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Regional Cost Share Necessary for Rancher Participation in Brush Control

Andrew C. Lee, J. Richard Conner, James W. Mjelde, James W. Richardson, and Jerry W. Stuth

Large-scale brush-control programs are being proposed in Texas to increase off-site water yields. Biophysical and economic simulation models are combined to estimate the effects of brush control on representative ranches in four ecological regions of the Edwards Plateau area of Texas. Net present values of representative ranches in three of four regions decrease with brush control. Cost shares necessary for ranches from the three regions to break even range from 7% to 31% of total brush-control costs. Any large-scale brush-control program will therefore require a substantial investment by the State of Texas.

Key words: brush control, cost share, Edwards Plateau, rancher focus groups, simulation

Introduction

Controlling brush encroachment has been a problem for livestock producers utilizing native rangelands in the Southwestern United States for most of the 20th century (Scifres et al.). Increased returns from improved animal performance are usually too low for brush control to be economically feasible (McBryde, Conner, and Scifres; Whitson and Scifres; Upper Colorado River Authority; Dugas, Hicks, and Wright; Thurow and Hester). In addition to increasing animal performance, brush control may increase off-site water yields via increases in surface run-off and percolation to underground aquifers (Meiman and Dils; Hibbert; Blackburn 1983, 1985; Upper Colorado River Authority; Whitson and Scifres). Ranchers, however, cannot fully capture the benefits associated with increased off-site water yields. Further, good estimates of these benefits have not been developed. In 1985, the Texas Legislature cited the relationship between reducing brush and increasing water yields as a rationale for passing the Texas Brush-Control Act to encourage brush control on private ranches (Texas State Legislature).

Recent droughts and municipal water shortages have prompted renewed interest in the water-harvesting potential of brush control in Texas. One such area receiving attention is the Edwards Plateau region. In this study, biophysical and economic simulation models are integrated to determine potential economic gains to ranchers in different regions of the Edwards Plateau from participating in a State-supported brush-control program.

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The primary objective of the study is to estimate regional levels of cost share required to entice rancher participation. In accomplishing this objective, the State's costs of implementing this program in the different regions of the Edwards Plateau are estimated. These cost estimates are necessary for evaluating policy implications of the Brush-Control Act to provide enhancement of off-site water yields in the Edwards Plateau.

Methodology

We adopt the methodology proposed by Conner, which integrates ecological and economic modeling with information from focus groups. Figure 1 provides a schematic flowchart detailing this methodology. The Edwards Plateau is divided into four ecological-economic regions (identified on the map in figure 2) to capture the diversity of the area.

One representative ranch for each of the regions is developed using data obtained from focus group sessions conducted in each region. Local soil, plant community, livestock characteristics, and simulated weather are used as biophysical inputs to the Phytomass Growth Simulator (PHYGROW) (Ranching Systems Group, Texas A&M University). Decision rules for stocking rates derived from focus groups are used as management inputs in PHYGROW to simulate daily forage production, stocking rates, and animal performance (offspring crops and weaning weights) for pre- and post-brush-control scenarios.

Results from PHYGROW, economic data from the focus groups, and other sources provide input for the Firm Level Income and Policy Simulator (FLIPSIM) (Richardson and Nixon) to simulate annual financial performance of the ranches. Results from the representative ranches are aggregated to obtain the State's cost shares for each region of the Edwards Plateau and total costs for the plateau. A detailed description of the methodology and ecological and economic characteristics of the representative ranches is provided in Lee.

Study Area

As seen from figure 2, the Edwards Plateau is located in west central Texas, stretching for approximately 200 miles west to east and 150 miles north to south. Austin and San Antonio are located at the eastern and southeastern edges. Covering approximately 15.8 million acres, the region is predominantly rangeland, with range-based livestock enterprises comprising the major industry. Originally grassland savanna, the region is heavily infested with brush species, mainly liveoak and juniper. Land productivity and ranch management practices vary throughout the plateau because of differences in financial, climate, and soil characteristics. Representative ranches for Crockett, Sutton, San Saba, and Kendall counties are constructed to portray the four respective ecological-economic regions: West, Central, East, and South.

