

**LANDOWNER SURVEY OF A COST-SHARE BRUSH MANAGEMENT  
PROGRAM IN TWO TEXAS WATERSHEDS**

A Thesis

by

CHRISTOPHER RAM NARAYANAN

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

August 2003

Major Subject: Rangeland Ecology and Management

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August 2003

Major Subject: Rangeland Ecology and Management

**ABSTRACT**

Landowner Survey of a Cost-Share Brush Management Program  
in Two Texas Watersheds. (August 2003)

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With the expanding population of Texas and the resulting increase in demand for water, the scarcity of water is becoming an increasingly urgent issue and research is being conducted to find ways to improve water yield, the amount of water that is used for aquifer recharge and riparian areas (lakes, streams, etc). Rangelands provide a major catchment for both surface reservoirs and aquifers. The Edwards Aquifer Recharge Zone and the Twin Buttes Drainage Area were selected to determine the tradeoffs between brush management for increased water yield and wildlife habitat improvement. In April 2002, a mail survey of 300 randomly selected landowners was conducted in each of the two watersheds to gain information regarding their demographics, land cover, and willingness to enter into a cost-share brush removal program. A total of 131 usable questionnaires (43.7%) were returned by Edwards Aquifer area participants, and 141 usable questionnaires (47.0%) were returned by Twin Buttes area participants. Respondents were asked questions including attitudes towards brush amounts and management strategies, and certain constraints that may be included in a cost-share brush removal program. Most respondents indicated interest in enrolling at least part of their land in such a program. Reasoning behind interest varied in each study area.

However, interest in various contractual agreements was neutral at best. Policy implications entail considering wildlife habitat mitigation, landowners' preferences, and potential for increasing water yield and determining if all can be managed, or if trade-offs must be considered.

## ACKNOWLEDGEMENTS

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## CHAPTER I

### INTRODUCTION AND LITERATURE REVIEW

Under one projected scenario of the current population boom, the number of Texas residents will almost double by 2040 (Texas State Data Center 2002). This increase in population will place greater demands on already limited water supplies. With this increase in demand for water, the scarcity of water is becoming an increasingly urgent issue and research is being conducted to find ways to improve water yield. Rangelands provide a major catchment for both surface reservoirs and aquifers.

Brush removal as a means of increasing water yields was first studied in the 1970s (Bach and Conner 1998), and Wilcox (2002) recently reviewed the literature to determine the feasibility of removing brush as a means to increase water yields. A study on the North Concho River watershed (Upper Colorado River Authority, 1998) indicated that removing brush could result in a significant increase in water yield and, in response to this report, the Texas Legislature appropriated funds to study the feasibility of this practice on eight additional watersheds (Bednarz et al., 2000). The U.S. Army Corps of Engineers sponsored additional studies to determine the tradeoff between brush management for increased water yield and wildlife habitat improvement in two of these eight watersheds (Twin Buttes and Edwards Aquifer).

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This thesis follows the style and format of the Journal of Range Management.

## **OBJECTIVES AND HYPOTHESES**

There were two primary purposes for this study. The first objective was to determine the proportion of landowners in the two watersheds who were willing to participate in a cost-share brush management program aimed at increasing water yields. In addition, characteristics, such as demographics and land use patterns, and their effect on landowners' willingness to participate were examined.

The second objective was to determine how various constraints placed on land management, such as fencing and excluding riparian areas from grazing, affected landowner willingness to participate in a brush management program.

The general hypothesis relating to these two objectives were:

First Objective:

H<sub>1o</sub>: Landowner willingness to participate in a cost-share brush management program to increase water yields are unaffected by landowner characteristics such as age, property size, and source and level of income.

H<sub>1a</sub>: Landowners' willingness to participate in a cost-share brush management program is correlated with characteristics such as age, level of education, property size, and source and level of income.

### Second Objective:

H<sub>2o</sub>: Constraints on land use in cost-share brush management programs do not affect the willingness of landowners to participate.

H<sub>2a</sub>: Constraints such as fencing and excluding riparian areas from grazing do affect the willingness of landowners to participate.

### **WATER YIELD STUDIES**

In his review of studies regarding brush control to increase water yields, Wilcox (2002) identified four criteria that must be met for this type of endeavor to succeed. First, increased water yields are unlikely in areas that receive an annual precipitation less than 450 mm (approximately 17.7 in.). Second, treatment of higher-density stands of brush will have a greater effect than lower-density stands. Third, runoff that is characterized by above ground flow (Horton overland flow) “will be little influenced by wood plant cover.” Finally, the extent to which a shrub intercepts precipitation affects water yield following brush removal. For example, junipers have a higher propensity to intercept rainfall than mesquite, and therefore make better candidates for removal to increase water yields. Based upon these arguments, many Texas rangelands may not be suitable for brush removal to increase water yields.

Richardson et al. (1979) studied the feasibility of brush removal to increase water yields in the Blackland Prairie and Edwards Plateau of Texas. In the Blackland Prairie site, honey mesquite (*Prosopis glandulosa*) was treated with chemicals, while brush in the Edwards Plateau site, which was a mixture of mesquite, ashe and redberry juniper (*Juniperus* spp.) and live oak (*Quercus virginiana*), was root-plowed and reseeded with

range grasses. The Blackland Prairie study found that mesquite control reduced evapotranspiration (ET) about 8 cm per year and increased runoff by approximately 10%, especially in the deep clay soils of the Blacklands with high soil moisture content (Richardson et al. 1979). By contrast, root plowing in the Edwards Aquifer reduced runoff by about 20%. Since the soils are shallower than in the Blacklands, root plowing provided large depressions to store the runoff, which allowed a considerable amount of water to percolate into the soil, thus reducing runoff.

A subsequent study conducted in northeast Uvalde County, Texas, reviewed the effects of ashe junipers on the ET and runoff in the Seco Creek watershed (Dugas et al. 1998). The authors noted that, “the amount of increased water yields from these rangelands, if any, resulting from vegetation management, depends upon vegetation type, vegetation treatment, type of soils, and climate”. The study concluded that removing junipers in northeast Uvalde County did increase water yield (runoff and percolation) for two years following treatment, and that the duration and magnitude of increased water yields might be extended if follow-up treatments were implemented to reduce leaf area increases of the remaining vegetation.

A more recent study using the Spur-91 hydrologic model to predict the effects of brush removal on water yield in the Cusenbary Draw basin, concluded that brush cover needs to be reduced to less than 20% to increase water yields and that at levels below 20%, water yields increase exponentially (Wu et al. 2001)

By contrast, three other studies concluded that brush removal had little effect on water yield. In a study near Throckmorton, Texas, a control site with mesquite and

herbaceous cover was compared to a treated area that had only herbaceous cover following chemical defoliation of mesquite (Dugas and Mayeux 1991). Daily total evaporation from rangeland varied greatly while ET differences between treated and untreated areas were small. The authors thus concluded that in environments with low potentials for runoff and deep percolation, removing mesquite is not expected to increase water yields because grasses are expected to use any water not transpired by mesquite in years following brush removal. However, they pointed out that there might be some water to gain if the new herbaceous growth was used within a proper grazing system.

Carlson et al (1990) reached a similar conclusion in a study north of Throckmorton, Texas conducted between 1986 and 1988. Using the water balance equation ( $ET = P - R - D \pm S$ ; where ET = evapotranspiration, P = precipitation, R = runoff, D = deep drainage and S = soil water content), the authors found that mesquite removal, followed by an increase in herbaceous cover, did not produce considerable off-site water yield because the clay soils and caliche layers caused most of the soil water to be lost to ET before percolation could occur. Therefore, they proposed that deep drainage, ET, and runoff levels would not likely change on rangelands where the herbaceous component increases in response to shrub removal.

In a study on La Copita Research Area, near Alice, Texas, bare ground was found to have significantly lower ET rates than either grass or shrub sites, but there was no significant difference in ET rates between grass and shrub sites (Weltz and Blackburn 1995). The results were similar for deep drainage and runoff, leading to the conclusion

that the efficacy of brush control designed to increase water yields in South Texas is marginal and only occurs if rainfall exceeds potential evapotranspiration.

## **WILDLIFE CONSIDERATIONS**

Wildlife is playing an increasingly important role in many parts of Texas as hunting leases become a greater revenue source for landowners, and rival income from traditional livestock ranching operations (Rollins 2000). For this reason, wildlife issues should be addressed when contemplating alternative brush management options. Rollins (2000) listed several points to consider regarding brush control and wildlife. These include: (1) thick stands of brush are not beneficial for water supply, wildlife, or livestock; (2) proper brush management plans can be effective for improving or maintaining wildlife habitats; (3) several aspects, such as wildlife species targeted, economics, and feasibility of certain practices must be considered when constructing a brush management plan; and (4) trade-offs between water yields and wildlife habitat should be quantified and compromises sought based on landowner's goals and society's needs (Rollins 2000). In short, brush management plans must be tailored to each individual area. The three economically most important native wildlife species in Texas include white-tailed deer (*Odocoileus virginianus*), bobwhite quail (*Colinus virginianus*), and the Rio Grande Turkey (*Meleagris gallopavo intermedia*). The effects of brush and its management on each species are reviewed.

### **Deer**

Brush cover between 30 and 60% is adequate to maintain, and even enhance, whitetail deer habitat. One study suggested that leaving 30 to 50% brush cover would

provide an adequate habitat, but, “as much as 70 percent of the range could be cleared mechanically (e.g., chaining) without adversely affecting deer use of habitats or deer populations within two years of treatment” (Rollins 2000). Another study found that maintaining 40 to 60% brush cover is suitable for effective deer management (Richardson 1999). In addition, brush at these levels will also encourage forb production, a key habitat consideration for deer (Lyons and Ginnet 1998). However, brush provides more than just food for wildlife, and the shelter that brush cover provides is important for both climatic shade and concealment. For white-tailed deer, brush height must be at least 36 inches tall to provide adequate screening cover (Rollins 2000).

Herbicides are useful in treating brush to improve wildlife habitat; the dead shrub can still be used for cover. However, depending on the herbicide and rate applied, it may take 2-4 years for forbs in the treated area to recover adequately for deer fodder and deer numbers may fall for one or more growing seasons following herbicide applications (Rollins 2000). Research conducted in the northern Rio Grande Plains found that in a pasture that was 80% treated with herbicides, deer populations declined dramatically, but, as shrub regrowth occurred, deer populations expanded to higher levels than previously observed (Richardson 1999).

Lyons and Ginnet (1998) suggest roller chopping as a means to remove shrubs and create clearings. Regrowth of shrubs occurs faster with this method and the nutritional quality of early shrub regrowth is very high, making it more palatable to deer than mature woody plants (Richardson 1999). Conversely, rootplowing can reduce the shrub regrowth diversity, as it is difficult to control brush selectively with this method



(Lyons and Ginnet 1998) and it can destroy cover (Richardson 1999). However, deer can use travel corridors created using this method (Rollins 2000). Thus, rootplowing should be carefully planned to include strips for travel lanes.

Prescribed burning is a third option for brush control. Fire effects on plants is similar to any other method of top removal, in that it reduces brush cover and increases the nutritional value of browse as shrubs regrow, especially during the first month following fire and fire can produce mosaic brush patterns for deer to use as cover (Richardson 1999).

### **Bobwhite Quail**

Woody plant cover requirements for bobwhite quail differ markedly from deer. Since the desired habitats for coveys tend to be located 50 to 75 yards from brush, brush cover should range from 15% for well-dispersed plants to 25% for more clustered plants, approximately 2 to 3 feet in height (Lyons and Ginnet 1998). Rollins (2000) similarly indicates that coveys are usually found 25 to 75 yards from brush and recommended that a maximum of 90% of the brush should be treated, and remaining woody cover stands being 75 to 150 square feet in area. In addition, Hanselka and Guthery (1991) supported the conclusion that bobwhite quail numbers decline as brush cover exceeds 15%, while they identified 5% brush cover as a minimum to meet the needs of bobwhites. In addition to the amount of brush cover, brush patterns play a key role in quail habitat, with beneficial patterns including strips, mottes, and blocks (Lyons and Ginnet 1998, Hanselka and Guthery 1991).

The suitability of various brush treatments for improving quail habitat has also been evaluated. Top kill methods have been identified as most suitable (Lyons and Ginnet 1998), because a root kill rate of greater than sixty-five percent is unlikely (Hanselka and Guthery 1991), allowing for more appropriate levels of brush. However, herbicides should only be applied using individual plant treatments (IPT) (Lyons and Ginnet 1998) because these allow greater flexibility and selectivity in brush management. Moreover, in addition to target brush species, herbicides can kill forbs, although these forbs may recover within two growing seasons following the treatment.

Rootplowing may also be acceptable if used carefully, despite the high costs (Hanselka and Guthery 1991) because rootplowing produces effective brush removal. In addition to rootplowing, other mechanical methods may be feasible. For example, roller chopping or disking works well on short to mid-height brush and on shallow soils (Hanselka and Guthery 1991). The regrowth that occurs after these mechanical methods provides good nutrition for browsing animals, as well as escape and loafing cover for quail.

Finally, carefully planned cool fires that minimize harm to quail can be a feasible control measure for woody plants to improve quail habitat (Lyons and Ginnet 1998). Hanselka and Guthery (1991) list a few criteria for an effective fire, including: (1) fires should remove excess litter buildup; (2) timing of fires should be in December to benefit forb growth; (3) dormant grasses should occur in patches to achieve a spotty burn to provide nesting and escape cover; and (4) soils should be moist at burn time. The

important thing to consider is that no one method of brush management achieves all the desired goals.

### **Turkey**

Turkeys need variety in their habitat (Lyons and Ginnet 1998). Breeding and nesting habitat should consist of 4 to 8 inch tall herbaceous vegetation for mating with 3 feet tall screen cover nearby, and 12 to 24 inch tall vegetation for rearing offspring. Trees are also important to the poults for shelter and escape cover. Finally, the presence of 8 to 50 feet tall live or dead roost trees is important in fall and winter habitats.

Neither large cleared areas nor dense wooded areas are suitable habitats for turkey (Lyons and Ginnet 1998) and 50% cover seems to be the limit for proper turkey habitat. Ideally, openings should not be more than half a mile across; half the area should consist of scattered trees and small stands, while the other half consists of blocks of brush with scattered openings. Known roost trees should also be left intact. Rootplowing should probably not be used due to these specific constraints.

### **LANDOWNER PARTICIPATION**

In areas where brush removal can increase water yield, high levels of landowner participation is important to make brush management programs aimed at increasing water yields socially meaningful. Landowner participation may be affected by numerous factors including the economic benefits derived from participating. In their analysis in the eight-watershed study, Bach and Conner (1998) performed an economic analysis of the costs to implement a brush removal program to increase water yields. They assumed that landowners would not be willing to pay for costs in excess of the

benefits they could expect to accrue to them from a brush management program. Thus, if such a program is to be implemented, someone else (e.g., the state) must pay for the remainder of the brush control program costs. The state must then determine whether the benefits of additional water for public use are equal to or greater than the state's share of the cost of brush management. Administrative costs such as implementation, administration and monitoring, were not addressed.

Thurow et al. (2001) state that landowners choose to engage in brush management plans only if livestock forage production increases after the brush is removed. However, they contend that the value of the increased forage offsets neither the costs of clearing the brush and subsequent maintenance, nor the reduced revenues from hunting leases.

A survey performed by Coppock et al. (1999) reported attitudes of Utah landowners. The survey questions included reasons for not using a variety of livestock and range management practices including brush management. Incompatibility between the use of brush control and the landowners' goals and needs on the operation was reported as the main reason for lack of use, and landowners reported associated costs as the second reason for not using brush control.

Johnson et al. (1999) studied the economic feasibility of redberry juniper (*Juniperus pinchotti*) control in the Texas Rolling Plains. They found that 2-way chaining, followed by periodic prescribed fire, for maintenance was economically feasible for shallow range sites in the Rolling Plains. Time to realize returns from such a program varied from 5 to 20 years based upon the returns of increasing range

productivity following juniper removal, and net present values of livestock prices, treatment costs and discount rates.

Tays (2001) conducted a survey of landowners located in Blanco and Gillespie Counties, Texas. He found that, of the respondents, over 80% of landowners indicated a willingness to participate at least partially in a cost-share brush control program.. Tays found that landowners with larger tracts of land were more likely to enroll than those with smaller tracts. Similarly, landowners who derived their primary source of income from their land were also generally more willing to participate in a cost-share program compared to those who held the land merely for a place to live. Finally, landowners whose source of income included wildlife production also demonstrated a greater willingness to participate.

In a coordinating study also funded by the U.S. Army Corps of Engineers, Olenick (2002) suggested five possible scenarios to incorporate brush management and wildlife concerns:

1. Control of all moderate and heavy brush cover (mesquite, juniper, mixed) on slopes less than 15 percent slope
2. Similar to scenario 1, but brush cover within 75 m of a mapped stream remains untreated
3. Similar to scenario 2, except that riparian-specific treatments are used in lieu of a 75 m buffer
4. Similar to scenario 2, but amounts of heavy and moderate cover will not be reduced to less than 40 percent.

5. Similar to scenario 4, except that riparian-specific treatments are used in lieu of a 75 m buffer

## **LEGAL INSTRUMENTS**

Various existing legal instruments can be used as models for landowner participation in publicly funded cost-share brush management programs because many of these instruments have common provisions including time period, responsibilities of the landowners and financing authority, cost-share payments and incentives. Variations between instruments include length of the contract, amount of cost-share, and responsibilities of both the landowner and the financing authority.

### **Conservation Easements**

A conservation easement (“easement”) is a constraint on certain activities that a landowner voluntarily places on his/her property (Francell 1997). The landowner retains ownership of the property, but certain activities are restricted, and the landowner concedes to the holder of the easement the right to periodically check the property for compliance. The Texas Natural Resource Code Annotated provides some reasons for landowners to place an easement on their property, including the protection of natural resources and the maintenance or enhancement of water quality and/or quantity. Easements are permanent unless otherwise specified within the contract (TNRCA 1983). They are written contracts that are recorded in the deed records of the appropriate county, and they generally offer tax relief to the landowner due to changes in property values. If an easement is terminated by the landowner, he or she is subject to the additional tax equal to any difference between taxes imposed on the land for the

previous 5 years after termination of the easement and the taxes that would have been due had the land not been subject to the easement, subject to a stipulated annual interest (TNRCA 1983).

### **Conservation Reserve Program (CRP)**

CRP was authorized by the Food Security Act of 1985 (FSA 1999) and was implemented to encourage landowners to restrict the planting of certain crops and to improve natural resources over an extended time. Administered through the Commodity Credit Corporation, the program offers annual rental payments, incentives, and cost-share to landowners for up to 50% of their cost of participating in the program. CRP contracts range in length from 10 to 15 years.

Requirements for land to be placed in CRP include the ability of targeted land to respond to practices that provide environmental benefits, land in national or state CRP priority areas, and land associated with or surrounded by non-cropped wetlands. Once a landowner applies for a contract, the Natural Resources Conservation Service collects data to evaluate the offered land in terms of wildlife habitat improvements, water quality benefits and projected cost of inclusion. Finally, to be eligible a landowner must have owned or operated the land for a minimum of 12 months prior to application, with certain exceptions (FSA 1999).

Cost-share rates are determined by the applicable county measure of relative soil productivity, and the past 3-year average of cash rent rates (or equivalent) for the land. In addition, landowners enter a “bid” for their cost-share, which may be equal to or less

than the maximum allowed rate of 50%, plus a onetime incentive payment of 25% of the costs incurred if wetlands are involved.

### **Environmental Quality Incentives Program (EQIP)**

EQIP was established under the 1996 Farm Bill to provide landowners with a voluntary conservation program designed to address threats to soil, water, and related natural resources (CCC 1997). This is a national program that provides technical, financial and educational assistance to landowners, and funding for it is provided by the Commodity Credit Corporation. Approximately one-half the assistance is provided to livestock-related natural resource areas, while the remainder supports other conservation priorities that provide off-site environmental benefits. Contracts range from 5 to 10 years in duration.

EQIP targets priority areas including watersheds, wetlands, and grazing lands that have serious natural resource problems. It also addresses statewide concerns outside the priority areas, focusing on areas of state or local government concerns. In Texas, two of these priority areas are the Middle Concho River and the Edwards Aquifer areas (NRCS 2000).

Assistance is provided to formulate an individual conservation plan for the landowner, with help from the Natural Resource Conservation Service (NRCS) or other service providers. The plan should focus on the primary natural resources concerns of the property and landowners are encouraged to construct a comprehensive course of action (NRCS 2003). Once applications are received by the NRCS, they are ranked by criteria including the projected environmental benefits weighted against implementation



costs, with higher rankings being given to plans that are sustainable, and that provide large environmental benefits per dollar spent (NRCS 2003).

