WILDLIFE AND WATER: COLLECTIVE ACTION AND SOCIAL CAPITAL OF SELECTED LANDOWNER ASSOCIATIONS IN TEXAS

A Dissertation

by

MATTHEW WAYNE WAGNER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2005

Major Subject: Urban and Regional Science

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ABSTRACT

Wildlife and Water: Collective Action and Social Capital of Selected Landowner Associations in Texas.

(December 2005)

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In Texas, landowner associations for the management of common-pool resources such as wildlife and groundwater have become increasingly popular. Successful management of white-tailed deer (*Odocoileus virginianus*) depends upon the collective decision-making of landowners. Likewise, aquifer reserves are a trans-boundary resource subject to the "rule of capture." Numerous factors may affect the success of common-pool associations, including property ownership and habitat characteristics, landowner demographics, and social capital. I used a mail questionnaire to explore the relationship between these factors and their effect on association activities and management practices for eight Wildlife Management Associations (WMAs) occurring within the Lower Post Oak Savannah (LPOS) and the Central Post Oak Savannah (CPOS). In addition, I compared responses of members of WMAs in CPOS to members of the Brazos Valley Water Alliance (BVWA), a groundwater association situated in the region.

Compared to CPOS, members of WMAs within the LPOS belonged to much larger groups, were generally more recent landowners that met more often, raised more money using more funding methods, and tended to have longer association membership than CPOS landowners, yet they had lower social capital. CPOS landowners owned significantly more land and considered relaxation/leisure and hunting more important land uses than LPOS landowners. The smaller group size in CPOS may be the most important factor in building social capital. Intra-association trust was positively influenced by the longevity of property ownership, the number of association meetings, the percentage of males in the association, and other factors. Negative influences on trust included absentee ownership and Habitat Cover Index, which was a measure of the amount of wooded habitat present.

In CPOS, members of the BVWA were part of a much larger, more heterogeneous, and more recently formed group than members of WMAs. They also placed greater importance on utilitarian aspects of their properties, as opposed to land stewardship for conservation as practiced by members of WMAs.

If associations are kept small (< 50) with more frequent meetings, greater social capital and information sharing may be achieved, which may lead to increased land stewardship practices. However, landowners may be motivated more by their shared values independent of any benefit from their association.

DEDICATION

I wish to dedicate this work to my parents, Richard and Midge Wagner. Their love, faith, and constant support have been the foundation for my life's work. Learning truly is a lifelong pursuit, but science holds only partial answers, and does not explain our purpose on this planet. Keeping all things in perspective, my parents have taught me that God, family, and vocation remain the priority order. And if we are true to that calling, all good things come in time.

ACKNOWLEDGEMENTS

At 48 years of age, I can say that learning is a lifetime adventure. Along the way there have been so many people that left a lasting impression on me and their names would add pages to this manuscript. I wish to recognize several of those who have provided guidance and support to me over the last 5 years in the pursuit of this degree.

I want to thank my committee members, Ron Kaiser, Urs Kreuter, Jon Rodiek and Neal Wilkins, each from different departments at the university. The multi-disciplinary nature of this study proved to be the most valuable, and, at the same time, most challenging, aspect of the project. As co-chairs Ron and Jon provided a balanced perspective between the departments of Parks, Recreation and Tourism Sciences and Landscape Architecture even though my subject matter did not fit neatly into either one. While Ron opened my eyes to the notion of social capital, Neal Wilkins always stimulated other lines of thought in understanding landowner motivations. I am especially grateful for the early guidance from Urs Kreuter whose course in Ecological Economics provided the forum for preparation of a manuscript which framed the thesis for this study.

To my employer, the Texas Parks and Wildlife Department, I deeply appreciate the time and financial support they have given me over the years. For that, Robert Cook, Mike Berger, Nathan Garner and David Sierra deserve special thanks. After 17 years with the agency I still feel I have the best job in the state. Working with landowners has been the greatest source of joy in my career and I will be forever grateful to those people and places that represent the greatest state in the nation.

I am indebted to the late Ron Linsky, Executive Director of the National Water Research Institute, in Costa Mesa, California. He, along with Research Advisory Board Member, William Blomquist, were instrumental in awarding me with a $45,000 Fellowship, without which this research would not have been possible.

I am especially grateful for the constant assistance from Satoshi Kamata. As a graduate student from Japan, Satoshi was a source of inspiration to me, with a work ethic and dedication to accuracy beyond my expectations. Thanks also are extended to Eric Hintze for statistical support and Richard Wagner for assistance with the non-response bias survey. I also want to acknowledge Stephen Lange, GIS specialist with TPWD. He promptly provided all graphic images for this and other manuscripts for publication.

For his love, friendship, and enduring support, I remember the late Donald Fox, long-time board member of Cal Domestic Water Company, who I was proud to call father-in-law. He, along with his wife, Patti, are responsible for my true love and wife of 22 years, Kathy. It was she that first pushed me into this endeavor. And at the end when I needed it most, pulled me through. To my son Devin and other family members from California to Massachusetts, thanks for your prayers and support throughout this project. With five sisters, and uncles, aunts and cousins too numerous to mention, you know who you are, and I love each one of you very much.

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CHAPTER I

INTRODUCTION

In the 37 years since Hardin (1968) presented his hypothesis about the inevitable overuse of common pool resources, social, political, and economic scientists have researched potential institutional frameworks for the sustainable use of such resources (Burger and Gochfeld 1998). Hardin's model of unrestrained use has been challenged by many examples in which resource users receive mutual benefit by adopting cooperative management strategies that are not only economically viable for the local community, but that lead to long-term sustainable use of the resource (Ostrom 1998). Well known examples include Maine lobstermen, New Jersey fishermen, and grazing lands in Namibia and southern Angola (Burger and Gochfeld 1998). The use of common pool resources in these studies were successful because the users who depended upon the resource understood that wise use leads to sustainability, and most importantly, they had an autonomous local controlling body (Ostrom 1998).

Land fragmentation and water supply are two priority natural resource issues facing Texas today (Governor's Task Force on Conservation 2000). Since about 95 percent of Texas is privately owned, economic incentives and public/private partnerships for land and water conservation are a necessity. Traditionally, farming and ranching enterprises have been the dominate use of Texas rural lands, but income from agriculture

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This dissertation follows the style of the Wildlife Society Bulletin.

is declining, while commercial wildlife recreation is becoming increasingly more important (Wilkins et al. 2000). As the economics of traditional farming and ranching becomes less viable, landowners may be forced to subdivide their property, making natural resource management more difficult (American Farmland Trust 2003).

According to a U.S. Department of Agriculture report, Texas led the nation in the loss of undeveloped land from 1992-1997. The report indicates that every two minutes, nearly 2.5 ha of Texas farm or ranch land becomes a subdivision, shopping mall or road. A weakened agricultural economy combined with increasing demand for land by the rapidly growing population has led to the conversion of over 1 million ha from rural land to urban uses between 1982 and 1997, placing Texas first in the nation in terms of rural land loss (Wilkins et al. 2000). In conjunction with the decline in total area of rural land, on average rural property size shrank by 4% across the state between 1985 and 1995, and by more than 10% in west, south and east Texas (Conner and James 1996), and the downward trend in size is accelerating (Wilkins et al. 2000).

Land fragmentation often results in decreased protection of watersheds and can accelerate extraction of groundwater through the "rule of capture". Over 86% of Texas is rural land with rangelands comprising the primary water source for its aquifers and reservoirs (Conner and James 1996). Aside from lower agricultural viability, less protection of watersheds, and a loss of public amenities, such land fragmentation usually exacerbates groundwater extraction when every additional landowner may pump as much water as he or she wishes. This was especially problematic in the Edwards Aquifer region prior to S.B. 1477 when land fragmentation increased by 3-50% from 1987 to

1997, and average property sizes ranged from 80 to 200 ha, well below the statewide average of 274 ha (Wilkins et al. 2000). Moreover, because the population of this area is expected to grow to 3.6 million by 2050 (up from 1.36 million in 1990) (Edwards Aquifer Authority 1998), annual demand for groundwater could exceed 850,000 acre-feet by 2020 (up from 120,100 acre-feet in 1940 and 489,000 acre-feet in 1990) despite the greater restrictions on pumping since the passage of S.B. 1477 (Edwards Underground Water District 1991).

The lack of regional or countywide water planning, unrestricted groundwater withdrawal rights, land subdivision and changing land ownership patterns, and economically adverse conditions for sustainable land management, pose serious obstacles for coordinated open space and groundwater management in Texas. However, it may be possible to find solutions for reducing groundwater extraction under these conditions through the formation of local landowner cooperatives that define members' groundwater property rights based on the sustainable yield of recharging aquifers.

Cooperative landowner arrangements could help supply future water demand in municipal areas and possibly obviate the need to construct costly new reservoirs. Increased landowner income from groundwater would also decrease disparities between the productive and market values of rural land, and the diversified income streams from the sale of groundwater and wildlife-related activities would reduce landowners' economic risks. Both results could reduce landowner incentives to sell all or part of their land to offset declining income, thereby reducing land fragmentation. In addition, such an approach would encourage landowners to implement management practices that enhance water supplies, maintain open space, and improve wildlife habitat, and it would facilitate coordinated land use planning.

To find alternative sources of land-based income, many property owners are turning to fee-based hunting. Currently, revenue from hunting leases surpasses income from livestock operations on many Texas properties (Benson et al.1999). To facilitate effective wildlife management on a landscape scale, while reducing the effects of land fragmentation, wildlife management associations or cooperatives have been formed in over 20 counties in Texas. These multi-landowner associations operate under voluntary Texas Parks and Wildlife Department (TPWD) management plans for the improvement of white-tailed deer (*Odocoileus virginianus*) herds in the area, hold regular meetings to educate and inform the membership on a variety of natural resource issues, and practice various wildlife habitat improvement techniques (Texas Parks and Wildlife 2004). About 160 such groups representing over 5,000 landowners and approximately 770,000 ha have been organized in the state. According to a recent study, about 66% of large landowners are interested in TPWD programs to protect quality and quantity of water on their land (Schmidly et al. 2001). Opportunities for direct landowner involvement in watershed management, protection of groundwater resources, and development of riparian corridors exist within the framework of wildlife management associations, water cooperatives or similar local public/private partnerships. Wildlife associations or co-ops may hold promise for the management of other common-pool resources in addition to wildlife, because the membership represents stakeholders that benefit from collective success. Landowner-based institutions within established groundwater districts may also be a key strategy to reduce the effects of fragmentation and non-sustainable groundwater use. Wildlife management associations may provide a model for cooperative management of other broad-based natural resources, including groundwater.

A second potential source of land-based income for many rural property owners can be from the sale or lease of groundwater. Increasingly, Texas cities are seeking to extend their water supplies through the acquisition of groundwater resources. Most of the groundwater acquisition efforts of cities occur in rural areas where water demands are less and groundwater resources are in greater supply (HDR Engineering 2000). The practice is encouraged by Texas groundwater law. Groundwater doctrine in Texas is based on the "rule of capture", a common law approach unique in the United States, which allows unrestricted pumping by competing landowners. In recent years however, the state legislature has mandated local control through groundwater conservation districts, creating some unique opportunities to develop public/private partnerships with landowners to manage this common-pool resource. At least three landowner groups have already formed to consolidate acreage over high-yielding aquifers, in order to pump groundwater through the sale or lease of water rights to off-site buyers. In the case of the Brazos Valley Water Alliance, about 1,000 landowners and 67,000 ha are involved (Lester 2003). Following the cooperative model for groundwater pumping in combination with the transfer of water rights for economic purposes, landowners may be able to organize for sustained aquifer use, while maintaining recharge, open space, and their rural lifestyles. Local landowner associations may investigate the feasibility for self-monitoring and regulation under the authority of local groundwater conservation districts, which would set pumping limits and well placement based upon hydrologic models (Wagner and Kreuter 2004). Aquifer recharge and open space protection through cooperative groundwater reallocation is a new paradigm in water management in Texas.

Elements of social capital may also be important in forming voluntary associations (Coleman 1990; Putnam 1995, 1996, 2000; Flora 1998). Social capital refers to the value of community engagement that leads to mutual benefits and cooperation. Group engagement in important values, like trust, reciprocity, or volunteering, may create social capital. Belonging to common interest organizations builds and maintains social capital. Examples include homeowner associations, church groups, sports clubs, fraternal groups (e.g. Lions, Jaycees), service organizations (e.g. Red Cross), and other associations that bind individuals to a common cause. According to Putnam (2000), these types of organizations form the very foundation for advanced democracy, especially in the United States. The social capital generated within voluntary associations is credited with increased voter activity, crosscutting social cleavages, mediating class conflict (Schultz 2002), and discouraging “free-riding” within the group (Putnam 2000). Local control through voluntary associations may also temper the regulatory complexity associated with a central authority (Ehrenberg 2002). Others argue that when individuals produce economic capital for themselves, they cannot be expected to engage in altruistic behavior or social collectivity that Putman advocates (Schultz 2002). This is because market-based systems do not demand honorable actions, but instead lead to deteriorating social capital, declining reciprocity, and other community values, and increased alienation (Steger 2002).

CONCEPTUAL FOUNDATION: VOLUNTARY ASSOCIATIONS AND SOCIAL CAPITAL

First described in 1916 by L.J. Hanifan (Putnam 2000), social capital refers to a variety of positive human values generated by social interaction. This includes good will, fellowship, trust, edification, security, and a host of other attributes necessary for a productive, democratic society. Equated to financial capital used to build businesses, and environmental capital in the form of timber, range, water, biodiversity, and mineral wealth, social capital has been reasoned to be an important catalyst in the progress of regional governments (Putnam 1993), the 50 United States (Putnam 2000), urban and rural communities (Flora 1998, Hofferth and Iceland 1998), public and private high schools (Coleman 1988), and to assess American confidence in government institutions (Brehm and Rahn 1997).

Since Alex Tocqueville's nineteenth century classic account of American democracy, the social benefits and potential pitfalls of group membership have been debated by numerous authors (Olson 1971, Coleman 1990, Stokowski 1994, Brehm and Rahn 1997, Putnam 2000, Schultz 2002). Organized groups are a powerful force in a democratic environment both from an individual member's perspective and as a structural whole. Coleman (1988, 1990) argues that repeated interaction by members of a group builds trust based on reciprocity, information sharing, and social norms, all core elements of his definition of social capital. This exchange of social attributes benefits individuals within the group, as well as the association's role in other community affairs. Political outcomes, wealth generation, job advancement, education achievement, and general well-being of individuals are all enhanced through the social capital generated in civic organization. When members of an organization are able to capture the private goods produced by social capital, then there is a tendency for the membership to reinvest in group activities as opposed to diverted benefits accruing to external individuals which is commonly known as "free-riding". In this way, group relationships are self-perpetuating, and the rewards of social capital become more of a public good which has many positive implications for society, but is more difficult to maintain outside of formal organizations.

The public benefits of social capital include increased economic development, more effective political institutions, and reduced crime, among others (Brehm and Rahn 1997). Public confidence in government institutions may also be increased when mutual trust is practiced among civic organizations, because group members who trust and expect others to follow the rules find it easier to accept the decisions of government authorities. In turn, this may reduce the expense of regulatory enforcement. Similarly, associations formed around managing common interests, may reduce confidence in a central authority by exploiting the notion of "self interest rightly understood" (Tocqueville 1994). When individuals pursue selfish aspirations in joining a local organization, over time they are enlightened to replace personal benefits with collective goods. This attitudinal change may be especially important when organizations are formed around solving common-pool natural resource problems such as watershed pollution (Plumlee et al. 1985, Webler and Tuler 2001, Curtis et al. 2002). Resolution of collective good problems within an organization is aided by reciprocal relationships bolstered by active civic engagement and interpersonal trust (Brehm and Rahn 1997).

If social capital is the energy that fuels American productivity, social networks are the distribution system. Social networks are systems of linkages between individuals, groups, corporations, or other collectivities. Linkages of individuals, either of similar personalities and values (strong or horizontal ties), or of differing social stature (weak or vertical ties), are necessary in forming advantageous social networks. Ties are used to facilitate resource flow, friendships, and transfers or exchanges of goods and information (Wellman and Berkowitz 1988). In her study of social networks and leisure activities, Stokowski (1994) states that networks exert influence directly or indirectly on social behavior. Network measures include interactional criteria (frequency of communication, the type of relational tie, the redundancy of relationships or multiplexity, reciprocity, and the strength or duration of ties), or structural criteria (size of the network, density or connectedness of linkages between nodes or actors, the number of links between any two nodes, and other measures). The analysis of social networks reveals patterns in resource flow, the transfer of power, and the creation of well-being within and among collectivities of individuals and groups.

Over the last 25 years, there has been a decline in the membership of nearly all civic organizations, while individual dependence upon technology for communication and entertainment has risen sharply (Putnam 1996). Between 1985 and 1994, active involvement in community organizations fell by 45% (Putnam 2000). National environmental organizations in particular have suffered dramatic losses in membership over the last decade. For example, of the 28,000 National Audubon Society members in Texas, less than 4% are active. Although local groups focused on issues like toxic waste and land conservation seem to have become more numerous, no evidence of growth in grassroots environmentalism seems to exist. Causes for the decline in social capital may include economic hard times, the disintegration of the traditional family unit, time pressures, suburbanization and sprawl, and a priority shift in values based on generational differences. However, the overriding factor is probably due to our escalating dependency on television, computers, and other multi-media innovations to relate to one another, instead of face to face contact. As Wellman (1999) indicates, the idea of community has moved home. Families spend more time at home on computers and telephones. Although the decline in social capital began before the internet age (Putnam 2000), the idea of community has moved from civic engagement to cyberspace, eroding the personal relationships vital to building and maintaining social capital. Today's North Americans go out to be private but stay inside to be public (Wellman 1999). Videos and fast food delivery are as much a part of American culture as baseball. All of these factors have led to more independence and less cooperation, leading to a decline in community spirit across the country.

The use of social networks and capital to manage natural assets has not been adequately investigated (Flora 1998). Common property resources such as public parks and wilderness areas, as well as private recreational or environmental resources may create a sense of place that affects the reproduction and maintenance of social networks, thereby generating social capital. Landowner associations such as soil and water conservation districts, farm cooperatives, or wildlife management associations are examples of social networks based on local natural resources. Landowners may be long-term neighbors, or casual acquaintances from widely different backgrounds and social status. The important factor is functionality of the network, and progress towards fulfillment of collective goals, whatever those might be. Social capital within a network such as a landowner association may manifest itself in a sense of mutual respect, social acceptance, conflict resolution, and self-recognition. In effect, social networks can become resources for the advancement of social capital through group membership, leading to sustainable natural resource use.

MEASURING SOCIAL CAPITAL

Measuring social capital is difficult, but several proxies have been used. As discussed by Putnam (1995), indicators may include voter turnout, newspaper readership, and civic club membership. Other indicators could be church membership, attending political rallies or working for a political party, leisure activities, family structure, volunteerism, or various demographics such as age and income level.

Brehm and Rahn (1997) used two "endogenous" variables from the General Social Survey (GSS) for 1972-1994 to model confidence in government, a supposed consequence of strong social capital: civic participation and interpersonal trust. For civic participation, measures included the number and type of group membership, newspaper reading, education level, family income, the number of preschool children, the number of hours spent watching television, longevity in place of residence, the size of the community of residence, and other factors. The level of interpersonal trust was based on three survey questions designed to ascertain respondents' attitudes on the fairness, helpfulness, and general trust of the public at large.

Putnam (2000) developed a comprehensive Social Capital Index using 14 different measures of five components used to compare American social capital among the 50 states (Figure 1.1). In addition to the group membership and trust data derived from the GSS, other measures included information about the number of club meetings, volunteering, community projects, and time spent socializing with friends, taken from the DDB Needham Life Style surveys. Finally, measures of public meetings attended and involvement in local organization leadership activities were compiled from the Roper survey organization, while the percent of voter turnout for each state was taken from the U.S. Statistical Abstract. Putnam's Social Capital Index is simply an average of the standardized scores for each of the 14 measures. Using Principle Component Analysis, correlations with the index were developed for each component, with almost 97% of the possible positive correlations significant at the 0.05 level of probability.

For landowner associations, selected components of social capital from Brehm and Rahn (1997) and Putnam (2000) could be used to relate to aspects of institutional form and function. For example, are members of some associations more trusting of

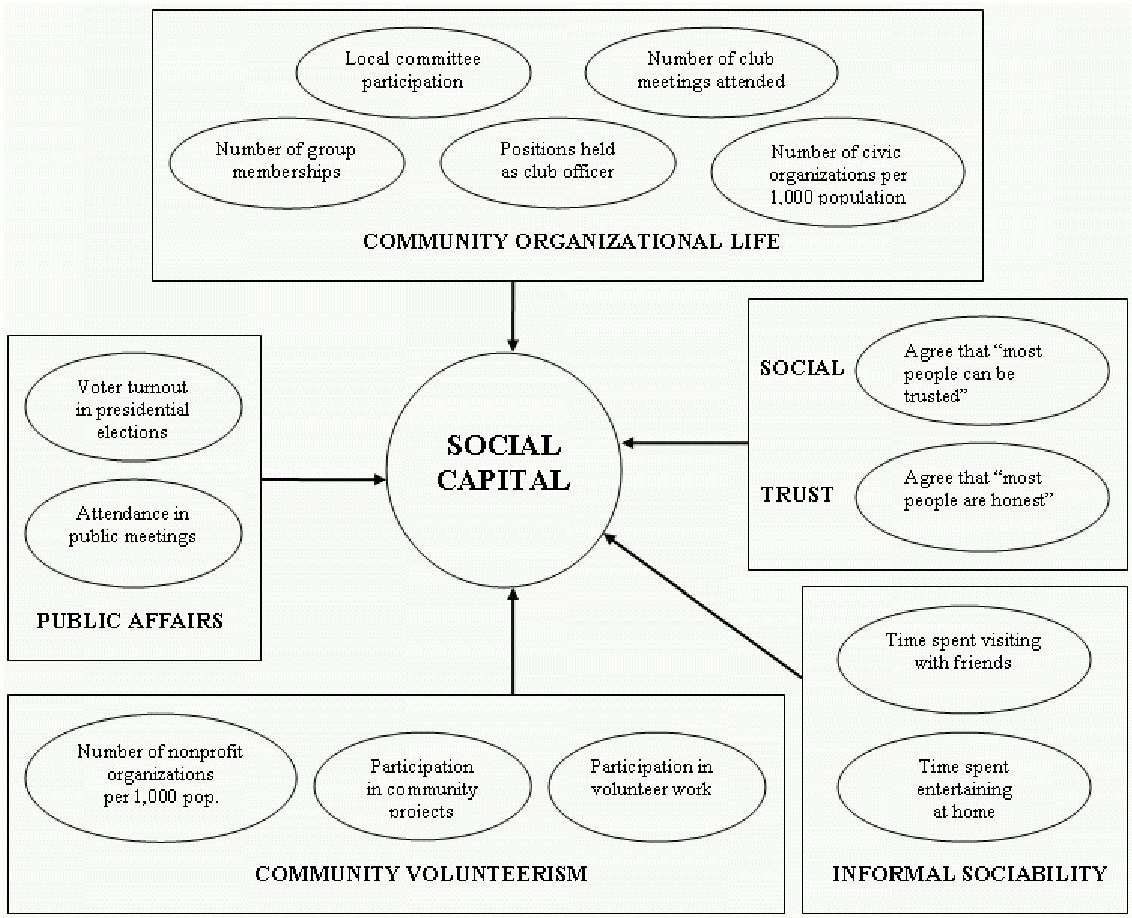

Figure 1.1. Components ( ) and Measures ( ) of Social Capital in the United States (Putnam 2000).

their neighbor and more engaged in civic activities in general? If so, what are the landowner attributes that may lead to these qualities, and how does social capital affect the overall form and function of the association? Some criteria here might include: the type and level of land and water conservation practices, level of understanding of land and water conservation issues (e.g. fragmentation and water rights), organizational structure (leadership positions and responsibilities), fiscal activities (fund raising, budgeting, and accounting procedures), decision making (rule-making process based on voting or board decision), and information and education services (means of communicating such as regular meetings, field days, newsletters, and web sites).

The association's functional performance could be measured by ascertaining a level of success from actual, on-the-ground land and water conservation practices as recommended under TPWD management plans, or from self-evaluation. For example, are wildlife populations healthier and more abundant? Is habitat improving through various enhancement activities? Is soil being conserved through erosion control practices? Is water quality and supply being protected through recharge and watershed management practices?

