed here. Instead, consideration has been given to the principle that the identification and analysis of patterns (spatial and temporal) in geographic data may be facilitated through visualization techniques that rely on the use of virtual and real maps (Clarke 1990) produced with the GIS. These tasks, which are undertaken in this study, rely conceptually on Peuquet's (1994) "Spatiotemporal Triad" framework which is concerned with the characteristics of objects and their positions in time and space.

Peuquet's framework, which has precedents in the fields of mathematics and journalism (1994: 448), allows the formulation of questions which follow these schema:

> 1) *when* + *where* ⟶ *what*: Describe the objects or sets of objects (what) that are present at a given location or set of locations (where) at a given time or set of times (when).
> 2) *when* + *what* ⟶ *where*: Describe the location or set of locations (where) occupied by a given object or set of objects (what) at a given time or set of times (when).
> 3) *where* + *what* ⟶ *when*: Describe the times or set of times (when) that a given object or set of objects (what) occupied a given location or set of locations (where). (Peuquet 1994:448)

As such, the framework can be seen as functioning within the object- and location-based views in which temporal operators (i.e., statements that produce operations) produce temporal snapshots that portray object and spatial information which correspond to different points or periods in time.

While the formulation of the spatiotemporal triad framework may indeed be seen to represent an attempt to describe what many investigators have been doing for many years (i.e., the taking of snapshots of phenomena distributed across space at different periods in time), its explicit consideration allows for experimentation with the representation of phenomena in maps to identify relationships and events. Hence, the stratification of the study area and the visualization of transfer events and types within these strata at various times within the study period may provide information that might otherwise not emerge.

In regard to the use of multivariate statistical analytical techniques in this study, the matter of the spatial character of the data must be considered. The selection of appropriate statistical analysis techniques depends on the presence or absence of spatial dependency or autocorrelation within the spatial transfer data. Spatially autocorrelated datapoints are said to be alike and predictable by nature of their spatial or geographical proximity to one another, thus violating the principle of independence of data and rendering common parametric multivariate statistics unusable (Cliff and Ord 1975). Therefore, the data are to be tested for spatial autocorrelation prior to subjecting them to multivariate analysis or modeling using the commonly employed Moran Index or coefficient (i.e., Moran's "C"):

$$C = (n/\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij})[\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}(y_i - \bar{y})(y_j - \bar{y}/\sum_{i=1}^{n}(y_i - \bar{y})^2] ;$$

where c_{ij} is a binary variable indicating connectivity and y_i is a quantitative variable indicating the magnitude of the observation (Griffith 1993: 21).

This coefficient, which measures covariation in contiguous data points or cells, specifies the direction and strength of autocorrelation and can be subjected to hypothesis testing. Its value may range from –1 to +1, with negative values indicating a trend toward larger cell values at the perimeter of the area of concern, and positive values a trend toward larger values at the center of said area. A value of zero indicates a complete lack of spatial autocorrelation in the data, which implies that the spatial pattern exhibited by the data is one of "complete spatial randomness" (Boots and Getis 1988: 15). While an absence of spatial autocorrelation in the data corresponding to the study area or any of the sub-units suggests that the use of parametric analyses is quite appropriate, the presence of spatial dependency requires a different approach.

Griffith's (1993) spatial multivariate statistical analysis techniques, which specify spatial models using geographic connectivity matrices and matrices of geographic weights, attempt to account for potential spatial dependence within georeferenced data by considering the latent locational information within the data and its effect on their values. These models may be compared to non-spatial parametric models to reveal relative latent spatial effects in the data on parameter and model estimation. In doing so, these analytical techniques convey important information concerning the strength of the relationships between independent and dependent variables, and also with regard to spatial structure and/or pattern inherent within the data (Griffith 1993). The specific spatial statistical analyses to be employed in this study, if merited, follow the methods of Griffith (1993) for several reasons. First, his multivariate approach is robust in that it allows the exploration of the strength of relationships between different variables in addition to providing descriptors of spatial structure. Second, the approach is flexible and broadly applicable, allowing for relative ease in replication and the comparison and interpretation of results from similar studies conducted in other areas. Lastly, Griffith has developed and disseminated computer programming code that runs on the personal computer using SAS™ statistical software for the broad implementation of this approach.

Because one of the primary objectives of the study is to identify any sociocultural variables associated with water right transfers occurring in the study area, specific statistical techniques can be seen as being more appropriate for utilization than others. The parametric and/or spatial multivariate analyses to be employed consist primarily of correlation and regression modeling techniques which allow for the measurement and testing of the strengths of relationships or associations between independent and dependent variables. Other multivariate approaches (i.e., factor or principal components analysis, discriminant function analysis, and/or cluster analysis techniques) have less utility in a study of this nature.

Lastly, the identification and analysis of temporal patterns in the modeled data requires explanation. Though it is quite unlikely that transfer events within the study area are temporally autocorrelated or dependent at any scale, such relationships are explored utilizing appropriate statistical diagnostic tools. The temporal dimension will be introduced into spatial regression and correlation models through the consideration of an independent variable which corresponds to the year in which transfer events occurred. The models therefore may provide information concerning temporal processes, though the inference of such results is necessarily restricted by all of the same factors and considerations that will limit inferences concerning spatial processes.

Other analytical techniques that, on the surface, might seem to lend themselves to the investigation of spatial patterns of water marketing are not employed. Gravity models, such as presented by Mitchell (1979), can reveal the spatial interactions of places and/or things as a function of distance and other factors but are not employed here because the distances between from and to transfer locations are not an important consideration in the study area given the administrative policy of hydrologic connectivity between surface and ground water sources in each of the sub-basins. Migration indices such as utilized by Manson and Groop (1996) to model interstate migration and migration efficiency within the United States are not employed because of their inability to accommodate explanatory variables from which process might be inferred.

5.2 Data and Variables

Water right transfer data derived from ACPPUs represent the dependent data in this study, especially those pertaining to amounts of water transferred per place of use.[34] The information required by the SEO for inclusion in an ACPPU is extensive and includes address, water right, locational, and intended use information categories (Table 5.1). Though each ACPPU submitted to the SEO must be complete with respect to this information if it is to be reviewed, processed,

Table 5.1. Information items required in "Application To Change Point of Diversion and Place and/or Purpose of Use From Surface to Ground Water" (ACPPU).

ACPPU Item Number	Item Name	Sub-Item(s)
1.	Name of Applicant	Address
2.	Type of Beneficial Use of Water Right	File No., Priority Date
3a.	Source of Water Supply	Tributary To.., Acequia?
3b.	Point of Diversion Location	USPLS Information
3c.	Quantity of Water to be Transferred	Places of Use, Ownership
3d.	Present Owner of Land(s)	
3e.	Present Owner of Water Right	
3f.	Supplemental Water Right(s) for Lands	File No., Acreage, Quantity
4.	Reason for Requested Change	
5.	Well to Which Change is to be Made	Location, Attributes, Etc…
6a.	Acreage to Which Change is to be Made	Area, Location, Owner
6b.	Use to Which Water is to be Transferred	
6c.	Other Appurtenant Water Rights to Land	
7.	Additional Statements or Explanations	
8.	Dates Transfer to be Accomplished	Pt. Of Diver., Place of Use
9.	Approval of State Engineer	Permit No., Publ. Date, Date of Approval, Etc…

[34] The amount of water (in AFCU) transferred per place of use (POU) is utilized as a dependant variable because any given transfer may include water from one or more POUs.

and approved, ultimate approval depends upon additional considerations which have been mentioned previously. These can include the following reviews: water right utilization and/or validity (especially in the case of unadjudicated water rights), injury to other appropriators based on changes in return flows from active diversions, injury to the public interest/welfare, and calculations of actual rates of consumptive use in the case of irrigation water rights (expressed in terms of acre-feet per year of consumptive use, or AFCU).

Data derived from ACPPUs for use as dependent variables include selected qualitative, quantitative, and locational information (Table 5.2). Initial assembly of the working database included the capture of all information documented in ACPPUs in order to avoid the duplication of individual records and in the interest of maintaining the completeness and integrity of the dataset. More personal and non-essential applicant and address information, water right diversion schedules, and ownership information for water rights, wells, and land were not utilized to construct working variables.

While the majority of the derived variables are self-explanatory at least with regard to the character and quality of the original and subsequent data, several require explanation owing to the manipulations involved in their construction. The SEO form submitted for review (i.e., surface water to surface water, surface water to ground water, etc.), classifies transfer applications on the basis of the nature of the proposed transfer and this classification has been followed and supplemented with the addition of a code for dedication related transfers. These data are contained under the variable entitled TYPE. Table 5.3 shows the SEO codes and application fees for the various water right transfer types.

Table 5.2. Dependent variables derived from ACPPU information.

Variable Name	Description of Variable	Quality of Data
TYPE	Type of Transfer (Transfer, Dedic.)	Qualitative
AFCU	Quantity Transferred in AFCU	Quantitative – Ratio
BENFRO	Beneficial Use – From	Qualitative
BENTO	Beneficial Use – To	Qualitative
POUFRO	Place of Use – From	Locational/Spatial
POUTO	Place of Use – To	Locational/Spatial
ACRES	Size of Place of Use (From) in Acres	Quantitative – Ratio
PRIORITY	Water Right's Date of Priority	Quantitative – Interval
MARKET	Market or Nonmarket Transfer?	Quantitative – Nominal, Binary
USERFRO	Type of User – From	Qualitative
USERTO	Type of User – To	Qualitative
PROTEST	Was Transfer Protested?	Quantitative – Nominal, Binary
YEAR	Year in Which Transfer Occurred	Quantitative – Ratio
AGE	Numerical Expression for YEAR	Quantitative – Ratio

The locations corresponding to original and proposed places of use (POUFRO and POUTO) represent spatial information that has been captured and stored in map form within the GIS component of the study. The process of data acquisition and capture is described in the section that follows. For the purposes of statistical modeling, these data are represented by coordinate information corresponding to the calculated centroids of mapped POUFRO and POUTO observations. These coordinates are expressed as Universal Transverse Mercator (UTM) meters utilizing the 1927 North American Datum for purpose of maintaining internal database consistency. For mapping and graphical purposes, however, POUs are represented by different cartographic symbols depending upon the size of the area depicted and the corresponding map scale.

A water right's date of priority (PRIORITY) reflects the reliability of that water right relative to others. In general, under the system of prior appropriation those appropriators with senior (i.e., older) water rights have priority in use over junior appropriators when sources of supply become diminished such that all appropriators' rights cannot be satisfied. And because a water right's priority date is generally transferable (see Table 3.1), more senior water rights should thus be more attractive for transfer purposes and should conceivably command a higher price in a market setting. Dates of priority reported in ACPPUs range from the year 1545, which remarkably predates the initiation of Spanish settlement in the study area, to approximately 1985. While claims of priority dating back to 1545 may seem to be suspect, especially in the case of unadjudicated water rights, those

Table 5.3. Water right transfer types as categorized by the New Mexico SEO. (Source: Colby and McGinnis 1988)

A. Change of ownership ($2, for groundwater (GW) and surface water (SW).
B. Change location of well ($25) ($5 for domestic well).
C. Change place or purpose of use of underground waters ($50).
D. Change location of well and place or purpose of use of underground water ($50).
E. Change point of diversion, surface waters ($25).
F. Change place or purpose of use, surface waters ($50).
G. Change point of diversion and place and/or purpose of use, surface waters ($50).
H. Change point of diversion and place and/or purpose of use from surface to groundwater ($50).
I. Dedication.

beginning at 1598 may in fact be quite legitimate in that the validity of such claims must be considered by the SEO when reviewing proposed transfers. For modeling purposes, values corresponding to the variable PRIORITY have been transformed into an age statistic (AGE) which is the difference between the date of priority and the date of approval by the SEO for any given transfer, expressed in years.

Information concerning parties involved in transfers is captured in the variables USERFRO and USERTO. Several different data classes may be applied to each of these variables depending upon the particulars of individual transfers. First, each party is classified as being either a private and unincorporated party (INDIV), an incorporated entity engaging in business for profit (CORP), a municipality which though incorporated for the purpose of providing infrastructure and public services is nonetheless differentiated from other corporations (MUNIC), any other public or governmental entity (PUBLIC), a mutual domestic water consumer's association from a rural community (MDWCA), or other party (OTHER). If appropriate for any of these classes, the designation is specified as a plural although singular and plural observations are pooled for the purposes of analysis. The class applicant (APPLIC) is utilized for USERTO in order to avoid confusion about the entities that are party to a transfer; if there is no second party involved (i.e., the transfer does not represent a market transaction) this designation is utilized.

Beneficial use information pertaining to transfer cases is represented by the variables BENFRO and BENTO. Because the BUs to which water may be applied are not specified by statute in New Mexico, these are somewhat variable with respect to the language utilized to describe them. Types of BUs considered and utilized within this study are drawn from the raw ACPPU data themselves, and are listed in Table 5.4 below. These uses are ordered according to their relative rank on a conceptual scale of lower-to-higher economic uses and with respect to their relative ease of transferability to other uses (i.e., liklihood of transfer to other uses). Qualitative variables such as USERFRO, USERTO, BENFRO, and BENTO are utilized primarily for the purposes of simple descriptive statistical and graphical analysis and for database stratification.

Table 5.4. Beneficial use classes corresponding to BENFRO and BENTO.

Beneficial Use	**Relative Economic Rank**	**Transferability**
Irrigation (IRRIG)	**Lower**	**Higher**
Stock (STCK)		
Domestic (DOM)		
Domestic and Related (DOM & REL)		
Commercial (COMMER)	**-to-**	**-to-**
Industrial (INDUST)		
Subdivision and Related (SUBDIV & REL)		
Municipal (MUNIC)		
Recreation (REC)	**Higher**	**Lower**
Miscellaneous (MISC)	N/A	N/A
Unknown (UNK)	N/A	N/A

Lastly, because the New Mexico water code allows for the public review and protest of proposed appropriations and transfers of state waters, information concerning the protest history of individual ACPPUs was gathered as supplementary data. Protest data is limited to a simple binary or indicator variable primarily for reasons related to the complexity of water right protests and their resolution, and also because of the fact that all unapproved and withdrawn ACPPUs were by necessity excluded from the database – including those which were protested. Some of the factors that add complexity to such actions include: protests are often based on a number of contested items or claims pertaining to the water right action of concern; complainant parties to a protest can sometimes be numerous; and protested water right actions generally involve lengthy negotiations between complainants, applicants, and the SEO.

Socioeconomic data from the 1990 Census of Population and Housing as collected and tabulated by the U.S. Bureau of the Census are utilized as independent sociocultural data in this study. The Census data are extensive, exhaustive, and detailed with respect to characteristics of population and housing, and for this reason a selected subset of more generalized population and housing variables has been selected for consideration in this study. These variables are shown in Table 5.5. Unless otherwise specified these data generally pertain to the year 1990. While it would be highly desirable to include data from the previous two decennial Censuses (i.e., the 1970 and 1980 Censuses of Population and Housing) in order to account for change in the variables of interest and to perform

Table 5.5. Sociocultural and development variables derived from U.S. Bureau of Census data.

Variable Name	Description of Data	Census Table/Field ID*
POLID	Polygon ID (i.e., for BNA or Tract)	N/A
TOTPOP	Total Population	P0010001
LANDSQMI	Area in Square Miles	N/A-1992 Tiger/Line™ File
POPSQMI	Population per Square Mile	TOTPOP/LANDSQMI
PCTRURAL	Percent Population that is Rural	P0060002
PCTONFARMS	Percent Population Living on Operating Farms	P0060003
PCTWHITE	Percent Pop. That is White	P0080001
PCTAMIND	Percent Pop. That is American Indian	P0080003
PCTHISP	Percent Pop. That is Hispanic	P0010001 – P0110001
MEDHHINC	Median Household Income	P080A001
MEDFAMINC	Median Family Income	P107A001
PCTPOOR	Percent Poor	P1170013 – P1170024
PCTVERYP	Percent Very Poor	P1210001/P0010001
PCTUNEMP	Percent Unemployed	P0700003+P0700007 /P0070002+P0700003 +P0700006+P0700007
PCTMGRPR	Pct. Managerial/Professional Empl.	P0780001+P078002 /P0700002+P0700006
PCTTECHS	Percent Technical Employed	P0780003+…+P0780005 /P0700002+P0700006
PCTSERV	Percent Service Employed	P0780006+…+P0780008 /P0700002+P0700006
PCTFARME	Percent Farm & Related Employed	P0780009 /P0700002+P0700006
PCTOTHOC	Percent Other Occupation	P0780010+…+P0780013 /P0700002+P0700006
TOTUNITS	Number of Housing Units	H0010001
CONDOS	Number of Condominiums	H0060001+…+H0060004 +H0070001+…+H0070003
PCTVACNT	Percent Vacant Housing Units	H0040002/H0010001
PCTOWNER	Pct. Owner Occupied Housing Units	H0080001/H0010001
PCTRENTR	Pct. Renter Occupied Housing Units	H0080002/H0010001
PCTBUILTA85	Pct. Units Built 1985 to March 1990	H0250001+H0250002 /H0010001
PCTBUILT80_	Percent Units Built During 1980s	H0250001+…+H0250003 /H0010001
PCTBUILT70_	Percent Units Built During 1970s	H0250004/H0010001
PCTBUILT60_	Percent Units Built During 1960s	H0250005/H0010001
PCTBUILT50_	Percent Units Built During 1950s	H0250006/H0010001
PCTBUILT40_	Percent Units Built During 1940s	H0250007/H0010001
PCTBUILTP40_	Percent Units Built Prior to 1940	H0250008/H0010001
MEDHVAL	Median Home Value	H061A001
MEDRENT	Median Rent	H043A001

*Note: Census Table/Field ID Numbers listed correspond to 1990 Census of Population and Housing.

more robust time-series analyses, this possibility is precluded by the nature of the geographic data themselves. Census geographic units at the sub-county level corresponding to the 1970 and 1980 Censuses generally show a low degree of spatial correspondence with their 1990 counterparts. This is largely due to incomplete mapping of Census geographic units during the earlier Censuses and to boundary changes of the mapped units themselves (Bureau of the Census 1998b). The degree of spatial correlation between Census Tracts (TRACTs) delineated for the 1980 and 1990 Censuses was tested for counties within the study area using the MABLE/Geocorr2 v2.01 geographic Correspondence Engine[35] and found to be excellent for urban TRACTs within the Albuquerque Metropolitan Statistical Area, but was generally poor for all other areas.

The data also provide the finest degree of spatial detail possible in that they correspond to the smallest units of geographic or spatial analysis (i.e., Census geography sublevels – see Table 5.6) permissible by the Bureau for the variables under consideration. For instance, the Bureau permits income and related information to be depicted for Block Groups (BGs), which are made up of more than one Block,[36] and for higher order sublevels to the level of the state to ensure

[35] These data were acquired via the internet from the Consortium for International Earth Science Information Network (CIESIN) - Socioeconomic Data and Applications Center (SEDAC), 1996, Archive of Census Related Products. [online]. University Center, Mich.: CIESIN/SEDAC. Available: http://plue.sedac.ciesin.org/plue/geocorr/ [9/7/98].

[36] Census blocks are defined as: "small areas bounded on all sides by visible features such as streets, roads, streams, and railroad tracks, and by invisible boundaries such as city, town, township, and county limits, property lines, and

Table 5.6. Hierarchy of Census geography.

United States
Region
Division
State
County
Minor Civil Division/Census County Division
Place
Census Tract/Block Numbering Area
Block Group
Block

the privacy of individuals and families. Census data utilized in this study correspond to the BG and the TRACT or Block Numbering Area (BNA) sublevels – these geographic sublevels then represent two distinct sample units. While both BGs and TRACT/BNAs are variable with respect to the size of discrete units, they are hierarchical in that BGs are nested within spatially larger TRACT/BNAs that include more than one BG. Data that correspond to two different levels of spatial scale are utilized in order to test the strength of spatial autocorrelation at various scales. The data were acquired from the Summary Tape File 3A (STF 3A)

short, imaginary extensions of streets and roads." (Bureau of the Census 1992, Appendix A-3) produced by the Bureau of the Census for the State of New Mexico for the 1990 decennial Census.[37]

Though self-explanatory in a general sense, the independent variables merit discussion with respect to their tabulation and definition. First, the variables are derived from both "100-percent" short-form data and from long-form "sample" data for the geographic levels of concern. The 100-percent data are enumerated for all housing units and include more general population and housing information, whereas the sample data are enumerated for some portion of households and include more specific population data on social and economic characteristics and more detailed housing information. The Bureau utilized a variable-rate sampling scheme for its long-form questionnaires such that spatially smaller census sampling areas were sampled at a higher rate than larger areas (Bureau of the Census 1989) to minimize errors due to sampling. As applied to sparsely populated and/or rural areas, this oversampling scheme ensured that approximately 50 percent of households received the long-form as opposed to the average of 1-in-6 households (Salant and Waller 1995). Because such a high rate of oversampling has the potential to disclose confidential personal and household information, disclosure edits relying on the substitution of imputed data (i.e., data that are normally utilized

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[37] These data were acquired via the internet from the Consortium for International Earth Science Information Network (CIESIN) - Socioeconomic Data and Applications Center (SEDAC), 1996, Archive of Census Related Products. [online]. University Center, Mich.: CIESIN/SEDAC. Available: http://plue.sedac.ciesin.org/plue/geocorr/ [9/7/98].

to estimate the characteristics of non-response observations) are employed (Bureau of the Census 1992).

Second, several variables (i.e., POLID, LANDSQMI, POPSQMI) are derived from 1992 Tiger/Line™ files that are digital maps depicting Census geography at different levels for any area under the purview of the Bureau of the Census. POLID is an identification number or code that links a geographic area of concern (i.e., BG or BNA) to the population and housing data that correspond to that area. LANDSQMI is derived from the projected Tiger/Line files, and is utilized to calculate POPSQMI. This last variable is included in the analyses to provide control for relative levels of population density and development within the study area.

The variables PCTRURAL and PCTONFARMS are meant to characterize the relative rurality of the sample units. The Bureau of the Census defines urban places as those incorporated or unincorporated places with populations of 2,500 or more persons, and rural places are by default all places or areas that do not meet this criterion (Salant and Waller 1995). Because of the variable nature of the sampling units with respect to size or area, and with respect to their inclusion within larger governmental units such as municipalities or metropolitan statistical areas, BGs and/or TRACT/BNAs may be classified as 100 percent urban regardless of their true character. Because of this potential problem, the percentage of the population living on operating farms is introduced as an additional variable.

The Census farm population information is primarily a function of farm residence. The Census definition of a farm residence is:

> An occupied one-family house or mobile home is classified as a farm residence if: (1) the housing unit is located on a property of 1 acre or more, and (2) at least $1,000 worth of agricultural products were sold from the property in 1989. Group quarters and housing units that are in multi-unit buildings or vacant are not included as farm residences. A one-family unit occupied by a tenant household paying cash rent for land and buildings is enumerated as a farm residence only if sales of agricultural products from its yard (as opposed to the general property on which it is located) amounted to at least $1,000 in 1989. A one-family unit occupied by a tenant household that does not pay cash rent is enumerated as a farm residence if the remainder of the farm (including its yard) qualifies as a farm. (Bureau of the Census 1992:B-40)

Ethnicity or ancestry is an important component of cultural and sociocultural identity, especially within the study area, and this characteristic of population is represented with variables which model racial diversity of the population. The use of terms which reflect the proportion or percentage of population which is either white, Native American, or Hispano (i.e., PCTWHITE, PCTAMIND, PCTHISP) may on the surface appear to be a crude approximation of culture, but within the study area it is an entirely accurate one given the long tenure of Hispano culture and the high degree of ethnic pride exhibited by this population.

Sociocultural characteristics of population within the study area are further described by a number of variables or indicators which reflect socioeconomic situation or status of sample units. These include variables pertaining to income (MEDHHINC and MEDFAMINC), poverty (PCTPOOR and PCTVERYP), and employment (PCTUNEMP, PCTMGRPR, PCTTECHS, PCTSERV, PCTFARME, PCTOTHOC). Income measures utilize median income levels rather than average incomes in order to diminish the effect of extreme outliers and the misrepresentation of the data (Bureau of the Census 1992), a common practice in social sciences research. PCTPOOR represents the percentage of population living below the 1989 poverty level,[38] and PCTVERYP represents the number of persons living below 50 percent of the 1989 poverty level.

Employment indicators model unemployment rates and the mix of occupations found within the sample units. The unemployment rate reported by the Bureau of the Census includes all non-military persons sixteen years of age and older who are within the workforce and met these conditions:

> (1) persons who worked at any time during the reference week; (2) persons who did not work during the reference week but who had jobs or businesses from which they were temporarily absent (excluding layoff); (3) persons on layoff; and (4) persons who did not work during the reference week, but who were looking for work during the last four weeks and were available for work during the reference week. (Bureau of the Census 1992:B-5)

The "reference week" utilized for the purpose of gathering employment data is the calendar week immediately preceding the day on which respondents completed their forms or interviews (Bureau of the Census 1992:B-31).

The occupational indicators provide a view of the economic structure of sample units with respect to the employment of their corresponding populations as opposed to actual production occurring within the units. While it would be both

[38] The national average poverty threshold (unadjusted for local, regional, or state variability in the cost of living) for a family of four persons in 1989 was $12,674 (Bureau of the Census 1992).

interesting and instructive to include data or a model of actual economic structure for the sample units, this would require the collection and analysis of data of various qualities from various sources and which correspond to a coarser scale of spatial resolution (Salant and Waller 1995). Such an exercise represents a study unto itself and is best considered as a separate endeavor.

The remaining Census variables utilized here pertain to the number and changing density of housing units in the sample units over time, to patterns of occupancy, and to the cost of housing in these areas in 1989. TOTUNITS and CONDOs provide an indication of the level of development related to housing in the sample units, and of potential recreational housing units. Housing unit occupancy and tenure information are provided by PCTVACNT, PCTOWNER, and PCTRENTR. It is not expected that any of these occupancy related variables will show strong associations with the dependent variable(s), but that one or more of the remaining variables which show changing levels of housing unit construction over time will. Of these seven variables (i.e., PCTBUILTA85, PCTBUILT80_, PCTBUILT70_, PCTBUILT60_, PCTBUILT50_, PCTBUILT40_, and PCTBUILTP40_), those corresponding to construction immediately preceding and continuing through the study period have the greatest potential of showing strong associations with water right transfer activity. However, data pertaining to historic housing unit construction are retained for use because they may provide important information related to the relative quality of housing and housing dynamics within the sample units.

5.3 Sampling Methods

Water right transfer data for the study region were acquired through several means. Nunn's (1990) water right census data for the period 1975-1987 were acquired in digital form and represent the foundation of the database constructed for this study. Her data were assembled for the entire state of New Mexico, and were pared down for inclusion within this study. In addition, these data were more detailed in that they were collected for utilization in a study that had as one of its primary objectives an assessment of relative water market transactions costs and transfer efficiency. Accordingly, more detailed data concerning protest histories, prices paid for market-based transfers, and participant name and address information were not utilized in this study.

Supplementing Nunn's data are those collected from a similar census of ACPPUs at the main office of the State Engineer in Santa Fe, and at the Albuquerque District office serving the MRG sub-basin. These data were collected for the period January 1, 1988, through September 1, 1995, utilizing internal SEO Application Status reports to identify water right transfer cases to consider for inclusion within the study. The appropriate water right files (i.e., source and/or destination water rights) were then reviewed to determine whether or not particular transfer cases met certain criteria for inclusion within the study. These criteria included: 1) the case does not represent an interbasin transfer of water right(s) with a source or destination outside of the Rio Grande basin; 2) the case represents an approved transfer that falls within the period of interest; 3) the case does not represent a simple change in POU or POD for a given water right (i.e., as in an irrigator shifting water rights between irrigable fields or pastures or changing the water right's point of diversion); and 4) the case must represent a permanent transfer of water rights and not a temporary transfer or lease arrangement.

Data concerning dedications of water rights to offset increases in levels of municipal groundwater pumping were acquired differently that those pertaining to ACPPUs. This was primarily due to the fact that dedications were not generally tracked internally within the SEO. However, because the practice of allowing dedications was the subject of reviews by the Attorney General of the State of New Mexico as discussed previously, the SEO had prepared lists of water right permitees who were in the practice of dedicating water rights for various purposes. These lists were consulted to identify water right files to be reviewed for dedication transactions.

Spatial POU data needed for spatial analyses were acquired in one of two primary ways for any given transfer: from a water right map or plat showing the water right and/or POU in question, or from locational information contained within the ACPPU itself which could be mapped or matched to existing maps of portions of the study area. The SEO generally requires the submission of a certified plat or map from a planimetric survey of a new water right prior to the granting of a permit to appropriate, and the submission of a plat showing intended transfer-to POU locations is also a general requirement of the transfer process. However, it was found through inspection of water right files and ACPPU materials that plats of existing or transferred water rights were largely missing or absent. Locational information from the ACPPUs themselves was utilized where possible in such cases. It was fortunate, however, in the case of transfers occurring within the bounds of the MRGCD (whether district transfers or not), that these ACPPUs were generally found to be accompanied by maps, plats, or drawings that could be matched to MRGCD digital map coverages.

Photocopies of plats, maps, and/or drawings were matched to SEO Hydrographic Survey Sheets,[39] U. S. Geological Survey topographic quadrangles, and digital map coverages showing tract boundaries of the MRGCD. Control points corresponding to observable features on both sources were identified and coordinate information documented for them. The plats, maps, and/or drawings were then digitized using ArcInfoPC™ GIS software and projected into the Transverse Mercator projection where appropriate for merging with other coverages. Places of use corresponding to MRGCD tracts were matched to digital tract coverages acquired from the district using tract identification codes, and the coverages were edited using ArcView™ to show only these POUs. Places of use spatially documented only with written descriptions of State Plane coordinates or U.S. Public Land Survey system (USPLS) descriptors (i.e., sections, quarter sections, quarter-quarter sections) were matched to topographic quadrangles and the quadrangles digitized to shown the areas of interest.

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[39] These are stereocompilations of planimetry from aerial photographs and were constructed primarily for the adjudication of water rights within surface and underground water basins.

Problems with the accuracy of depicted POUs stem from different sources owing to the number of sources and diversity of methods utilized. First, the spatial accuracy of digitized plats, Hydrographic Survey sheets, MRGCD coverages, and topographic quadrangles is affected by the manual measurement of coordinate information and is approximately five horizontal meters, at the minimum, in each case. Where USPLS descriptors are indicated as containing a transfer POU instead of matching it exactly or even roughly approximating it, these areas were digitized in their entirety for the purpose of comparison with Census geography. If such an area was found to have one-to-one correspondence with Census geographic units, it was retained for statistical analysis. Where one-to-many correspondence was found, the area was dropped from the database utilized for spatial analysis purposes. Such was also the case for platted POUs, and those lying within MRGCD boundaries, which were found to lie within a larger mapped area or tract and which could not be more exactly specified.

In a number of cases ACPPU information suggested that particular POUs would be best represented with point features rather than areal features (i.e., polygons). This occurred primarily for more localized BU classes such as individual domestic, commercial, and industrial uses. These cases were mapped and/or digitized as described above.

5.4 Data Management and Analysis

The water right transfer data utilized in this study consist of Nunn's ACPPU census data in digital form and those ACPPUs, maps, and related documents collected at the SEO in Santa Fe, New Mexico. Because Nunn's data were for the entire state, they were edited to select for Rio Grande basin cases that fell within the study's period of concern only. These data were converted from Lotus 123™ to Microsoft Excel™ spreadsheet format, and the raw ACPPU data were added to these new files. The data pertaining to all cases (i.e., those from Nunn and raw data collected in the field) were verified with the use of duplicated ACPPU forms and documents wherever possible.