Under EQIP, cost shares may pay up to 75% of the cost of the conservation plan with payments being payable up to 3 years. In addition, incentive payments may be awarded to encourage the landowner to implement certain land management practices, such as wildlife habitat improvement.

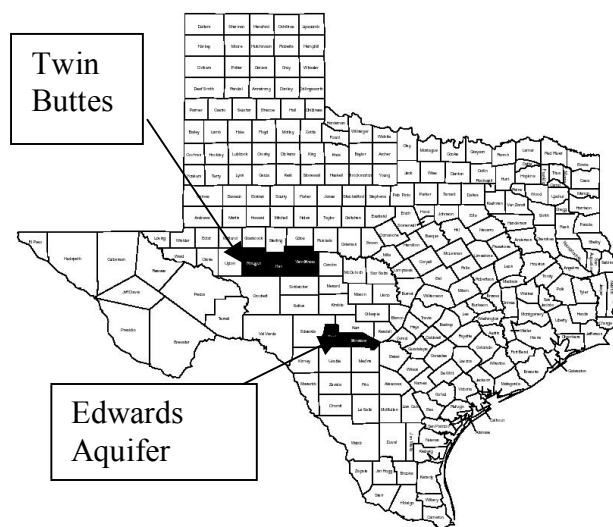
The use of brush management practices to increase water yields involves many variables. Not only must the economic costs and benefits of brush removal practices be considered, but also the wildlife consequences of altering habitats. In addition, since Texas is almost entirely privately owned, contractual agreements for cost-share must be used to gain participation. These agreements should be structured to include necessary provisions to remove enough brush to increase water yield, while maintaining or improving wildlife habitat through riparian area improvement. It is the objective of this study to account for these variables and compare various scenarios.

## CHAPTER II

### STUDY AREA & METHODOLOGY

Two areas were selected for this study. The Twin Buttes Drainage Area includes Reagan, Irion, and Tom Green counties in west Texas, while the Edwards Aquifer Recharge Zone includes Real and Bandera counties in the Hill Country of Texas (Figure 1).

The Twin Buttes area encompasses 2,423,854 acres (approximately 3787 square miles) and has areas of heavy and moderate brush (predominantly mesquite and some juniper) (Dybala 2000), especially in the aforementioned counties. The Edwards Aquifer zone encompasses 637,380 acres (approximately 996 square miles) and also has areas of heavy and moderate brush (predominantly juniper and some mesquite) (Muttiah and Rosenthal 2000).



**Figure 1. Study Area.**

## **METHODOLOGY**

A mail survey was used to obtain data from landowners. Landowner mailing lists were obtained from the county appraisal district office in each of the counties representing the two study areas. The lists were then standardized by eliminating landowners with less than 50 acres. 300 landowners were randomly selected in each of the two study areas, and each mailed a survey questionnaire.

The mail survey was administered using the multi-contact Tailored Design Method (Dillman 2000). This method had been used successfully in other surveys of Texas landowners (Thurow et al. 2000, Kreuter et al. 2001, and Tays 2001). A letter explaining the purpose of the survey and informing landowners that they will receive a questionnaire was mailed on April 1, 2002 (Appendix A). The initial survey questionnaire and cover letter (Appendix B) were then mailed on April 7. One week later, on April 14, a reminder card was mailed to landowners who had not yet returned the questionnaire. This was then followed by a second letter again explaining the purpose of the survey and second copy of the questionnaire on April 28 to those landowners who still had not returned the questionnaire. Finally, a second reminder card was mailed to non-respondents two weeks later.

Survey participants were first asked to only complete the survey if they were the owner, operator, or manager of at least 50 acres of private land. In addition, the recipients were asked to only include answers for the land for which property taxes were paid in Real, Bandera, Reagan, Irion, and/or Tom Green County. The survey questions were then divided into four sections.

The first section of the questionnaire asked for information on the characteristics of the property and land management practices. Included in these questions were landholding size (acres), the role of the survey participant on the property, and primary activities and income sources from the land. In addition, participants were asked to rate the importance of the existence of several rangeland components, certain land management objectives, factors that are considered important for alternative brush management options, and the use of water conservation practices on the land.

The second section requested information about amount, type and distribution of the brush present on the properties. Participants were first asked to determine the amount of land that was covered by various classes of vegetation, including open grassland, live oak, mesquite, juniper, and mixed stands. Next, participants were asked about the cover that occurred in areas with:

1. slopes greater than 15% gradient,
2. within 75 yards of streams/rivers, and
3. all other areas.

These questions were important for comparing the five scenarios proposed by Olenick (2002) (see Chapter I). In addition, landowners were asked to rate their opinions regarding the amount of various types of brush on their land, the percentage of canopy cover classes (open, moderate, heavy) and their willingness to enroll all or part of their land in a cost-share brush removal program. Finally, landowners were asked how their willingness to enroll land with moderate and/or heavy cover would change if brush removal was constrained within 75 yards of riparian (streams/rivers) areas and if 40% of land was to remain in moderate or heavy cover.

The third section addressed issues affecting riparian areas affected by cost-share brush management programs. Examples of questions asked included constraints or requirements regarding protection of hardwoods, placing buffers around riparian areas, and restricted grazing. Assuming sufficient funds were available for these constraints, participants were asked how their interest to enroll in a cost-share brush management program would change. Furthermore, landowners were asked to rate the importance of compensation for various actions designed to protect riparian areas such as fencing or grazing deferment. Landowners' experience and interest in various contractual agreements were also examined. Finally, landowners were asked what the minimum level of cost share would be acceptable for their participation.

The fourth section of the questionnaire asked for personal information, such as income level, residence on property and age. This information was requested to determine if there was a relationship between demographics and willingness to participate in a cost-share program.

Questionnaires that were returned by survey participants were either "usable" or "unusable." If a respondent returned the questionnaire with more than 2 pages (of 8) blank, the questionnaire was considered unusable. Additionally, if a considerable amount of responses were unclear, or were answered "don't know", the questionnaire was similarly classified as unusable.

Data was coded to account for the variations in responses. The Statistical Package for the Social Sciences (SPSS 1999) was used for statistical analysis. Analyses included frequency distributions and descriptive statistics for categorical questions. In

addition, comparisons of means (ANOVA) were conducted to identify statistically significant patterns and differences in the data reported. Finally, Spearman correlations (annotated  $r_s$ ) were used to determine patterns within cross tabulations of several variables. The format used to report differences between sample means is mean value  $\pm$  standard error of mean, appropriate test statistic, and p-value.

## CHAPTER III

### DESCRIPTIVE PARAMETERS OF RESPONDENTS

#### NATURE OF RESPONSES

In the Edwards Aquifer (EA) area, 60.3% of the questionnaires were returned. Of this amount, 50 were considered unusable, resulting in a 43.7% usable response rate (n=131). In contrast, 59.7% of the questionnaires sent to the Twin Buttes (TB) area were returned, of which 38 were considered unusable, representing a 47.0% usable response rate (n=141). Respondents overwhelmingly (81.3%) classified themselves as primary decision makers for the property, followed by one of the key decision makers (9.7%), spouse of key decision maker (1.9%), hired manager (0.7%), and other (6.4%).

#### RESPONDENT CHARACTERISTICS

##### Demographic Characteristics

Respondents in both areas indicated an average age of approximately 60 years (EA=60.7  $\pm$  1.1, TB=60.0  $\pm$  1.2, F=0.173, p=0.0.678). Overall, the 2 areas showed a mean level of 31.71 years of experience  $\pm$  1.7 years. On average, respondents in the Twin Buttes area had 37.0 years  $\pm$  2.4 years, of farming and/or ranching. This varied significantly with the Edwards Aquifer area where respondents indicated a mean level of 25.8 years  $\pm$  2.2 years of farming/ranching experience (F=11.468, p=0.001).

When asked if the landowner lived on the property reported in the questionnaire, Overall, 48.1% of the respondents in both areas indicated that they did live on the property ( $r_s=0.142$ , p=0.022). Comparing the two study areas, 46.0% of respondents in

the Edwards Aquifer area answered in the affirmative compared to 32.1% of the respondents in the Twin Buttes area.

Finally, responses indicate similar patterns in both watersheds regarding level of fixed improvements made within the previous 5 years, 1997-2002 (Figure 2), proportion of total income from property activities (Figure 3), and total income levels (Figure 4). Respondent indications of investments in fixed improvements were distributed nearly equally in thirds for each category in the study areas (<\$10K, \$10-50K, >\$50K). Respondents mainly indicated that their proportions of total income that was derived from the property was under 25% for both areas (EA=83.6%, TB=60.9%). However, the next highest category was 25-50% for the Edwards Aquifer (7.0%), while the next highest category was 51-75% for the Twin Buttes area (14.3%). The proportion of responses regarding total household income, for both areas, showed an increase as the income categories increased. Thus, the highest proportion of respondents stated that their total household income was over \$100,000 (EA=45.8%, TB=42.6%).



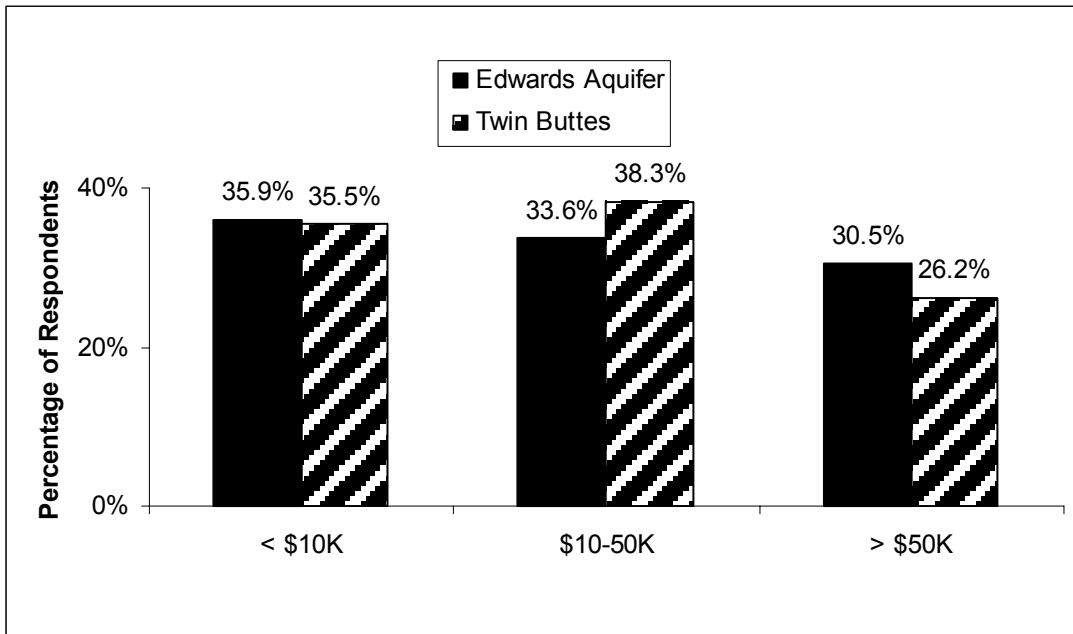


Figure 2. Investment in fixed improvements from 1997-2002.

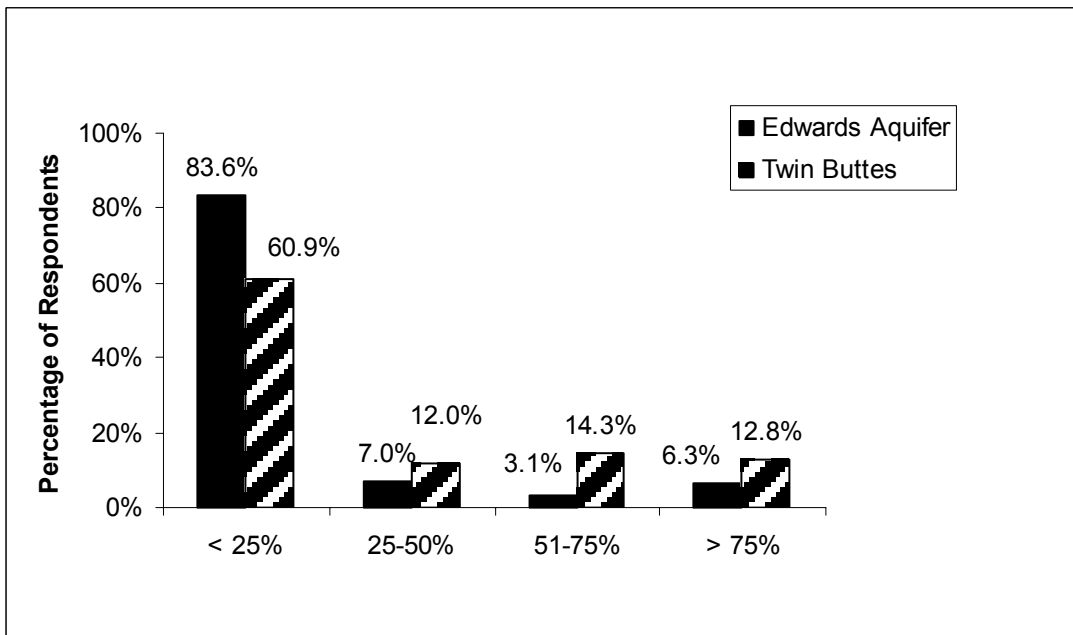
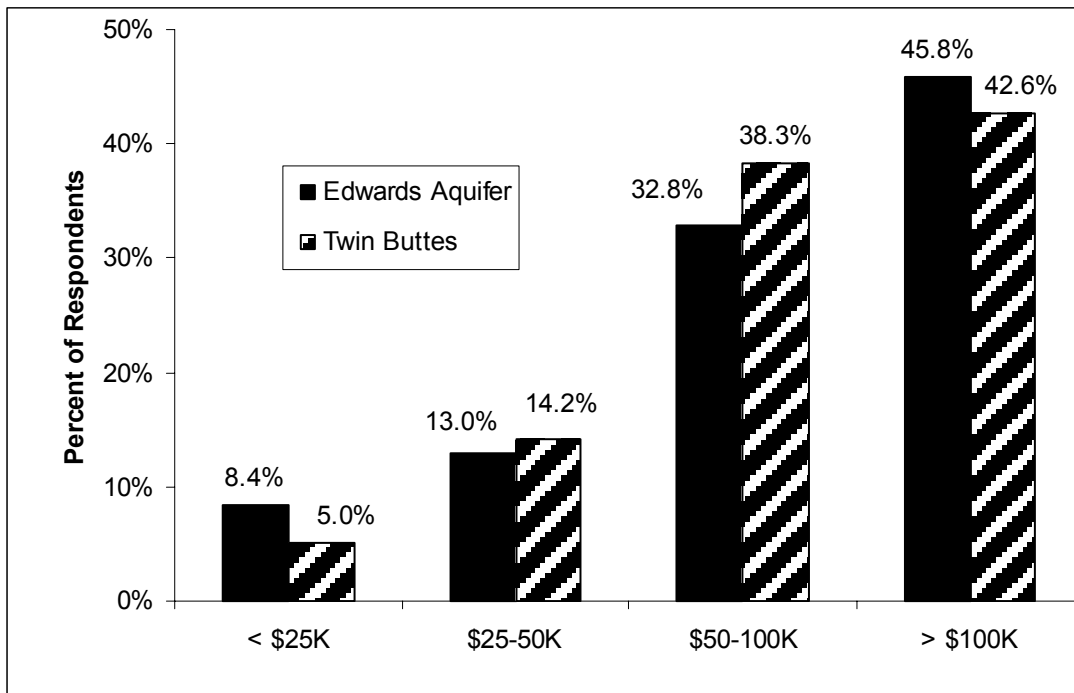


Figure 3. Proportion of total income derived from property.

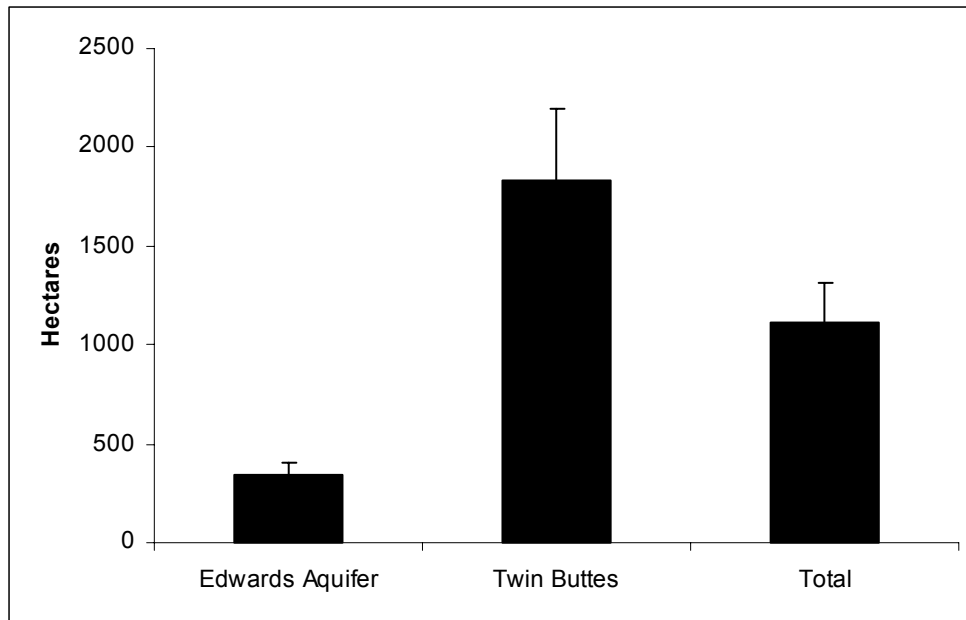


**Figure 4. Total household income of respondents by area.**

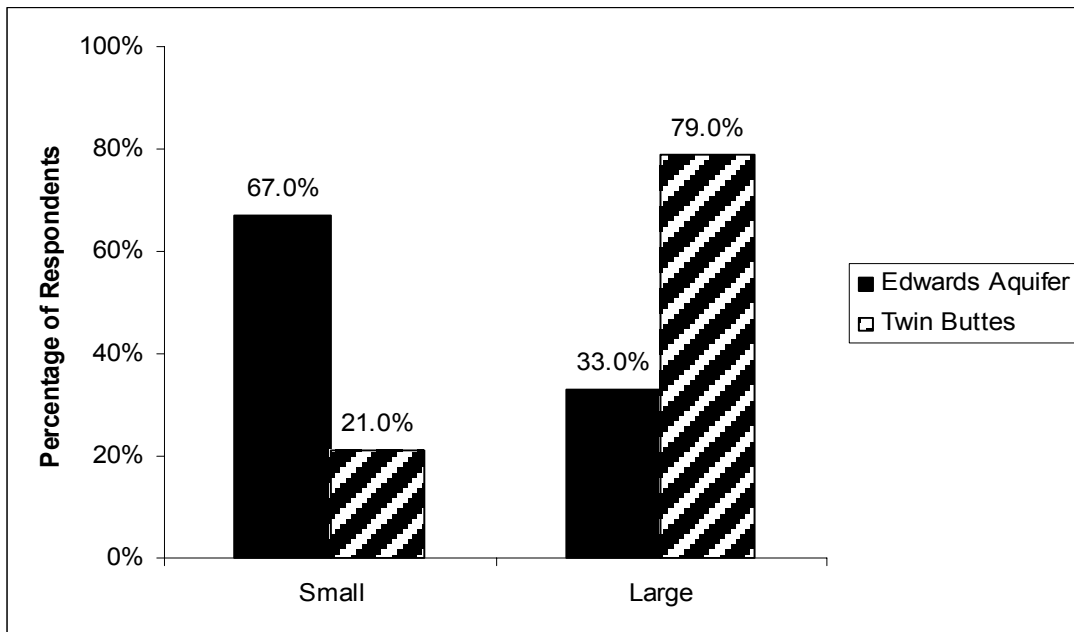
### Property Characteristics

Landholdings were significantly larger in the Twin Buttes Drainage Area than in the Edwards Aquifer Recharge Zone ( $F=14.6$ ,  $p \leq 0.000$ ). Twin Buttes respondents indicated a mean holding of 1827.8 ha with a standard error of mean (SEM) of 369.8 ha, while the Edwards Aquifer respondents indicated a mean holding of 345.6 ha with a standard error of mean of 59.4 ha (Figure 5). Responses for landholdings were divided between small landowners,  $\leq 260$  ha ( $260 \text{ ha} \approx 640 \text{ ac}$ ), and large landowners,  $> 260$  ha for both regions. Overall, 57.0% of respondents fell into the large landowner category.

However, 67.0% of Edwards Aquifer respondents were categorized as small landowners, while 79.0 % of Twin Buttes respondents were classified as large landowners (Figure 6).

