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MANAGING THE COMMONS TEXAS STYLE: WILDLIFE MANAGEMENT AND GROUND-WATER ASSOCIATIONS ON PRIVATE LANDS[1]

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ABSTRACT: As nearly all of Texas' rural lands are privately owned, landowner associations for the management of white-tailed deer and ground-water have become increasingly popular. Deer are a common-pool resource with transboundary characteristics, requiring landowner cooperation for effective management. Ground-water reserves are economically important to landowners, but are governed by the "rule of capture" whereby property rights are not defined. One ground-water association and four wildlife management associations (WMAs) were surveyed to characterize their member demographics, land use priorities, attitudes, and social capital. Members of the ground-water cooperative 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 ground-water 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 ground-water supply. This, coupled with pumping rules assigned by the local ground-water district, could yield an effective strategy that is ecologically and hydrologicaly sound, and that allows rural provision of water supply to urban consumers.

(KEY TERMS: ground-water management; private lands; social capital; landowner associations; water policy; planning.)

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INTRODUCTION

Private farms and ranches in Texas account for 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. By contrast, in prime deer habitat areas, revenue from hunting leases exceeds the agricultural production values from the land. Therefore, as traditional agricultural enterprises have lost profit potential, landowners have increasingly turned to the more lucrative business of leasing hunting rights on their property.

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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). In response to the increasing economic and social value of wildlife, many landowners have organized into multilandowner groups for more effective management of their wildlife resources, especially white-tailed deer. Currently, 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).

Texas also faces a daunting water supply problem. It is predicted that by 2050 a 43% shortfall would occur under drought conditions for 900 water user groups unless new sources are developed (Texas Water Development Board, 2002). The growing demand for rural water supplies has led to lucrative ground-water 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 ground water to offsite 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 ground water can exceed market values for farm and ranchland (Gilliland, 2000; Mesa Water, 2005).

Despite the potential increase in water supplies from water ranches, there are obstacles for coordinated surface and ground-water management. In Texas, these include the lack of regional or countywide water planning, unrestricted ground water withdrawal rights, increasing land subdivision, changing landownership patterns, and economically adverse conditions for sustainable land management. A mechanism for coordinating water management across private land is critical if ground-water extraction is to be sustainable especially when water planning and regulatory constraints are minimal. Landowner associations, such as WMAs, may hold promise for the management of natural resources that traverse private lands, including ground water, because they adhere to the model of mutual cooperation for mutual benefits (Hardin, 1968).

Cooperative management of wildlife and ground water 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, stewardship has not been emphasized for water ranches, although it is no less important for providing abundant clean water. However, as water demand outstrips aquifer replenishment, enhancing aquifer recharge becomes more critical. Establishing a ground-water 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 concept that has been used to explain differences in the level of cooperation within communities is social capital, which has been defined as 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). The most commonly cited measure of social capital is trust (Coleman, 1990; Brehm and Rahn, 1997; Putnam, 2000; Silverman, 2004; Halpern, 2005). Understanding the role of social capital in the 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. Furthermore, effective common-pool resource management is contingent upon collective choice arrangements grounded in measures of social capital including trust and reciprocity (Ostrom, 1990). Therefore, the evaluation of social capital across wildlife management and ground-water associations is a key objective of our study.

Deer and Ground-Water Management: Where Is the Connection?

Although obviously different in nature, wildlife and ground water represent two renewable common-pool resources with significant value to private landowners in Texas. While deer occur on the surface and ground water 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, overharvest of deer can be a problem.

By contrast, acquisition and use of ground water in Texas is governed by the "rule of capture," which allows landowners to withdraw unlimited ground water as long as it is not "wasted." The term "rule of capture" originated with the idea that ground water was like the "deer in the forest," whereby no person could own the deer unless it was physically captured (Blackstone, 1979). However, unrestrained extraction of ground water has caused a drawdown 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). Emphasis on education and conservation incentives increased as scarcity increased in districts located in western portions of the state (Somma, 1994). However, due to funding and enforcement constraints, the effectiveness of the current 89 water districts is generally inadequate, except for the Edwards Aquifer Authority which has required pumping limits in order to protect Endangered Species (Votteler, 1998).

In areas of Texas where both wildlife and ground water represent natural resources for more lucrative enterprises than traditional livestock production, 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 rewards may reduce pervasive incentives to subdivide and sell land 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 ground-water 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 ground water. To explore the feasibility of voluntary co-management of wildlife and water resources by landowner associations, we analyze a primary factor determining success of landowner associations – this is social capital among landowners.