Maps, plats, and locational information corresponding to transfer cases were digitized into map coverages as described above, and merged into polygon and point coverages utilizing ArcView™ extension tools. The creation of master coverages depicting POUs for each of the sub-basins and the MRGCD allowed for the creation of additional coverages for both illustrative and analytical purposes. Sub-basin point and polygon coverages were spatially joined with coverages depicting Census geographic units for the areas of concern (i.e., TRACTs and BGs) to check for the spatial correspondence of these different units and to identify POUs to be retained for spatial analysis. Interactive editing of the joined files permitted the selection and removal of polygon and sliver polygon features derived from errors in digitizing and georeferencing. The resulting new polygon coverages were then converted to point coverages to obtain point coordinates of POUs for spatial modeling. This was accomplished with an ArcView™ extension tool that calculates the centroids of polygons within existing polygon coverages and stores these centroids as point features in new point coverages. Coordinate information for the point features was obtained using a sample script, "View.AddXYCoordToFTab," included with ArcView™ software.

Simple statistical, exploratory, descriptive, and graphical data analyses of water right transfer data were primarily accomplished with the use of Microsoft Excel™ software. Although spatial statistical analyses were carried out using SAS™ statistical software, the GIS was employed for spatial data management tasks such as database linking, extraction, and data export to SAS for analytical procedures. Spatial regression, correlation, and analysis of variance (ANOVA) analyses were performed utilizing SAS™ code provided by Griffith (1993).

6. RESULTS AND FINDINGS

The results and findings reached in the conduct of this study are presented here. First, the general characteristics of the data are presented with attention given to the completeness of the dataset, the general trends in the data for the study area and its component sub-basins, and to the temporal distribution of observations. Simple descriptive statistics, diagrams, charts and maps are presented where appropriate. Second, the fit of the data to the conceptual model of transfer type likelihoods is investigated for the study area and its sub-basins. Third, the spatiotemporal patterns of transfer POUs and BUs are explored utilizing the sapiotemporal triad framework. Lastly, the processes and results of spatial regression modeling exercises exploring the strength of associations between transfer activity and the sociocultural variables are presented and discussed.

6.1 General Characteristics of the Data

The census of water right transfers conducted during August and September of 1995 found 282 cases that were added to 161 from Nunn (1990) to make a total population of 443 cases occurring during the period 1975-1995. These cases were distributed among the sub-basins as follows: the URG sub-basin had 136 cases (31 percent), the MRG sub-basin 274 cases (62 percent), and the LRG sub-basin 33 cases (7 percent). Because of file and/or document unavailability, 59 cases from the combined dataset were not able to be reviewed and/or edited for data accuracy.

Summary statistics calculated for the basin and sub-basins (Table 6.1) show that transfers occurring within the MRG dominate the pooled data. The mean and standard deviation (σ)[40] for the study area certainly affected by the high frequency of transfers occurring in this sub-basin. Of the sub-basins, however, the LRG accounts for the largest mean, median, and minimum transfer size, suggesting that transfer sizes are larger here. Single factor analyses of variance (ANOVAs) performed on the transfer amounts (AFCU/YR) considering the three sub-basins as separate groups in one iteration, and market and non-market transfers as separate groups in a second iteration, showed no significant differences between group means in either case.[41] Non-significant p-values of 0.1233 and 0.7621 were

Table 6.1. Summary statistics describing water right transfers within the study area and its sub-basin components, in AFCU (1975-1995).

Statistic	Study Area	URG	MRG	LRG
Mean Size	18.928	14.904	20.092	27.197
Median Size	7.530	3.680	8.484	18.856
Standard Deviation	36.714	41.755	34.674	29.724
Range	402.045	399.940	402.045	127.030
Minimum	0.045	0.060	0.045	1.930
Maximum	402.09	400.000	402.09	128.960
Count	443	136	274	33

[40] A population standard deviation was calculated for both pooled and stratified data.

[41] ANOVAs were performed using Statgraphics™ (Vers. 2.6) software.

obtained, respectively, indicating that null hypotheses of no significant difference in mean transfer size between groups be accepted.

A comparison of the mean and median transfer size values shows that the presence of outliers in each of the sub-basins has the effect of increasing the mean transfer size in each case. This is also demonstrated by Figure 6.1 which shows a histogram of transfer sizes for the study area. Smaller transfers (i.e., ten or fewer AFCU in size) clearly dominate the data. This is important to note given that the size of the average transfer occurring within the study area during the period of concern was 18.928 AFCU, or 6.168 million gallons. This translates to 16,898 gallons per day. Histograms plotted for each of the sub-basins showed patterns that were essentially the same as Figure 6.1.

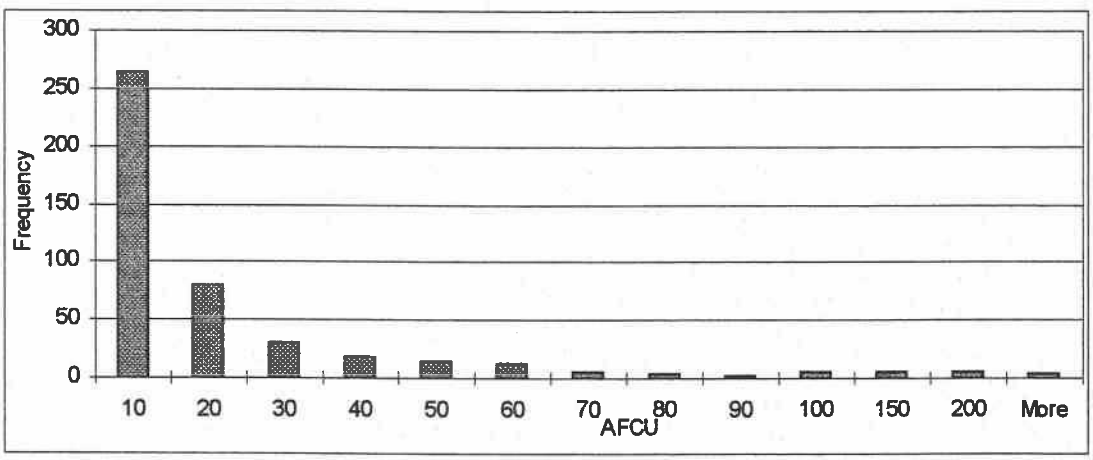


Figure 6.1. Frequency histogram: transfers occurring within the Rio Grande basin, N.M. (1975-1995).

Each of the sub-basins show different patterns of transfer activity during the study period (Figures 6.2 and 6.3). The data show that no transfer activity occurred

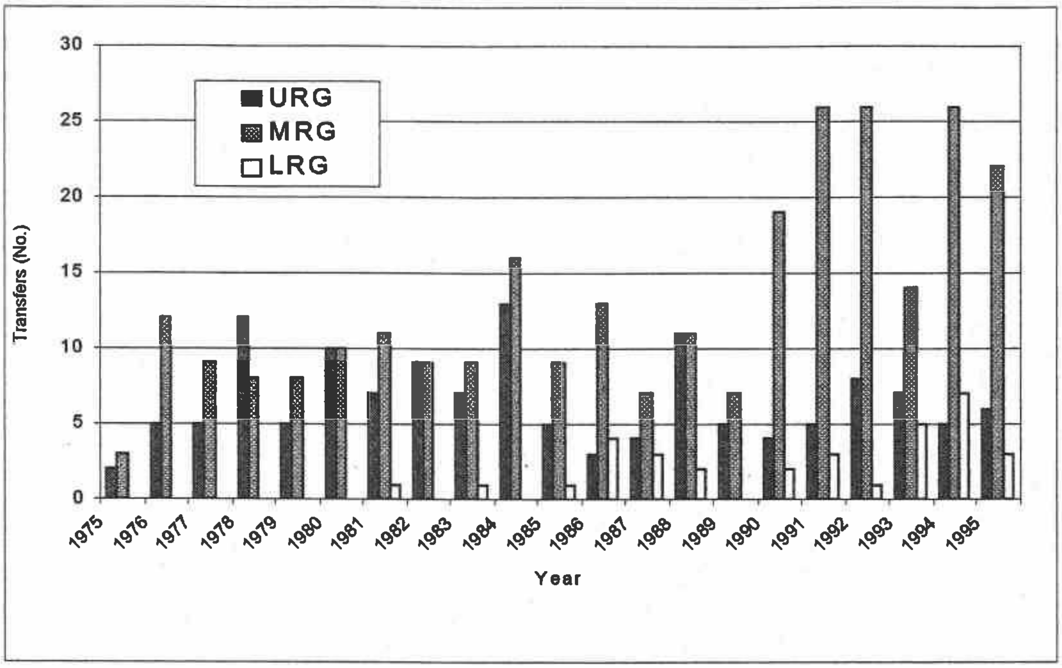


Figure 6.2. Annual water right transfer activity: Rio Grande basin, N.M. (1975-1995).

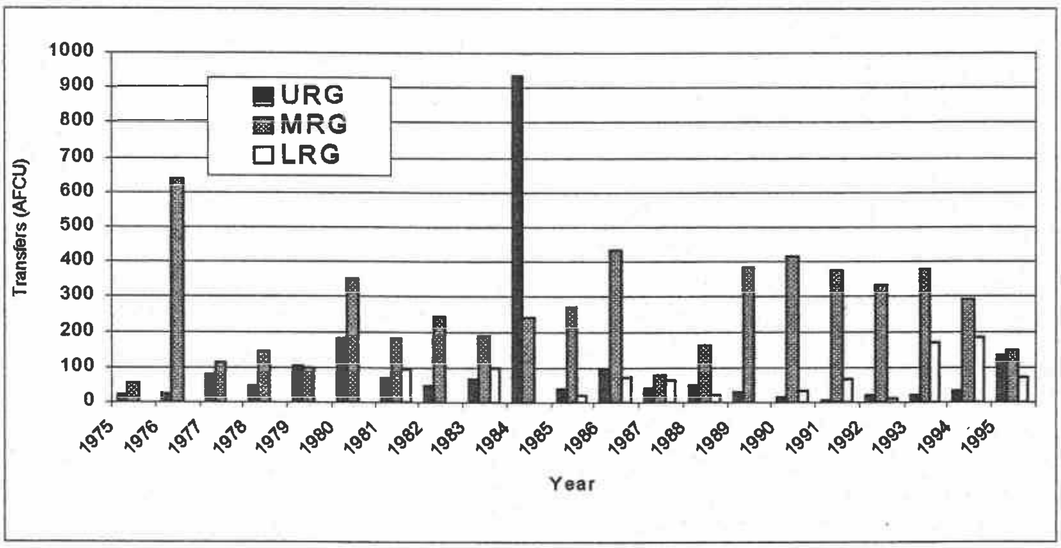


Figure 6.3. Annual amounts of water transferred: Rio Grande basin, N.M. (1975-1995).

within the LRG prior to 1981, but beginning that year a generally increasing trend in the number of transfers effected was established. The initiation of transfer activity in 1981 corresponds to the declaration of the Lower Rio Grande Underground Water Basin by the State Engineer in that year in response to the filing of a suit against him by the City of El Paso, Texas, on September 5, 1980. This suit, which was to become *El Paso* v. *Reynolds* (1983), placed the State Engineer in the position of having to assert his jurisdiction over the groundwater resources of the LRG in order to require that El Paso, and any other potential groundwater appropriator, become subject to the permit application process. There is no apparent trend or pattern in the magnitude of these LRG transfers (Figure 6.3).

Transfer activity within the MRG seemed to be more or less random prior to 1990 (Figure 6.2), after which the number of cases increased substantially for each of the following years. This pattern is essentially repeated for the amounts of water transferred during the study period (Figure 6.3), leading to the conclusion that renewed economic and development activity in the MRG following the recession of the 1980s had the effect of stimulating transfer activity as new water requirements were emerging.

The URG seems to show a somewhat cyclical pattern of transfer activity with a cycle length of about 4 years (Figure 6.2), though to what this might be attributed is difficult to identify. It is more likely a random occurrence of a perceived pattern. More important than this, however, is the fact that transfer activity throughout the study period is quite consistent with an average of perhaps five transfers per year. The most transfer activity occurring during any one calendar year was during 1984 when 13 separate transfers occurred, and the annual total of water transferred during any one year was the greatest here with 935.44 AFCU. Of this amount some 898.08 AFCU were transferred from irrigation uses to a molybdenum mining operation in the Questa basin in eight separate transfers by the Molycorp firm.

The vast majority of transfers effected in the study area relied upon changes in the place and/or purpose of use of ground waters, similar transfers involving changes from surface to groundwater utilization, and dedications (Figure 6.4). The data show that dedications as practiced in the basin generally substitute surface water rights for expanded groundwater pumping rights. This is important in this semiarid region in which the quality of surface waters for human consumption and

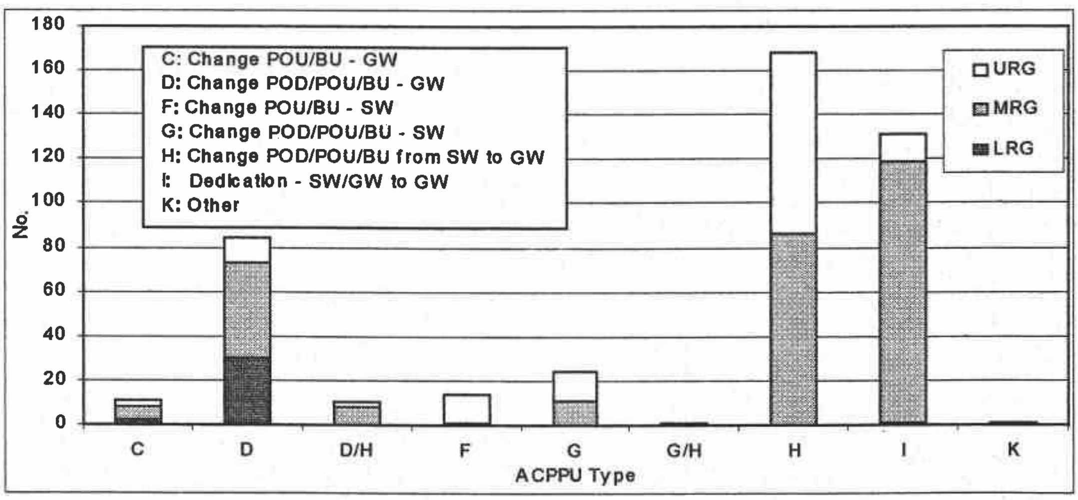


Figure 6.4. ACPPU types filed in the Rio Grande basin, N.M. (1975-1995).

Table 6.2. Surface-to-groundwater transfers in the Rio Grande basin, N.M. (1975-1995).

BENFRO	Number of ACPPUs	AFCU
Domestic	6	19.873
Irrigation	162	2075.669
Municipal	1	14.000
Recreation	1	21.000

other higher uses is generally compromised by a broad array of point and nonpoint pollution sources. Transfers involving only groundwater are for the greatest diversity of changes in BU (Figure 6.5). ACPPUs involving surface to groundwater changes in the place and/or purpose of use (i.e., Type H) are, as expected, dominated by transfers of irrigation waters to all other uses (Table 6.2).

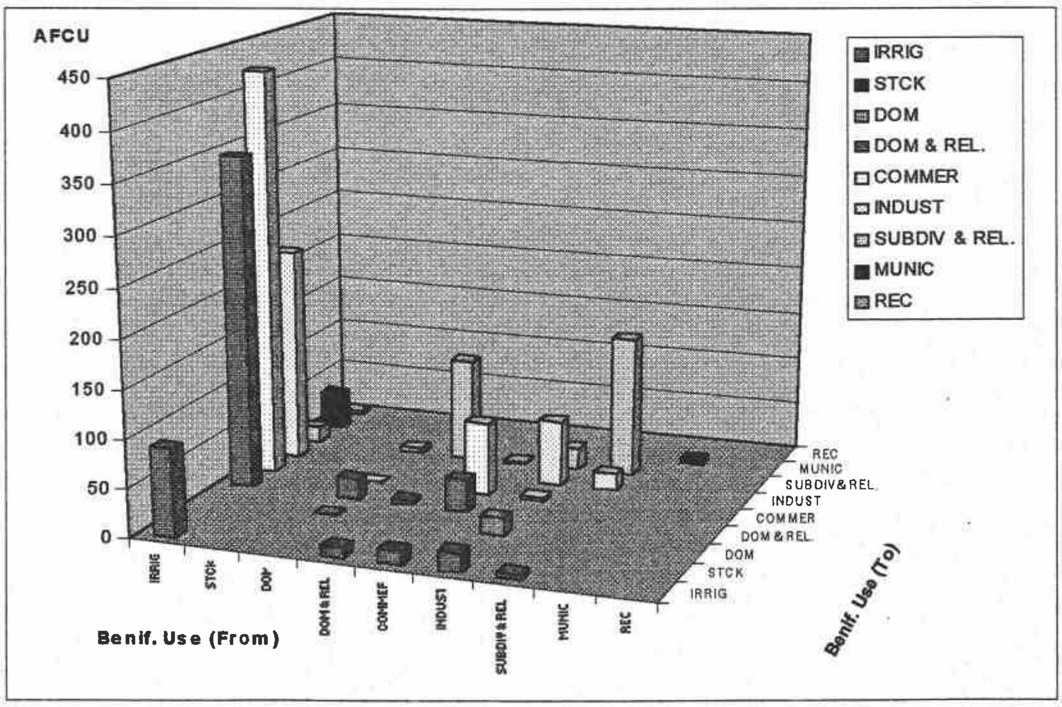
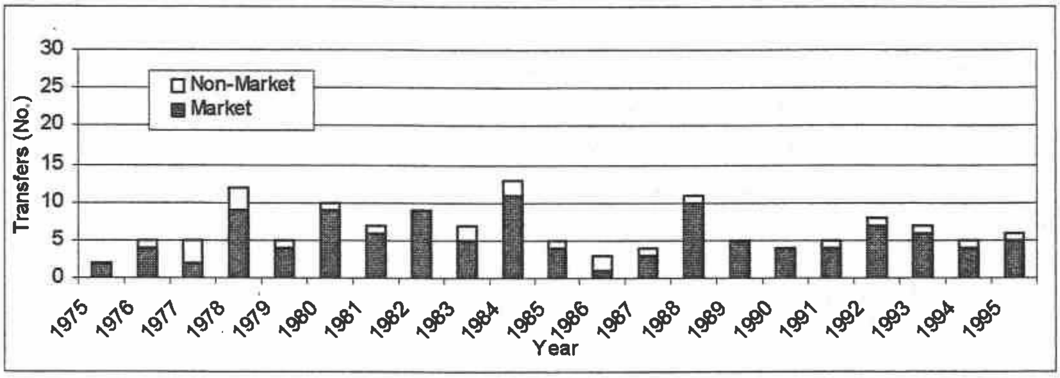
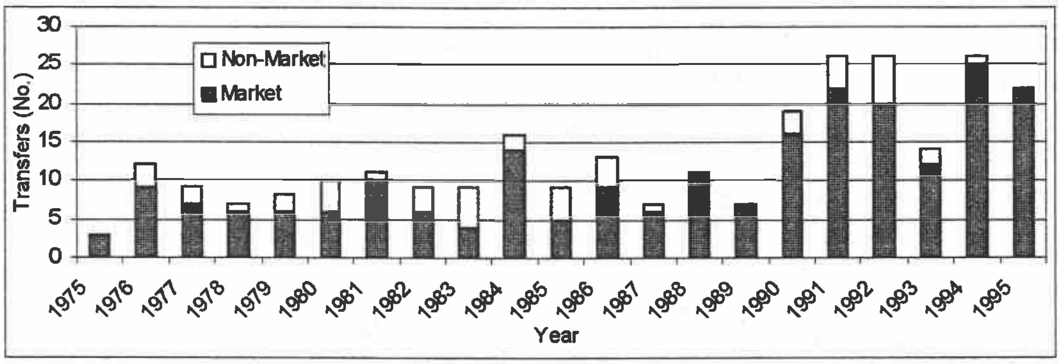


Figure 6.5. Groundwater-based transfers: Rio Grande basin, N.M. (1975-1995).

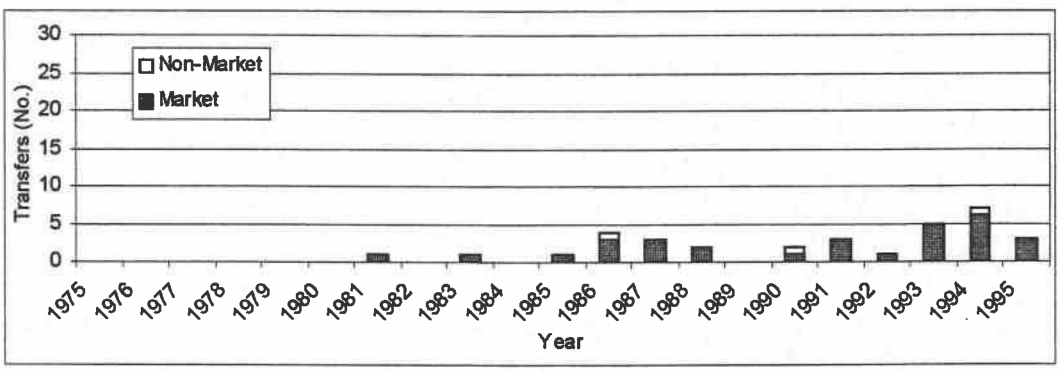
An especially significant aspect of this study concerns the importance of water market activity in the study area relative to non-market-based transfer activity, and how the relative importance of each has changed during the course of the study period for the study area. Figures 6.6a through 6.6c, and Figures 6.7a through 6.7c show the amount of market and non-market-based transfer activity occurring in each of the sub-basins during the study period. Market transactions have clearly dominated transfer activity in each of these areas, underscoring the importance of the market-based transfer as a reallocative mechanism in the study area. These figures also show the annual pattern of transfer activity for each of the sub-basins that are suggested in Figures 6.2. The relative amounts of water conveyed by market and non-market-based transfers occurring in each of the sub-basins are shown in Figures 6.7a through 6.7c. Annual transfer amounts corresponding to the URG show a rather constant trend, with the exception of the large Molycorp transfers occurring in 1984. The MRG, on the other hand, exhibits considerably more variability in terms of total quantities of water transferred and the relative importance of market and non-market-based transfer activity during the study period. The marked trend in increased transfer activity, especially market-based activity, occurring in this sub-basin beginning in 1989 (Figure 6.6b) had the effect of moving increased quantities of water between places of use, BUs, or users. The general correspondence between the number of transfers effected in each of the sub-basins and corresponding amounts of water conveyed implies that a relatively constant mean transfer size occurs within the study area during the period of



a. URG sub-basin.

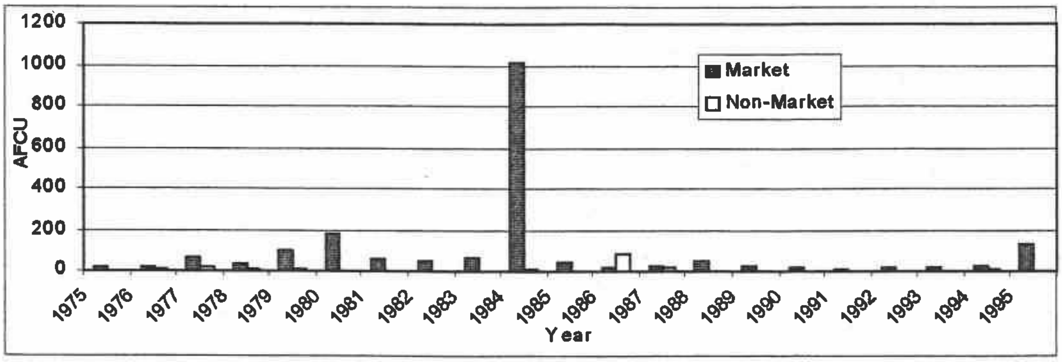


b. MRG sub-basin.

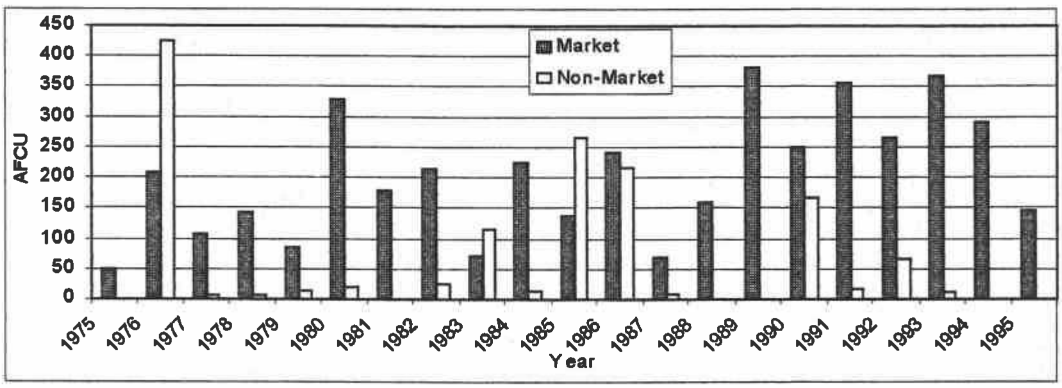


c. LRG sub-basin.

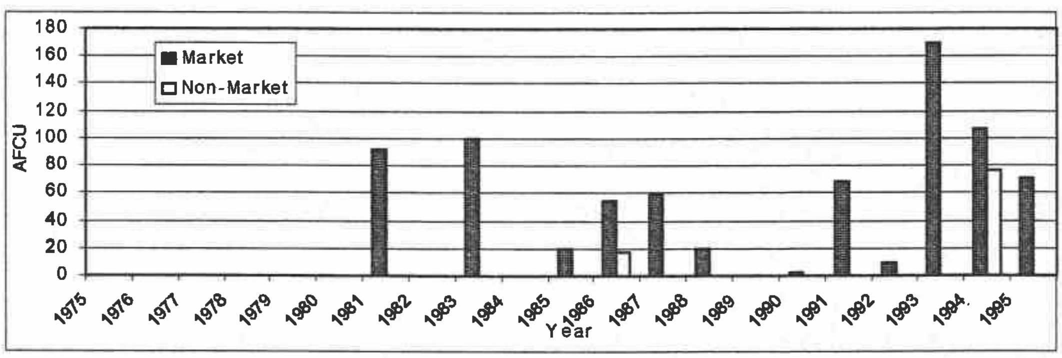
Figures 6.6a-c. Market- and non-market-based transfer activity in the sub-basins, 1975-1995.



a. URG sub-basin.



b. MRG sub-basin.



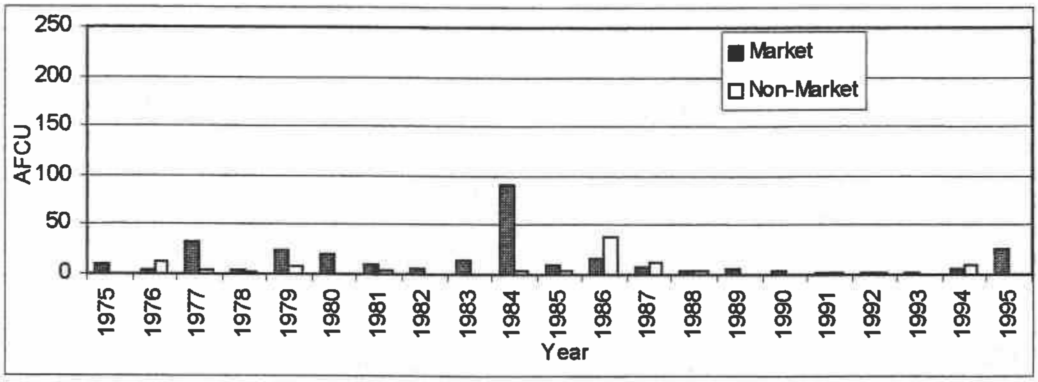
c. LRG sub-basin.

Figures 6.7a-c. Market- and non-market-based transfer amounts for the sub-basins, 1975-1995.

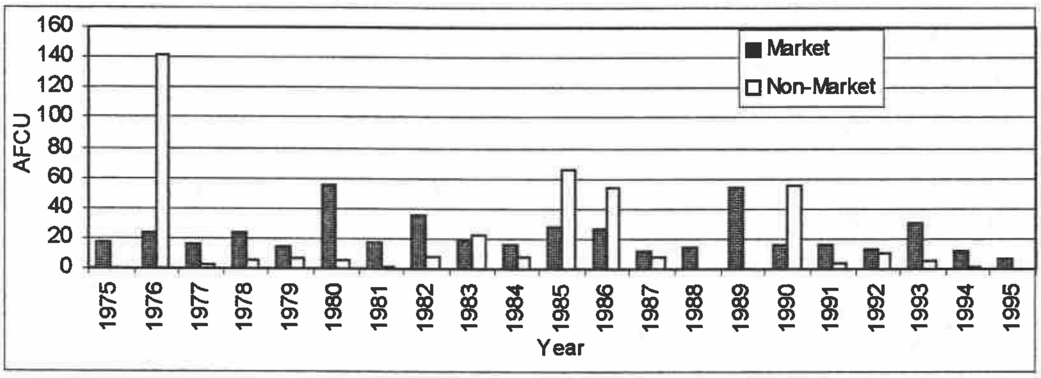
interest, however, this may be due to the fact that smaller transfers (i.e., less than 10 AFCU) dominate the data (Figure 6.1). This is explored graphically in Figures 6.8a through 6.8c which show the annual average transfer sizes corresponding to market and non-market-based transfers in each of the sub-basins. These figures show that the annual average transfer size has been quite variable for market and non-market transfers in each area except for those corresponding to market-based transfers occurring in the MRG. These have remained the most constant, overall, during the study period.

There are implications for the multivariate analyses to be undertaken which follow from the information presented in this section. First, the tendency toward smaller sized transfers coupled with the presence of several observations of considerable magnitude suggests that some transformation of the dependent AFCU data will be required in order to yield meaningful results (such may also be the case for selected independent variables). Second, the consideration of sample size in relation to the power of inference and prediction would normally suggest that the relatively small subset of data corresponding to the LRG sub-basin (33 observations) predisposes this area as one that is less suitable as a candidate for modeling. However, the data utilized in this study are from a census of transfer activity in the study area and its sub-units, and represent an estimated 80 to 100 percent reliable sample[42] which will be subjected to model-fitting. And thirdly, the

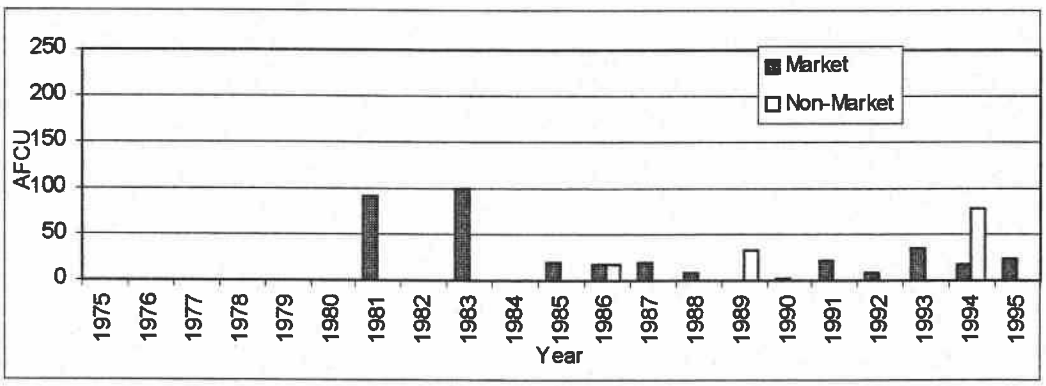
[42] This reliability range is based upon the observation by Nunn (1990:89) that her census had an estimated reliability of about 80 percent; her data were oversampled.



a. URG sub-basin.



b. MRG sub-basin.



c. LRG sub-basin.

Figures 6.8a-c. Annual average transfer sizes of market and non-market transfers.

relative infrequency of non-market transfer activity may predispose the binary independent variable, MARKET, to contributing little in the way of explanatory power in any model. The exploration of its utility will thus represent an early step in the modeling exercise.

6.2 Changes in Beneficial Use

When the data corresponding to the study area and the sub-basins are fitted to the conceptual model of transfer type likelihoods, and the likelihood rankings replaced by transfer quantities expressed in AFCU (Figures 6.9 – 6.12), the data generally conform to the expected pattern except for a notable lack of cases corresponding to many of the transfer types, and a smaller amount of transfer activity than is needed to fill in each of the transfer types represented. Each of the sub-basins also contribute transfer types that do not occur in either of the others, reinforcing the assertion that each of these units has a different character with regard to agricultural production and rates of development.