The purpose of this research was to assess landowner characteristics and social capital within associations engaged in common-pool natural resource management in Texas. In addition, demographic, and environmental information of associations was collected, as well as their levels of land and water conservation practices. This information could be used to gain insight into various institutional structures for sustainable use of common-pool natural resources in Texas. Three principle research questions were addressed:

1. Do landowner associations exhibit elements of social capital?
2. What landowner characteristics, if any, affect elements of social capital within landowner associations?
3. Do elements of social capital affect the level of land and water conservation practices conducted by members of landowner associations?

This study is of particular social and political importance because private lands and water management are two of the three priority issues identified by the Task Force on Conservation (Governor's Task Force on Conservation 2000). In addition, groundwater policy and statute will continue to be addressed by the Texas legislature. The results from this study could be used to determine the feasibility of forming local landowner cooperatives within groundwater districts for sustainable groundwater use. Financial benefits provided to private landowners may encourage them to collectively market their groundwater to meet urban demand while protecting the land surface for compatible open space and wildlife management purposes. A market-based approach to sustainable groundwater marketing and transfer may provide the economic incentive for habitat protection in the future. In addition, the need for more surface water reservoirs may be reduced, further protecting rural open space and critical wildlife habitat. If successful on a regional scale, sustainable groundwater transfers could translate into cost savings from a reduction in additional reservoir construction, conservation of valuable wildlife habitat on private land for commercial enterprise, and rural open space and land use planning, while meeting the water demands of the future in Texas.

CHAPTER II

THE PROBLEM AND ITS SETTING

THE WATER SITUATION IN TEXAS

In Texas, one of the top four water consuming states in the nation, the population is expected to almost double to 40 million and water demand is projected to increase from about 17 million to 20 million acre-feet per year by 2050 (Texas Water Development Board [TWDB] 2002). Limited water supply and distribution could severely limit economic growth in many areas (Smerdon et al. 1988). Houston is especially threatened by the lack of a dependable water source for projected residential and industrial growth. The city’s demand for water is expected to grow to 1 billion gallons per day by 2020 and could exceed the total current supply by 2040 if the present growth rate in demand persists (Trinity River Authority 2000).

In addition, the proportional distribution in water consumption is changing. While irrigation uses will likely decrease from 57% to 43% of total water consumption by 2050, municipal uses are expected to increase from 25% to 35% (Texas Water Development Board 2001). The growth in water demand and the shift from agriculture to urban uses will present serious challenges to water planners and authorities. As summarized in a report from regional water planning groups, the most frequently recommended strategies for meeting regional water needs in Texas are: conservation, expanding distribution from existing surface water supplies, and further developing new and existing groundwater supplies (Texas Water Development Board 2001).

Currently, surface water in Texas is supplied mainly by 190 major reservoirs that cover nearly 689,000 ha (Texas Center for Policy Studies 1995), and accounts for about 40% of total consumption (Texas Water Development Board 2002). Although proposed new surface water developments include 8 major and 10 minor reservoirs that would yield approximately 1.2 million acre-feet annually and cost over $ 3 billion to construct (Texas Water Development Board 2002), these developments were proposed by only 4% of 813 water user groups (Texas Water Development Board 2001). The potential for further exploitation of surface water is limited. The most favorable reservoir sites have already been developed and those that remain have numerous development constraints (Kaiser 1998). In addition, most existing surface water has already been adjudicated (Chang and Griffin 1992). Reservoirs have resulted in the loss of critical riparian and bottomland hardwood habitats that supply important ecological services (Frye and Curtis 1990, Telfair 1999). River impoundments have also decreased freshwater inflows to the Gulf of Mexico, threatening a multi-billion dollar commercial fishery. The limited development potential of surface water increases the importance of underground aquifers as water sources in Texas

In combination, aquifers underlie about 81% of Texas, with major aquifers being distributed throughout the state. In 1999, groundwater provided approximately 10 million acre-feet (60%) of the state’s total water consumption (Texas Water Development Board 2002). Currently, more than 80% of the extracted ground water is used for agricultural irrigation, but this is expected to decline to about 59% by 2050 while municipal use is expected to more than double to over 30% as a result of urban sprawl, subdivision of land, and a shift to non-agricultural activities in rural areas.

The rapid population growth in Texas, particularly along the I-35 corridor, has accelerated urban sprawl, especially west and south of Austin and San Antonio. As a result, the Governor's Task Force (2000) identified land subdivision or fragmentation, and limited water supply as two of the most serious natural resource issues facing Texas today. Land fragmentation often results in negative consequences for ecosystem services, including the provision of water, wildlife habitat, and carbon sinks. In order to reduce land fragmentation and the overuse of groundwater, it is imperative to explore ways of creating long-term economic incentives that encourage rural landowners to maintain open spaces and the redistribution of groundwater that they can extract.

USE OF MAJOR TEXAS AQUIFERS

Most of the aquifers in Texas suffer from limited recharge due to low annual precipitation or excessive pumping. For example, in the Ogallala Aquifer, water extraction has exceeded recharge since the mid-1940s (Texas Water Development Board 1997). In addition, some land surfaces over the Gulf Coast Aquifer, especially in Harris, Galveston and the adjacent counties, have experienced subsidence due to the long-term drop in water levels, which is raising concerns about increased groundwater extraction in the area (Feldstein 2000).

The Edwards Aquifer has received considerable attention in recent years because it is the primary water source for San Antonio, supplies water to about two million people, and charges the Comal and San Marcos Springs that maintain habitat for eight threatened or endangered species (Grubb 1997). The aquifer is an important water source because it covers 20,720 square kilometers in West-Central Texas (Edwards Underground Water District 1991) and recharges rapidly when precipitation is adequate. Average annual recharge is 600,000 acre-feet, ranging from 43,000 acre-feet in 1957 to 2.5 million acre-feet in 1992 (Votteler 1998). Increased pumping during dry periods can, however, reduce spring flow and imperil downstream uses of the Guadalupe River which receives 70% of its flow from the Comal and San Marcos Springs (Edwards Underground Water District 1991). Endangered species lawsuits, state actions, local ordinances, and water conservation efforts have intensified the debate about how best to use the aquifer. This also resulted in the formation of the Edwards Aquifer Authority, which was given the mandate to monitor water extraction from the aquifer and the power to restrict such extraction, and which set pumping limits at 450,000 acre-feet per year to maintain spring flows and protect endangered species (Kaiser and Phillips 1998).

An exception to the excessive extraction phenomenon in Texas is the Carrizo-Wilcox Aquifer in central and northeast Texas. This aquifer remains relatively untapped with the cities of Bryan/College Station, Tyler, and Nacogdoches being its largest metropolitan users (Preston and Moore 1991, Thorkildsen and Price 1991). In addition, compared to other aquifers, the Carrizo-Wilcox is replenished relatively rapidly and consistently due to greater annual rainfall, and surface water is more plentiful than in other parts of the state. Given these characteristics, use of groundwater from the Carrizo-Wilcox Aquifer may be sustainable provided the future demand for water and pumping costs are accurately anticipated and the incentives of overlying landowners to conserve water are harnessed.

THE LEGAL STATUS OF TEXAS GROUNDWATER

Subterranean aquifers in Texas represent “common pool" resources because they are generally too large and complex for the effective assignment of individual ownership rights. Texas groundwater law is based on the English common law doctrine of “absolute ownership” (Kaiser 1986), which makes the state unique throughout the western U.S. (Templer 1989). Since the number of landowners above aquifers is finite and only these landowners have use rights, Texas groundwater is actually a communal resource with “limited access”. However, the “rule of capture” law allows landowners to withdraw unlimited groundwater as long as it is not ‘wasted.’ Texas groundwater is thus one of the few natural resources in the U.S. that is not regulated by a central agency (Todd 1992). In addition, unrestricted pumping has led to many aquifers exhibiting draw down, saltwater intrusion, spring flow reduction, and land subsidence.

In an attempt to conserve water, protect water quality and prevent land subsidence, the Texas State Legislature created underground water conservation districts as early as 1949 (Urban 1992). Because of the “rule of capture” law and funding shortfalls, the existing 88 water districts have, however, restricted their activities to preventing water wastage, recharge-enhancement initiatives, data collection, and water conservation education instead of controlling groundwater extraction (Kaiser 1986). Despite the water districts’ regulatory ability, the “rule of capture” has thus hindered protection of aquifers from damage due to excessive pumping (Johnson 1982).

One exception to the lack of regulatory power over groundwater extraction in Texas occurs in the Edwards Aquifer. In response to a law suit brought by the Sierra Club and the consequent Federal ruling that the Texas Water Commission develop a plan to maintain threatened or endangered species habitat by ensuring adequate flows from Comal and San Marcos Springs, the Texas legislature passed S.B.1477 in May 1993 creating the Edwards Aquifer Authority (EAA) (Voteller 1998). Unlike other water conservation districts, the EAA was ordered to use its extensive powers, including the power to issue permits and regulate groundwater withdrawal in the seven counties overlying the aquifer's recharge and storage areas. While S.B. 1477 marked the end to unrestricted groundwater pumping of the Edwards Aquifer, other Texas aquifers do not have similar mandated restrictions (Kaiser and Phillips 1998).

With a growing demand for limited groundwater, legislative guidance is clearly needed to address issues of well interference, aquifer overdrafting, and water-mining problems exacerbated by the "rule of capture" (Kaiser and Skillern 2001). Because political and aquifer boundaries do not coincide, because landowners have a stake in sustainable aquifer use for the long term viability of their communities (Somma 1997), and because centralized water management agencies have a limited capacity to restrict water extraction by landowners, coordinated planning will become increasingly important to prevent continued depletion of groundwater.

One approach would be to establish aquifer-wide, regional, or sub-basin districts to coordinate planning and management of groundwater resources based on safe yield criteria. Local controls will be critical for implementing effective integrated groundwater management plans, which require close cooperation among local institutions (Smerdon et al. 1988). City, county, and regional water-based authorities should understand that their long-term well being depends upon cooperative planning of aquifer-wide groundwater resources. Since 88 local groundwater districts already exist and their representatives are more attuned than centralized planning agencies to local concerns, they are the logical institution for planning and coordinating future groundwater extraction. That regional, basin-wide, or other local organizations can successfully manage common pool groundwater is exemplified by examples in North Carolina (Riggs and Yandle 1997) and Nebraska (Kaiser and Skillern 2001). In addition, putting authority for groundwater transfers in the hands of local government was preferred over other arrangements in Arizona (Charney and Woodard 1990).

PLANNING AND MANAGEMENT OPTIONS

The American Society of Civil Engineers described a wide range of potential institutions for groundwater planning and management (American Society of Civil Engineers 1987). Two categories that apply to Texas include Governmental Institutions and Regional Planning Units or Districts. Governmental Institutions usually include State agencies that exercise powers to develop and implement comprehensive groundwater programs and they often incorporate state organizations, such as the Texas Commission on Environmental Quality (TCEQ) and the TWDB, which provide hydrology data and technical assistance. Such institutions have been developed in relatively low population states, including New Mexico and Arizona, but greater pressure for local control in more populous states may limit the capacity for government regulation of groundwater. In contrast, surface water in Texas is appropriated through the TCEQ, so that a single authority reduces the complexities in record keeping, water rights permitting, and regulation enforcement. A centralized approach to groundwater management has been recommended in Texas, since aquifer depletion is rapidly becoming a state-wide issue (Kaiser and Skillern 2001).

Regional Planning Units or Districts focus on area planning with cooperation from cities, local water districts, counties or other water institutions, which requires a commitment to negotiations through public participation. A regional approach to water resource planning was advocated at the state level by Smerdon et al. (1988) and the Texas Water District and River Authority Study Committee (1986), and more recently at the national level by Black and Fisher (2001).

The Texas legislature mandated regional water supply planning within the state with the passage of S.B. 1 in 1997. This created a "bottom-up" process that produced the State Water Plan of 2002, incorporating regional water plans from 16 planning regions, and making policy recommendations for the use of surface and groundwater (Texas Water Development Board 2002). Adding another layer of management responsibility are 88 Groundwater Conservation Districts. These districts are typically county based, falling within one or more of the 16 regional planning areas. They may encompass an entire hydrologic unit such as Edwards Aquifer Authority or one or more counties. This local approach to groundwater management was reinforced in the Central Carrizo-Wilcox Aquifer when H.B.1784 was passed during the 2001 legislative session. The bill ratified three multi-county groundwater conservation districts overlying the aquifer, and created the Central Carrizo-Wilcox Coordinating Council to provide aquifer-wide management guidance and ensure cooperative aquifer use among local groundwater districts.

GROUNDWATER MARKETING

The practice of marketing water is becoming common throughout the western U.S. (Landry 1998). Established surface water markets include California's Central Valley Project, Colorado's Big Thompson Project, and Nevada's Truckee and Carson Rivers (McCormick 1994, Michelsen 1994, Weinberg 1997). Other markets are developing in Arizona, New Mexico, Oregon, and Utah, mostly to protect in-stream flows for fish, wildlife and recreation (Landry 1998). In Texas, surface water marketing has been commonly practiced in the Lower Rio Grande Valley for at least 38 years (Chang and Griffin 1992). Some transactions have also occurred on the Colorado River (Miller 1994, Yoskowitz 1999), and water marketing was recommended to facilitate planning in both the 1990 and 2002 Texas State Water Plans.

Although most water transactions in the U.S. have involved surface water, groundwater marketing is becoming increasingly important as pressure on rivers and reservoirs increases and environmental concerns about diminishing water supplies grow. Groundwater marketing through private property rights has been advocated by the Environmental Defense Fund for California water policy, and for the Edwards Aquifer in Texas (Anderson and Snyder 1997). Numerous examples of groundwater trades exist. In Arizona, for example, municipalities, developers, speculators and the federal government acquired over 200,000 ha of land by 1990 solely for the associated groundwater rights (Charney and Woodard 1990). These "water farms" average about 12,150 ha, are valued at $15 million, and are expected to supply about 15,000 acre-feet of groundwater annually for 100 years. The price paid for such rights can be substantial. For example, in the Colorado Front Range where water is becoming increasingly scarce, water rights in 1990 sold for $1,000 to $4,000 per acre-foot (Colby 1990).

Texas has several examples of completed or proposed purchases of groundwater rights in order to ensure adequate water for metropolitan areas, notably Houston, San Antonio, Amarillo and El Paso. The Metropolitan Water Company proposed purchasing or leasing groundwater rights of portions of the Carrizo-Wilcox aquifer in Burleson, Milam, and Robertson Counties (Feldstein 2000, Hipp 2000, Carlson 2001). Similarly, the San Antonio Water System (SAWS) contracted to purchase up to 90,000 acre-feet of Carrizo-Wilcox Aquifer water in Lee and Burleson County from the Alcoa-Sandow lignite mine (Texas Water Development Board 1999). This water is pumped from beneath the mine to reduce water pressure and keep it dry, and will be sold to SAWS at an estimated price of $688 per acre-foot annually (HDR Engineering 2000). Further north, the city of Amarillo paid $679 per ha for groundwater rights on about 28,350 ha of land, which routinely sells for approximately $494 per ha (Gilliland 2000). Under the agreement, the landowners retain the right to use water for themselves but are restricted from constructing more than one residence per 65 ha, which ensures low-density development and open space conservation. Finally, the El Paso Water Utilities purchased more than 19,000 ha of ranchland to pump an estimated 15,000 acre-feet by 2010 (Texas Center for Policy Studies 2001).

CONCERNS OVER GROUNDWATER TRANSFERS

In most instances water markets have resulted in the transfer of agricultural water to municipal areas. This has raised questions about the effect of such transfers on agriculture communities. For example, in the case of the land purchases by the El Paso Water Utilities, nearby communities expressed concern about the effect of the proposed groundwater withdrawals on the local economy (Texas Center for Policy Studies 2001), as land uses shift from irrigated to dry land production, ranching, or possibly wildlife management.

Another concern is that a change in vegetation condition may follow the transfer of irrigation water to municipal areas, which can result in greater wind and water erosion (Checchio and Nunn 1988). However, the vegetation that invades abandoned farmland can also increase habitat diversity (Henderson 1988), which in turn benefits wildlife such as migratory and resident birds that consume the seeds of native forbs. Bobwhite quail for example, need sparse bunchgrass cover coupled with seed-producing forbs and low-growing brush, while wild turkey require grassy openings for nesting. Wildlife benefits have been recognized in the High Plains of Texas, where landowners affected by depleted aquifer levels are participating in the U.S. Department of Agriculture's Conservation Reserve Program to reduce erosion by establishing perennial grass cover. This has created habitat for species such as pronghorn antelope, lesser prairie chicken, and black-tailed prairie dog (Miller 2001).

In assessing the impact of agriculture to urban water transfers in a southeastern Colorado county, Taylor and Young (1995) found that, under uncertain water supplies and unproductive soils (such as those found in many ranching areas), the direct opportunity costs associated with lower agricultural productivity were relatively small, indicating that in transferring the water to municipal areas, the market allocated the water to the highest-valued use. Schaible et al. (1999) went even further and suggested that, in the case of the Edwards Aquifer, permanent water markets could resolve long-term conflicts because they would provide an incentive for municipal and industrial areas to mitigate losses when pumping is restricted and water markets could also generate payments to agricultural areas.

However, even where the net economic benefits of agricultural to municipal water transfers are positive, such transfers can redistribute incomes from rural to urban areas, which may not be desirable from a political standpoint (Nunn and Ingram 1988). In addition, a large governmental purchase of land can eliminate a significant share of the local tax base, emphasizing the need for land to remain in private hands. These impacts can be mitigated, however, if the income to sellers of water is reinvested in the exporting area. In this case, secondary benefits to the local economy may equal or exceed those that have been lost. Furthermore, if structured appropriately, special purpose "water districts" can mitigate third-party impacts through local representation.

PRIVATE RIGHTS, WATER PRICES AND EXTERNAL COSTS

The requirements for an effective water market include well defined and enforced property rights, a sufficient number of buyers and sellers, open access to market information, and an adequate conveyance system to transfer water (Miller 1994). As the disparity between the demand and supply for groundwater increases, water rights become increasingly critical to ensure the effective management of this scarce resource (American Society of Civil Engineers 1987). In highly developed areas, such as southern California, the formulation of property rights for water use has become ever more refined, but in Texas, where water is relatively more available, and any landowner can extract underlying groundwater, property rights for such water remain poorly specified.

Olstom (1990) identified organization design features of common-pool resources if collective use is to be sustained. In the case of groundwater in Texas, designing a management unit around an aquifer boundary is a critical first step. Since Groundwater Districts are aligned along county boundaries, landowners within a county may unite their properties to fit an underlying aquifer. Then, with District approval, they could set self imposed pumping rules based on sustained yield of the aquifer. Monitoring and enforcement of pumping rules should come from within the landowner group with District oversight.

Assigning well-defined private rights to groundwater through, for example, pumping permits, enhances the private value of water. This creates incentives for landowners to use water more efficiently and to seek ways to transfer water to third parties who are willing to pay for the pumping rights. With such rights, the price of groundwater responds to changing costs of extraction and to the growth in demand for water relative to its availability.

Price is the market mechanism that provides information about the scarcity of water, and that motivates individuals to respond to scarcity. If water-pricing mechanisms are allowed to operate freely, demand for water can decline, supply can increase, and water can be reallocated to it's highest and best use (Anderson and Snyder 1997). This would improve the efficiency of groundwater transfers from rural to municipal areas seeking to meet the water demand of current and future generations. Accordingly, several researchers have advocated a free market approach for the planning and use of water in Texas (Griffin and Boadu 1992, Todd 1992, Kaiser and Phillips 1998).

Before a broad scale market for groundwater in Texas can be established, however, the external costs of environmental and third party impacts need to be considered. Environmentally, excessive groundwater pumping in poorly controlled markets can threaten artesian springs, normal stream and river flow, water quality, riparian biota, and recreation opportunities (Colby 1990, Votteler 1998, Brennan and Scoccimarro 1999, Tisdell 2001). Potential third party effects of groundwater transfers include diminished economic activity in the areas of origin, reduced water availability for other water right holders in the area, and reduced land use options for future inhabitants (Colby 1990, Griffin and Boadu 1992).

In assessing the potential impacts of market-based groundwater extraction permitting systems, it is critical to use reliable hydrologic models that scientifically quantify the effect of extraction on spring and stream flow as well as freshwater inflows to Gulf Coast estuaries (Texas Water Development Board 2002). One option for reducing environmental impacts in the area of origin would be for environmental groups to acquire water rights and either retire these rights or sell water at high prices during droughts and then use the gains to acquire further rights when water prices decline (Brennan and Scoccimarro 1999). In attempting to address third party costs of water transfer systems, some economic models account for such “external costs” by including various compensation programs for affected communities (McEntire 1989), or by discounting the value of transferred water, which becomes unavailable to future users (Griffin and Boadu 1992). Other approaches to preserving the well being of rural areas might be to proactively assign a portion of agricultural water for environmental or other uses in the area of origin (Zilberman et al. 1994), or to tax water transfers and return the proceeds to the area of origin.

A MECHANISM FOR LOCAL CONTROL – LANDOWNER ASSOCIATIONS

Water extraction from aquifers such as the Carrizo-Wilcox, may be more effectively managed at the local level through the existing water district. By cooperatively assigning private rights to groundwater through a transferable permit system, a market approach to water distribution would help ensure the supply of this vital renewable resource to meet growing urban demand. Provencher (1993) stated that a private property rights regime for groundwater is a promising and practical alternative to traditional means of groundwater management, and is consistent with the emergence of markets for surface water.

In order to achieve private rights to groundwater, the hydrology of a particular location needs to be evaluated in order to estimate sustained yield. The Texas Water Development Board provides groundwater models for most major aquifers in the state, and more studies are ongoing (Texas Water Development Board 2001). Once the sustainable yield is determined for the area in question, a groundwater district encompassing the area could regulate pumping based on authority under existing legislation (Fipps 2002). Landowners within a water district would know how much groundwater each user was withdrawing for personal or agricultural purposes, and how much water would be required to avoid long-term depletion of the aquifer. The water district, headed by a board of local representatives, could assign transferable withdrawal permits based on historic use or some other mutually agreed upon criterion, such as property size, for the allocation of surplus aquifer water. By being transferable, extraction permits become economically valuable and marketable. Such a market-based approach would allocate water between competing users more in a more efficient manner.

The proceeds from the sale of the surplus groundwater would be distributed to each landowner based on their permit, or percentage of land over the aquifer. If appropriate hydrogeologic models are combined with the development of a private cooperative, landowners within a groundwater district could pool or "unitize" their acreage to provide a sustainable supply of water, much like oil and gas production in Texas (Anderson and Snyder 1997, Libecap and Smith 1999, Freeman 2000). In times of water deficit, all landowners in the cooperative would receive proportionately less compensation as extraction rates were reduced. Although, periodic government oversight would be necessary, self-enforcement of such market-based systems is usually effective when monitoring is conducted by a local entity, such as water districts, in which each landowner has a vested interest (Young 1992, Edwards Aquifer Authority 1998).

In the Edwards Aquifer, for example, a transferable permit system was established for landowners extracting over 25,000 gallons per day. In 1997, the Edwards

Aquifer Authority implemented an “Irrigation Suspension Program” whereby water rights were purchased from 40 farmers representing over 4,000 ha to supply water to San Antonio (Kaiser and Phillips 1998). The irrigators were paid $98 - $1,850 per ha not to irrigate, which resulted in an estimated water savings of 20,000 acre-feet at a cost of about $2.3 million that was provided by some 30 contributing cities, counties, and water companies. As a result of this experiment, a statewide water bank was proposed, to provide leadership in promoting and facilitating market transactions in the Edwards Aquifer region. The experience gained through the Edwards Aquifer Irrigation Suspension Program provides a useful basis for developing groundwater markets in Texas, especially where aquifers recharge regularly.

The creation of landowner associations, natural resource cooperatives, water districts, or other local institutions may reduce the deleterious effects of land fragmentation on groundwater use under the “rule of capture” law. This is because locally controlled resource management entities place the benefits and responsibilities of resource use in the hands of participating landowners. An example of private landowners organizing to protect groundwater rights can be found in the Brazos Valley Water Alliance. This limited partnership is comprised of nearly 1,000 landowners in central Texas who organized to protect substantial amounts of groundwater underneath their properties (Lester 2003). Under a five-year lease agreement, landowners would receive 10% royalty payments and 51% of the net profit from any water sales. Profits from the sale or lease of water rights would be equitably divided among Alliance members based on acreage or other correlative measure. Governed by a board of managers, the Alliance hopes to eventually cover 400,000 ha, with well drilling costs expected to exceed $100 million (Hipp 2002). There are at least five other similar landowner groups formed or forming over significant aquifer reserves in Burleson, Milam, Kinney, Hudspeth, and Roberts counties.