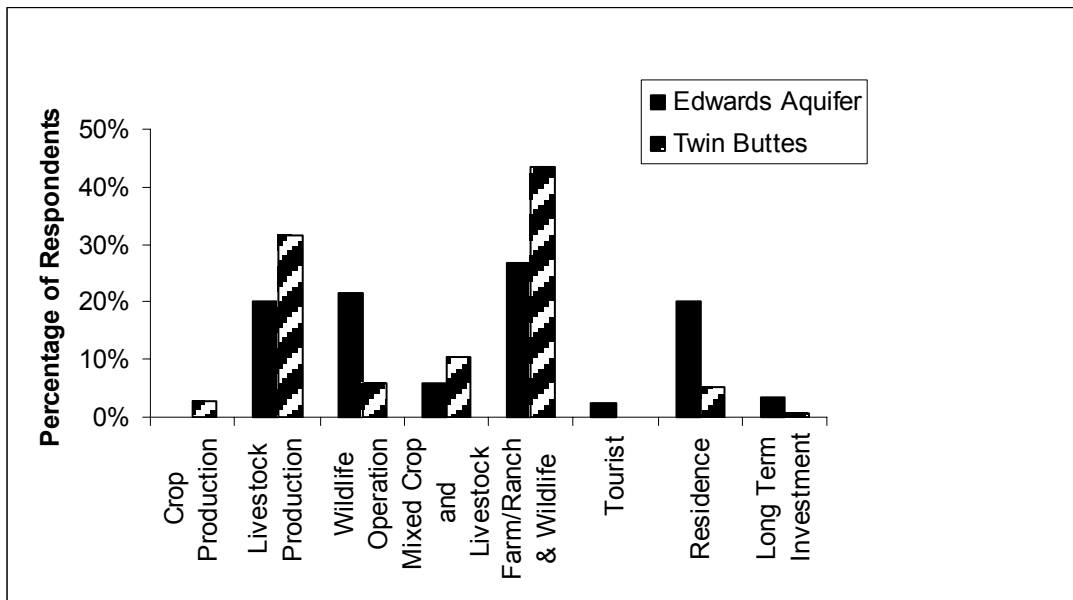


**Figure 5. Mean area of landholdings per landowner by watershed with standard error of mean bars.**



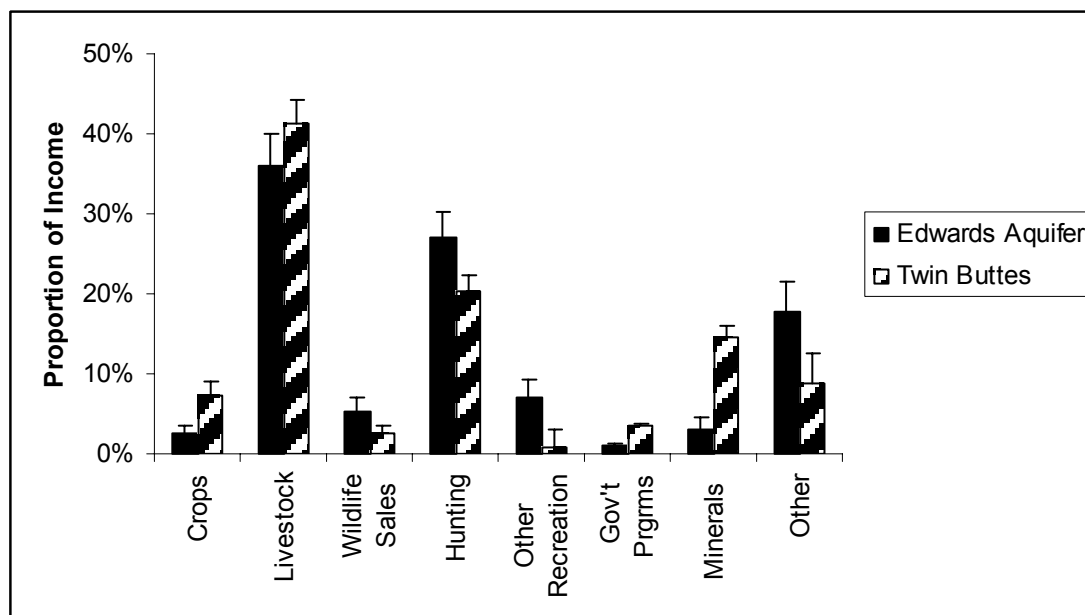
**Figure 6. Frequency distribution of small ( $\leq 260$  ha) and large ( $> 260$  ha) landowners by watershed area.**

When asked to describe the primary activity on their property, mixed farm/ranch activities combined with a wildlife operation were most common in both study areas (EA=26.7%, TB=43.4%), followed by a livestock operation (EA=20.0%, TB=31.6%) (Figure 7). In both cases, both these types of operations were proportionately more common in the Twin Buttes Area than in the Edwards Aquifer area. Conversely, mainly wildlife operation and primary residence were more common in the Edwards Aquifer than in the Twin Buttes area (wildlife: EA = 21.7%, TB = 5.9%; residence: EA = 20.0%, TB = 5.1%).



**Figure 7. Primary activities on property as reported by each area.**

Proportional income from several sources varied significantly between the areas (Figure 8). On average, landowners in the Edwards Aquifer area earned proportionately more income from non-hunting recreation (EA = 7.0% ± 2.3%; TB = 0.7% ± 0.4%, F=10.388, p=0.001) and other sources (EA = 17.7% ± 3.7%; TB = 8.4% ± 2.0%; F=5.291, p=0.022). In contrast, landowners in the Twin Buttes area earn more from crops (TB = 7.4% ± 1.6%; EA = 2.6% ± 0.9%; F=5.299, p=0.22), government program payments (TB = 3.5% ± 0.7%; EA = 1.0% ± 0.4%; F=8.017, p=0.005), and mineral sales and leases (TB = 14.5% ± 2.4%; EA = 2.9% ± 1.4%; F=13.392, p≤0.000).



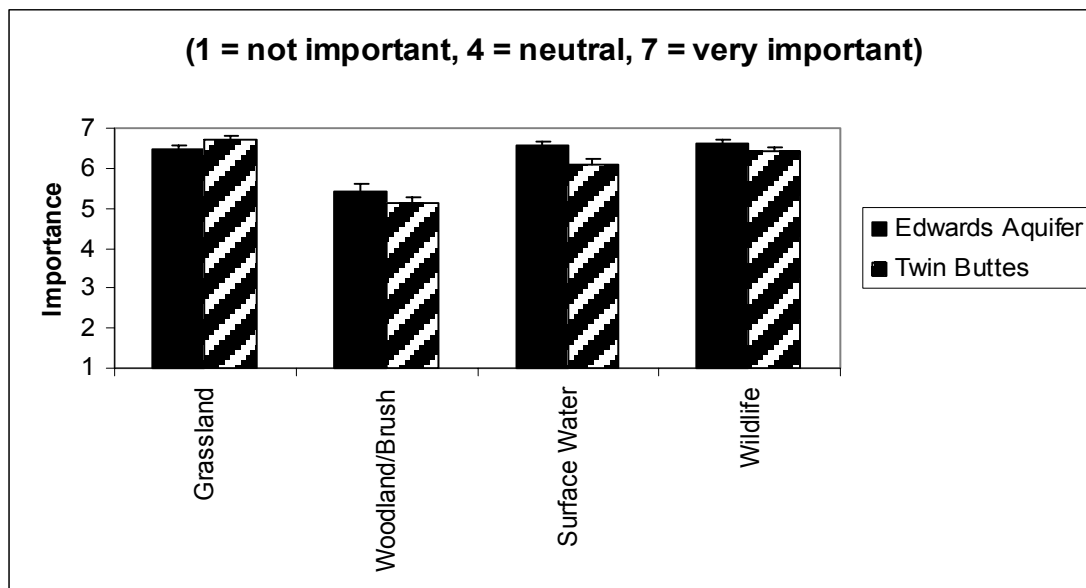
**Figure 8. Mean proportion of income by activity on property with standard error of mean bars.**

Landowners were asked to rate 3 categories of concern. Using a Likert Scale of 1 to 7, 1 indicated Not At All Important, 4 indicated Neutral, and 7 indicated Very Important. Overall, grassland was most important (mean=6.6  $\pm$ 0.1) and woodland/brush was least important (mean=5.3  $\pm$ 0.1). Landowners were first asked to rate the importance that they place on certain rangeland characteristics on their land (Figure 9). Grassland was significantly more important in the Twin Buttes area (F=4.064, p=0.045), while surface water was given more importance in the Edwards Aquifer area (F=7.909, p=0.005).

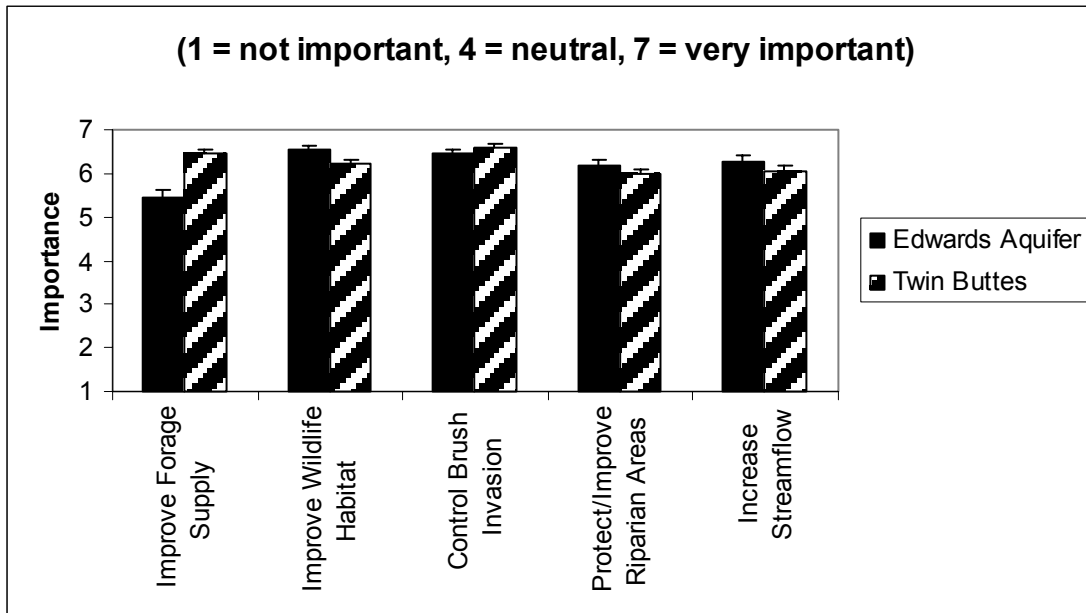
Overall, controlling brush invasion was most important (mean=6.5  $\pm$ 0.1) and improving forage supply was least important (mean=6.0  $\pm$ 0.1). Landowners were then asked to rate the importance of various land management objectives to them (Figure 10).

Improving forage supply was far more important to residents of the Twin Buttes area ( $F=22.169$ ,  $p\leq 0.000$ ), while improving wildlife habitat was more important to residents of the Edwards Aquifer area ( $F=5.003$ ,  $p=0.026$ ).

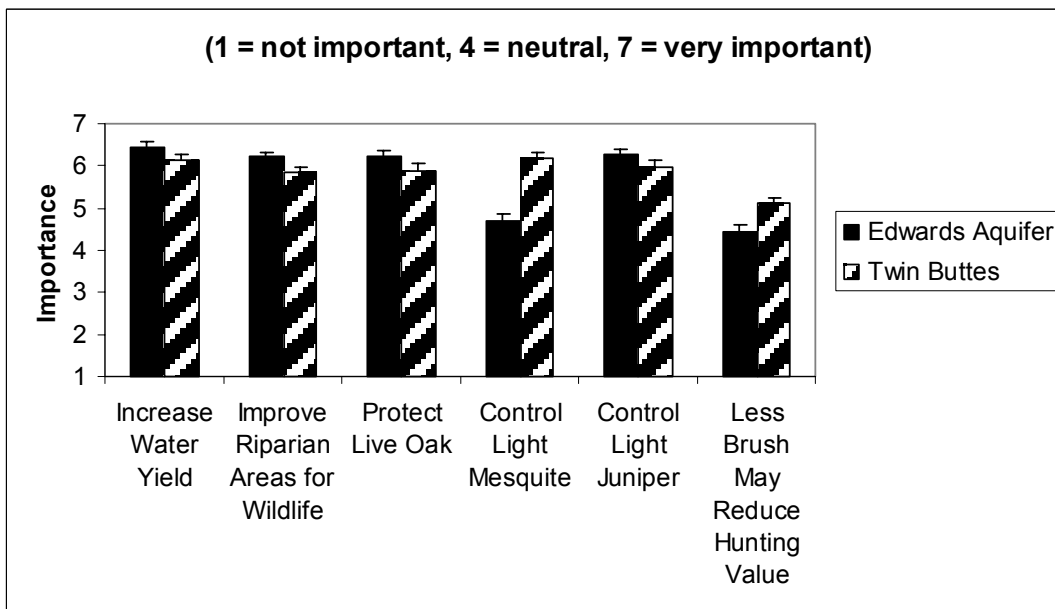
Finally, respondents were asked how important certain considerations were to them when making decisions about brush management options (Figure 11). Overall, increasing water yield was of the most importance (mean =  $6.3 \pm 0.1$ ) and less brush may decrease hunting value was least importance (mean =  $4.8 \pm 0.1$ ). Improving riparian areas was more important to respondents of the Edwards Aquifer ( $F=4.611$ ,  $p=0.033$ ). By contrast, controlling light mesquite was more important for respondents in the Twin Buttes area ( $F=45.058$ ,  $p\leq 0.000$ ). A notion that less brush may reduce hunting value was of more importance to respondents in the Twin Buttes Area ( $F=9.411$ ,  $p=0.002$ ).



**Figure 9. Mean importance of various rangeland characteristics on property with standard error of mean bars.**



**Figure 10. Mean importance of various land management objectives with standard error of mean bars.**

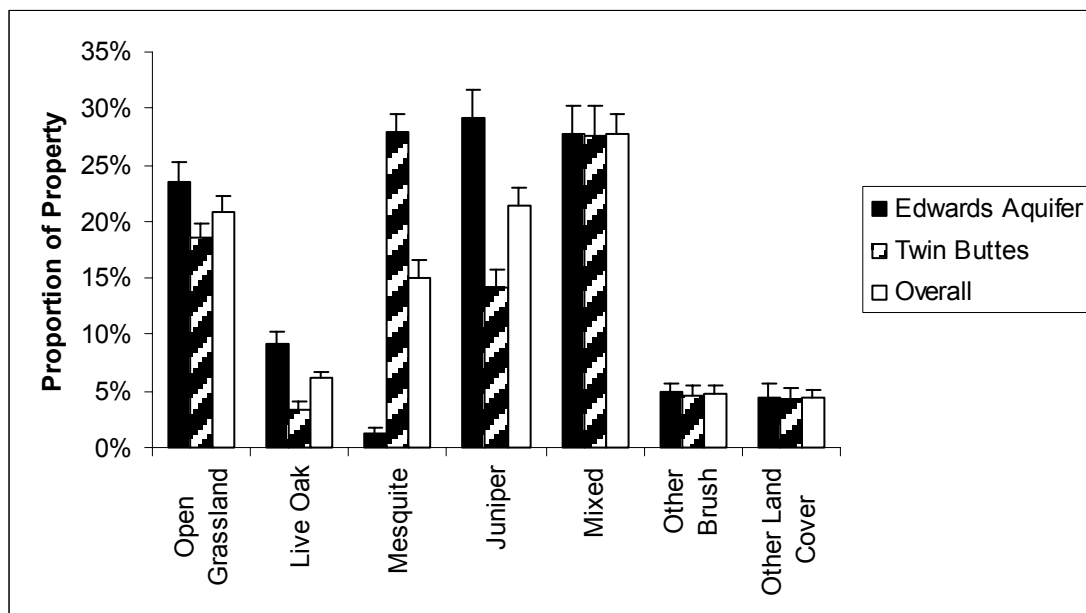


**Figure 11. Mean importance of various brush management options with standard error of mean bars.**



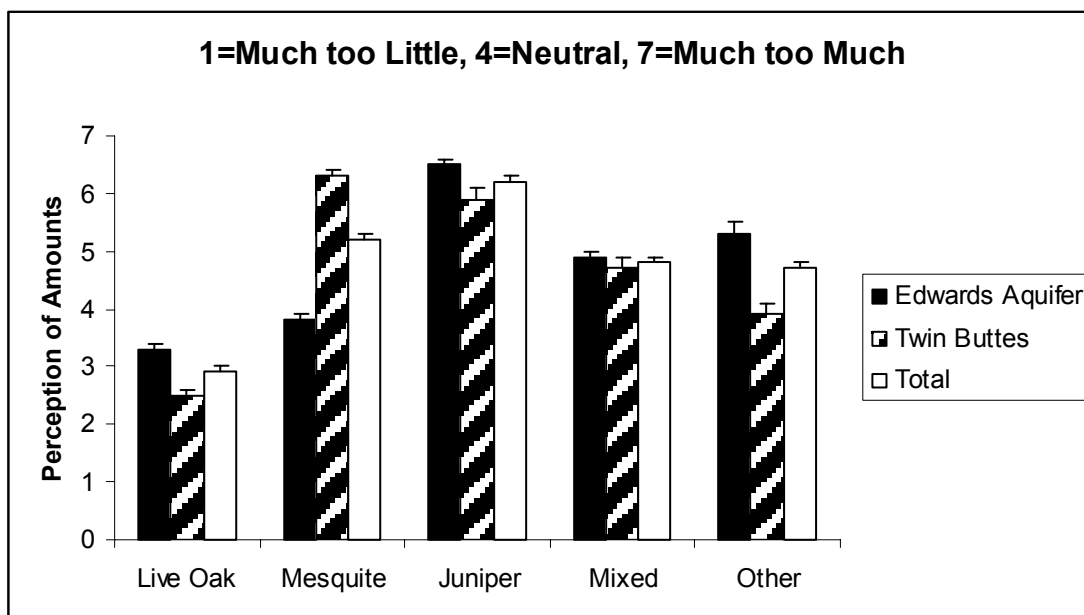
## CHARACTERISTICS OF BRUSH ON PROPERTY

Overall, proportion of land cover was highest for mixed brush (mean=27.7%  $\pm$ 1.8%), followed by juniper (mean=21.4%  $\pm$ 1.6%), open grassland (mean=20.9%  $\pm$ 1.3%) and mesquite (mean=15.1%  $\pm$ 1.6%). Results showed significant differences in the amounts of open grassland ( $F=3.988$ ,  $p=0.047$ ), live oak ( $F=20.664$ ,  $p\leq 0.000$ ), mesquite ( $F=89.702$ ,  $p\leq 0.000$ ) and juniper ( $F=23.986$ ,  $p\leq 0.000$ ) between the 2 areas. Open grasslands (EA=23.5%  $\pm$ 1.7%; TB=18.5%  $\pm$ 1.8%) live oak (EA=9.2%  $\pm$ 1.0%; TB=3.3%  $\pm$ 0.9%) and juniper (EA=29.2%  $\pm$ 2.5%; TB=14.2%  $\pm$ 1.9%) were more common in the Edwards Aquifer area, while mesquite was more prevalent in the Twin Buttes area (TB=28.0%  $\pm$ 2.7%, EA=1.2%  $\pm$ 0.6%). Properties in both areas showed similar proportional cover for all other types of land cover (Figure 12).



