Range Improvement Task Force • Report 79

Economic Implications and Surface Disturbance Mitigation of Oil and Gas Development on Otero Mesa

Range Improvement Task Force
Cooperative Extension Service / Agricultural Experiment Station
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Economic Implications and Surface Disturbance Mitigation of Oil and Gas Development on Otero Mesa

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INTRODUCTION

The people of this world have a serious addiction. They have become addicted to petroleum and natural gas. Global demand for crude oil continues to grow at a steady rate. In recent years world dependency has grown around 2% per year. This demand growth is highest in developing nations. As countries develop, industry, rapid urbanization, and higher living standards drive up energy use, of both electricity and oil. World demand for oil is predicted to increase up to 37% by 2030, according to the U.S.-based Energy Information Administration's (EIA) annual report (EIA, 2005). Demand is expected to reach 118 million barrels per day (bpd) from today's existing 86 million barrels per day. This increase is driven in large part by the transportation sector.

The transportation sector generally experiences the highest annual growth in petroleum demand. As countries continue to develop, the demand for oil will increase further, and much of this can be attributed to increased vehicle usage. The U.S. transportation sector has the highest consumption rates in the world, accounting for approximately 68.9% of the oil used in the U.S. during 2006, and 55% of oil use worldwide as documented in the EIA's Hirsch report (EIA, 2008).

Another factor in petroleum demand is increasing human population. This population increase, along with increases in disposable income, changes in tastes and preferences, and relative lack of substitutes causes an outward shift in the world demand curve for oil. This rapid shift in the demand curve along with a slower response in the supply has caused oil prices to increase significantly over the past few years.

The United States is the largest oil importer in the world, bringing in 13.5 million barrels per day, which make up 63.5% of total U.S. daily consumption (20.6 million bpd). Oil from the Middle East accounts for 20% of U.S. oil imports, and this dependency is growing. As U.S. dependence on oil continues to grow, some predict dire consequences for the economic well-being of the U.S., national security, and the American way of life (Cohen, 2007). In the U.S. there is a broad consensus, from the president to the average man on the street, that the current oil situation is detrimental to the country's economic well-being. Many believe that

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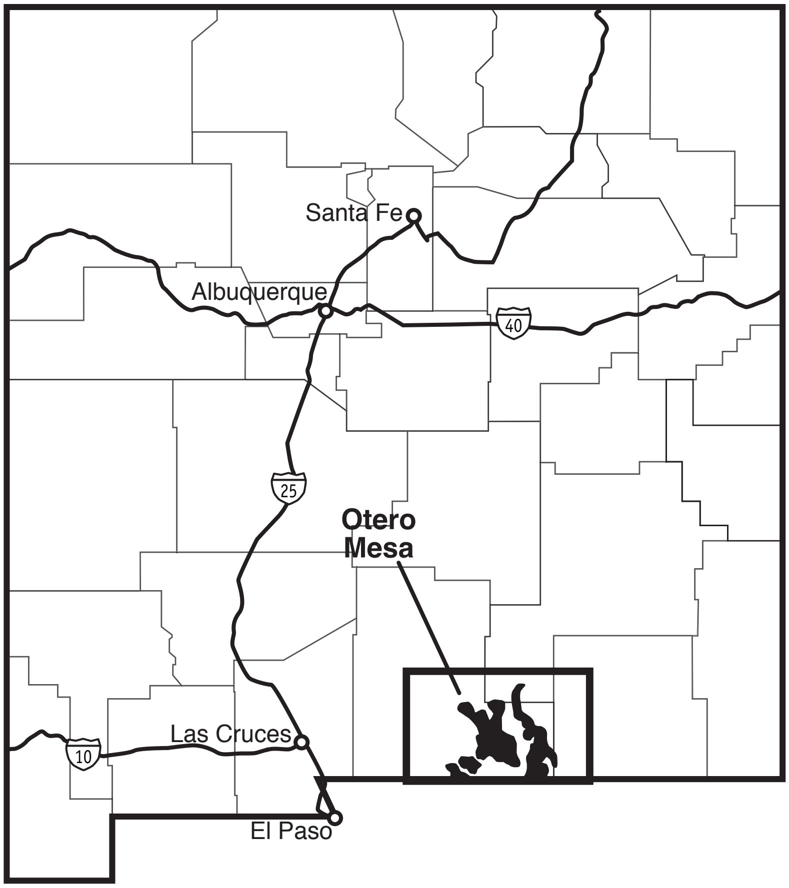

Figure 1. **Map showing location of Otero Mesa.**

the U.S. needs to achieve energy security, in which abundant and affordable energy supplies remain stable and within reach of all Americans.

As the United States strives to become more self-sustainable, one region being turned to for increased oil and natural gas production is the state of New Mexico. New Mexico is rich in fossil fuels as well as in renewable energy resources. The San Juan Basin in New Mexico's northwestern corner (shared with Colorado) is the largest field of proven natural gas reserves in the U.S. In the southeastern part of the state, the New Mexican portion of the Permian Basin (shared with Texas) is home to three of the U.S.'s 100 largest oil fields. Although New Mexico is rich in energy resources, it has a low energy demand, due in large part to its small population. In addition to oil and gas production New Mexico is a prime location for wind and solar energy.

In addition to the two major basins already in production, many other areas in New Mexico attract exploration for oil and gas. One area that piques interest in oil and gas development is the Otero Mesa. Otero Mesa is located in south-central New Mexico, in the southeastern corner of Otero County and comprises approximately 1.2 million acres (see Figure 1). Otero Mesa is also one of the largest Chihuahuan Desert grasslands in North America.

Otero Mesa is an area that attracts much attention, not only from oil and gas companies but from the public as well. Otero Mesa is home to many native species of flora and fauna. It is also home to several generations of independent cattle ranchers. These families have called Otero Mesa home for many, many years. They value not only the ranching prospects of the area, but also the way of life that is provided by the range. Otero Mesa sits numerous miles from civilization and has its own distinct features that make it valuable to the inhabitants of the area. These ranchers enjoy the fact that they can see company coming miles before they actually get there by the cloud of dust created.

Environmental groups value the pristine habitat Otero Mesa provides for numerous species of wildlife. They push to protect the wide open spaces that are enjoyed throughout the year. The people involved with these environmental groups use Otero Mesa to escape the everyday hustle and bustle of the city and town lifestyles in which many of them live.

They find solace in the opportunity to watch as the endangered Aplomado Falcon (*Falco femoralis*) flies over the landscape looking for a kangaroo rat (*Dipodomys deserti*) to feast upon.

Other interested parties value Otero Mesa for the possible natural gas reserves stored beneath it. Oil and gas companies look at the land for its production possibilities. The Bureau of Land Management (BLM) looks at the land for the royalties it will receive for each well put into place in addition to the grazing fees it receives from the ranchers in the area. As a public service agency the BLM is charged with the responsibility to help protect all entities involved with areas of public land. As the country pushes for self-sustainability the BLM opens more oil and gas leases in areas like Otero Mesa.

OBJECTIVES

Our first objective was to determine if oil and gas development adversely impacts forage production and will result in a negative impact on the range livestock industry. This economic evaluation had three main sub-objectives. The first sub-objective was to determine the forage composition and amount of forage available on the Otero Mesa. The second sub-objective was to determine the change in forage availability caused by oil and gas development. The third sub-objective was to determine the value of the available forage to the range livestock industry.

The second objective was to determine if surface disturbances from oil and gas development could be mitigated with alternate site-selection methods. The economic evaluation of Alternate Site Selection had two main sub-objectives. The first sub-objective was to determine potential surface impacts of oil and gas development. The second sub-objective was to determine the costs and benefits of alternate site-selection methods.

STUDY AREA

Bennett Ranch Unit is 8,857 acres of the total 1.2 million acres of Otero Mesa. The Bennett Ranch Unit is a group of federal and state fluid mineral leases that were joined together to form an exploratory unit. It is composed of approximately 91% federal land and 9% state land (BLM, 1997). There are 10 federal land oil and gas leases and four state land leases in the study area. Appendix A shows the land description and acreages of each of the existing leases.

METHODS

Forage availability data were collected over four years on eighteen transects using the Rapid Assessment Method. Data were also collected for three years on the proposed well site #006 (five total transects), and two years of data were collected on the reclaimed well site #1 (four transects), for a total of nine point-intercept transects. The data were collected to establish a baseline of forage composition, production and basal cover for the unit.

RAM

Forage availability and composition in the Bennett Ranch Unit were determined from monitoring 18 Rapid Assessment Method (RAM) transects over a four-year period. These transects were placed in groups of three. Each group contained a valley transect, a mid-slope transect, and a crest transect. These site-specific areas were chosen based on their ability to meet criteria set forth by the RAM manual created by the Range Improvement Task Force (RITF) in conjunction with faculty and staff from the Animal and Range Sciences Department at New Mexico State University (Allison et al., 2004).

Transects were monitored during the fall at the end of the growing season (2005–2008). For each transect, photo points were taken for qualitative analysis. The quantitative observations for each transect were made at paced intervals. Each step equals approximately three feet. Transects were run parallel to the contour lines with minimal deflection in elevation change. A total of 100 basal hits were recorded for each transect.

To determine available or residual forage biomass a quadrat method was used. In each transect a total of five 6-inch × 24-inch quadrats were clipped. The five sampling points were taken at the 20th, 40th, 60th, 80th, and 100th observation points. The herbaceous forage within the quadrat was clipped to ground level and placed in a paper bag. These samples were then placed in a drying oven for 24 hours at 60°C. The dried samples were weighed to the nearest 0.01 gram. A conversion factor of 96.05 (for the 6-inch × 24-inch sampling frame) was used to convert the grams per frame to pounds per acre.

Point-Intercept Method

Nine transects were set using a point-intercept method on a proposed well site and on a reclaimed well site (Herrick et al., 2005). Point-intercept is a rapid, accurate method for quantifying soil cover. These transects were placed in areas critical for monitoring forage disturbance caused by oil and gas production. Three of these transects were placed on the proposed well site. Two were placed in the draw bottom below the proposed pad to monitor for potential spills. The other four transects were placed across a reclaimed pad to calculate how much forage actually returned after the pad was tilled and reseeded during the reclamation process.

For these transects a tape was stretched and anchored at each end with a t-post (as directed by the Quick Start Monitoring Manual; Herrick et al., 2005). Data was recorded along the tape at every three feet. Photos were also taken to provide a qualitative analysis for the transects. The same quadrat method mentioned above was used to calculate the available or residual biomass. Forage samples were clipped and dried to 6% moisture and were also converted from grams per frame to pounds per acre.

Changes in Forage Availability

For the analysis of opportunity costs for the range livestock industry, alternative scenarios were created to show different levels of available forage lost due to different levels of oil and gas activity. Opportunity cost is defined as the costs incurred by an action taken due to forgoing its next best alternative. Table 1 displays a summary of these scenarios.