Transfers occurring within the greater study area (Figure 6.9) show the importance of irrigation water rights as a primary transfer source. This is true for irrigation-to-irrigation transfers that represent transfers between irrigators, and for all other transfer types excepting tranfers to stock and domestic uses. The contribution of irrigation water rights to municipal use are especially noteworthy and not an unexpected finding.

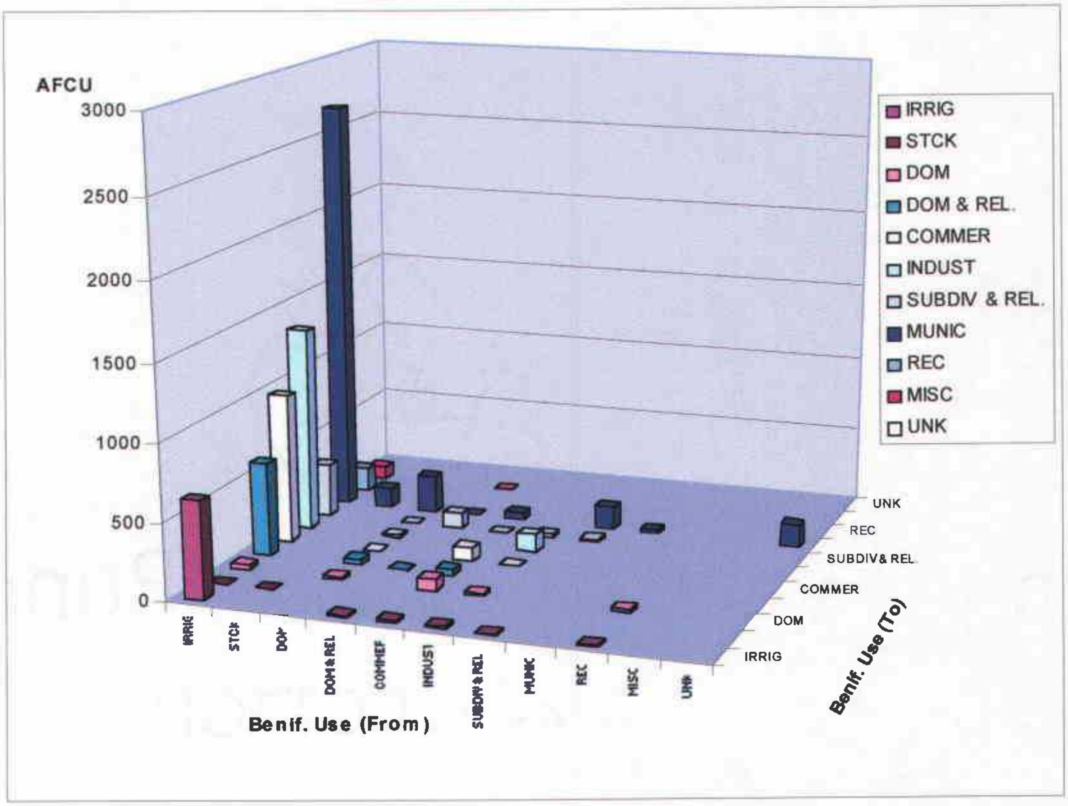


Figure 6.9. Types of transfers in the Rio Grande basin, New Mexico (1975-1995).

Perhaps the one most surprising trend exhibited by the data at the scale of the study area (i.e., Rio Grande basin), and for each of the sub-basins, is the frequency of transfers from higher-value uses to irrigation use. Though the conceptual model (Figure 5.2) posits that transfers of domestic and related water rights to irrigation uses might have some low likelihood, it doesn't allow for transfers of commercial, industrial, subdivision and related, or municipal uses to this lower-value activity. This is because it is assumed that water rights attached to a place of business or manufacturing would likely remain attached to that place even given the lack of economic or financial success of whatever endeavor was

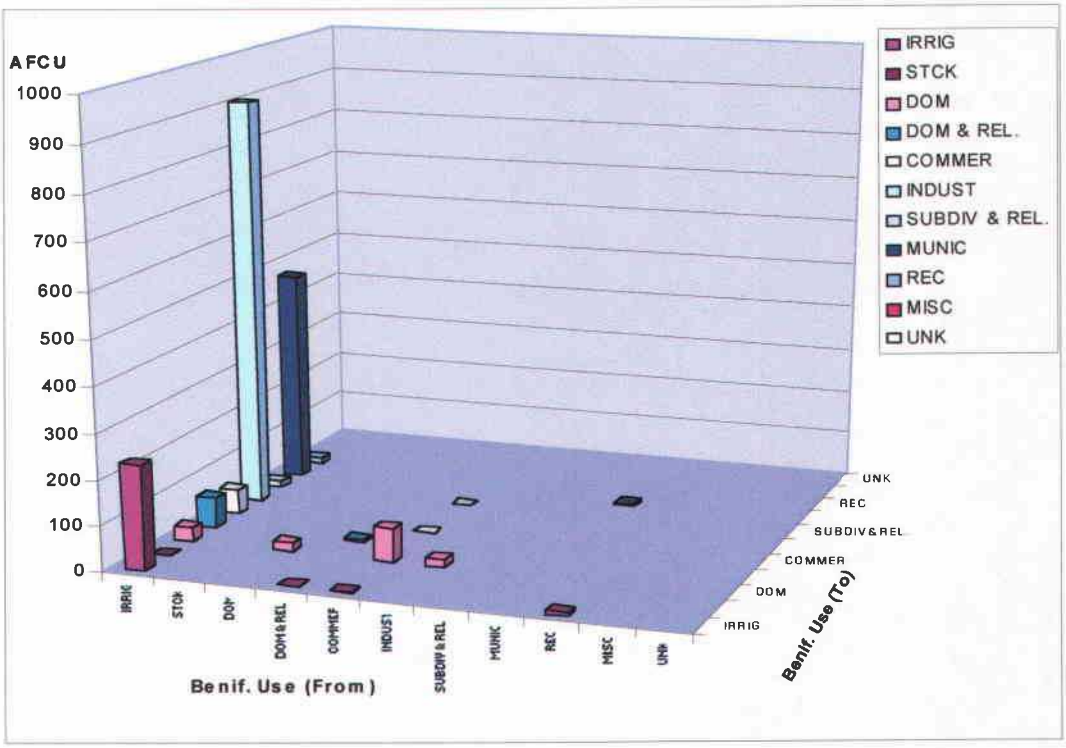


Figure 6.10. Types of water right transfers in the URG sub-basin (1975-1995).

occurring at that place (i.e., business failure). This would have the effect of increasing the relative attractiveness of such locations, at least during a period not exceeding 5 years of non-use of water rights (owing to abandonment or forfeiture provisions in the state water code), to other parties or firms that might desire to rent or purchase such properties for the purpose of doing business. However, the data show that in some cases commercial and industrial water rights are treated as capital in that they are severed from their place of use and transferred to other activities, which in the majority of cases represents the original BU and place of use corresponding to the water right.

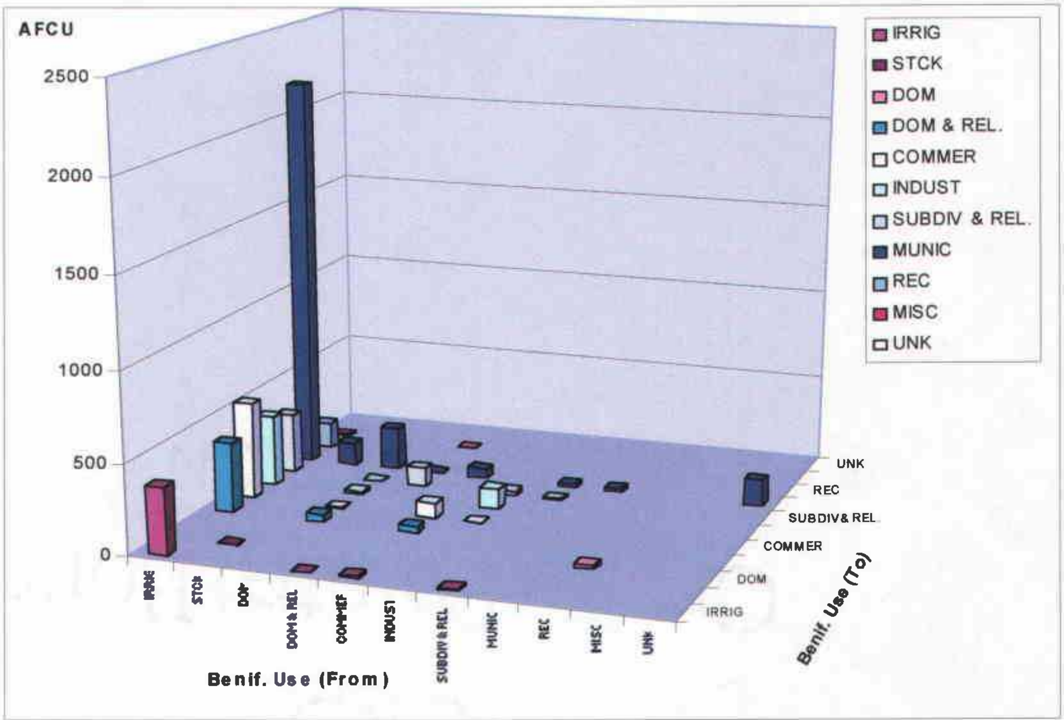


Figure 6.11. Types of water right transfers in the MRG sub-basin (1975-1995).

One other observable pattern of transfer activity that differs amongst the sub-basins concerns transfers from and to domestic and related use categories (these include the "domestic" and "domestic and related" categories, with the latter including some limited irrigation allowance). The URG is characterized by a larger amount of water transferred to domestic and related uses than from, with the highest proportion of such water being represented by a single transfer from the commercial use category (76.4 AFCU). This case represents a failed business endeavor, and the retention and conversion of a water right at the same place of use but for a different BU. Other transfer-to domestic and related use category transactions in this sub-basin reinforce the characterization of this area as one in

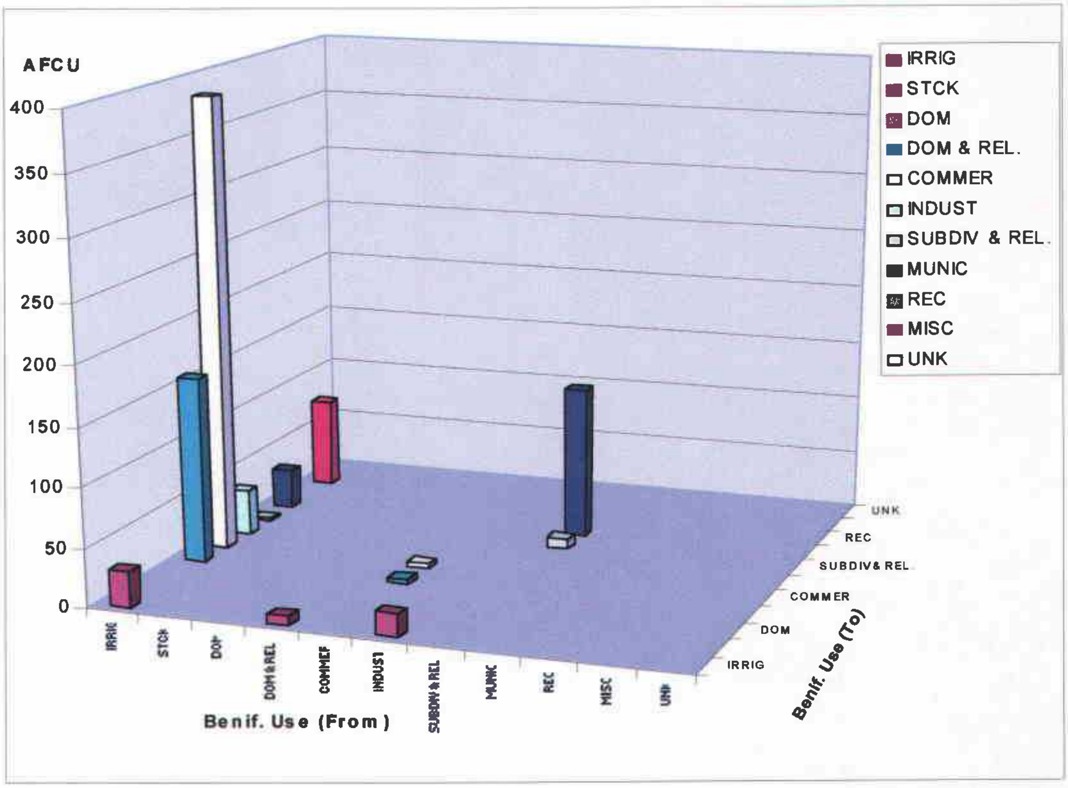


Figure 6.12. Types of water right transfers in the LRG sub-basin, (1975-1995).

which development related to recreation and tourism, especially second and/or vacation homes, is commonplace.

The MRG, on the other hand, is characterized by a notable trend of transfers from the domestic and related use categories. Included here is a large block (30 separate transfers totaling 238.48 AFCU) of domestic-to-municipal transfers occurring in the Village of Bosque Farms, a growing bedroom community to the City of Albuquerque situated along the Rio Grande and the Interstate 25 transportation corridor. These transfers from private water wells allowed the expansion of water delivery service within the community, and ensured that all transferors would receive water treated under federal guidelines. In comparison to this sub-basin and the URG, the LRG shows six transfers totaling 7.7 AFCU from the domestic and related use category to irrigation use. Though the total is relatively small, this activity is clearly more retrogressive than that occurring in either of the other two sub-basins.

6.3 Spatiotemporal Distribution of Transfer Activity

The spatial occurrence and/or distribution of water right transfers is shown at the scale of the study area and the sub-basins in the series of maps that follow. A number of questions can be explored through the use of these maps including: does the spatial occurrence of water right transfers exhibit any spatial pattern; does the range of original or move-from BUs corresponding to transfers exhibit any observable spatial pattern; and lastly, does the temporal occurrence of transfers exhibit any spatial pattern? These questions essentially follow the schema corresponding to Peuquet's (1994) Spatiotemporal Triad framework discussed previously in that they deal with the wheres, whens, and whats of transfer activity in the study area.

These themes are explored utilizing two basic map types: one which depicts transfers classified by their original or move-from BU, and one which depicts transfers classified by different time period subsets of the overall study time period. The illustration of classified phenomena using two map types instead of one was decided upon after viewing the complexity of information provided by just one of these – from a visualization standpoint too much complexity of information within a given map may actually serve to obscure interpretation. And in defense of this approach, it should be noted that while the Triad approach or framework can be seen as providing a foundation for the exploration of spatiotemporal phenomena, it should not be seen as a prescriptive approach to cartographic representation of such phenomena.

The overall distribution of transfer activity in the study area is depicted in Figure 6.13. The original or move-from POUs corresponding to each mappable transfer is depicted by a point which corresponds to the POD for a transfer originating from a non-irrigation or municipal water right, or to a centroid in the case of a polygonal POU such as would correspond to an irrigation water right. The figure clearly shows that transfer activity is clustered about major population centers and areas of settlement. This visual interpretation of pattern is supported by the first lag nearest-neighbor statistic, $R = 0.00678$ (where $n = 333$), indicating very strong clustering of the data points. Transfers in the three sub-basins, and for selected places around which a large number of transfers are located, also show generally quite strong clustering (Table 6.3) with the least amount occurring in the LRG.

The high degree of clustering of transfer POUs within the basin is not surprising. In addition to the fact that the pattern of human settlement in the study area is highly clustered owing to both physiographic and urban influences, this

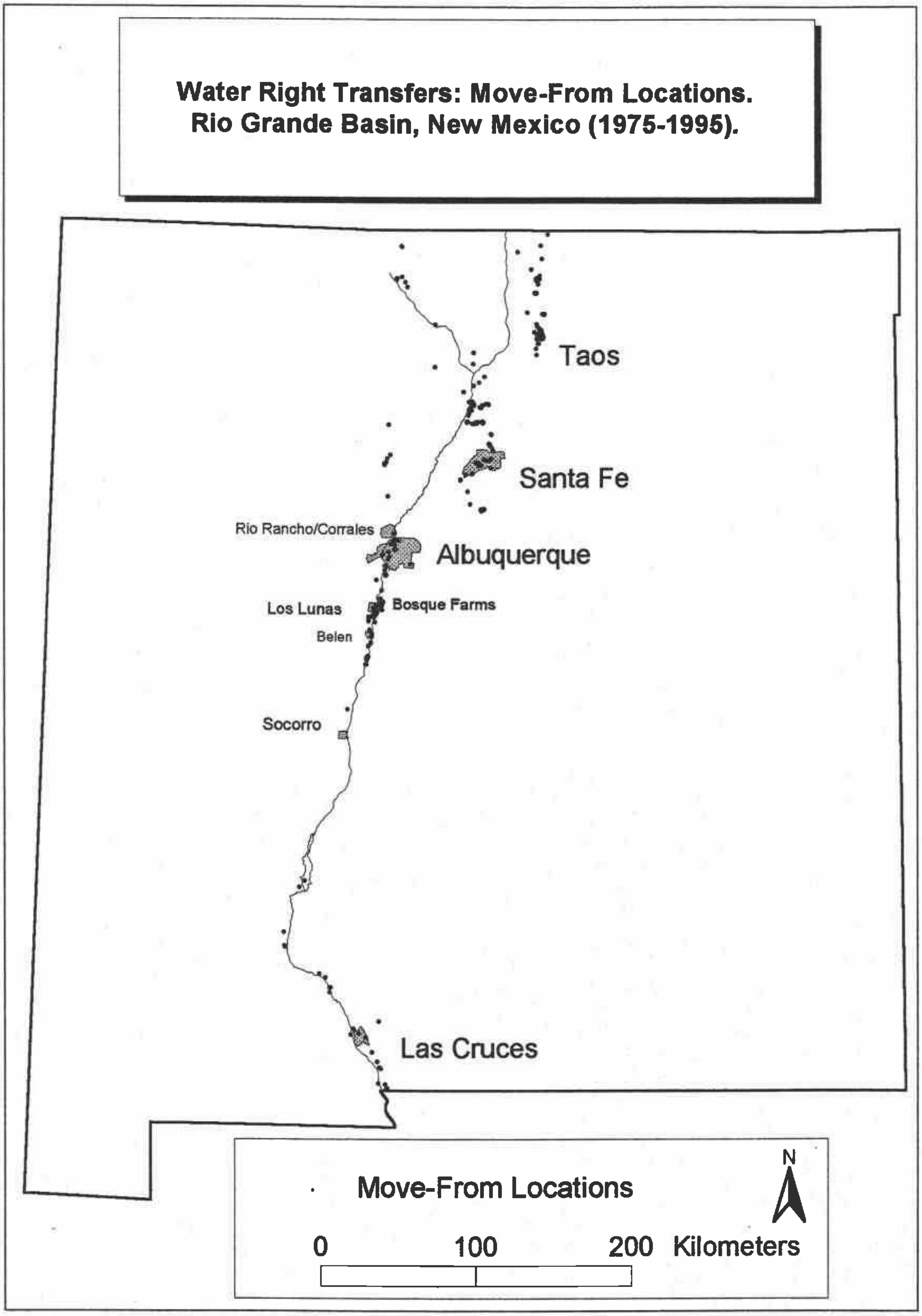


Figure 6.13. Transfer locations in the Rio Grande basin, New Mexico (1975-1995).

Table 6.3. First order nearest-neighbor statistics for POU centroids in the study area, its sub-basins, and selected places.

Unit	R – Value	No. Observations (n)
Rio Grande basin	0.00678	333
URG Sub-basin	0.01670	160
Taos Area	0.05370	74
MRG Sub-basin	0.01400	147
Santa Fe Area	0.03142	68
Albuquerque – Belen	0.02725	72
LRG Sub-basin	0.09543	24

pattern owes to the fact that a high proportion of the transfers have more than one POU associated with them. These POUs are generally located in close proximity to one another given that they all correspond to the same water right. Any spatial separation of POUs associated with a given water right generally occurs because of the existence of roads, ditches, or physical features in the area of concern. Another factor that can influence the spatial separation of POUs associated with a given water right is the decision of owners to sell the rights from selected portions of their property for reasons that are influenced by many factors (see Figure 3.1).

The distribution and arrangement (i.e., spatial occurrence and form) of move-from POUs in the study area is better demonstrated by maps drawn at the scale of the sub-basin. Figure 6.14 shows the distribution and arrangement of move-from POUs and their corresponding BUs for the URG. Some patterns that are evident on this map are the clustering of irrigation water right transfer POUs around the communities of Taos, Española, and in the Questa area (represented by the very small irregular polygon shapes which appear on the map), and the relative

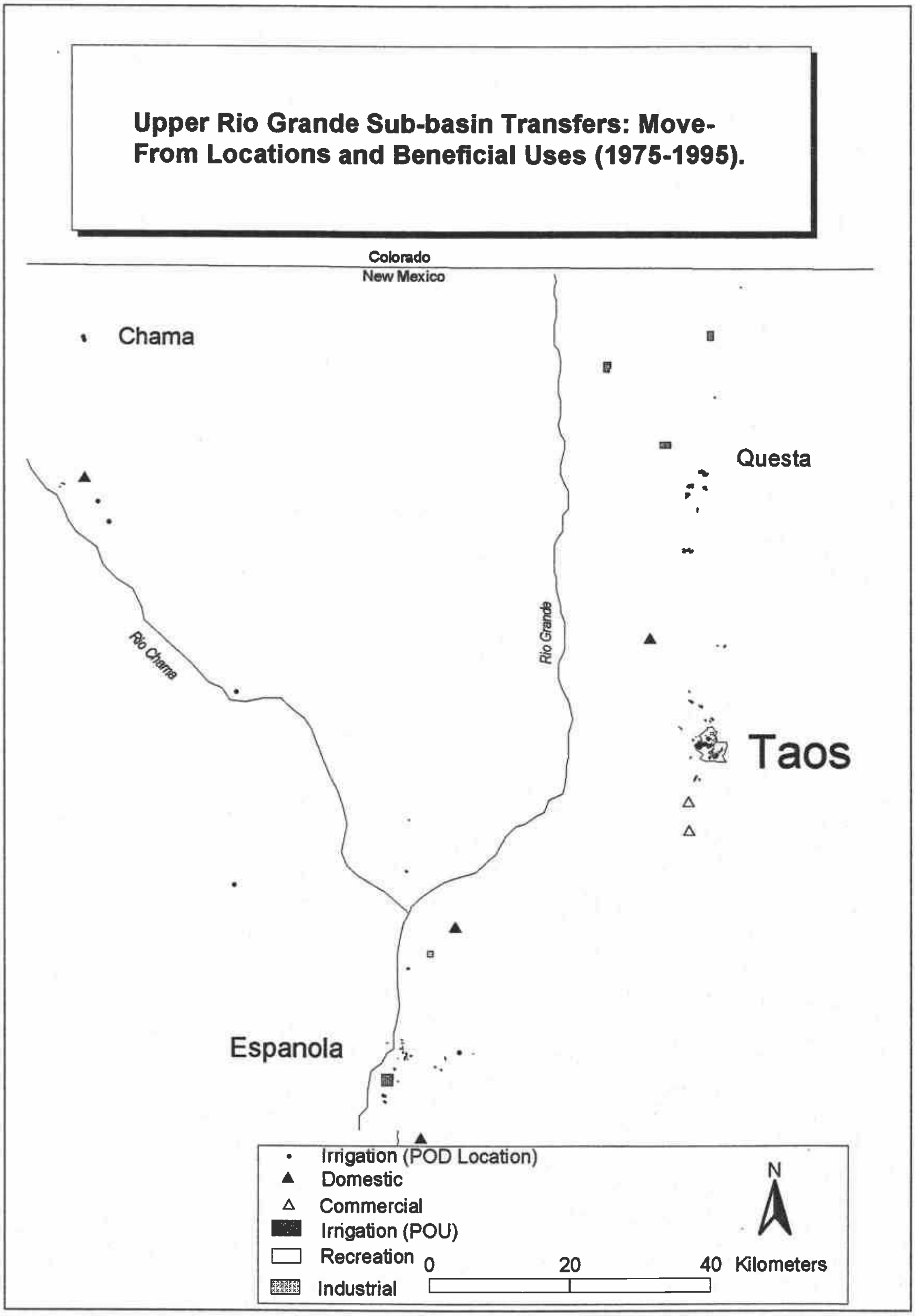


Figure 6.14. Transfer locations in the URG sub-basin (1975-1995).

unimportance of domestic- and commercial-based transfers. There are only two recreation-based transfer POUs, and these (though they cannot be visually located given the scale of the map and their relatively small size) are situated in the Taos area and correspond to the same water right transfer. Similarly, there is only one industrial-based transfer POU and this is situated just to the north of Española. The relatively large areas corresponding to certain irrigation POUs, such as those in the Questa and Española areas, correspond to POUs that were mapped based upon their locations within USPLS subdivisions. Two of these Questa area POUs correspond to center-pivot irrigation plots.

While the discussion of the social, cultural, and economic transformation of the Rio Arriba is complex given the existence of dimensions of varying importance to each of its communities (i.e., use of upland areas for transhumance activities, crop and manufacturing specialization, and the role of intra- and inter-regional trade),[43] the communities of Taos, Española, and Questa represent early Hispano settlements in the Rio Arriba which originally had at least some high degree of dependence on agriculture. The in-migration of Euro-American culture to this region and the concomitant expropriation of land and the transformation of the existing natural resources-based economy has largely resulted in the marginalization of already marginal agricultural tracts, changing patterns of land use, and an increased demand for limited water rights for development.

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[43] An abundance of studies and historical works have been compiled on this subject. See: Briggs and Van Ness (1987), Carlson (1990), Chavez (1984), Nostrand (1992), Rivera (1996), Rosenbaum (1981), and Zeleny (1974).

This is well demonstrated for the community of Taos (Figure 6.15) which is characterized by a relatively large number of transfers of irrigation water rights and a corresponding change in use of a significant portion of the community's land base. Though a number of irrigation-based water right transfers have been effected to the north and south of Taos (Figures 6.14 and 6.15), the predominance of activity has been within close proximity of the town itself. This is primarily a function of the occurrence of some twenty-seven separate transfers of irrigation water rights to municipal use by the Town of Taos.

Temporally, these transfers are dispersed in a rather even or regular pattern throughout the time-period corresponding to the study, and at the time the data were collected these transfers represented all of the transfer activity that had been engaged in by the community. With respect to the spatiotemporal occurrence of all transfers occurring within the Taos area, the pattern appears to trend towards concentricity (Figure 6.16). This pattern suggests that the availability of water rights for transfer varied here as a function of distance from the town center across the study period, supporting the idea that the outward directed growth and development which has served to enlarge the Town during this twenty-year time period has had an effect on the transferability of water rights there. This conclusion is in agreement with the density-distance decay concept discussed previously in this work.

A similar trend, though not as well defined owing to a reduced frequency of transfer activity, is exhibited for the community of Española (Figure 6.17). This

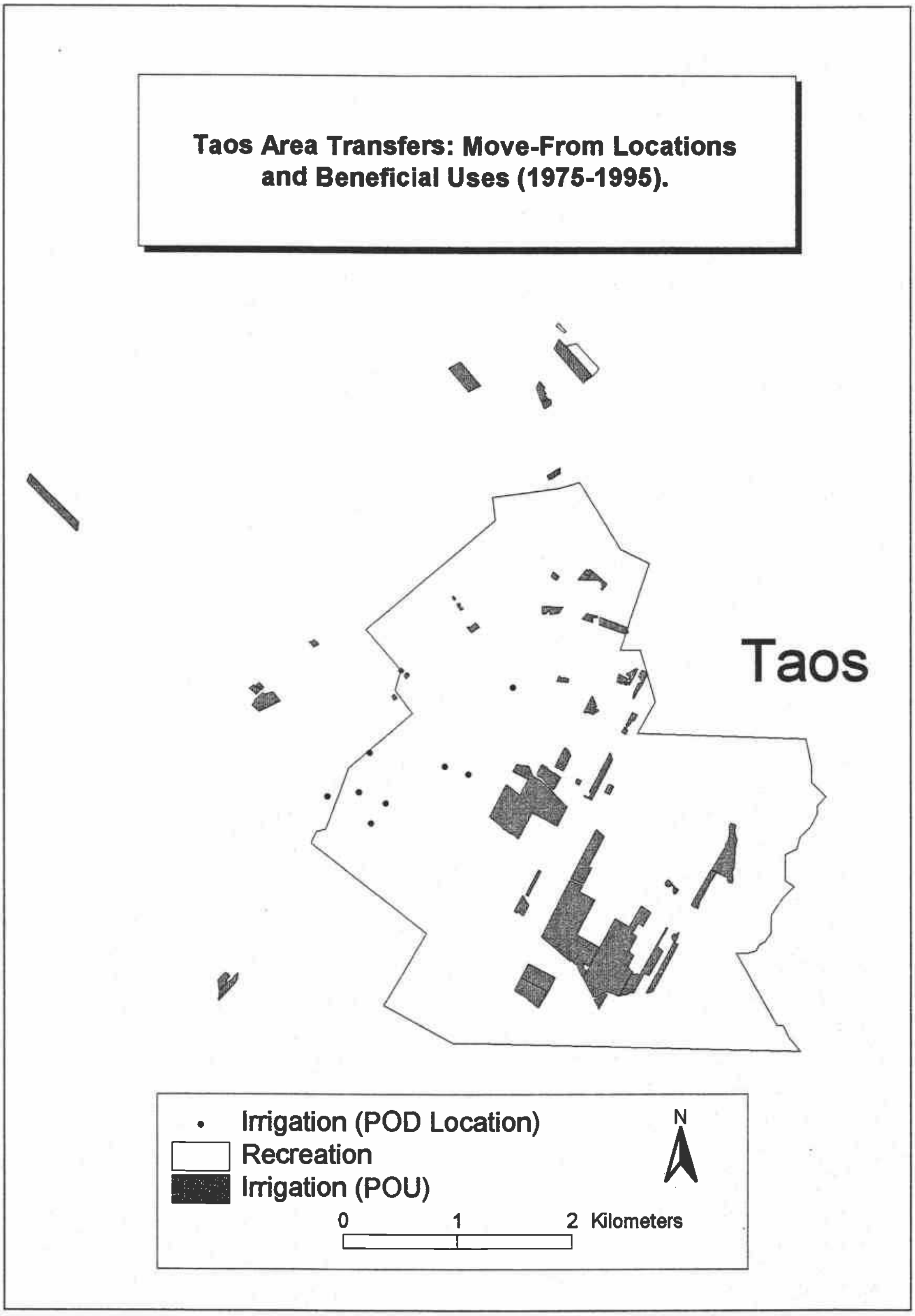

Figure 6.15. Transfer locations in the Taos area (1975-1995).