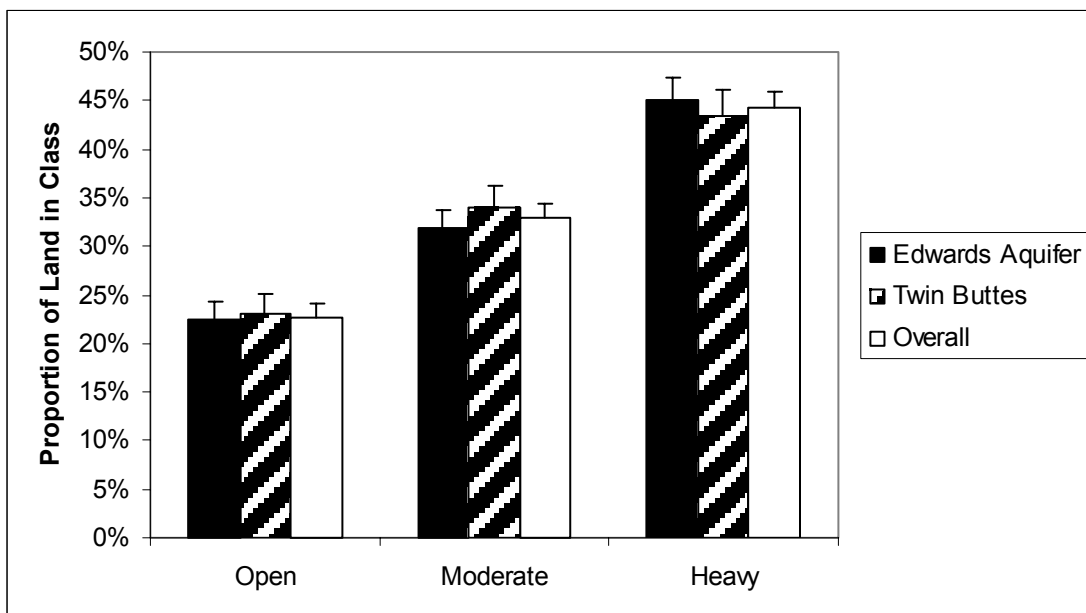
**Figure 12. Mean proportion of land cover types on property with standard error of mean bars.**

Overall, respondents felt that there was not enough live oak, and too much of other types of brush on their properties. Perceptions of the amount of brush cover varied between the two areas (Figure 13). Respondents in the Twin Buttes area felt stronger ( $F=19.165$ ,  $p\leq 0.000$ ) about not enough live oak on their property ( $TB=2.5 \pm 0.1$ ;  $EA=3.3 \pm 0.1$ ). By contrast, Twin Buttes area respondents felt much stronger ( $F=231.093$ ,  $p\leq 0.000$ ) about too much mesquite on their land ( $TB=6.3 \pm 0.1$ ;  $EA=3.8 \pm 0.1$ ). Edwards Aquifer respondents felt stronger that there was too much juniper ( $F=9.453$ ,  $p=0.002$ ) on their land ( $EA=6.5 \pm 0.1$ ;  $TB=5.9 \pm 0.2$ ) and that there was too much mixed (live oak, mesquite, and/or juniper) brush ( $F=38.836$ ,  $p\leq 0.000$ ) on their property ( $EA=5.3 \pm 0.1$ ;  $TB=3.9 \pm 0.2$ ). Perceptions among other brush species were not found to be different between the two areas ( $F=0.822$ ,  $p=0.366$ ).



**Figure 13. Mean perceptions of amounts of various types of brush on property with standard error of mean bars.**

Respondents were asked to approximate the amount of their property described by open (<10% canopy cover), moderate (10-30% canopy cover), and heavy (>30% canopy cover) cover on their land. No significant differences were found between the two areas (Figure 14). The proportion of the property in each canopy class was similar for both areas and the overall trend, with over 40% of the land in both areas having heavy canopy cover.

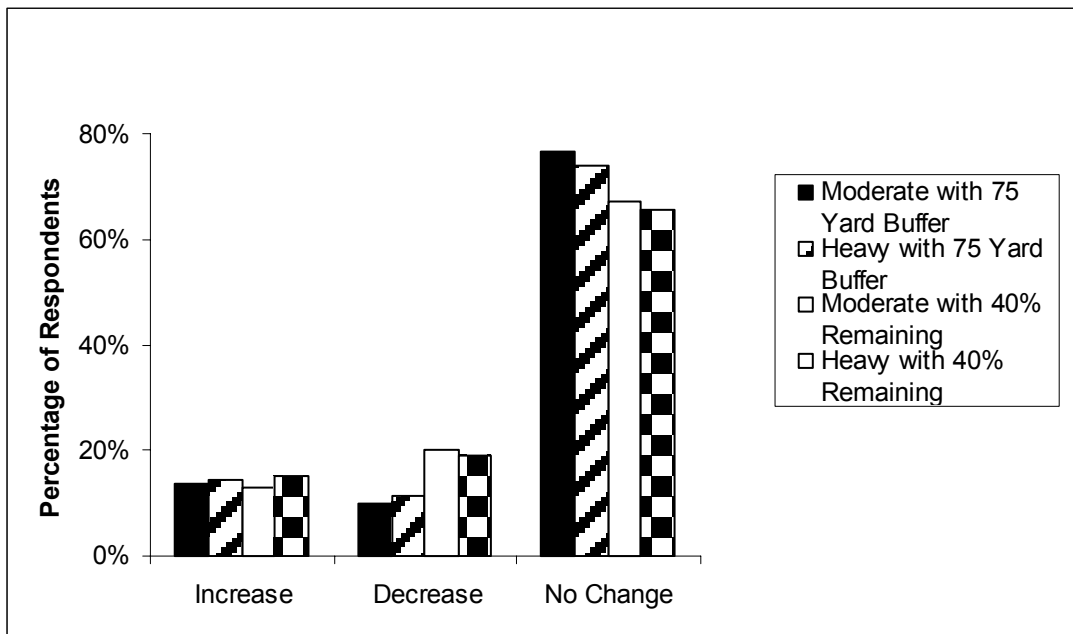


**Figure 14. Mean proportion of property in canopy classes with standard error of mean bars.**

## **PROGRAM PARTICIPATION**

Landowners were asked if they would include all, none, or part of their moderate and heavy cover into a cost-share brush management program. If respondents indicated that they would include at least a portion of their land into such a program, it was assumed that they were interested in participating. Upon reviewing the data, it was found that 94.0% of Edwards Aquifer area respondents and 85.0% of Twin Buttes area respondents had some sort of interest in a cost-share brush management program.

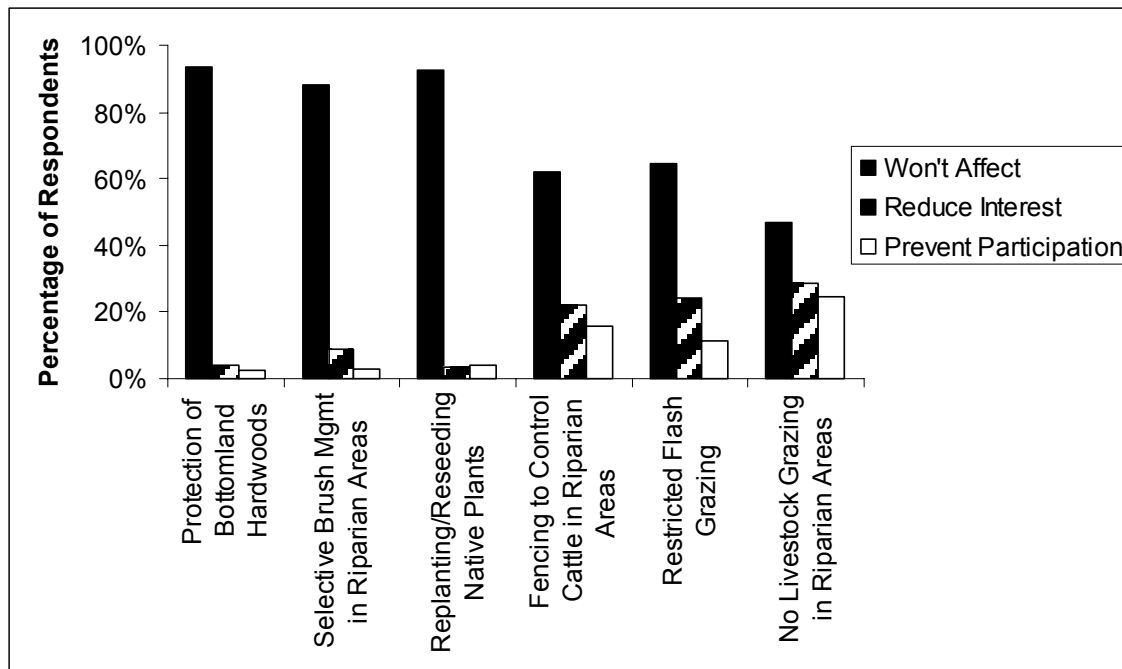
In addition to participation, landowners were asked how the constraints would affect their interest in enrolling moderate and heavy cover into a brush management program (Figure 15). The first constraint would not allow brush removal to take place within 75 yards of riparian areas. The second would leave a 40% brush cover residual following treatments. Respondents in both areas overwhelmingly stated that there would be no change in their interest. However, lower proportions of respondents indicated “no change” in regards to their interest in participating and, higher proportions of “increase” or “decrease” in interest, for constraints to heavy canopy cover areas with a 75 yard buffer. In addition, respondents seemed to have more concern for the 40% residual than a 75 yard buffer (higher proportions of “decrease” in interest and lower proportions of “no change” in interest).



**Figure 15. Effect of constraints on interest in participation in cost-share brush control programs.**

Several requirements were suggested as a means of protecting, restoring, or improving riparian areas. Respondents were asked how these requirements might affect their decision to participate in a cost-share brush removal program, if sufficient funds were provided to cover the costs associated with these constraints. Respondents overwhelmingly suggested that there would be no effect on their interest in participating if these constraints were included in the program (Figure 16). Most respondents in both areas indicated that these constraints would not change their interest in participating. However, approximately 35.3-53.3% less respondents indicated that there would be no effect in their willingness to participate if grazing was restricted in one of three ways. In addition, 10-20% more respondents indicated that grazing restrictions would either

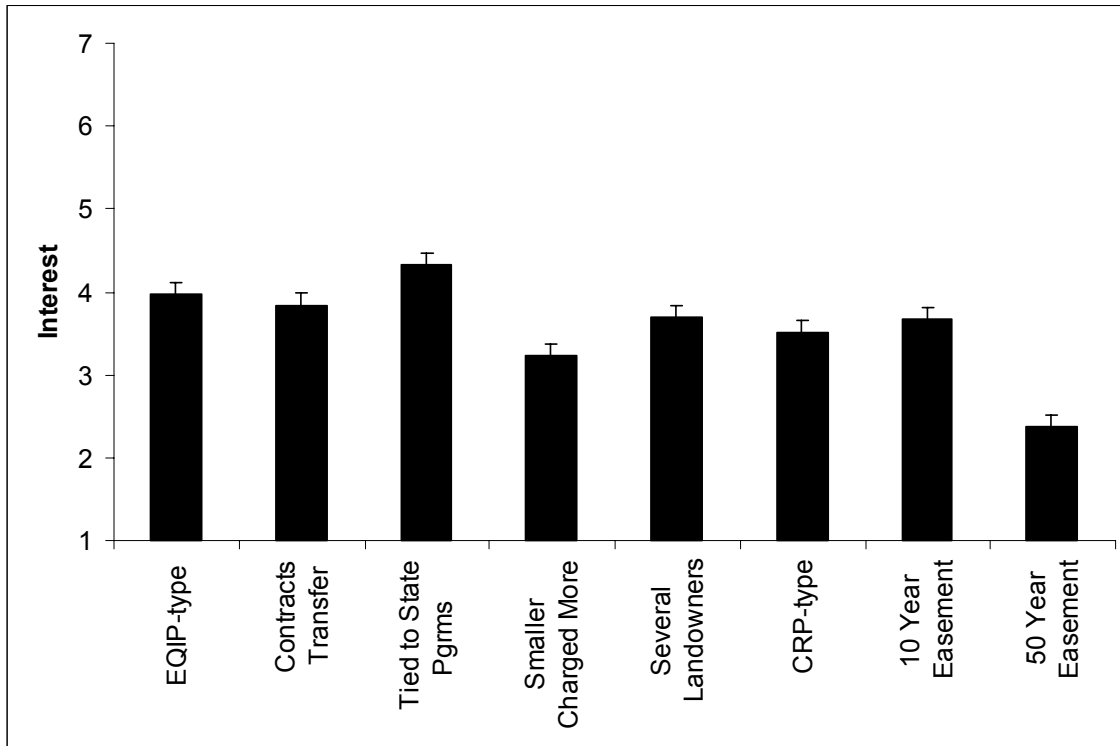
reduce their interest or prevent their participation compared to responses given for the first three constraints.



**Figure 16. Effect of requirements on interest in participation in cost-share brush control programs.**

Respondents were asked to rate the importance of compensation for various actions that may be required under a cost-share brush removal program for riparian area protection, restoration, and/or improvement (Figure 17). Overall, compensation was most important for water sources (mean=5.9 ±0.1) and least important for grazing deferments (mean=4.9 ±0.1). Of the actions that may be required, only grazing deferment was significantly different between the two areas (EA=4.6±0.17;

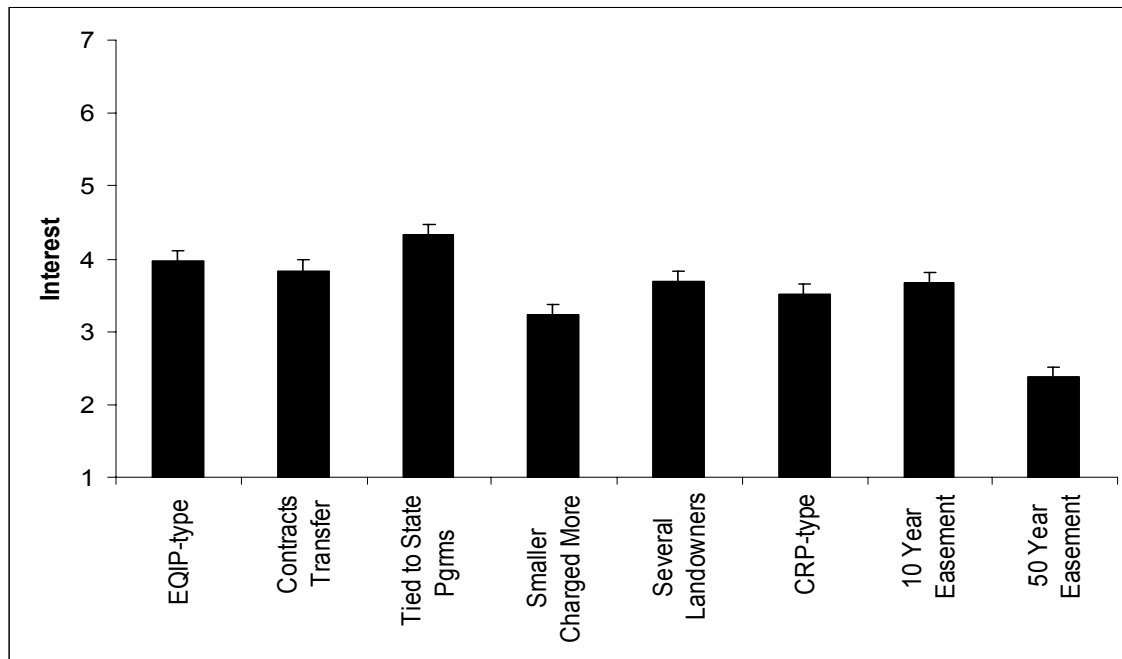
TB=5.2±0.12; F=8.259, p=0.004). Respondents in the Twin Buttes area, on average, rated compensation as more important.



**Figure 17. Mean importance of compensation to landowners for certain actions required to participate in cost-share brush control programs with standard error of mean bars.**

In any type of cost-share program, a contract is necessary for implementation. Respondents were asked to rate their interest in several contract examples to determine which types of contracts might garner the greatest interest. Interest in all contracts was limited to “somewhat interested,” or slightly above neutral. Interest was lowest for both areas in 50-year conservation easements. Respondents in the Twin Buttes area showed more interest than respondents in the Edwards Aquifer area in regards to two of these

contractual arrangements: EQIP-type contracts (EA=3.97±0.186; TB=4.54±0.180; F=4.776; p=0.030) and contracts tied to other state funded programs (EA=4.33±0.198; TB=4.90±0.173; F=4.848, p=0.029) (Figure 18).

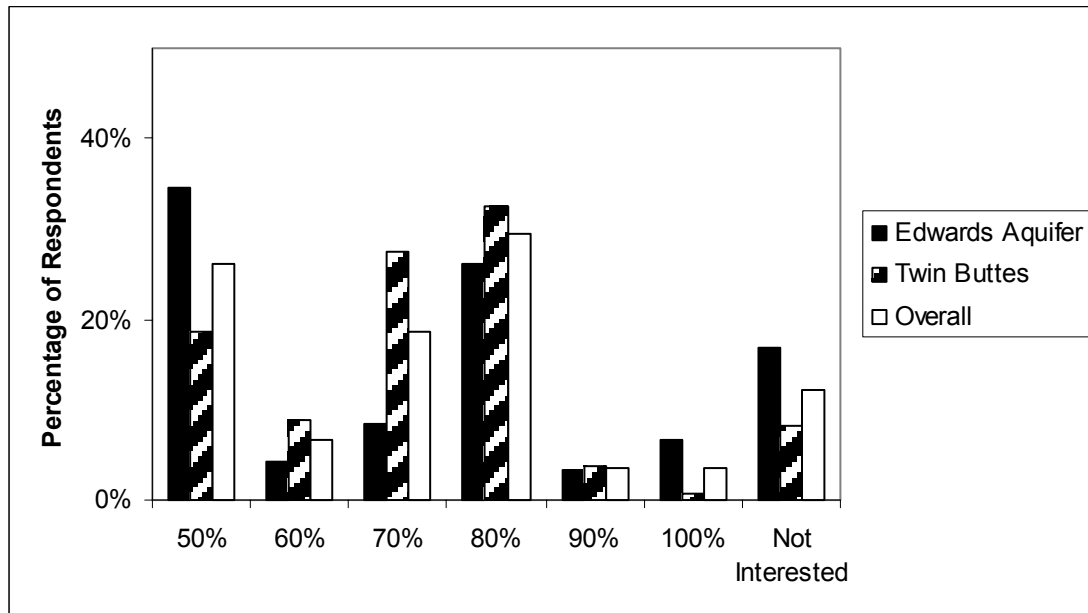


**Figure 18. Mean overall interest in various contract types for cost-share brush control program participation with standard error of mean bars.**

Finally, respondents were asked to specify what minimum level of cost-share they would require to participate in a brush removal program with choices, ranging in 10% increments, from 50% to 100%, or “not interested”. Overall, 80% cost-share was preferred by most respondents (29.5%), followed by 50% cost share (26.0%) and 70% cost-share (18.5%). Results compiled from responses of landowners in the Edwards Aquifer showed interest levels highest at the 50% (34.5% of respondents) and 80% (26.1% of respondents) levels of cost-share. In contrast, landowners in the Twin Buttes area showed greatest interest in the 70% (27.4% of respondents) and 80% (26.1% of



respondents) levels of cost-share. In addition, over twice as many respondents in the Edwards Aquifer area (16.8%) indicated “not interested” than in the Twin Buttes area (8.1%) (Figure 19).



**Figure 19. Minimum cost-share required for participation.**

## **CHAPTER IV**

### **FACTORS AFFECTING WILLINGNESS TO PARTICIPATE**

When comparing those respondents that indicated they were interested in participating with those who indicated that they were not, a few significant differences emerged. After comparing differences between those respondents indicating a willingness to participate with those not willing, differences between willing respondents of each study area were compared.

#### **WILLING VS. UNWILLING TO PARTICIPATE**

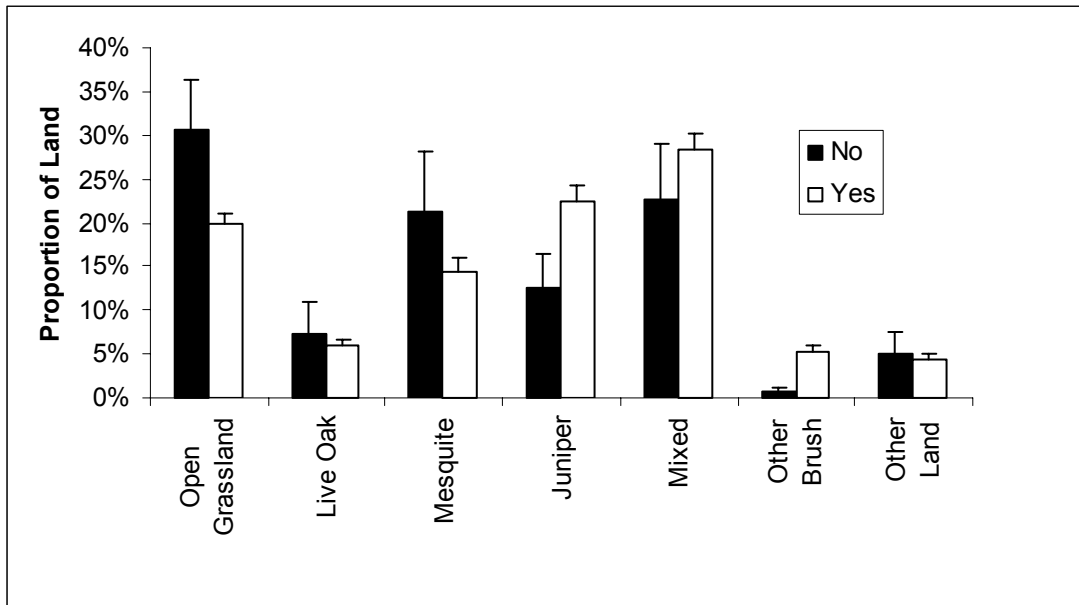
Respondents who were interested in participating in a brush removal program felt stronger about the importance of the presence of certain rangeland components (grassland, brush, surface water or wildlife) on their property, compared to those respondents not interested in participating. However, the differences were not significant.