These scenarios, however, have some limitations due to the fact that the maximum activity allowed on a given lease area is 5% of the total area. This means that if an oil and gas company possesses a 1,000-acre lease, only 50 acres can be disturbed at one time. If a company submits a new application for a permit to drill (APD) after the 50-acre disturbance limit has been reached, they must first reclaim a previous well site to BLM standards before another permit to drill will be issued. However, it was assumed that if the production proves to be great, this limitation may be relaxed to allow minerals to be extracted in a timely manner, or directional drilling will be employed to stay within the acreage limit while simultaneously acquiring the oil and/or gas.

Pounds per acre of available forage was determined on an annual basis and compared with data from the previous year to monitor changes in the amount of forage available within the study area. There were several factors taken into consideration when looking at the changes in forage production. The grazing capacity of the area directly correlated with the growth and production of forage. The length of grazing was also considered when calculating available forage. The amount of rainfall also had a positive correlation with forage production. It was noted that the rainfall for the four years of data was above average as determined from the Palmer Drought Severity Index (PDSI) (Appendix B).

Forage Valuation Methods

The forage available (pounds per acre), on a dry matter basis for each transect, was determined to be a baseline from which losses could be compared. The pounds of dry matter per acre were then converted to animal units per acre to value the forage. An animal unit is defined as: "one mature cow of about 1,000 pounds (450kg), either dry or with calf up to 6 months of age, or their equivalent, consuming about 20 pounds (9kg) of forage on an oven dry basis per day, 600 pounds per month, and 7,300 pounds per year" (Holechek et al., 2004).

The Bureau of Land Management (BLM) White Sands Resource Management Plan states that at no time will grazing exceed 60% forage utilization (BLM, 2000). The typical range of utilization for the study area was considered to be 40 to 60%. For this economic analysis it was assumed that the forage utilization was a conservative 35%, consistent with conservative stocking in the Chihuahuan desert ecosystem for black grama (*Bouteloua eriopoda*) rangeland. However, calculations were also made under the "take-half, leave-half" range management principle adopted by many range livestock operators and agencies. This higher utilization rate would cause the forage value dollar per acre to increase. Utilizable forage production was then calculated as follows:

Table 1. Oil and Gas Alternative Activity Scenarios on Otero Mesa

Scenario Number	Scenario Name	Scenario Description
1	Status Quo	No additional drilling beyond existing two wells
2	Previously Planned	One additional exploratory well
3	Actively Producing	Five wells per section
4	Alternate Site Selection	Costs and benefits of alternate site selection

Lbs/acre × Utilization Rate (0.35) = Utilizable forage (lbs/acre) × # acres

After the utilizable forage production was derived, the AU per acre was calculated using the 7,300 lbs per animal unit per year as mentioned in the definition above:

 # acres × Utilizable Forage (lbs/acre)/7,300 (lbs/year) = AU

See appendix C for a graph of forage availability per transect.

To calculate the effects of the forage lost on an income basis to the range livestock owner, an income statement was derived using the "Livestock Cost and Return Estimates, Southwest Region Large Cow/Calf Budget" developed by the Range Improvement Task Force at New Mexico State University (Hawkes et al., 2007). It was determined that the Otero Mesa and the Bennett Ranch Unit were best represented by ranches within the Southwest region. For the study area, the size of the herd and operations costs within the Bennett Ranch Unit were then adjusted and estimated based on the number of AUs. Table 2 displays the Budget Statement for 2008. The Adjusted Production and Revenue for Representative Ranch on Otero Mesa (2008) (seen in Table 3) was extracted from the Budget Statement and was then used to derive the Income Statement for year ending December 31, 2008 for the Representative Ranch, as shown in Table 4.

There were no inventory changes from 2005 to 2006 due to the representative rancher raising his own replacement heifers; however, in 2007 as a direct result of an increase in forage production the rancher expanded his operation. In 2008 he again raised his own replacement heifers, making all other livestock purchases for replacement purposes only. The income statement used reflects only the variable costs due to the fact that forage lost to oil and gas activity is not attributed to changes in fixed costs associated with the ranch budget, making this a short run evaluation. Variable costs are defined as: "costs that will occur only if production takes place and that tend to vary with the level of production" (Kay et al., 2008).

The dollars of net income generated per AU was then calculated by dividing the net cash ranch income above variable costs for the representative ranch by the total number of animal units supported on the representative ranch. Table 5 displays the distribution of supported animal units for the representative ranch in 2008.

The net income per animal unit was then multiplied by the number of animal units per acre to determine a dollar of foregone value per acre of forage production.

AU/acre × Net Income/AU =
$ Net Income/acre

For this evaluation the dollar Net Income was calculated for livestock production only. It did not account for the potential income from wildlife enterprises, carbon sequestration credits, wind or solar energy or other potential income sources or aesthetic values. Appendix D shows the calculations created for years 2005, 2006, 2007, and 2008.

The scenarios were analyzed with the calculated $ Net Income/acre and animal units per acre. The costs and benefits associated with the different scenarios were analyzed using net present value (NPV). NPV is defined as: "a project's net contribution to present wealth minus initial investment" (Brealey et al., 2006). NPV was used to determine the costs and benefits associated with each scenario due to the opportunity costs of the surface impacts that will occur over time. To compute the NPV, it was assumed that the rancher incurred an initial loss (cost) of forage during the first year of pad development (initial loss is not discounted). After the first year, initial reclamation practices of the excess pad were assumed to be complete; therefore, the level of foregone forage decreases and remains constant until the final reclamation is complete and pounds per acre of forage produced returns to original levels. Forage foregone or unavailable to the livestock dur-

Table 2. Representative Ranch Cow/Calf Budget, 2008

	Brood herd size	**325**	**Cow to bull**	**15**	**Calf crop percent[1]**	**84%**
	Cull rate	**15%**			**Replacement heifers kept**	**48.75**

Value of Production

						Value Per Cow
		Quantity	**Weight**	**Price[2]**	**Value**	
Steer calves		137	500	$1.13	$77,123	$237.30
Heifer calves		88	475	$1.05	$43,765	$134.66
Cull cows		37	900	$0.45	$14,985	$ 46.11
Cull bulls		1	1200	$0.52	$624	$ 1.92
		262				
	Total				$136,497	$419.99

Variable costs

						Value Per Cow
1. Feed Costs		**Units**	**Quantity/Percent**	**Price**	**Cost**	
	Hay	ton	22.00	$150	$3,300	$ 10.15
	State	auy	20.0%	$33.36	$2,168	$ 6.67
	Federal lease	auy	75.0%	$18.12	$5,889	$ 18.12
	Private (owned)	auy	5.0%	$0.00	$0	$ 0.00
	Private (leased grazing)	auy	0.0%	$0.00	$0	$ 0.00
	Salt & mineral	ton	5.00	$ 265	$1,325	$ 4.08
	Protein supp	ton	10.00	$ 390	$3,900	$ 12.00
	Total				$16,582	$ 51.02
2. Other Variable Costs					**Cost**	
	Vet and Medicine				$4,082	$ 12.56
	Livestock Hauling				$1,442	$ 4.44
	Hired Labor				$8,000	$ 24.62
	Operating Costs-Equip & Mach				$3,816	$ 11.74
	Operating Costs-Vehicle				$3,816	$ 11.74
	Ranch Maintenance				$2,915	$ 8.97
	Beef Checkoff				$224	$ 0.69
	Livestock Purchases				$1,500	$ 4.62
	Total				$25,796	$ 79.37
3. Interest on Variable Costs						
	Sum of Variable Costs X Months Borrowed					
	X Interest Rate Per Month					
	Annual Interest Rate				7.25%	
	Number of Months Borrowed				6	**Value Per Cow**
					$1,536	$ 4.73
	Total				$43,914	$135.12
					$92,583	$284.87

Ownership costs

Annual Capital Recovery[4] (At Replacement Valve):	Represents 65% Asset Ownership[5]	**Value Per Cow**
Cash Costs		
Taxes & Insurance	$12,617	$ 38.82
Overhead	$2,000	$ 6.15
Total	$ 14,617	$ 44.98
Non Cash Costs		
Purchased Livestock	$11,686	$ 35.96
Machinery & Equipment	$12,617	$ 38.82
Housing & Improvements	$20,141	$ 61.97
Interest on Retained Livestock	$15,326	$ 47.16
Management & Operation Labor (6% of gross returns)	$8,190	$ 25.20
Total	$67,960	$ 209.11
Total Fixed Costs	$82,577	$ 254.08
Total Cash and Variable Costs	$58,531	$ 180.10
Total Costs	$126,492	$ 389.20
Return Above Total Cash Costs	$77,966	$ 239.89
Return Above Total Costs	$10,005	$ 30.79

Breakeven Calculations

	Variable Costs	**Total Costs**
Required Average Calf Prices Cash Cost (cwt)	$33.00	$ 43.98
Required Average Calf Prices Cash Cost (cwt)	$33.00	$ 95.04

1) Calf crop is defined as the actual number of calves sold divided by the total number of cows (assuming all cows were exposed).
2) Prices represent 2008 price projections from Cattle Fax, Doane's Reports for New Mexico feeder cattle cash prices.
3) Market prices include commissions, brand inspections, beef council, yardage, feed, and insurance
4) Annual capital recovery is the method of calculating depreciation and interest recommended by the National Task Force on Commodity Costs and Returns measurement methods.
5) The 35% reduction in asset values which represent a mix of new and used machinery.
6) Interest on average investment.

Table 3. Adjusted Annual Production and Revenue for Representative Ranch on Otero Mesa (2008)

Category	Quantity	Sale weight (lb)	Sale price ($/lb)	Total Revenue	Revenue per AU
Steer calves	137	500	$1.13	$77,122.50	$214.38
Heifer calves	88	475	$1.05	$43,765.31	$121.65
Cull cows	37	900	$0.45	$14,985.00	$41.65
Cull bulls	1	1200	$0.52	$624.00	$1.73
Total	262			$136,496.81	$379.42

Table 4. Income Statement for Year Ending December 31, 2008 for Representative Ranch

Annual Cash Returns		Total ($)		Per AU ($)	
Cattle Sold		$136,496.81		$379.42	
Cash Ranch Income			$136,496.81		$379.42
Annual Cash Costs					
Feed Costs					
Hay		$3,300.00		$9.17	
BLM permits & SLO leases		$8,057.40		$22.40	
Supplement		$5,225.00		$14.52	
Vet supplies		$4,082.00		$11.35	
Livestock hauling		$1,442.38		$4.01	
Labor		$8,000.00		$22.24	
Equip and Mach operating costs		$3,816.00		$10.61	
Vehicle operating costs		$3,816.00		$10.61	
Ranch Maintenance		$2,915.00		$8.10	
Beef Checkoff		$224.25		$0.62	
Replacement Livestock		$1,500.00		$4.17	
Interest on Variable costs					
Annual interest rate	7.25%				
Number of months borrowed	6				
		$1,536.20		$4.27	
Total Operating Expenses			$43,914.23		$122.07
Net Cash Ranch Income Above Variable Costs			$92,582.58		$257.35

Table 5. Supported Animal Units on Representative Ranch

Catergory	Quantity
Brood cows	288
Replacement heifers	49
Bulls	13
Working horses	10
Total	360