Representative Ranches

A unique feature of the methodology developed here is the use of focus groups to construct representative ranches. In this study, only commercial ranches are considered. A commercial ranch is defined to be a range-based enterprise in which ranching constitutes full-time employment for the rancher and is the major source of income.

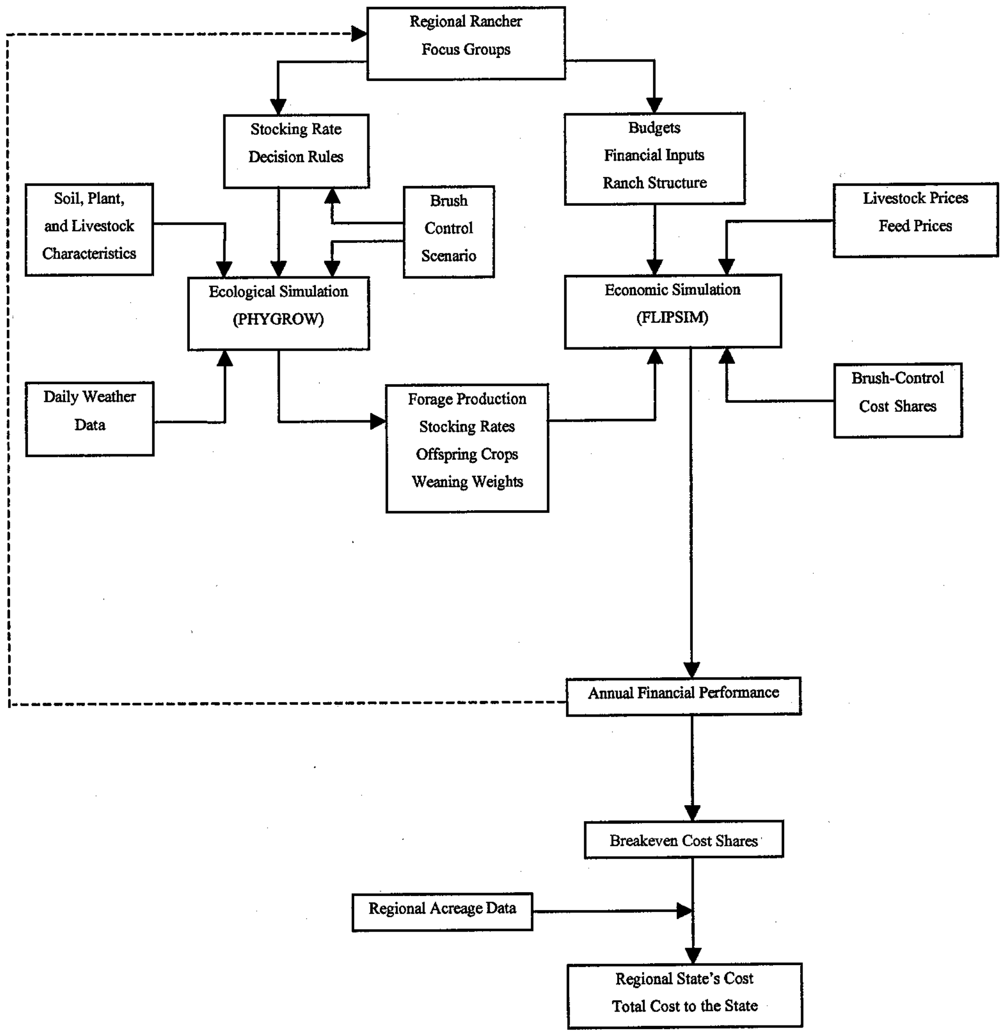

Figure 1. Schematic of the methods used to estimate the costs of implementing a brush-control program

Five to seven commercial ranchers from each county participated in their county's focus group. Members of each group developed a ranch representative of the commercial ranches in their county. To minimize strategic behavior from the ranchers, no mention of the State's cost shares for brush control was made at the focus groups. Consensus was reached on ranch size, animal enterprises, restock/destock decisions, average stocking rates, average animal performance, financial conditions, and production costs.