Social Capital: What Is the Relevance for Voluntary Action Affecting Natural Resources?

Ground-water 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). 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 $159.5m 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. In addition, 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, and Wuthnow (1994) suggests that group size should ideally be no more than 15-20 people for maximum trust building.

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 capital of landowners within wildlife and ground-water 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 ground-water 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).

Our hypothesis was twofold: (1) social capital within landowner associations is higher when group size and heterogeneity are reduced; and (2) as social capital (i.e., trust) increases, landowners engage in more active land and water conservation practices.

METHODS

Study Area

This study focuses on four WMAs, and the Brazos Valley Water Alliance (BVWA), a private ground-water cooperative situated in the central portion of the Post Oak Savannah Ecoregion and the intent of which is to coordinate the sale of ground water to which the member landowner has access (Figure 1).

The four 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 (U.S. 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. 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 ground-water resource (Figure 1). Effective recharge in the central portion of the aquifer is 97,600 acre-feet annually, about 2.69% 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 ground water in the Carrizo-Wilcox Aquifer is projected to remain by 2050. The surplus of ground water available from the Carrizo-Wilcox has attracted water speculators to the area, enticing landowners to sell or lease their ground-water rights to prospective buyers. A number of water companies have formed rural water cooperatives, pooling hundreds of landowners in order to accumulate enough ground water 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, ground-water leases specify a 5-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

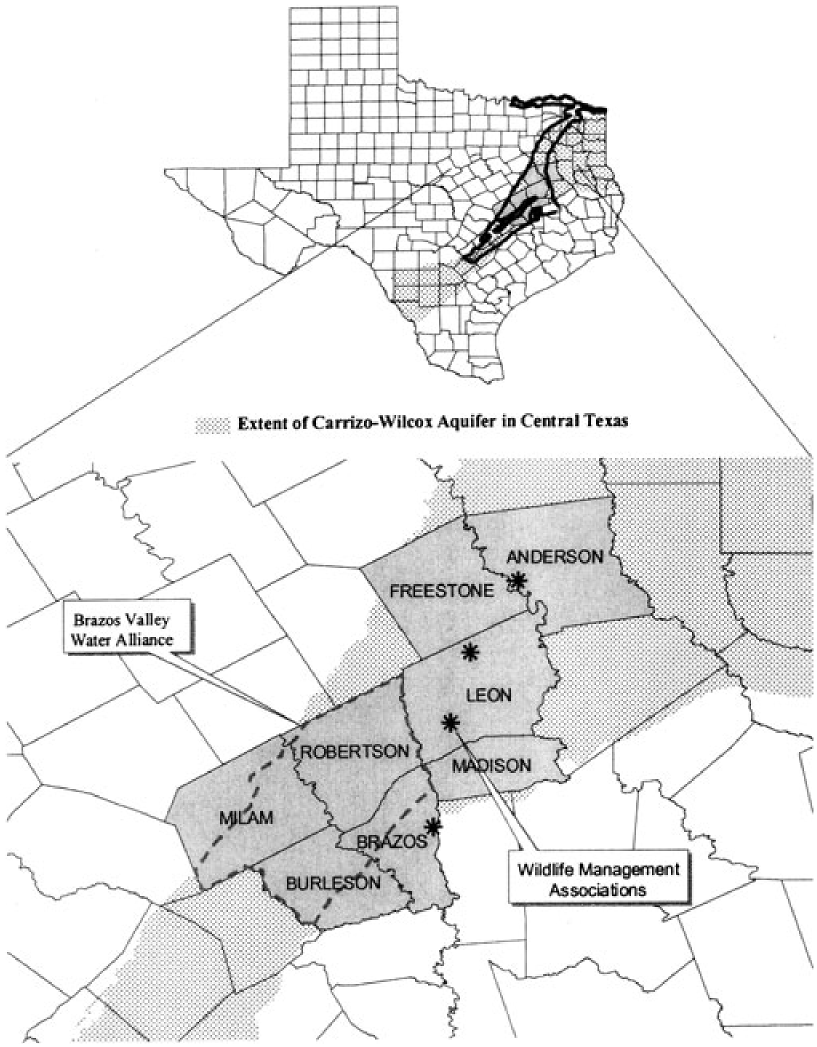

FIGURE 1. Locations of Brazos Valley Water Alliance and Four Wildlife Management Associations Within the Post Oak Savannah Ecoregion (–).

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, 2000).