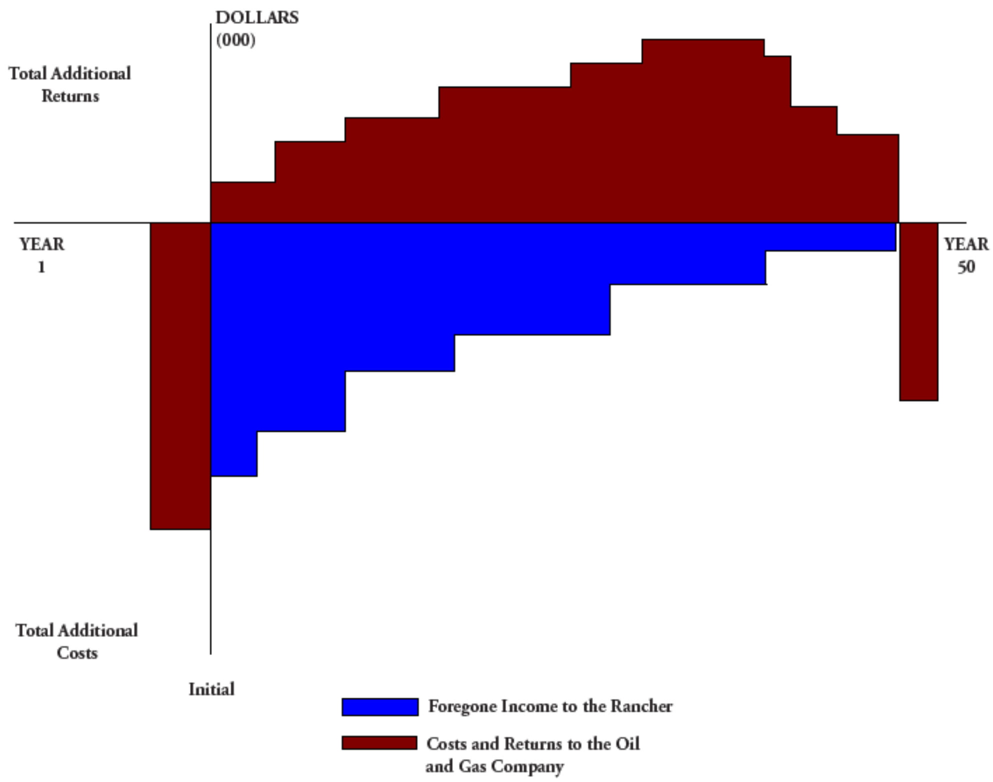

Figure 2. **Hypothetical costs and foregone income from oil and gas development**

ing oil and gas production cycles represented forage cost to the rancher and was discounted at 5% for the year in which the costs occurred. Figure 2 graphically depicts the additional costs and returns incurred by both the rancher and the oil and gas companies (Dunlap, 2008).

The rancher will experience a steady loss of income over time (seen in blue) as the forage previously grown on the pads is no longer available. The costs begin the moment the forage is taken out of production. These costs were discounted to show them in real time. Forage production was assumed to return to full capacity after successful reclamation and the rancher is assumed to eventually have no foregone income due to forage loss. It was also assumed that the oil and gas company (seen in maroon) would incur initial costs for well placement and drilling operations. They would then experience steadily increasing returns as long as the well remained in production. When the well no longer produced, the site would be reclaimed, causing the oil and gas company to incur costs for reclamation. The initial costs were compounded forward and the returns and reclamation costs were discounted to determine the NPV over the production life of the producing well site.

The discount rate was assumed to be 5% based on the bond maturity weighted average rate over 10 years as reported by Farm Credit Services (Farm Credit Services, 2007). This rate was compared to the discount rate aver-

Table 6. Scenarios Showing the Difference in Acreage Based on Activity Level

Activity Level	Approximate Area Used for Well Pads	Approximate # Well Pads	Acres of access roads	Acres not reclaimed	Gas transmission pipeline acres	Short term acres disturbed	Long term acres disturbed
1%	88.57	16	48.31	38.65	138.17	275.05	225.13
2%	177.14	32	96.62	77.30	276.34	550.09	450.25
3%	265.71	48	144.93	115.94	414.50	825.14	675.38
4%	354.28	64	193.24	154.59	552.67	1100.19	900.51
5%	442.85	80	241.55	193.24	690.84	1375.24	1125.63

Area for well pads (acres) =	8857 × activity level
# well pads =	area for well pads (acres)/well pad size (5.5 acres)
acres of access roads =	# well pads × (3 acres/pad)
acres not reclaimed =	# well pads × (2.4 acres/pad not reclaimed immediately)
gas transmission pipeline acres =	(3.3 miles) × (2.6 acres/mile) × # well pads
short term acres disturbed =	pipeline acres + access road acres + area used for well pads
long term acres disturbed =	pipeline acres + access road acres + acres not reclaimed

aged at 5.07% (Federal Reserve Bank, 2008). Calculations were also made at 4.00% and 6.00% for a comparison basis. The general compounding formula for the initial placement cost is as follows:

$$V_n = V_0(1+i)^n$$

The variables were defined as: V_n the future value of a present sum at the end of *n* years, V_0 the present sum, *i* the interest rate charged per period, and *n* the number of periods over which V_0 is compounded (Workman, 1986). The general discounting formula:

$$V_0 = V_n(1+i)^{-n}$$

This formula was used to discount future values to a base year for comparison. These variables were defined as the previous compounding variables (Workman, 1986). These steps were performed to focus on and compare the costs incurred by the rancher and the oil and gas companies relative to their income. Each side was calculated in this manner because inflation is not fixed and the economy is expecting inflationary pressures as a result of changes in the interest rate meant to stimulate the economy.

Financial Impacts on the Oil and Gas Companies

Financial impacts were determined for oil and gas development using hypothetical scenarios along with NPV and costs associated with pad reclamation for three different vegetation types. The data set for these scenarios was developed using three different variables: allowable development under current BLM regulations, vegetation types, and length of occupancy.

The BLM states only 5% of the total area may be disturbed at a given time. If an oil and gas company applies to drill a new location, they must first reclaim a previous site before another permit is issued. With this maximum allowable activity level, five hypothetical levels of activity were used: 1%, 2%, 3%, 4%, and 5%. Table 6 shows the scenarios showing the difference in acreage based on activity level. In addition to the five activity levels and the three vegetation types, five lengths of occupancy were used

(5, 10, 20, 30, 50 years). For each hypothetical length of occupancy there were fifteen different alternatives resulting in a total of 75 different cost scenarios (See Appendix E for these calculated scenarios).

In the development of these scenarios several assumptions were made. It was assumed, first, that all of the gathering lines follow the existing roads or new access roads, minimizing the surface impacts. Second, it was assumed that oil and gas development follows all current BLM regulations. Finally, it was assumed that shrublands self-reclaim; therefore there is assumed to be no vegetative reclamation of pads in shrublands. Soil reclamation and cleanup are still utilized, but there is no discing, planting or irrigating of vegetation on these well pads.

Reclamation costs per acre were determined using dirt work costs and costs for the reintroduction of vegetation. Shrubland reclamation practices for this evaluation were assumed to be dirt work only due to the self-reclamation of shrubs. Historic site-specific dirt work, or soil reclamation, ranges from $8,000 to $50,000 per pad, according to an industry source. This difference in cost is a result of different procedures and conditions of the soil.

Reclamation of the vegetation can also vary drastically in methods and costs. For this evaluation the NRCS EQIP Cost Guide was used (NRCS, 2007). The cost guide is determined from receipts submitted for reimbursement by farmers and ranchers in Otero County for reclamation projects conducted in the previous year. Fencing costs for well sites were assumed to be incurred just after well pad placement and are not discounted.

Due to the variability of different methods of reclamation, three different budgets were compiled to estimate the projected costs of reclamation. The costs for three intensities of vegetation reintroduction are displayed in Table 7. These budgets are the estimated costs for shrubland-grassland mix vegetation. For grasslands vegetation, the acreage will be doubled because the assumption was made that well pads are located on exactly half grasslands (2.75 acres) and half shrublands. Shrubland reclamation includes only fencing and dirt work due to the assumption that shrublands reclaim themselves.

The range of possible reclamation costs of dirt and vegetation reintroduction is demonstrated in Table 8. These costs were based on the NRCS EQIP cost guide and dirt reclamation costs from an industry source. These averages were used for all scenarios due to difficulty of predicting actual costs. For the purposes of this evaluation reclamation Budget Number Three is used, as it closely approximates the requirements set forth by the BLM for Otero Mesa. The $53,298.44 for reclamation costs of dirt and vegetation reclamation for the grass/shrub mix comprises $50,000 for caliche removal and $3,298.44 for vegetation reintroduction (See Table 8).

RESULTS

Forage Composition

Table 9 displays the forage composition on the Otero Mesa from 2005 to 2008. Otero Mesa is often described as predominately black grama (*Bouteloua eriopoda*) grass (New Mexico Wilderness Alliance, 2007); however, Table 9 shows blue grama (*Bouteloua gracilis*) as more predominant in the area surveyed. The grama grasses (blue [*Bouteloua gracilis*], black [*Bouteloua eriopoda*], and sideoats

Table 7. Vegetation Reintroduction Budgets for Otero Mesa Well Pads

Activity	Cost/Unit	# Units	Cost
Budget 1			
Site Preparation—Discing	$13.17	2.75	$36.22
Broadcast Seeding	$10.00	2.75	$27.50
Seed, Low Priced	$19.29	2.75	$53.05
Fencing 4 wire	$ 1.33	2,000.00	$2,660.00
Total			**$2,776.77**
Budget 2			
Site Preparation—Discing	$13.17	2.75	$36.22
Site Preparation Drilling	$13.17	2.75	$36.22
Broadcast Seeding	$10.00	2.75	$27.50
Seed, High Priced (Native)	$42.25	2.75	$116.19
Mechanical Competition Control/1st year	$10.30	2.75	$28.33
Fencing 4 wire	$ 1.33	2,000.00	$2,660.00
Total			**$2,904.45**
Budget 3			
Site Preparation—Discing	$13.17	2.75	$36.22
Site Preparation Drilling	$13.17	2.75	$36.22
Range Interseeding	$14.00	2.75	$38.50
Seed, High Priced (Native)	$42.25	2.75	$116.19
Planting Preparatory Cover Crop	$27.39	2.75	$75.32
Competitive Cover Crop	$37.00	2.75	$101.75
Competitive Range Planting	$85.18	2.75	$234.25
Fencing 4 wire	$ 1.33	2,000.00	$2,660.00
Total			**$3,298.44**

*Based on the 2007 Oero County NRCS EQIP Cost Guide

Table 8. Reclamation Costs of Dirt and Vegetation Reclamation

	Budget	Grassland	Grass/Shrub Mix	Shrublands
No Caliche Removal	1	$10,893.53	$10,776.77	$10,660.00
$8,000	2	$11,148.90	$10,904.45	$10,660.00
	3	$11,936.88	$11,298.44	$10,660.00
Average	1	$31,893.53	$31,776.77	$31,660.00
($29,000)	2	$32,148.90	$31,904.45	$31,660.00
	3	$32,936.88	$32,298.44	$31,660.00
Caliche Removal	1	$52,893.53	$52,776.77	$52,660.00
($50,000)	2	$53,148.90	$52,904.45	$52,660.00
	3	$53,936.88	$53,298.44	$52,660.00