COLLECTIVITY IN ACTION: WILDLIFE MANAGEMENT ASSOCIATIONS

Another instructive and potentially compatible development in Texas is the establishment of multi-landowner groups for the management of common-pool wildlife resources, especially white-tailed deer. These Wildlife Management Associations (WMAs) may be countywide, situated within an important watershed, or formed around other natural features. Participating properties may or may not be contiguous, although the success of long-term wildlife management goals are enhanced if the management unit is a single unit. Formation of a WMA typically involves the development of a landowner agreement that sets out guidelines for participating landowners' voluntary compliance with TPWD recommendations for deer harvest and habitat management. Management plans may be developed for the whole association or one or more individual ranches within the association (Texas Parks and Wildlife Department 2004). An early history on the formation of wildlife cooperatives in the north-central United States can be found in Leopold (1936, 1940).

Over 150 WMAs have been established across Texas representing more than 770,000 ha (Texas Parks and Wildlife Department 2004). About 60 WMAs belong to the Texas Organization of Wildlife Management Associations representing over 3,500 landowners (Texas Parks and Wildlife Department 2000). In addition to having become popular for managing wildlife on increasingly smaller land holdings, these associations may hold promise for the management of other common-pool resources because they adhere to the model of mutual cooperation for mutual benefits.

The first WMA in Texas was formed in 1955 (Texas Parks and Wildlife Department 2004). Today, WMAs can be found in at least 6 other states including Colorado, Louisiana, Mississippi, Oklahoma, Vermont, and Wyoming (Benson et al. 1999, Hendrix 2002, Benson 2004, Dobbs 2004, Mississippi State University Extension Service 2004, Rottman and Powell 2004). As small landholdings replace large agriculture operations, this system of collective wildlife management will become more popular. Small acreage forest owner cooperatives have been in existence since before 1940, with most located in the eastern United States (U.S. Forest Service 2002). A growing number are also located Alabama, Iowa, Minnesota, Oregon, and Wisconsin.

As parcel size decreases, managing free-roaming species such as deer, elk, and migratory birds, requires cooperative effort on the part of private landowners. Often, the habitat requirements for these species are only met on a landscape scale, during all, or a part of their life cycle. While one landowner may provide a food supply in the form of crops or native vegetation, another may provide cover for breeding purposes, or wetlands for water needs. Only by recognizing the important role each landowner provides in maintaining healthy wildlife populations, will the incentive to organize be realized. Wildlife resources held in common trust by landowners may generate a land stewardship ethic, which in turn not only provides private benefits in terms of hunting opportunities, but also public benefits in terms of open space protection and potential water supply. Instead of regulatory control of land use for conservation purposes, voluntary agreements based upon mutually-agreed to guidelines by TPWD may lead to landowner-driven success in maintaining and restoring ecosystems.

In Texas, the basis for cooperative wildlife management is provided in TPWD wildlife management plans, which identify suitable practices to enhance wildlife and habitat within the cooperative. Guidelines for improving white-tailed deer herds may specify doe and buck harvest based on annual census counts conducted by WMA members, protecting young bucks to attain trophy status, and keeping age, weight and antler measurements of harvested deer. At the same time, habitat improvement through native plant revegetation, prescribed burning, proper grazing management, protection of riparian areas and other beneficial practices are strongly encouraged. Often, a cooperative agreement is signed by each WMA member, indicating their support for the management guidelines. Although it is not necessary for every member to agree with each guideline, each participant supports the principles of land and wildlife conservation, and recognizes the need for sound stewardship to improve wildlife on their property. Associations may range from a half dozen to several hundred landowners and from less than 200 to over 40,000 ha. Some WMAs are highly organized with elected officers, regular meetings, field days, newsletters, and dues. Others are loosely organized with little social interaction. However, all WMA members are provided a metal gate sign from TPWD, recognizing the association name, a source of local pride. Other agencies having direct involvement in WMAs include the Texas Cooperative Extension Service, and the Natural Resources Conservation Service.

Forming a WMA usually follows three basic steps: 1) At the request of a local landowner, an initial meeting of neighboring landowners is held. Other interested parties (i.e. hunters) are also welcome. This is an informal fact-gathering session that seeks to establish overall goals for the association based on participant input. TPWD and other agency personnel are on hand to help facilitate the meeting. 2) Selection of leaders, and name for the association, usually based on some local feature (creek, river, community, or other geographic feature). Metal gate signs are ordered. Additional clarification of goals and objectives may take place, with written voluntary recommendations or wildlife management plan prepared by TPWD personnel. 3) Final approval of organization structure, officers, and dues (as necessary). Bylaws could be established and elections held based upon individual association needs. All written recommendations and plans, though voluntary, are generally agreed upon through landowner signature.

The benefits of WMAs accrue to individuals as well as to the landscape. The knowledge gained from regular meetings and information sharing may lead to better stewardship of the land and wildlife populations. A sense of community develops from regular contact with neighbors. Cost and equipment sharing may take place, increasing the implementation efficiency of the various habitat improvement practices. Through the use of the basic wildlife management tools (cow, plow, axe, fire, and gun), habitat restoration or diversity can take place on an ecosystem level, meeting the needs of wide-ranging wildlife species, and increasing their quantity and quality. This may in turn lead to economic opportunities to lease rights to wildlife recreation through hunting, viewing, photography and other outdoor pursuits, which could be marketed through various media. Finally, by coordinating various land management practices to restore and enhance wildlife habitat, the detrimental effects of land fragmentation may be reduced.

As with any collaborative effort, conflicts can and do arise. A lack of consensus may develop among members, inhibiting progress towards goals and objectives. Inadequate feedback on wildlife population status will prevent monitoring trends to determine if the written guidelines are working. A lack of participation and leadership at the local level may develop over time, dampening enthusiasm for the association as a whole. Though poaching is generally reduced during the initial stages of WMA development, as wildlife populations improve, poaching may actually increase.

Investigation into the social, economic, and environmental aspects of wildlife cooperatives and associations could provide insight into managing other common-pool resources, including groundwater. Landowners could potentially pool their acreage to amass a quantity of water that is desirable to a prospective purchaser (Gilliland 2000). Based on the sustainable yield of the aquifer, this system may reduce habitat fragmentation by creating an economic incentive to maintain contiguous areas of open space for aquifer recharge and protection.

A CASE STUDY

The Middle Trinity Basin Conservation Cooperative (MTBCC) is a WMA of landowners in Anderson and Freestone counties that encompasses about 48,600 ha. (Wagner 2000, Knight 2000). This land area lies on both sides of the Trinity River, representing one of the most important sites for bottomland hardwood conservation in the state (Frye and Curtis 1990). About 50 landowners are cooperatively managing their properties to improve the habitat for white-tailed deer and waterfowl with the intent of improving family or fee-based hunting opportunities on their collective acreage. In addition to wildlife management for outdoor recreation and commercial enterprise, some landowners within the MTBCC are considering groundwater marketing as a financial opportunity, with indirect benefits to open space and wildlife habitat. Compatible wildlife management and sustainable groundwater marketing is one approach that could lead to long-term land and water conservation.

Water supply from this conservancy was estimated using data from a 1972 Texas Water Development Board report, which indicated a supply of about 9 million gallons per day (mgd) from a well field consisting of no more than 10 wells spaced 0.8 km apart. A conservative estimate of three well fields in the 400 km^2 area of the MTBCC suggests a groundwater yield of 27 mgd, or over 30,000 ac-ft per year. At an estimated value of $250 per acre-foot, this output translates to annual gross revenues of approximately $7.5 million (Kaiser 2000, Carlson 2001). In addition, the groundwater could be pumped directly into the Trinity River with a “Bed and Banks” permit issued by the Texas Commission on Environmental Quality, eliminating the need for pipeline construction. The groundwater districts in Anderson and Freestone counties may impose permits, fees, and other restrictions on inter-district water transfers. The MTBCC could exempt existing domestic wells from a use permit, as long as pumping did not exceed 25,000 gallons per day (Kaiser and Phillips 1998). Permitted production wells would need to be spaced according to groundwater district guidelines, and metered for regular monitoring. Production per well would be based on total sustained yield of the regional aquifer, divided by the total number of production wells. The amount of water permitted for each well could follow a self-imposed version of correlative rights, where groundwater rights correspond to the percentage of land owned above the aquifer.

Because the MTBCC is in the initial stages of groundwater production, this case study provides a unique research opportunity. Initial meetings with landowners indicate a willingness to participate in a cooperative groundwater-marketing scheme, if details on pumping thresholds and potential impacts of water transfers on the local economy can be determined. Checchio and Nunn (1988) investigated municipally-owned water farms in Arizona, purchased from farmers dependant on irrigated agriculture. When rural land is owned by outside interests, the future of the area is somewhat dependent upon decisions made by persons with no vested interest in local welfare. The formation of a locally-owned groundwater cooperative could leave aquifer use decisions to landowners, which would conform to pumping limits set by the groundwater districts, and create a market incentive to lease groundwater supplies based on sustainable yield. King and Harris (1990) also advocated local control over aquifer resources based on their survey of 41 towns in Vermont and northern New York. Since few case studies currently exist, a detailed survey of the MTBCC, and other wildlife cooperatives in Texas, could make the connection between groundwater production and land stewardship practices benefiting wildlife. Although only a few "water ranches" have been formed in Texas, several such farms exist in Arizona (McEntire 1989), but none of these cases have investigated the relationship between aquifer use, economics, private property rights, and open space protection.

LANDOWNER ASSOCIATIONS: REBUILDING SOCIAL CAPITAL?

Building and maintaining social capital within landowner associations may be important in accomplishing land and water conservation goals. Many new landowners are absentee, living in urban areas where they are exposed to polarized viewpoints on environmental and other issues. This may lead to a decline in social capital (Putnam 1996, 2000). The "big four" effects of time and money pressures, suburbanization and sprawl, electronic entertainment, and generation differences are speculated to account for 10%, 10%, 25%, and 50% of the total decline in social capital in the United States (Putnam 2000). According to Putnam (1996), the decline in social capital can be correlated with the advent of the television. In the first 10 years after TVs introduction in 1950, the number of households with television sets grew from 10% to 90%, probably the fastest technological revolution of our time. The hours spent watching TV has robbed Americans of their civic duty to get involved, and filled the minds of our youth with absurd forms of entertainment instead of useful learning. Directly related to the long-term effects of television watching, is an erosion of civic engagement by future generations (Putnam 2000). The value placed on community life and public involvement by those born before 1946 is nearly twice as strong compared to the "X Generation", those born between 1965 and 1980.

Rural settings may offer a unified "sense of place" based on outdoor serenity and peace of mind. Seeking refuge in rural landscapes may lead to lifestyle changes and paradigm shifts that may generate social capital based on community-based natural resource values. The attraction of owning a piece of Texas' natural heritage draws people from urban as well as rural backgrounds, binding them to a common purpose in preserving a land-based culture rich with a historical legacy. This common purpose may be best fostered in the formation of various landowner associations centered around land, water, and wildlife conservation and away from technological forms of entertainment. The social interaction of members of these associations may further solidify a conservation ethic, and build upon civic participation, trust, and other values forming the foundation for social capital. Comparing measurements of social capital with levels of land and water conservation practices within and among various landowner associations may provide insight into various institutional structures suitable for managing common pool resources in Texas.

CHAPTER III

COLLECTIVE ACTION AND SOCIAL CAPITAL OF WILDLIFE MANAGEMENT ASSOCIATIONS IN TEXAS

SYNOPSIS

Wildlife management associations (WMAs), consisting of multiple private landowners, have become popular in Texas. As a common-pool resource, white-tailed deer (*Odocoileus virginianus*) require management over large areas which necessitates collective decision-making of landowners with technical assistance from professional biologists. Numerous factors affect the function of WMAs including habitat and property ownership characteristics, landowner demographics, and social capital. I used a mail survey questionnaire to explore the relationship between these factors, and their effect on association activities and management practices in 4 WMAs in each of 2 regions: the Lower Post Oak Savannah (LPOS) and the Central Post Oak Savannah (CPOS). LPOS landowners were members of larger associations, had generally acquired their land more recently, met more often, raised more money using more funding methods, and tended to have longer association membership than CPOS landowners, yet they had lower social capital. LPOS landowners owned significantly larger properties, and were predominantly absentee wealthy males that considered relaxation/leisure and hunting more important land uses than property ownership for a place to live. The larger average tract size in CPOS was correlated with smaller group size, which may be the most important factor in building and maintaining social capital. Intra-association trust

was positively influenced by the longevity of property ownership, the number of association meetings, the percentage of males in the association, and other factors. Conversely, negative influences on trust included absentee ownership, and the amount of wooded habitat present. Although CPOS landowners had higher social capital and practiced more wildlife management activities, regression analyses did not identify measures of social capital as important in understanding the wildlife management priorities and practices of landowners in WMAs. Perhaps landowner attitudes and activities are motivated more by shared values towards land stewardship, independent of any benefit from their association, or that the proxies used to measure social capital were inadequate.

INTRODUCTION

Deer hunting in Texas is big business. Hunting opportunities in the state are inextricably linked to private landowners who manage over 98 percent of the rural land. These landowners provide hunting opportunities through various forms of leases, whereby hunters pay landowners a fee to access their land for a fixed number of years, or by packaged hunts. More than 8.5 million ha of the state's private lands are under such hunting enterprises (J. Rivers, Texas Parks and Wildlife Department, unpublished report), with fees commonly ranging from $15 to $25 per ha, or more. In prime deer habitat areas, revenue from hunting exceeds the agricultural production values from the land.

Landowner cooperatives for managing wildlife resources in the north-central United States began over 70 years ago (Leopold 1936, Leopold 1940), and were started in Texas in 1955 (Texas Parks and Wildlife Department 2004). Multi-landowner groups formed to manage wildlife resources, especially white-tailed deer (*Odocoileus virginianus*), are of increasing importance with the number and acreage of Wildlife Management Associations (WMAs) on private land totaling about 160 on nearly 770,000 ha respectively (Texas Parks and Wildlife Department 2004). Such associations operate under a written wildlife management plan usually prepared by a wildlife biologist from the TPWD, and they vary in character, size, and organizational structure. Some are formed around natural features such as watersheds.

This study explores the relationship between landowner and property characteristics, and the role that social capital plays in collective action for managing a common-pool resource, specifically white-tailed deer. Wildlife associations may hold promise for the management of other natural resources that traverse private lands because they adhere to the model of mutual cooperation for mutual benefits (Hardin 1968). Understanding the optimum mechanisms of cooperative management of common-pool resources on private land may lead to other public benefits including sustained water supply (Wagner and Kreuter 2004), restoration of biodiversity (Pretty and Smith 2004), and protection of scenic open spaces in Texas.

Social Capital and Groups

The importance of social capital in forming voluntary associations has been extensively studied by political scientist and sociologists (Coleman 1990; Putnam 1995, 1996, 2000; Flora 1998; Stolle 2001; Anheier and Kendall 2002). They refer to social capital in terms of the value of community engagement that leads to mutual benefits and cooperation. Measures of social capital include general and interpersonal trust, reciprocity, and civic participation (Coleman 1990, Tyler and Degoey 1995, Brehm and Rahn 1997, Hofferth and Iceland 1998, Molm et al. 2000, Putnam 2000). Frequency of contact (Stokowski and Lee 1991, Weber and Carter 2003), and strength of relational ties (Stokowski 1990, Tyler and Degoey 1995, Hofferth and Iceland 1998, Weber and Carter 2003) have also been used to measure social capital.

A limited number of studies have compared social capital with approaches to natural resource management (Pretty and Ward 2001, Pretty 2003). For example, social capital led to collective action in forest and watershed management in India (D'Silva and Pai 2003), and communal forest biodiversity conservation in Guatemala (Katz 2000). Social capital may be mobilized from group response to local resource problems or events, rather than from pre-existing values shared by stakeholders (Mullen and Allison 1999). Although social capital may lead to increased productivity of natural environments, the long term effects of increased human use can also lead to soil erosion and site degradation (Flora et al. 1998, Rodriguez and Pascual 2004).

Research suggests that a number of factors play a role in determining social capital. Of particular importance are group size (McPherson 1983, Kerr 1989, Levine and Moreland 1990), residential stability (Putnam 1995, 2000; Hofferth and Iceland 1998; Anheier and Kendall 2002), and gender homogeneity (Levine and Moreland 1990, Putnam 2000, Halpern 2005). Large groups tend to demonstrate better membership retention than small groups (McPherson 1983), while small groups tend to be more participatory, cooperative, and better coordinated (Levine and Moreland 1990), and they tend to be more effective in problem solving (Kerr 1989). Members of organizations based on geographic proximity have an advantage over outsiders in understanding local conditions and mindsets (Anheier and Kendall 2002). Localized rural groups tend to be small (McPherson 1983) and may develop a "sense of place" unknown to larger, more urban or widespread organizations (Hofferth and Iceland 1998). In general, males tend to be more goal-oriented within their group, and more concerned with resolving issues of status, power, and wealth (Levine and Moreland 1990), while females are more friendly and agreeable toward others in their group, facilitating social interaction (Wood 1985).

In my study, group size, place of residence, gender, and other landowner characteristics are investigated as explanatory variables on measures of social capital within WMAs in the Post Oak Savannah of Texas. Secondarily, I hypothesized that increased social capital may lead to an increase in association priorities for wildlife management, and number of association activities.

STUDY AREA

The study area is located within the lower and central portions of the Post Oak Savannah Region of Texas (Figure 3.1). The Post Oak Savannah encompasses over 6.8 million ha of land in 32 counties in the east-central portion of the state. About 55% of this land is considered pastureland (United States Department of Agriculture 1997) comprised primarily of bermudagrass (*Cynodon* spp.). The ecoregion is situated between Dallas-Fort Worth, Houston, Austin, and San Antonio. As the population continues to grow in these urban centers, the ownership sizes of surrounding rural land tracts are shrinking. In addition, while the value of agriculture production is in decline, the

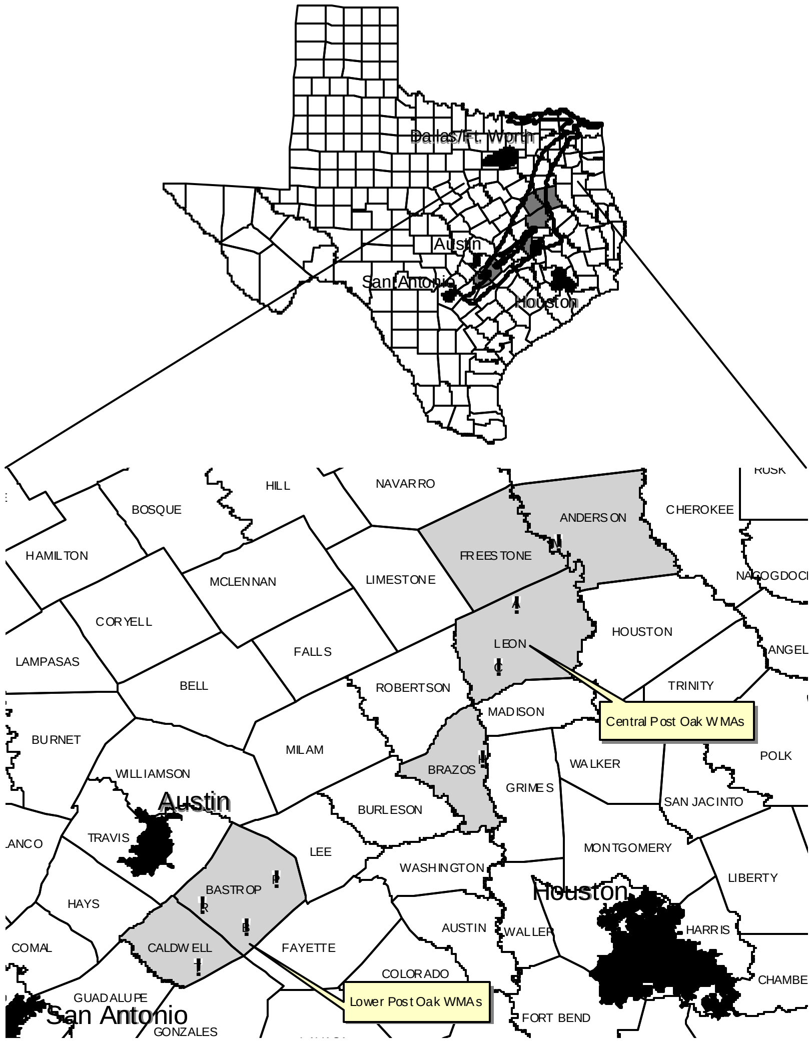

Figure 3.1. Locations of Lower and Central Post Oak Savannah Wildlife Management Associations.

<u>Lower Post Oak Savannah (LPOS)</u>

Bastrop County
- *B = Bartons Creek WMA*
- *P = Pin Oak Creek WMA*
- *R = Red Rock WMA*

Caldwell County
- *T = Tri-Community WMA*

<u>Central Post Oak Savannah (CPOS)</u>

Leon County
- *A = Alligator Creek WMA*
- *C = Clear Creek WMA*

Brazos County
- *H = Harvey WMA*

Anderson and Freestone Counties
- *M = Mid Trinity Basin Conservation Cooperative*

recreational value of rural land is increasing. Hunting, fishing, and recreation in scenic areas are major interests of city dwellers seeking an escape to the countryside. Newer landowners are increasingly interested in wildlife and habitat management, but the highly fragmented ownership patterns make management of wildlife habitat difficult. The solution has been the formation of WMAs, and the Post Oak Savannah Region has one of the highest concentrations of WMAs in the state.

This study focuses on 4 landowner associations in the Lower Post Oak Savannah (LPOS), and 4 associations in the Central Post Oak Savannah (CPOS) (Figure 3.1). The 4 WMAs in LPOS included Bartons Creek (BCWMA), Pin Oak Creek (POCWMA), Red Rock (RRWMA), and Tri-Community (TCWMA). The 4 WMAs in CPOS included Alligator Creek (ACWMA), Clear Creek (CCWMA), Harvey (HWMA), and Mid Trinity Basin Conservation Cooperative (MTBCC). The LPOS is characterized by smaller land tract size and higher rates of land fragmentation (Wilkins et al. 2005), and lower local deer populations (3.9 deer/km^2 compared to CPOS at about 31.7 deer/km^2) (M. Longoria, M.W. Wagner, Texas Parks and Wildlife Department, unpublished data). In general, WMAs in LPOS were formed to increase deer numbers, in part, by importing deer from other areas of the state, while simultaneously making habitat improvements. Associations in CPOS were formed around existing high deer numbers, but low quality caused by unbalanced sex ratios and lack of mature bucks. Differences in quantity and quality of deer may affect the willingness of landowners to cooperate, and levels of social capital within the group.

METHODS

A survey questionnaire was mailed to all 458 member landowners within the 4 WMAs in LPOS and 137 landowners in 4 WMAs in CPOS for a total of 595 survey participants. The questionnaire survey followed protocols outlined by Dillman (2000) and was designed to collect socio-demographic information on landowners, their property characteristics, and the degree of social capital they exhibited within their association. Twenty-one questions were divided into the following sections: Property and Land Management Characteristics, Social Interaction and Civic Participation, and Personal Information (see Appendix A for a list of questions in each category). A non-response bias survey was conducted for 19 landowners in 6 WMAs by phone interview of 11 questions selected from the original questionnaire (Lohr 1999, Czaja and Blair 2005).

Measures of social capital included intra-association trust, reciprocity, and civic involvement. A 5 point Likert-scale was used to elicit information on land management priorities, trust, and reciprocity with a range of 5 (responding very positively) to 1 (responding very negatively). Community involvement questions were similarly Likert-scale ranked, but with a range from 3 (very involved) to 0 (not involved). An index for landowner trust within an association was created by summing and averaging each respondent's level of agreement with the following 4 statements: 1) I know most members of my landowner association; 2) I meet with members outside of association activities; 3) There are many members I consider friends; and 4) I trust members of my landowner association. Responses to these statements were strongly correlated ($p < 0.01$)

with each other, with correlation coefficients ranging from 0.312 to 0.594, using a Kendall's tau-b correlation matrix. An index for reciprocity was similarly created by summing and averaging each respondents level of agreement with the following 4 statements: 1) I would loan equipment to any member of my landowner association; 2) I would provide personal time to help at least one non-kin member of my association; 3) I would provide personal time to help any member of my association; and 4) I would lend money to any member of my association. These questions were also correlated with each other, with correlation coefficients ranging from 0.110 ($p < 0.05$) to 0.522 ($p < 0.01$). Finally, an index for civic involvement was generated for each landowner by summing their level of involvement in each of 7 community organizations plus a category for "other", with scores ranging from 0 to 24.