A preliminary FLIPSIM analysis was performed using the consensus parameters, and the results were mailed to each focus group participant. All focus group members thought FLIPSIM modeled the representative ranches reasonably well.

Of all the soils found in each county, only two to four soils that make up the majority of the county are modeled. Each major soil is associated with a range site. A range site is an area of rangeland where climate, soil, and topography are sufficiently uniform to

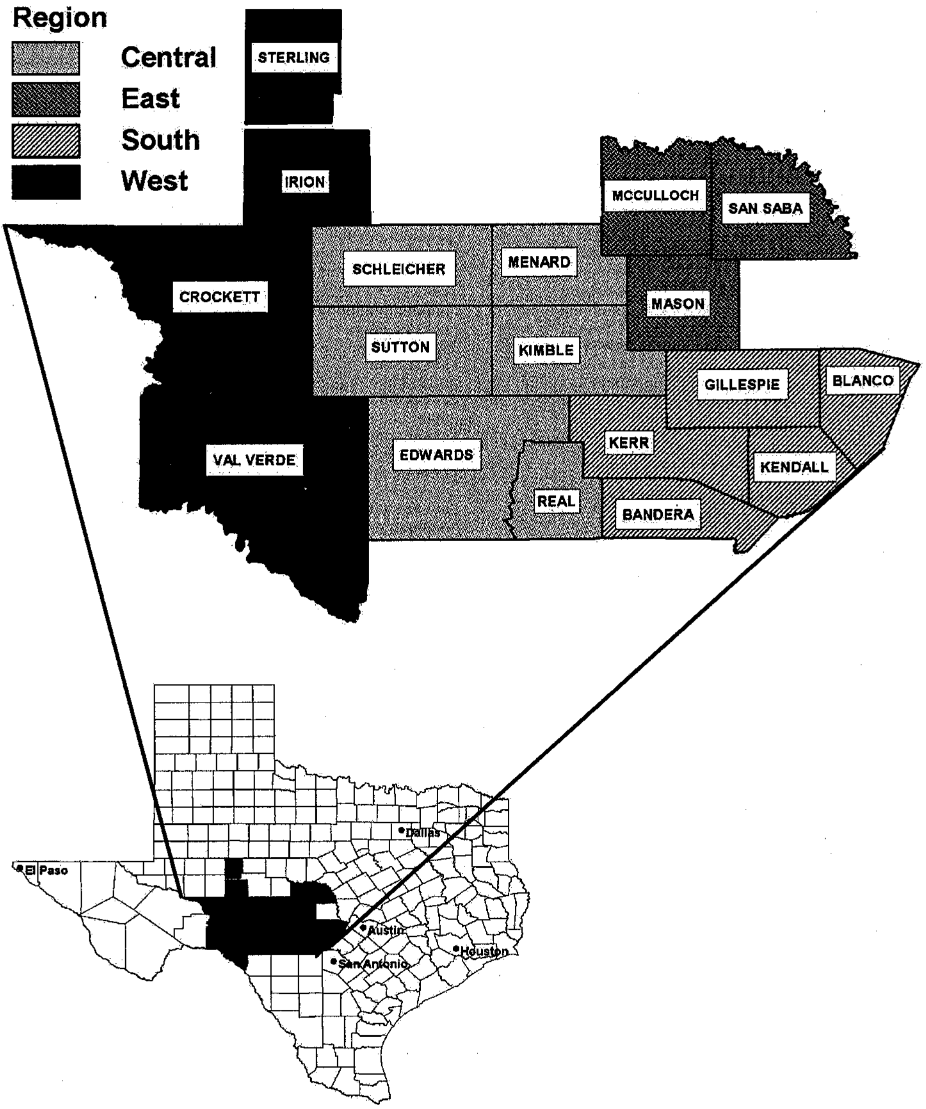

Figure 2. Ecological-economic regions of the Edwards Plateau, Texas

produce a distinct natural plant community [U.S. Department of Agriculture/Natural Resources Conservation Service (USDA/NRCS) 1982]. PHYGROW simulates each range site separately. Resulting forage production, stocking rates, and animal performance for each range site are combined according to the proportion each site occupies within a representative ranch.