(NRCS, 2007)
(Industry Source, 2006)

Table 9. Forage Composition for Bennett Ranch Unit of Otero Mesa during 2005–2008

	2005	2006	2007	2008	AVG
Blue Grama (*Bouteloua gracilis*)	39	44	35	33	38
Black Grama (*Bouteloua eriopoda*)	32	36	29	28	31
Sideoats Grama (*Bouteloua curtipendula*)	13	17	14	11	14
Threeawn (*Bouteloua aristida*)	2	3	2	3	2
Plains Bristlegrass (*Seteria leucopila*)	1	0	0	0	0
Hairy Grama (*Bouteloua hirsuta*)	0	0	4	3	2
Mountain Muhly (*Muhlenbergia montana*)	0	0	9	8	4
Bush Muhly (*Muhlenbergia porter*)	0	0	0	1	0
Fluffgrass (*Dasyochloa pulchella*)	0	0	2	2	1
Burrograss (*Scleropogon brevifolius*)	0	0	2	2	1
Sand Dropseed (*Sporobolus cryptandrus*)	11	0	2	1	3
Spike Pappas (*Enneapogon desvauxii*)	0	0	1	5	1
Vine Mesquite (*Panicum obtusum*)	0	0	1	1	1
Tabosa (*Pleuraphis mutica*)	1	0	0	0	0
Six Weeks Grama (*Bouteloua barbata*)	0	0	0	1	0
Grass unknown	2	0	1	1	1
	100	**100**	**100**	**100**	**100**

[*Bouteloua curtipendula*]) make up 83% of forage production on the Otero Mesa when averaged over the four-year monitoring period.

Basal Cover

Basal Cover is defined as: "…the area occupied at the intersection of the plant and soil surface" (Holechek et al., 2004). Percentage basal cover was determined based upon the number of hits out of the 100 possible locations along the 100-foot tape. Table 10 displays numerically that even on the highly productive Otero Mesa bare ground is the largest basal cover percentage. Bare ground is inversely correlated with litter and vegetation cover.

Opportunity Costs to the Range Livestock Industry

Scenario 1: Status quo

Scenario 1 was designed to show the actual costs incurred from two existing well sites on the Bennett Ranch Unit. Of these two existing well sites one has been capped and reclaimed by the oil and gas company but remains fenced. The other well site is potentially active and has not been reclaimed (also fenced). Each of these two well sites is 600 ft × 600 ft, equaling 8.26 acres per site. BLM guidelines for well pads in the area specify that they be 600 ft × 400 ft, a total of 5.51 acres.

For this analysis, foregone income from the loss of forage in 2005, 2006 and 2007 was compounded forward to a base year of 2008. Future costs were then discounted back to the base year 2008, using the discounting (present value) formula listed above. Calculations for this analysis were performed for 1-, 5-, 10-, 20-, 30-, and 50-year intervals. For this scenario, costs were calculated for the total 16.52 acres that are not useable (the two existing fenced sites).

At a 5% interest rate the rancher incurred \$112.64 of foregone income due to forage loss from oil and gas activity on the two well sites combined. This represents the \$97.30 actual foregone income for 2005 compounded forward (at 5%) to the base year of 2008 (See Table 11). In 2006 the amount of unrealized losses increased from that in 2005 due to an increase in the rancher's herd size. This increase in herd size was a direct result of the increased forage production from the previous year. The rancher's calf crop percentage also increased, due to increased health conditions of brood cows, allowing for more calves to be sold on the open market, which in turn increased the gross and resulting net income as a whole. The unrealized losses then decreased in 2007 and again in 2008. This decrease in foregone income is attributed to a decrease in the amount of available forage. The total foregone income from forage loss due to pads, expressed in 2008 dollars, was \$606.41 (See Table 11).

The future costs were also calculated at years 1, 5, 10, 20, 30, and 50 to demonstrate the long-term costs if the sites remained in production and were not reclaimed to full potential in a timely manner. For the first twenty years it was assumed that fixed costs remained constant, since twenty years is a rather short time period for forage and cattle production. The costs for the 30- and 50-year intervals may possibly be higher since fixed cost will not remain constant in the long run. In the long run, the operator will change the amounts of all inputs or resources available (Kay et al., 2008). Future calculations show that over time, NPV of foregone income will decrease. This decrease is a result of inflationary pressures on the dollar. These calculations were also performed at 4% and 6% interest rates to show a comparison in interest rate fluctuations. Table 12 displays the total foregone income stream discounted to the 2008 base year at 4%, 5%, and 6% interest rates. If the discount rate selected was lower, as indicated by the current t-bill rates, then the net present value would be much larger.

Scenario 2: Previously Planned

Scenario 2 was created to show the effects of an additional wildcat well. This well site was surveyed and marked for setup. This

Table 10. Basal Cover (%) on Otero Mesa

	2005	2006	2007	2008	AVG
Bare ground	48.0	14.5	45.9	47.8	39.0
Vegetation	30.0	31.8	21.5	35.6	29.7
Litter	12.0	39.9	32.3	12.5	24.2
Rock	10.0	13.8	0.4	4.1	7.1

Table 11. Present Value of Annual Income Lost for Scenario 1 (no additional wells drilled)

Well 1-Y & 1

50% Utilization Rate

Year	Acres (8.26 acres per pad)	$/acre (RAM Avg. $/ac.)	Total cost (acres × $/ac)	2008 base year Cost (4%) ($V_n=V_0(1+i)^n$)	2008 base year Cost (5%) ($V_n=V_0(1+i)^n$)	2008 base year Cost (6%) ($V_n=V_0(1+i)^n$)
2005	16.52	$5.89	$97.30	($109.45)	($112.64)	($115.89)
2006	16.52	$9.56	$157.93	($170.82)	($174.12)	($177.45)
2007	16.52	$9.19	$151.82	($157.89)	($159.41)	($160.93)
2008	16.52	$9.70	$160.24	($160.24)	($160.24)	($160.24)
Average	16.52	$8.59	$141.82			
Total				($606.41)	($598.40)	($614.51)

Year	Actual Year	2008 base year cost (4%) ($V_n=V_0(1+i)^n$)	2008 base year cost (5%) ($V_n=V_0(1+i)^n$)	2008 base year cost (6%) ($V_n=V_0(1+i)^n$)
1	2009	($136.37)	($135.07)	($133.80)
5	2014	($116.57)	($111.12)	($105.98)
10	2019	($95.81)	($87.07)	($79.19)
20	2029	($64.73)	($53.45)	($44.22)
30	2039	($43.73)	($32.81)	($24.69)
50	2059	($19.96)	($12.37)	($7.70)

Table 12. Total Income Lost for Scenario 1 (no additional wells drilled)

Present Value of Foregone Income Stream discounted to base year 2008.

Year	Actual Year	at 4%	at 5%	at 6%
1	2009	($136.29)	($135.01)	($133.74)
5	2014	($631.38)	($613.94)	($597.35)
10	2019	($1,150.30)	($1,095.13)	($1,043.80)
20	2029	($1,927.33)	($1,767.36)	($1,626.68)
30	2039	($2,452.35)	($2,180.06)	($1,952.15)
50	2059	($3,046.58)	($2,589.07)	($2,235.37)

pad was also set at 600 ft × 600 ft and is also 8.26 acres. New stipulations have been set forth by the BLM for this well pad. The first stipulation set forth is the movement of the site further from the Butterfield Stagecoach Trail. The second stipulation set forth is that the pad size be decreased to 400 ft × 400 ft (equal to 3.67 acres). The calculations were performed at the 8.26 acres to demonstrate the extreme possibility. These figures were calculated using an average of the eighteen RAM transects as well as the average available forage on the five permanent transects located on and near the proposed well site. Table 13 shows the calculations for the three well sites at a 50% utilization rate.

If the forage had been disturbed in 2006, according to the projected drill date, the rancher would have lost $372.62 in NPV income from the three well sites combined at 5% interest. The well was not drilled, so the rancher only incurred the $112.64 loss of income as calculated in Scenario 1. The same holds true for 2007; if the well had been drilled the rancher would have foregone $194.27 in income; since the forage was not disturbed in 2007 no additional loss was incurred above that in Scenario 1. The costs incurred in the future year intervals are also listed in Table 13. The future costs were calculated using a three-year average of available forage ($264.79). The total costs incurred after 1, 5, 10, 20, 30, and 50 years when discounted at 4%, 5%, and 6% are displayed in Table 14.

The forage on this site has yet to be disturbed, so there is no additional immediate impact on the rancher's income. However, once implemented after 50 years of disturbance at a 5% interest rate the rancher will have foregone a total present value of ($4,834.01) from the three well sites. If interest rates were set to 4% the present value of foregone income would increase to $5,688.22. If interest rates were set to 6% the present value of foregone income would decrease to $4,173.62.

For the additional well site no forage will be disturbed for placement of a road into this site (on its current location). The oil and gas company has taken steps to cut costs and decrease forage loss by surveying the proposed site near an existing road. The rancher is, however, incurring costs from the access roads to the other two sites. Table 15 shows the calculated income lost to access roads

Scenario 3: Actively Producing

Scenario 3 was developed to demonstrate extreme production possibilities. This scenario was modeled after oil and gas well placement in Lea County. It was estimated there are approximately five well pads per section in Lea County. The forage foregone for five well pads per section was then calculated for the Bennett Ranch Unit. The Bennett Ranch Unit is 8,857 acre which approximates 13.84 sections.

The maximum allowability regulation was assumed to be relaxed for this scenario to allow for timely extraction of the minerals. Calculations were then performed for three different well pad sizes. The existing pads are 600 ft × 600 ft (8.26 acres). New stipulations for the proposed well site allow for a 400 ft × 400 ft (3.67-acre) pad. In the Draft RMPA/EIS for Federal Fluid Mineral Leasing and Development in Sierra and Otero Counties by the Las Cruces Field Office of the BLM, Appendix A-IV, it is set that well sites be 600 ft × 400 ft (5.51 acres) for safety reasons on the Otero Mesa. These acreages were then

Table 13. Present Value of Annual Income Lost for Scenario 2 (One Additional Well Drilled)

Well #006 in addition to the two in Scenario 1

50% Utilization Rate

Year	Acres (8.26 acres per pad)	$/acre (RAM Avg $/ac)	total cost (acres × $/ac)	2008 base year cost (4%) ($V_n = V_0(1+i)^n$)	2008 base year cost (5%) ($V_n = V_0(1+i)^n$)	2008 base year cost (6%) ($V_n = V_0(1+i)^n$)
2006	24.78	$13.64	$337.97	($365.55)	($372.62)	($379.75)
2007	24.78	$7.47	$185.02	($192.42)	($194.27)	($196.12)
2008	24.78	$10.95	$271.38	($271.38)	($271.38)	($271.38)
Average	24.78	$10.69	$264.79			

Year	Actual Year	2008 base year cost (4%) ($V_n = V_0(1+i)^n$)	2008 base year cost (5%) ($V_n = V_0(1+i)^n$)	2008 base year cost (6%) ($V_n = V_0(1+i)^n$)
1	2009	($254.61)	($252.18)	($249.80)
5	2014	($217.64)	($207.47)	($197.87)
10	2019	($178.88)	($162.56)	($147.86)
20	2029	($120.85)	($99.80)	($82.56)
30	2039	($81.64)	($61.27)	($46.10)
50	2059	($37.26)	($23.09)	($14.38)

Table 14. Total Income Lost for Scenario 2 (one additional well drilled)

Present value of foregone income stream discounted to base year 2008.