The percentages of selected habitat types for each property within an association were combined into a single variable, Habitat Cover Index (HCI). This index was derived using the following formula:

$$HCI = TT + 0.67NR$$

where TT = % total timbered habitat, and NR = % native rangeland. This simple formula was only used to contrast coarse-scale ratios of timbered lands and open native rangelands. Totally timbered habitat was assigned the highest value because in the study areas, oak forest habitats in general are relatively limited, and considered the most important for deer since they reach their highest population densities in this habitat type (Yantis 1984). Non-native forage pastures were considered the poorest habitat and assigned a 0 value (Higginbotham 1999, Telfair 1999). Native rangelands were considered to be intermediate in value and were assigned roughly two-thirds the value of timbered lands based on experience from local biologists. The percent of total timbered habitat for each property was derived by combining the percent of upland timber with bottomland timber.

All statistical analyses were conducted using SPSS 11.5. Levene's tests were conducted to check for equality of variance before mean comparisons (Daley et al. 2004). To compare the mean values of all associations within the two regions, t-tests were conducted to detect differences between paired ordinal variables, or chi-square ($?^2$) in the case of categorical variables such as gender, education level, household income, percent of income from property, location of primary residence and occupation. Tract sizes and years of property ownership were highly skewed with small values producing non-normally distributed data. These variables required natural log (ln) transformation for use in data analysis. The percent of bottomland timber, percent of land affected by all activities (except for rotational grazing), the percent of association members that were related, and the number of fund raising methods, were also non-normally distributed due to the presence of zero values so that ln + 1 transformations were required for analyses. While we used transformed data for analyses, we present non-transformed values for clarity of interpretation. Means and standard errors are presented as follows: LPOS = $\bar{X}_L$, SE; CPOS = $\bar{X}_C$, SE. Mean differences were considered significant at $p < 0.05$.

Stepwise multiple regressions were conducted to identify the explanatory power of 20 independent variables for trust and reciprocity as the dependent variables. Categories for gender, primary residence, and occupation were recoded as separate dummy variables in the regressions. Variables entered the model one at a time when p = 0.05 and R^2 increased, and were removed when p = 0.10 and R^2 decreased. This was undertaken to explain a portion of the variability in social capital within a region as well as within an association. The goal of the stepwise regression procedure was to generate a model of independent variables that, in combination, explained a larger portion of variability in the dependent variables than could be explained by any other combination of variables. The stepwise procedure was used only for descriptive purposes and data exploration, not for predictive purposes.

Likewise, stepwise multiple regressions were conducted for 5 dependent variables: land use priority rankings of wildlife management, lease hunting and non lease hunting, the number of wildlife management activities, and the number of funding methods. In addition to the original 20 independent variables, trust and reciprocity were also included as independent variables in these 5 regressions. This was done in an attempt to explore the relationship between association priorities and activities, landowner characteristics, and social capital within individual associations and regions.

RESULTS

Of the 595 questionnaires, 306 were returned for an overall response rate of useable questionnaires of 52.0% for LPOS and 49.6% for CPOS (Table 3.1). Response rates for individual associations ranged from 42.6% for the MTBCC (47 members) to 83.3% for the ACWMA (6 members). Of the non-completed questionnaires, many did not reach their intended landowner because of incorrect address. Twenty-eight questionnaires were returned blank or unintelligible. From the non-response bias survey,

Table 3.1. Landowner associations, membership size, and survey response rate. (* Mean membership size is different [t = 4.822, p = 0.003])

	Members	(n)	Response Rate (%)
LOWER POST OAK SAVANNAH (LPOS)			
Bartons Creek Game Management Association (BCWMA)	119	60	50.4
Pin Oak Creek Wildlife Management Association (POCWMA)	100	54	54.0
Red Rock Wildlife Management Association (RRWMA)	148	79	53.4
Tri-Community Wildlife Management Association (TCWMA)	91	45	49.5
Total	458	238	
Mean	115*		52.0
CENTRAL POST OAK SAVANNAH (CPOS)			
Alligator Creek Wildlife Management Association (ACWMA)	6	5	83.3
Clear Creek Wildlife Management Association (CCWMA)	55	26	47.3
Harvey Wildlife Management Association (HWMA)	29	17	58.6
Mid Trinity Basin Conservation Cooperative (MTBCC)	47	20	42.6
Total	137	68	
Mean	34*		49.6

no differences were detected in age (p = 0.322) or property size (p = 0.440), between the questionnaire respondents and phone interviewees. Occupational differences were also non significant (p = 0.496), as were differences in land use priorities for wildlife management (p = 0.076), relaxation/leisure (p = 0.937), lease hunting (p = 0.441), or number of association meetings (p = 0.770). However, phone interviewees considered livestock management and forage production more important (t = -6.363, p < 0.001; t = -3.357, p = 0.003, respectively), and non lease hunting less important (t = 2.183, p = 0.030) than questionnaire respondents.

Respondent Demographics Between Regions

Association membership size was significantly greater in LPOS than CPOS ($\bar{X}_L$ = 115.0 members, SE = 12.6; $\bar{X}_C$ = 34.0, SE = 10.9, t = 4.822, p = 0.003). Landowners in this region also owned less land ($\bar{X}_L$ = 68.3 ha, SE = 7.7; $\bar{X}_C$ = 469.4, SE = 139.2, t = -8.393, p < 0.001), for about 10 years less time than landowners in CPOS ($\bar{X}_L$ = 34.5, SE = 2.2 years; $\bar{X}_C$ = 44.3, SE = 4.7, t = -1.745, p = 0.082).

There was a lower percentage of male respondents in LPOS compared to CPOS ($\bar{X}_L$ = 83.2%, $\bar{X}_C$ = 95.5%, $?^2$ = 6.535, df = 1, p = 0.011), but the percent of related members was not different between regions, averaging 2.1% or less (t = -1.219, p = 0.226). Mean age of landowners in associations did not differ between LPOS and CPOS ($\bar{X}_L$ = 59.8 years, SE = 0.8; $\bar{X}_C$ = 58.3, SE = 1.6, t = -0.844, p = 0.399).

Education level, income, primary residence, and occupation data are summarized in Table 3.2. The education level of landowners in LPOS appeared to be somewhat lower with 39.5% with a bachelors or higher degree, compared to 56.5% in CPOS. Fewer LPOS landowners earned more than $100,000, but no statistically significant difference in the percentage of income from land activities was detected, with 16% of the landowners in LPOS, and about 24% of the landowners in CPOS earning

Table 3.2. Education, income, primary residence, and occupation of landowners (%) in WMAs in the Lower Post Oak Savannah (LPOS) and Central Post Oak Savannah (CPOS).

	LPOS	CPOS
Education ($?^2$ = 9.630, df = 5, p = 0.086)	n = 213	n = 62
Less than High school	2.3	0.0
High school graduate	26.8	22.6
Vocational/technical training	3.3	0.0
Some college	28.2	21.0
Bachelor degree	24.9	29.0
Post-graduate degree	14.6	27.4
Annual income ($?^2$ = 18.002, df = 4, p = 0.001)	n = 208	n = 61
Less than $25,000	7.7	6.6
$25,000 - 49,999	28.8	21.3
$50,000 - 74,999	31.7	16.4
$75,000 - 99,999	16.3	16.4
More than $100,000	15.4	39.3
Primary residence ($?^2$ = 10.017, df = 2, p = 0.007)	n = 216	n = 60
On Property	67.1	45.0
In Town < 10,000	9.3	13.3
In Urban > 10,000	23.6	41.7
Occupation ($?^2$ = 1.620, df = 2, p = 0.445)	n = 165	n = 49
Agriculture	10.9	16.3
Professional	46.1	49.0
Retired	43.0	34.7

between 11-50% of their income from the land ($?^2$ = 5.249, df = 4, p = 0.263). Slightly more than 67% of LPOS members lived on their properties compared to 45% of CPOS members, a significant difference. Occupational differences between regions were not significant for those in agriculture, professional jobs or retired.

Habitat and Deer Populations

No difference between regions in the percent of total timbered habitat, native range, non-native forage pasture and HCI were detected. However, the percentage of bottomland timber was on average significantly lower in LPOS than CPOS (Table 3.3). CPOS associations tended to be situated on major rivers or sizeable tributaries within the watershed, supporting a higher occurrence of bottomland hardwoods. The lower amount of bottomland timber, combined with smaller tract size may partially explain the lower estimated deer densities in LPOS compared to CPOS. In general, as the amount of timbered habitat increased, the amount of improved pasture decreased for both regions.

Management Activities

Fewer wildlife management activities (i.e. deer counts, selective doe harvest, shallow water impoundments, feral hog control, etc.) were conducted in LPOS compared to CPOS ($\bar{X}_L$ = 2.7, SE = 0.1; $\bar{X}_C$ = 5.3, SE = 0.3, t = -7.500, $p < 0.001$), but there was no difference in the number of water conservation activities (averaging less than 2 for both regions, t = 0.184, p = 0.854).

As expected, wildlife management was a high priority across all associations (Table 3.4). Relaxation/leisure as a reason for property ownership was on average less important in LPOS than in CPOS, while LPOS landowners rated the importance of their

Table 3.3. Habitat composition (%) and Habitat Cover Index (HCI) of properties in WMAs in the Lower Post Oak Savannah (LPOS) and Central Post Oak Savannah (CPOS). Values for bottomland timber were ln+1 transformed prior to analysis.

Habitat composition	LPOS		CPOS			
	$\bar{X}$	SE	$\bar{X}$	SE	t	P
Bottomland timber	3.6	0.6	15.6	2.6	-4.965	<0.001
Total timber	37.5	2.4	43.4	3.5	-1.392	0.167
Native range	29.8	2.2	23.2	3.4	1.647	0.102
Improved pasture	25.4	1.9	20.4	2.9	1.433	0.154
HCI	58.1	2.0	58.9	2.8	-0.207	0.837

Table 3.4. Land use priorities of landowners in WMAs in the Lower Post Oak Savannah (LPOS) and Central Post Oak Savannah (CPOS) (1 = very unimportant, 2 = unimportant, 3 = undecided, 4 = important, 5 = very important).

Land use priorities	LPOS		CPOS			
	$\bar{X}$	SE	$\bar{X}$	SE	t	p
Wildlife management	4.6	0.1	4.7	0.1	-1.792	0.075
Relaxation/leisure	4.1	0.1	4.5	0.1	-2.369	0.019
Livestock production	3.7	0.1	3.6	0.2	0.477	0.635
Place to live	4.4	0.1	3.8	0.2	3.025	0.003
Lease hunting	1.5	0.1	2.0	0.2	-2.561	0.013
Non lease hunting	2.7	0.1	3.9	0.2	-5.273	<0.001

property as a place to live higher than CPOS. Lease hunting and non-lease hunting were both lower priorities in LPOS compared to CPOS.

There was no difference in the percent of land affected by various management practices over the previous 12 month period (Table 3.5). Although *percent* of land affected by the various practices did not differ significantly between regions, rotational grazing, controlled burning, and brush control were conducted on significantly more land area on CPOS properties. This is attributed to the higher average tract size of CPOS properties, which would require more effort to achieve meaningful results for certain land management activities.

Associations in LPOS on average, had greater longevity in membership $\bar{X}_L$ = 4.1 years, SE = 0.1; $\bar{X}_C$ = 3.1, SE = 0.2, t = 4.598, p < 0.001), more regular member meetings ($\bar{X}_L$ = twice per year, $\bar{X}_C$ < twice per year, t = 3.946, p < 0.001), and had a higher number of funding methods ($\bar{X}_L$ = 2.1, SE = 0.1 , $\bar{X}_C$ = 0.4 $\pm$ 0.1, t = 14.815, p < 0.001), than landowners in associations in CPOS, but the number of communication methods were lower ($\bar{X}_L$ = 2.9, SE = 0.1 , $\bar{X}_C$ = 3.6, SE = 0.2, t = -2.829, p = 0.005).

Social Capital

All three measures of social capital were lower in LPOS than CPOS, including trust ($\bar{X}_L$ = 3.3, SE = 0.1, $\bar{X}_C$ = 3.6, SE = 0.1, t = 2.198, p = 0.029), reciprocity ($\bar{X}_L$ = 3.0, SE = 0.1, $\bar{X}_C$ = 3.4, SE = 0.1, t = -3.339, p = 0.001), and civic involvement ($\bar{X}_L$ = 6.8, SE = 0.3, $\bar{X}_C$ = 8.2, SE = 0.7, t = -2.082, p = 0.038).

Table 3.5. Mean percent and area of land (ha) affected by six wildlife management activities. All categories except rotational grazing were ln +1 transformed prior to analysis.

		LPOS		CPOS			
		$\bar{X}$	SE	$\bar{X}$	SE	t	P
Rotational grazing	%	28.4	2.6	27.7	4.9	0.129	0.899
	ha	20.0	3.1	70.1	13.3	-3.595	0.000
Controlled burning	%	2.4	0.7	2.9	1.3	-0.574	0.566
	ha	0.7	0.2	17.6	9.4	-2.238	0.026
Native plant restoration	%	8.5	1.5	11.4	3.1	-1.212	0.226
	ha	2.3	0.4	11.3	3.5	-0.769	0.442
Food plots	%	5.5	0.9	3.6	1.1	0.473	0.637
	ha	1.7	0.2	11.6	8.0	-0.321	0.748
Brush control	%	11.4	1.3	7.7	1.7	0.454	0.651
	ha	7.2	1.6	33.1	10.2	-2.899	0.004
Erosion control	%	6.8	1.2	4.5	2.2	1.031	0.305
	ha	3.1	1.0	12.4	6.8	-.0608	0.543

The results of the stepwise regression models with trust as the dependent variable are shown in Table 3.6. Regressions for reciprocity are not presented because they did not provide any additional information beyond those for trust. The 20 independent variables are organized under 4 subheadings: Habitat, Ownership, Social Relationships, and Demographics.

In the model for all WMAs in LPOS, trust appeared to be positively influenced by the time of land ownership, the frequency of meetings, and the proportion of males participating in the association. Additional positive influences on trust included the percent of income from land activities, and civic involvement, which each appeared in

Table 3.6. Stepwise multiple regression table for trust as the dependant variable. Standardized coefficients are presented (p values are indicated in parentheses). (* Model did not explain any of the variation in trust for these associations).

	LPOS				
	All WMAs	BCWMA	POCWMA	RRWMA	TCWMA
HABITAT					
Percent improved pasture					
Percent timber					-0.523 (0.001)
Percent bottomland timber (ln + 1)					-0.487 (0.003)
Habitat Cover Index	-0.310 (0.001)	-0.489 (0.007)		-0.417 (0.008)	
OWNERSHIP					
Acres (ln)					
Years owned (ln)	0.205 (0.020)				
SOCIAL RELATIONSHIPS					
Percent related (ln + 1)					
Years as a member					
Number of meetings	0.256 (0.003)				
Civic Involvement			0.267 (0.045)		
Number of members					
DEMOGRAPHICS					
Year born					
Male	0.191 (0.025)				0.389 (0.010)
Income					
Percent income from land		0.375 (0.032)			
Education					
Live in town <10,000			-0.640 (0.000)		-0.332 (0.025)
Live in urban area >10,000					
Professional			-0.627 (0.000)		
Retired					
N	158	39	36	52	31
ADJUSTED R^2	0.208	0.330	0.705	0.152	0.549

	CPOS				
	All WMAs	ACWMA	CCWMA	HWMA	MTBCC
HABITAT					
Percent improved pasture					
Percent timber					
Percent bottomland timber (ln + 1)					
Habitat Quality Index				-0.625 (0.040)	
OWNERSHIP					
Acres (ln)					
Years owned (ln)					
SOCIAL RELATIONSHIPS					
Percent related (ln + 1)					
Years as a member			0.263 (0.004)		
Number of meetings					
Civic Involvement					
Number of members	-0.426 (0.013)				
DEMOGRAPHICS					
Year born			-1.266 (0.000)		
Male			0.126 (0.023)		
Income					
Percent income from land					
Education					
Live in town <10,000					
Live in urban area >10,000			-0.525 (0.000)		
Professional					
Retired					
N	42	2	14	13	13
ADJUSTED R^2	0.155	*	0.991	0.323	*

one of the individual WMA models in LPOS. Interestingly, HCI had an important negative effect on trust in the overall model, and for half of the individual models in LPOS. The percent of total timber and the percent of bottomland timber habitat were also negatively associated with trust in another WMA. Other factors that tended to negatively influence trust in LPOS included residency in a town versus on-property residence (half of the individual models), and professional compared to agricultural occupation in the POCWMA. Combined with the positive influence of civic involvement and the negative effect of living in a town, the adjusted R^2 for trust in this association was 0.705, the second highest of all models.

The only important independent variable for trust when modeled for all WMAs in CPOS was the number of members, which was negatively related. Two of the 4 individual WMA models in CPOS did not produce results. Due to the small sample size for ACWMA ($n = 2$), regression analysis was not possible, while no relationships explaining trust for MTBCC were identified as being significant. Other negative influences on trust were HCI, and residence in an urban area as opposed to on the property, which each appeared in one individual model. Year born was also negatively related to trust in one association (CCWMA). This indicated that age was positively related to trust in this association, along with 2 other positive variables: the percent of males in the association, and the years as an association member. These variables, along with whether a member lived in an urban area, accounted for over 99% of the variation in trust for CCWMA, the highest R^2 value for any model.

Social Capital and Association Activities

The stepwise regression models to explain association priorities and activities did not produce meaningful results. The 5 dependent variables included priority rankings of wildlife management, lease hunting, and non lease hunting, the number of wildlife management activities, and the number of funding methods. Trust and reciprocity indexes were included as independent variables with the same list of 20 variables used in the prior stepwise regression. No patterns in explanatory independent variables emerged from the analyses, and trust and reciprocity appeared as significant in only 4 of a possible 25 models in LPOS and none of the 25 models in CPOS. Five of the models in LPOS did not generate an R^2 value, while 12 of the models in CPOS did not generate an R^2 value, presumably due to the smaller sample sizes in CPOS. Further insights into the role of social capital in landowner associations are discussed below.

DISCUSSION

LPOS landowners tended to be more recent property owners that met more often, raised money by using more funding methods, and tended to have longer association membership than CPOS landowners, yet LPOS had lower social capital. The greater membership size associated with lower average tract size in LPOS may be the most important factor affecting social capital. Group size is an important aspect of social capital building because as membership increases it becomes more difficult to develop trust and reciprocity relationships among members (Wuthnow 1994). In CPOS, where group size ranged from 6 to 55 members, the number of members was negatively related to trust. In LPOS, group size ranged from 91 to 148 members, and did not appear as an important explanatory variable for trust. Some threshold of group size may exist, above which intra-group trust cannot be predicted. Pretty and Ward (2001) noted that most natural resource management groups with effective social capital are small, ranging from 20-30 members. Ideally, group size should be no more than 15-20 people for maximum trust building (Wuthnow 1994).

Overall, almost half of all responding landowners in this study were in "professional positions", which may have influenced their reasons for owning land. In the LPOS, more landowners lived on their properties, and indicated that living on their properties was an important ownership priority, while predominantly absentee CPOS members considered relaxation/leisure and hunting more important land uses. Therefore, LPOS landowners may be motivated more by a place to live and escape the city life rather than the ability and desire to purchase land exclusively for relaxation or wildlife-related recreation. The higher level of wealth in CPOS may afford landowners the luxury of acquiring larger properties of bottomland habitat with high deer numbers. In addition, since more landowners in LPOS live on their properties, more commuting may occur for those landowners in professional positions. Urban sprawl and commuting were suspected as major factors in the decline of social capital throughout the United States (Putnam 1995, 2000). In a study of 32 voluntary associations in Texas, work-related time constraints reportedly led to decreased civic engagement (Price 2002).

In general, trust within associations in LPOS tended to increase with increasing number of meetings, years of property ownership, the percentage of males in the association, and decreasing habitat cover. In group management of common pool resources, frequency of contact is important in developing trust relationships and rule compliance (Dietz et al. 2003), and undoubtedly becomes more important with increasing group size. Residential stability also leads to greater civic engagement (Putnam 1995). In terms of civic involvement, males tend to join more formal organizations while females are more likely to enjoy informal relationships among friends (Putnam 2000). It is possible that female landowners feel somewhat disconnected within the WMA network, although some leadership positions are occupied by women. The overall male dominance in WMA membership in CPOS may lead to increased homogeneity and social capital within the group.

Habitat Cover Index, or components thereof, were important negative explanatory variables for trust in half of all models. The negative relationship between HCI and trust in LPOS presents a number of interesting speculations. First, as HCI increased among associations in this region, the estimated density of deer also increased from an average of 2.9 deer/km^2 on BCWMA and POCWMA to over 9.8 deer/km^2 on TCWMA (M. Longoria, Texas Parks and Wildlife Department, unpublished data). As the population of deer increases, the perceived need for cooperation and social interaction may actually decrease, but when deer populations decline, it may become imperative for landowners to work more closely together to maintain viable populations. This situation may force landowners to form WMAs to organize and raise funds for deer trapping and relocation from other areas, thus leading to greater social capital. The decrease in social capital with increasing habitat cover may also simply reflect the fact that more timbered habitat is present, which may in turn create visual and psychological barriers to social contact among neighbors.

Landowners living in a town or urban area had lower trust than those living on their property for 3 of the 8 WMA models. Absentee landowners may view their rural neighbors with some level of skepticism and vice versa. Community ties are often stronger in rural areas where residents are less mobile and depend more on kin networks (Hofferth and Iceland 1998).

CPOS associations tended to be dominated by males who were somewhat more educated, and earned more money than LPOS members. Although not born out in our regression models for trust, social capital tends to increase with increasing education (La Porta et al. 1997, Halpern 2005) and income (Brehm and Rahn 1997, La Porta et al. 1997). However, D'Silva and Pai (2003) noted that an increase in level of education can lead to higher heterogeneity within a group, thereby decreasing social capital.

By far, the dominant feature of WMAs in CPOS is smaller group size due to larger tract size when compared to LPOS. This factor may override all others in the building and maintenance of social capital. Though a larger proportion of landowners in CPOS lived away from their properties, met less often, and had fewer fund raising methods, they utilized more communication methods, practiced more wildlife management activities and enjoyed higher deer populations. They placed more importance on relaxation and hunting values of their land. The increased level of wealth in this region probably contributed to more on the ground wildlife management. The higher population of deer in this region may tend to motivate landowners, shifting the emphasis away from improving quantity to improving the quality of deer herds, especially the number and quality of antler characteristics of bucks. This may require a higher level of social capital than groups with low deer populations, possibly requiring a higher level of social cohesiveness. In 2001, the average age of bucks harvested on HWMA was 3.9 years, with an average of 7.9 scorable points and a 37.8 cm inside spread (M. W. Wagner, Texas Parks and Wildlife Department, unpublished data). This compares to the average buck of 2.2 years, with 7 points and 30.2 cm for a surrounding three-county area. Likewise, in the same year on the MTBCC, the average buck harvested was 4.0 years of age with 8.3 points and a 38.4 cm inside spread, compared to 2.1 years, 6.3 points and 26.4 cm spread for bucks harvested in a surrounding five-county area. The higher social capital in the region may lead to increased management for white-tailed deer, but it may be a product of shared self-interests from a limited number of landowners, rather than dependence upon trust and reciprocity building through association involvement. Thus, communal management of a shared resource may occur without any altruistic feelings among members (Flora 1998). Social capital may still exist within the group, but it may be generated from rational choices from self-interested individuals, rather than a product of community bonding (Ostrom 1992).

The low R^2 values for social capital when averaged over all four associations in a region may imply that more factors play a role than the twenty independent variables in the model. Perhaps a consistently significant group of explanatory variables for social capital may not be possible for landowners over a multi-county area due to broad heterogeneity among landowners. When modeled within associations, the R^2 values tended to be greater, but besides measures of habitat quality in LPOS, no consistent patterns emerged in the explanation of social capital within or between regions. Social capital among landowners may depend on a mix of factors inherent in each individual that may be impossible to quantify. It is also possible that the proxies used to measure social capital were inadequate, and that other measures are needed.

The lack of relationships in our regression models for association priorities and activities precludes any meaningful insight into landowner characteristics, including social capital, as drivers of collective association activities. The diversity of goals, environmental settings, and landowner characteristics of WMAs in Texas makes comparisons difficult, and application of results over a wide area impossible. Grafton and Knowles (2003) found little or no relationship between national measures of civic social capital and environmental performance. Similarly, Flora (1998) concluded that though social capital was higher in some communities, it was difficult to generate collective action around important local issues. Mitraud (2001) laments that scholars are still unable to understand why social capital (trust and reciprocity) is an outcome of participation in some groups, and not others.

Results from this study suggest that in areas of poor habitat, small (<50 members) rather than large (>100) wildlife management associations may be more effective for building social capital. However, restricting association size may not be possible in rapidly fragmenting areas like the Post Oak Savannah of Texas. Conversely, where average property size approaches 80 ha per member, it may be possible to restore area-dependent species such as bobwhite quail (*Colinus virginianus*), with 25 or fewer association members, based on an average of about 2,000 ha for a viable population (Texas Quail Council 2005). As association membership increases with decreasing tract size, it may be necessary to conduct more meetings, and increase the methods of communication among members to build and maintain social capital. Cost share incentive programs, targeted at WMAs in priority areas, would significantly increase landowner participation and interest. Large-scale projects requiring multi-landowner collaboration could include native grassland restoration for quail, or brush control for enhanced water yields.