Differences in ranch size, land price, precipitation, range sites, herd size, and animal performance for representative ranches from each of the four regions are shown in table 1. Four range sites are used to model diversity of the South, whereas only two sites are used in each of the other regions.

The West receives the least amount of precipitation (table 1). Its soils are very shallow on hilly terrain and its rangeland is the least productive, requiring a larger area to support a given livestock population. Consequently, the West representative ranch is the

Table 1. Characteristics of the Representative Ranches in the Four Regions of the Edwards Plateau, Texas

				Major Range Sites/Soils		Animal Enterprises		Average Animal Performance	
REGION	Ranch Acreage	Land Price ($/acre)[a]	Mean Annual Precipitation (inches)[b]	Range Site/Soil	% of Ranch Acreage	Animal	Average Herd Size	Offspring Crop (%)	Weaning Weight (lbs.)
WEST	20,000	150	15.7	Limestone Hill/Ector	85	Cattle	150	89.3	525
				Steep Rocky/Ector-Rock Outcrop	15	Sheep	1,802	80.0	73
						Hair Goat	558	40.0	44
CENTRAL	6,400	275	20.5	Low Stony Hill/Tarrant	81	Cattle	125	89.6	625
				Shallow/Kavett	19	Sheep	300	104.0	75
						Hair Goat	840	50.0	44
						Meat Goat	100	100.0	44
EAST	6,000	750	27.0	Gravelly Redland/Rumple	37	Cattle	300	85.0	580
				Redland/Roughcreek	63				
SOUTH	5,000	2,072	27.8	Steep Adobe/Real	14	Cattle	100	82.0	438
				Adobe/Brackett	33	Sheep	300	125.0	68
				Low Stony Hill/Eckrant	27	Meat Goat	300	100.0	44
				Shallow/Doss	26				

[a] Land price ($/acre) is 1996 price obtained from ranch focus groups.
[b] Mean annual precipitation (inches) derived from Corbett et al. (1999).

largest of the four regions. The West is also most suitable for sheep and goat grazing. The Central region is similar in many ecological and economic characteristics to the West, but receives higher annual precipitation. In the East and South, soils are more fertile and precipitation is more abundant. Higher productive land is reflected in higher livestock carrying capacity per unit area and higher land prices. Cow-calf operations are the dominant enterprise for the East. Unlike the other regions, calving in the East occurs mainly in the fall. In addition to having more productive soils and higher precipitation, the South faces increasing pressure for development from San Antonio. This development pressure accounts for the higher land prices in the South compared to prices in the other three regions.

PHYGROW Ecological Simulation

To simulate a ranch's carrying capacity, PHYGROW requires parameters for plant communities, soil characteristics, meteorological conditions, grazing species, and management decisions. Using these parameters, PHYGROW simulates forage production (quantity and quality), stocking rates, and animal performance.

Plant communities are defined by the extent and content of species growing in each community. Typically, 20 to 30 species characterize a plant community. Growth attributes such as rooting depth, energy-to-matter conversion rate, leaf area index, leaf turnover rate, and canopy height are necessary for PHYGROW to simulate forage production. For our analysis, plant community data are derived from USDA/NRCS soil surveys of Sutton County (1977), San Saba County (1982), and Kendall County (1981), and from Coburn (personal communication, 1997) for Crockett County.

Each plant community is assigned to a multi-layer soil profile to reflect root growth, extraction, and water balance. Data related to major soil types and the proportion of each county these soil types occupy again are taken from the USDA/NRCS county soil surveys and from Coburn. Soil attributes like layer thickness, rock fragments, and saturated hydraulic conductivity are taken from the USDA/NRCS Map Unit Use File (1994).