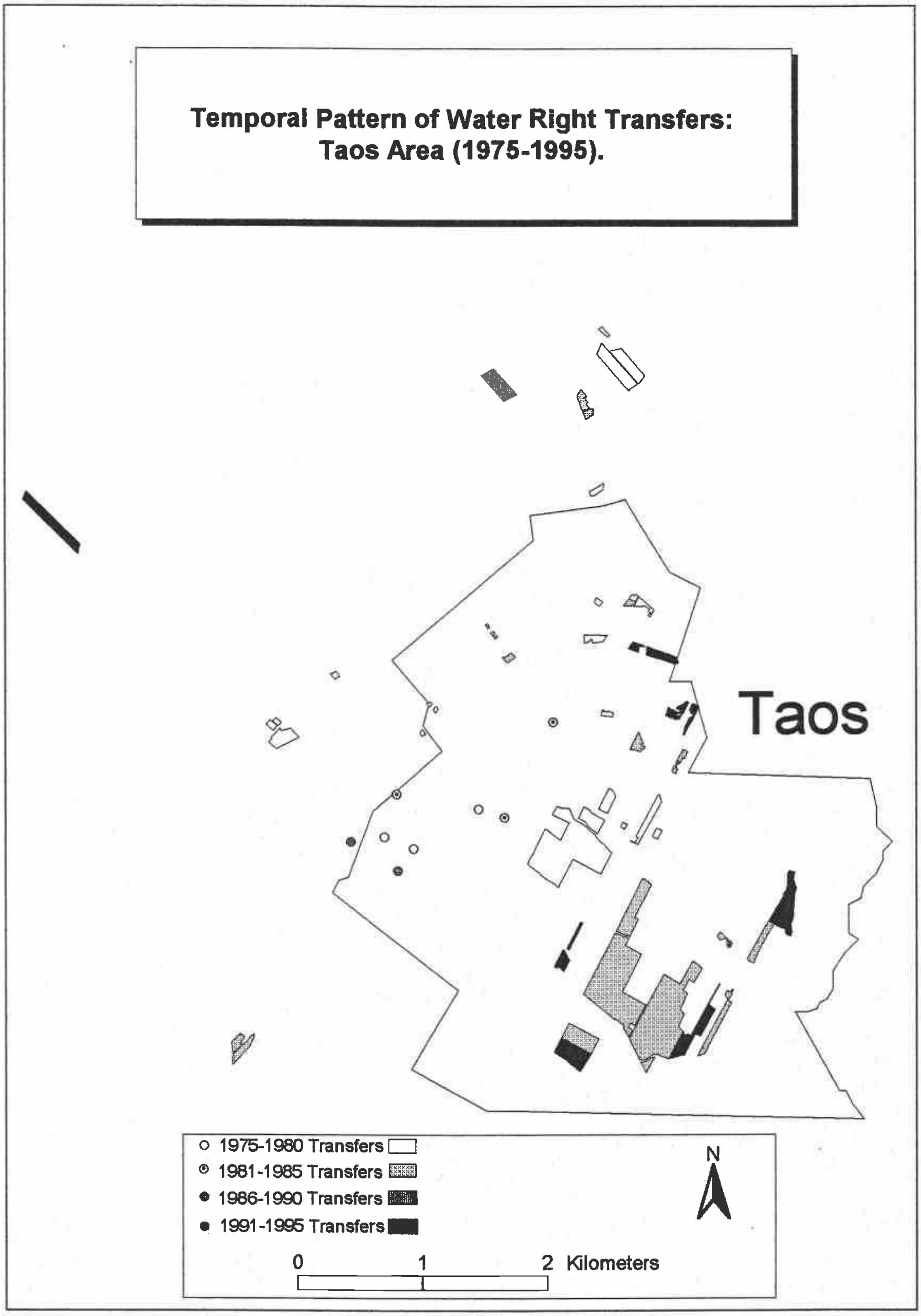

Figure 6.16. Spatiotemporal distribution of transfers, Taos area (1975-1995).

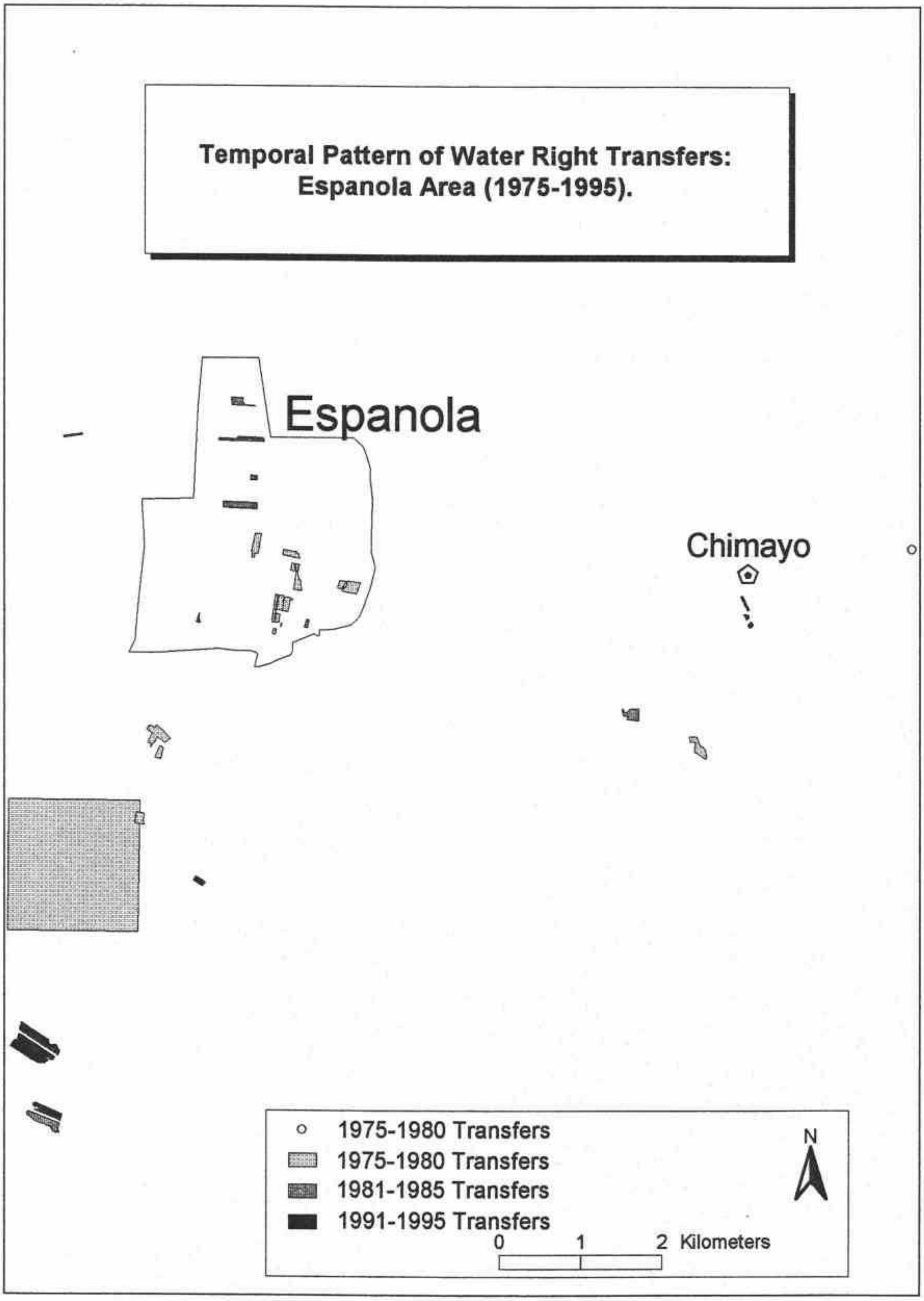

Figure 6.17. Spatiotemporal distribution of transfers, Española area (1975-1995).

community, which has long been noted as an important commercial service center for the region (Weigle 1975), has been experiencing increased rates of growth in recent decades as it has assumed the character of a bedroom community to the cities of Santa Fe and Los Alamos. Española, however, is characterized by a later start with regard to the initiation of transfer activity suggesting that growth in this community has been temporally delayed relative to Taos. The reasons underlying this trend are probably related more to Taos' longer history of growth and development relative to that of Española. Taos underwent significant Euro-American in-migration beginning in 1917 associated with the establishment of an artists' colony there and with the concomitant tourism which has since evolved into a post-modern "luxury tourism real-estate boom" that threatens what remains of the traditional Hispano land and water base (Rodríguez 1987). Growth and development in Española, on the other hand, has been linked to the expansion of operations at the Los Alamos National Laboratory during the 1980s that was associated with defense spending and with growth and development occurring in more upscale Santa Fe.

Relative to the spatiotemporal patterns of transfers exhibited in the Taos and Española areas, the overall pattern corresponding to the URG is rather unremarkable save for a general predominance of transfers occurring during the period 1981-1985, especially within the vicinity of Questa (Figure 6.18). This cluster of transfers is associated with the Molycorp mining operation situated along the Red River near the village of Questa. As was noted previously, these transfers

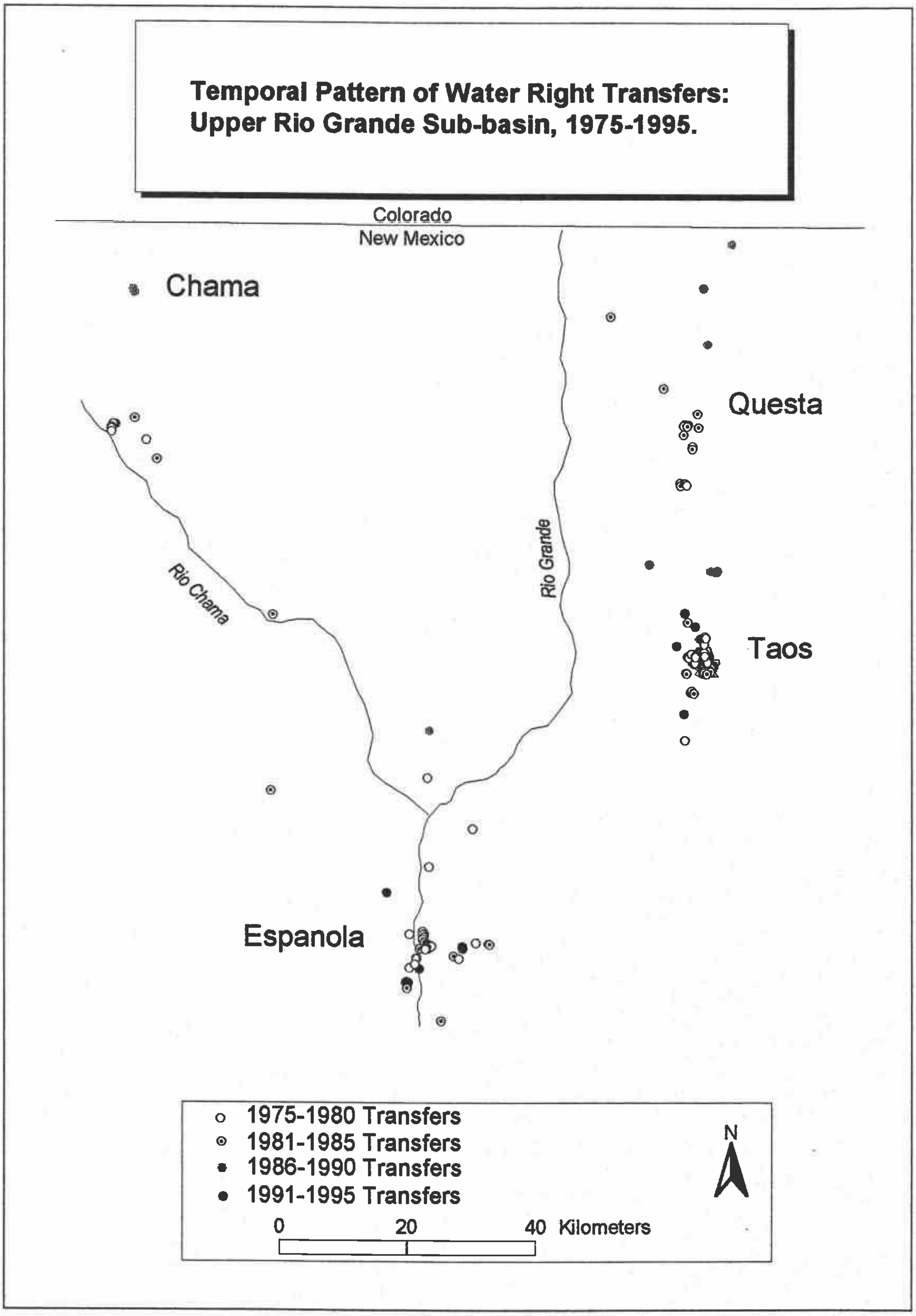

Figure 6.18. Spatiotemporal distribution of transfers, URG sub-basin (1975-1995).

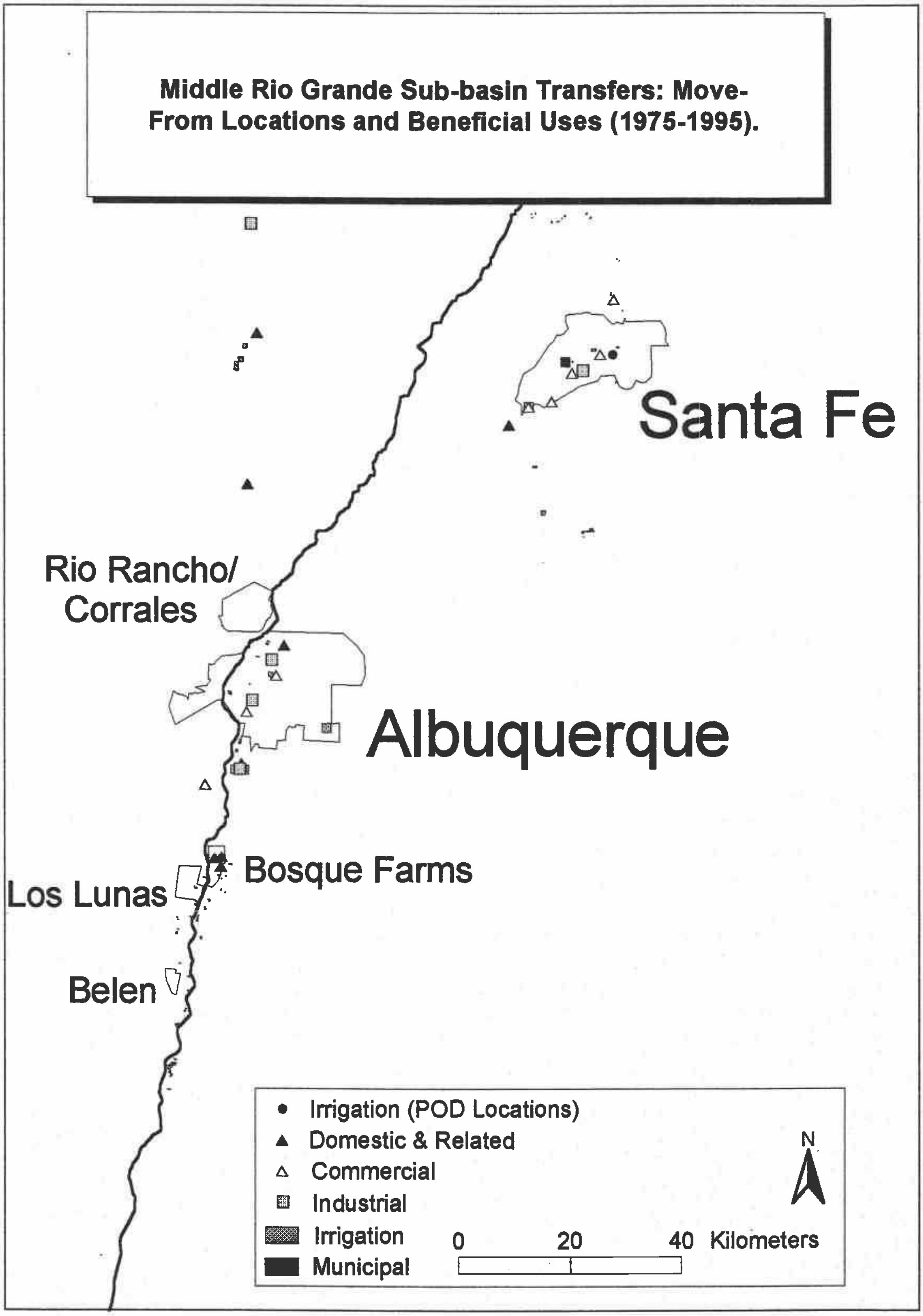

Figure 6.19. Water right transfer locations, MRG sub-basin (1975-1995).

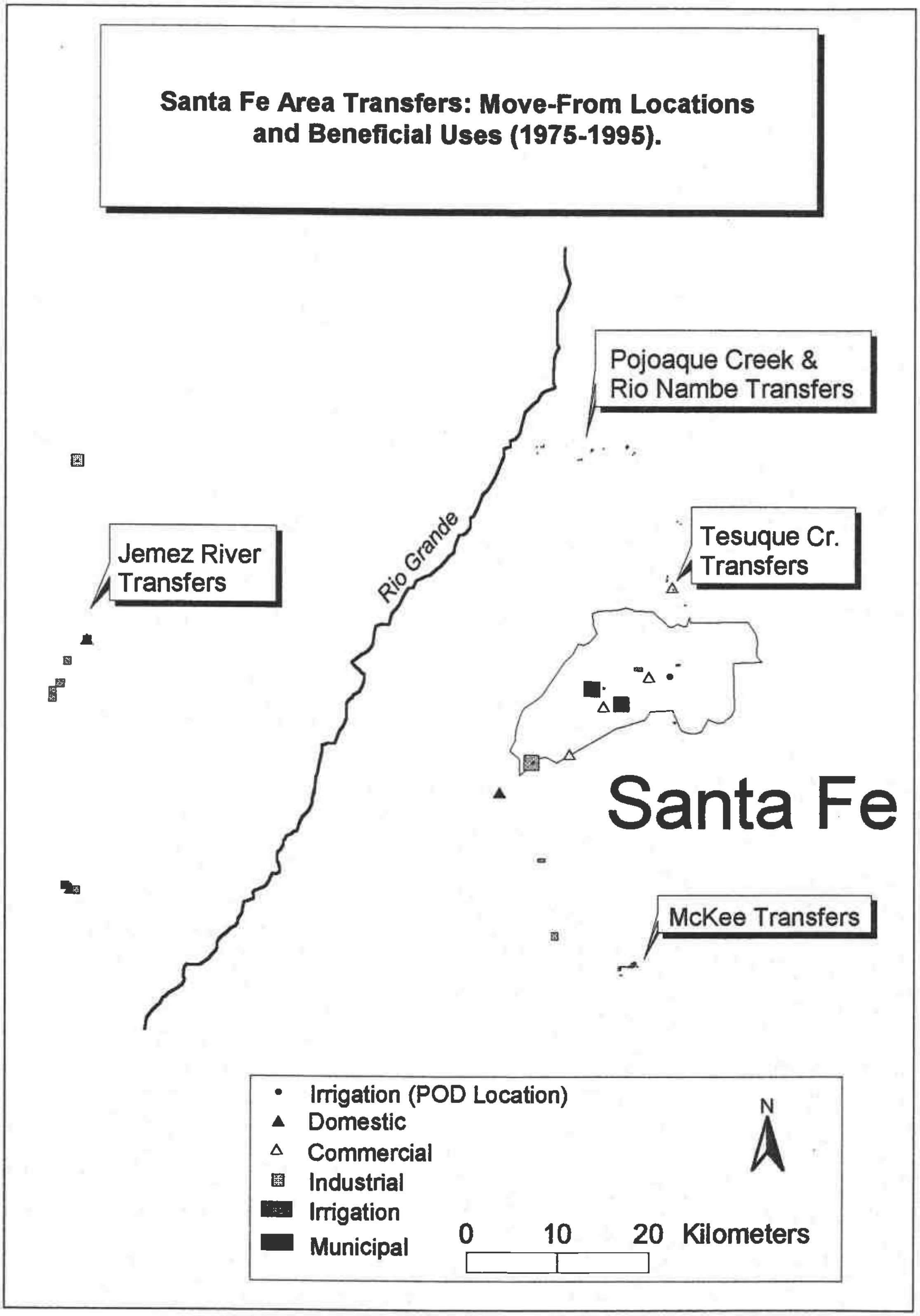

Figure 6.20. Water right transfer locations, Santa Fe area (1975-1995).

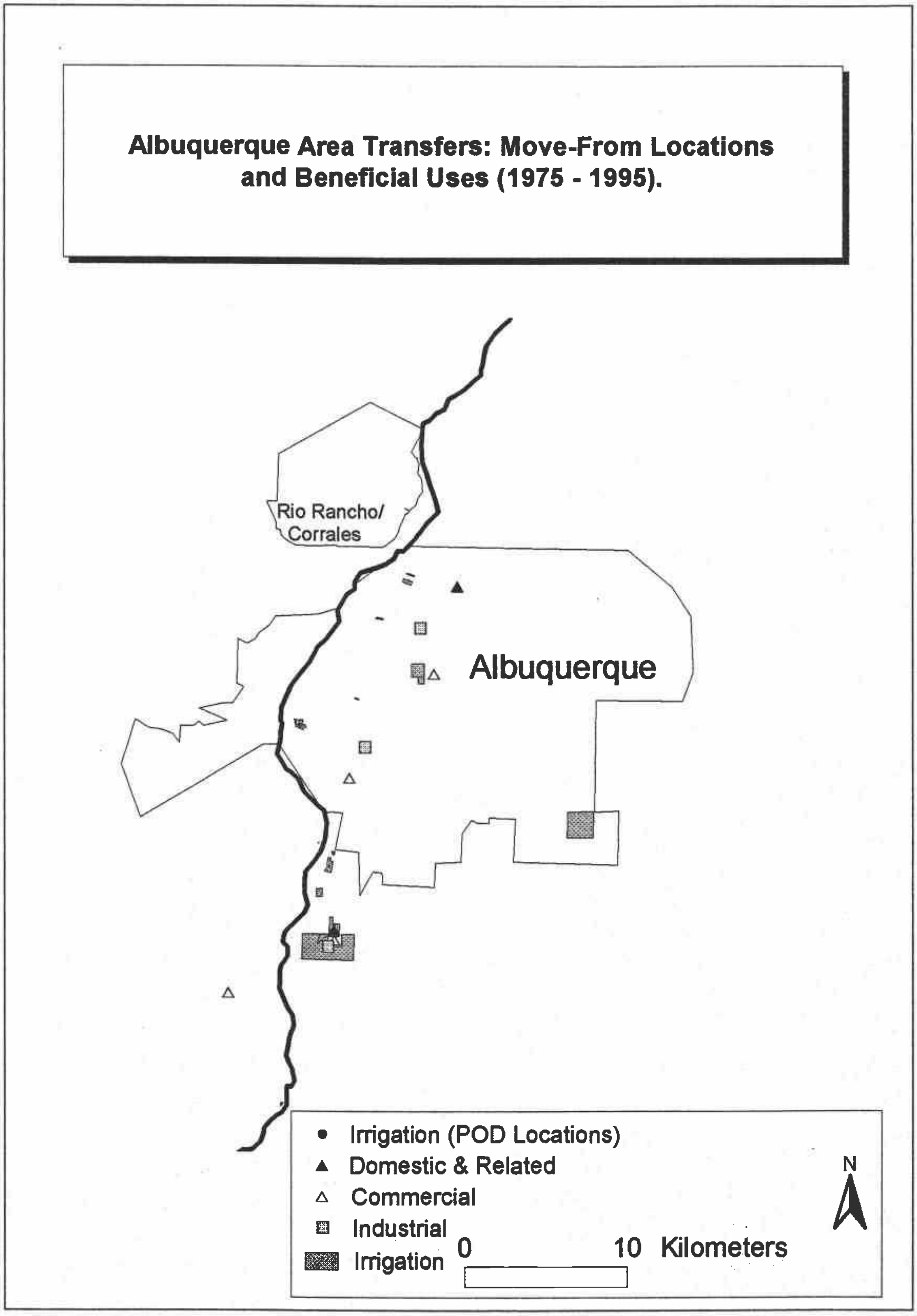

Figure 6.21. Water right transfer locations, Albuquerque area (1975-1995).

all involved irrigation water rights. Other than this, the overall distribution of points corresponding to each of the time periods appears to be random as opposed to clustered or regular.

Though difficult to see at first given map scale and the relative size of transfer POUs, transfer activity occurring within the MRG shows just two major trends with respect to move-from BUs and POUs (Figures 6.19 – 6.21). These are both related to the occurrence of a large number of irrigation-based transfers. The first of these is depicted as a comparatively large cluster of transfers or POUs located directly to the south of Santa Fe (i.e., the southernmost cluster), representing twenty-one separate POUs corresponding to some twelve transfers from the McKee Ranch properties (Figure 6.20). The second corresponds to the MRGCD lands extending from Bosque Farms to the south of Belen, and includes an especially large cluster at the southernmost end of the sub-basin (Figure 6.19). This cluster of POUs to the south of Belen appears to be similar to the McKee transfers for the fact that the data suggest it represents a series of separate tranfers, primarily to municipal uses in Albuquerque and Los Lunas, of irrigation water rights from the lands of at least two different (probably extended) families. In the case of the McKee Ranch and POU clusters in the extreme southern part of the MRG, the close spatial proximity of POUs and the condition of what appears to be common ownership suggests that a strategy of capitalizing on the marketability of water rights is being followed in these cases.

Other information presented in Figure 6.19 includes a number of more spatially isolated transfers occurring in the Jemez River basin directly to the north of Rio Rancho and Corrales, one of which actually represents a transfer of an industrial water right to commercial use within the community of Placitas just to the north of Albuquerque. Several other transfers of water rights previously devoted to industrial purposes occurred within the City of Albuquerque and just to the south, and one such within the City of Santa Fe. The few commercial transfers are similarly clustered in and around these cities.

One important piece of information concerning transfers of domestic water rights that is not conveyed by the maps concerns the conversion of the previously mentioned domestic use rights within the Village of Bosque Farms to municipal use. These transfers are represented by three separate map symbols that correspond to the centroids of the USPLS units documented in the water right files.

The spatiotemporal distribution of transfers and their associated POUs occurring within the MRG (Figures 6.22 – 6.24) seems not to demonstrate any distinct patterns, especially relative to transfers occurring in the URG. There is a greater frequency of occurrence of transfers corresponding to the most recent time period (i.e., 1991-1995), however, these seem to be randomly distributed throughout the region relative to the overall pattern of clustering and the POUs corresponding to other time periods. This is an unexpected conclusion, for indeed the spatiotemporal patterns of transfers evident in and around Taos and Española in the URG were seemingly well established. It may just be that, in the case of the

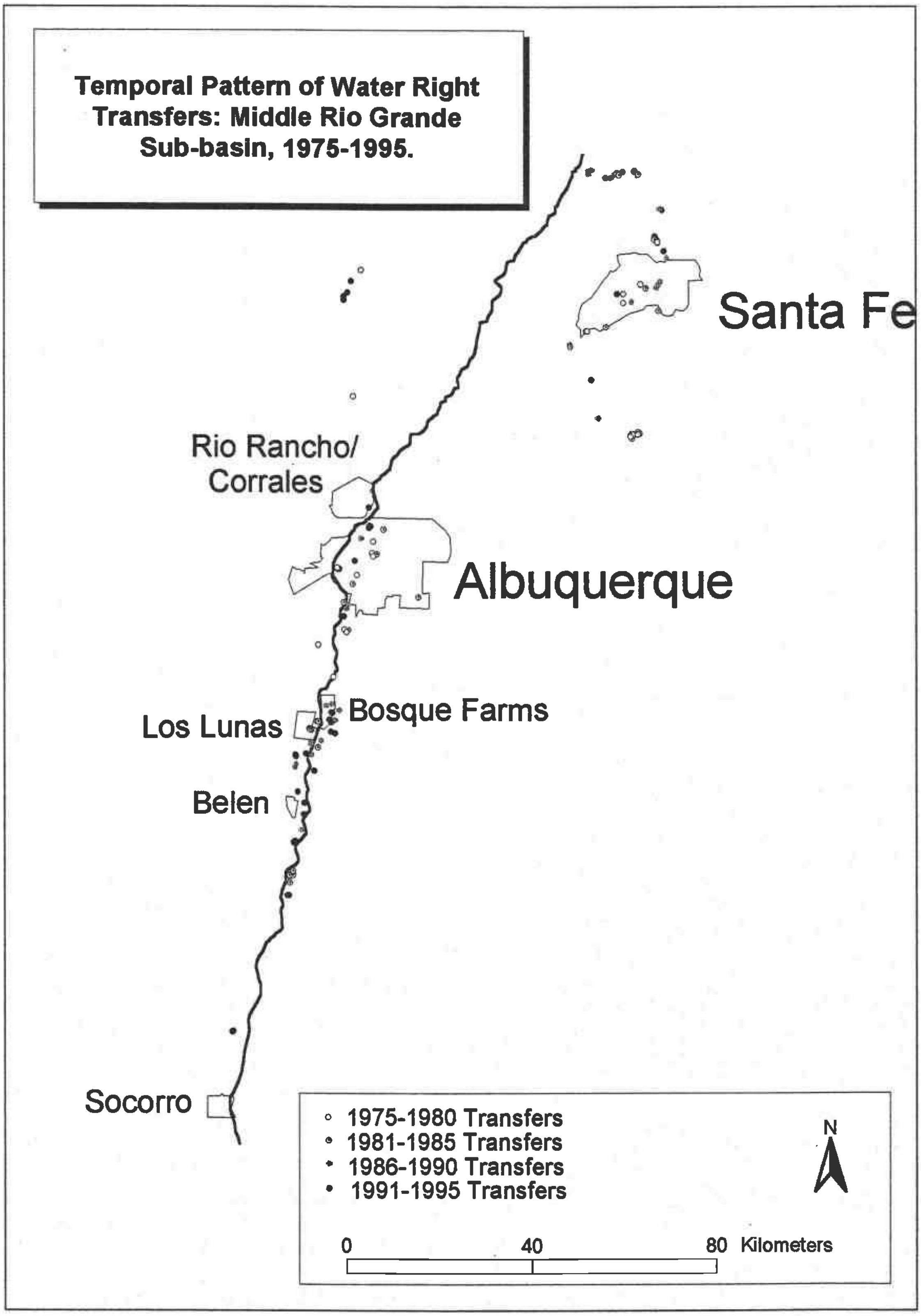

Figure 6.22. Spatiotemporal distribution of transfers, MRG sub-basin (1975-1995).

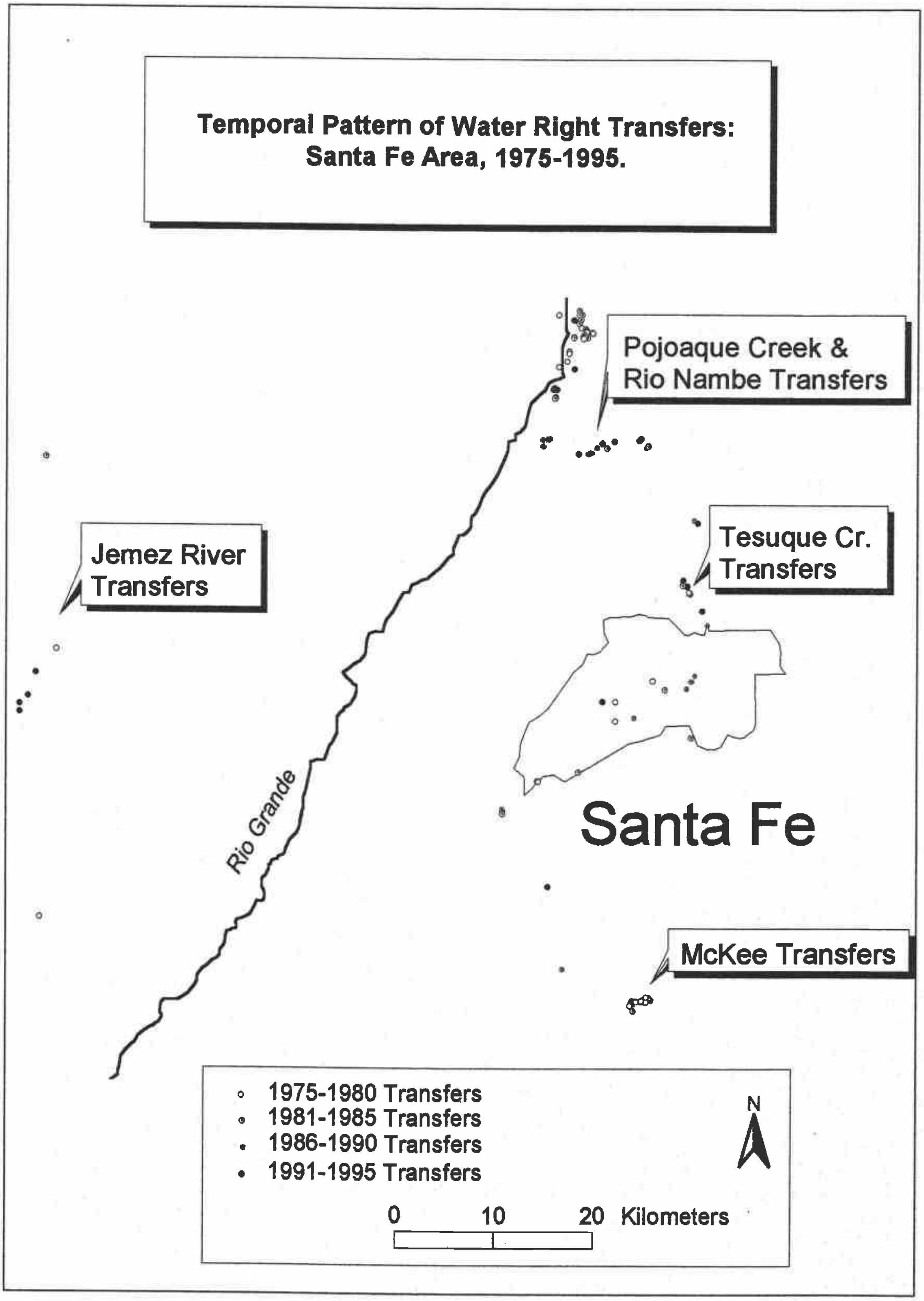

Figure 6.23. Spatiotemporal distribution of transfers, Santa Fe area (1975-1995).