When asked about the importance of certain land management practices, respondents who were willing to participate, on average, felt stronger about the importance of improving wildlife habitat, controlling brush invasion, protecting or improving riparian areas, and increasing streamflow. Respondents who were unwilling to participate, on average, felt slightly stronger about improving forage supply. However, none of these differences were statistically different.

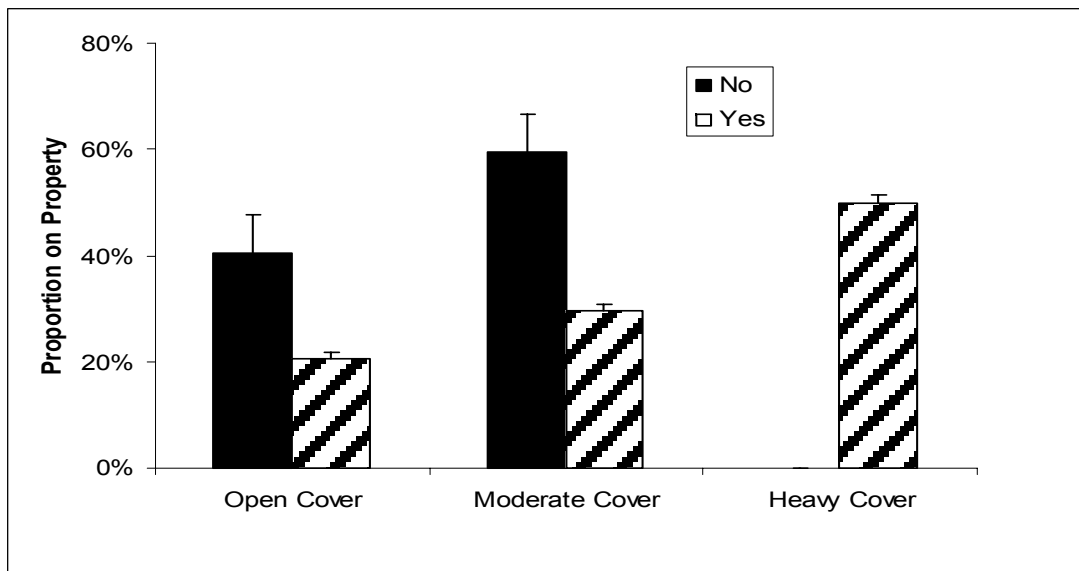
With regard to brush management options, respondents who were willing to participate in a brush removal program showed greater interest in increasing water yields, protecting live oak, controlling light juniper and that less brush may reduce

hunting values than those unwilling to participate. In comparison, respondents who were not willing to participate showed more interest in controlling light mesquite. Again, these comparisons were not significantly different. However, respondents who were interested in participating did place significantly more importance on improving riparian areas for wildlife habitat than those unwilling to participate, when considering brush management options (Yes=6.08±0.09; No=5.46±0.34; F=4.705; p=0.031).

On average, respondents who indicated an interest in participation reported less open grassland on their land than uninterested respondents (Yes=19.8% ± 1.2%, No=30.6% ± 5.9%, F=7.088, p=0.008), and a higher proportion of their land covered by other (than juniper, mesquite and live oak) brush species (Yes=5.3% ± 0.6%, No=0.7% ± 0.4%, F=5.913, p=0.016) (Figure 20). Similarly, respondents who were willing to participate reported that their land was covered by areas of less open and moderate cover and more heavy cover than those who were not willing to participate (Figure 21). On average, those willing to participate reported nearly half as much open (Yes=20.5% ± 1.2%, No=40.5% ± 7.1%, F=22.639, p≤0.000) and moderate (Yes=29.6% ± 1.2%, No=59.5% ± 7.1%, F=49.740, p≤0.000) cover as those who indicated they were not willing to participate. In addition, only those landowners who indicated that they were interested in participating in such a program reported any heavy cover on their properties (Yes=49.70% ± 1.6%, No=0.0% ± 0.0%, F=115.318, p≤0.000).



**Figure 20.** Mean differences in land cover proportions between those landowners interested and uninterested in participating in a cost-share brush removal program with standard of mean bars.

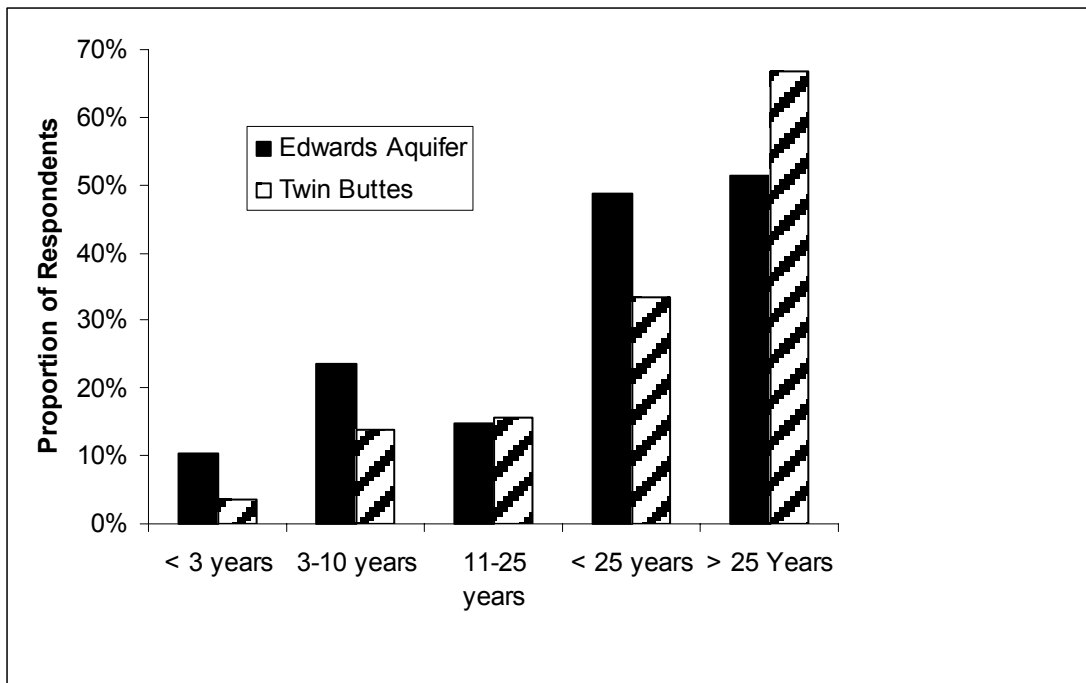


**Figure 21.** Mean canopy cover levels for landowners willing to participate and landowners not willing to participate with standard error of mean bars.

## DIFFERENCES BETWEEN WILLING RESPONDENTS IN TWO STUDY AREAS

### Demographic Differences

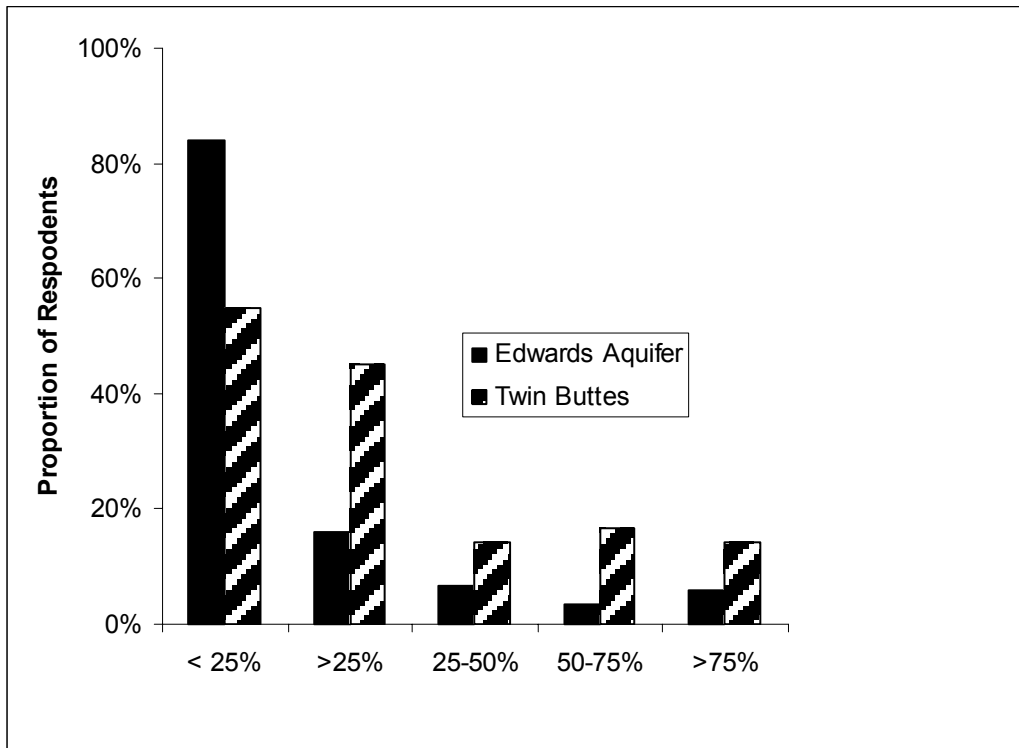
Landowners in the Twin Buttes area who were willing to participate generally owned their land longer than their counterparts in the Edwards Aquifer area (Figure 22). A greater proportion of Twin Buttes area respondents owned their property for over 25 years compared to Edwards Aquifer area respondents ( $r_s=0.183$ ,  $p=0.005$ ).



**Figure 22. Length of ownership of property reported.**

Respondents in the Twin Buttes area derived more of their total household income from the property than those in the Edwards Aquifer area (Figure 23).

Approximately 55.0% of Twin Buttes respondents indicated that they derive less than 25.0% of their household income from their property, compared to approximately 85.0% of Edwards Aquifer ( $r_s = 0.316$ ,  $p \leq 0.000$ ).

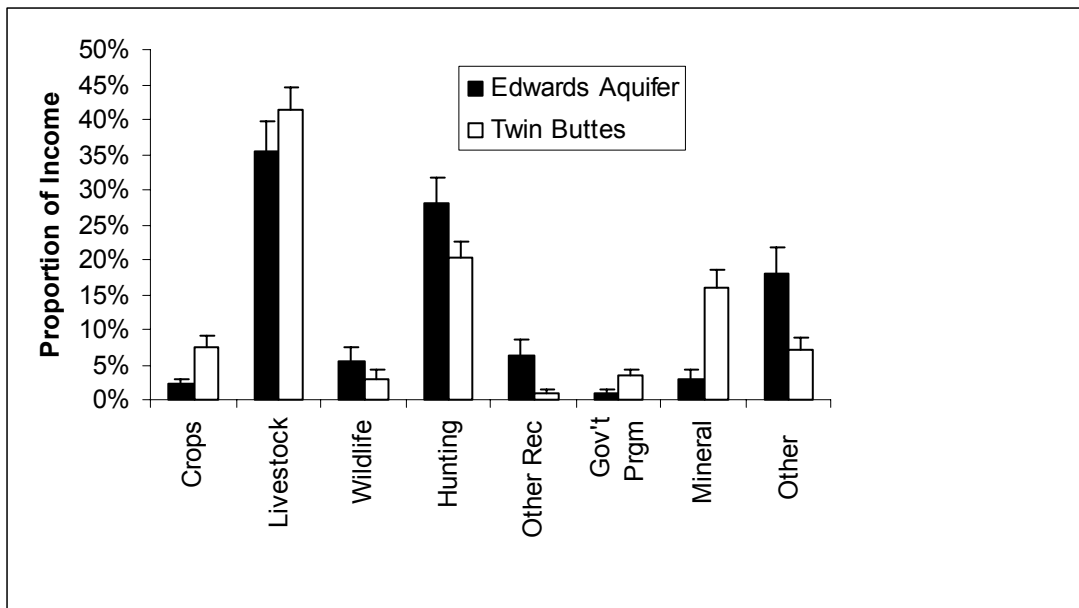


**Figure 23. Proportion of household income derived from property.**

### Property Characteristics

Several differences between the 2 study areas were also noted when considering various sources of income for the property. For example, respondents in the Twin Buttes area, on average, reported higher proportions of income derived from sale of crops (TB=7.4%  $\pm$  1.8%, EA=2.2%  $\pm$  0.8%,  $F=5.555$ ,  $p=0.019$ ), government payment

programs (TB=3.5%  $\pm$  0.7%, EA=1.0%  $\pm$  0.4%, F=7.812, p=0.006), and mineral sales and leases (TB=16.0%  $\pm$  2.7%, EA=2.9%  $\pm$  1.5%, F=14.816, p $\leq$ 0.000). In contrast, respondents in the Edwards Aquifer area reported higher average proportions of income derived from other (non-hunting) recreation (EA=6.3%  $\pm$  2.2%, TB=0.8%  $\pm$  0.5%, F=7.317, p=0.007), and other sources not listed (EA=17.9%  $\pm$  3.8%, TB=6.9%  $\pm$  1.9%, F=7.469, p=0.007). Differences between the 2 areas for income from wildlife and livestock were not significant (Figure 24).



**Figure 24. Mean differences in sources of income for two study areas with standard error of mean bars.**

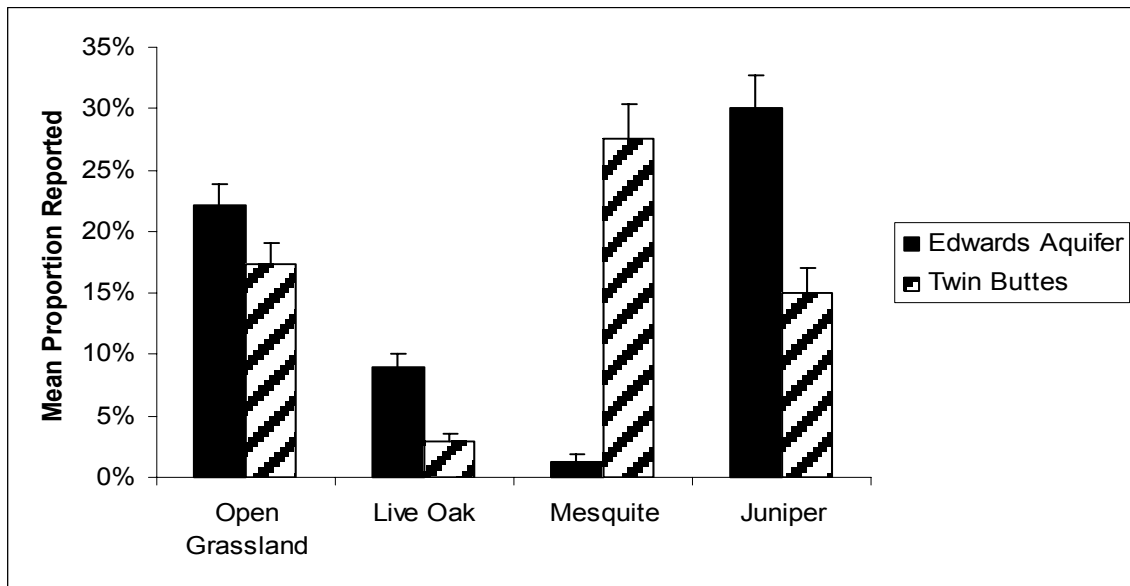
When asked to rate the importance of certain characteristics when considering rangeland components, land management objectives, and brush management options, respondents in the Edwards Aquifer area placed greater importance on surface

(EA=6.62±0.112; TB=6.09±0.130; F=9.677; p=0.002) and wildlife habitat (EA=6.56±0.095; TB=6.25±0.095; F=5.200; p=0.024) as land management objectives than respondents in the Twin Buttes. By contrast, respondents in the Twin Buttes area placed greater importance on improving forage supply as a land management objective than those in the Edwards Aquifer area (EA=5.46±0.197; TB=6.40±0.122; F=16.334; p≤0.000). Additionally, controlling light levels of mesquite (EA=4.69±0.190; TB=6.19±0.142; F=40.121; p≤0.000) and a notion that less moderate or heavy brush cover may reduce the hunting value of the land (EA=4.43±0.206; TB=5.19±0.137; F=9.354; p=0.003) were more important to respondents in the Twin Buttes area when considering brush management options than in the Edwards Aquifer area.

### **Characteristics of Brush on Property**

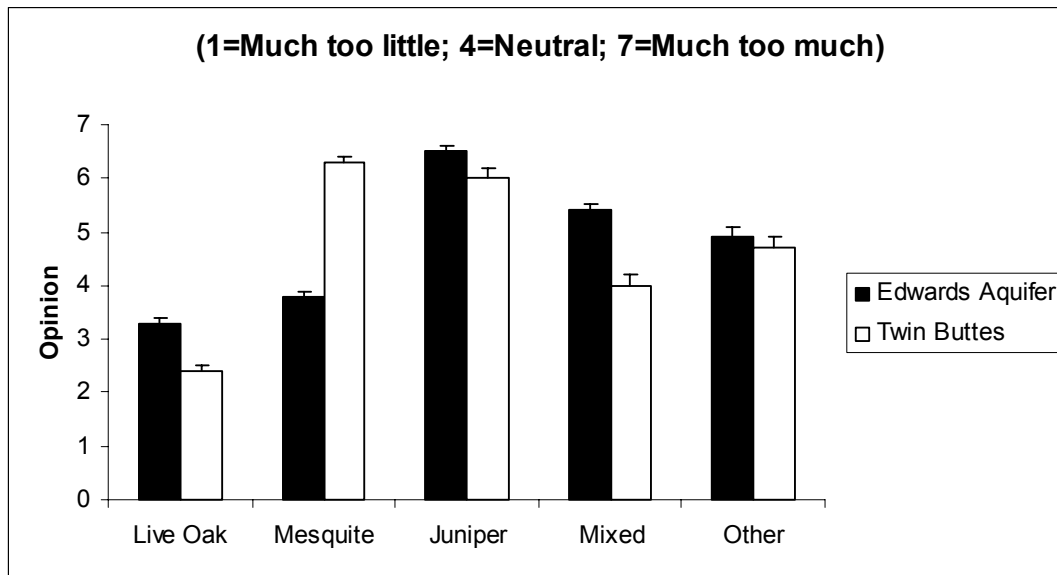
Plant cover on the property varied significantly between the 2 study areas (Figure 25). Mesquite coverage was, on average, higher in the Twin Buttes area for mesquite than in the Edwards Aquifer area (F=88.572, p=0.003). In contrast, grassland, live oak, and juniper coverage was higher in the Edwards Aquifer (grassland: F=4.071, p=0.45), live oak (F=27.2834, p=0.003), and juniper (F=20.635, p=0.003).





**Figure 25. Mean proportion of property covered by various land cover types with standard error of mean bars.**

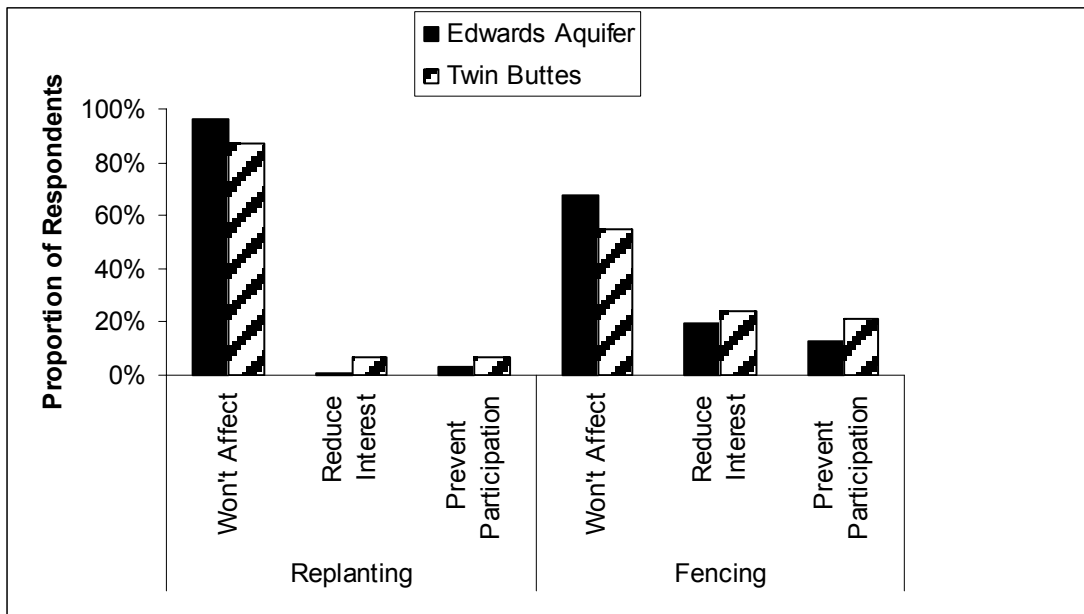
Respondent perceptions of the amount of certain brush types also varied between the 2 study areas (Figure 26). Twin Buttes area respondents felt strongly that their land was covered by too much mesquite, compared to Edwards Aquifer respondents who indicated a neutral perception (EA=3.80±0.13; TB=6.34±0.12; F=207.171; p≤0.000). In contrast, Edwards Aquifer respondents indicated too much mixed brush on their property, while Twin Buttes respondents indicated a neutral perception (EA=5.38±0.14; TB=1.00±0.21; F=32.308; p≤0.000). Respondents in both areas felt there was too much juniper on their land, although Edwards Aquifer respondents indicated a stronger perception (EA=6.50±0.10; TB=5.96±0.16; F=8.729; p=0.003). Finally, respondents in both areas felt that there was not enough live oak on their land, with Twin Buttes respondents indicating a stronger tendency in this regard (EA=3.31±0.13; TB=2.39±0.14; F=24.037; p≤0.000).