Mail Survey

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 ground-water 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 four WMAs, following protocols of Dillman (2000). A presurvey 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: (1) property and land management characteristics – property size, years of ownership, land use priorities, land area affected by a choice of three land management practices, the number of water conservation practices, and the relative importance of maintaining riparian buffers and erosion control; (2) ground-water issues – opinions on several separate issues; (3) 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 three categories, and the number of communication methods used; and (4) socioeconomic information – gender, year born, primary residence, education level, occupation, household income, and percent of income from property (see details in Appendix I). Land use priorities, opinions on ground-water 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).

Measures of social capital included intra-association trust, reciprocity, and community involvement. An Association Trust Index was created by averaging each respondent's level of agreement with four 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." These statements were considered to be indicative of the level of inter-personal familiarity among landowners within an association, with a Cronbach alpha reliability coefficient of 0.831. Alpha reliability values above 0.700 are considered adequate for assuming the items in an index are related to each other (Foster, 2001). An Association Reciprocity Index was created by summing and averaging each respondents agreement to the following four 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 statements revealed the strength of exchange relationships among landowners within an association, with an alpha reliability coefficient of 0.737. Finally, a Civic Involvement Index was generated for each landowner by summing their level of involvement in each of seven community organizations plus a category for "other," ranging from very involved (3) to not involved (0) with the maximum score being 24. The alpha reliability coefficient for the seven community organizations was 0.681.

Data Analysis

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-squared (χ^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. For each landowner, the level of trust within an association was correlated with the number of water conservation activities performed, the number of wildlife management activities, the percent of land undergoing native plant restoration, and the level of importance placed on maintaining riparian buffer areas. These measures were selected because they provide an indication of the level of commitment by landowners to land management practices that benefit wildlife and ground-water resources.

Responses for property size and years of property 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 we used transformed data for analyses, we present nontransformed 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, six did not reach their intended landowner due to insufficient or unknown address. Eleven questionnaires were returned blank or unintelligible.

A nonresponse bias survey was conducted for eight landowners in BVWA and five landowners in WMAs by phone interview. Six questions were selected from the original questionnaire, including age and occupation, and four 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 ($\chi^2 = 0.987$, $p = 0.611$) 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 ($\chi^2 = 1.020$, $p = 0.600$), 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 compared with $\bar{X}_{wm} = 469.4$, 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 with $\bar{X}_{wm} = 0.5\%$, $\chi^2 = 14.937$, $p < 0.001$) and a lower percent of related members ($\bar{X}_{bv} = 0.20\%$ compared with $\bar{X}_{wm} = 2.1\%$, $t = -2.882$, $p = 0.005$). Members of BVWA were on average older ($\bar{X}_{bv} = 65$, SE = 1.3 years compared with $\bar{X}_{wm} = 58$, SE = 1.6, $t = -3.370$, $p = 0.001$), and more were retired, while more WMA landowners held professional jobs (Table 1).

TABLE 1. Occupation, Education, Income, and Primary Residence of Landowners in the BVWA and WMAs in the Post Oak Savannah, Texas.

	BVWA	WMAs
Occupation (%) ($\chi^2 = 4.696$, $p = 0.096$)	$n = 70$	$n = 48$
Agriculture	14.3	14.6
Professional	31.4	50.0
Retired	54.3	35.4
Education (%) ($\chi^2 = 3.734$, $p = 0.443$)	$n = 85$	$n = 62$
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
Postgraduate degree	30.6	27.4
Annual income (%) ($\chi^2 = 7.447$, $p = 0.114$)	$n = 83$	$n = 61$
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 $100,000	19.3	39.3
Primary residence (%) ($\chi^2 = 0.583$, $p = 0.747$)	$n = 75$	$n = 60$
On property	45.3	45.0
In town <10,000	9.3	13.3
In urban >10,000	45.3	41.7

Members of both associations were highly educated, with an average of 75% having attended college and about 30% had postgraduate degrees (Table 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 (Table 1). 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 = 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 streamsides, and increased water infiltration), were conducted in BVWA compared with WMAs ($\bar{X}_{bv} = 1.2$, SE = 0.1, $\bar{X}_{wm} = 1.8$, SE = 0.2, $t = -2.464$, $p = 0.015$). Table 2 provides information explaining landowners' involvement in three land conservation practices: native plant restoration (revegetation with native grasses, forbs, and trees), 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 land area affected by each practice among respondents indicating they used the practice. 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 of 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 with about 10 and 19%, respectively, for BVWA respondents, but the average percentage and acreage of land on each

TABLE 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 Land Area (ha) Affected by Use of Each Practice for Only That Respondents Answering Positively.