CHAPTER IV

MANAGING THE COMMONS TEXAS STYLE: WILDLIFE MANAGEMENT AND GROUNDWATER ASSOCIATIONS ON PRIVATE LANDS

SYNOPSIS

Since nearly all of Texas' rural lands are privately owned, landowner associations for the management of wildlife and groundwater have become increasingly popular. Deer are a common-pool resource with trans-boundary characteristics, requiring landowner cooperation for effective management. Sub-surface groundwater reserves are economically important to landowners, but are governed by the "rule of capture" whereby property rights are not defined. One groundwater association and 4 wildlife management associations were surveyed to characterize their member demographics, land use priorities, attitudes, and social capital. Members of the groundwater cooperative were part of a much larger, more heterogeneous, and more recently formed group than members of wildlife management associations. They also placed greater importance on utilitarian aspects of their properties, as opposed to land stewardship for conservation as practiced by members of wildlife management associations. If groundwater association members could be more locally organized with more frequent meetings, social capital and information sharing may be enhanced and lead to land stewardship practices for improved hydrologic functions and sustained groundwater supply. This, coupled with pumping rules assigned by the local groundwater district, could yield an effective

strategy that is ecologically and hydrologically sound, and that allows rural provision of water supply to urban consumers.

INTRODUCTION

Private farms and ranches in Texas account for more than 58 million ha – or approximately 84% of the state's land area. Accordingly, economic incentives and public/private partnerships for land, water, and wildlife are necessary as a part of public policy, if organized conservation programs are to have any impact. Traditionally, farming and ranching enterprises have been the dominant uses of rural land in Texas, but income from agriculture is declining. As traditional agricultural enterprises have lost profit potential, landowners have increasingly turned to the more lucrative business of leasing hunting rights on their property.

Recreational hunting leases are well-established in Texas, with the area under leases currently exceeding 8.5 million ha (J. Rivers, Texas Parks and Wildlife Department, unpublished report). As a result of the economic and social value of wildlife, landowners throughout the state have organized into multi-landowner groups for more effective management of their wildlife resources, especially white-tailed deer. To date, over 150 Wildlife Management Associations (WMAs) have been established across Texas with nearly 770,000 ha under such cooperative management (Texas Parks and Wildlife Department 2004). In prime deer habitat areas, revenue from hunting leases exceeds the agricultural production values from the land.

Texas also faces a daunting water supply problem, with a 43% shortfall predicted for 900 cities by 2050 unless new sources are developed (Kaiser 2004). The lack of regional or countywide water planning, unrestricted groundwater withdrawal rights, land subdivision and changing land ownership patterns, and economically adverse conditions for sustainable land management, pose serious obstacles for coordinated surface and groundwater management in Texas. The growing demand for rural water supplies has led to lucrative groundwater leases for landowners in areas with plentiful supplies. At least four private "water ranches" on over 200,000 ha have been formed in Texas to sell or lease significant amounts of groundwater to off-site users, principally cities (Texas Center for Policy Studies 2001, Brazos Valley Water Alliance 2005). Although relatively new to Texas, several such water ranches have been operating in Arizona for over a decade (McEntire 1989). In many parts of Texas, the calculated value of groundwater can exceed market values for farm and ranchland (Gilliland 2000, Mesa Water Inc. 2005).

Cooperative management of wildlife and groundwater in Texas represents interesting opportunities for research and policy development with potentially significant economic incentives for private landowners. The successful management of these resources depends upon the collective decision making of landowners at a landscape scale. At the same time, prudent land stewardship leads to resource sustainability, the cornerstone of WMA development. Unfortunately, this aspect has not been emphasized for water ranches, although it is no less important for providing clean, abundant water. Clearly articulating a land ethic for water provision is challenging because direct benefits are difficult to measure. As water demand outstrips aquifer replenishment however, enhancing aquifer recharge becomes more critical. Establishing a groundwater leasing system that not only rewards landowners for water found underneath their land, but compensates them for maintenance and improvement of aquifer supplies, may provide the impetus needed to conduct land conservation activities over a large area. This concept goes to the heart of valuing the products and services that functioning ecosystems provide, a critical ingredient missing in policy discussions in the state. Other complicating factors include a diverse array of social, environmental, and economic considerations affecting cooperative management of commonly held natural resources among multiple landowners over thousands of hectares.

Deer and Groundwater Management: Where's the Connection?

Although obviously different in nature, wildlife and groundwater represent two renewable common-pool resources with significant value to private landowners in Texas. While deer occur on the surface and groundwater lies beneath, they both transcend ownership boundaries – and therefore, some form of restraint must be used to avoid a "tragedy of the commons" scenario often associated with common-pool resources (Hardin 1968). The consequence of unrestricted use is overexploited or unbalanced deer herds for one resource and aquifer depletion for the other.

In Texas, white-tailed deer hunting is regulated by a central authority, the Texas Parks and Wildlife Department. Limits are placed on the number of deer a single hunter may harvest annually, but the number of hunters on a given tract of land is not regulated. Thus, in areas with small ownerships, over-harvest of deer can be a problem.

In contrast, acquisition and use of groundwater in Texas is governed by the "rule of capture", which allows landowners to withdraw unlimited groundwater as long as it is not "wasted". The term "rule of capture" originated with the idea that groundwater was like the "deer in the forest", whereby no person could own the deer unless it was physically captured (Blackstone 1766). However, unrestrained extraction of groundwater has caused a draw down of many aquifers resulting in saltwater intrusion, spring flow reduction, and land subsidence. In an attempt to prevent these problems, the Texas State Legislature began creating underground water conservation districts as early as 1949 (Urban 1992). However, due to funding and enforcement constraints, the effectiveness of the current 88 water districts is generally inadequate, except perhaps for the Edwards Underground Water District which has required pumping limits in order to protect Endangered Species (Votteler 1998).

In areas of Texas where wildlife management and groundwater management are jointly providing the natural resources for more lucrative enterprises, landowners may find that it is beneficial to collectively manage these resources. Through landowner cooperatives, self-imposed limits to resource extraction can be agreed upon to ensure sustainability while reaping economic benefits. While either wildlife or water may be of more importance to an individual landowner, the prospect of being able to jointly manage both resources requires stronger cooperation among landowners. Increased income from groundwater marketing and/or hunting rights may narrow the margin between the agricultural and market values of rural land while also managing economic risks through enterprise diversification. The resulting economic incentives may reduce the pervasive incentives to subdivide and sell lands in smaller parcels in order to capture the disparity between productivity and market values of rural farms and ranches, thereby reducing land fragmentation.

As described by Wagner and Kreuter (2004), local landowner associations could investigate the feasibility for self-monitoring and regulation under the authority of local groundwater conservation districts, which would set pumping limits and well placement based upon hydrologic models. In addition, such an approach would encourage landowners to implement management practices that enhance water conservation and supplies, maintain open space, and improve wildlife habitat, and it would facilitate coordinated land use planning. Open space protection and aquifer recharge through cooperative landowner associations is a new approach in managing Texas groundwater. To explore the feasibility of voluntary co-management of wildlife and water resources by landowner associations, I analyze an important factor related to group involvement – this is social capital among landowners.

Social Capital and Voluntary Associations

Social capital refers to the value of community engagement that leads to mutual benefits and cooperation (Putnam 1995, 1996, 2000). The importance of social capital in forming voluntary associations has been extensively studied by political scientist and sociologists (Coleman 1990; Putnam 1995, 1996, 2000; Flora 1998; Stolle 2001; Anheier and Kendall 2002). Measures of social capital include general and interpersonal trust, reciprocity, and civic participation (Coleman 1990, Tyler and Degoey 1995, Brehm and Rahn 1997, Hofferth and Iceland 1998, Molm et al. 2000, Putnam 2000).

Groundwater basin management in California was found to be successful due to the relationships, confidence, and trust among the rival users of a shared resource (Blomquist and Ingram 2003), while a lack of community caused by a large, heterogeneous user group led to failed cooperation in San Bernardino County, California (Taylor and Singleton 1993). A limited number of studies have investigated the effect of social capital on group management of natural resources (Pretty and Ward 2001, Leach et al. 2002, Pretty 2003). For example, increased social capital led to collective action in forest and watershed management in India (D'Silva and Pai 2003), and communal forest biodiversity conservation in Guatemala (Katz 2000). One of the largest efforts in group management of natural resources is Landcare, an Australian institution (Landcare 2005). Over 4,000 voluntary community groups have been formed in this country, involving 40% of the landowners who manage 60% of the land and 70% of the nation's diverted water. The program was so successful in fostering collaboration that the Australian government dedicated $159.5 million in support for a 4-year period beginning in 2004.

Pretty (2003) concludes that the benefits of social capital in managing the commons have been largely at the local to regional level, where resources can be "closed-access" and where institutional conditions and market pressures support local control. The social capital generated within voluntary associations may discourage "free-riding" within the group (Putnam 2000). Local control through voluntary associations may also temper the regulatory complexity from a central authority (Ehrenberg 2002). Others argue that when individuals produce economic capital for themselves, they cannot be expected to engage in altruistic behavior or social collectivity that Putman advocates (Schultz 2002). This is because market-based systems do not demand honorable actions, but instead lead to deteriorating social capital, declining reciprocity, and increased alienation (Steger 2002). Yet, some economists believe that social capital, particularly trust, reduces transaction costs, risk, and uncertainty while saving time in *ex ante* and *ex post* contracting activities (Wilson 2000).

Group size is also an important aspect of social capital building. As membership increases, it becomes more difficult to develop trust and reciprocity among members (Wuthnow 1994). Pretty and Ward (2001) note that most natural resource management groups with effective social capital are small, with 20-30 members. Ideally, group size should be no more than 15-20 people for maximum trust building (Wuthnow 1994).

Property owners seeking refuge in rural landscapes may generate social capital by sharing community-based natural resource values. The attraction of owning a piece of Texas' natural heritage draws people from urban as well as rural backgrounds, binding them to a common purpose in preserving a land-based culture rich with a historical legacy. This common purpose may be best fostered in the formation of various landowner associations centered around land, water, and wildlife conservation. The social interaction of members of these associations may further solidify a conservation ethic, and build upon civic participation, trust, and other values forming the foundation for social capital.

Research Purpose and Hypotheses

The purpose of this study was to ascertain the landowner characteristics, land use practices, conservation attitudes and social aspects of landowners within wildlife and groundwater associations. This information will provide insight into various institutional structures that foster the sustainable management of common pool resources in Texas. For example, if appropriate hydrogeologic models are combined with land and water conservation practices by private cooperatives, landowners within a groundwater district could pool or "unitize" their acreage to provide a sustainable supply of water, much like oil and gas production in Texas (Anderson and Snyder 1997, Libecap and Smith 1999, Freeman 2000).

I hypothesized that landowner groups can best manage common-pool natural resources when group size and heterogeneity are minimal. This will tend to elevate social capital, and possibly influence a land ethic within the group, leading to on-the-ground management for positive change on the landscape.

STUDY AREA

This study focuses on 4 WMAs, and the Brazos Valley Water Alliance (BVWA), a private groundwater cooperative situated in the central portion of the Post Oak Savannah Ecoregion (Figure 4.1). The 4 WMAs were: Alligator Creek WMA, Clear Creek WMA, Harvey WMA, and Mid Trinity Basin Conservation Cooperative. The Post Oak Savannah encompasses all or parts of 32 counties in the east-central portion of the state, occupying a total of almost 7 million ha of land, of which 55% is considered pastureland (United States Department of Agriculture 1997), dominated by bermudagrass, an exotic forage. The region is also situated between the largest metropolitan areas in the state: Dallas-Fort Worth, Houston, Austin, and San Antonio. As the population continues to grow, ownership sizes of land tracts are shrinking.

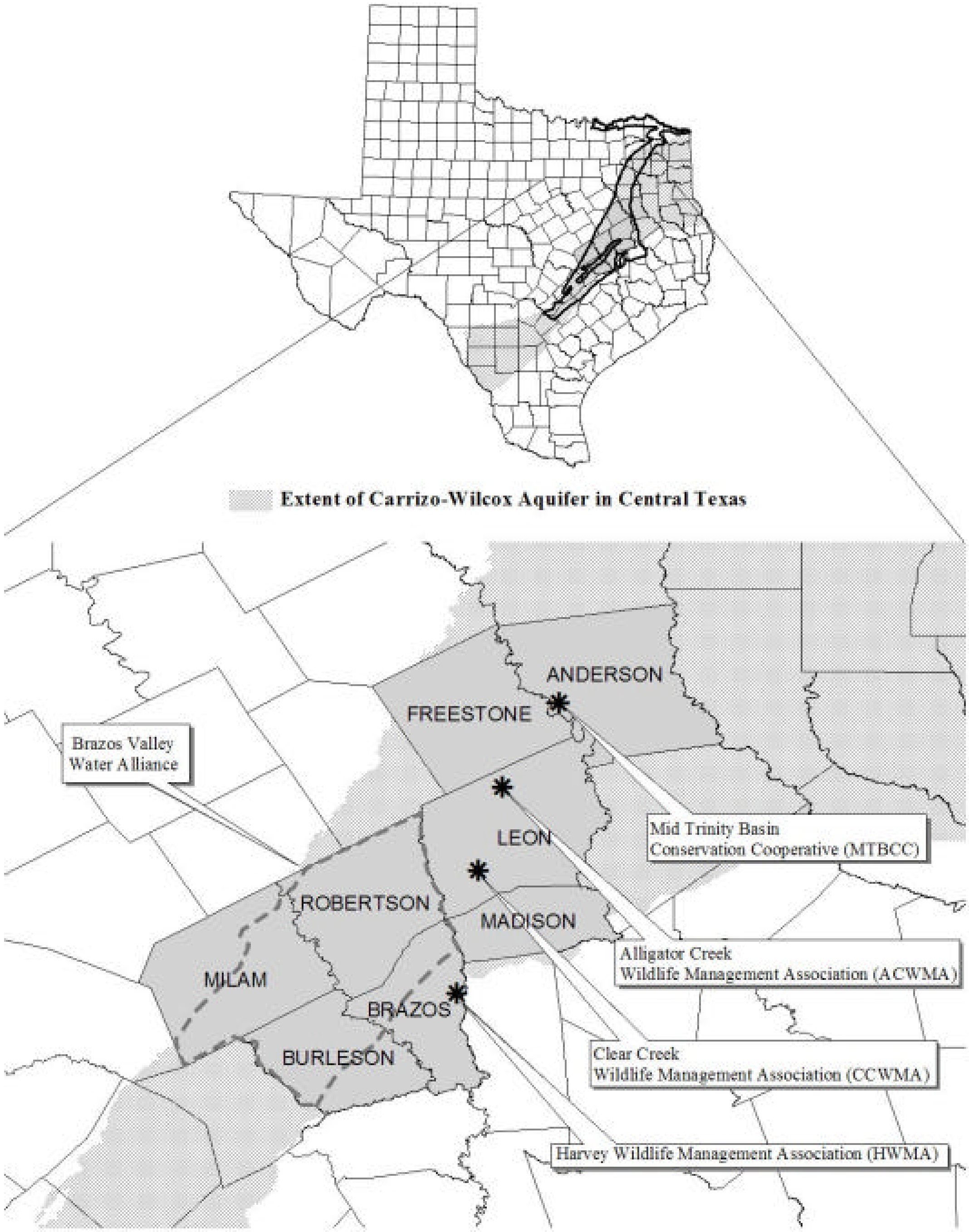

Figure 4.1. Locations of Brazos Valley Water Alliance and Four Wildlife Management Associations Within the Post Oak Savannah Ecoregion.

Smaller landholdings (less than 200 ha) are concentrated in this part of the state. The growth in demand for residential and recreational land has also led to a growth in coordinated wildlife management. As a result, the Post Oak Region has more wildlife associations today than any other ecoregion in Texas.

Most of the Post Oak Savannah is underlain by the Carrizo-Wilcox Aquifer, a relatively untapped groundwater resource (Figure 4.1). Effective recharge in the central portion of the aquifer is 97,600 acre-feet annually, about 2.7% of the mean annual rainfall over the outcrop area (Thorkildsen and Price 1991). Pumping for municipal and irrigation uses accounts for approximately 35% and 51% of total extraction, respectively (Texas Water Development Board 2002). Although water levels have declined in some areas, over 90% of the available groundwater in the Carrizo-Wilcox Aquifer is projected to remain by 2050. The surplus of groundwater available from the Carrizo-Wilcox has attracted water speculators to the area, enticing landowners to sell or lease their groundwater rights to prospective buyers. A number of water companies have formed rural water cooperatives, pooling hundreds of landowners in order to accumulate enough groundwater to market to offsite consumers. One example is the BVWA. This limited partnership is comprised of about 900 landowners in Brazos, Burleson, Milam and Robertson Counties (Brazos Valley Water Alliance 2005). Although not yet operational, groundwater leases specify a five-year term under which landowners would receive 10% royalty payments and 51% of the net profit from any water sales. Profits from the sale or lease of water rights would be divided among BVWA members based on property size or some other correlative measure. Governed by a board of managers, the BVWA hopes to eventually cover about 400,000 ha, with well drilling costs expected to exceed $100 million (Hipp 2002).

METHODS

We used a survey questionnaire designed to collect information about: 1) landowner and property characteristics of the associations; 2) land management practices and attitudes of association landowners that may contribute to enhanced groundwater management; and 3) characteristics of social capital (trust, reciprocity, and civic involvement) within the associations.

The survey was mailed to 200 randomly selected landowners within the 902-member BVWA, and all 137 landowners that were members of the 4 WMAs, following protocols of Dillman (2000). A pre-survey letter describing the study was mailed on September 28, 2004. On October 4, 2004, the survey instrument and cover letter were sent, followed by a reminder card 10 days later. A reminder letter and second questionnaire were sent on November 1, 2004, and a final reminder card 15 days later.

The survey instrument consisted of 21 questions divided into the following sections: A) property and land management characteristics – property size, years of ownership, land use priorities, land area affected by various land management practices, the number of water conservation practices, and the relative importance of maintaining riparian buffers and erosion control; B) groundwater issues - opinions on several separate issues; C) social interaction and civic participation - years as an association member, number of association meetings, intra-association trust and reciprocity, the number and involvement in various community groups, the percent of members related to each other in an association, an association success ranking in 3 categories, and the number of communication methods used; and D) socio-economic information - gender, year born, primary residence, education level, occupation, household income, and percent of income from property (see details in Appendix A).

Land use priorities, opinions on groundwater issues, trust, and reciprocity questions were Likert-scale ranked from 5 (responding very positively) to 1 (responding very negatively). Community involvement questions were similarly Likert-scale ranked, but with a range from 3 (very involved) to 0 (not involved). An Association Trust Index was created by averaging each respondent's level of agreement with 4 statements: 1) I know most members of my landowner association; 2) I meet with members outside of association activities; 3) There are many members I consider friends; and 4) I trust members of my landowner association. According to a Kendall's tau b correlation matrix, there was a strong correlation among the respondents' level of agreement with these statements, with a range of 0.325 ($p < 0.001$) to 0.657 ($p < 0.001$). An Association Reciprocity Index was created by summing and averaging each respondents agreement to the following 4 statements: 1) I would loan equipment to any member of my landowner association; 2) I would provide personal time to help at least one non-kin member of my association; 3) I would provide personal time to help any member of my association; and 4) I would lend money to any member of my association. Again, the respondents' level of agreement with these statements were significantly correlated, with a range from 0.162 ($p = 0.028$) to 0.518 ($p < 0.001$). Finally, a Civic Involvement Index was generated for each landowner by summing their level of involvement in each of 7 community organizations plus a category for “other”, ranging from very involved (3) to not involved (0) with the maximum score being 24.

Statistical analyses were conducted using SPSS 11.5. To compare the mean values between BVWA and WMAs, t-tests were conducted to detect differences between ordinal variables, or chi-square ($?^2$) in the case of categorical variables such as gender, education level, household income, percent of income from property, primary residence and occupation. Lavene's tests were conducted to check for equality of variance before mean comparisons.

Responses for property size and years of ownership were highly skewed with small values producing non-normally distributed data. The percent of land affected by all activities, and the percent of association members that were family-related, were also non-normally distributed due to the presence of zero values. For analyses, these variables were transformed to stabilize variance (ln and ln + 1, respectively). While I used transformed data for analyses, I present non-transformed values to facilitate interpretation. Means and standard errors are presented as follows: WMAs = $\bar{X}_{wm}$, SE BVWA = $\bar{X}_{bv}$, SE. Mean differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Of the 337 questionnaires, 160 were completed and returned for an overall response rate of useable questionnaires of 46.0% for BVWA and 49.6% for WMAs. Of the non-completed questionnaires, 6 did not reach their intended landowner due to insufficient or unknown address. Eleven questionnaires were returned blank or unintelligible.

A non-response bias survey was conducted for 8 landowners in BVWA and 5 landowners in WMAs by phone interview. Six questions were selected from the original questionnaire, including age and occupation, and 4 Likert-scale questions concerning land use priorities and the number of annual association meetings attended. For BVWA, no differences were detected in age ($p = 0.436$) or occupation (?^{2} = 0.987, df = 2, p = 0.611) between the original questionnaire respondents and phone interviewees. Of the remaining questions, no differences were detected in land use priorities in livestock management ($p = 0.849$), relaxation/leisure ($p = 0.313$), forage production for livestock ($p = 0.346$), weed control in agricultural fields ($p = 0.102$), or number of association meetings ($p = 0.927$). For WMAs, no differences were detected in age ($p = 0.140$), occupation (?^{2} = 1.020, df = 2, $p = 0.600$), relaxation ($p = 0.701$), or weed control (p = 0.515). However, phone interviewees considered livestock management more important ($t = -4.049$, $p = 0.001$), forage production more important ($t = -6.649$, $p < 0.001$), and responded that their association met more often ($t = -13.933$, $p < 0.001$) than the questionnaire respondents. This difference may be partially explained by the low sample size of phone interviewees.

Landowner Characteristics

Landowners within the BVWA were part of a much larger group ($\bar{X}_{bv} = 902$ members) than WMAs ($\bar{X}_{wm} = 34$). This was due to the fact that these landowners owned smaller properties ($\bar{X}_{bv} = 114.5$ ha, SE = 14.3 ha compared to $\bar{X}_{wm} = 469.4$, SE = 139.2, $t = -3.346$, $p < 0.001$), and that the target area for BVWA covered multiple counties. The BVWA was also more heterogeneous with a higher percent of females

($\bar{X}_{bv}$ = 28.7% compared to $\bar{X}_{wm}$ = 0.5%, $?^2$ = 14.937, df = 1, $p < 0.001$) and a lower percent of related members ($\bar{X}_{bv}$ = 0.20% compared to $\bar{X}_{wm}$ = 2.1%, t = -2.882, p = 0.005). Members of BVWA were on average older ($\bar{X}_{bv}$ = 65, SE = 1.3 years compared to $\bar{X}_{wm}$ = 58, SE = 1.6, t = -3.370, p = 0.001), and more were retired, while more WMA landowners held professional jobs (Table 4.1).

Members of both associations were highly educated, with an average of 75% having attended college and about 30% had post-graduate degrees (Table 4.1). For WMA members, more than twice the percentage of BVWA members earned over $100,000, and about half of all landowners in both associations earned over $75,000. About 70% of the landowners in both groups earned less than 10% of their income from the land. About 45% of BVWA and WMA members lived on their properties. Those living in a town < 10,000 or urban area > 10,000 were 9.3% and 45.3% for BVWA and 13.3% and 41.7% for WMAs, respectively.