**Figure 26. Mean perceptions of amount of brush cover on property with standard error of mean bars.**

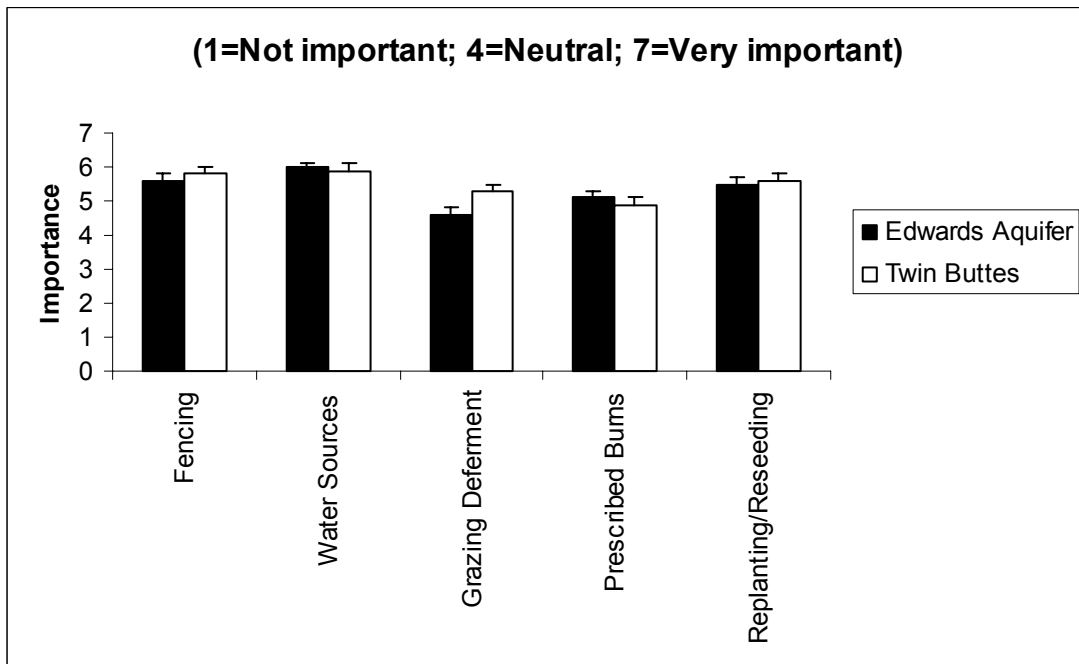
### **Program Issues**

Differences between the 2 study areas were noted when considering the effects of certain constraints proposed for a cost-share brush removal program (Figure 27). Most respondents in both areas reported that there would be no change in interest in participating if there was a requirement to replant or reseed native plants. However, 3.6% of Edwards Aquifer respondents indicated either a reduced interest or no participation, compared to 13% of Twin Buttes respondents ( $r_s = 0.168$ ,  $p = 0.013$ ). Similarly, most respondents in both areas reported that there would be no change in interest in participating if there was a requirement to add fencing to control the movement of cattle in riparian area, but 32.1% of Edwards Aquifer respondents indicated either a reduced interest or no participation, compared to 45.0% of Twin Buttes respondents ( $r_s = 0.139$ ,  $p = 0.038$ ).



**Figure 27. Effects of constraints on willingness to participate in cost-share brush removal program.**

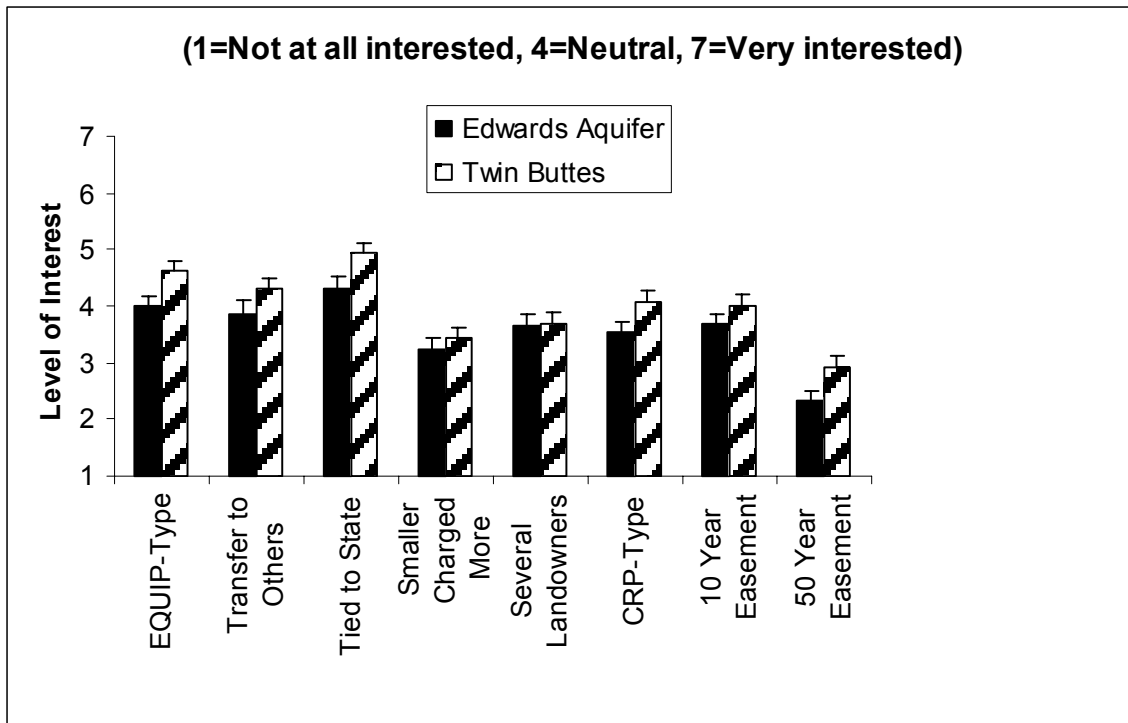
Respondents were asked to rate the importance of compensation for fencing, new water sources, grazing deferments, prescribed burns, and replanting or reseeding native plants (Figure 28). In most cases, respondents in both watersheds indicated that compensation was important for these activities. However, in the case of compensation for grazing deferments, Edwards Aquifer respondents indicated a slightly above neutral importance, while Twin Buttes respondents indicated a stronger level of importance (EA=4.57±0.18; TB=5.26±0.16; F=8.264; p=0.004).



**Figure 28. Mean importance of compensation for certain activities that may be required for participation with standard error of mean bars.**

Generally, there was no better than neutral interest in any contract type that was proposed to respondents in both study areas. However, there were some contracts in which there were significant differences between the two study areas (Figure 29). First, Edwards Aquifer respondents showed a neutral interest in EQUIP-type contract, while Twin Buttes respondents showed some interest (EA=3.99±0.19; TB=4.62±0.20; F=5.249; p=0.023). Similarly, while Edwards Aquifer respondents showed a slightly above neutral interest in contracts tied to other state funded programs, Twin Buttes respondents expressed less resistance. While respondents from either area showed low interest in 50 year conservation easements, Twin Buttes respondents showed slightly more interest. Finally, it was noted that the only 2 contract types that showed a mean

interest level greater than neutral were EQUIP-type contracts and those contracts tied to other state funded programs.



**Figure 29. Mean interest differences in various contract types with standard error of mean bars.**

## **CHAPTER V**

### **DISCUSSION AND CONCLUSION**

Randomly selected landowners from two Texas watersheds were asked to participate in a survey regarding a cost-share brush removal program designed to increase off-site water yields. In addition to water yields, wildlife habitat mitigation was an issue of concern in the survey. This thesis, therefore, examined the trade-offs between water yield and wildlife habitat management.

#### **RESPONDENT AND RANCH CHARACTERISTICS**

Respondents in the two study areas have different reasons to enroll in a cost-share brush removal program. For example, landholdings were larger in the Twin Buttes area than in the Edwards Aquifer area. In addition, there were more livestock operations and mixed farm/ranch, ranch and wildlife operations, in the Twin Buttes area. This suggests that Twin Buttes respondents would prefer a higher portion of their land to be agriculturally productive and would be more willing than landowners in the Edwards Aquifer to participate in a program that would offset the cost of removing brush.

This implication is further supported by the greater importance placed on open grassland, improving forage supply, and controlling light levels of mesquite by Twin Buttes respondents than the Edwards Aquifer respondents. Furthermore, these findings support the conclusion that the primary reason for implementing a brush removal program in the Twin Buttes area is to increase the agricultural productivity of the land.

In contrast, there were more wildlife operations and more respondents who used the land primarily as a residence in the Edwards Aquifer area than in the Twin Buttes.

Thus the primary reasons for owning land in the Edwards Aquifer appear to include improving or maintaining land for personal hunting access, leased hunting income, and ownership of aesthetically pleasing land. Edwards Aquifer respondents may be more willing to manage brush to optimize wildlife habitat, while maintaining a “presentable” landscape.

Respondents in the Edwards Aquifer area also rated having surface water and improving riparian areas as more important in this area than in the Twin Buttes. In addition, improving wildlife habitat was also rated more important here. Edwards Aquifer respondents felt that there was too much juniper on their properties. Any program that would increase water yield, as well as the aesthetic and hunting values of property, can be inferred to be attractive to respondents in the Edwards Aquifer. However, a larger proportion of Edwards Aquifer respondents stated they were not interested in participating in the proposed program than in Twin Buttes, which may be explained by landowners who do not use their property for agricultural purposes, being less concerned about loss of agricultural productivity.

Finally, because total household income was higher in the Edwards Aquifer area, Twin Buttes area respondents may need higher levels of cost-share to participate in a brush removal program. In addition, the fact that many Twin Buttes area respondents rely on income from hunting leases to augment their livestock and/or crop incomes, explains why they would perceive more strongly that less brush may decrease hunting lease values. These respondents would require higher cost-shares to supplement the lost revenue of hunting fees.

## **WILLING VS. UNWILLING TO PARTICIPATE**

Those landowners that are willing to participate in the proposed cost-share brush removal program designed for off-site water yield and wildlife habitat mitigation rated improving riparian areas for wildlife and increased water yield as more important than those unwilling to participate. In addition, the amount of open grassland a respondent owns was found to be negatively related to his/her willingness to enter a brush removal program, while the amount of moderate and especially heavy cover was positively correlated with willingness to participate. This suggests that the amount and type of land cover a respondent owns influences his/her decision to enter into a brush removal program, and targeting landowners with more cover is more likely to increase level of participation.

## **WILLING PARTICIPANT DIFFERENCES IN THE TWO STUDY AREAS**

Respondents in the Twin Buttes area reported living on their land for a longer period than those in the Edwards Aquifer area. This, along with larger landholdings in the Twin Buttes area, reinforces the notion that Twin Buttes area residents are generally longer-term owners and more involved in traditional agricultural enterprises, which is corroborated by the finding that higher numbers of Twin Buttes respondents attributed more than 25% of their total household income to the property than did Edwards Aquifer respondents. Furthermore, Edwards Aquifer respondents reported a higher proportion of property income from hunting fees than those in the Twin Buttes area, while the latter tended to earn a greater proportion of their income from livestock. It is not surprising, then, that Twin Buttes area respondents placed more importance on compensation for



livestock grazing deferments than the Edwards Aquifer respondents. In addition, 45% of Twin Buttes respondents indicated that a requirement for fencing to control the movement of cattle in riparian areas would either reduce interest or prevent participation in the proposed program, compared to only 32% of Edwards Aquifer respondents who indicated a similar opinion. This is underscored by the fact that 10% more respondents in the Edwards Aquifer area indicated that a requirement to reseed or replant native species to stabilize riparian areas would reduce interest or prevent participation than in the Twin Buttes area. Lastly, it may be due to the fact that reseeding is considered less feasible in the Twin Buttes area due to its low annual precipitation.

Wildlife is playing an increasingly important role in many parts of Texas as hunting leases become a greater revenue source for landowners with traditional livestock ranching operations (Rollins 2000). Respondents in the Twin Buttes area reported less proportions of open grassland than those in the Edwards Aquifer which may be one reason why many Twin Buttes landowners have turned to lease hunting to increase revenues. Therefore, it is of no surprise that landowners in the Twin Buttes area felt stronger about a notion that less brush may reduce hunting values than did the respondents in the Edwards Aquifer area. In addition, differences in dominant species in the two areas (mesquite in Twin Buttes and juniper in Edwards Aquifer) may also affect motivations for landowners to enter a cost-share brush management program due to different types of feasible brush removal methods. Finally, Twin Buttes landowners have a stronger positive feeling about government input on management plans for their

property, possibly because they appear to have more experience with government programs.

## **POLICY RECOMMENDATIONS**

Increased water demand, caused by the expansion of population centers, is a very real problem, while interest in improving wildlife habitat is also growing. With several parties affected by sometimes conflicting goals and effects, the interests of multiple parties (i.e., landowners, urban dwellers, etc.) must be addressed. One approach to maintaining open rangelands that can enhance water yield is to develop and implement a cost-share brush management program using state or federal funds to offset the costs to rural landowners of brush management that benefit off-site urban and/or suburban residents. However, with growing societal and economical interests in wildlife habitat, several factors must be considered before implementing such a program.

Different wildlife species have different brush cover level requirements: White-tailed deer generally require 30 to 60% brush cover, while bobwhite quail require 15 to 25% cover, and Rio Grande turkey need 50% brush cover. In addition to brush cover requirements, different methods of brush removal produce various effects on the species of interest. For example, rootplowing can be effective in deer habitat management strategies if it is used to create travel corridors, but can cause loss of biodiversity if too much vegetation is removed, and if a landowner is additionally managing for quail, more careful treatment is required to promote habitat requirements.

Various water yield studies have come to different conclusions. For example, Wu et al. (2001) predicted that water yields would only increase if brush cover is

reduced to 20% and that at lower levels, water yields increase exponentially, requiring the removal of considerable amounts of brush to provide substantial increases in water (Thurrow and Hester 1997). Finally, the considerations raised by Wilcox (2002) raise the premise that brush removal to increase water yields may not be suitable for many of Texas' rangelands, especially in semi-arid areas with deep soils where ET exceeds annual precipitation, e.g., the Twin Buttes area.

These varying requirements and considerations must be carefully considered when planning a brush management program designed to increase water yields. For example, landowners may have a need or desire to be compensated for a loss of wildlife habitat from severe (less than 10% residual cover) brush removal. Particularly, landowners in the Twin Buttes may feel that reducing brush cover to such a low level may affect the revenues they can receive from hunting leases. Conversely, if not "enough" brush is removed, desired water yields may not be reached and a state cost-share brush removal program may prove to be ineffectual. Depending on the wildlife species targeted, it may be more feasible to target either increasing water yields or mitigating wildlife habitats.

Finally, the low interest in various contractual arrangements may be a problem when attempting to implement this proposed program. Twin Buttes residents had more experience with government programs than Edwards Aquifer residents. However, neither study area seemed very interested in contractual arrangements. Possible reasons for this include lack of information, bad prior experiences, or lack of interest in such a program. If this program is to be successfully implemented, contracts should reflect

concerns of the possible enrollees, and landowners must be educated on the specifics of the contract. Kreuter et al. (2003) suggest additional funding be allocated for educational messages regarding the importance of lowering brush levels to maintain or increase water yields be sent to prospective participants to explain and encourage participation.

### **LIMITATIONS OF STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH**

In retrospect, it seems that the questionnaire distributed was too long and fairly complicated due to the large number of low responses to several questions. In the first section, it seems redundant to ask landowners to list the primary activity on the property, as well as to list the percentages of the property income that is derived from various activities. A landowner's perception of his/her own enterprise(s), and the income sources from the property may not always be the same. It would have been sufficient to just ask the respondents to approximate the percent of property income from various land-based activities.

Landowners were also asked to rate the importance of rangeland components, land management objectives, and brush management options. The similarities between some of the variables (e.g., the importance of "surface water", "increase stream flow", and "increase water yield and streamflow" in these three areas of inquiry, respectively) may lead to identical responses. Combining these three areas of inquiry may have resulting in results that stronger correlated with other variables (e.g., proportion of income from various sources, landholding size, etc.) because of potentially greater response rates and easier understanding of questions; and simplified the questionnaire.

The question that seemed to confuse respondents most was one that asked them to indicate the proportion of certain types of brush cover that occurred in one of 3 physiographic categories (slopes > 15%, within 75 yards of streams/rivers, and all other areas). This question was intended to gauge the amount of brush that may or may not be removed using the constraints proposed by Olenick (2002), but it appeared to be difficult to answer. Estimating the amount of land covered by brush type in several physiographic categories is quite challenging, even with the aid of Geographic Information System (GIS) data. A simpler question would be to ask what proportion of each brush cover category (light, moderate, heavy) occurred in each physiographic category. This may have yielded a higher response rate.

Two questions asked landowners if they were interested in participating in a cost-share brush management program: (1) landowners were asked what minimum level of cost-share they would accept as a condition for participation they were given the option to answer “not interested in such a program,” and (2) if respondents indicated that they would include any proportion (greater than 0%) of their moderate or heavy cover, they were categorized as willing to participate. However, approximately 20 (7.4%) respondents indicated that they were “not interested in such a program” but also specified they would include a proportion of their moderate or heavy cover in a cost-share brush removal program.

One option is to ask survey participants at the beginning of the questionnaire, with the instructions to explain why the respondent is unwilling to participate. Alternatively, survey participants could be asked the question twice, at the beginning

and end of the questionnaire, to determine how a better understanding of the proposed program may change their responses.

Making an appropriate policy decision of this magnitude involves several variables, some of which are contradictory (i.e., adequate brush cover for wildlife habitat and adequate brush removal for increasing water yields). In examining two watersheds, it was found that land cover, demographics, wildlife habitat requirements, and climate all play varying roles in constructing a feasible management plan. Future research should address these and other issues to determine if all those variables can be suitable for a contract, or if trade-offs exist for a successful program.

## **CONCLUSION**

Based on the results, there is not enough data to support rejecting  $H_{10}$ . No correlation was found between landowners' willingness to participate in a cost-share brush removal program and landowner characteristics, such as age, property size, and sources and levels of income. There is, however, some data to support rejecting  $H_{20}$ . Although most respondents reported that constraints such as fencing and grazing exclusions would not affect their willingness, the results varied depending upon the constraint. Specifically, any constraint that restricted livestock grazing produced more respondents that indicated reduced, or loss of, interest. This must be considered when designing an appropriate plan.

Policy provisions may need to differ between the two study areas. In light of the different motivations for respondents to enroll in a cost-share brush removal program, implementation may need to take different forms, such as different goals of the program,

based on the area. Twin Buttes area residents are more attracted to widespread brush removal to increase land productivity, while Edwards Aquifer residents are more attracted to water yields and wildlife habitat management. Coupled with the differing types of brush cover, brush treatments need to be area specific to maximize results. For example, land in the Twin Buttes area, covered by mesquite, needs a combination of chemical and mechanical treatment, followed by periodic prescribed burns to maintain the brush levels. In contrast, the Edwards Aquifer area, with its rolling hills and juniper, require more precise chemical treatments, especially in areas where mechanical treatment is not feasible (e.g., areas with high slope gradients). Also, areas that are deemed impractical to treat (e.g., high slope areas) should be left alone. This could help to find a way to improve wildlife habitat, while increasing water yields.

Finally, more research is needed to determine the effects of brush removal in consideration with water yield and wildlife habitat. Based on the literature reviewed in this thesis, it may be necessary to choose between managing for both wildlife habitat mitigation and increased water yields. Certain areas may be better suited than others for constructing a brush removal plan to increase water yields. However, if other species of wildlife are the target of habitat mitigation, the requirements may allow enough brush to be cleared to increase water yield. Therefore, based on the literature reviewed, it is the opinion of this author that specific species must be studied based upon the area in which the program will be implemented.