Superimposed on each plant community-soil profile is a daily weather profile. One hundred 10-year daily weather data sets are generated using the USCLIMAT.BAS model (Hanson et al.) and parameters from weather stations in Texas. Del Rio and San Angelo stations are used to generate weather patterns for the West and Central regions. The Fredericksburg station is used to generate weather patterns for the East and South. Daily minimum and maximum temperatures (°C), precipitation (cm), and solar radiation (langley) are used by PHYGROW.

Each grazing species and ecological-economic region has a unique decision rule for stocking rates based on the consensus of the focus groups. Decisions in the fall and summer are modeled within PHYGROW. Focus groups determined the "average" stocking rate and the range of stocking rates to use in the simulations. Each focus group reached consensus about the average stocking rate of all species that would be employed under typical range conditions. Next, questions were asked to obtain the highest (lowest) stocking rate ranchers would employ if range conditions were excellent (poor). Average stocking rates from 100 simulations of a 10-year planning horizon by PHYGROW approximate those given by the focus groups.

Animal performance is calculated using a forage value index. This index represents quantities of daily available preferred, desirable, and undesirable forages. Offspring crops and weaning weights are based on the forage quality during critical time periods. Forage quality during the critical time period from birth to weaning affects the weaning weight within PHYGROW. An animal's body condition at breeding influences fertility. Body condition is affected by forage quality during a specified period before breeding, which depends on the animal species.

To calculate current annual offspring crops and weaning weights, average pre-brush-control values (table 1) are adjusted based on deviations in the current year's forage value index from the long-term average index. These adjustments are made by constructing an interval about the long-term average index. This interval is determined through a calibration procedure that ensures PHYGROW simulations approximate the long-term average animal performance obtained from each focus group. If the current year's index falls within the interval, no adjustment of the offspring crop or weaning weight is made. When the current year's index is below (above) the lower (upper) bound, offspring crop or weaning weight is adjusted down (up). For each 1% decrease (increase) in forage value index outside of the nonadjustment interval, average calf weaning weights are adjusted down (up) by 10 lbs. (5 lbs.), average lamb weaning weights are adjusted down (up) by 1.4 lbs. (0.8 lb.), and average kid weaning weights are adjusted down (up) by 1 lb. (0.5 lb.). Average calf crops are adjusted down (up) by 2% (0.5%), average lamb crops are adjusted down (up) by 1% (1%), and average kid crops are adjusted down (up) by 0.5% (0.5%).

Adjustment rules for weaning weight reflect a greater negative effect from declining forage quality than a positive effect from improving forage quality for all three species. The calf crop adjustment rule also captures these asymmetric effects of declining and improving forage quality. However, for lamb and kid crops, it is assumed the adjustment magnitude is the same in both directions.

To simulate a brush-controlled ranch, a 50% rate of brush control is used in place of the pre-brush-control plant community. The brush-controlled community is modeled by reducing the canopy cover of woody brush species of the pre-brush-control community by 50% on all acreage, with increased grass production filling in newly available niches.

After brush control, a ranch's carrying capacity increases. For the Edwards Plateau region, 100% brush control and periodic maintenance to keep up the 100% brush-controlled state would result in forage improvement that allows a 60% to 100% increase in stocking rates without deteriorating the pre-brush-control forage availability and animal performance (Scifres et al.). A 50% brush-controlled ranch would therefore accommodate increases in the stocking rate of approximately 30–50% while maintaining pre-brush-control range conditions and animal performances. The focus groups, however, indicated more conservative management practices. In this study, a 15% increase in the average stocking rate is adopted to utilize the increased carrying capacity of the brush-controlled ranch. All focus groups thought this increase was reasonable.

To account for variability in weather patterns and the medium-term nature of brush-control investments, 100 simulations of a 10-year planning horizon were run using PHYGROW. Daily weather varies in these 100 simulations. Livestock output variables from the PHYGROW simulation, used as input to FLIPSIM, are annual stocking rates, offspring crops, and weaning weights. Daily stocking rates from PHYGROW are averaged to obtain annual stocking rates.