Year	Actual Year	At 4%	At 5%	At 6%
1	2009	($254.46)	($252.08)	($249.70)
5	2014	($1,178.85)	($1,146.28)	($1,115.30)
10	2019	($2,147.71)	($2,044.71)	($1,948.85)
20	2029	($3,598.50)	($3,299.81)	($3,037.14)
30	2039	($4,578.75)	($4,070.35)	($3,644.83)
50	2059	($5,688.22)	($4,834.01)	($4,173.62)

Table 15. Forage Lost to Access Roads for Each Well Site

Well site	Width (Feet)	Length (Feet)	Total Sq ft	Total Acreage (Total Sq ft ÷ 43,560)	$/acre (Avg $/ac [RAM])	Total Cost (Total ac × $/ac)
#1-Y	50	660	33,000	0.76	$10.69	$8.10
#1	50	1,320	66,000	1.52	$10.69	$16.19
#006	0	0	0	0	$10.69	$0.00
Total						$24.29

expanded for the five possible locations to determine forage lost per section. A dollar figure for the five wells per section was calculated, and present value was used to correlate the amounts for 1-, 5-, 10-, 20-, 30-, and 50-year marks. Table 16 shows these calculations as performed under the "take-half, leave-half" utilization principle per section.

Table 17 shows the total amount of unrealized gains or losses over 1, 5, 10, 20, 30, and 50 years as calculated at 4%, 5%, and 6% interest rates. These numbers are calculated on a per section basis and at a 50% utilization rate.

If the Bennett Ranch Unit was turned into a full production oil and gas field these numbers would be multiplied by 13.84 sections to get a total loss of income calculation. If each pad was 8.26 acres, at a 5% interest rate the rancher would lose a total of $104,357.48 (i.e., $7,540.28 × 13.84) of income [NPV] over fifty years of production. This is greater than the rancher's annual net cash ranch income above variable cost.

For this extreme scenario there would also be additional permanent forage lost to roads built in order for the gas companies to monitor the wells and the pipelines. The building of pipelines removes forage temporarily, and forage is expected to return to full production capabilities after a few years. Over this period of time the rancher may be forced to sell a portion of the herd to adjust his production cycle to compensate for this forage loss. After successful reclamation the rancher can then again increase his herd size.

Although income effects seem relatively minor, these well sites carry other implications. If these wells are left unreclaimed for extended periods of time the overall value of the ranch will decrease. This decrease will affect the rancher if and when he decides to sell the ranch. This decrease could be significant enough that the ranch's visual appeal is lost and it may not sell on the open market. Not only do the effects increase to the rancher the longer these sites are left unreclaimed, but reclamation also becomes more costly to the oil and gas companies. The longer topsoil sits piled, the more of it is lost to wind and runoff erosion and the less productive this soil becomes.

Scenario 4: Alternate Site Selection

This scenario was developed to show the possibilities of alternate site selection. Alternate site selection focuses on moving well sites from areas of dense high-quality forage to less productive areas. Examining the forage availability data indicates that there is less forage available on the crests then on the side slopes or valley bottoms. The crests also have the least black grama (*Bouteloua eriopoda*) grass production. If the goal on the Bennett Ranch Unit is to protect the black grama grass and decrease the amount of forage lost to drilling practices, the crests would be the best locations to drill from, using directional drilling practices. For the Bennett Ranch Unit, directional drilling would be beneficial in allowing for less surface disturbance by grouping wellheads and allowing the drill rigs to be placed in less vegetated areas. Directional drilling could also be cost effective for the drilling companies by allowing them to drill more than one well without moving the drilling rig and by cutting reclamation costs by disturbing (and reseeding) less ground.

The transects studied show only slight differences in forage availability from shrubland to grassland. The difference in black

Table 16. Present Value of Annual Income Lost per Section for Scenario 3 (five pads per section)

50% Utilization Rate			
Pad size	**Acres/site**	**Total acreage (ac/site × 5)**	**Total cost (total ac × combined avg $/ac [$10.00])**
600 ft × 600 ft	8.26	41.3	$413.03
600 ft × 400 ft	5.51	27.55	$275.52
400 ft × 400 ft	3.67	18.35	$183.51

4% interest rate				
Year	**Actual Year**	**8.26 acres (V_o=$V_n(1+i)^{-n}$)**	**5.51 acres (V_o=$V_n(1+i)^{-n}$)**	**3.67 acres (V_o=$V_n(1+i)^{-n}$)**
1	2009	($397.15)	($264.92)	($176.46)
5	2014	($339.48)	($226.46)	($150.84)
10	2019	($279.03)	($186.13)	($123.98)
20	2029	($188.50)	($125.74)	($83.75)
30	2039	($127.35)	($84.95)	($56.58)
50	2059	($58.12)	($38.77)	($25.82)
5% interest rate				
1	2009	($393.36)	($262.40)	($174.78)
5	2014	($323.62)	($215.88)	($143.79)
10	2019	($253.57)	($169.15)	($112.66)
20	2029	($155.67)	($103.84)	($69.16)
30	2039	($95.57)	($63.75)	($42.46)
50	2059	($36.02)	($24.03)	($16.00)
6% interest rate				
1	2009	($389.65)	($259.93)	($173.13)
5	2014	($308.64)	($205.89)	($137.13)
10	2019	($230.63)	($153.85)	($102.47)
20	2029	($128.79)	($85.91)	($57.22)
30	2039	($71.91)	($47.97)	($31.95)
50	2059	($22.42)	($14.96)	($9.96)

Table 17. Present Value of Total Income Lost per Section for Scenario 3 (by pad size and discount rate)

Year	8.26 at 5%	5.51 at 5%	3.67 at 5%
1	($393.20)	($262.30)	($174.70)
5	($1,788.01)	($1,192.73)	($794.41)
10	($3,189.42)	($2,127.57)	($1,417.06)
20	($5,147.18)	($3,433.53)	($2,286.90)
30	($6,349.10)	($4,235.29)	($2,820.92)
50	($7,540.28)	($5,029.89)	($3,350.16)
Year	**8.26 at 4%**	**5.51 at 4%**	**3.67 at 4%**
1	($396.92)	($264.77)	($176.35)
5	($1,838.81)	($1,226.62)	($816.99)
10	($3,350.09)	($2,234.74)	($1,488.45)
20	($5,613.08)	($3,744.32)	($2,493.90)
30	($7,142.11)	($4,764.29)	($3,173.25)
50	($8,872.71)	($5,918.72)	($3,942.16)
Year	**8.26 at 6%**	**5.51 at 6%**	**3.67 at 6%**
1	($389.49)	($259.82)	($173.05)
5	($1,739.68)	($1,160.49)	($772.94)
10	($3,039.90)	($2,027.83)	($1,350.63)
20	($4,737.45)	($3,160.21)	($2,104.86)
30	($5,685.36)	($3,792.53)	($2,526.02)
50	($6,510.18)	($4,342.75)	($2,892.48)

grama production is, however, more evident. The valley bottoms support more black grama then the crests; therefore, if we are to protect the black grama the crests are the better candidate for a well site. However, characteristics of the viewshed would be impaired by the crest location.

Reclamation Costs to the Oil and Gas Companies

The reclamation costs differ based on the vegetation type, length of occupancy, and activity level. These impacts do not include potential revenues from drilling but are limited to the reclamation costs of well sites. The vegetation type impacts the costs based on the assumption that shrubland reclaims itself. The cost of seed also varies with the mix of existing vegetation. Black grama grass seed is the most expensive seed needed for reclamation. Length of occupancy plays a dual role. The longer the topsoil is piled and out of production the more of it is lost to erosion. However, the reclamation costs are discounted more as the length of time increases before reclamation begins. Inflationary pressures can also make the nominal costs increase over time. Activity level directly correlates with costs of reclamation. The larger the area that is disturbed during well placement the larger the area that needs to be reclaimed. Table 18 displays the lowest reclamation scenarios, the highest scenarios and an average between the two (See Appendix E for all scenario calculations).

The reclamation costs for the long term are slightly lower (assuming the reclamation practices remain the same) than the costs in the short term. The initial reclamation of the well pad, performed after drilling, decreases the number of acres disturbed in the long term, therefore decreasing the costs of reclamation. The discounted cost of reclamation is substancially lower due to the length of time the costs are discounted.

DISCUSSION

Oil and gas development and ranching can be accomplished simultaneously. If each interested party takes the necessary precautions and procedures, the entities can exist in harmony. Proper management, successful reclamation practices, and correct timing can help to ensure that ecological integrity, the utilization of forage, and harvesting of sub-surface minerals can co-exist on the Bennett Ranch Unit of the Otero Mesa. Successful reclamation consists of re-establishing equivalent species composition and basal cover to its original preconstruction range forage baseline. The establishment of these transects and collection of the data can give

Table 18. Present Value of Reclamation Costs to Oil and Gas Companies

Vegetation	Activity Level	Length of Occupancy	Short term acres disturbed	Long term acres disturbed	Reclamation Costs—Short term	Reclamation Costs—Long term	Discounted Costs—Long Term
Shrubland	1%	50	275.05	225.13	$1,450,264.39	$1,187,049.70	$103,515.16
Grass/Shrub	1%	50	275.05	225.13	$1,599,946.60	$1,309,565.45	$114,198.99
Grassland	1%	50	275.05	225.13	$1,616,606.38	$1,323,201.58	$115,388.11
Shrubland	5%	5	1375.24	1125.63	$7,251,269.21	$5,935,143.07	$4,650,339.90
Grass/Shrub	5%	5	1375.24	1125.63	$7,999,674.81	$6,547,710.92	$5,130,302.83
Grassland	5%	5	1375.24	1125.63	$8,082,973.10	$6,615,890.33	$5,183,723.18
Average			825.14	675.38	$4,666,789.08	$3,819,760.17	$2,549,578.03

Short term acres disturbed =	area used for well pad + access road acres + pipeline acres
Long term acres disturbed =	acres not reclaimed + access road acres + pipeline acres
Reclamation costs—Short term =	short term acres × average vegetation and dirt reclamation cost
Reclamation costs—Long term =	long term acres × average vegetation and dirt reclamation cost

monitoring agencies and reclamation specialists the baseline needed to ensure this successful reclamation.

Proper management of development and reclamation practices ensure that the biological integrity of the unit can be maintained with a 5% activity level. The rancher may experience a short-term decrease in carrying capacity but with effective reclamation the long-term carrying capacity should not be adversely impacted at the current state of finances. There are opportunities to explore compensation or mitigation of carrying capacity reductions through 1) direct compensation payments, 2) alternative range improvements, 3) provisions of other ecosystem or ranching services. Management agencies must also ensure that reclamation practices are performed at the right time and done correctly.