Association Activities

Landowners in BVWA tended to own their properties for a longer period of time than WMA members ($\bar{X}_{bv}$ = 52.8, SE = 4.1 years, $\bar{X}_{wm}$ = 44.3, SE = 4.7, t = 1.726, p = 0.086), but had less longevity in association membership ($\bar{X}_{bv}$ = 2.1, SE = 0.1 years, $\bar{X}_{wm}$ = 3.1, SE = 0.2, t = -4.698, $p < 0.001$) and fewer communication methods ($\bar{X}_{bv}$ = 2.6, SE = 0.2, $\bar{X}_{wm}$ = 3.6, SE = 0.2, t = -3.189, p = 0.002). BVWA rated the success of organizational leadership lower than WMAs ($\bar{X}_{bv}$ = 3.4, SE = 0.1, $\bar{X}_{wm}$ = 4.2, SE =

Table 4.1. Occupation, education, income, and primary residence (%) of landowners in the BVWA and WMAs in the Post Oak Savannah, Texas

	BVWA	WMAs
Occupation (%) ($?^2$ = 4.696, df = 2, p = 0.096)	n = 70	n = 48
Agriculture	14.3	14.6
Professional	31.4	50.0
Retired	54.3	35.4
Education (%) ($?^2$ = 3.734, df = 4, p = 0.443)	n = 85	n = 62
Less than High school	4.7	0.0
High school graduate	21.2	22.6
Some college	15.3	21.0
Bachelor degree	28.2	29.0
Post-graduate degree	30.6	27.4
Annual income (%) ($?^2$ = 7.447, df = 4, p = 0.114)	n = 83	n = 61
Less than $25,000	10.8	6.6
$25,000 - 49,999	27.7	21.3
$50,000 - 74,999	18.1	16.4
$75,000 - 99,999	24.1	16.4
More than $100,000	19.3	39.3
Primary residence (%) ($?^2$ = 0.583, df = 2, p = 0.747)	n = 75	n = 60
On Property	45.3	45.0
In Town < 10,000	9.3	13.3
In Urban > 10,000	45.3	41.7

0.1, $t = -5.616$, $p < 0.001$), which may be related to the larger group size and greater heterogeneity. There was no difference in the number of association meetings, averaging between once and twice per year, for both types of associations ($t = 0.160$, $p = 0.873$).

Fewer water conservation activities, (i.e. stream side buffers, excluding livestock from stream sides, and increased water infiltration), were conducted in BVWA compared to WMAs ($\bar{X}_{bv} = 1.2$, SE = 0.1, $\bar{X}_{wm} = 1.8$, SE = 0.2, $t = -2.464$, $p = 0.015$). Table 4.2 provides information explaining landowners' involvement in 3 land conservation practices: native plant restoration, brush control, and erosion control. The rows show the overall mean percent of land affected, the percent of respondents indicating that they implemented each practice, and the percent and area of land affected by each practice among the respondents. When comparing overall responses, native plant restoration was conducted on a smaller ($p = 0.002$) percentage of land area by BVWA members than WMA members. Overall, brush control was practiced on over twice the percentage of land for BVWA members than WMA members, but ln +1 transformed data were not found to differ significantly for brush control nor for erosion control. About 30% of respondents in WMAs indicated they practiced native plant restoration and erosion control, compared to about 10% and 19%, respectively, for BVWA respondents, but the average percentage and acreage of land on each respondent's property affected by these treatments did not differ statistically among WMA and BVWA members. About half of respondents for both WMAs and BVWA reported that they practice brush control. Although the average percent of land affected

Table 4.2. Means and (SE) for overall percent of land affected by three land management activities, percent of respondents answering that they used each practice, and the percent and area (ha) of land affected by use of each practice. (* data was [ln + 1] transformed prior to analysis. ** data was [ln] transformed prior to analysis).

	Native Plant Restoration				Brush Control				Erosion Control			
	BVWA	WMAs	t or ?^{2}	P	BVWA	WMAs	t or ?^{2}	p	BVWA	WMAs	t or ?^{2}	p
Overall % of land affected *	2.7 (1.3)	11.4 (3.1)	-3.135 (t)	0.002	17.9 (3.1)	7.7 (1.7)	1.400 (t)	0.164	5.5 (2.1)	4.5 (2.2)	-0.370 (t)	0.712
% respondents indicating use of practice	10.5	32.3	11.094 (?^{2})	0.001	50.0	56.3	0.569 (?^{2})	0.451	18.8	30.8	2.882 (?^{2})	0.090
% of land affected by use of practice	25.6(10.3)	35.2(7.1)	0.756 (t)	0.456	35.7(4.7)	13.6(2.6)	-4.101 (t)	< 0.001	29.4(9.3)	14.6(6.6)	-1.338 (t)	0.190
Area of land affected by use of practice **	51.2(30.5)	62.3(18.2)	0.683 (t)	0.500	46.0(10.0)	87.1(40.2)	-1.232 (t)	0.222	34.3(12.6)	67.1 (50.2)	-1.631 (t)	0.112

by brush control was greater ($p < 0.001$) among BVWA members, the acreage of land affected by brush control did not differ between the 2 groups. Accounting for this result was the smaller overall acreage size of BVWA properties, combined with a high degree of variability and relatively small “positive response” sample sizes.

Land use and management priorities for landowners within both association types are shown in Table 4.3. Revegetation for erosion control was somewhat important for both BVWA and WMA members, and did not differ, but maintenance of buffer strips along stream sides was less important to BVWA than to WMA members. By contrast, members of BVWA ranked livestock production higher than those in WMAs, as well as farming/hay production, and mineral extraction. Relaxation and leisure uses of the land ranked lower on BVWA. BVWA members rated overall conditions for rainfall infiltration lower ($\bar{X}_{bv} = 2.7$, SE = 0.1, $\bar{X}_{wm} = 3.4$, SE = 0.1, $t = -3.881$, $p < 0.001$) and improved conditions for erosion control lower ($\bar{X}_{bv} = 2.9$, SE = 0.1, $\bar{X}_{wm} = 3.4$, SE = 0.1, $t = -2.716$, $p = 0.008$) than WMAs.

Fewer water conservation activities, less native plant restoration, and less importance on maintaining riparian buffer areas characterized the BVWA, yet these are important land stewardship practices for maintaining an optimum water cycle on private property. In addition, both BVWA and WMA members practice brush control, another practice with major implications for groundwater recharge, especially in areas with over 18 inches of annual rainfall (Thurow 1998). Since BVWA members are more interested in livestock production and farming/haying operations, it seems likely that these

Table 4.3. Importance of various land use or management priorities ($\bar{X}$ and [SE]) for members of BVWA and WMAs. (1 = very unimportant, 2 = somewhat unimportant, 3 = undecided, 4 = somewhat important, 5 = very important).

Land use/management priority	BVWA	WMAs	t	p
Erosion control	4.0 (0.1)	4.1 (0.1)	-0.422	0.674
Buffer strips	3.0 (0.1)	3.5 (0.1)	-2.386	0.018
Livestock production	4.6 (0.1)	3.6 (0.2)	4.387	< 0.001
Farming/hay production	3.7 (0.2)	3.0 (0.2)	2.626	0.010
Mineral extraction	4.1 (0.1)	3.1 (0.2)	4.028	< 0.001
Relaxation/leisure	3.7 (0.1)	4.5 (0.1)	-4.164	< 0.001

members may practice brush control for purposes of expanding their agricultural operations rather than to improve the water conservation and wildlife habitat values of their properties. Perhaps more important than the total amount of brush control being conducted, are the target species, location, and configuration of the practice. This "strategic" approach to brush control would take into consideration soil type, topography, and wildlife concerns to restore ecosystem functions. From their higher priorities on non-agricultural land uses, it is assumed that WMA members were more sensitive to these considerations, but further research is needed.

From the prior results, it appears that BVWA members were motivated more by utilitarian and economic objectives of their properties as opposed to land stewardship for the less tangible amenities of wildlife habitat, water conservation and recreational uses.

That is not to say that these latter values could not be enhanced among BVWA members if community education, combined with possible cost-sharing incentives were provided through public agencies. WMA members placed a higher priority on maintaining the natural values of their properties, practiced more water conservation practices, and had greater organizational leadership. As a result, these associations rated conditions for rainfall infiltration and erosion control higher than BVWA members.

Education efforts through print media and regular workshops could lead to increased information sharing among BVWA members to promote a greater land ethic, and fill the knowledge gap between groundwater extraction and land stewardship. This is not only important in identifying non-market assets of land, but in developing a conservation ethic that may yield sustainable ecosystem services with significant economic potential.

Groundwater Issues

Landowners in both types of associations were asked their opinion about 15 groundwater issues. BVWA respondents had more favorable opinions on all the issues, and all but 5 were significantly different than WMAs (Table 4.4). BVWA members were significantly more favorable than WMAs members towards the following issues: The buying and selling of groundwater, a landowner's right to buy groundwater, a neighbor's right to buy groundwater, a landowner's right to sell groundwater, a neighbor's right to sell groundwater, the transfer of groundwater from rural to urban uses, evaluating the economic impacts of groundwater transfers, a permit system for groundwater pumping for non-domestic uses, private "groundwater cooperatives" for water marketing, and groundwater pumping based on sustainable yield from an aquifer. In addition, both BVWA and WMAs members were between “undecided” and “somewhat favorable” in their opinions regarding the “rule of capture”, and did not differ. Both types of associations were similarly favorable towards evaluating the ecological and social impacts of groundwater transfers, but both were less favorable toward state and local government oversight of groundwater issues.

While both BVWA and WMA members were slightly receptive toward the rule of capture, they shared less favorable feelings towards state and local government oversight of groundwater resources. This leaves open the possibility of regulating groundwater marketing and extraction through landowner associations with groundwater district oversight, as a potential solution to locally controlled water supply problems. At the same time, both associations hold similar concerns about the ecological and social impacts of groundwater transfers. BVWA members were quite favorable towards groundwater pumping based on sustainable yield. Since sustainable yield is contingent upon adequate recharge to the aquifer, it is critical that landowners understand the relationship of land management on groundwater supply. This is especially true as demands placed on the aquifer water increase over time. Information sharing through regular meetings and other forms of communication would serve to foster education and greater awareness of this relationship. BVWA members were more receptive than WMA members to a pumping permit system for non-domestic uses. The BVWA could assign private rights to groundwater through a transferable permit system, thus establishing a market approach to water supply to meet growing urban demand. A similar system is

Table 4.4. Landowner opinions ($\bar{X}$ and [SE]) of groundwater issues. (1 = very unfavorable, 2 = somewhat unfavorable, 3 = undecided, 4 = somewhat favorable, 5 = very unfavorable).

Opinions on groundwater issues	BVWA	WMAs	t	p
Rule of capture	3.5 (0.2)	3.4 (0.1)	0.238	0.812
Purchase and sale of groundwater	4.2 (0.1)	2.6 (0.2)	8.289	< 0.001
Your right to buy groundwater	3.7 (0.1)	3.0 (0.2)	3.557	0.001
Your right to sell groundwater	4.4 (0.1)	3.2 (0.2)	6.717	< 0.001
Your neighbor's right to buy groundwater	4.0 (0.1)	3.1 (0.2)	4.906	< 0.001
Your neighbor's right to sell groundwater	4.1 (0.1)	3.0 (0.2)	5.607	< 0.001
The transfer of groundwater from rural to urban uses	3.8 (0.1)	2.4 (0.2)	6.463	< 0.001
Evaluating economic impacts of groundwater transfers	4.2 (0.1)	3.6 (0.2)	3.142	0.002
Evaluating ecological impacts of groundwater transfers	4.0 (0.1)	3.9 (0.1)	0.915	0.362
Evaluating social impacts of groundwater transfers	4.0 (0.1)	3.7 (0.2)	1.136	0.258
State government oversight of groundwater issues	3.0 (0.2)	2.7 (0.2)	1.338	0.183
Local government oversight of groundwater issues	3.1 (0.2)	2.8 (0.2)	1.643	0.102
A permit system for non-domestic groundwater pumping	3.4 (0.2)	2.7 (0.2)	3.017	0.003
Private groundwater cooperatives for water marketing	4.1 (0.1)	2.9 (0.2)	5.750	< 0.001
Groundwater pumping based on sustainable yield	4.2 (0.1)	3.4 (0.2)	4.470	< 0.001

already in place for the Edwards Aquifer (Edwards Aquifer Authority 2005). Provencher (1993) stated that a private property rights regime for groundwater is a promising and practical alternative to traditional means of groundwater management, and is consistent with the emergence of markets for surface water.

Social Capital

All three measures of social capital were lower in BVWA than WMAs, including trust ($\bar{X}_{bv} = 2.6$, SE = 0.1, $\bar{X}_{wm} = 3.6$, SE = 0.1, $t = -6.057$, $p < 0.001$), reciprocity ($\bar{X}_{bv} = 2.5$, SE = 0.1, $\bar{X}_{wm} = 3.4$, SE = 0.1, $t = -6.865$, $p < 0.001$), and civic involvement ($\bar{X}_{bv} = 5.7$, SE = 0.4, $\bar{X}_{wm} = 8.2$, SE = 0.7, $t = -3.157$, $p = 0.002$). These results may be explained by the observation that group size and heterogeneity are negatively related to social capital (Kerr 1989, Levine and Moreland 1990, Taylor and Singleton 1993, Wuthnow 1994, Halpern 2005), while association longevity is positively related to social capital (Stolle 2001, Leach et al. 2002). BVWA was much larger, more heterogeneous, and had more recent members than each of the 4 WMAs. The dilemma is that common-pool resource associations are formed around large natural features (i.e. watersheds, aquifers, and wildlife habitat), while most successful voluntary associations are formed around small, homogenous groups of individuals. In large organizations, it may be necessary to increase the number of meetings and means of communication in order to generate social capital, leading to stronger intra-group relations and possibly a stronger conservation ethic. Or, as advocated by Kerr (1989), it may be necessary to subdivide the BVWA into smaller groups, possibly representing more localized areas with more defined endemic conditions. This would reduce group size, further enhancing social capital. Another important aspect of social capital building is longevity of relationships. Leach et al. (2002) state that it typically takes 4-6 years for watershed partnerships to fully educate participants, overcome distrust, and reach agreements.

CHAPTER V

CONCLUSIONS

Traditional agriculture operations are struggling to remain viable, while new landowners are interested in the value of the wildlife and water resources on their properties. This creates simultaneous challenges and opportunities that beg for a unified and locally controlled approach to land conservation. Land use decisions occur in the context of economic constraints, private property rights, and the changing values of new property owners. Added to this mix are a rapidly changing socio-economic population and accelerating land fragmentation. On small tracts, hunting rights and groundwater marketing are economic incentives that require collective decision making among landowners in order to insure sustainable use. New approaches to common-pool resource management are needed.

Voluntary associations of landowners engaged in cooperative wildlife management are one approach with significant potential for improving populations of white-tailed deer. Lower quality habitat and highly fragmented ownerships may reduce deer abundance, prompting landowners to pool their ownerships and make management decisions collectively to increase deer numbers. In areas with existing high deer numbers, shared values of landowners wishing to improve herd quality may prompt landowners to organize and set harvest management guidelines, but this may require a higher level of social capital.

The different conditions for WMA formation reflect different needs according to land ownership and use patterns. Social capital may be generated from the shared values of local landowners, but trust and reciprocity relationships are enhanced through regular contact of association members. Small (< 50 members) rather than large (>100) associations are best suited for building social capital, but this may not be feasible in areas of small land ownership. When membership becomes too large, it may be advantageous to increase the number of association meetings, increase the means of communication, or reduce group size in order to increase social capital that is associated with stronger intra-group relations.

In addition to group size, other factors play a role in social capital building among landowners within WMAs. Those factors include longevity of property ownership, gender homogeneity, frequency of meetings, and years as an association member. Social capital may be negatively impacted by an increase in absentee landowners, or those in distant, professional positions who might be less familiar with and trusting of neighbors than local landowners engaged in agriculture. Another dampening effect on social capital, particularly trust, could be the relative abundance of heavily timbered habitat in an open pasture dominated region. First, locally wooded environments may create visual and psychological barriers to community involvement, although more research is needed in this area. Secondly, the elevated deer densities associated with wooded habitats may possibly decrease the perceived need for landowners to cooperate to improve deer numbers. Once high deer numbers are achieved, collective management to improve herd quality may require high levels of social capital, particularly trust, which is best achieved in small, homogeneous associations.

Disappointingly, our study did not reveal any consistent causal relationships between an increase in social capital and an increase in association priorities or activities. It is quite possible that the diversity of landowner characteristics and property settings inherent in each WMA precluded identification of adequate independent variables in our model. It is also possible that the proxies used to measure social capital were inadequate, and that other measures are needed.

Comparisons between WMAs and groundwater associations may lead to understanding the shared interests of landowners in managing common pool resources. Members of BVWA belonged to a newer, much larger, and more heterogeneous group than WMA members. They were, on average, also older, tended to be retired, and owned their properties for a longer period of time. They were more interested in livestock production, farming/hay production, and mineral extraction, while WMA landowners held more professional jobs and placed a higher priority on relaxation and leisure uses of their properties. Members of both associations were highly educated, and had high incomes on average. Somewhat less than half of both association members lived on their properties, with the other half residing in towns or more urban areas.

Although both types of associations met about the same number of times annually (between once and twice per year), WMA members had more communication methods and a higher ranking of organizational leadership. WMA members also had higher social capital.

WMA members placed a higher emphasis on water conservation practices on their lands, suggesting a higher sense of the non-market values of land ownership. It is uncertain if higher social capital leads to better land and water management, or if land stewardship is a product of the shared values of landowners that existed prior to association formation. In any case, regular communication and frequent face-face interaction among members of both types of associations would likely lead to a greater sense of community that may lead to long term resource protection and sustainable use.

Members of both BVWA and WMAs were mostly undecided about how they felt about the "rule of capture", but were less favorable towards state and local government control of groundwater supplies. BVWA members were more receptive to the ideas of sustainable aquifer use and a pumping permit system than WMA members. This leads to the possibility of privatization of groundwater through landowner cooperatives. If the link between land stewardship, water conservation and sustainable aquifer pumping can be made, landowners may be more receptive to land practices that insure adequate recharge over time. This is especially true as water supplies become scarcer and their economic value grows. Coupled with increased social capital through regular meetings and educational programs, members of groundwater associations may develop a sense of community responsibility for valuable aquifer supplies. Finally, existing state and federal cost share programs for land stewardship would allow landowners in common-pool associations to enhance aquifer recharge and open space protection on a landscape scale, in effect reversing the trend of land fragmentation.

Opportunities for direct landowner involvement in watershed management and protection of groundwater resources exist within the framework of wildlife management associations, water cooperatives or similar local private partnerships. Landowner groups can best manage common-pool natural resources when group size and heterogeneity are limited, and strong inter-personal relationships are secured over time. This will likely elevate social capital and possibly influence a land ethic leading to on-the-ground management for conserving the state's water and wildlife resources. Following the cooperative model for groundwater pumping in combination with the transfer of water rights for economic purposes, landowners may be able to organize for sustained aquifer use, while maintaining recharge, open space, and their rural lifestyles. This may reduce the deleterious effects of land fragmentation on groundwater use under the "rule of capture" law. Locally controlled resource management, fostered by a sense of community and social capital, places the benefits and responsibilities of resource use in the hands of participating landowners.

To be successful, groundwater transfers must fit onto existing institutional and legal frameworks though local water districts. New legislation may help or hinder this process. For nearly 100 years, the "rule of capture" has survived attempts to regulate groundwater use in Texas. Although government oversight and technical assistance is vital, a carefully-crafted free-market system based on private rights to a communal resource is likely to become increasingly important as water scarcity and increasing land fragmentation unites property owners to determine the fate of groundwater supply and open spaces in Texas. Sustainable groundwater marketing may provide an economic incentive to prevent land fragmentation, maintain open space and wildlife habitat, protect the recharge zone, and limit the number of water wells drilled in the future, thereby protecting aquifer sustainability.

LIMITATIONS AND FUTURE WORK

More research is needed in the area of social capital and natural resource management on private lands. The field is severely lacking in the study of shared values and relationships of landowners engaged in cooperative resource management under changing physical, biological, and economic conditions over time. In particular, more research is needed to describe the relationship between intra-association social capital, and changing habitat conditions and deer populations. As habitat cover increases, does social capital decrease as a result of visual and psychological barriers to social interaction? How does social capital change as deer density and herd quality moves from low to high? How important are measures of social capital to association form and function, and are better measures needed? Is social capital important in managing other common-pool resources such as groundwater, or are the financial rewards of water marketing enough for collective action? And finally, can land stewardship be fostered through social interaction and information sharing, or are land ethics based on individual beliefs? These are the questions for future researchers to address. To be certain, land fragmentation, loss of habitat, and water supply will continue to be important issues. Only by encouraging innovative approaches to conservation on private lands will these problems be solved. The future is in the hands of those who own the land, while environmental policy is influenced by urban constituencies. Wildlife and water supply may be the link that binds these factions to a common cause. White-tailed deer are a classic example of a common property resource with significant value to landowners. If landowner motivation in improving this resource can be better understood, association building around other common property resources, such as water supply, may be possible.

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APPENDIX A

QUESTIONNAIRE FOR MEMBERS OF TEXAS LANDOWNER ASSOCIATIONS

In answering the following questions, please provide answers for the land for which you pay property taxes, and which is within the landowner association you are a member of (identified below). Please **do not** include property outside your association. **If you own several tracts of land within the association, please answer the questions based on all of your landholdings within the association.**

SECTION A. PROPERTY AND LAND MANAGEMENT CHARACTERISICS

A1. Which of the following landowner associations are you a member of ? (check one):

? Alligator Creek Wildlife Management Association (Leon County)

? Barton’s Creek Wildlife Management Association (Bastrop and Fayette counties)

? Brazos Valley Water Alliance (Brazos, Burleson, Milam and Robertson counties)

? Clear Creek Wildlife Management Association (Leon County)

? Harvey Wildlife Management Association (Brazos County)

? Mid Trinity Basin Conservation Cooperative (Anderson, Freestone, and Navarro counties)

? Pin Oak Creek Wildlife Management Association (Bastrop County)

? Red Rock Wildlife Management Association (Bastrop County)

? Tri-Community Wildlife Management Association (Caldwell County)

A2. How many acres within your landowner association do you own? _______

A3. How many years have you or your family owned this acreage? (If multiple tracts are owned, please provide the longest period of time) _______

A4. Approximately what percent of your total acreage is comprised of: (Please ensure that your percentages total 100%)

_______ % Non-flooded native rangeland _______% Non-flooded timberland

_______% Bottomland timber (flood-prone) _______% Bottomland pasture (flood prone)

_______% Open water wetlands (sloughs, Lakes, marsh, etc) _______% Cropland

_______% Improved forage pasture (bermudagrass, bahiagrass, K-R bluestem, etc)

A5. Please check your land use priorities for each category below. (Please check only one box per row).

	Very Important	Somewhat Important	Undecided	Somewhat Unimportant	Very Unimportant
Wildlife management	?	?	?	?	?
Livestock production	?	?	?	?	?
Farming/hay production	?	?	?	?	?
Relaxation/leisure	?	?	?	?	?
Nature tourism/recreation	?	?	?	?	?
Lease hunting	?	?	?	?	?
Non-lease hunting	?	?	?	?	?
Scenic beauty	?	?	?	?	?
Place to live	?	?	?	?	?
Investment	?	?	?	?	?
Commercial/residential development	?	?	?	?	?
Mineral extraction	?	?	?	?	?
Other (please describe below)	?	?	?	?	?

____

A6. Please check how you would rate your landowner association in each of the following categories.

(Please check only one box per row).

	Very Successful	Somewhat Successful	Undecided	Somewhat Unsuccessful	Very Unsuccessful
Organizational leadership	?	?	?	?	?
Regular meetings	?	?	?	?	?
Communication (newsletter, website, etc)	?	?	?	?	?
Improved quantity of white-tailed deer	?	?	?	?	?
Improved quality of white-tailed deer	?	?	?	?	?
Improved habitat for other game species	?	?	?	?	?
Improved habitat for nongame species	?	?	?	?	?
Improved condition for rainfall infiltration	?	?	?	?	?
Improved condition for erosion control	?	?	?	?	?

A7. Please indicate the approximate number of acres affected on your property in the last 12 months by each of the following land management activities:

_____ Rotational grazing

_____ Controlled burning

_____ Native plant restoration

_____ Overseeding improved pasture with winter cover crops

_____ Wildlife food plots

_____ Mechanical or chemical brush control

_____ Erosion control

_____ Disking to produce wildlife foods

_____ Other

____

____

A8. Please indicate whether you have used the following wildlife management activities on your property in the last 12 months. (Check all that apply)

_____ Pond construction

_____ Shallow water impoundment for wildlife

_____ Coyote control

_____ Feral hog control

_____ Fire ant control

_____ Deer counts

_____ Deer harvest records

_____ Selective buck harvest

_____ Selective doe harvest

_____ Provide supplemental shelter (brush piles, nest boxes, etc.)

_____ Other

____

____

A9. Have you previously, or are you currently participating in any of the fo llowing federal or state funded land improvement programs? (Please check only one box per row)

	Am currently	Have in the past	Never
Environmental Quality Incentives Program (EQIP)	?	?	?
Conservation Reserve Program (CRP)	?	?	?
Wildlife Habitat Incentives Program (WHIP)	?	?	?
Wetland Reserve Program (WRP)	?	?	?
Partners for Wildlife	?	?	?
Landowner Incentive Program (LIP)	?	?	?
Pastures for Upland Birds Program (PUB)	?	?	?
Other (Please describe below)	?	?	?