Table 2. Acreage and Number of Representative Ranches by Region in the Edwards Plateau, Texas

	Region			
Region Characteristics	West	Central	East	South
Region acreage[a]	6,467,000	4,900,000	2,100,000	2,280,000
Acreage of representative ranches	3,796,129	2,876,300	1,232,700	1,338,360
Total no. of representative ranches	190	449	205	268

[a] Data taken from Godfrey, McKee, and Oakes, General Soil Map of Texas (1973).

FLIPSIM Economic Simulation

FLIPSIM simulates annual livestock production, marketing, financial, income tax, and accounting activities of each ranch. To link FLIPSIM to PHYGROW, FLIPSIM is modified to enable it to utilize PHYGROW-generated annual stocking rates, offspring crops, and weaning weights. Budgets to define production costs for all enterprises are from the focus groups. The initial financial situation for each representative ranch is based on the focus group's information, as well as local market values for land, machinery, and livestock.

Projections of annual mean livestock and feed prices for 10 years are taken from the Food and Agricultural Policy Research Institute (FAPRI). Production and price variability are both included in FLIPSIM. Production variability comes from the underlying weather variability simulated by PHYGROW. Variabilities around mean price projections are based on historical variability for these variables. Projections of annual inflation rates for assets and costs and annual interest rates consistent with the projected mean prices are also taken from FAPRI. FLIPSIM summarizes the economic performance of a ranch by simulating net present value over the 10-year horizon.

Aggregation Procedure

Results from the representative ranches are aggregated to obtain estimates for each region. Ranch size is important in the aggregation procedure, because the representative ranches typify only commercial ranches in the area and not all enterprises. This is a critical distinction for determining breakeven cost shares and the State's costs. Non-commercial ranchers and recreational landowners will likely have different breakeven cost shares because of different financial structures and operations. Unfortunately, data on ranch size are available only for Sutton County.

Based on his 1995 study of forage, White reports 250 ranches in Sutton County. Of these, 82 are similar in size to the Central region's representative ranch. The total combined acreage of these 82 ranches is 58.7% of the total rangeland in the county. Because ranch size data are not available for the other counties, the Sutton county figure of 58.7% is applied to the other regions. The number of acres in each region, number of commercial ranches, and the acreage contained within these ranches are given in table 2. The number of ranches is obtained by dividing total commercial rangeland acreage by the representative acreage. Regional-level brush-control costs are obtained by multiplying ranch-level cost shares by the total number of representative ranches in each region.

Brush-Control Cost Shares

For the Edwards Plateau, initial costs of brush control with chemicals are estimated to be $25 per acre for 100% control (Reinecke, Conner, and Thurow). Prescribed burning every five years is necessary to maintain 100% control. Estimated costs of prescribed burning are $5 per acre for 100% control (Reinecke, Conner, and Thurow). Using these estimates, the costs for 50% control are assumed to be $12.50 per acre for the initial control and $2.50 per acre for the periodic maintenance in 1996 dollars. To finance the initial brush-control investment, it is assumed the rancher takes out a 10-year intermediate-term loan. Maintenance costs for years 5 and 10 are included as operating expenses.

After-tax net present values of ranches for six cost-share proportions (rancher:state) are simulated by FLIPSIM as follows: 0:100, 15:85, 30:70, 50:50, 70:30, and 100:0. The cost share resulting in the net present value that approximates the pre-brush-control value is defined as the "breakeven" cost share. At this level of cost share, it becomes economically feasible for ranchers to participate in a brush-control program. Breakeven cost shares are determined by using linear interpolation between the two cost-share proportions that bracket the net present value associated with no brush control.

Results

For each representative ranch, FLIPSIM simulations are performed for the pre-brush control and each cost-share scenario. Economic conditions prior to brush control are obtained by running FLIPSIM using outputs from PHYGROW with no brush control. For the cost-share scenarios, FLIPSIM uses outputs from PHYGROW simulations of the brush-controlled ranches, with initial outlay and maintenance costs appropriately added for each cost share.