The most crucial element to both parties is the amount of acreage disturbed. For the oil and gas companies, the smaller the well pads, the less reclamation costs. If smaller well pads are used or if more then one well is drilled from one location reclamation cost will decrease and less forage will be disturbed, thereby benefiting both parties.

Another sensitive topic regarding the Otero Mesa is its aesthetic value to the general public. The BLM manages public lands for multiple uses. To satisfy these responsibilities, aesthetics must be considered when managing well placement. As the public interest in the Otero Mesa increases, aesthetic values become more important. To protect aesthetics in the form of viewshed, it may be beneficial to place wells in the productive valley bottoms. This carries negative financial impacts to the range livestock industry as well as to the oil and gas companies. To protect aesthetics and to decrease financial impacts to the range livestock industry and the oil and gas companies, the side slopes may be best suited to drill from (depending on steepness.

CONCLUSION

The range livestock industry incurs a financial impact the moment forage is disturbed. The amount of standing forage lost forces the rancher to either give up income by selling off part of their herds or increase their costs by supplementing feed. This income is not recovered until the well site is reclaimed to full production potential and the fences are removed. The overall value and investment potential of the ranch are also impacted when forage is not utilized. The ranchers also experience negative emotional impacts. Some ranching families on the Otero Mesa have been there for several generations. To them the land carries intrinsic value that cannot be summed up by a number. The values that have been calculated are relatively minor when compared to the overall wealth of the resource base on the Otero Mesa but are essential to the profitability of the range livestock industry. In the long run the overall value of the ranch and natural resources may be negatively impacted by the potential scars left on the landscape, even after reclamation practices unless managed appropriately.

Under the scenario described here, the oil and gas companies experience initial losses due to the placement of the well pads and drilling practices. They then experience steadily increasing returns as long as the well is in production. When the well no longer produces and the site is reclaimed they will incur reclamation cost. These costs can be alleviated by using alternate site-selection methods. By selecting alternate drill sites and using directional drilling the oil and gas companies can drill several wells from one pad and lower costs associated with movement of the drill rig. This also aids in decreasing the amount of acreage disturbed with each new well pad, decreasing reclamation costs.

Selecting a pad location at a site dominated by creosote or other invasive brush species rather then locating the pad or road on native grama grassland can do much to reduce reclamation costs and simultaneously protect sensitive pristine ecosystems.

NEED FOR FURTHER RESEARCH

There are several entities involved in the protection and development of the Otero Mesa. Each of these entities carries their own concerns; all of these concerns need to be studied in order to show total impacts from oil and gas development. Some of the concerns that have been raised include contamination of groundwater from drilling practices, forage disturbance impacts to wildlife, reclamation practices and the negative impacts of alternate site selection on the oil and gas companies. Many are also concerned with the negative impacts on intrinsic values of the landscape that cannot be represented by a number. Otero Mesa also shows potential for development of wind and solar energy projects. These impacts need to be studied to provide an accurate estimate of the impacts they may cause to the entities of Otero Mesa.

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LIST OF TABLES, FIGURES AND APPENDICES

Tables

Figures

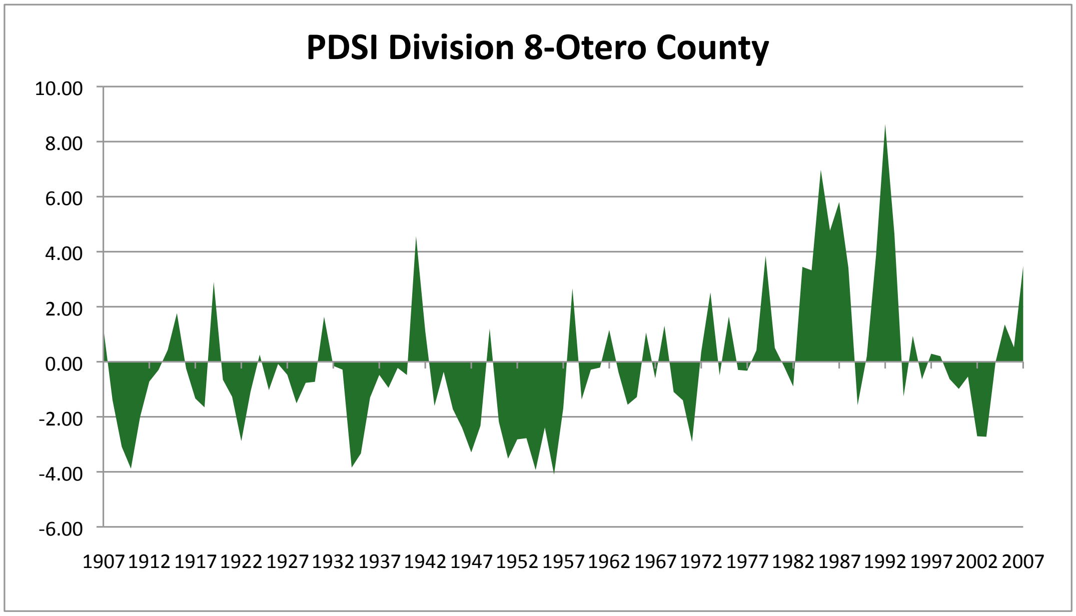
Appendices

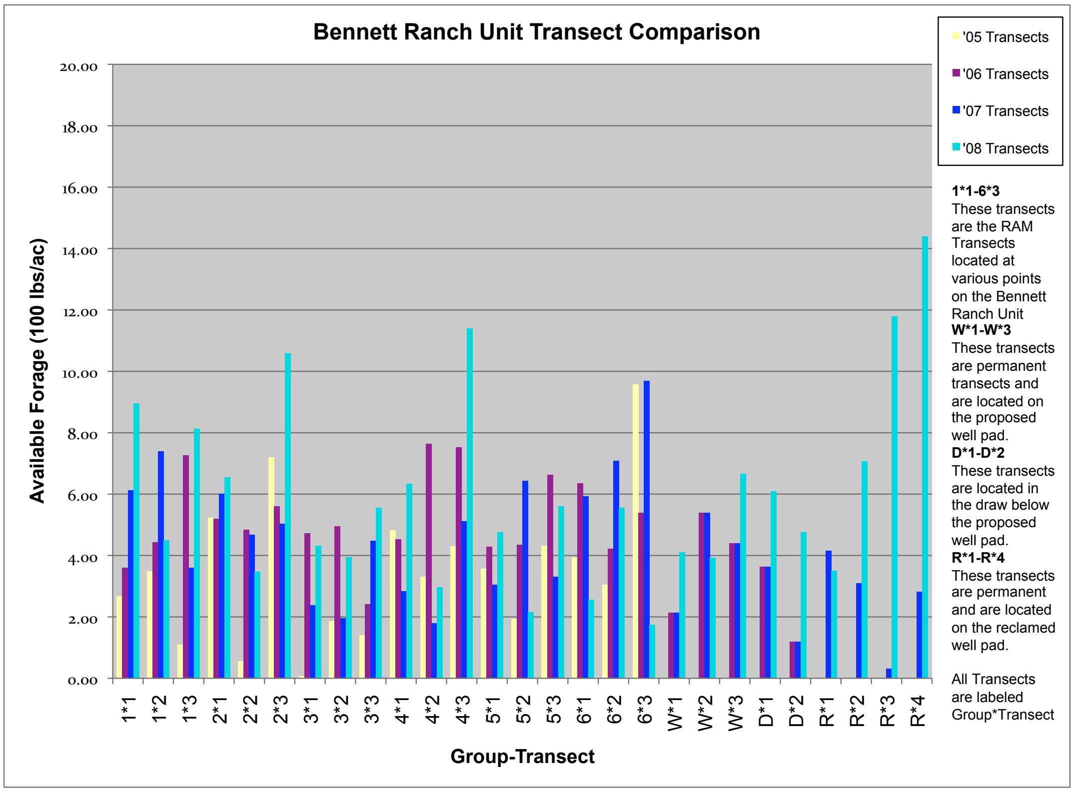
APPENDIX A—BENNETT RANCH UNIT AGREEMENT: LAND DESCRIPTION AND ACREAGE

Tract No.	Land Description	Number of Acres
Federal Lands:		
1	T-26S, R-12E; sec 3: E/2, E/2 W/2; sec 10: All; sec 11: All	1,760.00
2	T-26S, R-12E; sec 12: W/2, SE/4, S/2 NE/4, NW/4 NE/4; sec 13: W/2, N/2 NE/4, SW/4 NE/4, SW/4 SE/4; sec 14: All; sec24: All	2,360.00
3	T-26S, R-12E; sec 26: N/2, SE/4, E/2 SW/4; sec 27: NE/4 NE/4; sec 35: Lots 3, 4, N/2 NE/4	699.89
4	T-26S, R-12E; sec 1: SW/4 SW/4	40.00
5	T-26S, R-12E; sec 25: All	640.00
6	T-26S, R-13E; sec 18: Lots 2	40.36
7	T-26S, R-13E; sec 19: Lots 1-4 SW/4 NE/4, W/2 SE/4	282.36
8	T-26S, R-13E; sec 30: lots 1-4, NW/4 NE/4, S/2 NE/4, SE/4	444.52
9	T-26S, R-13E; sec 31: lots 1-4, N/2 NE/4	189.07
10	T-26S, R-12E; sec 15: N/2, SE/4, E/2 SW/4; sec 22: E/2, E/2 NW/4; sec 23: All	1,600.00
Total		8,056.20
State Lands:		
11	T-26S, R-12E; sec 2: S/2 NW/4, SW/4, NW/4 SE/4, S/2 SE/4	360.00
12	T-26S, R-12E; sec 36: lots 1-4, N/2 N/2	199.84
13	T-26S, R-12E; sec 13: SE/4 NE/4, N/2 SE/4, SE/4 SE/4	160.00
14	T-26S, R-13E; sec 18: lots 3, 4	80.86
Total		800.70

(BLM, 1997)

Rainfall for the years 2005–2008 was above average, as determined by the Palmer Drought Severity Index (PDSI).