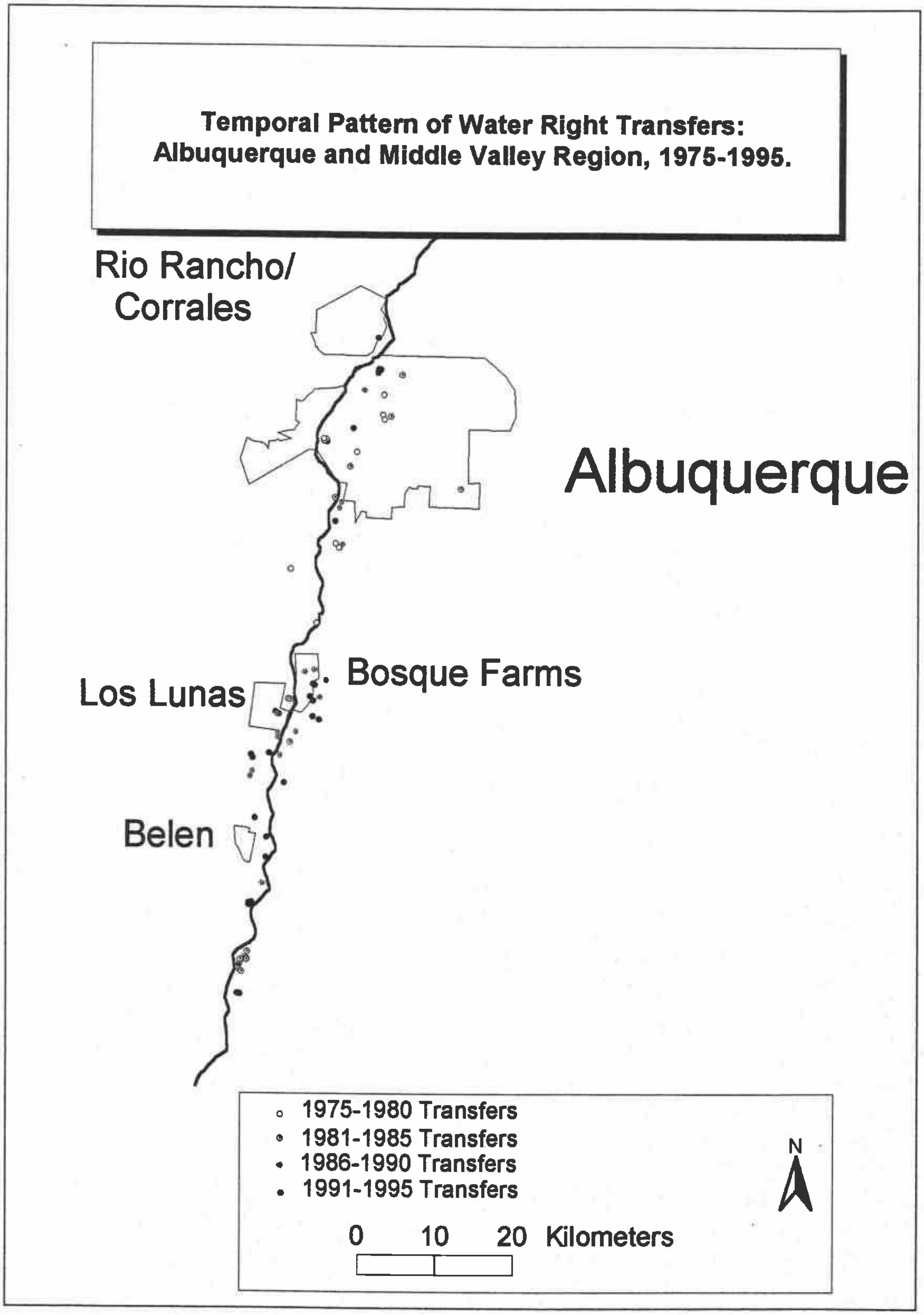

Figure 6.24. Spatiotemporal distribution of transfers, Albuquerque area (1975-1995).

MRG, a discernible pattern will begin to emerge from continued transfer activity or that the occurrence of more intense and widespread growth and development in this sub-basin precludes the emergence of such a localized pattern.

The distribution of transfers of water rights associated with MRGCD lands is compared with that of other MRG transfers in Figure 6.25. This figure clearly shows that aside from the occurrence of several MRGCD related transfers within and immediately adjacent to Albuquerque, there is a notable clustering of such transfers in the area to the south of this city. Because of MRGCD policy restricting the marketing and transfer of district water rights to locations outside of its boundaries, all transfers associated with district lands as shown involve water rights perfected prior to the establishment of irrigation impoundments and district water rights (i.e., circa 1927). This arrangement is, in actuality, much more complicated that this. Both the SEO and MRGCD assert authority over non-district water rights, and both recognize different priority dates on which they base their jurisdiction (i.e., 1927 and 1907, respectively).

Examination of Figure 6.26 shows another notable trend associated with these MRGCD related transfers – that the majority of these were effected through the use of the dedication process rather than by ACPPUs. Furthermore, a closer examination of the data reveals that nearly the full majority of these dedications (as well as the few others occurring to the north of Santa Fe) were effected by municipal water service providers. This is significant for the fact that, in the case of the MRGCD dedicated water rights, municipalities are acquiring water rights

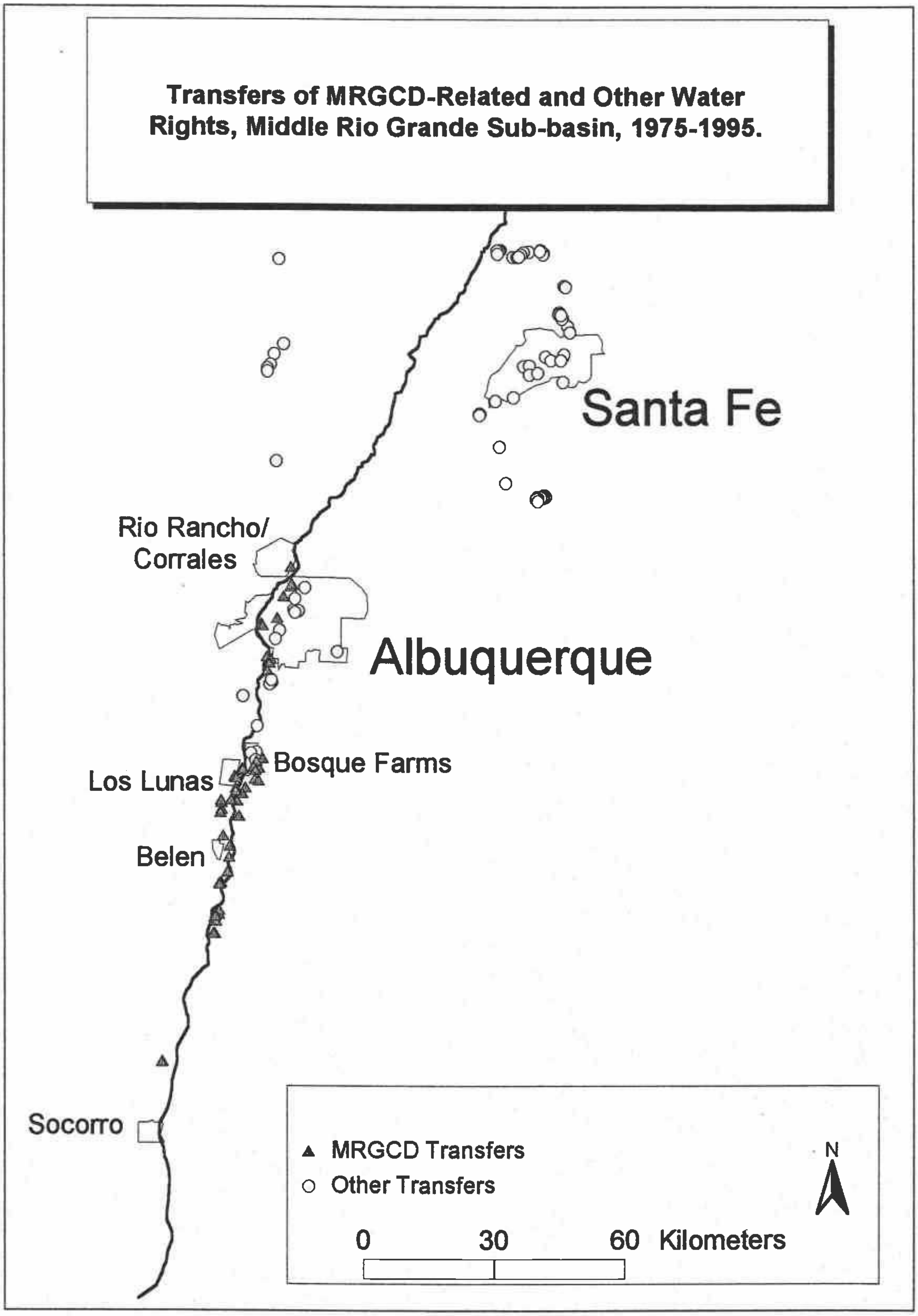

Figure 6.25. MRGCD-related and other transfers, MRG sub-basin (1975-1995).

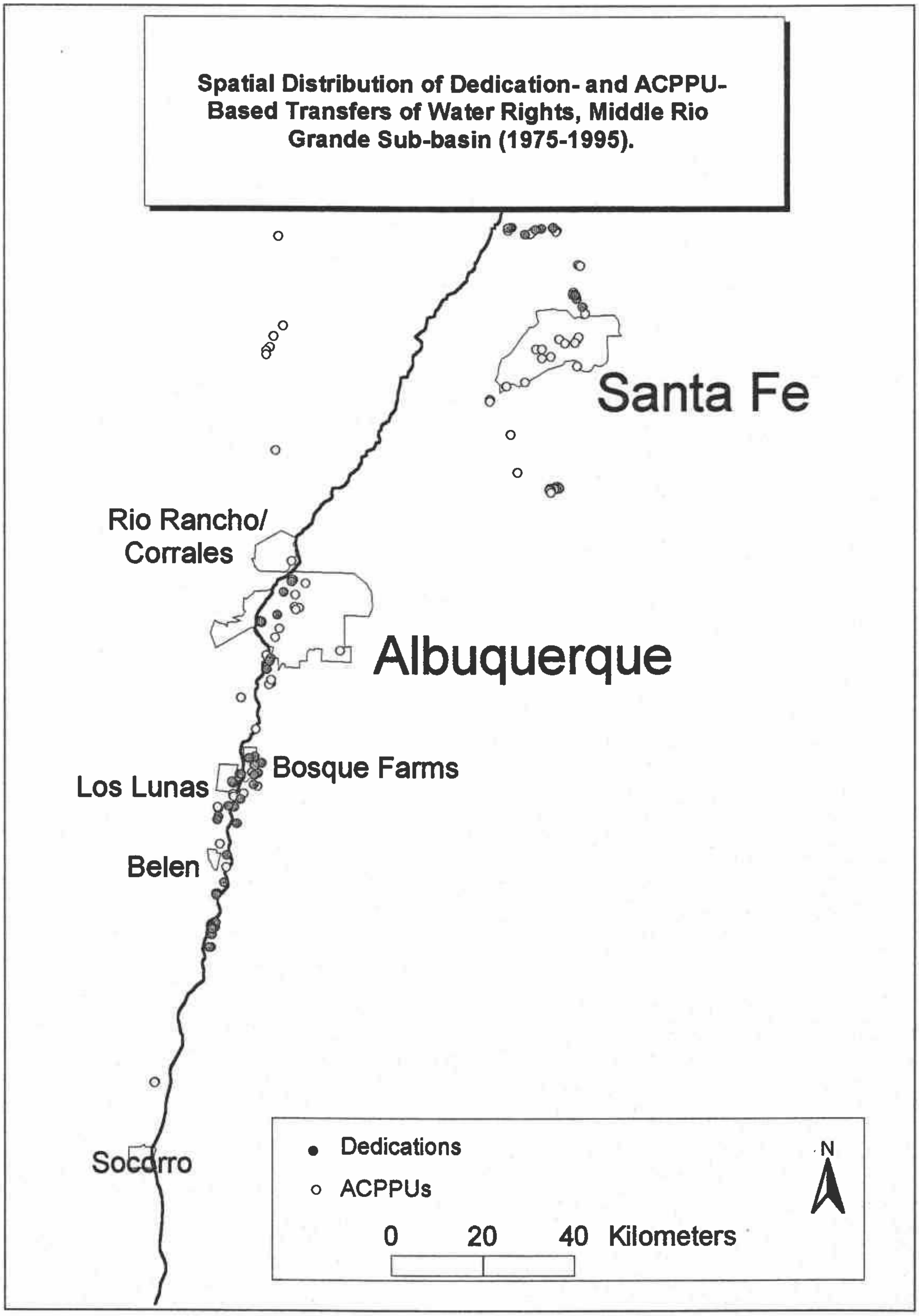

Figure 6.26. Dedications and ACPPU-based transfers, MRG sub-basin (1975-1995).

with priority dates senior to the year 1927 which have a relatively high degree of reliability, and that these acquisitions were effected without meeting public notification requirements that apply to the ACPPU process.

Compared to the URG and MRG sub-basins, the distribution of transfer locations, BUs, and spatiotemporal occurrences in the LRG (Figures 6.27 and 6.28) shows very little that is noteworthy. This sub-basin is characterized by a predominance of irrigation water right transfers, none of which occurred prior to 1981, and by the dominance of more recent (i.e., post 1991) transfer activity. The initiation of transfer activity in this sub-basin in 1981 was in response to the previously mentioned suit, *El Paso* v. *Reynolds*. A large number of ACPPUs were actually filed in the sub-basin, many by parties in Texas, in response to the suit and the declaring of the groundwater basin, and though many of these were later withdrawn as the case was resolved and the parameters for appropriation became understood a backlog of ACPPUs from the sub-basin still exists (Chavez 1995).

One transfer of interest in Figure 6.27, owing to its situation within the Caballo Reservoir pool, is a transfer of a recreation-based water right. This transfer of what was essentially a rare instream water right moved water northward and upstream from this sub-basin to the Albuquerque area for conversion to domestic and related purposes. Another transfer of note is that represented by the sole industrial transfer near the town of Hatch midway between Las Cruces and the reservoirs upstream. This transfer represents a failed attempt to establish yet another green chile processing plant in this noted chile producing area, and the water right in question reverted back to the neighboring irrigation place of use from which it originally came.

The move-from POU locations of market and non-market transfers of water rights are mapped in Figure 6.29. This map condenses and supplements some of the thematic information conveyed by the maps presented above. In particular, the clusters of transfer activity corresponding to Questa, Taos, Santa Fe, Albuquerque, and the MRGCD is shown to be represented primarily by market-based transfers – a not unexpected finding. Also, comparison of Figure 6.26 (showing dedications) and Figure 6.29 demonstrates that the majority of the dedication-based transfers are indeed market transactions. Lastly, Figure 6.29 shows the spatial influence of the market-based transfer of water rights within the study area, a finding that has potential implications for water right transfer policy in the state.

The spatial distributions of *move-to* POUs and BUs corresponding to transfers in each of the sub-basins are shown in Figures 6.30-6.32. These maps show the POD locations corresponding to water rights transferred to municipal use in each of the sub-basins, a general predominance of new commercial POUs in and around the cities and towns of the study area, and a seemingly random pattern of new domestic and related uses of water in the sub-basins. Though the data show several irrigation-to-domestic and related transfers that appear to have moved water rights to new dwelling units, the majority of the new domestic uses appear to represent attempts to bolster the water supplies of existing dwelling units. Other

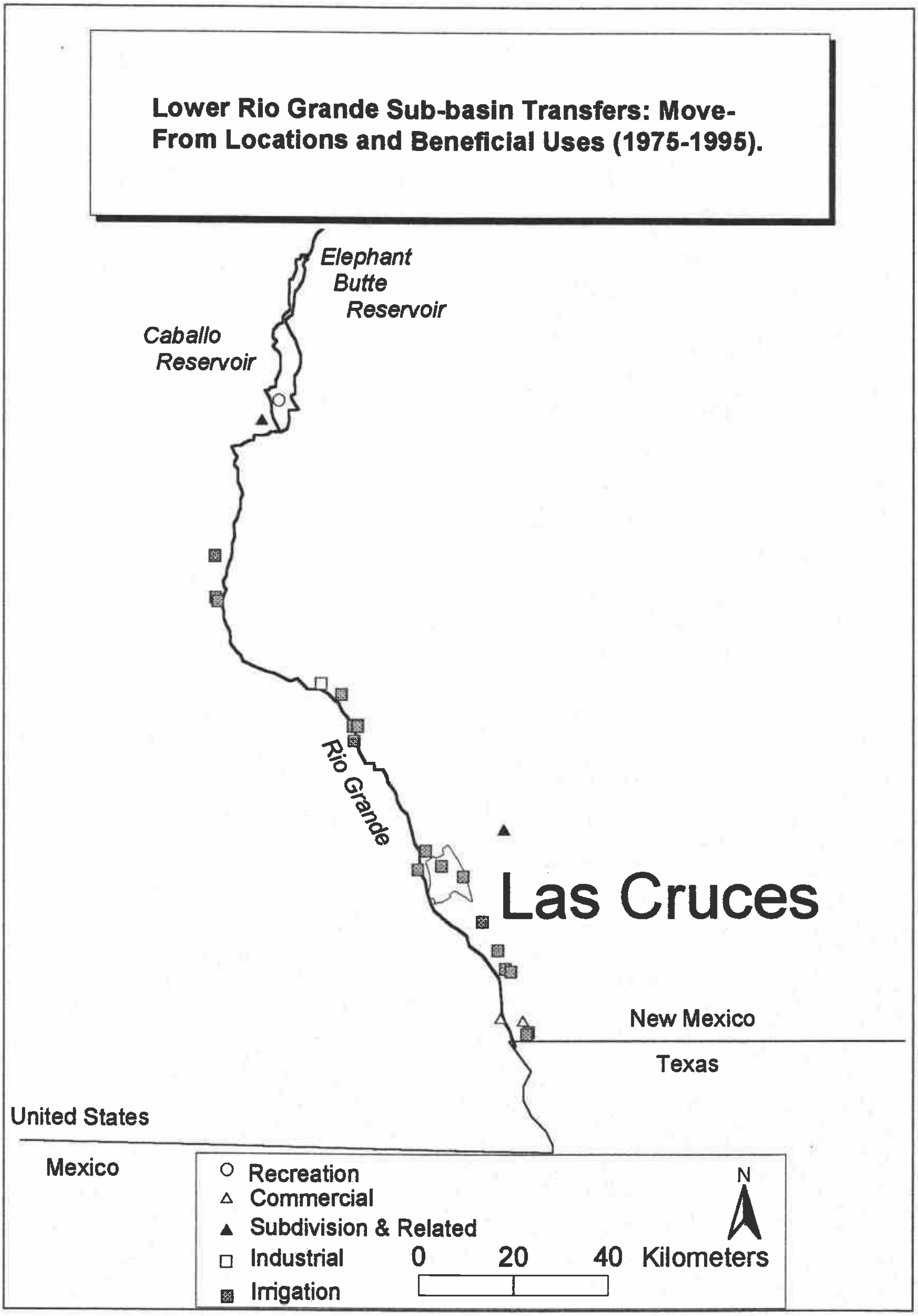

Figure 6.27. Transfers in the LRG sub-basin, (1975-1995).

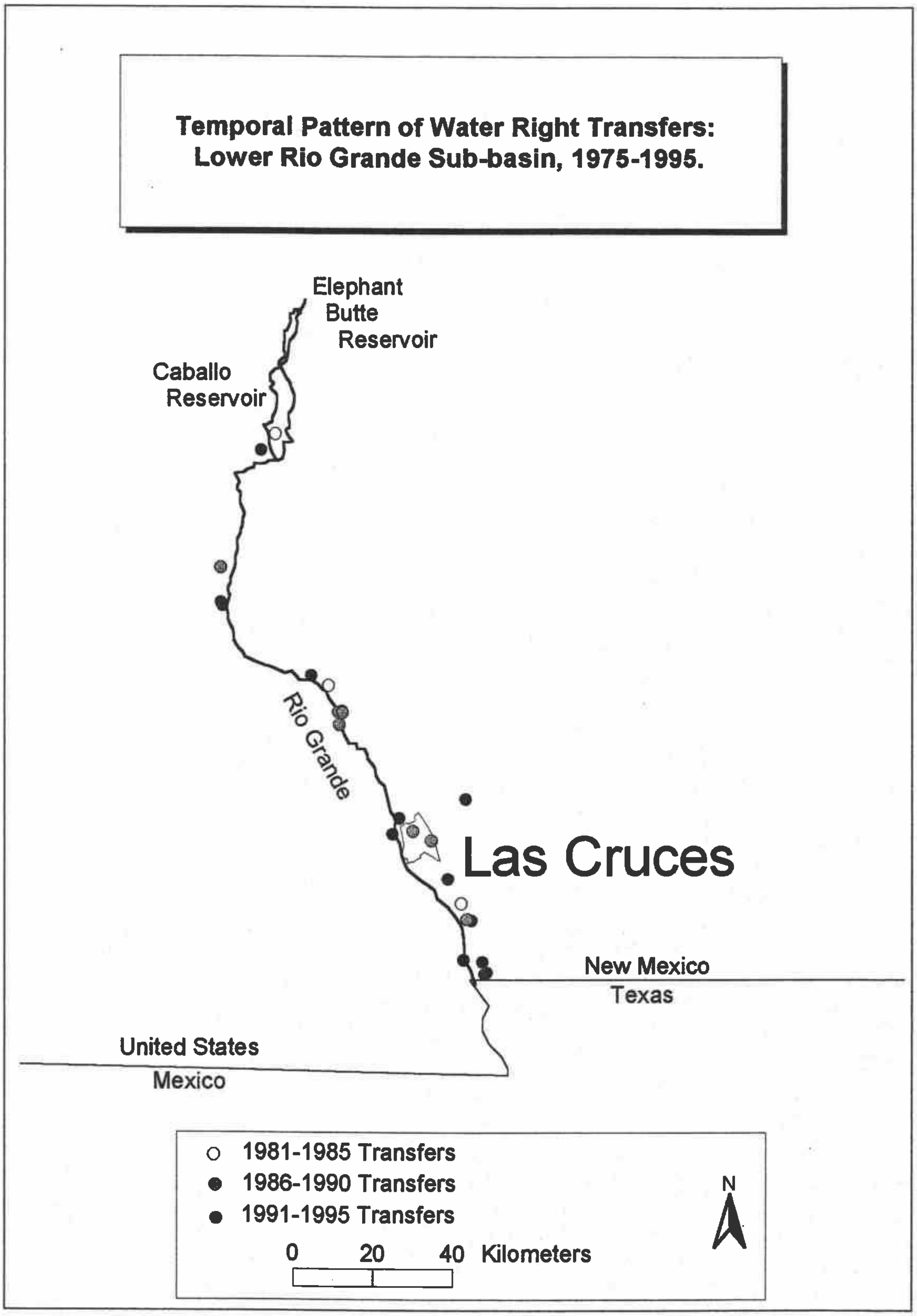

Figure 6.28. Spatiotemporal distribution of transfers, LRG sub-basin (1975-1995).

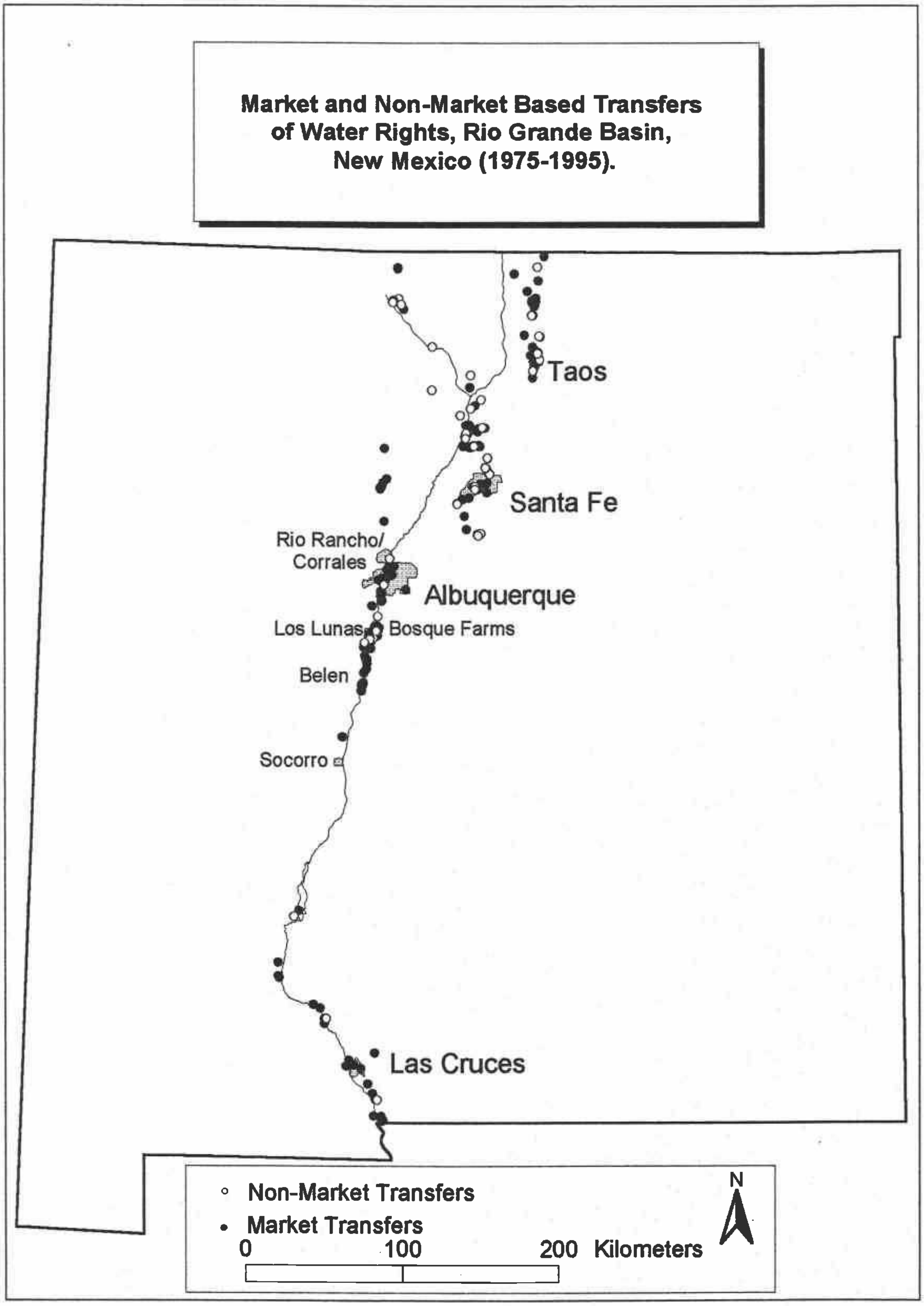

Figure 6.29. Market and non-market transfers in the study area, 1975-1995.

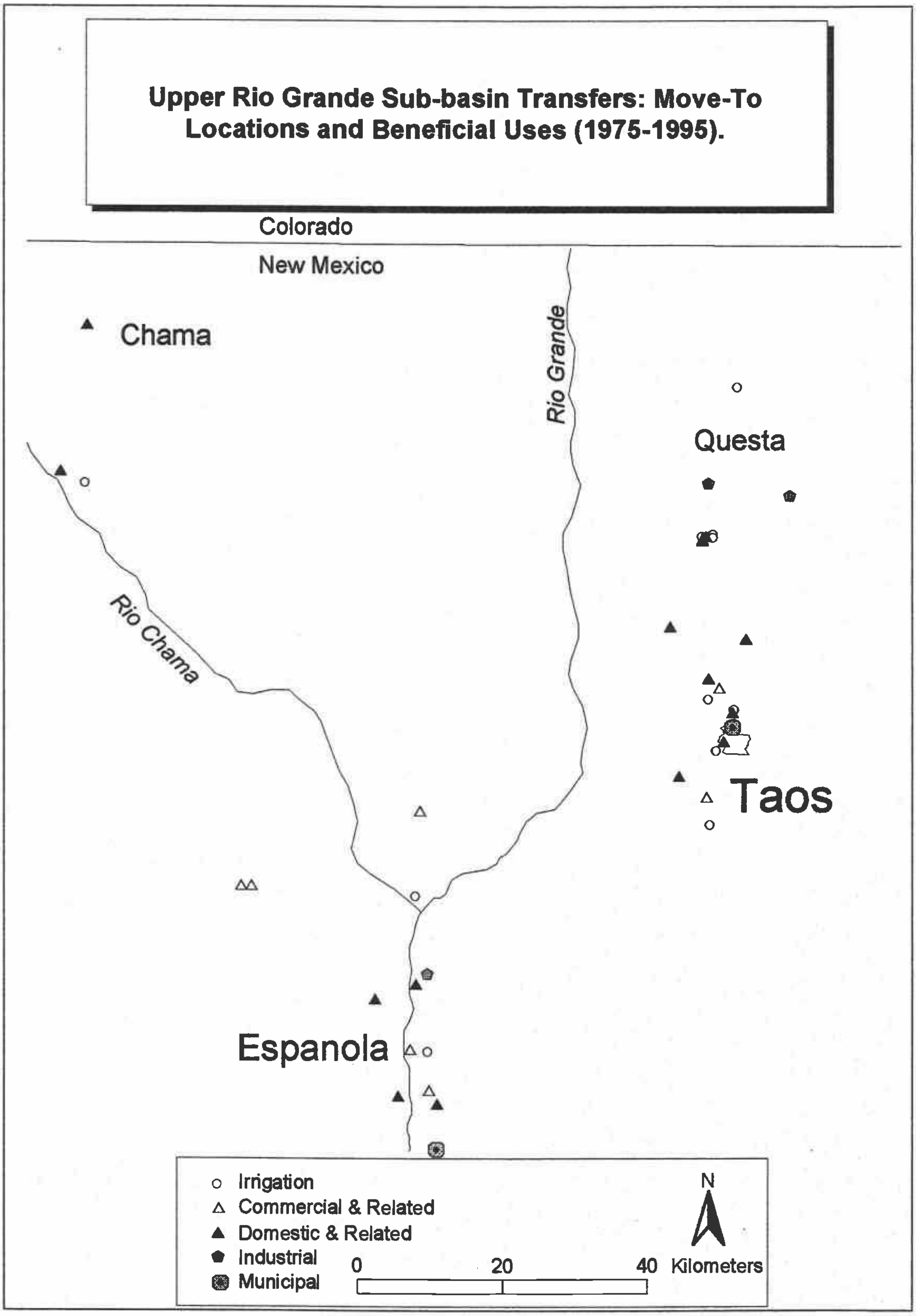

Figure 6.30. Move-to POU locations and BUs, URG sub-basin (1975-1995).