Mean after-tax net present values of the representative ranches are reported in table 3. Net present value is defined as the sum of the present values of net cash income plus the present value of change in net worth over the planning horizon. A 6% discount rate is used to reflect an after-tax rate of return to equity, assuming ranchers have the opportunity to earn around 9% interest on their equity by owner financing of the sale of land. Net present values summarize overall economic performance of the ranches over the planning horizon.

The West breaks even at a 69:31 cost share, whereas the Central region breaks even at 93:7 and the South at 79:21 (table 3). In the East, net present values associated with brush control are higher than the pre-brush-control value regardless of the cost share used. Using the 100 simulated values of net present value, coefficients of variation are calculated, and are reported in parentheses in table 3. Coefficients of variation indicate that relative variability in net present value decreases after brush control, but increases as the rancher's cost share increases.[1]

The importance of modeling the diversity of the regions is reflected by the economic impacts of 50% brush control. The East is unique in that brush control is feasible without the State providing a cost share. Brush control is profitable in the East because its range

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[1] The coefficient of variation increases as the rancher's cost share increases because the higher costs reduce mean net present value. In this study, standard errors for net present value vary little across cost shares because brush-control cost is non-stochastic.

Table 3. Mean After-Tax Net Present Value of the Representative Ranches for Pre-Brush-Control and Cost-Share Scenarios over 10-Year Planning Horizon (100 simulations)

Represent. Ranch	Pre-Brush Control	% Rancher : % State Cost Shares						Breakeven Cost Share[a]
		0:100	15:85	30:70	50:50	70:30	100:0	
West	153,770 (49.90)	421,880 (17.58)	364,220 (20.58)	305,870 (24.65)	227,430 (33.35)	148,470 (51.29)	29,570 (258.08)	69:31
Central	182,610 (16.2)	287,420 (11.1)	270,430 (11.8)	253,430 (12.6)	230,770 (13.8)	208,110 (15.3)	174,110 (18.3)	93:7
East	885,810 (8.92)	1,088,850 (6.81)	1,077,820 (7.25)	1,065,200 (7.58)	1,047,770 (7.96)	1,029,490 (8.22)	1,001,080 (8.57)	—
South	1,150,260 (1.57)	1,218,440 (1.51)	1,205,530 (1.52)	1,192,620 (1.54)	1,175,410 (1.56)	1,158,200 (1.59)	1,132,380 (1.62)	79:21

Note: Values in parentheses are coefficients of variation (in %). Coefficients of variation are calculated from the empirical distributions of the 100 ten-year simulations.
[a] Breakeven cost shares are linearly interpolated.

is more productive and its livestock enterprises are higher valued. Only cattle are raised in the East, whereas the other three regions have sheep and goat enterprises in addition to cattle. Sheep and goat enterprises are generally on less productive soil and yield lower net returns per acre.

The State's shares of brush-control costs are $20.6, $3.5, and $4.9 million in 1996 dollars over the 10-year planning horizon for the West, Central, and South regions, respectively (using the linearly interpolated cost shares). Cost differences occur because of different geographic size and breakeven cost shares of the regions. The total cost to the State, excluding the East, is $29 million. These values represent the minimum cost to the State given the linearly interpolated cost-share values.

Discussion

This study provides useful information for the policy assessment of the costs of proposed brush-control programs in Texas. The methodological approach developed provides defensible estimates of the cost shares for different regions in the Edwards Plateau. More important, the general methodology can be applied to other regions to calculate similar cost-share information. The costs and benefits of brush control can be used to assess the economic feasibility of government-sponsored programs for brush control.

Further, simulation results demonstrate that differences in climate, soil, plant communities, animal species, and management practices result in different economic benefits achievable from brush control. Cost shares necessary to entice rancher participation in government-sponsored brush-control programs will therefore differ from one location to another. The State's cost share for the West, for example, is $17.1 million greater than for the Central. Of this $17.1 million, 29% is due to the differences in size of the regions and 71% is attributed to the different breakeven cost shares.