Bennett Ranch Unit Transect Comparison
'05 Transects
'06 Transects
'07 Transects
'08 Transects
1*1-6*3
These transects are the RAM Transects located at various points on the Bennett Ranch Unit
W*1-W*3
These transects are permanent transects and are located on the proposed well pad.
D*1-D*2
These transects are located in the draw below the proposed well pad.
R*1-R*4
These transects are permanent and are located on the reclamed well pad.
All Transects are labeled Group*Transect
Available Forage (100 lbs/ac)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1*1
1*2
1*3
2*1
2*2
2*3
3*1
3*2
3*3
4*1
4*2
4*3
5*1
5*2
5*3
6*1
6*2
6*3
W*1
W*2
W*3
D*1
D*2
R*1
R*2
R*3
R*4
Group-Transect

APPENDIX D-1—2008 FORAGE PRODUCTION DATA

Group	Transect	Forage (g) = (Total wt-Bag wt)	Forage (g) per clip = (Forage (g)/5)	lbs/ac= (Forage (g) per clip × 96.05)	Utilization Rate	Utilizable forage lbs/ac= (lbs/ac × 0.50)	AU/acre= (Utilizable forage lbs/ac/7,300)	$/acre= (AU/ac × Net Income/AU)
1	1	46.62	9.32	895.57	0.50	447.79	0.0613	$15.79
1	2	23.42	4.68	449.90	0.50	224.95	0.0308	$7.93
1	3	42.35	8.47	813.54	0.50	406.77	0.0557	$14.34
2	1	34.11	6.82	655.25	0.50	327.63	0.0449	$11.55
2	2	18.07	3.61	347.12	0.50	173.56	0.0238	$6.12
2	3	55.15	11.03	1059.43	0.50	529.72	0.0726	$18.67
3	1	22.52	4.50	432.61	0.50	216.30	0.0296	$7.63
3	2	20.52	4.10	394.19	0.50	197.09	0.0270	$6.95
3	3	28.89	5.78	554.98	0.50	277.49	0.0015	$0.39
4	1	32.97	6.59	633.35	0.50	316.68	0.0434	$11.16
4	2	15.44	3.09	296.60	0.50	148.30	0.0203	$5.23
4	3	59.32	11.86	1139.54	0.50	569.77	0.0781	$20.09
5	1	24.75	4.95	475.45	0.50	237.72	0.0326	$8.38
	2	11.18	2.24	214.77	0.50	107.38	0.0147	$3.79
5	3	29.18	5.84	560.55	0.50	280.27	0.0384	$9.88
6	1	13.34	2.67	256.26	0.50	128.13	0.0176	$4.52
6	2	28.90	5.78	555.17	0.50	277.58	0.0380	$9.79
6	3	9.09	1.82	174.62	0.50	87.31	0.0120	$3.08
Avg.		28.66	5.73	550.49	0.50	275.25	0.0377	$10.38
W	1	21.36	4.27	410.33	0.50	205.16	0.0281	$7.23
W	2	20.42	4.08	392.27	0.50	196.13	0.0269	$6.91
W	3	34.68	6.94	666.20	0.50	333.10	0.0456	$11.74
D	1	31.71	6.34	609.15	0.50	304.57	0.0417	$10.74
D	2	24.75	4.95	475.45	0.50	237.72	0.0326	$8.38
R	1	18.25	3.65	350.58	0.50	175.29	0.0240	$6.18
R	2	36.77	7.35	706.35	0.50	353.18	0.0484	$12.45
R	3	61.41	12.28	1179.69	0.50	589.84	0.0808	$20.79
R	4	74.92	14.98	1439.21	0.50	719.61	0.0986	$25.37
Avg.		36.03	7.21	692.14	0.50	346.07	0.0474	$16.41
Total Average			6.47	621.32		310.66	0.0426	$13.39

Net Income/AU=$257.35

(As determined in the Income Statement Year Ending December 31, 2008 for Representative Ranch)

APPENDIX D-2—2007 FORAGE PRODUCTION DATA

Group	Transect	Forage (g) = (Total wt-Bag wt)	Forage (g) per clip = (Forage (g)/5)	lbs/ac= (Forage (g) per clip × 96.05)	Utilization Rate	Utilizable forage lbs/ac= (lbs/ac × 0.50)	AU/acre= (Utilizable forage lbs/ac/7,300)	$/acre= (AU/ac × Net Income/AU)
1	1	31.87	6.37	612.22	0.50	306.11	0.0419	$11.65
1	2	38.50	7.70	739.59	0.50	369.79	0.0507	$14.08
1	3	18.77	3.75	360.57	0.50	180.29	0.0247	$6.86
2	1	31.30	6.26	601.27	0.50	300.64	0.0412	$11.44
2	2	24.37	4.87	468.15	0.50	234.07	0.0321	$8.91
2	3	26.20	5.24	503.30	0.50	251.65	0.0345	$9.58
3	1	12.45	2.49	239.16	0.50	119.58	0.0164	$4.55
3	2	10.18	2.04	195.56	0.50	97.78	0.0134	$3.72
3	3	23.35	4.67	448.55	0.50	224.28	0.0307	$8.54
4	1	14.74	2.95	283.16	0.50	141.58	0.0194	$5.39
4	2	9.36	1.87	179.81	0.50	89.90	0.0123	$3.42
4	3	26.66	5.33	512.14	0.50	256.07	0.0351	$9.75
5	1	15.89	3.18	305.25	0.50	152.62	0.0209	$5.81
5	2	33.51	6.70	643.73	0.50	321.86	0.0441	$12.25
5	3	17.21	3.44	330.60	0.50	165.30	0.0226	$6.29
6	1	30.87	6.17	593.01	0.50	296.51	0.0406	$11.29
6	2	36.90	7.38	708.85	0.50	354.42	0.0486	$13.49
6	3	50.42	10.08	968.57	0.50	484.28	0.0663	$18.43
Avg.		25.14	5.03	482.97	0.50	241.49	0.0331	$9.19
W	1	11.12	2.22	213.62	0.50	106.81	0.0146	$4.07
W	2	28.06	5.61	539.03	0.50	269.52	0.0369	$10.26
W	3	22.95	4.59	440.87	0.50	220.43	0.0302	$8.39
D	1	18.94	3.79	363.84	0.50	181.92	0.0249	$6.92
D	2	6.18	1.24	118.72	0.50	59.36	0.0081	$2.26
R	1	21.67	4.33	416.28	0.50	208.14	0.0285	$7.92
R	2	16.11	3.22	309.47	0.50	154.74	0.0212	$5.89
R	3	1.64	0.33	31.50	0.50	15.75	0.0022	$0.60
R	4	14.66	2.93	281.62	0.50	140.81	0.0193	$5.36
Avg.		15.70	3.14	301.66	0.50	150.83	0.0207	$5.74
Total Average		20.42	4.08	392.32		196.16	0.0269	$7.47

Net Income/AU=$277.87
(As Determined in the Income Statement Year Ending December 31, 2007 for Representative Ranch)

APPENDIX D-3—2006 FORAGE PRODUCTION DATA

Group	Transect	Forage (g) = (Total wt- Bag wt)	Forage (g) per clip = (Forage (g)/5)	lbs/ac= (Forage (g) per clip × 96.05)	Utilization Rate	Utilizable forage lbs/ac= (lbs/ac × 0.50)	AU/acre= (Utilizable forage lbs/ac/7,300)	$/acre= (AU/ac × Net Income/AU)
1	1	18.80	3.76	361.15	0.50	180.57	0.0247	$6.61
1	2	23.10	4.62	443.75	0.50	221.88	0.0304	$8.12
1	3	37.80	7.56	726.14	0.50	363.07	0.0497	$13.28
2	1	27.10	5.42	520.59	0.50	260.30	0.0357	$9.52
2	2	25.20	5.04	484.09	0.50	242.05	0.0332	$8.85
2	3	29.20	5.84	560.93	0.50	280.47	0.0384	$10.26
3	1	24.60	4.92	472.57	0.50	236.28	0.0324	$8.64
3	2	25.80	5.16	495.62	0.50	247.81	0.0339	$9.07
3	3	12.60	2.52	242.05	0.50	121.02	0.0166	$4.43
4	1	23.60	4.72	453.36	0.50	226.68	0.0311	$8.29
4	2	39.80	7.96	764.56	0.50	382.28	0.0524	$13.98
4	3	39.20	7.84	753.03	0.50	376.52	0.0516	$13.77
5	1	22.30	4.46	428.38	0.50	214.19	0.0293	$7.84
5	2	22.70	4.54	436.07	0.50	218.03	0.0299	$7.98
5	3	34.50	6.90	662.75	0.50	331.37	0.0454	$12.12
6	1	33.10	6.62	635.85	0.50	317.93	0.0436	$11.63
6	2	22.00	4.40	422.62	0.50	211.31	0.0289	$7.73
6	3	28.10	5.62	539.80	0.50	269.90	0.0370	$9.87
Avg.		27.19	5.44	522.41	0.50	261.20	0.0358	$9.56
W	1	30.60	6.12	587.83	0.50	293.91	0.0403	$10.75
W	2	57.90	11.58	1112.26	0.50	556.13	0.0762	$20.34
W	3	72.20	14.44	1386.96	0.50	693.48	0.0950	$25.37
D	1	47.00	9.40	902.87	0.50	451.44	0.0618	$16.51
D	2	44.50	8.90	854.85	0.50	427.42	0.0586	$15.64
Avg.		50.44	10.09	968.95	0.50	484.48	0.0664	$17.72
Total Average		38.82	7.76	745.68		372.84	0.0511	$13.64

Net Income/AU=$267.04
(As Determined in the Income Statement Year Ending December 31, 2006 for Representative Ranch)

APPENDIX D-4—2005 FORAGE PRODUCTION DATA

Group	Transect	Forage (g) = (Total wt- Bag wt)	Forage (g) per clip = (Forage (g)/5)	lbs/ac= (Forage (g) per clip × 96.05)	Utilization Rate	Utilizable forage lbs/ac= (lbs/ac × 0.50)	AU/acre= (Utilizable forage lbs/ac/7,300)	$/acre= (AU/ac × Net Income/AU)
1	1	13.9	2.8	267.02	0.50	133.51	0.0183	$4.54
1	2	18.2	3.6	349.62	0.50	174.81	0.0239	$5.94
1	3	5.7	1.1	109.50	0.50	54.75	0.0075	$1.86
2	1	27.2	5.4	522.51	0.50	261.26	0.0358	$8.87
2	2	2.9	0.6	55.71	0.50	27.85	0.0038	$0.95
2	3	37.5	7.5	720.38	0.50	360.19	0.0493	$12.23
3	1	0.4	0.1	7.68	0.50	3.84	0.0005	$0.13
3	2	9.7	1.9	186.34	0.50	93.17	0.0128	$3.16
3	3	7.3	1.5	140.23	0.50	70.12	0.0096	$2.38
4	1	25.1	5.0	482.17	0.50	241.09	0.0330	$8.19
4	2	17.2	3.4	330.41	0.50	165.21	0.0226	$5.61
4	3	22.4	4.5	430.30	0.50	215.15	0.0295	$7.31
5	1	18.6	3.7	357.31	0.50	178.65	0.0245	$6.07
5	2	10.1	2.0	194.02	0.50	97.01	0.0133	$3.30
5	3	22.5	4.5	432.23	0.50	216.11	0.0296	$7.34
6	1	20.5	4.1	393.81	0.50	196.90	0.0270	$6.69
6	2	15.9	3.2	305.44	0.50	152.72	0.0209	$5.19
6	3	49.9	10.0	958.58	0.50	479.29	0.0657	$16.28
Total Avg.		18.1	3.6	346.8	0.50	173.42	0.0238	$5.89

Net Income/AU=$247.97
(As Determined in the Income Statement Year Ending December 31, 2005 for Representative Ranch)