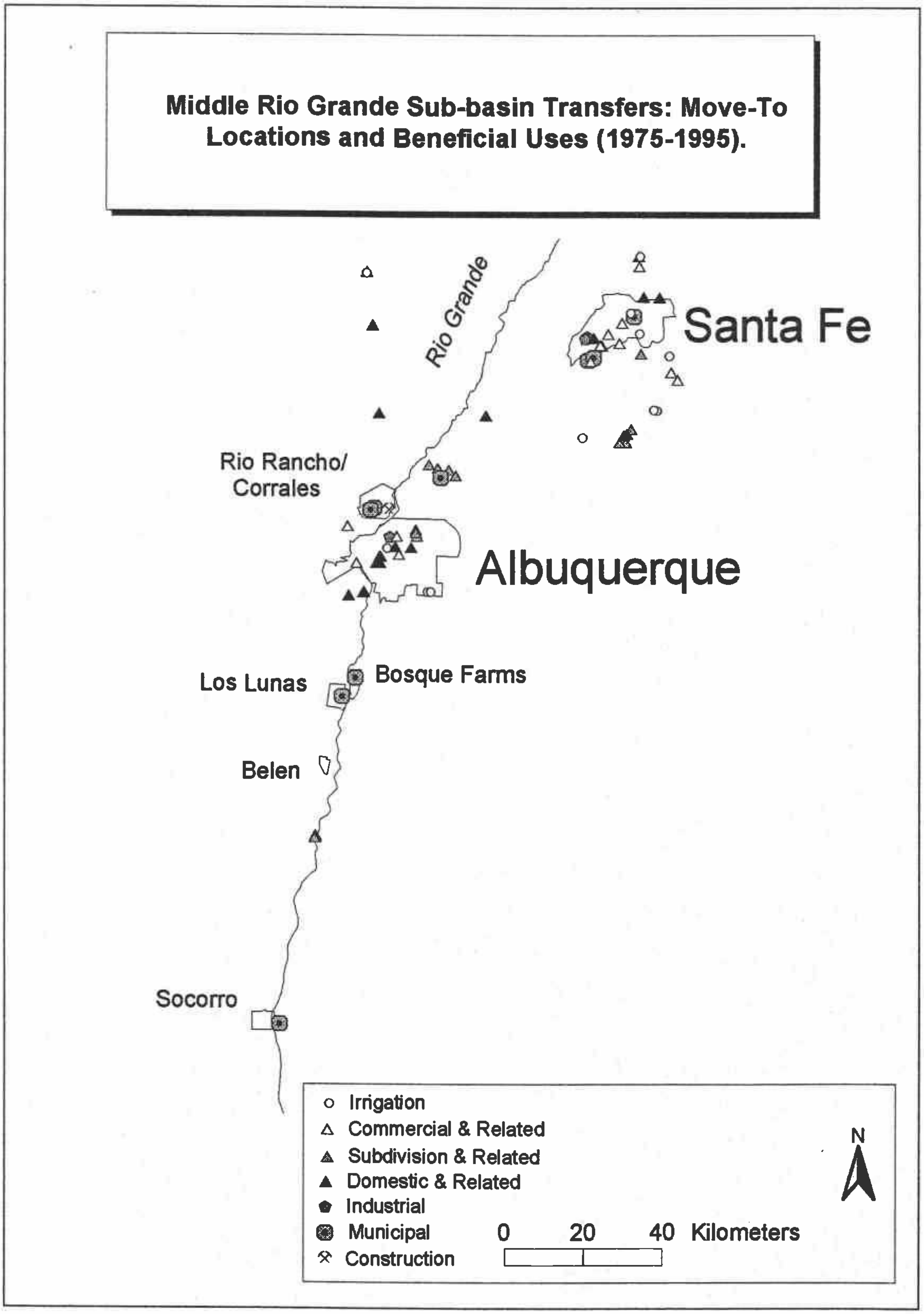

Figure 6.31. Move-to POU locations and BUs, MRG sub-basin (1975-1995).

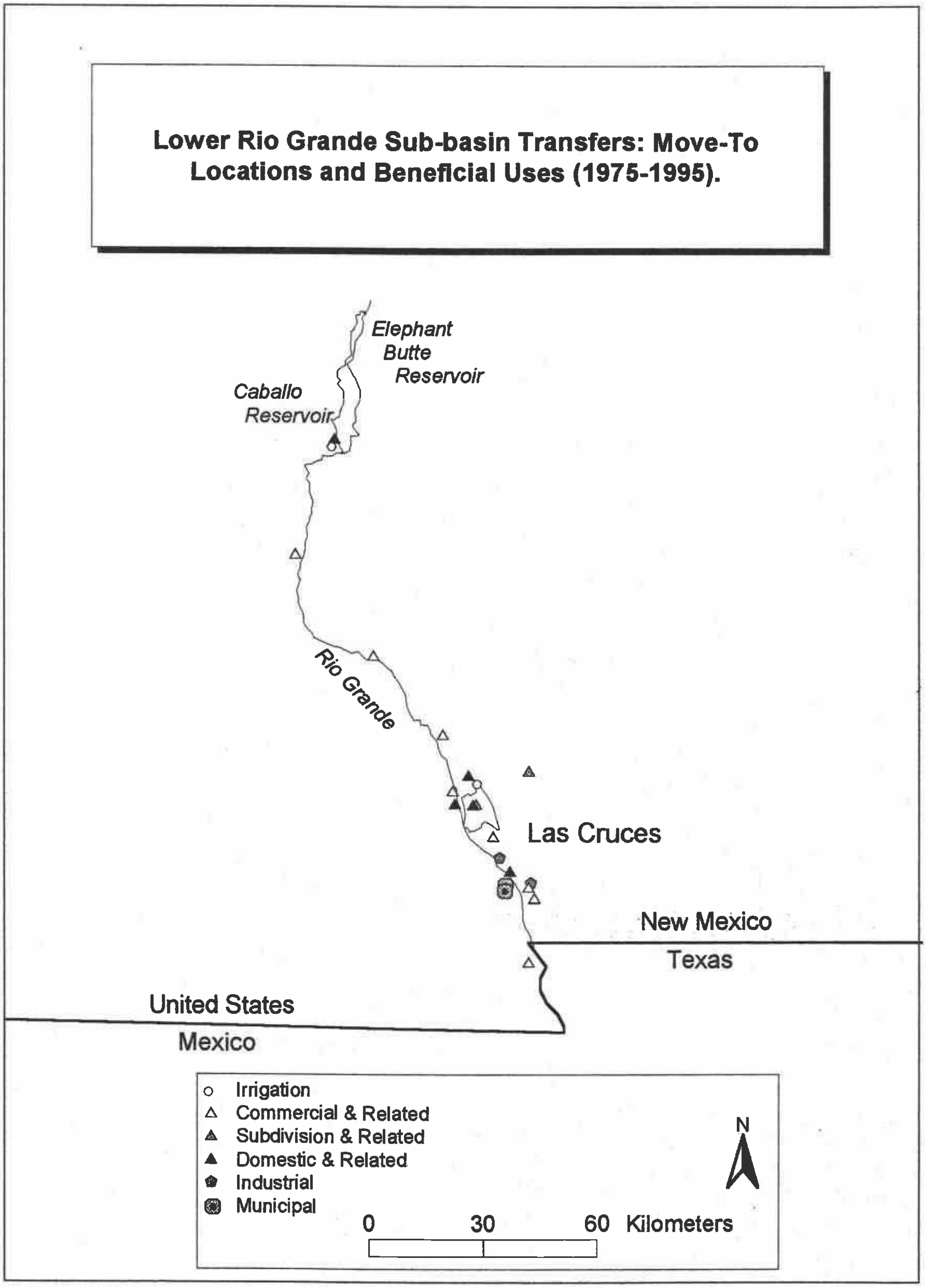

Figure 6.32. Move-to POU locations and BUs, LRG sub-basin (1975-1995).

transfers of note include those related to the operations of the Molycorp mine in the Questa area (shown as industrial POUs in Figure 6.30), and the occurrence of a new construction-related use of water in the community of Corrales intended for road building and related activities.

6.4 Multivariate Analysis of Variables Associated with Water Right Transfer Magnitudes

6.4.1 Testing for Spatial Autocorrelation

As discussed in Section 5.1, the spatial transfer data (i.e., transfer amounts corresponding to spatially specified move-from POUs) which comprise the dependent variable must be examined and tested for the presence of spatial autocorrelation or dependency before the appropriate multivariate analytical approach (i.e., parametric or spatial) can be deemed applicable. Griffith's (1993) SAS™ program code (WORKSHP1.SAS) for testing georeferenced datasets for the presence or absence of spatial autocorrelation was adapted for use with spatial data corresponding to each of the sub-basins.

The tests for autocorrelation using the adapted program first required the construction of binary (i.e., 1/0) geographic connectivity matrices specifying nearest-neighbor transfer points for each of the sub-basins. Inter-point transfer distances corresponding to centroids calculated for each mapped move-from POU in each sub-basin were measured using an Arcview™ program or script (view.calcdist), and the resultant distance matrices were converted to binary matrices specifying the nearest-neighbor centroids. The modified program then linked these matrices with their corresponding transfer size data, expressed in AFCU per year, and the Moran coefficient and corresponding z-statistics and p-values were calculated. These are shown in Table 6.4.

Table 6.4. Spatial autocorrelation results for sub-basins.

Sub-basin	Moran's C	Z	p-value
URG	-0.075	-0.462	0.678
MRG	0.177	1.031	0.151
LRG	-0.382	-0.896	0.815

The results suggest that though the computed values of Moran's coefficient are not significant, there is some latent spatial dependency exhibited within the data at the level of the sub-basin and this appears to vary in magnitude across the study area. Specifically, Moran's C varies from a slight negative value in the case of the URG sub-basin to a positive value of larger magnitude in the MRG sub-basin, to the largest calculated value (albeit a negative one) in the LRG sub-basin. The magnitudes and direction of these values (i.e., with respect to sign) can be explained by characteristics of the data that have already been shown to be important or notable in preceding sections.

First, the slight amount of negative spatial dependence in the URG sub-basin is a product of the large irrigation-to-industrial transfers in the Questa area near the periphery of this sub-unit which are imposed on a field of values that has the character of "complete spatial randomness" (i.e., it is a relatively large sample of points having assigned weights and locations that are more random than otherwise) (Boots and Getis 1988:15). Second, the larger positive coefficient corresponding to the MRG sub-basin may be explained by the many small domestic-to-municipal transfers within the Village of Boque Farms (near the middle of this sub-unit), all of which correspond to two points which are the centroids of the USPLS units designated on the dedication documents. Lastly, the large negative value of the coefficient corresponding to the LRG sub-basin owes to the presence of a large (128.96) subdivision & related-to-municipal transfer occurring in the vicinity of the City of Sunland Park located at the extreme southern end of this sub-basin. Furthermore, this value is somewhat inflated relative to those of the other sub-basins because of the fact that this large transfer is imposed on a smaller field of observations.

While these results are not significant with respect to a null hypothesis of no significant spatial autocorrelation in the data, they do show some level of spatial dependence within the study area at the scale of the sub-basin. This is not an unexpected finding because it would be highly unlikely to obtain results suggesting absolutely no spatial dependence unless an arrangement having the quality of complete spatial randomness were considered. Also, it is important to note that owing to software limitations it was not possible to construct a 333 by 333 connectivity matrix corresponding to the pooled observations of the study area considered as a whole, and a test for spatial autocorrelation in these data at this spatial scale was not conducted. However, given the values and directions of

Moran's C obtained for the sub-basins, and the evidence for the operation of asymptotic reduction in probability of significant results demonstrated for the sub-basins, it is assumed that no significant spatial autocorrelation exists in the data at this scale. And finally, because none of the tests produced significant p-values calling for rejection of the null hypothesis, the data are considered to be completely appropriate for parametric (i.e., non-spatial) multivariate analysis techniques without consideration of the spatial dimension beyond stratification of the study area.

6.4.2 Correlation of Sociocultural Variables with Transfer Size

Consideration of the strength and direction of the correlations existing between selected sociocultural variables and a variable or variables selected to represent transfer activity permits the identification of potentially useful variables to include in multivariate or bivariate regression modeling. Furthermore, correlation modeling is practicable in its own right given that it allows for the examination of the relationships existing between variables and permits full specification of the joint distribution of the variables of interest rather than simply specifying the distribution of one as a function of some value of the other as in regression modeling (Neter et al. 1989:519). Correlation models, like any other parametric statistical technique, assume that the observations corresponding to the variables of interest are independent, random, and normally distributed. In particular, the models assume that the data are characterized by a bivariate normal distribution.

Pearson product-moment correlations comparing the variable characterizing transfer activity (AFCU), the water right variable AGE, and selected sociocultural and development variables from the 1990 Census of Population and Housing were calculated for both census block group tract level data for the study area, each of the sub-basins, and for the MRGCD utilizing Statgraphics™ (Vers. 2.6) statistical computing software. The Pearson product-moment correlation coefficient, *r*, has a range of values similar to that of Moran's C (i.e., from −1 to +1) and is calculated as follows:

$$r = \sum(x - \bar{x})(y - \bar{y}) \,/\, (n - 1)\, s_x\, s_y ,$$

where s_x = the variance of x, and s_y the variance of y.

Because of the obvious non-normal distribution of the variable AFCU at the scale of both the study area and sub-basin (Figure 6.1), this variable was subjected to a logarithmic (base 10) transformation in order to normalize it and satisfy the condition of bivariate normality of the variables. A commonly accepted practice in regression modeling, this transformation is easily extended to correlation analysis given the similarity of the two techniques with respect to their basic approach and requirements. A frequency histogram of the transformed variable is shown in Figure 6.33.

The resultant correlation coefficients (*r*), the number of observations (*n*), and levels of significance (i.e., p-values) were reported in a matrix generated for

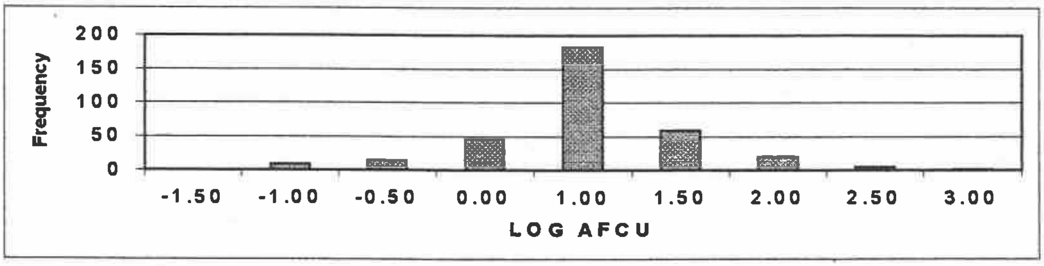

Figure 6.33. Frequency histogram of transformed variable, AFCU.

each multivariate correlation exercise, and the results are shown in Table 6.5. Only significant relationships between AFCU and other variables are reported, and significant relationships between the selected sociocultural and development variables are discussed where appropriate in the text which follows. It is important to note that the reported p-values concern critical *t* values calculated in order to test the null hypothesis that *r* is equal to zero (i.e., there is no relationship between the two variables of concern).

The correlation results show that although numerous significant bivariate relationships exist between the transformed variable AFCU for each of the iterations considered, these are generally quite weak. No reported correlation coefficient *r* has an absolute value exceeding 0.400. Furthermore, scatter diagrams plotted for these relationships showed that the patterns of these relationships appear to be quite variable in nature and lack distinct linearity; two such diagrams of the more significant relationships reported in Table 6.5 are shown below (Figures 6.34 and 6.35). While the physical form of the relationships existing between variables

Table 6.5. AFCU multivariate correlation results for the study area and sub-basins.*

Variable	Study Area	URG	MRG	MRGCD	LRG
AGE	-0.042 -0.071 (387) (340) 0.412 0.189	-0.066 -0.074 (161) (144) 0.407 0.377	**0.272** **0.219** (199) (174) **0.000** **0.004**	0.225 0.222 (58) (58) 0.089 0.094	**0.385** 0.283 (27) (22) **0.048** 0.201
POPSQMI	0.049 0.059 (387) (340) 0.336 0.279	-0.091 -0.104 (161) (144) 0.253 0.213	0.053 0.115 (199) (174) 0.454 0.131	-0.099 -0.041 (58) (58) 0.461 0.763	0.171 0.132 (27) (22) 0.393 0.600
PCTRURAL	**-0.139** **-0.161** (387) (340) **0.006** **0.003**	0.097 0.076 (161) (144) 0.221 0.363	**-0.291** **-0.285** (199) (174) **0.000** **0.000**	0.015 0.013 (58) (58) 0.910 0.923	-0.034 **0.196** (27) (22) 0.868 **0.038**
PCTONFARM S	**0.115** **0.225** (387) (340) **0.024** **0.000**	-0.010 0.075 (161) (144) 0.898 0.370	0.033 **0.156** (199) (174) 0.645 **0.040**	0.021 -0.073 (58) (58) 0.875 0.585	-0.076 0.094 (27) (22) 0.708 0.677
PCTHISP	-0.044 -0.043 (387) (340) 0.384 0.425	0.078 0.026 (161) (144) 0.323 0.756	0.105 **0.211** (199) (174) 0.141 **0.005**	0.047 0.134 (58) (58) 0.725 0.317	0.187 0.091 (27) (22) 0.350 0.686
PCTWHITE	-0.035 0.090 (387) (340) 0.495 0.098	-0.104 -0.045 (161) (144) 0.190 0.589	-0.076 0.111 (199) (174) 0.285 0.147	-0.072 -0.224 (58) (58) 0.590 0.092	-0.122 0.049 (27) (22) 0.545 0.828
MEDHHINC	0.033 -0.012 (387) (340) 0.517 0.827	0.006 -0.010 (161) (144) 0.942 0.909	**-0.160** -0.024 (199) (174) **0.024** 0.757	0.060 0.300 (58) (58) 0.654 0.083	-0.146 -0.151 (27) (22) 0.469 0.504
PCTPOOR	0.073 -0.002 (387) (340) 0.154 0.967	0.001 -0.050 (161) (144) 0.988 0.560	**0.204** **0.183** (199) (174) **0.004** **0.016**	-0.120 -0.052 (58) (58) 0.368 0.699	0.191 0.094 (27) (22) 0.340 0.677
PCTFARME	**0.198** **0.242** (387) (340) **0.000** **0.000**	-0.056 -0.078 (161) (144) 0.479 0.355	0.082 **0.183** (199) (174) 0.249 **0.016**	-0.008 -0.080 (58) (58) 0.952 0.552	0.04 0.207 (27) (22) 0.844 0.356
(BUILT70+ BUILT80)/ TOTUNITS	**0.128** **0.116** (387) (340) **0.012** **0.032**	0.137 -0.035 (161) (144) 0.083 0.676	0.066 -0.005 (199) (174) 0.354 0.946	-0.156 -0.016 (58) (58) 0.241 0.907	-0.091 -0.232 (27) (22) 0.651 0.298
PCTBUILT85	**0.130** **0.183** (387) (340) **0.011** **0.001**	0.054 0.027 (161) (144) 0.495 0.750	0.035 0.073 (199) (174) 0.620 0.337	-0.201 -0.156 (58) (58) 0.131 0.244	-0.171 -0.252 (27) (22) 0.394 0.259
CONDOS	**-0.126** **-0.126** (387) (340) **0.013** **0.020**	-0.138 0.047 (161) (144) 0.081 0.577	-0.025 -0.051 (199) (174) 0.731 0.503	-0.084 -0.200 (58) (58) 0.530 0.133	0.15 0.009 (27) (22) 0.942 0.969

*Note: values displayed on the left side of each cell represent block-group results, those displayed on the right represent tract level results. Bold type indicates significant values (i.e., $p < 0.050$). The sequence of values, from top to bottom is: *r*, *n*, p-value.

subjected to correlation analysis is important with respect to the validity of reported results and their interpretation, non- linear relationships should not be seen as precluding the suitability of the variables for linear bivariate and multivariate regression modeling without further prior mathematical transformation of the variables of interest. This task is prescribed only through interactive residual analysis in the model building exercise.

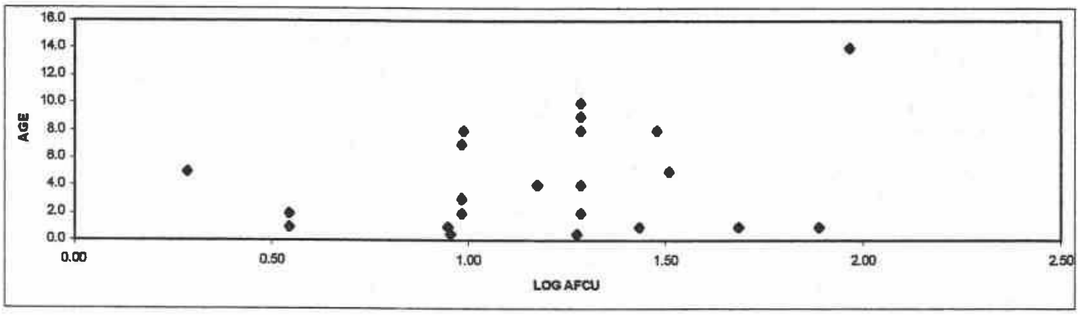

Figure 6.34. Scatter diagram of LOG AFCU against AGE, LRG sub-basin block-group level data.

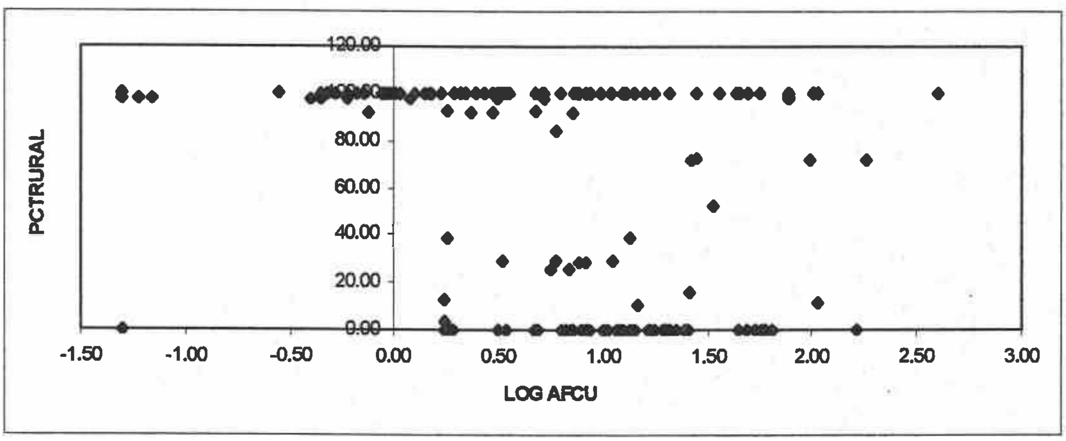

Figure 6.35. Scatter diagram of LOGAFCU against PCTRURAL, MRG sub-basin block-group level data.

Though correlation analysis does not permit an investigator to pose hypotheses concerning the strength of relationships between variables of interest and conduct definitive tests that can ascertain their validity, the method is like any other analytical technique in that it relies to a large extent on the experience and familiarity of the investigator with the data and issues at hand. This said, it must be noted that the overall weak and generally non-linear correlations existing between the selected sociocultural, development, and water right variables were quite unexpected. It was expected that one or more relationship would have emerged as being strong enough to permit interpretation and inference regarding the geographic factors of the study area and its sub-basins and their proclivity toward being the source areas for water right transfers.

Similarly, it was further expected that several meaningful cross-correlations between particular sociocultural variables (other than obvious covariants such as MEDHHINC and PCTPOOR) would emerge from the multivariate correlation analysis, reinforcing the county-level socioeconomic statistics reported for the study area and sub-basins in Table 4.2. Though not reported in Table 6.5, inspection of the correlation matrices produced in each iteration of the analysis revealed a number of such relationships at the sub-basin level and at both census levels. These are reported in Table 6.6 below.

Table 6.6 shows that only three correlations produced in two iterations each for the three sub-basins, for the MRGCD, and for the study area (a total of 10 iterations examining 12,100 bivariate relationships) had correlation coefficients that

Table 6.6. Cross-correlations and strengths of association.

Variables	Geog. Level	r	n	p-value	Linearity
PCTWHITE & POPSQMI	LRG BG	-0.700	27	0.000	Poor
PCTHISP & PCTPOOR	LRG BG	0.754	27	0.000	**Good**
PCTFARME & MEDHHINC	LRG BG	-0.687	27	0.000	Poor
PCTWHITE & POPSQMI	LRG TR	-0.790	22	0.000	None
PCTWHITE & PCTRURAL	LRG TR	0.734	22	0.000	Poor
PCTWHITE & PCTFARME	LRG TR	0.751	22	0.000	Poor
PCTFARME & MEDHHINC	LRG TR	-0.816	22	0.000	Poor
PCTHISP & PCTPOOR	LRG TR	0.900	22	0.000	**Excel.**
PCTWHITE & PCTRURAL	MRGCD BG	0.700	58	0.000	Poor
PCTWHITE & PCTONFARMS	MRGCD BG	0.667	58	0.000	Poor
PCTWHITE & PCTRURAL	MRGCD TR	0.773	58	0.000	Fair
PCTWHITE & PCTONFARMS	MRGCD TR	0.853	58	0.000	None
PCTONFARMS & PCTPOOR	MRGCD TR	0.681	58	0.000	Poor
PCTRURAL & PCTPOOR	MRGCD TR	0.618	58	0.000	Fair
PCTHISP & PCTPOOR	MRGCD TR	0.607	58	0.000	**Good**
PCTHISP & (BUILT70_ + BUILT80_)/ TOTUNITS	MRGCD TR	-0.606	58	0.000	Poor

exceed the value of 0.800, and 13 more had values exceeding 0.600. Raw data corresponding to each variable, and scatter diagrams produced for each relationship, were visually examined to assess the actual linearity and ultimate validity of each, and the results are reported in the last field entitled "Linearity." The "goodness of fit" with regard to the demonstrated linearity of the distribution of points in each scatter diagram was determined through the consideration of three criteria: 1) is there a linear trend to the distribution; 2) are the data corresponding to each variable well distributed across the range of values; and 3) is the bivariate distribution of points corresponding to each relationship well distributed across the range of both variables?

The results of this visual inspection and assessment of the correlations showed that only three of the 16 relationships demonstrated the qualities of a "good" bivariate relationship, but most importantly that these relationships involved the same two variables for two different sub-regions. The variables PCTHISP and PCTPOOR show a pattern of strong correlation at the tract level within the LRG sub-basin, a "good" relationship for this same sub-basin at the block group level, and a "good" pattern at the tract level for the MRGCD. These results are close to what might be expected based upon the information reported in Table 4.2.

The relative strength of the reported LRG sub-basin tract level correlation, however, is likely a product of a small sample size and a large amount of duplication of bivariate observations in the data at this census level owing to the occurrence of multiple transfers within given census tracts. Only 9 distinct bivariate data points or observations were found to occur at this level out of the total 22 observations, and the relatively small value of n (i.e., 22) considered in combination with reduced variances owing to duplication of values serves to inflate the coefficient r. At the block group level some 17 of 27 points contributed to the value of the coefficient (i.e., ten bivariate observations were duplicates of others). The value of the MRGCD tract level coefficient is the most affected by data duplication with only twelve distinct bivariate observations out of a possible 58 occurring.

Though a socioeconomic description of the study area and its sub-basins is not an explicit objective of this study, it should be noted that the correlation results reported in Table 6.6 are clearly underestimated though not necessarily incorrect given the objectives and approach of this study. In order to arrive at true estimates of the strength of correlation between socioeconomic variables in the study area, data duplication owing to multiple transfers from given census units should be remedied by removing repeated bivariate observations. Furthermore, estimates should be based either on random samples of the unit of concern from the larger population or on entire populations in order to arrive at true estimates of the coefficient for each geographic area and census level. Such an exercise, while clearly beyond the scope of this investigation, would undoubtedly produce results that mirror the socioeconomic statistics reported in Table 4.2.

6.4.3. Regressing Sociocultural Variables Against Transfer Size

While the multivariate correlation analysis contributed little substantive information to the question of concern (i.e., "are there specific socioeconomic or sociocultural variables that show a high degree of association with areas from which water rights have been transferred within the study area?"), it has provided information that assisted in the identification of potentially significant variables to introduce into multivariate regression models. Because of the fundamental difference between correlation and regression analysis already discussed (i.e., the specification of the distribution of independent and dependent variables as functions of one another), and because of the opportunity to impose transformations, and to introduce indicator variables and interaction terms, the variables that showed no meaningful correlations with AFCU might behave differently when introduced into linear regression models.

When considering a large number of variables for inclusion in multivariate regression models, the issue of model development becomes a critical one. Each introduced variable can either contribute to the overall model or detract from it relative to the other variables present, and the interactions between distinct or combined (i.e., indicator) variables can play an important role. It is for these reasons that it is important to consider any information - whether based upon other analyses, intuition, or experience – when engaging in the process of regression model development or construction (Neter et al. 1989). Similarly, the choice of a method of model development and refinement can be a critical one.

Of the several different approaches that exist (i.e., stepwise forward regression, stepwise backward regression, ridge regression, and the all-possible regressions procedure using different decision criteria), a combination of the stepwise forward procedure and the all-possible regressions approach utilizing the pooled mean square error (MSE_p), or adjusted coefficient of multiple determination (R_a^2), approach was selected for use. The stepwise forward variable selection procedure facilitates variable selection and testing given that it iteratively and interactively adds variables to a model and accepts or rejects them based upon their relative contribution to the enhancement of the adjusted coefficient of multiple determination. The use of this coefficient as a decision criterion is based upon the consideration that its calculated value does not decrease as the number of variables or parameters increases, and its value is adjusted for the degrees of freedom (Neter et al 1989:446). The coefficient is calculated as follows:

$$R_a^2 = 1 - (n - 1/n - p)(SSE / SSTO) = 1 - [MSE(n - 1 / SSTO)] ;$$

where: p = number of parameters,

SSE = error sum of squares,

SSTO = total sum of squares,

MSE = mean sum of squares.

This procedure allows a larger number of variables to be considered in the model, and this is important to this study given that the mix of variables convey different kinds of information about the areas of concern. Statgraphics™ (Vers. 2.6) statistical computing software, and Microsoft Excel™ (Vers. 97) spreadsheet software were both utilized for the purpose of model construction.

Multivariate models were attempted for each of the sub-basins, the entire study area, and for the MRGCD data. Because of the previously discussed problem presented by the large number of domestic-to-municipal transfers within the Village of Boque Farms, analyses for the study area and the MRG sub-basin were to be conducted at the tract level only. And though the ANOVA conducted for mean transfer sizes between sub-basins was not significant, the correlation analyses suggest that different sociocultural variables might contribute to models describing quantities of water transferred in each of the sub-basins. Lastly, the models were not be subjected to validation using reserved data for the following reasons: 1) this study is observational in nature; 2) the population of mappable tranfer POUs is being considered rather than a representative sample; 3) the multivariate regression analyses are being undertaken solely for the purpose of identifying sociocultural variables that might be associated with AFCU; and 4) future prediction of transfer activity using sociocultural indicators is not an objective of this study.

Using the stepwise forward regression modeling approach with the R_a^2 decision rule, it was possible to construct at least one model corresponding to one of the census geographic levels for each of the areas under consideration. Each of the models was linear in its parameters, and analysis of normal probability plots and residual plots of the transformed dependent variable (AFCU) against each of the independent variables confirmed that there were no observable departures from normality nor linearity. Through the reordering of significant variables and interactive variable inclusion, rejection, and substitution, the full complement of sociocultural indicators was tested for each area. Parameters corresponding to introduced variables and terms were retained or rejected based upon inference tests concerned with a null hypothesis of no significant difference of the value of the parameter from a value of zero (such a case would imply no relationship between the independent of interest and dependent variable). Non-significant intercept parameters were retained, however, because such values have no interpretive power other than specifying that the line of best fit corresponding to a given model passes through the origin. The results are presented in the form of equations in the text which follows in order that the ordering of variables and terms is demonstrated, and the discussion relating to each includes the calculated values of R_a^2 and goodness of fit statistics (i.e., F statistics) and their corresponding p-values. All values are reported to three significant figures.