	Native plant restoration				Brush control				Erosion control			
	BVWA	**WMAs**	***t* or χ^2**	***p* value**	**BVWA**	**WMAs**	***t* or χ^2**	***p* value**	**BVWA**	**WMAs**	***t* or χ^2**	***p* value**
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 (χ^2)	0.001	50.0	56.3	0.569 (χ^2)	0.451	18.8	30.8	2.882 (χ^2)	0.090
% of land affected for only those respondents answering positively	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
Land area affected for only those respondents answering positively**	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

Notes: **p* values for [ln + 1] transformed data and ***p* values for [ln] transformed data. BVWA = Brazos Valley Water Alliance, WMA = wildlife management association.

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 practiced brush control. Although the average percent of land affected by brush control was greater ($p < 0.001$) among BVWA members that indicated they used the practice, the acreage of land affected by brush control did not differ between the two 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 3. Revegetation for erosion control was somewhat important for both BVWA and WMA members, and did not differ, but maintenance of buffer strips along streamsides 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 practiced brush control, another practice with major implications for ground-water recharge, especially in areas with over 18 inches of annual rainfall (Thurow, 1998). As BVWA members were more interested in livestock production and farming/haying operations, it seems likely that these 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 nonagricultural 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

TABLE 3. Importance of Various Land Use or Management Priorities (Mean and SE) for Members of BVWA and WMAs.

Land Use/Management Priority	BVWA	WMAs	*t* Value	*p* Value
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

Notes: 1 = very unimportant, 2 = somewhat unimportant, 3 = undecided, 4 = somewhat important, 5 = very important. BVWA = Brazos Valley Water Alliance, WMA = wildlife management association.

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 ground-water extraction and land stewardship. This is not only important in identifying nonmarket assets of land, but in developing a conservation ethic that may yield sustainable ecosystem services with significant economic potential.

Ground-Water Issues

Landowners in both types of associations were asked their opinion about 15 ground-water issues. BVWA respondents had more favorable opinions on all the issues, and all but five were significantly different than WMAs (Table 4). BVWA members were significantly more favorable than WMAs members towards the following issues: the buying and selling of ground water, a landowner's right to buy ground water, a neighbor's right to buy ground water, a landowner's right to sell ground water, a neighbor's right to sell ground water, the transfer of ground water from rural to urban uses, evaluating the economic impacts of ground-water transfers, a permit system for ground-water pumping for nondomestic uses, private "ground-water cooperatives" for water marketing, and ground-water 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 evalu-

TABLE 4. Landowner Opinions (Mean and SE) of Ground-Water Issues.

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

Notes: 1 = very unfavorable, 2 = somewhat unfavorable, 3 = undecided, 4 = somewhat favorable, 5 = very unfavorable.

ating the ecological and social impacts of ground-water transfers, but both were less favorable toward state and local government oversight of ground-water 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 ground-water resources. This leaves open the possibility of regulating ground-water marketing and extraction through landowner associations with ground-water 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 ground-water transfers. BVWA members were quite favorable towards ground-water pumping based on sustainable yield. As sustainable yield is contingent upon adequate recharge to the aquifer, it is critical that landowners understand the relationship of land management on ground-water 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 nondomestic uses. The BVWA could assign private rights to ground water through a transferable permit system, thus establishing a market approach to water supply to meet growing urban demand. A similar system is already in place for the Edwards Aquifer (Edwards Aquifer Authority, 2005). Provencher (1993) stated that a private property rights regime for ground water is a promising and practical alternative to traditional means of ground-water management and is consistent with the emergence of markets for surface water.

Social Capital, Group Size, and Conservation Practices

All three indices of social capital were lower in BVWA than WMAs, including trust ($\bar{X}_{\mathrm{bv}} = 2.6$, SE = 0.1, $\bar{X}_{bv} = 3.6$, 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 four 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 obtain a higher level of social capital that is normally associated with increased intragroup interactions, and that can lead to stronger intragroup 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.

We considered trust the primary measure of social capital as it is most commonly cited metric in the social capital literature. We found that the level of intra-association trust exhibited by survey respondents was significantly and positively correlated with the number of water conservation activities, the number of wildlife management activities, and the percent of land undergoing native plant restoration (Table 5). Although positive, the correlation between trust and the importance of riparian buffers was only significant at $p = 0.077$. Such land management practices may reflect a sense of community responsibility for their common-pool resource. For example, Kreuter *et al.* (2006) found that willingness by landowners to adopt socially desirable rangeland management objectives was positively correlated with the social responsibility dimension of respondents' property rights. An

TABLE 5. Correlations Between Intra-Association Trust and the Number of Water Conservation Activities, the Number of Wildlife Management Activities, the Percent of Land Undergoing Native Plant Restoration, and the Importance of Riparian Buffer Areas.