A10. Please indicate your willingness to participate in each of the following land conservation programs: (Please check only one box per row).

	Very Willing	Somewhat Willing	Undecided	Somewhat Unwilling	Very Unwilling	Not Familiar
Conservation easements	?	?	?	?	?	?
Mitigation banking	?	?	?	?	?	?
Carbon sequestration	?	?	?	?	?	?

SECTION B WATER CONSERVATION ISSUES

B1. Which of the following practices for water conservation do you use? (Check all that apply)

_____ Terraces

_____ Vegetation management for increased water infiltration

_____ Shaped waterways (drainages)

_____ Exclude livestock from stream sides

_____ Rainwater harvesting

_____ Stream side buffer areas (vegetated waterways)

_____ Grey water re-use

_____ Reseeding with native plants

_____ Conservation tillage (e.g. no till planting, contour planting. etc)

_____ Other

____

____

B2. Please check the importance of each of the following issues when considering land management practices: (Please check only one box per row).

	Very Important	Somewhat Important	Undecided	Somewhat Unimportant	Very Unimportant
Improve ground and surface water quantity for your land	?	?	?	?	?
Improve ground and surface water quantity downstream	?	?	?	?	?
Maintain buffers along stream side areas	?	?	?	?	?
Revegetation for erosion control	?	?	?	?	?
Improve forage quantity for livestock	?	?	?	?	?
Control of weeds in agriculture fields	?	?	?	?	?
Improve wildlife habitat	?	?	?	?	?
Improve real estate value	?	?	?	?	?
Improve aesthetic value	?	?	?	?	?
Treatment cost	?	?	?	?	?

B3. Please check your opinion regarding each of the following groundwater issues: (Please check only one box per row).

	Very Favorable	Somewhat Favorable	Undecided	Somewhat Unfavorable	Very Unfavorable
The "rule of capture"	?	?	?	?	?
The purchase and sale of groundwater in general	?	?	?	?	?
Your right to buy groundwater	?	?	?	?	?
Your right to sell groundwater	?	?	?	?	?
Your neighbor's right to buy groundwater	?	?	?	?	?
Your neighbor's right to sell groundwater	?	?	?	?	?
The transfer of groundwater from rural to urban uses	?	?	?	?	?
Evaluating economic impacts of groundwater transfers	?	?	?	?	?
Evaluating ecological impacts of groundwater transfers	?	?	?	?	?
Evaluating social impacts of groundwater transfers	?	?	?	?	?
State government oversight of groundwater issues	?	?	?	?	?
Local government oversight of groundwater issues	?	?	?	?	?
A permit system for groundwater pumping for non-domestic use	?	?	?	?	?
Private "groundwater co-operatives" for water marketing	?	?	?	?	?
Groundwater pumping based on sustainable yield from an aquifer	?	?	?	?	?

SECTION C LANDOWNER ASSOCIATION AND CIVIC PARTICIPATION

C1. How many years have you been a member of your landowner association? __________

C2. How often does your landowner association meet? (please check one)

_____ Less than once per year   _____ Once per year

_____ Twice per year   _____ Three or more times per year

C3. How involved are you and/or your spouse (if applicable) in each of the following types of community organizations? (Please check only one box per row)

	Very Involved	Somewhat Involved	Not Involved
Church groups	?	?	?
Civic organizations (Rotary, Jaycees, Lions, etc.)	?	?	?
Athletic/recreation groups (softball, soccer, card games, etc.)	?	?	?
Education/school groups (PTA, boosters, etc.)	?	?	?
Youth-oriented groups (4-H, scouts, etc.)	?	?	?
Community government (city, county commissions, etc.)	?	?	?
Ranch/farm organizations (Farm Bureau, Cattlemans Assn, etc.)	?	?	?
Other (please describe below)	?	?	?

C4. Approximately how many meetings of the organizations listed above do you attend annually? (please exclude weekly church services)

_____ Less than one per year _____ About 1-2 per year

_____ About 3-6 per year _____ About 7-12 per year

_____ More than 12 per year

C5. In which of the following natural resource organizations are you a member? (check all that apply)

_____ Ducks Unlimited _____ National Wild Turkey Federation

_____ Quail Unlimited _____ Coastal Conservation Association

_____ Sierra Club _____ The Nature Conservancy

_____ National Wildlife Federation _____ Audubon Society

_____ Soil and Water Conservation District _____ Texas Wildlife Association

_____ Texas Deer Association _____ The Wildlife Society

_____ Society for Range Management

_____ Other

____

____

C6. Approximately how many meetings of the organizations listed above do you attend annually?

_____ Less than one per year _____ About 1-2 per year

_____ About 3-6 per year _____ About 7-12 per year

_____ More than 12 per year

C7. Which of the following positions have you held inside your landowner association within the last 5 years? (check all that apply)

_____ President _____ Vice President _____ Director

_____ Secretary _____ Treasurer _____ Committee Chair

_____ Committee Member _____ No positions held

_____ Other

____

____

C8. Which of the following positions have you held in groups other than your landowner association within the last 5 years? (check all that apply)

_____ President _____ Vice President _____ Director

_____ Secretary _____ Treasurer _____ Committee Chair

_____ Committee Member _____ No positions held

_____ Other

____

____

C9. Please check your level of agreement with each of the following statements: (Please check only one box per row).

	Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree
Generally speaking, most people can be trusted	?	?	?	?	?
I know most of the members of my landowner association	?	?	?	?	?
I meet with members of my landowner association outside of assoc activities	?	?	?	?	?
There are many members of my landowner association I consider friends	?	?	?	?	?
I trust members of my landowner association	?	?	?	?	?
If my landowner association urged members to follow land conservation practices, it is likely most would voluntarily comply	?	?	?	?	?
If my landowner association urged members to follow deer hunting guidelines (i.e. protect young bucks, doe harvest, report kills), it is likely most would voluntarily comply	?	?	?	?	?
I would loan equipment to at least one non- kin member of my landowner association	?	?	?	?	?
I would loan equipment to any member of my landowner association	?	?	?	?	?
I would provide personal time to help at least one non-kin member of my landowner association	?	?	?	?	?
I would provide personal time to help any member of my landowner association	?	?	?	?	?
I would lend money to at least one non-kin member of my landowner association	?	?	?	?	?
I would lend money to any member of my andowner association	?	?	?	?	?

C10. Approximately how many of the property owners in your landowner association are you related to?

____

C11. How are leadership positions within your landowner association filled? (please check one)

_____ Elected _____ Appointed _____ Self-volunteered

_____ Other

____

____

C12. Does your landowner association raise money? ? Yes ? No

If yes, how are funds raised? (check all that apply)

_____ Member dues _____ Donations _____ Sale of products

_____ Workshops/seminars _____ Auctions

_____ Other

____

____

C13. Please check the level of use of the following means of communication used by your landowner association. (Please check only one box per row).

	Commonly Used	Somewhat Used	Seldom Used	Not Used	Not Sure
Face to face interaction	?	?	?	?	?
Email	?	?	?	?	?
Phone	?	?	?	?	?
Newsletter	?	?	?	?	?
Web Site	?	?	?	?	?
Workshops/Seminars	?	?	?	?	?
Other (please describe below)	?	?	?	?	?

SECTION D. PERSONAL INFORMATION

To understand differences among landowners regarding their interest and concerns about land and water conservation, we ask you to provide some information about yourself. We want to assure you that **YOUR RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL**, and will not be shared with any individual, business, or government agency. Results of this study will be reported only in the form of statistical summaries of several associations. At no time will the identity of your response be disclosed. We thank you in advance for your willingness to provide this information.

D1. What is your gender?

? Male ? Female

D2. What year were you born? _________

D3. Where is your primary residence? (Please check one).

_____ On my property within my association _____ Rural area outside my association

_____ Town under 10,000 person _____ City between 10,000 - 49,999 persons

_____ City between 50,000-99,999 persons _____ City over 100,000 persons

_____ Other (Please describe)

____

____

D4. If your property within your association is your primary residence, how many years have you lived there? ______

D5. If your association property is **not** your primary residence, approximately how many miles is your residence from your property by road? _______

D6. What is your highest level of formal education? (Please check one).

_____ Less than high school
_____ High School Graduate or GED
_____ Vocational/Technical training
_____ Some college
_____ Bachelor's degree
_____ Post-graduate degree

D7. What is your primary occupation? (Please check one).

_____ Agriculture (Farming or ranching)
_____ Professional
_____ Service
_____ Homemaker
_____ Retired
_____ Other ________________________________

D8. Please select the category that best indicates your average annual household income in 2003: (Please check one).

_____ Less than $25,000
_____ $25,000-49,999
_____ $50,000-74,999
_____ $75,000-99,999
_____ More than $100,000

D9. Approximately what percent of your average annual household income is derived from activities related to your property in your landowner association? (Please check one).

_____ Under 10%　　_____ 11-25%

_____ 26-50%　　_____ 51-75%

_____ Over 75%

APPENDIX B

DESCRIPTIONS OF INDIVIDUAL WMAs

LOWER POST OAK SAVANNAH (LPOS)

Bartons Creek Wildlife Management Association (BCWMA)

HCI was a negative explanatory variable for trust, while percent of income from land was a positive explanatory variable. The percent of improved pasture, and percent of income from land activities were important positive variables for reciprocity. Members of BCWMA tended to have higher social capital, and longer years of property ownership ($\bar{X}$ = 47.1) compared to RRWMA ($\bar{X}$ = 22.8, $p = 0.001$) and TCWMA ($\bar{X}$ = 30.5, $p = 0.029$). They had longer association membership ($\bar{X}$ = 5.5 years compared to less than 4.0 years for the other WMAs ($p < 0.05$), yet met fewer times than the other associations in the region (less than twice per year compared to at least twice per year ($p < 0.05$). The average HCI for property owners in BCWMA was lower ($\bar{X}$ = 54.5) than TCWMA ($\bar{X}$ = 70.4, $p < 0.05$).

Pin Oak Creek Wildlife Management Association (POCWMA)

The level of civic involvement had a positive influence on trust and reciprocity, while the number of people living in a town were significant negative variables influencing trust and reciprocity. The proportion of members in professional occupations was also negatively related to trust. POCWMA members had somewhat higher trust ($\bar{X}$ = 3.5) than TCWMA ($\bar{X}$ = 3.0, $p = 0.097$) and lower reciprocity ($\bar{X}$ = 2.9) than BCWMA ($\bar{X}$ = 3.2, $p = 0.038$). The HCI of 50.7 was lower ($p < 0.05$) than TCWMA.

POCWMA had the fewest members living in urban areas ($\bar{X}$ = 6.0%), and the most living on the land ($\bar{X}$ = 77.0%, ?^{2} = 48.304, df = 18, p < 0.001). Though non-significant, they had fewer professional members ($\bar{X}$ = 30.0%), and more retired members ($\bar{X}$ = 45.5%).

Red Rock Wildlife Management Association (RRWMA)

HCI was the only important explanatory independent variable for trust, and it had a negative effect. The percent of males had a positive influence on reciprocity while size of property was inversely related to reciprocity. RRWMA was the largest association (n = 148) in LPOS with the smallest average acreage size ($\bar{X}$ = 126.7 acres) compared to BCWMA ($\bar{X}$ = 192.6, p = 0.000) and TCWMA ($\bar{X}$ = 195.3, p = 0.011). Members of RRWMA were more recent landowners ($\bar{X}$ = 22.8 years of ownership) than BCWMA (p = 0.001), met more often than BCWMA and POCWMA (p < 0.05), and tended to be younger ($\bar{X}$ = 57.0 years), although age difference was non-significant. They also tended to have a higher percentage of females ($\bar{X}$ = 24.7%) and professionals ($\bar{X}$ = 50.0%), and had more fund raising methods ($\bar{X}$ = 2.8) than all other associations in the region (p < 0.05).

Tri-Community Wildlife Management Association (TCWMA)

The percent of total timbered habitat, and the percent of bottomland timber were important negative explanatory variables for trust in TCWMA, as was living in a town compared to on the land . The percent of males had a positive influence on trust. No significant relationships for reciprocity in TCWMA were identified using the model. TCWMA had the smallest group size (n = 91), and largest property sizes ($\bar{X}$ = 195.3

acres) of better quality habitat. Mean HCI was 70.4 compared to BCWMA ($\bar{X}$ = 54.5) and POCWMA ($\bar{X}$ = 50.7, $p < 0.05$). These factors may in part be responsible for the higher deer population compared to the other associations in the region ($\bar{X}$ = 39.2 deer per 1,000 acres compared to the region average of 15.4 deer per 1,000 acres). They tended to have lower social capital (all measures except reciprocity which was lower on POCWMA). TCWMA members tended to have the most living in urban areas ($\bar{X}$ = 49.0%) and fewest living on the land ($\bar{X}$ = 41.0%, $?^2 = 48.304$, df = 18, $p < 0.001$). They also had the fewest fund raising methods ($\bar{X}$ = 1.2), compared to POCWMA and RRWMA ($p < 0.05$).

CENTRAL POST OAK SAVANNAH (CPOS)

Alligator Creek Wildlife Management Association (ACWMA)

Due to the small sample size (n = 5) for ACWMA, comparisons with other associations in the region are tenuous, and regression analysis was not possible. Members of ACWMA tended to have higher social capital (trust averaged 4.2 compared to 3.2 for MTBCC, $p < 0.10$). This association had members with longer years of property ownership ($\bar{X}$ = 73.2) than MTBCC ($\bar{X}$ = 24.9, $p < 0.05$). Members of ACWMA had longer time as association members ($\bar{X}$ = 5 years) compared to CCWMA and MTBCC (less than 3 years, $p < 0.05$), and met more frequently than HWMA (at least twice per year compared to less than once per year, $p < 0.05$). Their HCI tended to be lower ($\bar{X}$ = 38.9) than MTBCC ($\bar{X}$ = 65.3, $p = .087$) with more improved pasture ($\bar{X}$ = 41.6%), than HWMA ($\bar{X}$ = 12.2%) and MTBCC ($\bar{X}$ = 11.3%, $p < 0.05$). Landowners in ACWMA were older ($\bar{X}$ = 70.0 years) than landowners in HWMA ($\bar{X}$ =

54.0, p = 0.046) and MTBCC ($\bar{X}$ = 53.0, p = 0.028). ACWMA had the highest percent of members living on their properties ($\bar{X}$ = 60.0%, $?^2$ = 37.360, df = 15, p = 0.001), and they were either in agriculture ($\bar{X}$ = 40.0%) or retired ($\bar{X}$ = 40%, $?^2$ = 18.775, df = 12, p = 0.094). They had a higher number of funding methods ($\bar{X}$ = 1.2) than CCWMA and HWMA ($\bar{X}$ = 0.2 for both, $p < 0.05$), and they valued livestock production ($\bar{X}$ = 5.0) higher than HWMA ($\bar{X}$ = 3.3) and MTBCC (X = 2.7, $p < 0.05$).

Clear Creek Wildlife Management Association(CCWMA)

The high R^2 (0.991) for trust in CCWMA was explained by 2 negative independent variables: year born, and whether a member lived in an urban area, and 2 positive variables: years as an association member, and the percent of males. Year born was also significantly and negatively related to reciprocity in this association, as was residence in an urban area. The percent of bottomland timber was positively related to reciprocity in this association, an opposite relationship compared to all other associations in the study. CCWMA had the largest group size in the region (n = 55), and the smallest average acreage size ($\bar{X}$ = 198.3) compared to MTBCC ($\bar{X}$ = 2,872.5, $p < 0.001$) and HWMA ($\bar{X}$ = 620.7, p = 0.025). Members of CCWMA owned their properties for a longer period of time ($\bar{X}$ = 54.7 years) compared to MTBCC ($\bar{X}$ = 24.9, $p < 0.05$). They also tended to be less educated ($?^2$ = 15.835, df = 9, p = 0.070) than members of other associations with 43.0% possessing a high school education and 23.8% with a bachelor's degree. Their income levels were somewhat lower ($?^2$ = 26.276, df = 12, p = 0.010), with 41.7% reporting an annual income between $25,000 and $49,999. In addition, they had a high percent of retired members (47.4%), and they were more interested in livestock production ($\bar{X}$ = 4.3) than HWMA ($\bar{X}$ = 3.3) and MTBCC ($\bar{X}$ = 2.7). They performed the fewest wildlife management activities ($\bar{X}$ = 3.8) of all other associations in the region ($\bar{X}$ = 5.9 or higher, $p < 0.05$). CCWMA had more related members ($\bar{X}$ = 2.7%) than HWMA and MTBCC ($p < 0.05$).

Harvey Wildlife Management Association (HWMA)

HCI had a negative effect on trust in HWMA, the only association in the region with this relationship. Years as a member and professional status were positively related to reciprocity in HWMA. Members of HWMA met significantly fewer times than the other associations in the region (not more than once per year compared to more than once per year, $p < 0.05$). They owned more bottomland hardwoods ($\bar{X}$ = 21.1%) than CCWMA ($\bar{X}$ = 0.6, $p < 0.05$) and less improved pasture ($\bar{X}$ = 12.2%) than ACWMA ($\bar{X}$ = 41.6%) and CCWMA ($\bar{X}$ = 29.4%, $p < 0.05$). They were younger ($\bar{X}$ = 54.0 years) than ACWMA ($\bar{X}$ = 70.0, $p = 0.046$), and overall, better educated (53% had a post graduate degree, $?^2 = 15.836$, df = 9, $p = 0.070$). This association tended to be all male, with 53% of their members earning over $100,000 annually ($?^2 = 26.276$, df = 12, $p = 0.010$). HWMA members lived mostly in an urban area ($\bar{X}$ = 52.9%, $?^2 = 37.360$, df = 15, $p = 0.001$), and were mostly professional ($\bar{X}$ = 58.8%). They rated livestock production a lower priority than ACWMA and CCWMA ($p < 0.05$).

Mid Trinity Basin Conservation Cooperative (MTBCC)

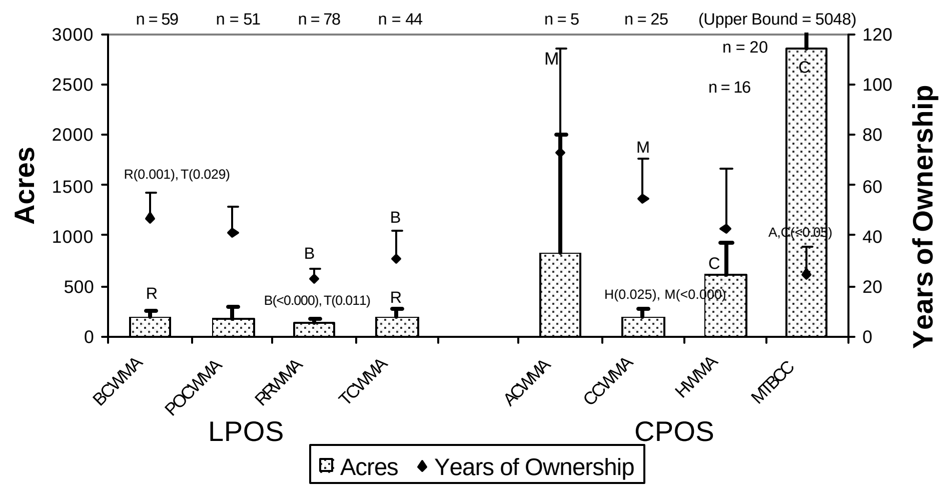
No relationships explaining either trust or reciprocity for MTBCC were identified using the model, though their membership characteristics were very similar to

HWMA. They tended to have the lowest social capital, with a somewhat lower trust level than ACWMA ($p < 0.10$). They and tended to own quite large acreages ($\bar{X}$ = 2,872.5), yet their members were newer property owners ($\bar{X}$ = 24.9 years) than both ACWMA ($\bar{X}$ = 73.2) and CCWMA ($\bar{X}$ = 54.7, $p < 0.05$). They had more bottomland hardwoods ($\bar{X}$ = 29.6%) than CCWMA ($\bar{X}$ = 0.6, $p < 0.05$), less improved pasture ($\bar{X}$ = 11.3%) than ACWMA ($\bar{X}$ = 41.6%) and CCWMA ($\bar{X}$ = 29.4%, $p < 0.05$), and tended to have a higher HCI than members of ACWMA ($p = 0.087$). Members of MTBCC were younger ($\bar{X}$ = 53.0 years) than CCWMA ($\bar{X}$ = 63.0, $p = 0.032$) and ACWMA ($\bar{X}$ = 70.0, $p = 0.028$), and were highly educated (68.4% had a bachelors or post graduate degree, ?^{2} = 15.836, df = 9, $p = 0.070$). They were mostly males with 64.7% earning $100,000 or more annually (?^{2} = 26.276, df = 12, $p = 0.010$). They generally lived in an urban area or a town (65.0% combined, ?^{2} = 37.360, df = 15, $p = 0.001$), and were mostly professional ($\bar{X}$ = 57.9%). They also rated livestock production lower than ACWMA and CCWMA ($p < 0.05$). As a percent of land area affected, members of MTBCC had higher values for prescribed burning ($\bar{X}$ = 8.4%) compared to HWMA ($\bar{X}$ = 0, $p < 0.05$), native plant restoration ($\bar{X}$ = 17.3%) compared to ACWMA ($\bar{X}$ = 0.30%, $p < 0.05$), and brush control ($\bar{X}$ = 10.3%) compared to CCWMA ($\bar{X}$ = 3.2%, $p < 0.05$).

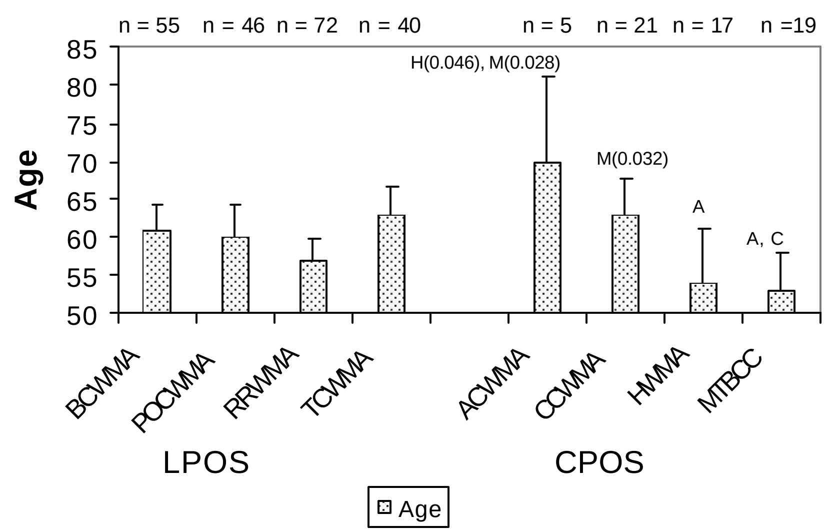
APPENDIX C

DATA FOR INDIVUDUAL WMAs

C-1. Mean acreage and years of property ownership among WMAs in 2 regions. Error bars represent 95% confidence intervals for raw data. Letters and (p value) indicate significant differences of ln transformed values within a region.



C-2. Mean age of association members. Error bars represent 95% confidence intervals. Letters and (p value) indicate significant differences within a region.