6.4.3.1 Regression Model for the Rio Grande Basin

The regression model developed for the study area (i.e., the Rio Grande basin) at the census tract level contains a large number of variables and takes the form:

$$LOG(AFCU) = 0.971 - 0.014(PCTRURAL) + 0.146(PCTONFARMS) - 0.029(PCTMGPR) + 0.020(PCTOWNER) - 0.018(MEDHVAL) + 0.025(PCTBLT85).$$

The value of R_a^2 is 0.207, and though its magnitude is lower than generally desired, the calculated value of F (15.71) is significant at p = 0.000. The model accounted for only 28.31 percent of the total error, the rest being partitioned to the data themselves.

This model is interesting for the fact that it contains considerable information about socioeconomic factors (no cultural variables were found to contribute to the model) associated with areas from which water rights have been transferred. The negative direction of the association between AFCU and the percent of population living in rural areas is different than was expected given the high proportion of irrigation-based transfers occurring in the study area, and trends reported in the literature. This relationship is best explained, however, by the general tendency of transfers to be clustered either within or near the major cities or metropolitan areas of the study area, especially within the URG and MRG sub-basins where the vast majority of observations occur.

The directions of the remaining associations within the model conform better to prior expectations. These indicate that greater volumes of water are transferred from areas having larger farm populations, a lower proportion of working individuals employed in the managerial and/or professional occupations, lower home values, and which experienced higher amounts of housing construction in the period 1985-1990. The positive association between PCTOWNER and AFCU is less telling, however. The best inference that can be tendered is that those areas having more water transferred from or within them show higher rates of owner occupied housing because they are less urban in character though not actually classified as rural. The inclusion of PCTOWNER in the model corresponds with and complements the information conveyed by PCTONFARMS, and did contribute slightly to the reduction of error variance.

The resultant model constructed for the overall study area thus contains variables which explain volumes of water transferred as a function of proximity to urban areas, a greater significance of agriculture in the areas of concern, occupational structure that is perhaps weighted toward lower tiers, lower income levels, and more recent development. Taken individually and collectively, however, these relationships are clearly not strong ones which requires that these inferences be offered cautiously if at all. They do have significance for the intent of the study, however, in that they show to a limited extent that there are areas having particular characteristics which appear to predispose them for transfer activity, and perhaps for economic and/or sociocultural third-party effects.

6.4.3.2 Regression Model for the Lower Rio Grande Sub-basin

The modeling exercise performed for the LRG sub-basin was considerably less successful than that corresponding to the overall study area; it produced only a bivariate model for census block group level data. Furthermore, the independent variable contributing to this model, AGE, is that which was retained for use as a remedy for potential serial autocorrelation (i.e., time related data dependency) existing within the data. The precise form of the model is as follows:

$$LOGAFCU = 2.44 + 0.090(AGE).$$

The value of R_a^2 is 0.114, and the calculated F-statistic (4.34) is just significant with a p-value of 0.048. The percentage of error accounted for by this limited model is only 17.54 percent.

This model has no utility with respect to the characterization of areas experiencing transfer activity, and serves only to summarize the information conveyed in the graph showing amounts of water transferred in the sub-basin across the study period (Figure 6.7c); older transfers are slightly larger than those which are more recent. Given that this sub-basin does contain considerable sociocultural variability as evidenced by the correlation analysis and Table 4.2, the poor performance of the sociocultural data within it is certainly influenced by the small number of observations.

6.4.3.3 Regression Model for the Middle Rio Grande Sub-basin

As was the case for the overall study area, the only regression model attempted for the MRG sub-basin was at the census tract level owing to the large number of domestic-based transfers occurring in the Village of Bosque Farms and their relation to census geography. The resultant model is similar to that for the study area, and this was not unexpected owing to the characteristics of this portion of the study area and the large number of observations within it. This model is configured as follows:

$$LOGAFCU = -0.913 + 0.079(AGE) - 0.016(PCTRURAL) + 0.016(PCTHISP) + 0.148(PCTFARME) + 0.022(PCTOWNER).$$

The value of R_a^2 is 0.261, the F-statistic (13.22) is significant with a p-value of 0.000, and this model can be said to be perhaps the most powerful of those presented thus far due to the fact that it accounts for a larger proportion (39.36) percent of the total variation in the contributing data than the others.

This model is very similar to that produced for the study area at this same census level, and this is not surprising given that the data from the MRG sub-basin represent approximately 51.18 percent of the data contributing to that model. And though it conveys the same basic information, some different variables emerged as having more explanatory power in this area than those of the Rio Grande basin. The variable AGE occurs here, and though residual plots corresponding to this model without inclusion of this variable showed no real evidence of serial correlation, it was retained because of its marginal effect in enhancing the model's explanatory power.

The variable PCTHISP shows a significant positive association with AFCU in this sub-basin at the tract level, and this constitutes the only occasion of a variable describing culture or ethnicity playing a role within a regression model in this study. Though significant at a level of 0.012, the parameter corresponding to this variable does not indicate that the association with the dependent variable is a strong one; like the variable AGE, the power of this variable lies in its marginal contribution to the model's reduction of variance in the dependent variable.

The variable PCTFARME emerges as having a significant positive association with the dependent variable in this sub-basin, and provides essentially the same information as PCTONFARMS did in the case of the model corresponding to the study area (i.e., those census tracts having a stronger expression of dependence on farming and/or agriculture are characterized by larger quantities of water transferred). Even the magnitude of the parameters corresponding to each of these variables is approximately equal. As in the case of the study area model, the presence of this variable in the context of a negative association between PCTRURAL and AFCU presents a complication with respect to interpretation of the model. Again, it is assumed that the joint occurrence of descriptors related to rurality and agriculture which show opposite relationships (i.e., negative and positive, respectively) is best explained by the general association of transfer-from POUs within geographic units that are classified as being urban places and within large metropolitan areas. This has implications for the issues of farm land retention at the rural-urban fringe that did not emerge from the map-based spatiotemporal analyses.

6.4.3.4 Regression Model for the Middle Rio Grande Conservancy District

As occurred in the case of the LRG sub-basin, only one model (albeit at the block group level) emerged as being significant for the MRGCD. Furthermore, this is a bivariate model involving a variable without great explanatory strength:

$$\text{LOGAFCU} = -0.548 + 0.045(\text{PCTOWNER}).$$

The value of R_a^2 is 0.063, the F-statistic has a value of 4.89 which is significant at the level of $p = 0.031$. The model, however, accounts for only 8.74 percent of the variance in the dependent data. Like the model presented for the LRG sub-basin, this model has little or no utility with respect to the characterization of areas experiencing transfer activity in this area of concern, and this is especially unfortunate in this case given the social and economic importance of the MRGCD to the MRG sub-basin. While the variable PCTOWNER had marginal utility in reducing error variance in the study area model, by itself it is undoubtedly a poor descriptor of process. On the other hand, it may be important that sociocultural descriptors show no association with transfer quantities in the MRGCD for it may imply that the spatial occurrence of transfers is more random in nature and that aside from the obvious implications of farmland retirement associated with transfer activity, sociocultural third-party effects are not likely to be significant here.

6.4.3.5 Regression Models for the Upper Rio Grande Sub-basin

The model building exercise performed for this sub-basin produced a model for each census level, however, these models are essentially identical with respect to the contributing variables and overall model strength. These models are presented together here (that corresponding to the block group level data is shown first):

$$LOGAFCU = 0.594 - 0.031(CONDOS) + 0.117(CONDOS*BUILT80\_);$$

and

$$LOGAFCU = 0.381 - 0.022(CONDOS) + 0.104(CONDOS*BUILT80\_).$$

The values of R_a^2 corresponding to each are 0.029 and 0.032, respectively, and their respective F statistics of 3.43 and 3.39 are both significant at a p-value of 0.037 or less.

Neither of the two models appears to perform better than the other with respect to the various criteria of interest. While the block group model does show a larger R_a^2 statistic, the percentage of error variance it accounts for is less than that of the tract level model (4.34 percent as opposed to 4.81 percent) and the estimated parameters corresponding to the variables do not show the same level of significance (i.e., their confidence intervals are wider).

Regardless of which of the two models is selected to represent this sub-basin, the fact remains that both are quite poor even though the occurrence of variables related to recreational or second home development was expected based on field experience and given the descriptions of current issues impacting the Rio Arriba within the literature. Were a similar analysis to be conducted at a coarser level of spatial resolution and produce similar results, it would be easy to explain the association between the dependent and independent variables as a function of general association within the study area. The consideration of data at the scale of the census block group and tract, however, points to the fact that though they are weak these associations have implications for the sub-region.

6.5 Discussion

The results of the various analyses presented in this chapter address the study objectives well, and demonstrate a number of important points about water right transfers and marketing within the Rio Grande basin. First, transfer activity within the basin and its sub-units has been considerable, and market-based transfers of water rights play an important role in water resources reallocation there. This is particularly the case for irrigation water rights which are especially important in the context of the expansion of municipal water supplies in the URG and MRG sub-basins. Second, spatiotemporal patterns of water right transfers vary among the sub-basins, yet the relative size of communities within the basin appears to be an important factor with respect to these patterns. It was mentioned previously that the communities of Taos and Española appeared to demonstrate the operation of the density-distance decay principle with respect to spatiotemporal patterns of transfers, and that a similar pattern does not appear to occur elsewhere within the study area.

Perhaps the most important findings emerging from the study are those produced by the multivariate correlation and regression analyses. Though these results were generally quite weak, it is clear that the data corresponding to the MRG sub-basin really served to drive the results. This is certainly due to the greater incidence of transfers occurring in this area, and probably also to the fact that transfer activity was better distributed across a landscape displaying a wider variety of sociocultural conditions than in the other two sub-basins. The tract level model constructed for this sub-basin was clearly the best that was produced for any area.

While the multivariate analyses were performed for a sample consisting of the mappable population of transfers occurring within the study area for the period of concern, and were performed primarily for the purpose of description, the re-examination of the regression model constructed for the MRG sub-basin using more recent transfer data would be instructive. Such an exercise would serve the function of model validation and would undoubtedly provide information concerning the influence of policy changes on transfer activity.

7.0 SUMMARY AND CONCLUSIONS

New Mexico's Rio Grande basin has served as an excellent case study for an investigation of the spatiotemporal and sociocultural patterns associated with water right transfers. This is true largely because of the specific reasons for which it was selected from among other Western states. These included: a condition of full appropriation of surface water and groundwater rights within the basin, the basin is representative of other states or regions in West with respect to its generally spatially unequal pattern of urban growth and economic development, a generally high degree of transferability of water rights owing to state policy, and the suggestion of a large amount transfer activity relative to other regions and/or states.

Some other factors which served to exemplify the study area but which emerged following its selection included: the administrative subdivision of the basin into three separate sub-basins which are spatially coincident with three sub-regions having distinct physiographic, sociocultural, and economic characteristics; and a variety of potential transfer types owing to the generally permissive nature presented by the state water code, and the administrative rules and practices of the State Engineer Office. Related to this last characteristic are the statutory requirement of the recognition and consideration of the public interest/welfare and potential third-party effects, and the efficient yet now illegal practice of effecting water right transfers while circumventing public scrutiny via the dedication process.

7.1 Summary and Conclusions of the Research

This study was undertaken for the principal purpose of describing water right transfer characteristics, identifying spatiotemporal patterns of transfer activity on the sociocultural landscape of New Mexico's Rio Grande basin, and determining the degree to which sociocultural and other factors are associated with such activity. The methods utilized included: simple quantitative analyses intended to describe the general characteristics of transfers, the fitting of transfer data to a conceptual model of transfer type likelihoods in order that adherence to the basic principles underlying transfer activity might be explored, the use of a Spatiotemporal Triad approach to examine spatiotemporal patterns of transfers, and multivariate statistical techniques to explore the strength of associations between transfer activity and sociocultural descriptors of transfer locations. The basic intent of the multivariate analyses was to identify those areas which may be more or less predisposed to experience adverse economic and/or sociocultural third-party effects related to transfer activity, and it is hoped that this substantive information will aid policy makers and water resource administrators in their efforts to limit the occurrence and severity of third-party effects associated with water right marketing in the study area, and elsewhere in the West.

At the most basic level, this study provides essential quantitative and qualitative information concerning the characteristics of water right transfers in the study area and its three sub-basins (i.e., the Upper, Middle, and Lower Rio Grande sub-basins) that has not emerged from other research. The findings show that water right transfers in the study area are skewed toward smaller transactions (less than 10 AFCU), are primarily market-based, and usually involve the transfer of irrigation water rights to other higher-value uses. This is significant for the fact that though irrigation accounts for the single largest consumptive use of water in the study area (and particularly in the MRG sub-basin), irrigation withdrawals in the basin rank behind those made for the purposes of municipal supply and power production (U.S. Geological Survey 1996b). There is no significant difference between the mean transfer sizes corresponding to either the sub-basins or to market and non-market based transfers. The predominance of transfers involving groundwater and/or surface-to-groundwater shifts was expected and demonstrates the importance of groundwater as a source of higher-quality water in a semi-arid region that is characterized by water quality limited streams and rivers. The significance of the *Templeton* doctrine for water right transferability and levels of activity cannot be over-emphasized.

The study has clearly demonstrated the importance of the water right transfer as a reallocative mechanism within the Rio Grande basin of New Mexico, and the importance of transfers and water marketing to the continued economic evolution of this area. The large amount of primarily market-based transfer activity involving generally small quantities of water, typically irrigation water, supports this conclusion. Furthermore, the data suggest that the water requirements of various entities within the study area; including those of the growing urban places, developers, and rural residents and business people; are being met through the ability to incrementally transfer needed quantities of water to new uses. This is certainly the case for each of the sub-basins although at different rates and/or levels, but is especially so for the more rapidly developing MRG sub-basin which has shown an increase in the frequency of transfer activity in the latter part of the study period.

The conceptual model of transfer type likelihoods presented in Chapter 5 posited that water rights are more or less likely to move from one BU to another depending on the relative value of water in these uses, and indeed it was pointed out that this principle of the movement of goods from lower- to higher-value economic activities is one that underpins the concept of a market. The findings demonstrate that transfers occurring in the Rio Grande basin generally conform to this model. Water right transfers occurring within the study area and its sub-units, both market and non-market-based, are serving to move water from lower- to higher-value uses. Barring an unexpected long-term economic recession of the type that could serve to limit continued growth and development in the study area, it is expected that transfer activity in this region will continue to occur and that it will continue to conform to the conceptual model presented in this study.

The use of Peuquet's (1994) Spatiotemporal Triad Framework was proposed as an approach to data visualization and characterization using virtual and real map products. The maps constructed for the study area and its sub-units for these purposes did reveal some notable trends in the spatiotemporal patterns of transfer POUs. Though the interpretations of pattern and association were visually-based, aside from the nearest neighbor analysis of points indicating intense clustering at all scales of concern, they did provide information about transfer activity that would otherwise not likely emerge. They help to tell a story that is substantively supported by the multivariate statistical analyses that were employed.

First, the intense clustering of transfer POUs at the scales of the study area, its sub-basins, and important cities and sub-regions was not an unexpected finding when patterns of settlement and agricultural development within the context of river basins is considered. Such environments usually offer a discontinuous linear template within which natural and human processes occur, leading to patterns of landscape and ecosystem patchiness. This is certainly the case in the Rio Grande basin in which local floodplain environments suitable for agriculture and initial human settlement are indeed discontinuous and are also affected by other physical forces (i.e., climate, soils, hydrology). It is highly probable that *all* water right POUs within the study area, outside of the center-pivot irrigated lands of the Taos plateau to the north of Taos, show this same intense pattern of clustering along and adjacent to sources of surface water and on arable soils.

Second, aside from this more general observation concerning the spatial arrangement of transfer POUs in the study area, the spatiotemporal patterns of transfer activity in and around the communities of Taos and Española seem to indicate that a distance related force such as the density-distance decay principle, or one analogous to the gravity concept as applied in gravity modeling, is at work. As mentioned previously, it was expected that similar spatiotemporal patterns of transfer POUs would be found to correspond to the major cities and towns of the MRG sub-basin thus more directly implicating urban and suburban sprawl in the process of water right conversion. While such a pattern did not present itself for the MRG sub-basin, it appears to function at some level at the scale of the study area. More specifically, the relative size (i.e., area and/or population) of places appears to be negatively related to the degree of clustering of water right transfers.

The difference in the exhibition of pattern between the Upper and Middle sub-basins is probably more a function of the intense values associated with local (especially surface) water resources within the Rio Arriba, and the consideration of the public interest/welfare by the SEO. Indeed, though it is not explicitly demonstrated by a particular map, the data show that within the URG sub-basin, nearly every transfer has move-from and move-to POU (and POD) locations in close proximity to one another. This implies that although the task of water resources management largely falls under the aegis of the state, local control is strongly asserted within this distinct culture region.

Another factor which has likely served to limit broader-scale transferability of water rights within the URG sub-basin concerns the physical (i.e., geological) character of this sub-basin as compared with the MRG sub-basin. Owing to its upstream location amidst a more upland environment, the URG is simply more geologically heterogeneous than the MRG which is underlain by the Santa Fe group (a unit primarily composed of welded tuff) for its entire length. It is the principle of hydrologic connectivity which is applied in the context of geologic homogeneity which has done much to facilitate the high transferability of water rights within this sub-basin.

The evidence of clustering of move-from POU locations within the URG and MRG sub-basins suggested that the transfer data, especially AFCU, might be spatially autocorrelated and not appropriate for parametric statistical analysis techniques. Tests for autocorrelation performed at the scale of the sub-basin, however, revealed that this phenomenon was very weak and not significant for each area.

Accordingly, parametric multivariate analyses (i.e., correlation and regression analyses) of sociocultural patterns associated with water transfers were undertaken, and these showed that generally weak and/or poor bivariate associations between the descriptor of market activity (AFCU) and sociocultural descriptors characterize the study area and its sub-basins. These weak bivariate correlation associations suggested that generally poor regression models would be produced for the data, if significant models emerged at all, and this was generally the case. Though models were ultimately produced for the study area, its sub-basins, and for the MRGCD, only the models corresponding to the greater study area and the MRG sub-basin were sufficiently powerful and complex enough to merit attention. It is important to note that these models were very similar in their relative explanatory power and with respect to the nature of the variables present in each, and this is a function of the large relative contribution of the MRG sub-basin data to the overall study.

The important sociocultural descriptors that showed significant associations with AFCU included those describing relative rurality (these were negatively associated), relative strength of farming and/or agricultural employment, occupational structure, levels of income, and home construction during the late 1980s. Additionally, a variable indicating the percent of population that is Hispanic was included in the MRG sub-basin model. Other variables with less explanatory power were included in the models because they contributed to the overall reduction of error variance. These findings are in general agreement with what was expected for the study area, in particular, given the general tone of the literature and familiarity with this area.

It was expected, however, that sociocultural descriptors would also prove to be significant in the case of the URG sub-basin – such an expectation is indeed merited given the weight and amplitude of concerns related to modern resource expropriation in the Rio Arriba (i.e., the URG sub-basin) contained in the literature and emerging from the region's residents. The models constructed for this area were instead very weak and included only descriptors of recreational residential development during the 1980s. While this does not necessarily depart from a priori expectations, it was hoped that stronger and more complex models would emerge from the analyses.

In summary, it can be inferred from the regression analyses that there is a tendency, though weak, for areas characterized by higher population and income levels within which agriculture remains important to experience greater levels of water transfer activity as expressed by the volume of water transferred. This has implications for the majority of the MRG sub-basin, large portions of which have strong functional relationships with the Albuquerque Metropolitan Area, and for traditional agricultural areas at the rural-urban fringe of Santa Fe.

Lastly, with regard to these analyses, the methods and techniques employed in this study were appropriate and methodologically correct. However, the general poor performance of the multivariate correlation and regression analyses suggests that these methods were not well suited for the data at hand. These approaches were chosen because of their relative ease in application and interpretation, because of the need to associate independent and dependent variables to meet the study objectives, and because other methods did not present themselves as being useful or appropriate. Rather than reject the analyses out of hand and search for other methods that might produce stronger results, it is important to consider that the data collected for this investigation do not lend themselves well to such analytical techniques. This conclusion certainly bears testing with water market or transfer data from other areas.

Another important, though serendipitous, finding emerging from the research concerns the importance of the dedication procedure to levels of transfer, and especially market, activity. Much of the success of the market-based transfer in shifting water from lower- to higher-value economic uses was a function of the rather widespread and illegal practice of dedicating (i.e., retiring) surface water rights to hydrologically compensate for increased groundwater pumping requirements by municipal service providers and others. The data suggest that it is the dedication itself, which as practiced allowed the transferor to avoid the statutory public notice and review requirements of the transfer process, which has promoted the significance of the incremental small transfer within the basin. This practice was basically confined to the MRG sub-basin which has experienced more rapid rates of growth and economic development during the 1990s. However, the circumvention of statutory requirements concerning water right transfer procedure has been curtailed, and though incremental small transfers will almost certainly continue to occur within the study area they will likely be somewhat more difficult and costly to effect.

It can be seen that the dedications of MRGCD related (i.e., 0620) water rights to municipal use in the MRG sub-basin represent a fait accompli for municipal water service providers, much as did the later acquisition of water rights by Intel Corporation for its new computer micro-chip manufacturing plant in Rio

Rancho. The legal and public outcry over such practices has had the effect of forcing the SEO to follow the book when it comes to the consideration, review, and processing of transfer requests, and to draft new rules concerning the application for permits to appropriate groundwater in the MRG sub-basin.

Today, the practice of dedicating water rights without public notice is not permitted, and entities which had previously relied on this approach (i.e., holding a permit to appropriate groundwater which specifies that they must offset depletions with retired surface water rights) must now demonstrate that they have acquired surface rights for retirement and submit ACPPUs on them prior to enlarging their depletions (State Engineer Office 1995). The holders of new ground water permits in the MRG must acquire and transfer quantities of surface water equivalent to groundwater depletions prior to the commencement of pumping. Specifically, "groundwater appropriations that impact surface water sources by 0.10 af per year or more within ten years following permit approval should offset 100% of the ultimate surface water depletions caused by the appropriation." (Office of the State Engineer 1999:5)

The relative significance of the dedication to water resources reallocation in the MRG sub-basin, particularly as it has affected lands associated with the MRGCD, was an unexpected finding. This is not necessarily the case, however, for the occurrence and spatial expression of market and non-market-based transfer activity in the Rio Arriba. These patterns corresponded well with a priori expectations (forged from exposure to the scientific and popular literature of the region, through contact with its residents, and through direct observation) that transfer activity would correspond spatially to those places and areas which are experiencing more strongly the forces of acculturation and economic transformation.

An important observation concerning the spatiotemporal pattern of transfer POUs in the URG sub-basin that has not yet been discussed concerns the general lack of occurrence of transfers either within or from the traditional Hispano villages of the Rio Arriba. While it is true that several seemingly isolated transfers have occurred in and around the physically less-isolated communities of Questa, Rio Hondo, Ranchos de Taos, Abiquiu, Chama, and Chimayo, no cases were shown to have occurred (mappable or otherwise) in other traditional villages of the Rio Arriba. In spite of the evidence which indicates some steady market-based transfer activity within the Rio Arriba, especially associated with the larger towns of Taos and Española, the general lack of either type of transfer corresponding to the traditional villages certainly supports the observations of Brown and Ingram (1987) concerning the unwillingness of the Rio Arriba's Hispano residents to part with their water rights.

Related to this relative lack of transfer activity in the more traditional communities of the Rio Arriba and the general unwillingness to participate in a market that serves to move water away from said communities, may be the condition of a general lack of economic opportunity which operates in the more rural areas of the Rio Arriba and which could serve to preclude the non-market transfer of irrigation rights to other higher-value uses by the region's residents themselves. The existence of such a condition is implied by the census data corresponding to such areas which were presented in Chapter 4, and has been discussed at length by Brown and Ingram (1987), and by Carlson (1990). It is a multifaceted problem that has existed for some 150 years and which has deep substantive implications for the region's Hispano residents. The position of Hispanos in the Rio Arriba today is characterized as one of reactive entrenchment (Brown and Ingram 1987; Carlson 1990; Rodríguez 1987) owing to the vectors and magnitudes of the forces directed against them, and community economic development endeavors that are sustainable from all standpoints have proven to be highly elusive. But, in the context of longer-term attrition and acculturation, rural economic development will be as important to the maintenance of Hispano culture in the Rio Arriba in the long run as is the maintenance of links to land and water.

It would seem that the water resources of the Rio Arriba could represent an important economic development resource to its communities, however, the identification of activities and products that can compete with those manufactured elsewhere using economies of scale has proven to be difficult thus far (Brown and Ingram 1987). Certainly the retention of community water (i.e., acequia) rights is of fundamental importance to the maintenance of culture within the region; this assertion is supported by the views of the residents themselves, and by the historical record. Otherwise, the pattern of resource expropriation that has characterized much of the last 150 years will continue with the net result of further cultural erosion. From the bioregional perspective, which probably best accommodates the conceptualization and characterization of the pre-American occupation cultural ecology of the region, a dependency economy and culture has already been forced upon the Hispano communities of the region and water marketing has had the potential to further this state.

However, legislation (i.e., the 1985 water code amendments concerning the public interest) and case law are seemingly adequate to protect the public interest barring the continued erosion of culture owing to larger scale structural economic forces and change. Thus, the importance of economic opportunity which must include economic diversification, community generation and retention of earnings and capital, and sustainable enterprise cannot be overstressed. This has already been proven to be of vital importance to the Village of Tierra Amarilla (near Chama) through the operation of "Ganados del Valle," a specialty wool production and weaving community enterprise. This business enterprise has captured the attention and imaginations of advocates for the culture and region, and of the sustainable development community (Peña 1992; Sargent et al. 1991) alike because it demonstrates the effectiveness of the traditional cultural ecology of the Hispanos there and testifies to the importance of finding ways to make this work again to their advantage.

An equally important observation related to those concerning transfer activity in the Rio Arriba concerns the near complete lack of transfer activity associated with the Native American Pueblos and reservation lands of the study area, excepting two transfers occurring within the lands of the Santa Clara Pueblo adjacent to Española. One of these transfers represents an irrigator shift that was retained in the database because it involved a change from surface to groundwater usage, whereas the other represents a market transaction of an irrigation water right to mobile home park use. Applicant information documented on the ACPPU corresponding to the latter suggests that this transfer involved a non-Indian inholding on the reservation, perhaps relating to Dawes Act subdivisions, and its possible return to Indian ownership. This would be consistent with the fact that transfers of Pueblo water rights to off-reservation locations are effectively forbidden by Pueblo leadership and Bureau of Indian Affairs policies owing to the intensity of values concerning land and water that equal or even exceed those corresponding to the Hispanic residents of the region.

7.2 Implications of the Findings

In addition to those implications of the research presented in the preceding section, some additional topics bear consideration. First, to briefly revisit the topic of water marketing in the study area, the evidence of large-scale and widespread use of the market mechanism to effect transfers of water rights within the study area for the purpose of accommodating growth and economic development is an important finding emerging from this study. As mentioned previously, this finding serves to underscore the importance of water right marketing as a reallocative mechanism in the study area, and though it was not unexpected owing to previous investigations into water market activity in New Mexico and elsewhere, this finding certainly has implications for other states who have not yet chosen to adopt this strategy but may yet choose to do so.

These implications are related to the administrative environment in which water marketing has functioned within the study area, its role as an agent of land use change, and the retention of land for agriculture. First, the extension of the *Templeton* doctrine to the MRG sub-basin has created a de facto hydrologic linkage between the Rio Grande and the aquifers of the Santa Fe group underlying it that is assumed to exist but which is under scrutiny today by the U.S. Geological Survey (McAda 1996). This is significant because, in a large way, it is the application of the doctrine within this sub-basin which has allowed the development of a strong market for water rights there.

This situation, which has already begun to change with respect to groundwater pumping offset requirements and water right acquisition, will almost certainly be made more difficult if it is found that the hydrologic linkages are not as strong as was previously supposed. This would likely serve to increase the cost of market transactions, and the transfer process in general, by increasing transactions costs through the added requirement of geohydrologic studies to support transfer proposals. The role and function of intermediary parties (i.e., water brokers) in transfers and market transactions would also likely be expanded. It may also serve to further subdivide the sub-basin for purpose of water right permit and transfer administration thus narrowing the field of potential transfer sources and the field of potential parties to transactions.

Increases in transactions costs should have the effect of increasing the price of water in a market setting, and were this to happen the dominance of the municipalities as bargaining partners willing to pay prices above those which can be afforded by other entities would only be expanded. And, while it might be argued that this would represent a progressive scenario from the point of view of land use planning in that the non-agricultural use of irrigation water would likely occur in existing urban environments, it could serve to limit the economic and community development opportunities of rural communities.

Second, it is clear that transfer activity in the study area and in the MRG sub-basin has had the effect of forcing agricultural lands into retirement. At the consumptive use rate of 2.1 AFCU per acre, the amount of agricultural land retired in the MRG sub-basin during the study period owing to transfers of water rights was approximately 2096 acres (3.275 square-miles), enough to support the operation of one or two full time farm operations. Assuming that the average amount of water transferred per year over the study period will remain somewhat constant even in the face of changing administrative procedure, an average of 104.8 acres (0.16 square-miles) of agricultural land will be retired in the MRG sub-basin each year.

It is scenarios like this, pervasively incremental and spatially diffuse losses of farmland, that have prompted the development of land use protection policies in various states and nations of the world. And it is precisely this situation that has generated concern over the continued and future viability of the MRGCD which provides essential services to the agricultural, urban, and suburban communities within the MRG sub-basin (Brown et al. 1982; DuMars and Nunn 1993). Indeed, the district fought a long legal battle (i.e., *Middle Rio Grande Conservancy District* v. *Cox*) over the issue of its jurisdiction over non-district water rights associated with district lands only to have the case dropped and the issue remain unresolved (Daves 1992).

The research has shown that the general concern regarding the erosion of culture within the Rio Arriba and elsewhere in the study area, while well intended and grounded in a conservative approach to resources management, can only be based on the occurrence of several high-profile cases rather than upon the existence and awareness of a serious problem. And while it can be argued that the potential problem of widespread transfer activity from or within the traditional communities of the Rio Arriba will be effectively handled by existing legislation, case law, and the oversight of the agencies and organizations charged with this task, the calls for stronger protection of the cultural resources of the basin continue. A recent example, provided by Klein-Robbenhaar (1996), calls for the Office of the State Engineer to develop an operational definition of "public welfare" to be utilized in application and ACPPU reviews, to specify the limits of burden of proof, and to require transfer applicants to submit "public welfare impact statements."

There do exist, however, at this time a number of related issues that have captured the attention of policy makers and others who are recognizing the changes that growth and economic development are bringing to the basin. These issues include: water conservation (State Engineer Office 1998b); interbasin diversions, and hydropower for economic development in the northern New Mexico (State Engineer Office 1998b); the linking of water quality considerations to permit administration by the SEO (Office of the State Engineer 1999); the management of the Bosque of the Middle Rio Grande as a greenway and the development of a water bank by the MRGCD to provide a flexible supplemental water supply to the MRG sub-basin (DuMars and Nunn 1993).

7.3 Suggestions for Further Study

This study has represented an important first attempt at mapping and modeling transfers of water rights occurring within a western state. It has provided an approach and a class of information that has thus far been lacking in the literature, and will hopefully present resource managers, policy makers in a number of different areas and jurisdictions, and researchers with food for thought and ideas which may generate research that will ultimately complement this study. Some issues, points, and topics that emerged from this study that merit investigation as questions or problems in their own right are presented here.

First, given the large amount of transfer activity occurring in the MRG sub-basin from 1989 to 1995, and the forces that are coming to bear on this area, a follow-up or continuation of this study utilizing the same approach would provide information pertinent to the implications discussed above. Along these lines, an investigation of this nature could make use of the data coming from the 2000 Census of Population and Housing, and could employ independent variables concerning change in the characteristics of population and housing that were considered here. This would likely provide some different results concerning the strength of the relationships between the independent sociocultural variables and quantities of water transferred than emerged here. Similarly, the geographic study of transfer and market activity in other states would provide much needed complementary information that is conditioned by context such that a fuller or more complete and broader-scale picture of the spatiotemporal patterns of transfer activity can emerge.