Since this study was begun, the State of Texas has commissioned a cursory feasibility study and implemented a pilot brush-control program on the North Concho River (NCR) basin in the Northwestern portion of the Edwards Plateau (Bach and Conner; Walker and Dugas). The NCR basin contains approximately one million acres, of which 40% were estimated to have 10% or greater brush canopy. The NCR feasibility study estimated the State's total cost of brush control to be $11.15 million exclusive of transaction and administrative costs, using an approximate 65% State cost share (Upper Colorado River Authority). Furthermore, the State of Texas has recently funded feasibility studies for brush control/water enhancement programs in eight additional river basins across the state, clearly indicating the State's commitment to brush control. Such feasibility studies confirm there is an interest, at the State level, in brush control as a method to enhance water yield.

In Texas there are approximately 96 million acres of rangeland, of which the Edwards Plateau represents 16%. The State's cost share required for controlling only 50% of the brush on approximately 58.7% of the Edwards Plateau is estimated at $29 million in 1996 dollars over the 10-year planning horizon. Clearly, the costs of a statewide brush-control program are high. As the State begins to assess the implementation of various brush control/water enhancement programs, budget limitations will likely result in priorities being set among other water supply options. Some options being considered are cities buying out and retiring irrigated agricultural land, tradable water rights, injection of waste water into aquifers, inter-basin transfers, pricing mechanisms, cloud seeding, desalination plants, and waste water reuse.

Many benefits and costs would occur from a large-scale brush-control program. Benefits include economic gains for ranches (as calculated in the methodology) and potential enhancement in off-site water yield and ecological restoration. For example, a large-scale brush-control program in the Edwards Plateau region can help restore the region's native state of grassland savanna. Of course, cost shares of brush removal are not the only costs. Transaction costs involved in development and implementation of a cost-share program, such as public hearings, landowner contract development, and compliance monitoring increase the amount of the State's outlays for a brush-control program.

For modeling convenience in this study, the representative ranches were simulated from the time of establishment with replacement forages. In reality, removing woody brush species may cause soil erosion, particularly on sloped terrain. Impact on the region's wildlife is another issue of a large-scale brush-control program. Many ranches in Texas receive a significant portion of their income from wildlife-related enterprises.

Studies have shown that landowners are generally reluctant to engage in extensive brush control because of the perceived negative impact brush removal would have on the deer lease-hunting potential and the market value of their land (Thurow et al.; Conner and Bach). Other studies have found that net returns from agricultural (livestock) production land uses would generally justify only 25% or less of the observed market value of rural land (Pope and Goodwin; Real Estate Center, Texas A&M University).

Thus, most landowners are reluctant to use brush control to increase the livestock production potential of land at the expense of lowering its potential wildlife lease-hunting and market value. Admittedly, our models cannot capture all aspects of ranchers' utility functions and livestock production firms. As such, we include the caveat that our analysis does not capture all the information many landowners may consider when making brush-control decisions.

Effects of a large-scale brush-control program on atmospheric carbon dioxide concentrations are unknown. Burning of brush will emit carbon dioxide, but this may be compensated, at least partially, by the increased productivity of the brush-controlled land.

Complete cost-benefit analyses required for ranking prospective investments in brush control should consider all impacts, positive and negative, caused by brush control. The costs estimated in this study should be interpreted in this broader context.

For many environmental and economic policy recommendations, projects that involve regional scale and long-term analysis are necessary. Such projects require costly investment in both time and dollars. Simulation modeling is an attractive approach to contain the costs of the analysis over long-term field-level water basin studies. The integrated modeling system developed in this study is suitable for carrying out such project analyses. Although we investigated here the economic impact of a brush-control cost-share program on commercial ranches, the framework developed is also applicable to noncommercial ranches.

If policy makers are willing to provide funds for brush control, the next step is a full-blown cost-benefit analysis. Determining all costs and benefits will require hydrological and water economic modeling, in addition to ecological and climate modeling. This undertaking will be expensive and must contain regional components. Each region will have different costs and benefits. Knowledge of regional costs and benefits will help allocate limited funds. If policy makers are not willing to provide the funds necessary for brush control, a cost-benefit analysis is not warranted. In this case, focusing on the cost side provides first-step information to determine if the project should proceed or not.

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