	Intra-association Trust	
	Correlation (r)	**p Value**
Number of water conservation activities	0.316	<0.001*
Number of wildlife management activities	0.435	<0.001**
Percent of land undergoing native plant restoration	0.203	0.004*
Importance of riparian buffer areas	0.159	0.077**

*Kendall's tau b correlations.
** Pearson correlations.

increased sense of community also led to successful management of transboundary aquifers by local user groups as reported by Blomquist and Ingram (2003), and Taylor and Singleton (1993). In addition, increased social capital also 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).

SUMMARY AND CONCLUSIONS

Members of BVWA belonged to a newer, much larger, and more heterogeneous group than WMA members. BVWA respondents 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 a higher percentage of WMA respondents held professional jobs and they placed a higher priority on relaxation and leisure uses of their properties. Respondents from both sets of associations were, on average, highly educated, and had comparatively high incomes. Somewhat less than half of both association respondents 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), WMAs had more communication methods, a higher ranking of organizational leadership, and they exhibited higher levels of social capital. In addition, WMA respondents placed greater emphasis on the importance of water conservation practices on their lands. This result was surprising because the explicit purpose of the BVWA is to market ground water, which would suggest that associated landowners would have a strong interest in land management practices that conserve water. The rather counterintuitive result might be explained by a higher level of social capital among WMA respondents. We found that intra-association trust, our primary measure of social capital, was positively correlated with the number of water conservation activities, as well as the number of wildlife management activities and the percent of land undergoing native plant restoration. However, it is uncertain whether higher social capital among WMA respondents has led to better land and water management, or if more active land stewardship is the result of landowners' shared values that existed prior to formation of the WMAs. In any case, small homogenous groups with regular communication and frequent face-to-face interaction among members have been found to lead to a greater sense of community, trust, and reciprocity among members that have been associated with more sustainable use of natural resources (Taylor and Singleton, 1993; Katz, 2000; Blomquist and Ingram, 2003; D'Silva and Pai, 2003; Kreuter *et al.*, 2006). However, balancing group size and conservation actions is difficult to achieve in areas with rapid land fragmentation patterns being experienced throughout the Post Oak Eco-region of Texas. One possible solution is the development of a tiered association structure consisting of local chapters with no more that 50 members of a larger association, the members of which all have a common resource management interest (Ostrom, 1990). One example of such a two-tiered structure is the Edwards Plateau Prescribed Burning Association in Texas, which consists of 340 members in eight chapters (Taylor, 2005). If this is not possible, then more frequent meetings and increased communication tools (i.e., newsletters and websites) may help elevate common interests and trust, and therefore social capital, in larger groups.

Respondents from both BVWA and WMAs were mostly undecided about how they felt about the "rule of capture," but they were less favorable towards state and local government control of ground-water supplies. BVWA respondents were more receptive than WMA respondents to sustainable aquifer use and a pumping permit system. This finding leads to the possibility of privatizing ground-water marketing by landowner cooperatives based on a properly monitored extraction permit system. However the finding also suggests that existing WMAs may not be a suitable basis for ground-water cooperatives and that it may be necessary to form new landowner associations, members of which may or may not belong to WMAs.

Efforts to enhance social capital, especially intra-association trust, by developing multitiered association membership structures and holding frequent informative meetings, as suggested above, in combination with the use of state and federal incentive programs to improve land stewardship could encourage members of ground-water associations to develop a greater sense of community responsibility for ensuring the sustained supply of valuable ground water by adopting more effective watershed management practices. In turn, this would facilitate the maintenance of open space at a landscape scale and reduce the deleterious effects of land fragmentation on ground-water extraction. In this way, locally controlled resource management, fostered by elevated sense of social responsibility and increased trust through community participation would place the benefits and responsibilities of sustainable ground-water extraction in the hands of participating landowners.

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APPENDIX I. Survey Questions Sent to Landowners in BVWA and WMAs.