Second, an investigation of the environmental effects of water right transfer activity in the Rio Grande basin would serve to greatly complement the findings reached here. In particular, a study focussing on the condition of retired agricultural tracts and the extent and direction of land use change associated with such areas in the different sub-basins would be quite instructive. An investigation of this nature would require considerable field study given the extremely small size of many transfer POUs; remote sensing techniques would likely prove to be difficult to implement and probably unreliable. Similarly, an investigation of transfer impacts on riparian and aquatic environments associated with the streams and ditches of the basin would be highly interesting, substantive, and timely given local and regional concerns over water quality and endangered species.

And lastly, the extent of sociocultural change in rural and smaller urban environments such as are found in the Rio Arriba that is associated with larger-scale economic processes is always an intriguing and challenging question to address. This is obviously difficult given the spatial and human scales at which such a study would need to be conducted (such as between regions but focused on communities) and the issue of privacy becomes critical. However, it would shed light on a process which operates at the national and international scales, yet which has effects at the level of the community and even the family and individual. Furthermore, it would permit the development of more effective policies, where needed, that are better able to consider the forces that operate on the populations of concern.

7.4 Conclusion

Water marketing is a mechanism of water resources reallocation whose importance lies in its seeming flexibility – its ability to incrementally move water to where it is needed or desired most. Many feel that this mechanism has the power to correct many deficiencies and evils of historic patterns of water resources management because of this flexibility and because it is assumed that it functions best in the absence of interference by other institutions. This geographic study has shown that this does indeed seem to be the case in one area of the West, albeit with the important oversight of institutions including the courts, the legislature, and a state agency. This mechanism, however, should not be viewed as a panacea because it clearly has the power to effect change in landscapes and human ecology that are perhaps quite permanent in nature. Hence, the importance of observation and monitoring to ensure that the vectors and extents of change fall within the parameters that our society has established as acceptable.

We are witnessing a transition to a period in which it is felt that the market can accomplish anything, or nearly so. A number of western states continue to flirt with the concept of the market-based transfer of water rights, and undoubtedly we will witness its adoption in these and others as time progresses. It is hoped that the information and findings reached in the course and conduct of this study, and those which follow, will be of utility to those who seek to amend their state water codes to provide for the greatest good to the greatest number. Though the recommendations concerning the implications of the research for policy makers is limited here owing to the fact that considerable attention is already being devoted to these and related topics and issues bearing on the study area, the implications bear consideration because of their relevance to other basins and regions outside of the study area and the state of New Mexico.

Lastly, it should be noted that these issues relating to the changing environment for water resources management in the West, which have been discussed here and addressed in part by the research, are also being shown to be of growing importance to our elected officials in Washington, D.C. In spite of trepidation owing to the unfulfilled promises of the past, it is uplifting to observe the refocusing of regional and national attention on the water resources issues that are so vital to the West. The Western Water Policy Review Advisory Commission, a group composed of citizens, agency representatives, and ex-officio Congressional Representatives, had this to say about water transfers in the executive summary of its final report:

> The Commission finds that water transfers are an essential part of any discussion of the future of the West and its water, particularly given growth projections. Voluntary water transfers are occurring throughout the West and are helping to meet the demand for new urban supplies and for environmental flows in a manner that is both fair and efficient. They are also a critical aspect of viable Indian water rights settlements. However, water transfers that occur without attention to their potentially damaging effects on local communities, economies, and environments can be harmful to ecosystems and social systems that are dependent on irrigation economies. (Western Water Policy Review Advisory Commission 1998:xxiv)

BIBLIOGRAPHY

Albrecht, D. E., and Murdock, S. H. 1990. *The Sociology of U.S. Agriculture*. Ames: Iowa State University Press.

Arizona. 1994. *Arizona Revised Statutes, Annotated.* Volume 14, Title 45. (1996 Supplement.) St. Paul, Minn.: West Publishing Co.

Ballard, S. C., and Gunn, E. M. 1983. State government capacity for managing Sunbelt growth. In, *The Future of the Sunbelt: Managing Growth and Change,* ed. S. C. Ballard and T. E. James, New York: Praeger Publishers.

Bohnhoff, H. M. 1989. Overview of the Texas v. New Mexico settlement. In, *The Relationship of Water Issues: Southeastern New Mexico as a Case Study,* Proceedings of the 34th Annual New Mexico Water Conference, New Mexico Water Resources Research Institute, Las Cruces: New Mexico State University.

Bogue, D. J. 1956. *Metropolitan Growth and the Conversion of Land to Nonagricultural Uses.* Oxford, Ohio: Scripps Foundation.

Boots, B. N., and Getis, A. 1988. *Point Pattern Analysis*. London: Sage Publications.

Bosch, D. J. 1991. Benefits of transferring streamflow priority from agricultural to non-agricultural use. *Water Resources Bulletin* 27(3): 397-405.

Bowler, I. R. (ed.). 1992. *The Geography of Agriculture in Developed Market Economies*. New York, New York: Longman Group and John Wiley & Sons, Inc.

Briggs, C. L., and Van Ness, J. R. (ed.). 1987. *Land, Water, and Culture: New Perspectives on Hispanic Land Grants.* Albuquerque: University of New Mexico Press.

Brown, F. L., McDonald, B., Tysseling, J., and DuMars, C. 1982. Water reallocation, market proficiency, and conflicting social values. In, *Water and Agriculture in the Western U.S.: Conservation, Reallocation, and Markets,* ed. G.D. Weatherford, Boulder, Colorado: Westview Press, Inc.

Brown, F. L., and Ingram, H. M. 1987. *Water and Poverty in the Southwest.* Tucson: The University of Arizona Press.

Brown, J. 1999. Personal communication with Jan Brown, Executive Director of the Henry's Fork Foundation, February, 1999.

Bryant, B. E. 1991. United States population: the changing face of the United States. In, *The World Almanac and Book of Facts: 1992,* ed. M. S. Hoffman, New York: Pharos Books.

Bryant, C. 1992. Farming at the urban fringe. In, *The Geography of Agriculture in Developed Market Economies*, ed. Bowler, I. R. , New York, New York: Longman Group and John Wiley & Sons, Inc.

Bureau of the Census. 1989. *1990 Census of Population and Housing Tabulation and Publication Program*. Washington, D.C.: U.S. Department of Commerce, Bureau of the Census.

Bureau of the Census. 1992. *Census of Population and Housing, 1990: Summary Tape File 3 on CD-ROM* [machine-readable data files]. Washington, D.C.: The Bureau [producer and distributor].

Bureau of the Census. 1998a. *School District Special Tabulation*. Available: http://govinfo.library.orst.edu/document/sddb/sddbcont.html [8/27/98].

Bureau of the Census. 1998b. *TIGER/Line™ Files, 1992 – Chapter 4: Geographic Entities*. Available: http://www.census.gov/ftp/pub/geo/www/tiger/chapter4.asc [5/25/98].

Bush, D. B. 1988. Dealing for water in the west: water rights as commodities. *Journal of the American Water Works Association* 80(3):30-37.

Buttel, F. H., and Newby, H., (eds.). 1980. *The Rural Sociology of the Advanced Societies: Critical Perspectives*. Montclair, New Jersey: Allanheld, Osmun & Co. Publishers, Inc.

California. 1971. *West's Annotated California Codes*. Volume 68. (1997 Supplement.) St. Paul, Minnesota: West Publishing Co.

California Department of Water Resources. 1992. *The 1991 Drought Water Bank.* Sacramento: California Department of Water Resources.

Carlson, A. W. 1990. *The Spanish-American Homeland: Four Centuries in New Mexico's Rio Arriba*. Baltimore, Maryland: The Johns Hopkins University Press.

Chang, C. and Griffin, R. C. 1992. Water marketing as a reallocative institution in Texas. *Water Resources Research* 28(3): 879-890.

Changnon, S. A., Jr. 1987. An assessment of climate change, water resources, and policy research. *Water International* 12: 69-76.

Chavez, C. 1995. Personal Communication with Calvin Chavez, Water Resource Engineering Specialist, New Mexico State Engineer Office (8/25/95 – 8/28/95).

Chavez, J. R. 1984. *The Lost Land: the Chicano Image of the Southwest.* Albuquerque: University of New Mexico Press.

Chen, R. S., Boulding, E., and Schneider, S. H., (eds.). 1983. *Social Science Research and Climate Change: An Interdisciplinary Appraisal.* Dordrecht, Holland: D. Reidel Publishing Company.

Christensen, J. 1994. Las Vegas wheels and deals for Colorado River water. *High Country News* 26(3): 12-13.

Clark, C. D. 1965. Our complex water laws and water use customs. In, *Water Law, Policy, and Economics*, Corvallis, Oregon: Oregon Water Resources Research Institute, Oregon State University.

Clark, I. G. 1987. *Water in New Mexico: A History of Its Management and Use.* Albuquerque: University of New Mexico Press.

Clark, R. E. 1964. *New Mexico Water Resources Law: A Survey of Legislation and Decisions.* Albuquerque: Division of Government Research, University of New Mexico.

Clarke, K. C. 1990. *Analytical and Computer Cartography.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Clawson, M. 1971. *Suburban Land Conversion in the United States: An Economic and Governmental Process.* Baltimore: Johns Hopkins Press.

Cliff, A. D. and Ord, J. K. 1975. Model building and the analysis of spatial pattern in human geography. *Journal of the Royal Statistical Society* 37:297-348.

Clyde, E. W. 1986. Institutional response to prolonged drought. In, *New Courses for the Colorado River: Major Issues for the Next Century,* ed. G. D. Weatherford and F. L. Brown, Albuquerque: University of New Mexico Press.

Colby, B. G. 1988. Economic impacts of water law: state law and water market development in the Southwest. *Natural Resources Journal* 28: 721-749.

Colby, B. G. 1992. Water transfers and water markets: economic equity. In, *Oregon Water Policy Issues.* Extension Miscellaneous 8528. Corvallis: Oregon State University Extension Service.

Colby, B. G., and McGinnis, M. A. 1988. *Water Transfer Procedures and Transaction Costs – New Mexico.* Tucson: RFF Research, Department of Agricultural Economics, University of Arizona.

Cobourn, J., Johnson, W., Ford, J., Reid, M., and Allen, N. 1992. *Nevada's Water Future: Making Tough Choices.* Reno: University of Nevada.

Colorado. 1990. *Colorado Revised Statutes.* Volume 15, Title 37. (1992 Supplement.) Denver, Colo.: Bradford Publishing Co.

Commission on Geosciences, Environment, and Resources. 1991. *Managing Water Resources in the West Under Conditions of Climate Uncertainty.* Washington, D. C.: National Academy Press.

Coppock, R. H., and Kreith, M., (eds.). 1993. *California Water Transfers: Gainers and Losers in Two Northern Counties.* Proceedings of a Conference Sponsored by the Agricultural Issues Center and the Water Resources Center, University of California. Davis: University of California Agricultural Issues Center.

Cronon, W. J., Miles, G. and Gitlin, J. 1992. *Under an Open Sky: Rethinking America's Western Past.* New York and London: W. W. Norton and Company.

Daves, G. 1992. *Law(s) of the Rio Grande del Norte: an Interstate Seminar – Change of Use From Irrigation to M & I.* Seminar delivered to the 1992 CLE program of the State Bar of New Mexico.

De Young, T. J. 1994. *Water of Enchantment: A Citizen's Guide to New Mexico Water Law.* Boulder, Colorado: Land and Water Fund of the Rockies.

Dick-Peddie, W. A. 1993. *New Mexico Vegetation: Past, Present, and Future.* Albuquerque: University of New Mexico Press.

Dideriksen, R. I., Hidlebaugh, A. R., and Schmude, K. O. 1977. *Potential Cropland Study.* Statistical Bulletin 578. Washington, D.C.: Soil Conservation Service.

DuMars, C. T. 1989. Texas v. New Mexico: it's time to correct some judicial mistakes. In, *The Relationship of Water Issues: Southeastern New Mexico as a Case Study,* Proceedings of the 34th Annual New Mexico Water Conference, New Mexico Water Resources Research Institute, Las Cruces: New Mexico State University.

DuMars, C. T., and Nunn, S.C. 1993. *Middle Rio Grande Conservancy District Water Policies Plan.* Albuquerque, New Mexico: Middle Rio Grande Conservancy District.

Dunbar, R. G. 1983. *Forging New Rights in Western Waters.* Lincoln: University of Nebraska Press.

Eaton, D. J., and Hurlbut, D. 1992. *Challenges in the Binational Management of Water Resources in the Rio Grande/Río Bravo.* Austin: Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin.

Ebright, M. 1987. New Mexican land grants: the legal background. In, *Land, Water, and Culture: New Perspectives on Hispanic Land Grants.* Eds. Briggs, C. L., and Van Ness, J. R., Albuquerque: University of New Mexico Press.

El-Ashry, M. T., and Gibbons, D. C. 1986. *Troubled Waters: New Policies for Managing Water in the American West.* Washington, D. C.: World Resources Institute.

Emel, J., and Roberts, R. 1995. Institutional form and its effect on environmental change: the case of groundwater in the southern High Plains. *Annals of the Association of American Geographers* 85(4): 664-683.

Flora, C. B., Flora, J. L. Spears, J. D., and Swanson, L. E. 1992. *Rural Communities: Legacy and Change*. Boulder, Colorado: Westview Press.

Folk-Williams, J. A., Fry, S. C., and Hilgendorf, L. 1985. *Western Water Flows to the Cities.* Santa Fe, New Mexico: Western Network.

Furuseth, O. J., and Pierce, J. T. 1982. *Agricultural Land in and Urban Society.* Washington, D.C.: Association of American Geographers.

Getches, D. H., and Meyers, C. J. 1986. The river of controversy: persistent issues. In, *New Courses for the Colorado River: Major Issues for the Next Century,* ed. G. D. Weatherford and F. L. Brown, Albuquerque: University of New Mexico Press.

Goldschmidt, W. F. 1978. *As You Sow*. New Jersey: Allenheld, Osmun and Co.

Gould, G. A. 1989. Transfer of water rights. *Natural Resources Journal* 29(2): 457-477.

Greene, R. P., and Harlin, J. M. 1995. Threat to high market value agricultural lands from urban encroachment: a national and regional perspective. *The Social Science Journal* 32(2):137-155.

Griffith, D. A. 1993. *Spatial Regression Analysis on the PC: Spatial Statistics Using SAS.* Washington, D.C.: Association of American Geographers.

Hernandez, J. W. 1995. Order No. 152, Hearing Examiner's Findings and Recommendations: In the Matter of the Proposed Promulgation of Article 1-19 - Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico (February 5, 1995). Santa Fe: State Engineer Office.

Howitt, R. 1993. Economic and social factors. In, *California Water Transfers: Gainers and Losers in Two Northern Counties*, ed. Coppock, R. H., and Kreith, M. Proceedings of a Conference Sponsored by the Agricultural Issues Center and the Water Resources Center, University of California. Davis: University of California Agricultural Issues Center.

Hundley, N. Jr. 1986. The West against itself: the Colorado River - an institutional history. In, *New Courses for the Colorado River: Major Issues for the Next Century,* ed. G. D. Weatherford and F. L. Brown, Albuquerque: University of New Mexico Press.

Idaho. 1996. *Idaho Code*. Volume 8, Title 42. Charlottesville, Virginia: Michie Law Publishers.

Ilbery, B. W. 1985. *Agricultural Geography: A Social and Economic Analysis.* New York, New York: Oxford University Press.

Jackson, R. H. 1981. *Land Use in America.* London: V.H. Winston and Sons.

Kansas. 1989. *Kansas Statutes Annotated.* Volume 6A. (1995 Supplement.) Topeka: Division of Printing.

Karpisak, N. M. 1980. *Secondary Succession of Abandoned Field Vegetation in Southern Arizona*. Doctoral Dissertation, Department of General Biology, Tucson: University of Arizona.

Klein-Robbenhaar, J. F. 1996. Balancing efficiency with equity: determining the public welfare in surface water transfers from Acequia communities. *Natural Resources Journal* 36(1):37-58.

Kneese, A. V., and Brown, F. L. 1981. *The Southwest Under Stress.* Baltimore and London: The Johns Hopkins University Press for Resources for the Future, Inc.

Kneese, A. V., and Bonem, G. 1986. Hypothetical shocks to water allocation institutions in the Colorado basin. In, *New Courses for the Colorado River: Major Issues for the Next Century,* ed. G. D. Weatherford and F. L. Brown, Albuquerque: University of New Mexico Press.

Lamb, R. 1975. *Metropolitan Impacts on Rural America.* Chicago: Department of Geography, The University of Chicago.

Lansford, R. R. 1989. Projections for the future. In, *Water Planning From the Town Up*, Proceedings of the 33rd Annual New Mexico Water Conference, WRRI Report No. 238, Las Cruces: New Mexico Water Resources Research Institute, New Mexico State University.

Lobao, L. M. 1990. *Locality and Inequality: Farm and Industry Structure and Socioeconomic Conditions.* Albany: State University of New York Press.

Lopez, T. R., Jr. 1974. *Prospects for the Spanish American Culture of New Mexico.* San Francisco, California: R and E Research Associates.

MacCannell, D. 1986. Agribusiness and the small community. In, *Technology, Public Policy and the Changing Structure of American Agriculture*, Volume II. Washington, D. C.: Office of Technology Assessment.

Malone, M. P., and Etulain, R. W. 1989. *The American West: A Twentieth-Century History.* Lincoln and London: University of Nebraska Press.

Mann, D. 1982. Institutional framework for agricultural water conservation and reallocation in the West: A policy analysis. In, *Water and Agriculture in the Western U.S.: Conservation, Reallocation, and Markets,* ed. G. D. Weatherford, Boulder: Westview Press, Inc.

Manson, G. A., and Groop, R. E. 1996. Ebbs and flows in recent U.S. interstate migration. *Professional Geographer* 48(2): 156-166.

Marston, E. 1996. Cease-fire called on the Animas-La Plata front. *High Country News* 28(21): 1, 10-12.

Matheson, S. M. 1991. Future water issues: confrontation or compromise. *Journal of Soil and Water Conservation*, March/April: pp. 96-99.

Matthews, O. P. 1984. *Water Resources, Geography and Law.* Washington, D.C.: Association of American Geographers.

McAda, D. P. 1996. *Plan of Study to Quantify the Hydrologic Relations Between the Rio Grande and the Santa Fe Group Aquifer System Near Albuquerque, Central New Mexico.* U.S. Geological Survey, Water-Resources Investigations Report 96-4006. Albuquerque, New Mexico: U.S. Geological Survey.

McBean, E. 1993. Environmental effects. In, *California Water Transfers: Gainers and Losers in Two Northern Counties*, ed. Coppock, R. H., and Kreith, M. Proceedings of a Conference Sponsored by the Agricultural Issues Center and the Water Resources Center, University of California. Davis: University of California Agricultural Issues Center.

McCord, M. 1998. Personal communication with Michael McCord, Oregon Water Resources Department, 1/29/98.

McDaniel, P. 1996. Planning the future of the Middle Rio Grande Bosque: preserving the river through a revival of public deliberative democracy. *Natural Resources Journal* 36(4).

Meitl, J. M., Hathaway, P. L., and Gregg, F. 1983. *Alternative Uses of Arizona Lands Retired From Agriculture.* Tucson: Cooperative Extension Service, College of Agriculture, University of Arizona.

Mitchell, B. 1979. *Geography and Resource Analysis*. New York: Longman Group Limited.

Molnar, J. J. (ed.). 1986. *Agricultural Change: Consequences for Southern Farms and Rural Communities*. Boulder, Colorado: Westview Press, Inc.

Montana. 1995. *Montana Code Annotated.* Volume 10, Title 85. Helena: Montana Legislative Council (printed and bound by Darby Printing, Atlanta, GA).

Muckleston, K. W. 1980. International management of the Columbia. In, *Conflicts Over the Columbia River*, Corvallis, Oregon: Oregon Water Resources Research Institute, Oregon State University.

Muckleston, K. W. 1990. Integrated water management in the United States. In, *Integrated Water Management,* ed. B. Mitchell, London and New York: Bellhaven Press.

Nebraska. 1993. *Revised Statutes of Nebraska.* Volume 3A, Title 46. Lincoln: Revisor of Statutes.

Neter, J., Wasserman, W., and Kutner, M. H. 1989. *Applied Linear Regression Models.* Homewood, Illinois: Richard D. Irwin, Inc.

Nevada. 1995. *Nevada Statutes Annotated.* Volume 14. Charlottesville, Virginia: Michie Law Publishers.

New Mexico. 1978. *New Mexico Statutes.* Volume 13, Chapter 72. (1997 Replacement.) Charlottesville, Virginia: Michie Law Publishers.

New Mexico State Engineer Office. 1994. *Annual Report.* Santa Fe: New Mexico State Engineer Office.

Nichols, J. 1974. *The Milagro Beanfield War.* New York: Ballantine Books.

North Dakota. 1995. *North Dakota Century Code.* Volume 12, Title 61. (1997 Supplement.) Charlottesville, Virginia: Michie Butterworth Law Publishers.

Northwest Power Planning Council. 1990. *Tenth Annual Report of the Pacific Northwest Electric Power and Conservation Planning Council.* Portland, Oregon: Northwest Power Planning Council.

Northwest Power Planning Council. 1993. *Strategy for Salmon.* Portland, Oregon: Northwest Power Planning Council.

Nostrand, R. L. 1987. The century of Hispano expansion. *New Mexico Historical Review* 62(4):361-386.

Nostrand, R. L. 1992. *The Hispano Homeland.* Norman, Oklahoma: University of Oklahoma Press.

Nunn, S. C. 1987. Urban purchases of water from farms: is the market the answer to western water scarcity? In, *Ground Water Management.* Proceedings 32nd Annual New Mexico Water Conference, WRRI Report No. 229. Las Cruces: New Mexico Water Resources Research Institute, New Mexico State University.

Nunn, S. C., and Ingram, H. M. 1988. Information, the decision forum, and third-party effects in water transfers. *Water Resources Research* 24(4):473-480.

Nunn, S. C. 1990. Transfers of New Mexico water: a survey of changes in place and/or purpose of use, 1975-1987. In, *The Relationship of Water Issues: Southeastern New Mexico as a Case Study*. Proceedings 34th Annual New Mexico Water Conference, WRRI Report No. 248. Las Cruces: New Mexico Water Resources Research Institute, New Mexico State University.

Office of the State Engineer. 1999. *Guidelines for Review of Water Right Applications*. A draft report prepared for internal use by the Office of the State Engineer, New Mexico, March 30, 1999. Santa Fe: Office of the State Engineer. Available: http://www.seo.state.nm.us/doing-business/mrg-criteria/mid-rio-grande.html [4/18/99].

Oklahoma. 1990. *Oklahoma Statutes Annotated.* Title 82. (1993 Supplement.) St. Paul, Minn.: West Publishing Co.

Oregon. 1995. *Oregon Revised Statutes.* Chapters 537 & 540. (1996 Supplement.) Salem: Oregon Legislative Counsel Committee.

Oregon Water Resources Department. 1992. *Oregon Water Laws: Volume 1.* Salem: Oregon Water Resource Department.

Pearce, T. M. (ed.). 1965. *New Mexico Place Names: A Geographical Dictionary*. Albuquerque: University of New Mexico Press.

Peña, D. 1992. The `Brown' and the `Green': Chicanos and environmental politics in the upper Rio Grande. *Capitalism, Nature, Socialism: A Journal of Socialist Ecology* 3(1): 79-103.

Peuquet, D. J. 1994. It's about time: a conceptual framework for the representation of temporal dynamics in geographic information systems. *Annals of the Association of American Geographers* 84(3):441-461.

Pisani, D. J. 1992. *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902*. Albuquerque: University of New Mexico Press.

Platt, R. H., and Macinko, G. 1983. *Beyond the Urban Fringe: Land Use Issues of Nonmetropolitan America.* Minneapolis: University of Minnesota Press.

Plaut, T. 1976. *The Effects of Urbanization on the Loss of Farmland at the Rural-Urban Fringe: A National and Regional Perspective.* Philadelphia: Regional Science Research Institute.

Reisner, M. 1997. Deconstructing the age of dams. *High Country News* 29(20): 1, 8-11.

Reisner, M. 1993. *Cadillac Desert.* New York: Penguin Books.

Reisner, M., and Bates, S. 1990. *Overtapped Oasis: Reform or Revolution for Western Water.* Washington, D. C.: Island Press.

Rice, T. A., and MacDonnell, L. J. 1993. *Agricultural to Urban Water Transfers in Colorado: An Assessment of the Issues and Options.* Fort Collins, Colorado: Colorado Water Resources research Institute.

Rivera, J. A. 1996. Irrigation Communities of the upper Rio Grande biosphere: sustainable resource use in the global context. *Natural Resources Journal* 36(4):491-520.

Roberts, R. S., and Butler, L. M. 1983. The Sunbelt phenomenon: causes of growth. In, *The Future of the Sunbelt: Managing Growth and Change,* ed. S. C. Ballard and T. E. James, New York: Praeger Publishers.

Rodríguez, S. 1987. Land, water, and ethnic identity in Taos. In, *Land, Water, and Culture: New Perspectives on Hispanic Land Grants,* ed. Briggs, C. L., and Van Ness, J. R., Albuquerque: University of New Mexico Press.

Root, A. L. 1993. *Improving Instream Flow Protection in the West: An Evaluation of Straegies with an Analysis of Oregon's Program.* Doctoral Dissertation, Department of Geosciences. Corvallis: Oregon State University.

Rosapepe, J. 1996. Water, water everywhere and not a drop to adjudicate. *High Country News* 28(19): 3.

Rosen, M. D. 1992. Conflict within irrigation districts may limit water transfer gains. *California Agriculture* 46(6):4-7.

Rosenbaum, R. J. 1981. *Mexicano Resistance in the Southwest.* Austin, Texas: University of Texas Press.

Salant, P., and Waller, A. J. 1995. *Guide to Rural Data.* Washington, D. C.: Island Press.

Saliba, B. C. and Bush, D. B. 1987. *Water Markets in Theory and Practice: Market Transfers, Water Values, and Public Policy.* Boulder, Colorado: Westview Press.

Samora, J. (ed.). 1966. *La Raza: Forgotten Americans.* Notre Dame, Indiana: University of Notre Dame Press.

Sargent, F. O., Lusk, P., Rivera, J. A., Varela, M. 1991. *Rural Environmental Planning for Sustainable Communities.* Washington, D.C.: Island Press.

Schnepf, M. (ed). 1979. *Farmland, Food and the Future.* Ankeny, Iowa: Soil Conservation Society of America.

Schoolmaster, A. F. 1991. Water marketing and water rights transfers in the lower Rio Grande Valley, Texas. *Professional Geographer* 43(3): 292-304.

Scurlock, D. 1988. The Rio Grande Bosque: everchanging. *New Mexico Historical Review* 63(2):131-140.

Selcraig, B. 1994. Albuquerque learns it really is a desert town. *High Country News* 26(24): 1, 10-11.

Sibley, G. 1996. Glen Canyon: using a dam to heal a river. *High Country News* 28(13): 1, 8-12.

Solley, W. B., Chase, E. B., and Mann IV, W. B. 1983. *Estimated Use of Water in the United States in 1980.* U.S. Geological Survey Circular 1001. Washington, D.C.: U.S. Government Printing Office.

Solley, W. B., Pierce, R. R., and Perlman, H. A. 1993. *Estimated Use of Water in the United States in 1990.* U.S. Geological Survey Circular 1081. Washington, D.C.: U.S. Government Printing Office.

South Dakota. 1987. *South Dakota Codified Laws.* Volume 13B, Title 46. (1996 Supplement.) Charlottesville, Virginia: The Michie Company Law Publishers.

State Engineer Office. 1995. *Order No. 152: In the Matter of the Proposed Promulgation of Article 1-19 Rules and Regulations Governing Drilling of Wells and Appropriation and use of Ground Water in New Mexico – Hearing Examiner's Findings and Recommendations.* Issued February 5, 1995. Santa Fe: State Engineer Office.

State Engineer Office. 1998a. Water Conservation Legislation. *Water Line,* Winter 1997/Spring 1998. Available: http://www.seo.state.nm.us/ publications/winter97 waterline.html [4/18/98].

State Engineer Office. 1998b. Water Conservation Legislation. *Water Line,* Spring 1998. Available: http://www.seo.state.nm.us/publications/wl-spring-98.html#Water Conservation Legislation 4/18/99].

Swainson, N. A. 1986. The Columbia River Treaty: where do we go from here? *Natural Resources Journal* 26: 243-259.

Tarlock, A. D. 1991. New water transfer restrictions: the West returns to riparianism. *Water Resources Research.* 27(6):987-994.

Texas. 1988. *Texas Codes Annotated.* (1997 Supplement.) St. Paul, Minn.: West Publishing Co.

Thomas, G. W. 1981. Water for the Sunbelt: a global perspective. In, *Water for a Growing and Changing Sunbelt State,* Proceedings of the Twenty-sixth Annual New Mexico Water Conference, New Mexico Water Resources Research Institute, ed. L. MacKichan, Las Cruces: New Mexico State University.

Trewartha, G. T. 1957. *Elements of Physical Geography.* New York: McGraw Hill Book Company, Inc.

Udall, T. 1994. Opinion of Tom Udall, Attorney General, Opinion N. 94-07. Santa Fe: Attorney General of New Mexico.

U.S. Geological Survey. 1996a. *The National Water-Use Information Program.* A USGS Water-Use Fact Sheet. Available: http://water.usgs.gov/public/watuse/ wufactsheet.html [8/22/97].

U.S. Geological Survey. 1996b. nm85w8.exe and nm90w8.exe: 1985 and 1990 digital water use datafiles. Available: http://water.usgs.gov/watuse/wudl.wrcu.exe.html [7/29/97].

U.S. Geological Survey. 1997. *Programs in New Mexico.* Available: http://water.usgs.gov/public/pubs/FS/FS-031-96/#HDRO1 [7/25/97].

Utah. 1989. *Utah Code Annotated.* Volume 7C, Title 73. (1996 Supplement.) Charlottesville, Virginia: Michie Law Publishers.

Van Ness, J. R. 1987. Hispanic land grands: ecology and subsistence in the uplands of Northern New Mexico and Southern Colorado. In, *Land, Water, and Culture: New Perspectives on Hispanic Land Grants*. Eds. Briggs, C. L., and Van Ness, J. R., Albuquerque: University of New Mexico Press.

Vranesh, G. 1987. *Colorado Water Law*. Boulder: Vranesh Publications.

Wahl, R. W., and Osterhoudt, F. H. 1985. Voluntary transfers of water in the West. In, *National Water Summary, 1985*. U.S. Geological Survey Water-Supply Paper 2300, Washington, D. C.: U.S. Government Printing Office.

Washington. 1992. *Revised Code of Washington Annotated.* Title 90. (1997 Supplement.) St. Paul, Minn.: West Publishing Co.

Weatherford, G. D. 1982. Thematic overview of the conserve-and-transfer strategy of water management. In, *Water and Agriculture in the Western U.S.: Conservation, Reallocation, and Markets,* ed. G.D. Weatherford, Boulder, Colorado: Westview Press, Inc.

Weatherford, G. D., and Brown, F. L. 1986. Introduction: a timely look at a timeless river. In, *New Courses for the Colorado River: Major Issues for the Next Century,* ed. G. D. Weatherford and F. L. Brown, Albuquerque: University of New Mexico Press.

Weigle, M. 1975. *Hispanic Villages of Northern New Mexico*. Santa Fe, New Mexico: The Lightning Tree.

Western Network. 1995. *Threatened and Endangered Species in New Mexico.* (Map) Santa Fe, New Mexico: Western Network.

Western Water Policy Review Advisory Commission. 1998. *Water in the West: The Challenge for the Next Century*. Report of the Western Water Policy Review Advisory Commission. Springfield, Virginia: National Technical Information Service.

Wilson, J. P. 1988. How the settlers farmed: Hispanic villages and irrigation systems in early Sierra County, 1850-1900. *New Mexico Historical Review* 63(4):332-356.

Zeilig, N. M. 1988. Theme introducion: water marketing. *Journal of the American Water Works Association* 80(3): 29.

Zeleny, C. 1974. *Relations Between the Spanish-Americans and Anglo-Americans in New Mexico*. Doctoral Dissertation originally presented to the Faculty of the Graduate School, Yale University, in 1944; copyrighted by the author in 1966. New York: Arno Press.