APPENDIX E-1—PRESENT VALUE OF RECLAMATION COSTS TO OIL AND GAS COMPANIES

Scenario	Vegetation	Activity Level	Length of Occupancy	Short term acres disturbed	Long term acres disturbed	Acres not reclaimed	Reclamation Costs—Short term	Reclamation Costs—Long term	Discounted Reclamation Costs—Long Term
1	Grassland	1%	5	275.05	225.13	38.64829091	$1,616,588.93	$1,323,179.93	$1,036,746.10
2	Grassland	1%	10	275.05	225.13	38.64829091	$1,616,588.93	$1,323,179.93	$812,317.70
3	Grassland	1%	20	275.05	225.13	38.64829091	$1,616,588.93	$1,323,179.93	$498,692.60
4	Grassland	1%	30	275.05	225.13	38.64829091	$1,616,588.93	$1,323,179.93	$306,154.00
5	Grassland	1%	50	275.05	225.13	38.64829091	$1,616,588.93	$1,323,179.93	$115,386.22
6	Grassland	2%	5	550.09	450.25	77.29658182	$3,233,177.86	$2,646,359.87	$2,073,492.20
7	Grassland	2%	10	550.09	450.25	77.29658182	$3,233,177.86	$2,646,359.87	$1,624,635.39
8	Grassland	2%	20	550.09	450.25	77.29658182	$3,233,177.86	$2,646,359.87	$997,385.20
9	Grassland	2%	30	550.09	450.25	77.29658182	$3,233,177.86	$2,646,359.87	$612,307.99
10	Grassland	2%	50	550.09	450.25	77.29658182	$3,233,177.86	$2,646,359.87	$230,772.44
11	Grassland	3%	5	825.14	675.38	115.9448727	$4,849,766.79	$3,969,539.80	$3,110,238.30
12	Grassland	3%	10	825.14	675.38	115.9448727	$4,849,766.79	$3,969,539.80	$2,436,953.09
13	Grassland	3%	20	825.14	675.38	115.9448727	$4,849,766.79	$3,969,539.80	$1,496,077.80
14	Grassland	3%	30	825.14	675.38	115.9448727	$4,849,766.79	$3,969,539.80	$918,461.99
15	Grassland	3%	50	825.14	675.38	115.9448727	$4,849,766.79	$3,969,539.80	$346,158.66
16	Grassland	4%	5	1100.19	900.51	154.5931636	$6,466,355.72	$5,292,719.73	$4,146,984.40
17	Grassland	4%	10	1100.19	900.51	154.5931636	$6,466,355.72	$5,292,719.73	$3,249,270.79
18	Grassland	4%	20	1100.19	900.51	154.5931636	$6,466,355.72	$5,292,719.73	$1,994,770.40
19	Grassland	4%	30	1100.19	900.51	154.5931636	$6,466,355.72	$5,292,719.73	$1,224,615.99
20	Grassland	4%	50	1100.19	900.51	154.5931636	$6,466,355.72	$5,292,719.73	$461,544.89
21	Grassland	5%	5	1375.24	1125.63	193.2414545	$8,082,944.65	$6,615,899.66	$5,183,730.50
22	Grassland	5%	10	1375.24	1125.63	193.2414545	$8,082,944.65	$6,615,899.66	$4,061,588.49
23	Grassland	5%	20	1375.24	1125.63	193.2414545	$8,082,944.65	$6,615,899.66	$2,493,463.00
24	Grassland	5%	30	1375.24	1125.63	193.2414545	$8,082,944.65	$6,615,899.66	$1,530,769.98
25	Grassland	5%	50	1375.24	1125.63	193.2414545	$8,082,944.65	$6,615,899.66	$576,931.11
26	Shrubland	1%	5	275.05	225.13	38.64829091	$1,450,247.84	$1,323,179.93	$1,036,746.10
27	Shrubland	1%	10	275.05	225.13	38.64829091	$1,450,247.84	$1,323,179.93	$812,317.70
28	Shrubland	1%	20	275.05	225.13	38.64829091	$1,450,247.84	$1,323,179.93	$498,692.60
29	Shrubland	1%	30	275.05	225.13	38.64829091	$1,450,247.84	$1,323,179.93	$306,154.00
30	Shrubland	1%	50	275.05	225.13	38.64829091	$1,450,247.84	$1,323,179.93	$115,386.22
31	Shrubland	2%	5	550.09	450.25	77.29658182	$2,900,495.67	$2,646,359.87	$2,073,492.20
32	Shrubland	2%	10	550.09	450.25	77.29658182	$2,900,495.67	$2,646,359.87	$1,624,635.39
33	Shrubland	2%	20	550.09	450.25	77.29658182	$2,900,495.67	$2,646,359.87	$997,385.20
34	Shrubland	2%	30	550.09	450.25	77.29658182	$2,900,495.67	$2,646,359.87	$612,307.99
35	Shrubland	2%	50	550.09	450.25	77.29658182	$2,900,495.67	$2,646,359.87	$230,772.44
36	Shrubland	3%	5	825.14	675.38	115.9448727	$4,350,743.51	$3,969,539.80	$3,110,238.30
37	Shrubland	3%	10	825.14	675.38	115.9448727	$4,350,743.51	$3,969,539.80	$2,436,953.09
38	Shrubland	3%	20	825.14	675.38	115.9448727	$4,350,743.51	$3,969,539.80	$1,496,077.80
39	Shrubland	3%	30	825.14	675.38	115.9448727	$4,350,743.51	$3,969,539.80	$918,461.99
40	Shrubland	3%	50	825.14	675.38	115.9448727	$4,350,743.51	$3,969,539.80	$346,158.66
41	Shrubland	4%	5	1100.19	900.51	154.5931636	$5,800,991.35	$5,292,719.73	$4,146,984.40
42	Shrubland	4%	10	1100.19	900.51	154.5931636	$5,800,991.35	$5,292,719.73	$3,249,270.79
43	Shrubland	4%	20	1100.19	900.51	154.5931636	$5,800,991.35	$5,292,719.73	$1,994,770.40
44	Shrubland	4%	30	1100.19	900.51	154.5931636	$5,800,991.35	$5,292,719.73	$1,224,615.99
45	Shrubland	4%	50	1100.19	900.51	154.5931636	$5,800,991.35	$5,292,719.73	$461,544.89
46	Shrubland	5%	5	1375.24	1125.63	193.2414545	$7,251,239.19	$6,615,899.66	$5,183,730.50
47	Shrubland	5%	10	1375.24	1125.63	193.2414545	$7,251,239.19	$6,615,899.66	$4,061,588.49

APPENDIX E-2—PRESENT VALUE OF RECLAMATION COSTS TO OIL AND GAS COMPANIES (CONT.)

Scenario	Vegetation	Activity Level	Length of Occupancy	Short term acres disturbed	Long term acres disturbed	Acres not reclaimed	Reclamation Costs—Short term	Reclamation Costs—Long term	Discounted Reclamation Costs—Long Term
48	Shrubland	5%	20	1375.24	1125.63	193.2414545	$7,251,239.19	$6,615,899.66	$2,493,463.00
49	Shrubland	5%	30	1375.24	1125.63	193.2414545	$7,251,239.19	$6,615,899.66	$1,530,769.98
50	Shrubland	5%	50	1375.24	1125.63	193.2414545	$7,251,239.19	$6,615,899.66	$576,931.11
51	Grass/Shrub	1%	5	275.05	225.13	38.64829091	$1,599,929.71	$1,323,179.93	$1,036,746.10
52	Grass/Shrub	1%	10	275.05	225.13	38.64829091	$1,599,929.71	$1,323,179.93	$812,317.70
53	Grass/Shrub	1%	20	275.05	225.13	38.64829091	$1,599,929.71	$1,323,179.93	$498,692.60
54	Grass/Shrub	1%	30	275.05	225.13	38.64829091	$1,599,929.71	$1,323,179.93	$306,154.00
55	Grass/Shrub	1%	50	275.05	225.13	38.64829091	$1,599,929.71	$1,323,179.93	$115,386.22
56	Grass/Shrub	2%	5	550.09	450.25	77.29658182	$3,199,859.42	$2,646,359.87	$2,073,492.20
57	Grass/Shrub	2%	10	550.09	450.25	77.29658182	$3,199,859.42	$2,646,359.87	$1,624,635.39
58	Grass/Shrub	2%	20	550.09	450.25	77.29658182	$3,199,859.42	$2,646,359.87	$997,385.20
59	Grass/Shrub	2%	30	550.09	450.25	77.29658182	$3,199,859.42	$2,646,359.87	$612,307.99
60	Grass/Shrub	2%	50	550.09	450.25	77.29658182	$3,199,859.42	$2,646,359.87	$230,772.44
61	Grass/Shrub	3%	5	825.14	675.38	115.9448727	$4,799,789.13	$3,969,539.80	$3,110,238.30
62	Grass/Shrub	3%	10	825.14	675.38	115.9448727	$4,799,789.13	$3,969,539.80	$2,436,953.09
63	Grass/Shrub	3%	20	825.14	675.38	115.9448727	$4,799,789.13	$3,969,539.80	$1,496,077.80
64	Grass/Shrub	3%	30	825.14	675.38	115.9448727	$4,799,789.13	$3,969,539.80	$918,461.99
65	Grass/Shrub	3%	50	825.14	675.38	115.9448727	$4,799,789.13	$3,969,539.80	$346,158.66
66	Grass/Shrub	4%	5	1100.19	900.51	154.5931636	$6,399,718.83	$5,292,719.73	$4,146,984.40
67	Grass/Shrub	4%	10	1100.19	900.51	154.5931636	$6,399,718.83	$5,292,719.73	$3,249,270.79
68	Grass/Shrub	4%	20	1100.19	900.51	154.5931636	$6,399,718.83	$5,292,719.73	$1,994,770.40
69	Grass/Shrub	4%	30	1100.19	900.51	154.5931636	$6,399,718.83	$5,292,719.73	$1,224,615.99
70	Grass/Shrub	4%	50	1100.19	900.51	154.5931636	$6,399,718.83	$5,292,719.73	$461,544.89
71	Grass/Shrub	5%	5	1375.24	1125.63	193.2414545	$7,999,648.54	$6,615,899.66	$5,183,730.50
72	Grass/Shrub	5%	10	1375.24	1125.63	193.2414545	$7,999,648.54	$6,615,899.66	$4,061,588.49
73	Grass/Shrub	5%	20	1375.24	1125.63	193.2414545	$7,999,648.54	$6,615,899.66	$2,493,463.00
74	Grass/Shrub	5%	30	1375.24	1125.63	193.2414545	$7,999,648.54	$6,615,899.66	$1,530,769.98
75	Grass/Shrub	5%	50	1375.24	1125.63	193.2414545	$7,999,648.54	$6,615,899.66	$576,931.11

Short term acres disturbed = area used for well pad + access road acres + pipeline acres

Long term acres disturbed = acres not reclaimed + access road acres + pipeline acres

Reclamation costs—Short term = short term acres × average vegetation and dirt reclamtion cost (for vegetation type)

Reclamation costs—Long term = long term acres × average vegetation and dirt reclamation cost (for vegetation type)

Discounted Reclamation Costs—Long term = Reclamation Costs—long term/$(1.05)^{\text{length of occupancy}}$

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