Topic	**Question**
Property and Land Management Characteristics	How many acres within your landowner association do you own?
	How many years have you or your family owned this acreage?
	Indicate your land use priorities for each category below (5 = very important and 1 = very unimportant) (1) Wildlife management (2) Livestock production (3) Farming/hay production (4) Relaxation/leisure (5) Mineral Extraction
	Indicate the approximate number of acres affected on your property in the last 12 months by each of the following land management activities: (1) Native plant restoration (2) Mechanical or chemical brush control (3) Erosion control (4) Other
	Which of the following practices for water conservation do you use? (Check all that apply) (1) Terraces (2) Vegetation management for increased water infiltration (3) Shaped waterways (drainages) (4) Exclude livestock from streamsides (5) Rainwater harvesting (6) Stream side buffer areas (vegetated waterways) (7) Grey water reuse (8) Reseeding with native plants (9) Conservation tillage (e.g., no till planting, contour planting. etc)
	Indicate the importance of the following issues when considering land management practices (5 = very important and 1 = very unimportant): (1) Maintaining buffers along stream side areas (2) Revegetation for erosion control
Ground-Water Issues	Indicate your opinion regarding each of the following groundwater issues (5 = very favorable and 1 = very unfavorable) (1) The "rule of capture" (2) The purchase and sale of groundwater in general (3) Your right to buy groundwater (4) Your neighbor's right to buy groundwater (5) Your right to sell groundwater (6) Your neighbor's right to sell groundwater (7) The transfer of groundwater from rural to urban uses (8) Evaluating economic impacts of groundwater transfers (9) Evaluating ecological impacts of groundwater transfers (10) Evaluating social impacts of groundwater transfers (11) State government oversight of groundwater issues (12) Local government oversight of groundwater issues (13) A permit system for groundwater pumping for nondomestic use (14) Private "groundwater cooperatives" for water marketing (15) Groundwater pumping based on sustainable yield from an aquifer

APPENDIX (*Continued*)

Topic	Question
Social Interaction and Association Activities	How many years have you been a member of your landowner association? How often does your landowner association meet? (1) Less than once per year (2) Once per year (3) Twice per year (4) Three or more times per year Indicate your level of agreement with each of the following statements (5 = strongly agree and 1 = strongly disagree): (1) Generally speaking, most people can be trusted (2) I know most of the members of my landowner association (3) I meet with members of my landowner association outside of assoc activities (4) There are many members of my landowner association I consider friends (5) I trust members of my landowner association (6) If my landowner association urged members to follow land conservation practices, it is likely most would voluntarily comply (7) 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 (8) I would loan equipment to at least one non-kin member of my landowner association (9) I would loan equipment to any member of my landowner association (10) I would provide personal time to help at least one non-kin member of my landowner association (11) I would provide personal time to help any member of my landowner association (12) I would lend money to at least one non-kin member of my landowner association (13) I would lend money to any member of my and owner association How involved are you and/or your spouse (if applicable) in each of the following types of community organizations? (3 = very involved and 0 = not involved) (1) Church groups (2) Civic organizations (Rotary, Jaycees, Lions, etc.) (3) Athletic/recreation groups (softball, soccer, card games, etc.) (4) Education/school groups (PTA, boosters, etc.) (5) Youth-oriented groups (4-H, scouts, etc.) (6) Community government (city, county commissions, etc.) (7) Ranch/farm organizations (Farm Bureau, Cattlemans Assn, etc.) Approximately how many of the property owners in your landowner association are you related to? Please rate your landowner association in each of the following categories (5 = very successful and 1 = very unsuccessful) (1) Organizational leadership (2) improved conditions for rainfall infiltration (3) improved conditions for erosion control Indicate the level of use of the following means of communication used by your landowner association. (1) Face to face interaction (2) Email (3) Phone (4) Newsletter (5) Web Site (6) Workshops/Seminars (7) Other
Personal Information	What is your gender? What year were you born? Where is your primary residence? (1) On my property within my association (2) Town under 10,000 person (3) Urban area over 10,000 persons What is your highest level of formal education? (1) Less than high school (2) High School Graduate or GED (3) Vocational/Technical training (4) Some college (5) Bachelor's degree (6) Postgraduate degree What is your primary occupation? (1) Agriculture (Farming or ranching) (2) Professional (3) Retired (4) Other Select the category that best indicates your average annual household income in 2003: (1) Less than $25,000 (2) $25,000-49,999 (3) $50,000-74,999 (4) $75,000-99,999 (5) More than $100,000 Approximately what percent of your average annual household income is derived from activities related to your property in your landowner association? Under 10% (2) 11-25% (3) 26-50% (4) 51-75% (5) Over 75%