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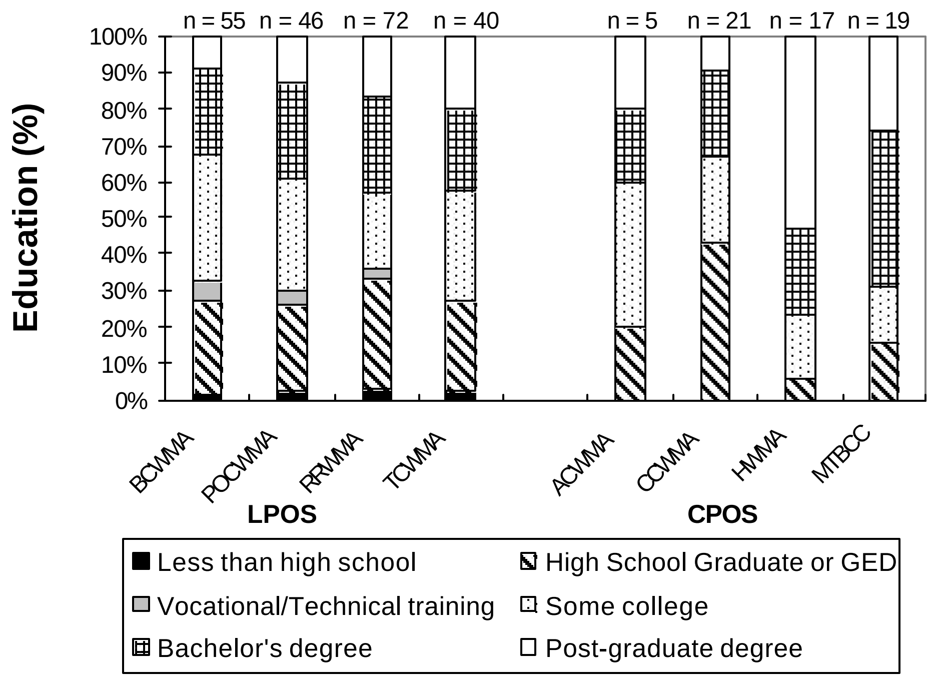
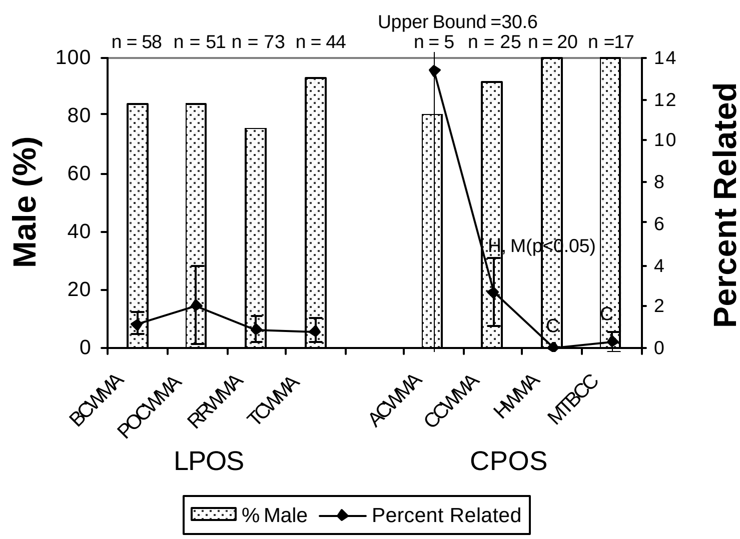
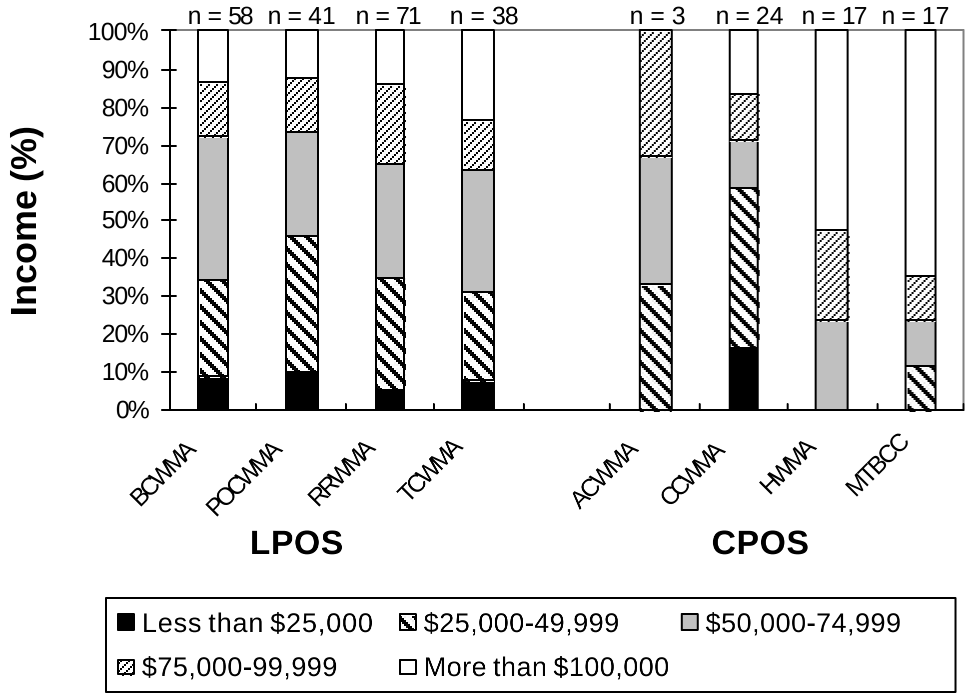
C-3. Education levels of association members (?[2] for CPOS = 15.836, df = 9, p = 0.070)



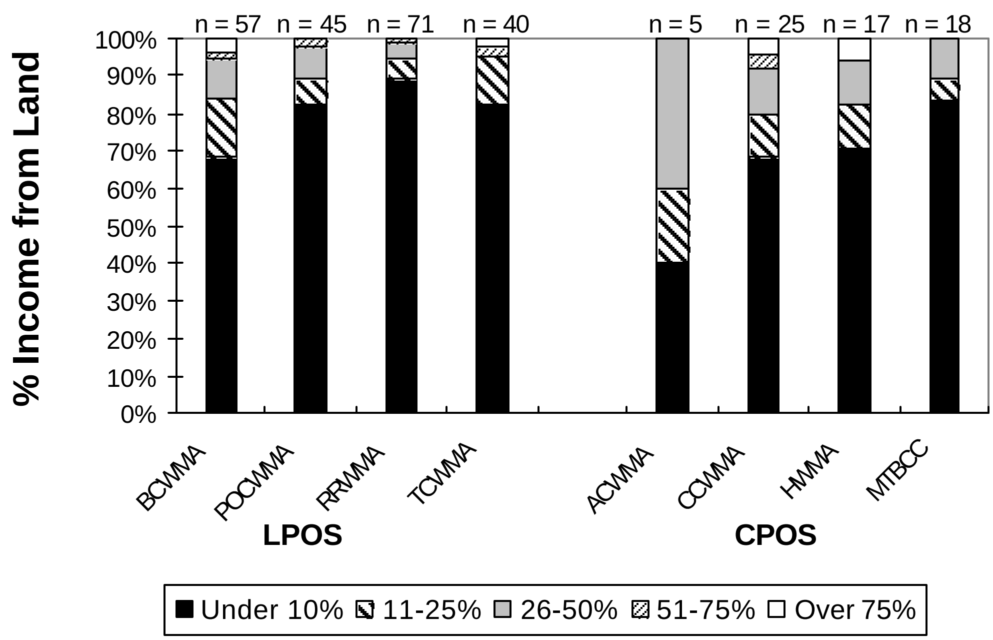
C-4. Mean percent of males and percent of related members WMAs in 2 regions. Error bars represent 95% confidence intervals on raw percent related data. Letters indicate significant differences in ln + 1 transformed values within a region.



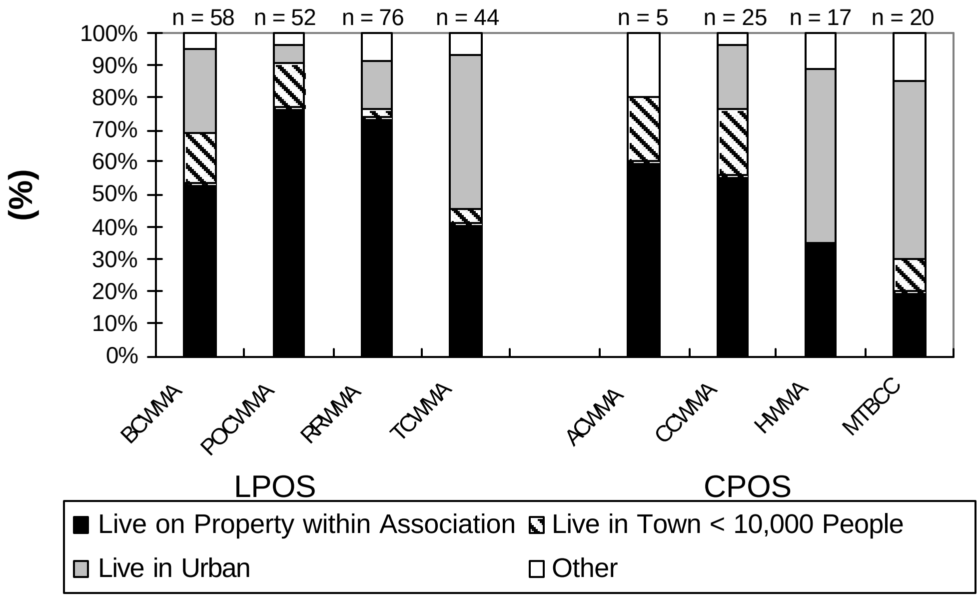
C-5. Mean income for members of WMAs (?^{2} for CPOS = 26.276, df = 12, p = 0.010)



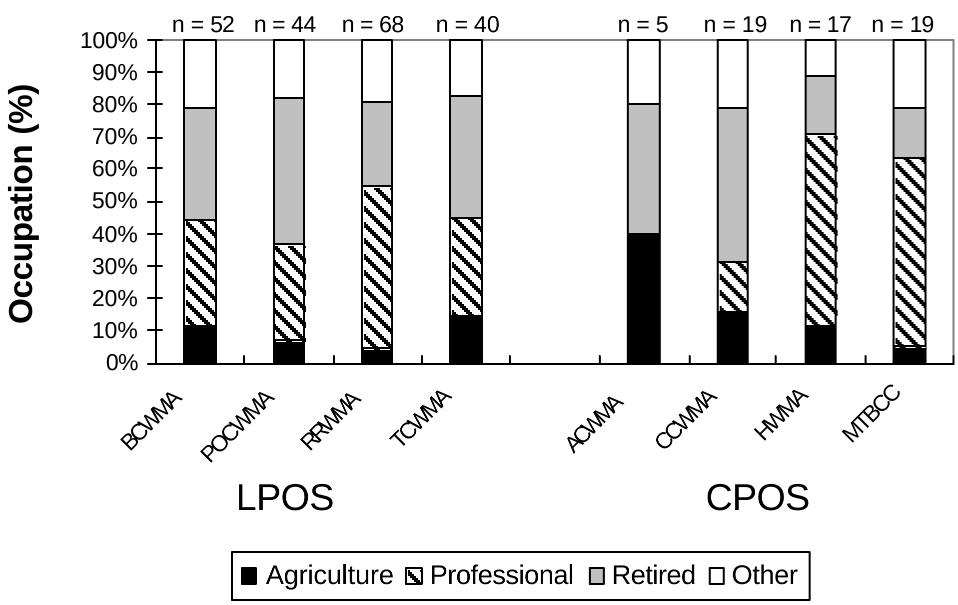
C-6. Mean percent of income from property for members of WMAs



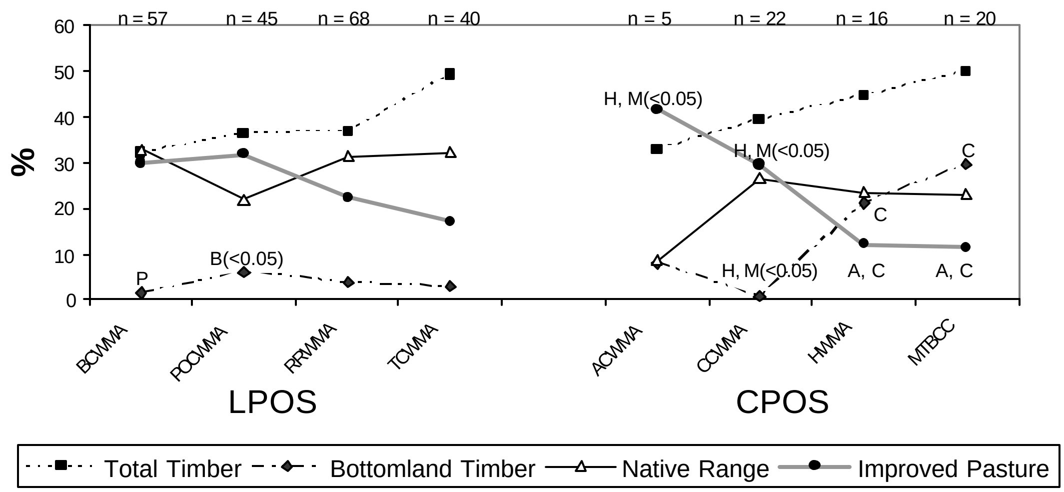
C-7. Primary residence of WMA members in 2 regions ($?^2$ for LPOS = 48.304, df = 18, p < 0.001, $?^2$ for CPOS = 37.360, df = 15, p = 0.001)



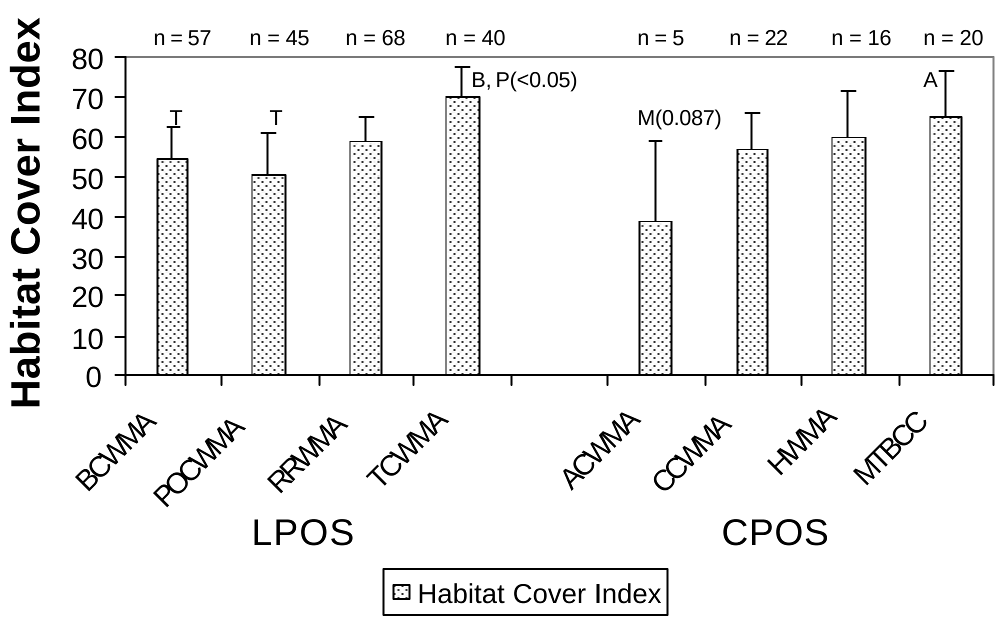
C-8. Occupation of members of WMAs in 2 regions ($?^2$ for CPOS = 18.775, df = 12, p = 0.094)



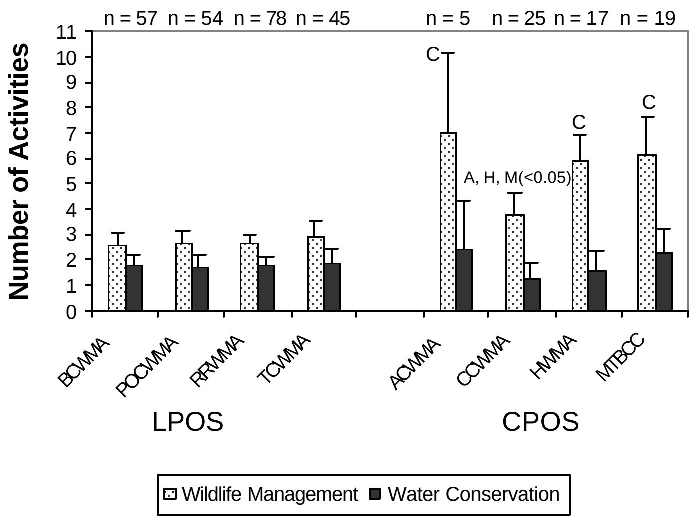
C-9. Habitat composition of WMAs in 2 regions. Letters and (p value) indicate significant differences within a region. Percentages of bottomland timber were ln+1 transformed before analysis.



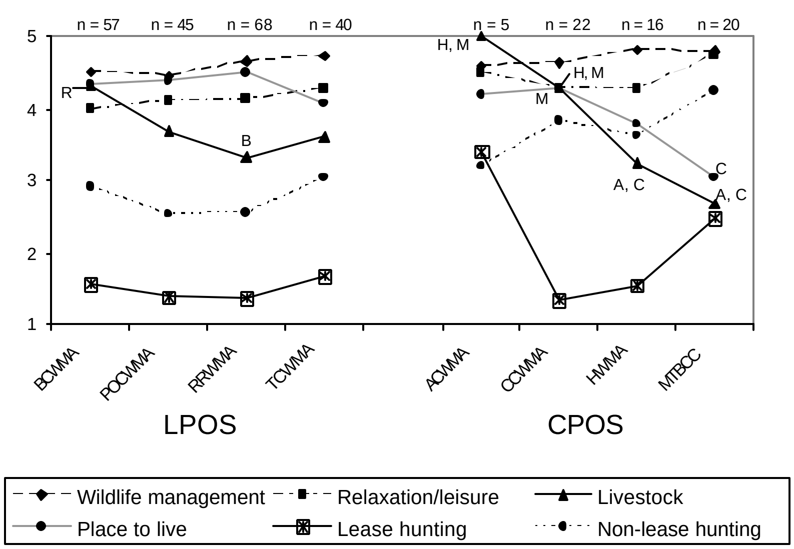
C-10. Habitat Cover Index (HCI) for WMAs in 2 regions. Error bars represent 95% confidence intervals. Letters and (p value) indicate significant differences within a region.



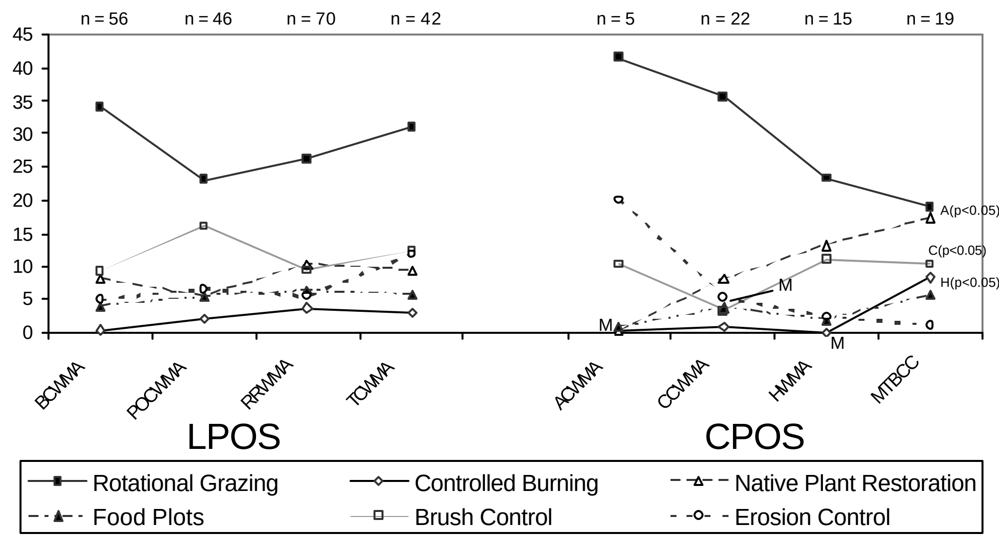
C-11. Mean number of wildlife management and water conservation activities conducted by members of WMAs in 2 regions. Error bars represent 95% confidence intervals. Letters and (p value) indicate significant differences within a region.



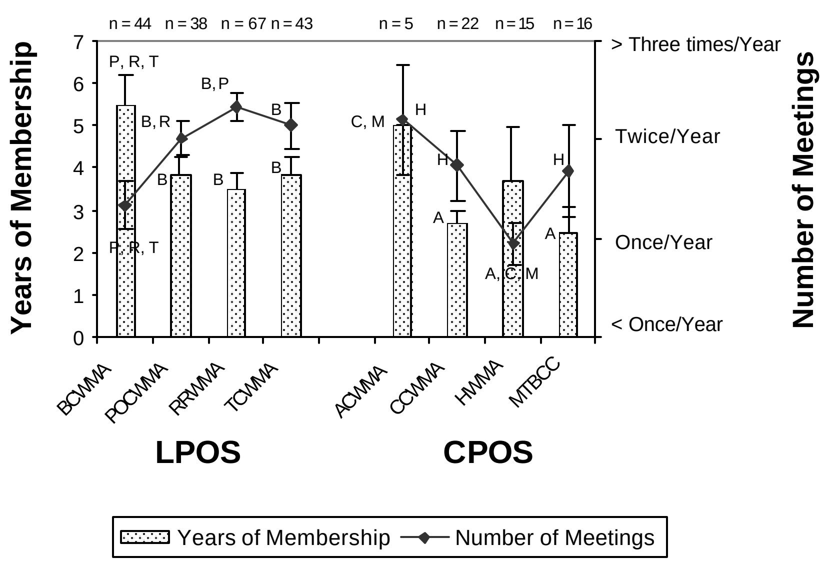
C-12. Land use priorities for WMAs in 2 regions (1 = very unimportant, 2 = unimportant, 3 = undecided, 4 = important, 5 = very important). Letters indicate significant differences within a region.



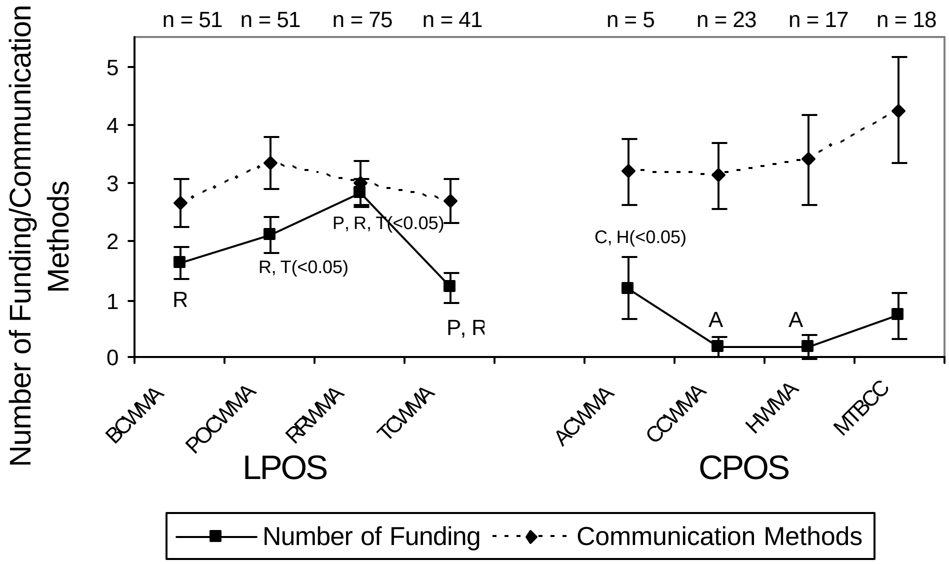
C-13. Percent of land affected by 6 wildlife management activities. Letters indicate significant differences of ln + 1 transformed values within a region.



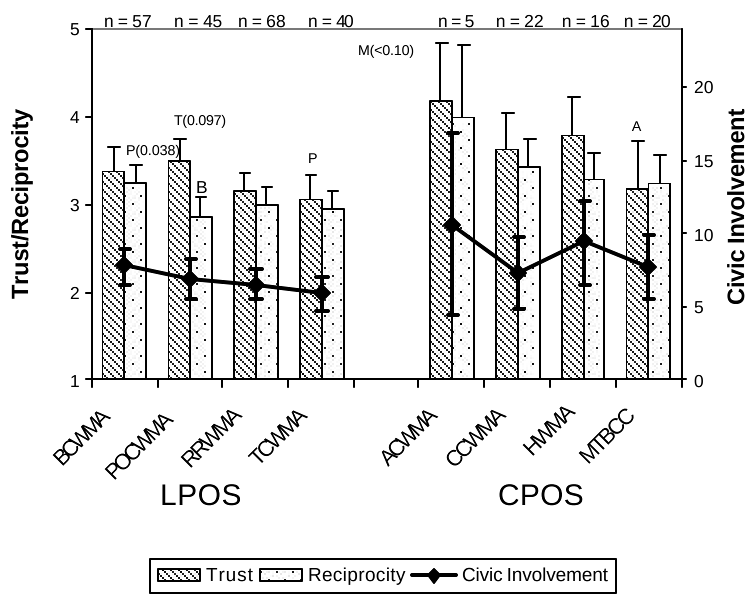
C-14. Mean years of membership and number of meetings of association members. Error bars represent 95% confidence intervals. Letters indicate significant differences within a region (p < 0.05).



C-15. Mean number of fund raising and communication methods used by members of WMAs in 2 regions. Error bars represent 95% confidence intervals. Letters and (p value) indicate significant differences within a region.



C-16. Measures of social capital among WMAs in 2 regions. Error bars represent 95% confidence intervals. Letters and (p value) indicate significant differences within a region.



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Wagner, Matthew W., Ronald A. Kaiser, Urs P. Kreuter, and R. Neal Wilkins. 2005. Managing the Commons Texas Style: Wildlife Management and Groundwater Associations on Private Lands. Journal of the American Water Resources Association. In review.