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## APPENDIX A

### Exhibit A1. Notification Letter.

April 1, 2002

Dear Landowner,

Within the next few days you will receive a questionnaire in the mail, requesting your participation in an important study being conducted by Texas A&M University. You are among a randomly selected sample of landowners in the Twin Buttes drainage area or the Edwards Aquifer Recharge Zone who we are contacting, and **we are asking you to help by completing and returning the questionnaire when you receive your copy.**

Increasing distribution and density of brush (woody plants) can create problems for landowners and society. These may include lower forage production, inferior wildlife habitat, and reduced stream flow and water yields. During the last three years the State of Texas has started funding cost-share brush removal programs in some watersheds to increase water yields. There may be expanded opportunities for these programs in other watersheds.

**Our study is designed to let landowners like you voice their views and concerns about a cost-share brush management program that would simultaneously improve riparian areas.** We want to know how you feel about different aspects of such a program and the extent to which you would be willing to participate in such a program if it is implemented in your area.

Your responses will be used to develop a report on landowners' interests and concerns regarding potential participation in a cost-share brush management program aimed at increasing water yield and possibly improving riparian areas. The report will be shared with policy makers, resource management agencies, and local communities so that they can effectively respond to landowners' interests and concerns about such a program.

We know you are busy, but we hope that you will be willing to participate in this study by completing our questionnaire when you receive it. Our research can succeed only through the generous help of people like you.

If you have any questions about the study after you receive the questionnaire packet, please feel free to contact me either by phone (979-845-5583) or by e-mail ([urs@tamu.edu](mailto:urs@tamu.edu)). Thank you in advance for your help.

Sincerely,

Urs P. Kreuter  
Assistant Professor, Texas A&M University

## Exhibit A2. Cover Letter.

April 7, 2002

Dear Landowner,

A few days ago we sent you a letter about our study examining **landowners' views and concerns about a cost-share brush management program that would simultaneously improve riparian areas.**

Enclosed you will find a copy of our questionnaire. We need your input so that we can help policy makers better understand the views and concerns that landowners have about such programs and associated issues.

Your name was selected at random from a list of property owners in your county who own at least 50 acres of land. In order for the results to truly reflect the views and experiences of all landowners in your area, it is critical that each questionnaire be completed and returned in the postage-paid envelope provided.

The questionnaire focuses on issues such as the type and amount of brush on your property and the amount of land that you would be willing to include in a cost-share brush and riparian area management program. It also includes questions about various aspects of potential contracts. Finally, the questionnaire asks for some information about yourself and your property so that we can aggregate information for different types of landowners. The survey should take about 20-30 minutes to complete.

**We want to assure you that your participation and responses to all questions will be kept strictly confidential.** Any published results from the study will be based on the combined responses of all survey participants. Absolutely no information that could identify your individual answers will be released to anyone. The tracking number printed on the cover of the questionnaire simply allows us to check your name off our mailing list once we receive your completed questionnaire. This way we can avoid bothering you with additional mailings. Please do not sign or put your name anywhere on the completed survey.

**The survey is designed to be completed by people who currently own or manage land in the Twin Buttes Drainage Area and the Edwards Aquifer Recharge Zone.** If you do not fit that category – or if you feel you cannot complete the questionnaire for any reason – we ask that you indicate that on the cover of the survey and return it to us as soon as possible. We will then remove your name from our mailing list.

If you have any questions or comments, please feel free to contact me either by telephone (979-845-5583) or by e-mail ([urs@tamu.edu](mailto:urs@tamu.edu)). Thank you in advance for your help!

Sincerely,

Urs P. Kreuter  
Assistant Professor, Texas A&M

P.S. This study has been reviewed and approved by the Institutional Review Board-Human Subjects in Research, Texas A&M University. For research related problems or questions regarding subjects' rights, contact the Institutional Review Board through Dr. Michael W. Buckley, Director of Support Services, Office of Vice President for Research at 979-458-4067

## **Tradeoffs in Brush Management for Water Yield and Habitat Management in Texas:**

Twin Buttes Drainage Area and Edwards Aquifer Recharge Zone



*Department of Rangeland Ecology and Management  
Texas A&M University  
TAMU 2126  
College Station, TX 77843-2126  
April, 2002*

We are asking that this questionnaire be completed by the addressee or by the individual most knowledgeable about this property (if applicable).

*If you encounter a question that does not apply to your property, please indicate this by writing "NA" in the margin next to the question. If you encounter a question for which you do not know the answer, please indicate this by writing "DK" in the margin next to the question.*

*If you have any questions, please contact Dr. Urs Kreuter (tel: 979-845-5583 or email: urs@tamu.edu) or Dr. Richard Conner (tel: 979-845-7456 or email: jrc@tamu.edu).*

**INITIAL QUESTION:** *First, we want to make sure you should complete the entire questionnaire.*

*Are you the owner, operator, or manager of at least 50 acres of private land?*

- No → *Please stop here and return the survey in the envelope provided. It is important we hear back from everyone who receives a questionnaire. We thank you for taking the time to place the entire questionnaire in the enclosed addressed envelope, and returning it to us. No postage is necessary.*
- Yes → Please go to SECTION A on the next page and complete the questionnaire.

In answering the questionnaire, please provide answers for the land for which you pay property taxes in **Real** and **Bandera** County or in **Reagan**, **Irion**, and **Tom Green** County. Please **DO NOT** include any property from other counties. **IF YOU OWN SEVERAL TRACTS OF LAND IN ONE OR MORE OF THESE COUNTIES, PLEASE ANSWER THE QUESTIONS BASED ON ALL OF YOUR LANDHOLDINGS WITHIN THE COUNTIES.**

**SECTION A – CHARACTERISTICS OF YOUR PROPERTY AND LAND MANAGEMENT**

Please fill in the requested information or check ONE box that best describes your property.

**A1.** How many acres of your property are located in each of the following counties?Edwards Aquifer Recharge ZoneTwin Buttes Watershed

Real \_\_\_\_\_ acres

Reagan \_\_\_\_\_ acres

Bandera \_\_\_\_\_ acres

Irion \_\_\_\_\_ acres

**Total** \_\_\_\_\_ **acres**

Tom Green \_\_\_\_\_ acres

**Total** \_\_\_\_\_ **acres****A2.** ***How would you describe your role at this property?***

- I make most of the management decisions and have an ownership interest in this property.
- I am one of several key decision makers with an ownership interest in this property
- I am the spouse of a key decision maker with an ownership interest in this property
- I am a hired farm manager with no ownership interest in this property
- Other (Please describe: \_\_\_\_\_ )

**A3.** ***How is your property business organized?***

- Sole proprietorship (single family or individual operation)
- Family partnership
- Non-family partnership
- A family corporation
- A non-family corporation
- Other (e.g., Estate, trust, etc. Please describe \_\_\_\_\_ )

**A4.** ***What are the primary activities on your property?*** (Check only THE MOST applicable box)

- Mainly crop production
- Mainly livestock production
- Mainly a wildlife operation
- Mixed crop and livestock operation
- Farm or ranch combined with wildlife operation
- Tourist operation (e.g., dude ranch, bed and breakfast, etc.)
- Minimal income generating activity – primary residence or weekend hideaway
- Minimal income generating activity – long term investment



A5. **Approximately what percent of your property income is derived from each of the following activities? (Please ensure that your answers total to 100%)**

- Income from the sale of crops \_\_\_\_\_ %
- Income from the sale of livestock \_\_\_\_\_ %
- Income from the sale of wildlife for breeding stock, meat or other products \_\_\_\_\_ %
- Fees for hunting of native or exotic wildlife \_\_\_\_\_ %
- Income from recreation related activities (other than hunting) \_\_\_\_\_ %
- Government program payments \_\_\_\_\_ %
- Mineral sales and leases \_\_\_\_\_ %
- Other (Please specify \_\_\_\_\_) \_\_\_\_\_ %

**Total = 100 %**

A6. **How important to you is it for each of the following RANGELAND COMPONENTS to be present on your land?** (In each row, circle the ONE value that best reflects your opinion).

<i>-3 = very unimportant ... 0 = neutral ... +3 = very important</i>							
Grassland	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Woodland/brush	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Surface water (springs, ponds, creeks)	-	-	+	0	+	+	+
	3	2	1	0	1	2	3
Wildlife	-	-	-	0	+	+	+
	3	2	1	0	1	2	3

A7. **How important is each of the following LAND MANAGEMENT OBJECTIVES to you?** (In each row, circle the ONE value that best reflects your opinion).

<i>-3 = very unimportant ... 0 = neutral ... +3 = very important</i>							
Improve forage supply for livestock	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Improve wildlife habitat	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Control brush invasion	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Protect and/or improve riparian areas	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Increase stream flow	-	-	-	0	+	+	+
	3	2	1	0	1	2	3

- A8. **How important is each of the following considerations to you when considering BRUSH MANAGEMENT OPTIONS?** (In each row, circle the ONE value that best reflects your opinion).

	-3 = very unimportant ... 0 = neutral ... +3 = very important									
Increase water yield and stream flow	-	-	-	0	+	+	+	3	2	1
Improve riparian areas for wildlife habitat	-	-	-	0	+	+	+	3	2	1
Protect live oak in brush control areas	-	-	-	0	+	+	+	3	2	1
Control light levels of mesquite infestation	-	-	-	0	+	+	+	3	2	1
Control light levels of juniper infestation	-	-	-	0	+	+	+	3	2	1
Less moderate or heavy brush cover may reduce the value of land for hunting	-	-	-	0	+	+	+	3	2	1

- A9. **Do you use any WATER CONSERVATION practices on your land?**

- No → Please go to Section B.  
 Yes → **Which of the following water-related practices do you use on your land?**

	<u>Don't Use</u>	<u>Use</u>
• Ponds	<input type="checkbox"/>	<input type="checkbox"/>
• Terraces	<input type="checkbox"/>	<input type="checkbox"/>
• Shaped waterways (drainages)	<input type="checkbox"/>	<input type="checkbox"/>
• Exclude grazing from riparian areas	<input type="checkbox"/>	<input type="checkbox"/>
• Flash graze riparian areas	<input type="checkbox"/>	<input type="checkbox"/>
• Brush control	<input type="checkbox"/>	<input type="checkbox"/>
• Reseeding and/or replanting to protect drainage areas	<input type="checkbox"/>	<input type="checkbox"/>

## SECTION B – BRUSH ON YOUR PROPERTY

In this section we ask you about the brush cover that currently occurs on your property and the methods that you use for managing brush.

B1. **Approximately what percentage of your property is currently covered by each of the following land plant types?** (Please ensure that your answers total to 100%)

- Open grassland \_\_\_\_\_%
  - Predominantly live oak \_\_\_\_\_%
  - Predominantly mesquite \_\_\_\_\_%
  - Predominantly Juniper (Cedar) \_\_\_\_\_%
  - Mixed live oak/mesquite \_\_\_\_\_%
  - Mixed live oak/juniper \_\_\_\_\_%
  - Mixed mesquite/juniper \_\_\_\_\_%
  - Other brush species \_\_\_\_\_%
  - Other land cover (Please specify \_\_\_\_\_) \_\_\_\_\_%
- Total = 100 %**

B2. **On your property, what percentage of each of the following types of plants occurs in each of the areas indicated?** (If you check the first column don't enter a value in the next three columns. If you don't check the first column, the values in each row should total 100%)

	<i>Not common on my property</i>	<i>Slopes greater than 15% gradient</i>	<i>Within 75 yards of streams/rivers</i>	<i>Other areas: less than 15% slope and more than 75 yards from streams</i>
Live oak	<input type="checkbox"/>	_____%	_____%	_____%
Mesquite	<input type="checkbox"/>	_____%	_____%	_____%
Mixed live oak/mesquite	<input type="checkbox"/>	_____%	_____%	_____%
Juniper	<input type="checkbox"/>	_____%	_____%	_____%
Mixed live oak/juniper	<input type="checkbox"/>	_____%	_____%	_____%

- B2. **Indicate whether you feel you currently have too much or too little of each of the following types of brush (woody plants) on your land?** (In each row, using a scale of -3 to +3 please circle the ONE value that best reflects your opinion).

	-3 = much too little ... 0 = just right ... +3 = much too much						
Live oak	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Mesquite	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Mixed live oak/mesquite	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Juniper (Cedar)	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Mixed live oak/juniper	-	-	-	0	+	+	+
	3	2	1	0	1	2	3
Other brush species	-	-	-	0	+	+	+
	3	2	1	0	1	2	3

Please answer the next four questions about brush canopy cover on your land by referring to the DIAGRAMS ON PAGE 9, which illustrate what is meant by **CANOPY COVER** and diagrammatically show **10% and 30% cover**. The scatter diagrams show two distribution patterns for each percentage cover. The first column (diagrams A and B) shows a dispersed and a clumpy pattern for 10% canopy cover, while the second column (diagrams C and D) shows a dispersed and a clumpy pattern for 30% canopy cover. In the questions below we ask for information about three categories of canopy cover:

- **Open cover** = Less than 10% (equal to or less than the cover shown in A and B)
- **Moderate cover** = 10% to 30% (between the A and C cover or between B and D cover)
- **Heavy cover** = Greater than 30% (greater than the cover shown in C and D)

- B3. **Approximately what percentage of your property is best described by each of the following CANOPY COVER classes?** (Please ensure that your answers total to 100%)

- Open cover \_\_\_\_\_ %
  - Moderate cover \_\_\_\_\_ %
  - Heavy cover \_\_\_\_\_ %
- Total = 100 %**

- B4. We anticipate that if a cost-share brush removal program is implemented in your area, funding will be provided to help landowners reduce undesirable woody plant canopy cover (mesquite and juniper) to less than 10%. We also expect that each landowner's cost for participating in the program will not exceed the additional income that will occur as a result of participating. If these assumptions are correct, **how much of each of canopy cover category on your land would you be willing to include in a cost-share brush removal program aimed at reducing canopy cover to less than 10%?** (Check only the canopy cover categories included question B3).

	<i>All</i>	<i>None</i>	<i>Part (What %?)</i>
• Moderate cover	<input type="checkbox"/>	<input type="checkbox"/>	_____ %
• Heavy cover	<input type="checkbox"/>	<input type="checkbox"/>	_____ %

- B5. If the cost-share brush control program places constraints on brush removal within 75 yards of riparian areas, **would your willingness to include moderate or heavy brush cover in the program increase, decrease or not change?** (Check only the canopy cover categories included in question B3).

	<i>Increase</i>	<i>Decrease</i>	<i>No change</i>	<i>Don't know</i>
• Moderate cover	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Heavy cover	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- B6. If the program requires that 40% of your land remain in moderate or heavy canopy cover after brush control has been completed, **would your willingness to include moderate or heavy brush cover in the program increase, decrease or not change?** (Check only the canopy cover categories included in question B3)

	<i>Increase</i>	<i>Decrease</i>	<i>No change</i>	<i>Don't know</i>
• Moderate cover	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Heavy cover	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## SECTION C – COST-SHARE BRUSH MANAGEMENT PROGRAM ISSUES

With societal interests focused on both water and the ecosystem, protection, restoration or improvement of riparian areas could be requirements for participating in a funded cost-share brush management program. In addition, there are some other issues relating to the implementation of cost-share contracts about which participants involved in initial brush control focus group meetings raised questions. In this section we ask questions about these issues.

- C1. If sufficient funds are provided to cover the costs of protecting, restoring or improving riparian areas, **how would the following CONSTRAINTS OR REQUIREMENTS affect your interest in participating in a cost-share brush removal program?** (Please check only ONE box in each row).

	<i>Won't affect my interest</i>	<i>Reduce my interest</i>	<i>Prevent my participation</i>
• A 75 yard buffer along both sides of streams and rivers in which all or some brush removal may be restricted	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Protection of bottomland hardwoods (e.g., cypress, dogwood, hackberry, pecan, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Selective brush management in riparian areas including removal of limited amounts of Juniper and/or mesquite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Replanting or reseeding native plants to stabilize stream banks and/or improve wildlife habitat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Fencing to control movement of cattle in riparian areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• Restricted flash grazing of livestock in riparian areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• No grazing of livestock in riparian areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- C2. **How important would COMPENSATION be to you for the following actions that might be required for riparian area protection, restoration or improvement as part of a cost-share brush removal program?** (In each row, circle the ONE value that best reflects your opinion).

	<i>-3 = very unimportant ... 0 = neutral ... +3 = very important</i>						
Fencing	-3	-2	-1	0	+	+	+
New water sources	-3	-2	-1	0	+	+	+
Grazing deferment	-3	-2	-1	0	+	+	+
Prescribed burns	-3	-2	-1	0	+	+	+
Replanting or reseeding of native plants	-3	-2	-1	0	+	+	+

- C3. If you were to participate in a cost-share brush control program, **how interested would you be in each of the following types of CONTRACTUAL ARRANGEMENTS?** (Please circle one value on a scale of -3 to +3 that best corresponds with your level of comfort).

<i>-3 = not at all interested ... 0 = neutral ... +3 = very interested</i>							
Contracts like those used to implement the NRCS-USDA Environmental Quality Initiative Program.	-3	-2	-1	0	+1	+2	+3
Contract that transfers to new owners if the land is sold	-3	-2	-1	0	+1	+2	+3
Contract that is tied to other State funded programs aimed at removing brush	-3	-2	-1	0	+1	+2	+3
Contract in which smaller properties would be charged a larger contract set up fee than larger properties because smaller properties generate less brush removal	-3	-2	-1	0	+1	+2	+3
Group contract that includes several landowners	-3	-2	-1	0	+1	+2	+3
Lease agreements like those used to implement the NRCS Conservation Reserve Program	-3	-2	-1	0	+1	+2	+3
Short-term (10 year) conservation easement	-3	-2	-1	0	+1	+2	+3
Long-term (50 year) conservation easement	-3	-2	-1	0	+1	+2	+3
Other (Please specify _____)	-3	-2	-1	0	+1	+2	+3

- C4. **Have you or are you currently participating in any other Federal or State funded programs such as EQUIP?**

No → Please go to Question C5.

Yes → **In which of the following programs have you participated or are you currently participating?**

	<i>Have participated in the past</i>	<i>Am currently participating</i>
• Environmental Quality Initiative Program (EQIP)	<input type="checkbox"/>	<input type="checkbox"/>
• Conservation Reserve Program (CRP)	<input type="checkbox"/>	<input type="checkbox"/>
• Other (Please specify _____)	<input type="checkbox"/>	<input type="checkbox"/>

- C5. Since a limited amount of funding is likely to be available for implementing a cost-share brush control program in your area, and given that a cost share level of 80% has resulted in an extremely high participation in the EQIP program, **what is the MINIMUM LEVEL OF COST SHARE that you would require in order to participate in a brush control program in your area?** (Check only ONE box).
- 50%                                       70%                                       90%  
 60%                                       80%                                       100%  
 I am not interested in participating in such a program?

#### SECTION D – PERSONAL INFORMATION

To properly understand differences among landowners regarding their interest and concerns about cost-share programs aimed at increasing water yield and improving wildlife, we ask you to provide us some basic information about yourself. We understand that you may be uncomfortable sharing this information with an outsider. However, we want to assure you that **YOUR RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL**, and we will never release them to any individual, business, or government agency. Results of this study will be reported only in the form of statistical summaries of many operations. At no time will the identity of your operation be disclosed. We thank you in advance for your willingness to provide this information.

- D1. ***In which year were you born?*** \_\_\_\_\_
- D2. ***Since age 18, how many years of ranching or farming experience do you have?*** \_\_\_\_\_
- D3. ***For how long have you or your family owned this property? (Check only ONE box)***
- Less than 3 years                                       More than 25 years (single generation)  
 3-10 years     More than one generation  
 11-25 years     I manage but don't own the property
- D4. ***How many years do you estimate you will continue to own the property? (Check the ONE box for the answer that best applies to your situation.)***
- 1 to 3 years     Indefinitely  
 3 to 10 years     I don't own the property
- D5. ***Do you currently live on your property?***
- Yes → Please skip to question D6 below.  
 No → Please answer the following questions.
- (a) ***How far from your ranch or farm do you live?***
- Less than 10 miles from your ranch or farm  
 11-50 miles from your ranch or farm  
 51 to 100 miles from your ranch or farm  
 More than 100 miles from your ranch or farm
- (b) ***In what type of community do you live?***
- The country or small rural community (under 2,500 population)  
 Small town (2,500-5,000 population)  
 Small city (5,000-25,000 population)



- Medium-sized city (25,000-50,000 population)
- Large city (50,000-250,000 population)
- Very large city or metropolitan area (over 250,000 population)

D6. **Please check the category that most accurately reflects your overall level of investment in fixed improvements on your property during the last five years.** (By fixed improvements we mean such things as contouring, fencing, water facilities, roads, brush clearing, etc. Please do not include moveable equipment or operating expenses such as fertilizer, supplemental feeds, veterinary expenses, etc. in this estimate.)

- |  |  |  |
|--|--|--|
| <input type="checkbox"/> Under \$1,000     | <input type="checkbox"/> \$1,000-\$9,999   | <input type="checkbox"/> \$10,000-\$24,999 |
| <input type="checkbox"/> \$25,000-\$49,999 | <input type="checkbox"/> \$50,000-\$99,999 | <input type="checkbox"/> Over \$100,000    |

D7. **What proportion of your household's total income usually comes from activities related to your property?**

- under 10%    11-25%    26-50%    51-75%    over 75%

D8. **Please check the category that best represents your household's total income before taxes in 2001?** (Include net property income, income from wages, salaries, nonfarm businesses, rental payments, investments, retirement accounts, and any other major income sources).

- |  |   |
|--|---|
| <input type="checkbox"/> Less than \$25,000  | <input type="checkbox"/> \$75,001 - \$100,000   |
| <input type="checkbox"/> \$25,001 - \$50,000 | <input type="checkbox"/> \$100,001 - \$500,000  |
| <input type="checkbox"/> \$50,001 - \$75,000 | <input type="checkbox"/> Greater than \$500,000 |

**Please write any other comments or suggestions that can help us better understand the situation of ranches and farms like your own.**

**THANK YOU FOR TAKING THE TIME TO FILL OUT THIS QUESTIONNAIRE. Your participation is greatly appreciated. Please send the completed questionnaire to us in the enclosed postage-paid envelope.** If you wish to receive a summary of the survey results, please check the box below.

*Would you like to receive a summary of the results of this study once they are available?*

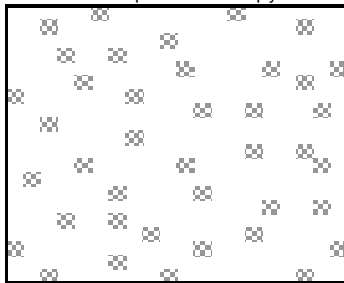
- No    Yes

**CANOPY COVER** is defined as the total ground area covered by the aboveground aerial parts (branches, leaves) of woody plants, as shown on the diagram below.

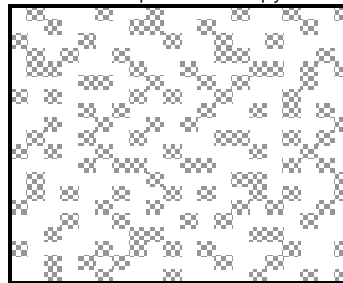


**SCATTER DIAGRAMS** showing two distribution patterns for 10% and 30% canopy cover. The first column (diagrams A and B) shows a dispersed and a clumpy pattern for 10% canopy cover, while the second column (diagrams C and D) shows a dispersed and a clumpy pattern for 30% canopy cover. In the questions below we ask for information about three categories of canopy cover:

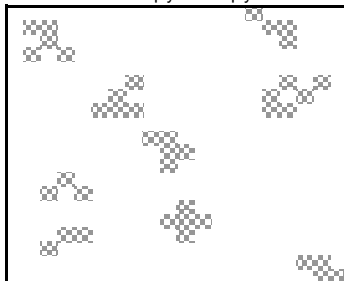
**A** - 10% dispersed canopy cover



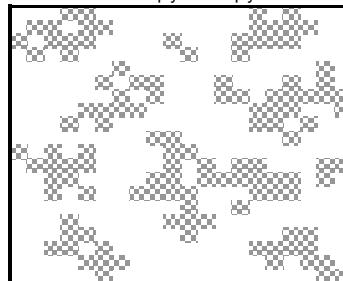
**C** - 30% dispersed canopy cover



**B** - 10% clumpy canopy cover



**D** - 30% clumpy canopy cover



## APPENDIX B

### B1. Individual watershed results.

#### B1a. Edwards Aquifer.

Variable	N	Min	Max	Mean	Std. Error of Mean	C.V.
Age	122	29.0	92.0	60.7	1.12	0.02
Farming/Ranching Experience (yrs)	119	0	74	20.9	1.58	0.08
Property Size (ha)	129	20.2	5261.0	350.9	60.18	0.17
Income from Crops	98	0	50	2.6	0.88	0.35
Income from Livestock	101	0	100	36.0	4.09	0.11
Income from Wildlife	98	0	100	5.2	1.81	0.35
Hunting Fees	98	0	100	26.9	3.43	0.13
Income from Other Recreation	97	0	100	7.0	2.26	0.32
Government Program Payments	97	0	22	0.9	0.37	0.39
Mineral Sales and Leases	97	0	100	2.9	1.44	0.49
Other Income	97	0	100	17.7	3.65	0.21
Grassland Importance	121	1	7	6.5	0.10	0.01
Woodland/Brush Importance	114	1	7	5.4	0.16	0.03
Surface Water Importance	116	1	7	6.6	0.11	0.02
Importance of Wildlife	120	1	7	6.6	0.09	0.01
Improve Forage Supply	116	1	7	5.4	0.19	0.04
Improve Wildlife Habitat	119	1	7	6.5	0.09	0.01
Control Brush Invasion	117	1	7	6.4	0.11	0.02
Protect/Improve Riparian Areas	113	1	7	6.2	0.12	0.02
Increase Streamflow	115	1	7	6.3	0.13	0.02
Increase Water Yield	120	1	7	6.5	0.11	0.02
Improve Riparian Areas for Wildlife	117	1	7	6.2	0.11	0.02
Protect Live Oak	120	1	7	6.2	0.12	0.02
Control Light Mesquite	114	1	7	4.7	0.18	0.04
Control Light Juniper	121	1	7	6.3	0.13	0.02
Less Brush May Reduce Hunting Value	118	1	7	4.4	0.20	0.04
Open Grassland	120	0	90	23.5	1.71	0.07
Predominantly Live Oak	119	0	40	9.2	0.96	0.10
Predominantly Mesquite	118	0	50	1.2	0.56	0.46
Predominantly Juniper	118	0	90	29.2	2.47	0.08
Mixed Live Oak and Mesquite	117	0	30	0.5	0.29	0.54
Mixed Live Oak and Juniper	119	0	95	26.7	2.53	0.09
Mixed Mesquite and Juniper	117	0	35	1.2	0.48	0.40
Other Brush Species	117	0	40	5.0	0.70	0.14
Other Land Cover	117	0	80	4.4	1.16	0.26
How Much Live Oak	114	1	7	3.3	0.12	0.04
How Much Mesquite	97	1	7	3.8	0.12	0.03
How Much Mixed Live Oak/Mesquite	84	1	6	3.8	0.10	0.03
How Much Juniper	121	1	7	6.5	0.10	0.02
How Much Mixed Live Oak/Juniper	102	1	7	5.3	0.13	0.02
How Much Other Brush Species	109	2	20	4.9	0.18	0.04
Compensation for Fencing	122	1	7	5.6	0.16	0.03
Compensation for New Water Sources	123	1	7	5.9	0.14	0.02
Compensation for Grazing Deferment	123	1	7	4.6	0.17	0.04
Compensation for Prescribed Burns	124	1	7	5.1	0.16	0.03
Compensation for Replanting/Reseeding of Native Plants	123	1	7	5.5	0.16	0.03
EQUIP-type Contracts	92	1	7	4.0	0.19	0.05
Contracts that Transfer to New Owners	105	1	7	3.8	0.22	0.06
Contracts Tied to Other State Funded Programs	104	1	9	4.3	0.20	0.05
Contracts in Which Smaller Properties are Charged More	105	1	7	3.2	0.20	0.06
Contracts that Include Several Landowners	107	1	7	3.7	0.21	0.06
CRP-type Contracts	97	1	7	3.5	0.18	0.05
10 Year Conservation Easement	107	1	7	3.7	0.20	0.05
50 Year Conservation Easement	104	1	7	2.4	0.15	0.06

**B1b. Twin Buttes.**

Variable	N	Minimum	Maximum	Mean	Std. Error of Mean	C.V.
Age	132	27	92	60.0	1.2	0.02
Years Farming/Ranching Experience Since Age 18	125	0	74	29.1	1.7	0.06
Property Size (ha)	141	25.1	38446.0	1827.8	369.8	0.20
Income from Crops	138	0	100	7.3	1.6	0.22
Income from Livestock	137	0	100	41.3	3.0	0.07
Income from Wildlife	138	0	100	2.4	1.2	0.49
Hunting Fees	137	0	100	20.2	2.1	0.10
Income from Other Recreation	138	0	50	0.7	0.4	0.64
Government Program Payments	138	0	50	3.5	0.7	0.20
Mineral Sales and Leases	138	0	100	14.5	2.4	0.17
Other Income	137	0	100	8.7	2.0	0.23
Grassland Importance	127	1	7	6.7	0.1	0.01
Woodland/Brush Importance	121	1	7	5.1	0.2	0.03
Surface Water Importance	117	1	7	6.1	0.1	0.02
Importance of Wildlife	131	1	7	6.4	0.1	0.01
Improve Forage Supply	124	1	7	6.4	0.1	0.02
Improve Wildlife Habitat	128	1	7	6.2	0.1	0.01
Control Brush Invasion	128	1	7	6.6	0.1	0.01
Protect/Improve Riparian Areas	118	1	7	6.0	0.1	0.02
Increase Streamflow	121	1	7	6.0	0.1	0.02
Increase Water Yield	123	1	7	6.1	0.1	0.02
Improve Riparian Areas for Wildlife	121	1	7	5.8	0.1	0.02
Protect Live Oak	114	1	7	5.9	0.2	0.03
Control Light Mesquite	128	1	7	6.2	0.1	0.02
Control Light Juniper	119	1	7	6.0	0.1	0.02
Less Brush May Reduce Hunting Value	120	1	7	5.1	0.1	0.03
Open Grassland	127	0	90	18.5	1.8	0.10
Predominantly Live Oak	127	0	95	3.3	0.9	0.27
Predominantly Mesquite	128	0	100	27.9	2.7	0.10
Predominantly Juniper	127	0	75	14.2	1.9	0.13
Mixed Live Oak and Mesquite	127	0	40	2.3	0.6	0.24
Mixed Live Oak and Juniper	127	0	55	4.7	1.0	0.21
Mixed Mesquite and Juniper	127	0	100	20.6	2.5	0.12
Other Brush Species	127	0	50	4.6	0.9	0.20
Other Land Cover	127	0	63	4.3	1.0	0.23
How Much Live Oak	107	1	7	2.5	0.1	0.05
How Much Mesquite	129	1	7	6.3	0.1	0.02
How Much Mixed Live Oak/Mesquite	79	1	7	3.7	0.2	0.05
How Much Juniper	115	1	7	5.9	0.2	0.03
How Much Mixed Live Oak/Juniper	78	1	7	3.9	0.2	0.05
How Much Other Brush Species	95	1	7	4.7	0.2	0.04
Compensation for Fencing	129	1	7	5.8	0.2	0.03
Compensation for New Water Sources	129	1	7	5.8	0.1	0.03
Compensation for Grazing Deferment	128	1	7	5.2	0.2	0.03
Compensation for Prescribed Burns	130	1	7	5.0	0.2	0.03
Compensation for Replanting/Reseeding of Native Plants	128	1	7	5.6	0.2	0.03
EQUIP-type Contracts	117	1	7	4.5	0.2	0.04
Contracts that Transfer to New Owners	125	1	7	4.3	0.2	0.04
Contracts Tied to Other State Funded Programs	124	1	7	4.9	0.2	0.04
Contracts in Which Smaller Properties are Charged More	124	1	7	3.4	0.2	0.05
Contracts that Include Several Landowners	124	1	7	3.7	0.2	0.05
CRP-type Contracts	118	0	7	4.0	0.2	0.05
10 Year Conservation Easement	124	0	7	4.0	0.2	0.05
50 Year Conservation Easement	119	0	7	2.8	0.2	0.07

**B2. Willing vs. unwilling to participate.**

<b>Participate</b>		<b>Improve Riparian Areas</b>	<b>Open Grasslan</b>	<b>Other Brush</b>	<b>Percentage of Open Cover</b>	<b>Percentage of Moderate Cover</b>	<b>Percentage of Heavy Cover</b>
<b>No</b>	N	24	26	26	29	29	29.0
	Minimum	1.0	0.0	0.0	0.0	0.0	0.0
	Maximum	7.0	90.0	10.0	100.0	100.0	0.0
	Mean	5.5	30.6	0.7	40.5	59.5	0.0
	SEM	0.3	5.9	0.4	7.1	7.1	0.0
	C.V.	0.06	0.19	0.62	0.18	0.12	-
<b>Yes</b>	N	214	221	218	232	232	233.0
	Minimum	7.0	0.0	0.0	0.0	0.0	5.0
	Maximum	7.0	90.0	50.0	90.0	90.0	100.0
	Mean	6.1	19.8	5.3	20.5	29.6	49.7
	SEM	0.1	1.2	0.6	1.2	1.2	1.6
	C.V.	0.01	0.06	0.12	0.06	0.04	0.03

### B3. Differences in willing participants in each study area.

#### B3a. Edwards Aquifer.

Variable	N	Minimum	Maximum	Mean	Std. Error of Mean	C.V.
Income from Crops	90	0	50	2.2	0.8	0.36
Income from Livestock	93	0	100	35.5	4.2	0.12
Income from Wildlife	90	0	100	5.5	2.0	0.36
Hunting Fees	90	0	100	27.9	3.6	0.13
Income from Other Recreation	89	0	100	6.2	2.2	0.35
Grassland Importance	113	1	7	6.5	0.1	0.01
Woodland/Brush Importance	106	1	7	5.5	0.2	0.03
Surface Water Importance	108	1	7	6.6	0.1	0.02
Importance of Wildlife	112	1	7	6.7	0.1	0.01
Improve Forage Supply	108	1	7	5.5	0.2	0.04
Improve Wildlife Habitat	111	1	7	6.6	0.1	0.01
Control Brush Invasion	109	1	7	6.5	0.1	0.02
Protect/Improve Riparian Areas	105	1	7	6.2	0.1	0.02
Increase Streamflow	107	1	7	6.3	0.1	0.02
Increase Water Yield	112	1	7	6.5	0.1	0.02
Improve Riparian Areas for Wildlife	109	1	7	6.2	0.1	0.02
Protect Live Oak	112	1	7	6.2	0.1	0.02
Control Light Mesquite	107	1	7	4.7	0.2	0.04
Control Light Juniper	113	1	7	6.3	0.1	0.02
Less Brush May Reduce Hunting Value	110	1	7	4.4	0.2	0.05
Open Grassland	112	0	75	22.2	1.6	0.07
Predominantly Live Oak	111	0	40	9.0	1.0	0.11
Predominantly Mesquite	110	0	50	1.2	0.6	0.49
Predominantly Juniper	110	0	90	29.9	2.6	0.09
Total Mixed Brush	109	0	90	28.3	2.5	0.09
Other Brush Species	109	0	40	5.2	0.7	0.14
Other Land Cover	109	0	80	4.6	1.2	0.27
How Much Live Oak	106	1	7	3.3	0.1	0.04
How Much Mesquite	91	1	7	3.8	0.1	0.03
How Much Mixed Live Oak/Mesquite	78	1	7	3.7	0.1	0.03
How Much Juniper	113	1	7	6.5	0.1	0.02
How Much Mixed Live Oak/Juniper	94	1	7	5.4	0.1	0.03
How Much Other Brush Species	101	1	7	4.9	0.2	0.04
Compensation for Fencing	114	1	7	5.6	0.2	0.03
Compensation for New Water Sources	115	1	7	5.9	0.1	0.02
Compensation for Grazing Deferment	115	1	7	4.6	0.2	0.04
Compensation for Prescribed Burns	116	1	7	5.1	0.2	0.03
Compensation for Replanting/Reseeding of Native Plants	115	1	7	5.5	0.2	0.03
EQUIP-type Contracts	86	1	7	4.0	0.2	0.05
Contracts that Transfer to New Owners	97	1	7	3.9	0.2	0.06
Contracts Tied to Other State Funded Programs	97	1	7	4.3	0.2	0.05
Contracts in Which Smaller Properties are Charged More	98	1	7	3.2	0.2	0.06
Contracts that Include Several Landowners	99	1	7	3.7	0.2	0.06
CRP-type Contracts	90	1	7	3.5	0.2	0.05
10 Year Conservation Easement	100	1	7	3.7	0.2	0.06
50 Year Conservation Easement	97	1	7	2.3	0.2	0.06

**B3b. Twin Buttes.**

Twin Buttes						
Variable	N	Minimum	Maximum	Mean	Std. Error of Mean	C.V.
Income from Crops	118	0	100	7.4	1.8	0.25
Income from Livestock	117	0	100	41.5	3.2	0.08
Income from Wildlife	118	0	100	2.8	1.4	0.50
Hunting Fees	117	0	100	20.4	2.3	0.11
Income from Other Recreation	118	0	50	0.8	0.5	0.64
Grassland Importance	110	1	7	6.7	0.1	0.01
Woodland/Brush Importance	107	1	7	5.1	0.2	0.03
Surface Water Importance	104	1	7	6.1	0.1	0.02
Importance of Wildlife	112	1	7	6.4	0.1	0.02
Improve Forage Supply	108	1	7	6.4	0.1	0.02
Improve Wildlife Habitat	111	1	7	6.3	0.1	0.02
Control Brush Invasion	109	1	7	6.6	0.1	0.01
Protect/Improve Riparian Areas	103	1	7	6.0	0.1	0.02
Increase Streamflow	105	1	7	6.0	0.2	0.03
Increase Water Yield	106	1	7	6.2	0.1	0.02
Improve Riparian Areas for Wildlife	105	1	7	5.9	0.1	0.02
Protect Live Oak	98	1	7	5.9	0.2	0.03
Control Light Mesquite	111	1	7	6.2	0.1	0.02
Control Light Juniper	103	1	7	6.0	0.2	0.03
Less Brush May Reduce Hunting Value	104	1	7	5.2	0.1	0.03
Open Grassland	109	0	90	17.3	1.8	0.10
Predominantly Live Oak	109	0	35	2.9	0.6	0.20
Predominantly Mesquite	110	0	100	27.6	2.7	0.10
Predominantly Juniper	109	0	75	15.0	2.1	0.14
Total Mixed Brush	109	0	100	28.4	2.9	0.10
Other Brush Species	109	0	50	5.3	1.1	0.20
Other Land Cover	109	0	63	4.0	1.0	0.25
How Much Live Oak	93	1	7	2.4	0.1	0.06
How Much Mesquite	112	1	7	6.3	0.1	0.02
How Much Mixed Live Oak/Mesquite	68	1	7	3.7	0.2	0.05
How Much Juniper	100	1	7	6.0	0.2	0.03
How Much Mixed Live Oak/Juniper	67	1	7	4.0	0.2	0.05
How Much Other Brush Species	84	1	7	4.7	0.2	0.04
Compensation for Fencing	112	1	7	5.8	0.2	0.03
Compensation for New Water Sources	112	1	7	5.9	0.2	0.03
Compensation for Grazing Deferment	111	1	7	5.3	0.2	0.03
Compensation for Prescribed Burns	111	1	7	4.9	0.2	0.04
Compensation for Replanting/Reseeding of Native Plants	111	1	7	5.6	0.2	0.03
EQUIP-type Contracts	104	1	7	4.6	0.2	0.04
Contracts that Transfer to New Owners	110	1	7	4.3	0.2	0.04
Contracts Tied to Other State Funded Programs	110	1	7	4.9	0.2	0.04
Contracts in Which Smaller Properties are Charged More	109	1	7	3.4	0.2	0.06
Contracts that Include Several Landowners	109	1	7	3.7	0.2	0.06
CRP-type Contracts	103	1	7	4.1	0.2	0.05
10 Year Conservation Easement	109	1	7	4.0	0.2	0.05
50 Year Conservation Easement	104	1	7	2.9	0.2	0.07

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### Experience

- May 2003 – Present, Research Analyst, AgriLogic, Inc., College Station, Texas
- June 2001 – August 2003, Research Assistant, Department of Rangeland Ecology and Management, Texas Agricultural Experiment Station, College Station, Texas
- August 2000 – June 2001, Teaching Assistant, Department of Animal Science, Texas A&M University, College Station, Texas
- September 1999 – January 2001, Futures Broker/Market Reporter, Agricultural Risk and Marketing Services, Inc., College Station, Texas
- May 1994 – May 1998, Infantry Unit Leader, U.S. Marine Corps, Camp Lejeune, North Carolina

### Memberships

- Society for Range Management
- Texas and Southwestern Cattle Raisers Association
- Veterans of Foreign Wars of the United States